Before the Federal Energy Regulatory Commission

Amended Final Application for New License for Major Water Power Project – Existing Dam

Turners Falls Hydroelectric Project (FERC Project Number 1889)
Northfield Mountain Project (FERC Number 2485)

VOLUME II OF V (PUBLIC), PART 2 OF 4

- **EXHIBIT E- ENVIRONMENTAL REPORT (PART 1 OF 4)**
- **EXHIBIT E- ENVIRONMENTAL REPORT (PART 2 OF 4)**
- **EXHIBIT E- ENVIRONMENTAL REPORT, APPENDICES (PART 3 OF 4) SECTION 1.0 INTRODUCTION TO 3.3.4 TERRESTRIAL RESOURCES**
- **EXHIBIT E- ENVIRONMENTAL REPORT, APPENDICES (PART 4 OF 4) SECTION 3.3.5 RARE, THREATENED, & ENDANGERED SPECIES TO END**

DECEMBER 2020

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Amended Final License Application for New License for Major Water Power Project – Existing Dam

Northfield Mountain Pumped Storage Project (FERC Project Number 2485)
Turners Falls Hydroelectric Project (FERC Project Number 1889)

EXHIBIT E – ENVIRONMENTAL REPORT

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3.3.3 Aquatic Resources

The Turners Falls Project and Northfield Mountain Project provide aquatic habitat for a variety of plants and animals. Studies conducted in the Project area provide information on the presence and distribution of the aquatic biota and on potential effects of Project operation on these resources.

Studies performed by FirstLight that pertain to aquatic resources include:

- Study 3.3.1 – Conduct Instream Flow Habitat Assessments in the Bypass Reach and Below Cabot Station (FirstLight, 2016a)
  - Addendum 1- Reply to comments (4/30/2017)
  - Addendum 2- Yellow Lampmussels Reach 5 (5/1/2018)
  - Addendum 3- Yellow Lampmussels Reach 3 (5/1/2018)
  - Addendum 4- Sea Lamprey Habitat Suitability Index Curves (5/1/2018)
  - Addendum 5- Sea Lamprey Assessment and Yellow Lampmussels in Reach 3 (3/1/2019)
  - Addendum 6- Seal Lamprey Assessment and Yellow Lampmussels Reach 4 (4/19/2019)
  - Addendum 7- Yellow Lampmussels Reach 4 (9/30/2019)
- Study 3.3.2 – Evaluate Upstream and Downstream Passage of Adult American Shad (FirstLight, 2016b)
  - Addendum 1- Reply to comments (5/1/2017)
- Study 3.3.3 – Evaluate Downstream Passage of Juvenile American Shad (FirstLight, 2016c)
  - Addendum 1- Reply to comments (5/1/2017)
- Study 3.3.4 – Evaluate Upstream Passage of Juvenile American Eel at the Turners Falls Project (FirstLight, 2016d)
- Study 3.3.5 – Evaluate Downstream Passage of American Eel (FirstLight, 2017a)
- Study 3.3.6 – Impact of Project Operations on Shad Spawning, Spawning Habitat, and Egg Deposition in the Area of the Northfield Mountain and Turners Falls Projects (FirstLight, 2016e)
  - Addendum 1 (10/14/2016)
- Study 3.3.7 – Fish Entrainment and Turbine Passage Mortality Study (FirstLight, 2016f).
- Study 3.3.8 – Computational Fluid Dynamics Modeling in the Vicinity of the Fishway Entrances and Powerhouse Forebays (FirstLight, 2016g)
  - Addendum 1 (10/14/2016)
- Study 3.3.9 – Two-Dimensional Modeling of the Northfield Mountain Pumped Storage Project Intake/Tailrace Channel and Connecticut River Upstream and Downstream of the Intake/Tailrace (FirstLight, 2015a)
- Study 3.3.10 – Assess Operational Impacts on Emergence of State-Listed Odonates in the Connecticut River (FirstLight, 2016i)
  - Year 2 (3/1/2017)
- Study 3.3.11 – Fish Assemblage Assessment (FirstLight, 2016j)
- Study 3.3.12 – Evaluate Frequency and Impact of Emergency Water Control Gate Discharge Events and Bypass Flume Events on Shortnose Sturgeon Spawning and Rearing Habitat in the Tailrace and Downstream from Cabot Station (FirstLight, 2016k)
- Study 3.3.13 – Impacts of the Turners Falls Project and Northfield Mountain Project on Littoral Zone Fish Habitat and Spawning Habitat (FirstLight, 2016l)
- Study 3.3.14 – Aquatic Habitat Mapping of the Turners Falls Impoundment (FirstLight, 2015a)
- Study 3.3.15 – Assessment of Adult Sea Lamprey Spawning within the Turners Falls Project and Northfield Mountain Project Area (FirstLight, 2016m)
  - Addendum 1 (5/1/2018)

- Study 3.3.16 – Habitat Assessment, Surveys, and Modeling of Suitable Habitat for State-listed Mussel Species in the CT River below Cabot Station (FirstLight, 2016n)
- Study 3.3.17 – Assess the Impacts of Project Operations on the Turners Falls Project and Northfield Mountain Project on Tributary and Backwater Area Access and Habitat (FirstLight, 2015b)
- Study 3.3.18 – Impacts of the Turners Falls Canal Drawdown on Fish Migration and Aquatic Organisms (FirstLight, 2015c)
  Addendum 1- (3/1/2016)
- Study 3.3.19 – Evaluate the Use of an Ultrasound Array to Facilitate Upstream Movement to Turners Falls Dam by Avoiding Cabot Station Tailrace (FirstLight, 2017b)
  - 2018 Study (3/12/2019)
  - 2019 Study (3/31/2020)
- Study 3.3.20 – Northfield Mountain Project American Shad Ichthyoplankton Entrainment Assessment (FirstLight, 2016o)
  - Addendum 1 (7/28/2017)
  - Year 2 (3/1/2017)

Additionally, results and analyses from Study 3.2.2 – *Hydraulic Study of the Turners Falls Impoundment, Bypass Reach, and below Cabot Station* and Study 3.8.1 – *Evaluate the Impact of Current and Proposed Future Modes of Operation on Flow, Water Elevation, and Hydropower Generation* were useful for evaluating the effects of baseline and FirstLight's proposed operations across relatively large areas and given varying river flow conditions.

Pertinent information from each study is provided in this AFLA, though additional details regarding each study can be found in the study reports and addendums filed with FERC.

3.3.3.1 Affected Environment

The Connecticut River in the vicinity of the Projects is generally narrow, with areas of floodplain and terraces of silt, sand, and gravel. The basin is steep and drains quickly to the river during rain events, snow melts and storms. The Turners Falls Project and Northfield Mountain Project areas include various habitats and aquatic pathways for resident and migratory species. In general, this includes the TFI, power canal, bypass reach and downstream areas in the Connecticut River.

Turners Falls Impoundment

The TFI extends approximately 20 miles upstream from the Turners Falls Dam to the Vernon Dam (FERC No. 1904) tailrace and includes two major tributaries (Ashuelot and Miller Rivers) along with several smaller tributaries (Figure 3.3.3.1-1).

Physical Habitat

Both lentic and lotic conditions are present in the TFI. Study No. 3.3.14 *Aquatic Habitat Mapping of the Turners Falls Impoundment* was conducted to determine the distribution and abundance of aquatic habitat within the TFI (FirstLight, 2015a). The distribution and abundance of aquatic habitats, including biological and geomorphological characteristics, were documented during field surveys in 2014 and 2015. Survey results were used to develop maps depicting the distribution of mesohabitat. Littoral habitat mapping of substrates and wetlands in the TFI are shown in Figure 3.3.3.1-2 (9 maps). Habitat maps of the bypass reach and below Cabot Station are shown in and Figure 3.3.3.1-3 (22 maps)

The upstream reach of the TFI, extending approximately 15 miles from Vernon Dam tailrace to the Northfield Mountain Project tailwater, is located within a broad floodplain and is relatively uniform and generally shallow, with gentle bends. A river channel exists with rock shorelines and lotic conditions. The substrate in this reach is variable ranging from sand to boulders. There are a few narrow islands comprised of alluvial materials such as gravel, cobble, and fines. There are also a few deep pools that are generally confined to locations downstream of features such as bridge piers, which have created scour holes and shoals. Scour holes provide the most extensive cover; object cover in the littoral zone is sparse, consisting primarily of isolated patches of submerged aquatic vegetation (SAV) and clusters of woody debris.

The downstream reach of the TFI extends approximately 5.2 miles from the Northfield Mountain Project tailrace to the Turners Falls Dam and is constrained by bedrock, which controls much of the stream geometry and substrate features. The geometry of the lower TFI is complex. It is defined by both bedrock and depositional features, and includes a complex of embayment, points, coves, islands, and a wide range of substrates, and features shallow lacustrine littoral habitat with a deeply incised thalweg, in contrast to the riverine habitat found further upstream in the TFI. Within the French King Gorge is a small but deep (depth > 100 feet) area of river with sheer rock faces, possibly formed by weakening of bedrock along a fault line. This area is unique in that it harbors freshwater sponges and bryozoans in its depths. The lowest section of the TFI has several large areas off the channel which are shallow, with SAV and muck bottom habitats characteristic of lentic conditions.

Study No. 3.3.13 (*Impacts of the Turners Falls Project and Northfield Mountain Project on Littoral Zone Fish Habitat and Spawning Habitat*, (FirstLight, 2016l) documented varied substrates in the TFI littoral zone. In some locations the littoral zone is absent due to vertical bedrock cliffs, while in other areas there are broad horizontal shoals composed of gravel, sand or other fines, particularly in embayed sections (Figure 3.3.3.1-2). The thalweg is deeply incised. Most banks are wooded and composed of predominantly deciduous trees. Shoreline development ranges from residential (seasonal and year-round homes) to urban. The least developed shorelines are those furthest upstream from Gill and Turners Falls.

Littoral zone substrates composed of fines (e.g., sand/silt, clay) and cobble collectively accounted for about 50% of all littoral substrate (Table 3.3.3.1-1). Fines comprised 29% of the study area, followed by cobble (21%), then bedrock (17%) and gravel (16%). Littoral habitats where cobble substrates were combined with either fines (6%) or boulder (1 %) were also present in scattered, small areas. Littoral habitats with fines were widely distributed throughout the study area; however, cobble and gravel were most common above the French King Gorge area. Bedrock and wetland areas were most abundant in the reach from French King Gorge downstream. Riprap accounted for approximately 7% of littoral substrates and is found in patches throughout the study area where either erosion abatement or other infrastructure such as bridges or developed shorefronts were located.

Flow Effects on Habitat and Migratory Fish Pathways

Habitats and migratory fish pathways through the TFI are affected by river flow, operating levels at the Turners Falls Dam, and operations at the Northfield Mountain Project. Relicensing Study 3.3.9 - *Two-Dimensional Modeling of the Northfield Mountain Pumped Storage Intake/Tailrace Channel and Connecticut River Upstream and Downstream of the Intake/Tailrace* was performed to:

- Assess velocities and flow fields at, and in proximity to, the Northfield Mountain Project intake/tailrace structure, when pumping or generating, and their potential to interfere with fish migration;
- Assess the potential for velocity barriers in the Connecticut River in the vicinity of the Northfield Mountain Project tailrace due to pumping and generation flows alone or in conjunction with generation flows from the upstream Vernon Project;
- Characterize water column velocity profiles in the immediate vicinity of the Northfield Mountain Project intake/tailrace (i.e. inside the boat barrier);
- Assess the potential for Northfield Mountain Project operations to create undesirable attraction flows to the intake/tailrace area that may result in entrainment or delay of migratory fish; and

- Assess potential migratory fish impacts due to flow reversals under:
  - Pumping conditions, such that river flows move upstream below the Northfield Mountain Project intake/tailrace; and
  - Generating conditions, such that river flows move upstream above the Northfield Mountain Project intake/tailrace toward Vernon Dam.

A two-dimensional (River2D) model of the Northfield Mountain Project intake/tailrace and Connecticut River five km upstream and five km downstream of the Northfield Mountain Project intake/tailrace was developed to evaluate hydraulic (depth, velocity, water surface elevation) conditions in the 10 km reach over a range of flow and Northfield Mountain Project operating conditions (two units pumping, four units pumping, two units generating, four units generating).

The results of this study are extensive and are documented in a report filed with FERC on March 1, 2016 (FirstLight, 2016h). In general, the results of the study found:

- Water velocities were generally higher at low TFI levels, due to shallower water and more river gradient. The velocities predicted for many scenarios were often greatest at the French King Gorge, except for scenarios where the Turners Falls Dam WSEL was 181.3 feet or higher and the Northfield Mountain Project was in pumping mode. During these scenarios, the French King Gorge exhibited similar or slightly lower velocities than near the Northfield Mountain Project intake/tailrace area. Velocities in the French King Gorge reached >10 ft/s in some areas during the most extreme scenarios when river flow was high, the TFI WSEL at the dam was low, and the Northfield Mountain Project was generating. Velocity is high in many areas across the channel, but there are areas along the river margins with lower velocities that migrating fish could utilize.
- Flow reversals upstream of the Northfield Mountain Project intake/tailrace were predicted to occur during two-unit generation and low river flow, and the greatest extent of reversals during these low flow scenarios occurred when the TFI WSEL was high. Flow reversals up to or beyond Kidds Island were observed for scenarios of inflows up to 4,900 cfs, and low TFI WSELs tended to reduce the extent of reversals under similar flow conditions. Similar patterns were observed for full generation, except that flow reversals to, or beyond, Kidds Island were present at incoming flows up to 8,440 cfs.
- Flow reversals downstream of the Northfield Mountain Project intake/tailrace were predicted during pumping scenarios under low incoming flow conditions, with reversals predicted only at the lowest incoming flow (1,760 cfs) under 7,600 cfs of pumping, and primarily up to 4,900 cfs incoming flow during full pumping at 15,200 cfs. One exception to this was that flow reversals were predicted under an inflow of 8,440 cfs under full pumping and high (185 ft) TFI WSEL.

The effects of flow reversals on upstream and downstream migrating fish are poorly understood in upriver areas. Fish that encounter flow reversals may change direction, similar to how migratory fish sometimes respond to tide changes when entering estuarine areas (i.e. Grote *et al.*, 2014), resulting in migration delay, though directional changes documented in the literature are normally thought to be related to salinity. Eddies in the vicinity of the Northfield Mountain Project intake/tailrace also have the potential to confuse fish and delay their migration. Migrating fish that move during the daytime may encounter flow reversals upstream of the tailrace due to generation and low incoming flow, if these conditions occur during migration periods. Alternatively, migrating fish that move at night may encounter flow reversals downstream of the tailrace due to pumping and low incoming flow from upstream. In general, the conditions amenable to flow reversals would be uncommon during spring migration periods, when river flows tend to be higher than flows where reversals could occur. Passage of migratory fish beyond the Northfield Mountain Project intake/tailrace at existing operational conditions was evaluated directly using tagging/tracking studies, as described in Section 3.3.3.2.3.

Turners Falls Power Canal

The Turners Falls Power Canal is 2.1 miles long leading from the gatehouse to Cabot Station. The original upstream portion of the canal was constructed around 1866, and the canal was subsequently widened, extended, and heightened around 1915. The canal supplies water to Station No. 1, Cabot Station, two smaller hydropower facilities (Milton Hilton, LLC[1] and Turners Falls Hydro, LLC[2]), and the Silvio O. Conte Anadromous Fish Research Laboratory. The first 3,900-ft reach of the canal downstream of the gatehouse is rectangular with canal walls varying from masonry to concrete to cut-rock faces. The bottom width ranges from 170 ft at the gatehouse to 123 ft at the end of this 3,900-ft reach. The next 3,300-ft reach has been excavated to a trapezoidal shape with 1.5H:1V slopes on both sides; the canal walls are generally similar to the preceding segment. The remaining segment (about 4,300 ft upstream of the Cabot Station) is essentially a pond covering about 50 acres, which was excavated to provide fill for the canal dikes. The width of the pond is approximately 783 ft at its widest point. The bottom of the pond was not originally excavated. It was a field having an average surface elevation of 159 ft at the upstream end, with a few trees that were removed. The average depth of the pond was about 14 ft when the canal level was raised in 1915.

The last 600 ft of the canal, extending from the “pond” to the Cabot Station, was excavated from rock and has earth and concrete walls. It is generally trapezoidal in shape and riprap was added to the earth portions of the channel slopes for slope protection.

Also associated with the canal are two drainage tunnels (Keith and Lower Drainage); a branch canal to FirstLight’s Station No. 1 powerhouse; fish passage structures; and an emergency spillway structure adjacent to Cabot Station. The concrete-lined Keith Tunnel is in the upper quarter of the canal and serves as the primary means of dewatering the upper portion of the canal. The Keith Tunnel typically remains open for the duration of the canal outage period. The concrete lined Lower Drainage Tunnel is located just upstream of where the canal widens out into the pond. The non-project works Lower Drainage Tunnel is abandoned and has never been used to FirstLight’s knowledge; it is not considered part of the Project.

During a recent engineering inspection of the canal under de-watered conditions, it was reported that bottom elevations of the pond have changed dramatically since construction in 1915. Areas of higher flow velocities have scoured the bottom and areas of low velocity, particularly where the canal begins to widen, have large silt deposits. The topography of the lower portion of the canal now ranges from large areas of silt deposits, to areas of exposed bedrock, and areas with coarse and fine grain sediments.

Canal Forebay Flow Fields

Flow conditions in portions of the canal were documented by the results of Relicensing Study No. 3.3.8 *Computational Fluid Dynamics Modeling in the Vicinity of the Fishway Entrances and Powerhouse Forebays*. The study report was filed with FERC on March 1, 2016, and Addendum 1 filed with FERC on October 14, 2016 (FirstLight, 2016g). The specific study objectives of the Computational Fluid Dynamics (CFD) Study were as follows:

- Characterize the hydraulics of current (existing) conditions and any changes to:
    - Fishway attraction flows;
    - Turbine operations; and
    - log sluice gates
- Develop a series of velocity maps at select discharges showing approach velocities and flow fields that may create a response in fish;
- Characterize the flow field in front of the Cabot Station and Station No. 1 intakes using velocity maps and cross-sectional plots;
- Assess whether fish are directed to the surface bypass weir near Cabot Station;

[1] This was formerly PaperLogic which has no FERC license.
[2] This site is owned by Eagle Creek Renewable Energy (FERC No. 2622), which is undergoing licensing.

- Characterize the near-rack "sweeping" velocities at the Cabot Station and Station No. 1 intakes

The CFD model simulations for this study were conducted using the Flow-3D CFD code developed by Flow Science, Inc. FLOW-3D is a general-purpose CFD software that employs numerical techniques to solve the equations of motion for fluids to obtain transient, three-dimensional (3D) solutions to multi-scale, multi-physics flow problems (Flow Science, 2012). Flow-3D solves the Reynolds Averaged Navier-Stokes (RANS) equations.

Station No. 1 Forebay Flow Fields

The CFD models showed that, when most of the canal flow is being passed through Station No. 1, the highest velocities are predominately in front of the Station No. 1 intake racks and on the northern side of the forebay entrance from the power canal. When Cabot Station is generating at maximum capacity, the predominant flow pattern is created by flow passing through the power canal and on to Cabot Station. As a result of the higher velocities in the power canal under this scenario, the flows (high velocities) tend to concentrate on the southern side of the forebay entrance and cause significant eddies just inside the forebay. The velocities immediately in front of the intake racks at Station No. 1 were not affected by flow in the canal. One of the primary uses of the CFD modeling was to describe the ratio of velocity parallel to the racks (sweeping) to velocities perpendicular to the racks as well as the total velocity immediately in front of the racks. CFD modeling scenarios indicated that even during periods when the majority of the canal flow is directed to Station No. 1, the sweeping velocity is larger than the approach velocity over half of the racks.

Cabot Forebay Flow Fields

Under the range of flows evaluated, between approximate minimum and maximum capacities, the velocities in the power canal and forebay tend to be higher near the inside of the bend (north and west side) than near the outside of the bend (south and east side). Because log sluice flows are relatively low compared to the generation flows, the log sluice flows tend to have minimal impact on the flow fields in front of the intake racks. The CFD modeling indicated that during one out of the six Cabot operation, the majority of racks have a sweeping velocity in excess of the approach velocity. During three unit operation about half of the racks have a sweeping velocity in excess of the approach velocity, but with all six unit operations, the majority of the racks have approach velocities in excess of the sweeping velocity.

<u>Bypass Reach</u>

The 2.5-mile long bypass reach runs from the base of Turners Falls Dam to Cabot Station tailrace. This reach contains mostly bedrock, boulder, cobble, and gravel substrates; and is primarily comprised of pool mesohabitat, followed by riffle and backwater types. Per the FERC license, a continuous minimum flow of 200 cfs is maintained in the bypass reach starting on May 1 and increases to 400 cfs when fish passage starts by releasing flow through a bascule gate. The 400 cfs continuous minimum flow is provided through July 15, unless the upstream fish passage season has concluded early in which case the 400 cfs flow is reduced to 120 cfs to provide a zone of passage for SNS. The 120 cfs continuous minimum flow is maintained in the bypass reach from the date the fishways are closed (or by July 16) until the river temperature drops below 7°C, which typically occurs around November 15.

The distribution and abundance of aquatic habitats, including biological and geomorphological characteristics were broadly documented during field reconnaissance surveys in 2012 (Figure 3.3.3.1-3, 22 maps), with more detailed mapping and modeling of habitats in the bypass reach performed as part of Study 3.3.1 – *Conduct Instream Flow Habitat Assessments in the Bypass Reach and Below Cabot Station* (FirstLight, 2016a). For this study, portions of the bypass reach and areas downstream were delineated into separate study reaches based on general habitat characteristics. Study reaches in the bypass reach include:

Reach 1. This reach extends from the Turners Falls Dam downstream to the confluence with the Station No. 1 tailrace. Stream channel structure and geomorphology are controlled primarily by bedrock.

From the Turners Falls Dam to below the Fall River confluence is the plunge pool, which remains wetted from leakage and Fall River flows. The bypass channel here is dominated by scoured ledge substrate, and a poorly defined thalweg, before it begins to narrow upstream from the Station No.1 tailrace. Mesohabitat in this reach is dominated by a deep pool, but also includes run and riffle. Flow exiting the plunge pool has two major outlets. The river-right[3] channel follows the western shore and immediately bifurcates upon exiting the plunge pool. The two sub-channels are divided by a bedrock outcrop and both have well-defined channel cross-sections. The river-left channel has a poorly defined channel and lacks a distinct thalweg. Flow passes over broken ledge and rubble through crevasses, and over short vertical drops. All channels converge near the upstream end of the large pool near the Turners Falls Road Bridge.

Reach 2. This reach extends from the Station No. 1 tailrace downstream, terminating at the Rawson Island complex and a geological feature including a natural ledge drop known as "Rock Dam". Stream channel structure is controlled primarily by bedrock. Reach 2 channel morphology is relatively well defined, and includes pool, run and riffle mesohabitats with bedrock overlaid with rubble and cobble substrates. On the right bank, the substrate consists of a wide bench of vertically folded bedrock along most of this reach. The downstream-most segment of this reach is a pool that terminates in a bifurcated channel at the Rock Dam/Rawson Island complex.

Reach 3. This reach extends from below the Rock Dam/Rawson Island complex downstream to the USGS gage on the Connecticut River at Montague City (Gage No. 01170500). The portion of Reach 3 upstream of the Cabot Station tailrace is within the bypass reach. Stream channel structure is dominated by alluvial deposits, including an island and split channel complex both upstream, across, and downstream from the Cabot Station powerhouse. Hydraulic effects are complex and include flow-dependent backwatering from Cabot Station upstream to Rock Dam, as well as flow between islands. Mesohabitat includes pools, riffles and runs; substrate is dominated by gravel bars and cobble.

<u>Downstream Riverine Habitat</u>

Downstream of Cabot Station is a low-gradient reach forming a wide flood plain with alluvial-dominated substrates, with a meandering channel in many places. Run habitat comprises over 75% of the riverine reach by length, with pool comprising the next most abundant mesohabitat type (13%). The distribution and abundance of aquatic habitats, including biological and geomorphological characteristics, were initially documented during mesohabitat mapping surveys in 2012 (Figure 3.3.3.1-3, 22 maps). Detailed mapping and modeling of habitats downstream were performed as part of Study 3.3.1 – *Conduct Instream Flow Habitat Assessments in the Bypass Reach and Below Cabot Station* (FirstLight, 2016a). For this study, areas downstream were delineated into separate study reaches based on general habitat characteristics. Study reaches downstream include:

Reach 3. This reach extends from below the Rock Dam/Rawson Island complex downstream to the USGS gage on the Connecticut River at Montague City (Gage No. 01170500). The 0.75-mile portion of Reach 3 downstream of the Cabot Station tailrace is within the downstream areas. Stream channel structure is dominated by alluvial deposits, including an island and split channel complex both upstream, across, and downstream from the Cabot Station powerhouse. Habitat is primarily riffle and run; substrate is dominated by gravel bars and cobble and includes ledge outcrops at the General Pierce Bridge area. Riffle habitats are more common in this area than further downstream. The Deerfield River enters the Connecticut River just downstream of Cabot Station (Figure 3.3.3.1-1), which can result in some hydraulic complexities, depending on flows in the Connecticut River and those flowing in from the Deerfield River.

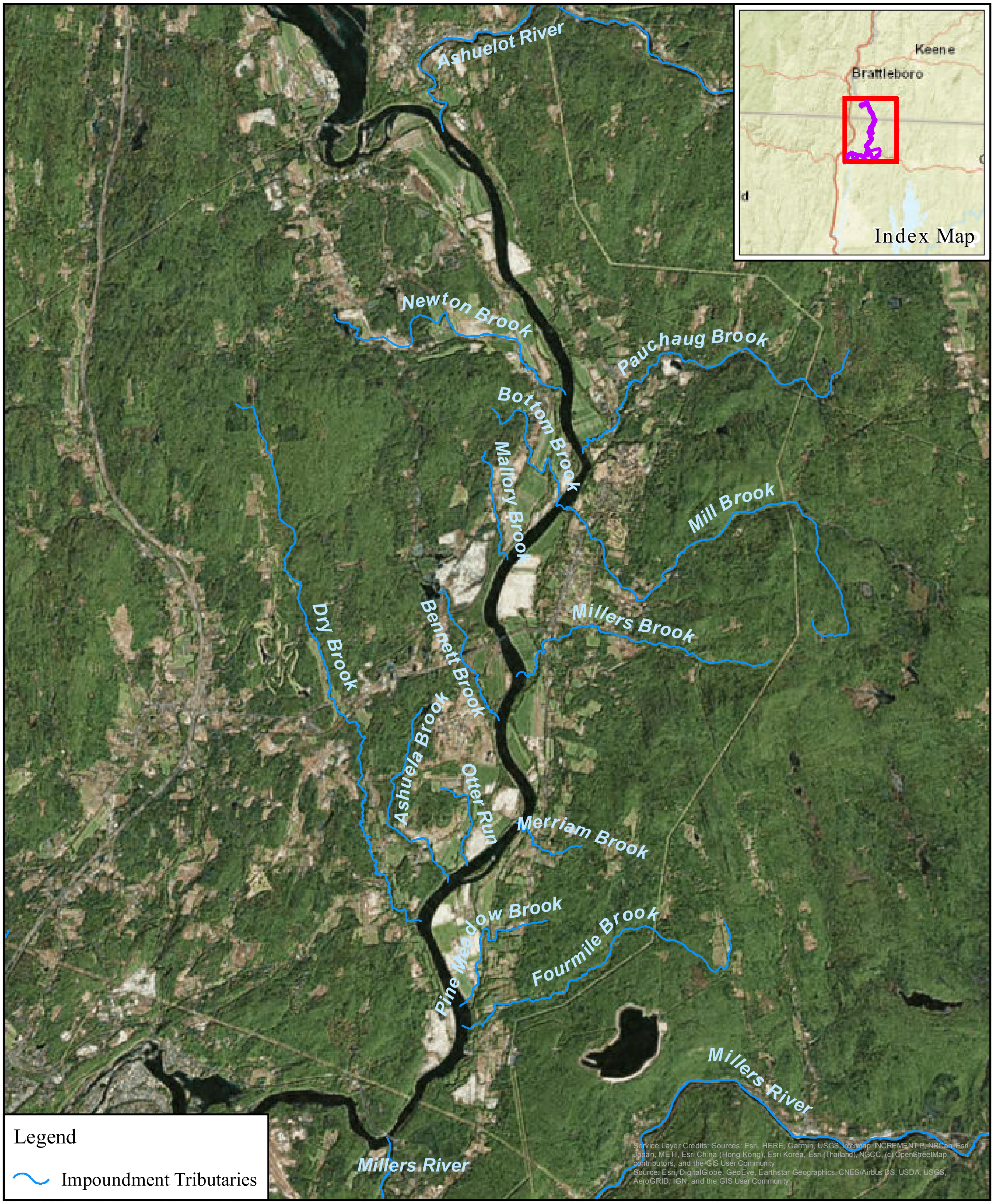
[3] All terms such as "river-right" in this document are based on looking downstream.

Reach 4. This reach is approximately nine (9) miles long and extends from the Montague USGS Gage downstream to the Route 116 Sunderland Bridge. Flow in this reach consists of combined flows through the Turners Falls Project and Deerfield River discharges. This section of river is alluvial and low gradient, with a well-defined channel and embankments, and repeating patterns of pool and run habitat. Substrate varies but is dominated by cobble, gravel and fines.

Reach 5. This reach extends 22 miles from the Route 116 Bridge downstream to a natural hydraulic control in the vicinity of Dinosaur Footprints Reservation. This reach becomes increasingly impounded by Holyoke Dam with distance downstream. It is a low gradient, alluvial reach with limited mesohabitat variability and in many cases, very gradual transitions from one mesohabitat type to the next contiguous type. Over 75% of the mesohabitat in this reach is comprised of run and most of the remainder is pool. Hydraulics in this reach are influenced by Holyoke Dam operations (1.2-foot water level operational range) and flow from upstream (i.e. combined flows from the Turners Falls Project, Deerfield River, and minor tributaries).

Table 3.3.3.1-1: Relative Abundance of Littoral Zone Habitats Identified in the TFI

Habitat Type	% of Total
Fines	29%
Cobble	21%
Bedrock	17%
Gravel	16%
Riprap	7%
Fines / Cobble Patch	6%
Wetlands	4%
Boulder / Cobble Patch	1%
Total does not add to 100% due to rounding	



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0 0.75 1.5 3 Miles

Figure 3.3.3.1-1:
Location of Target Tributaries in the Turners Falls Impoundment for FirstLight's Tributary and Backwater Access Study

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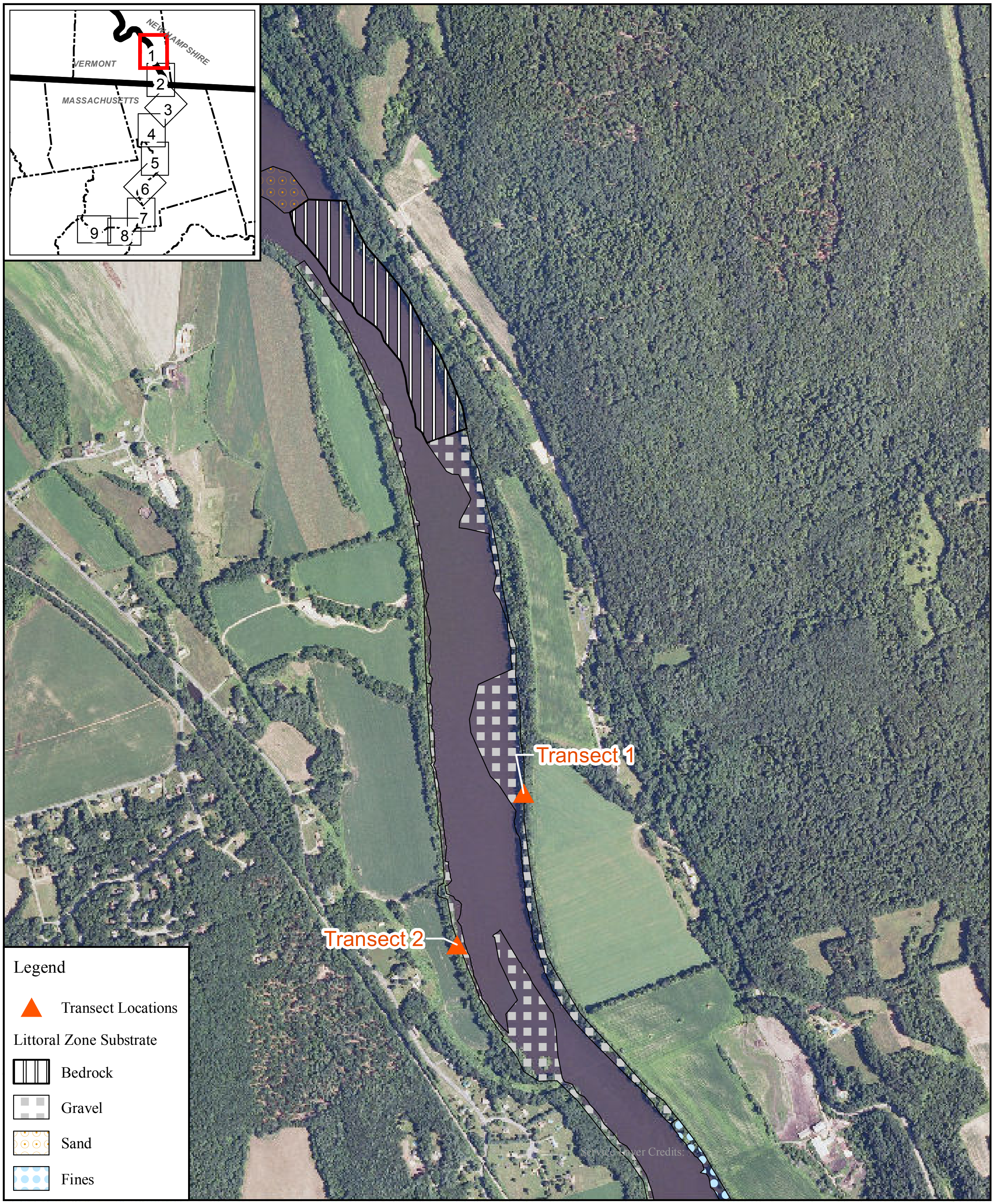

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0 500 1,000 2,000 Feet

Figure 3.3.3.1-2:
Littoral Habitat Mapping
Map 1

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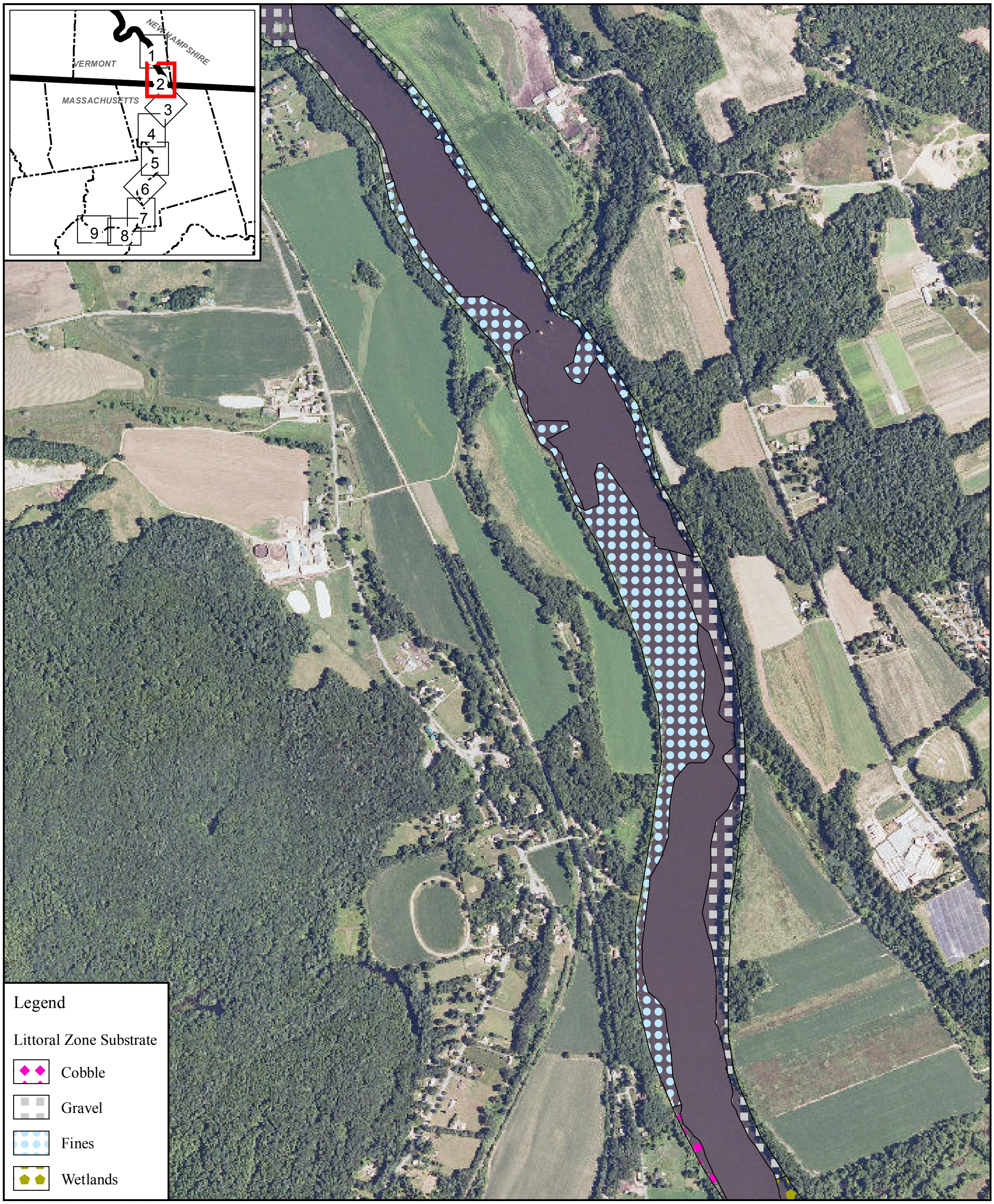

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Figure 3.3.3.1-2:
Littoral Habitat Mapping
Map 2

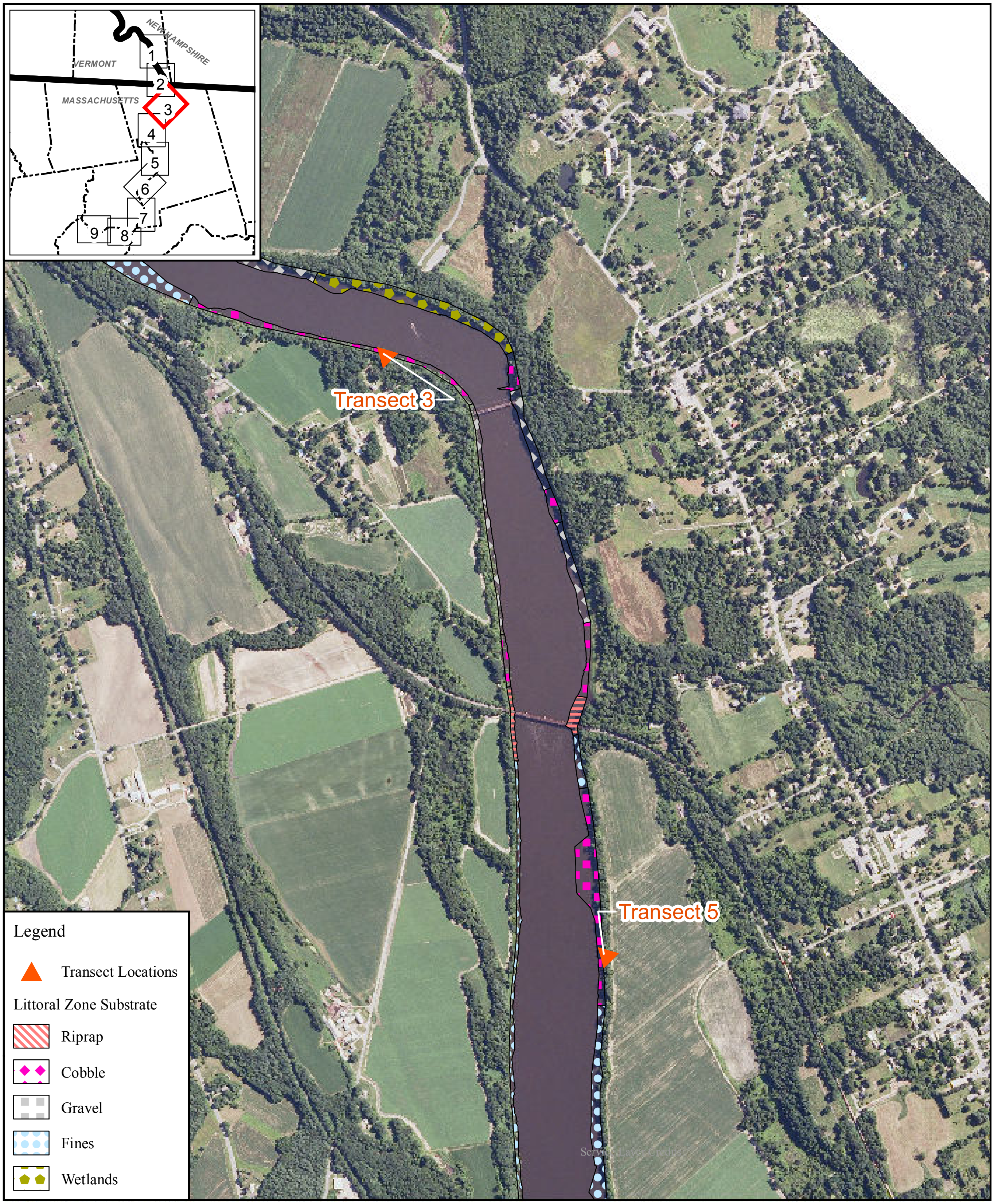

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Figure 3.3.3.1-2:
Littoral Habitat Mapping
Map 3

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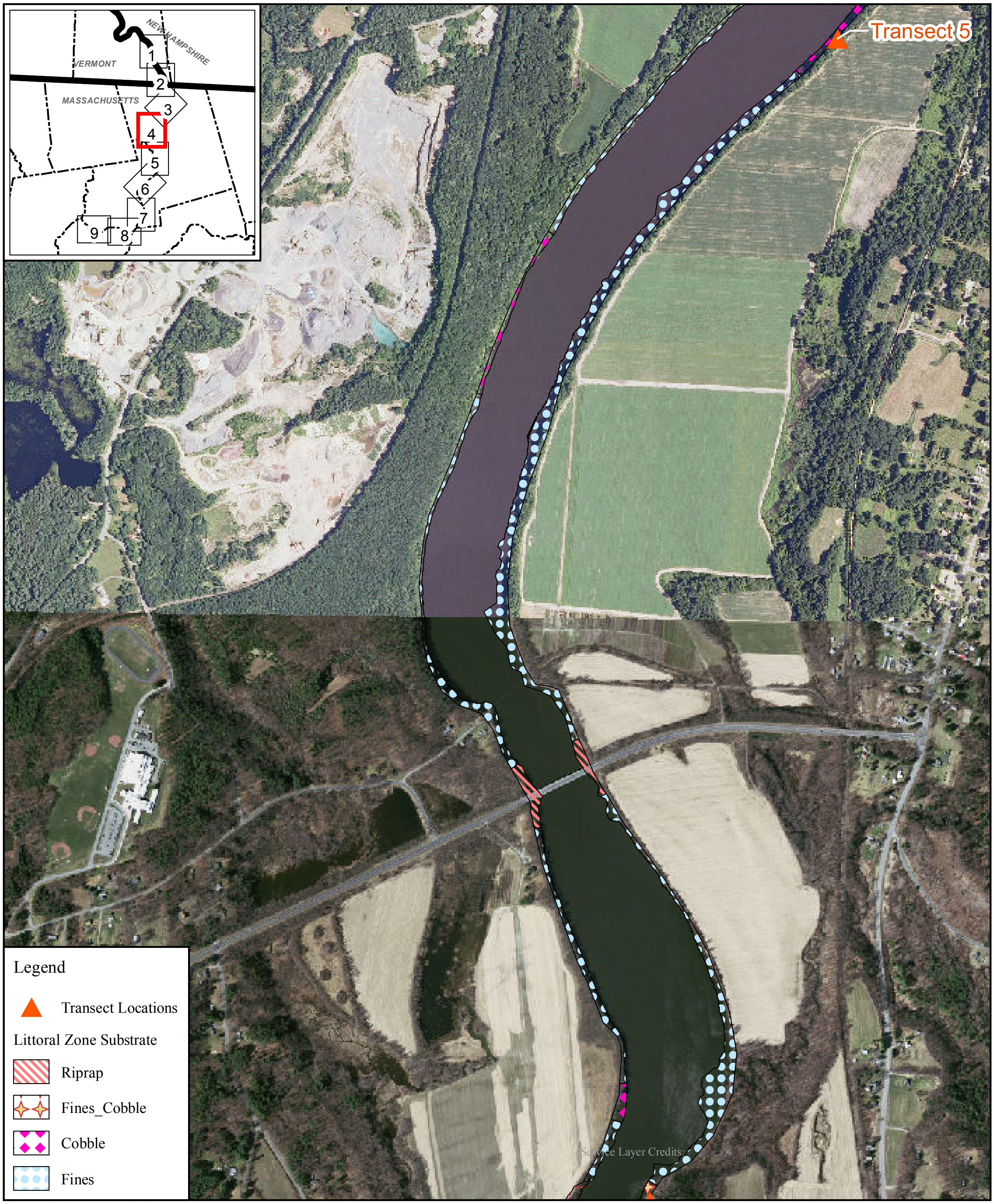

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Figure 3.3.3.1-2:
Littoral Habitat Mapping
Map 4

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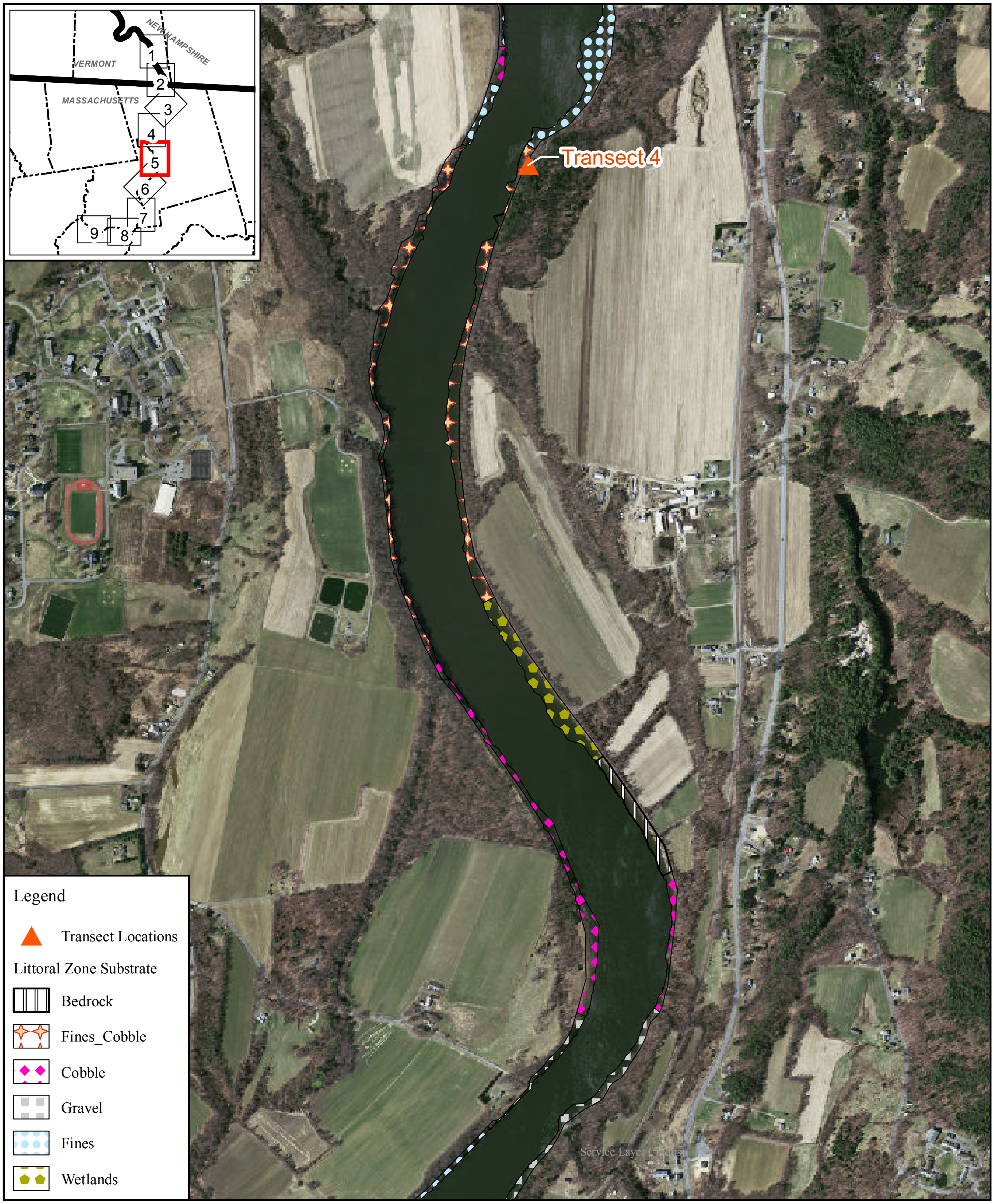

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Figure 3.3.3.1-2:
Littoral Habitat Mapping
Map 5

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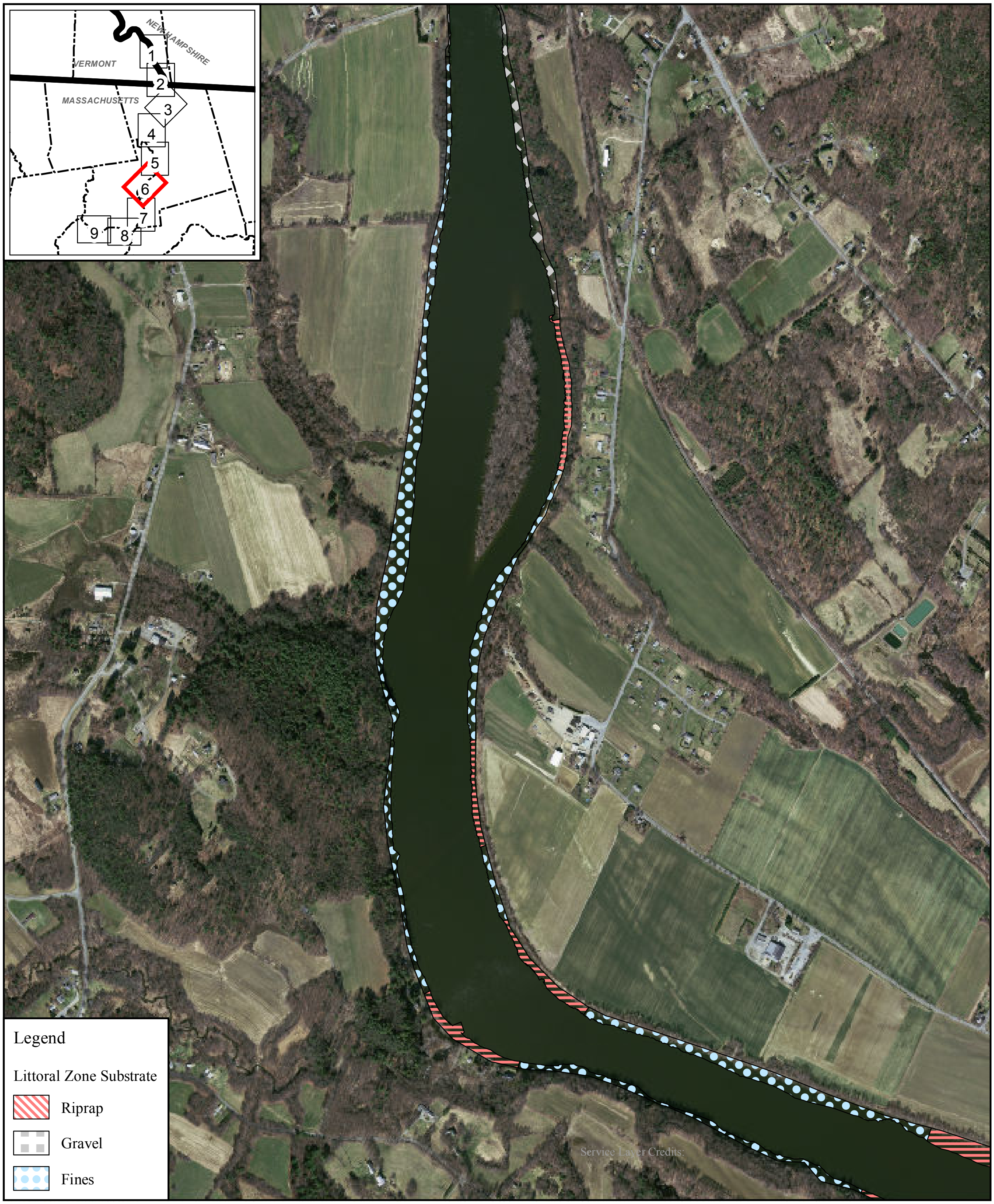

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Feet

Figure 3.3.3.1-2:
Littoral Habitat Mapping
Map 6

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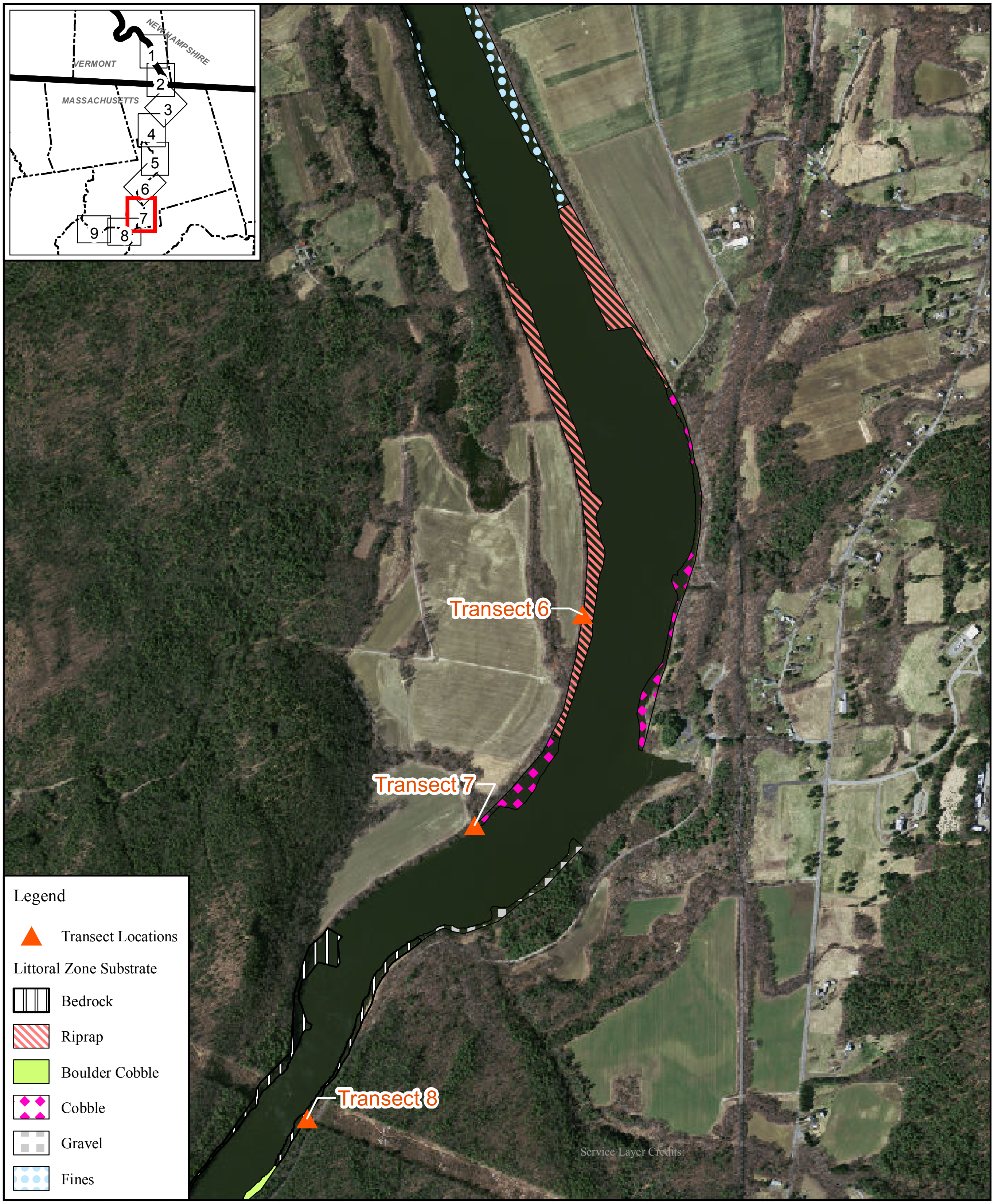

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Figure 3.3.3.1-2:
Littoral Habitat Mapping
Map 7

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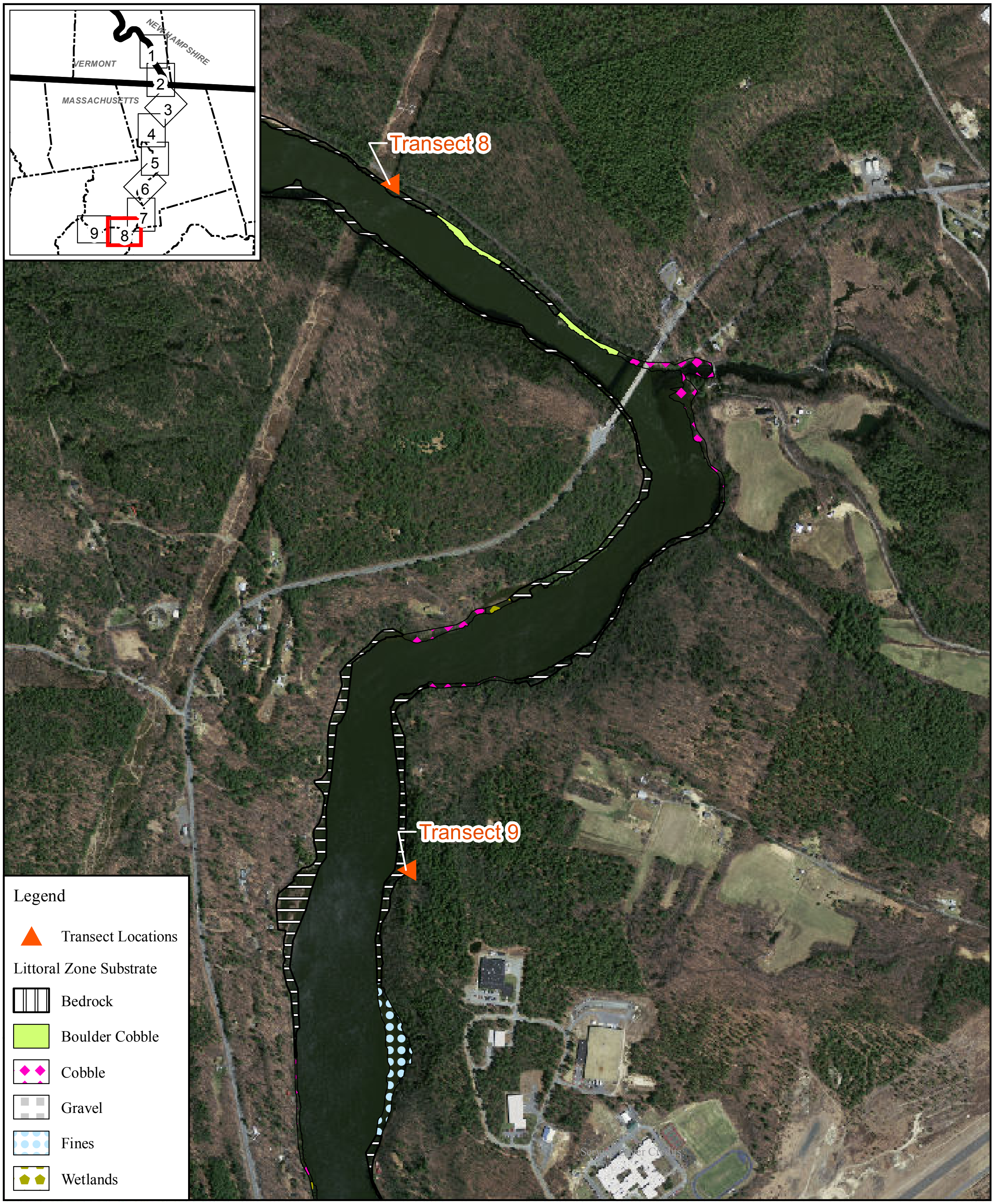

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Figure 3.3.3.1-2:
Littoral Habitat Mapping
Map 8

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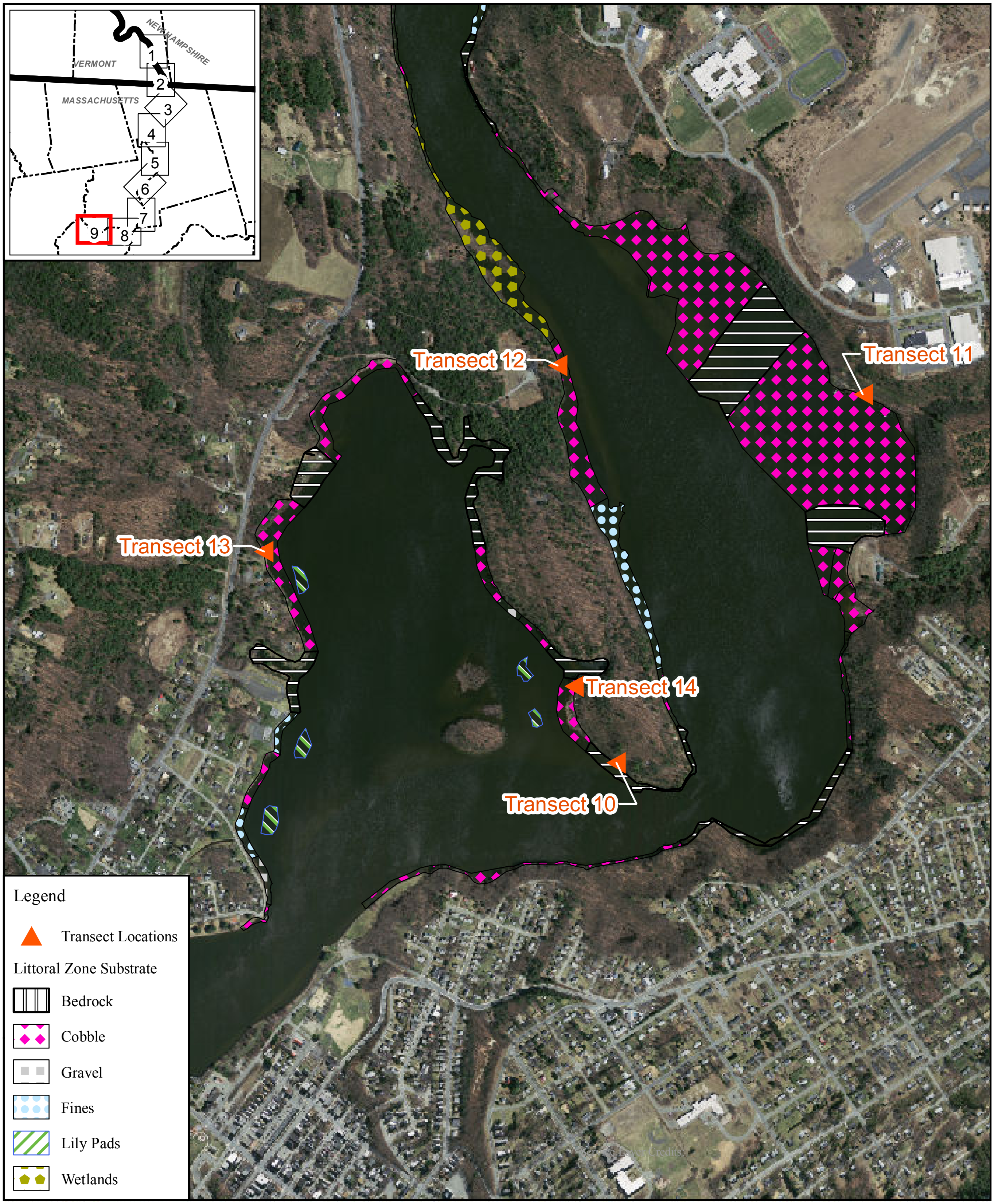

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Figure 3.3.3.1-2:
Littoral Habitat Mapping
Map 9

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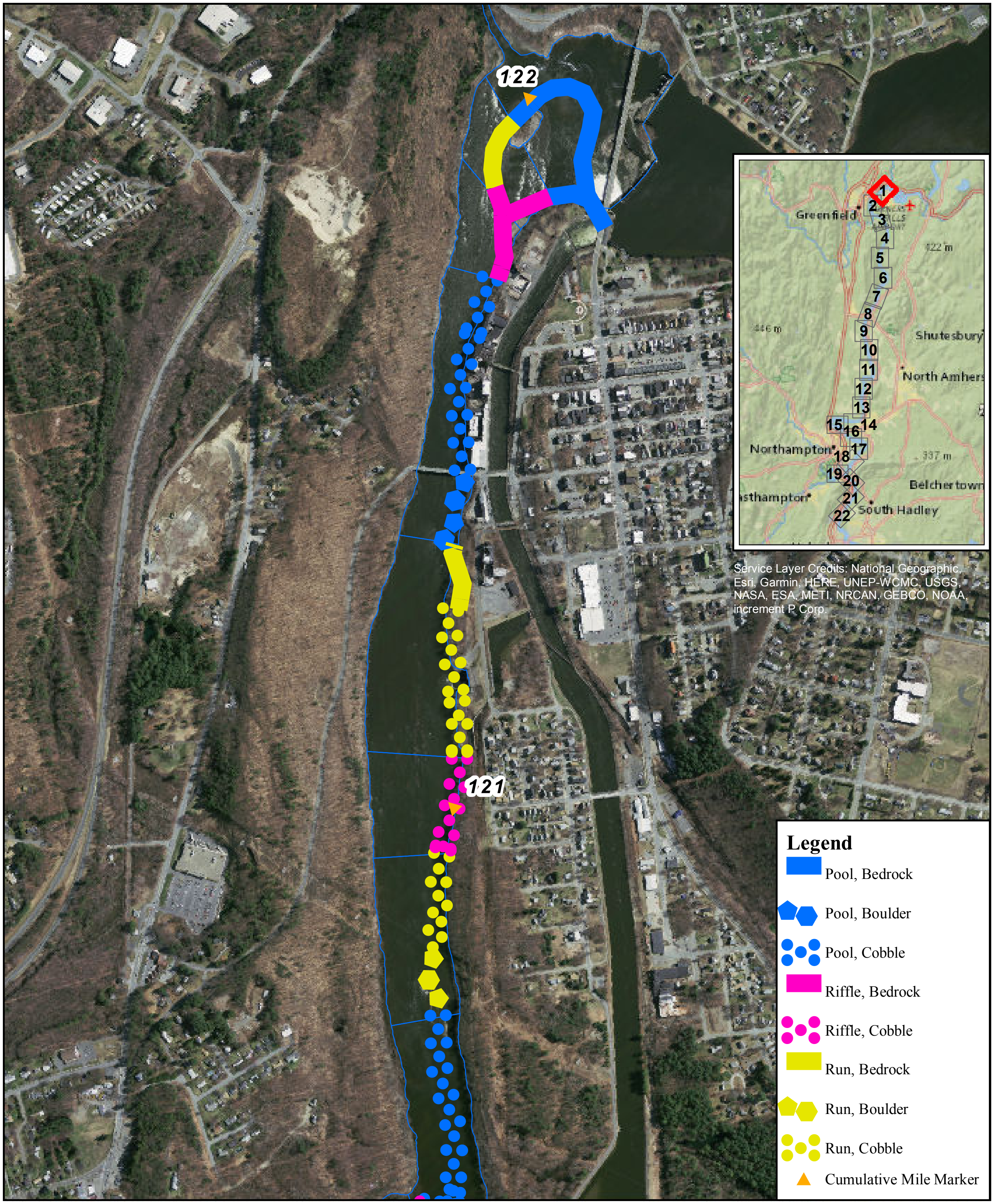

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 1

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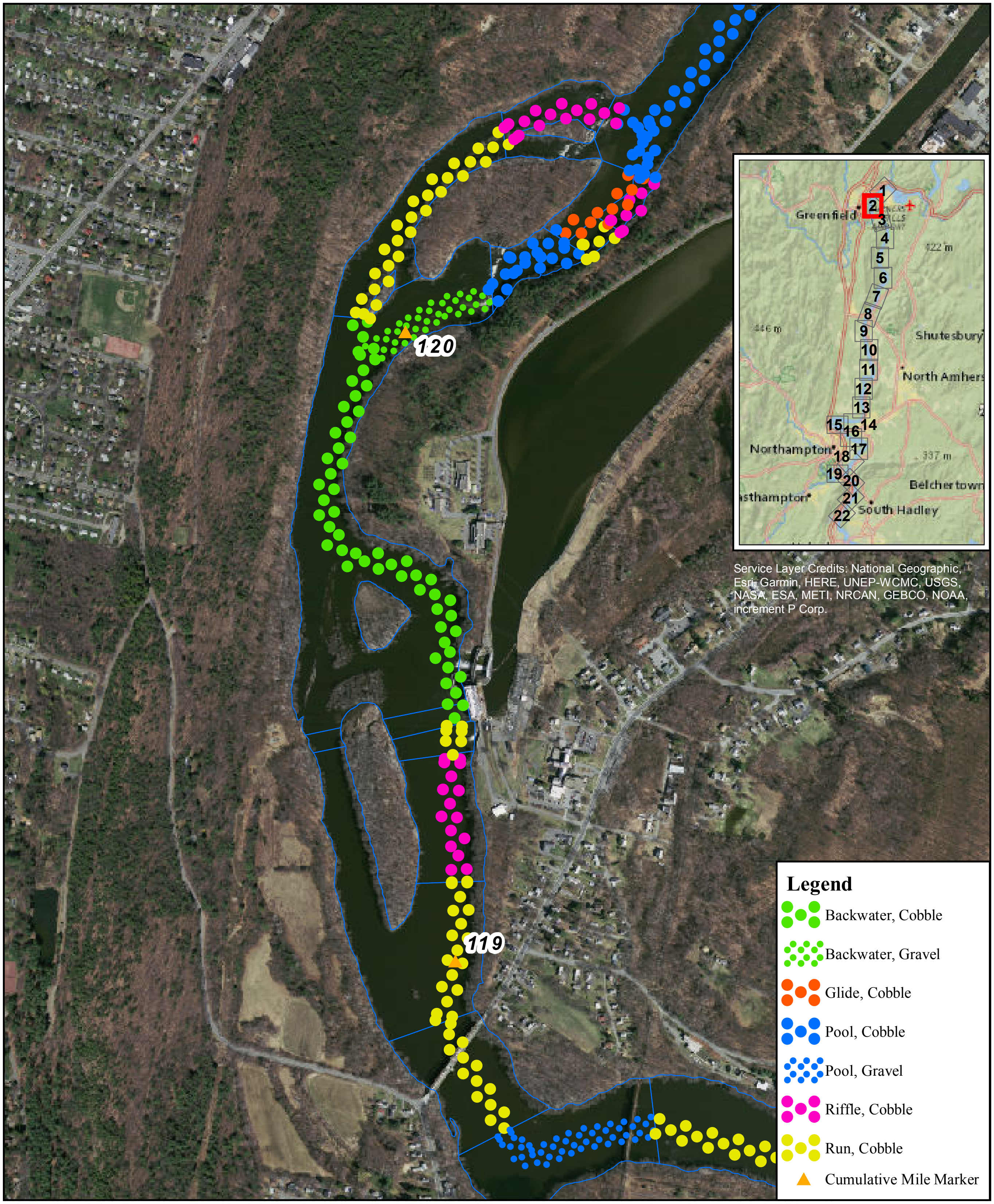

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 2

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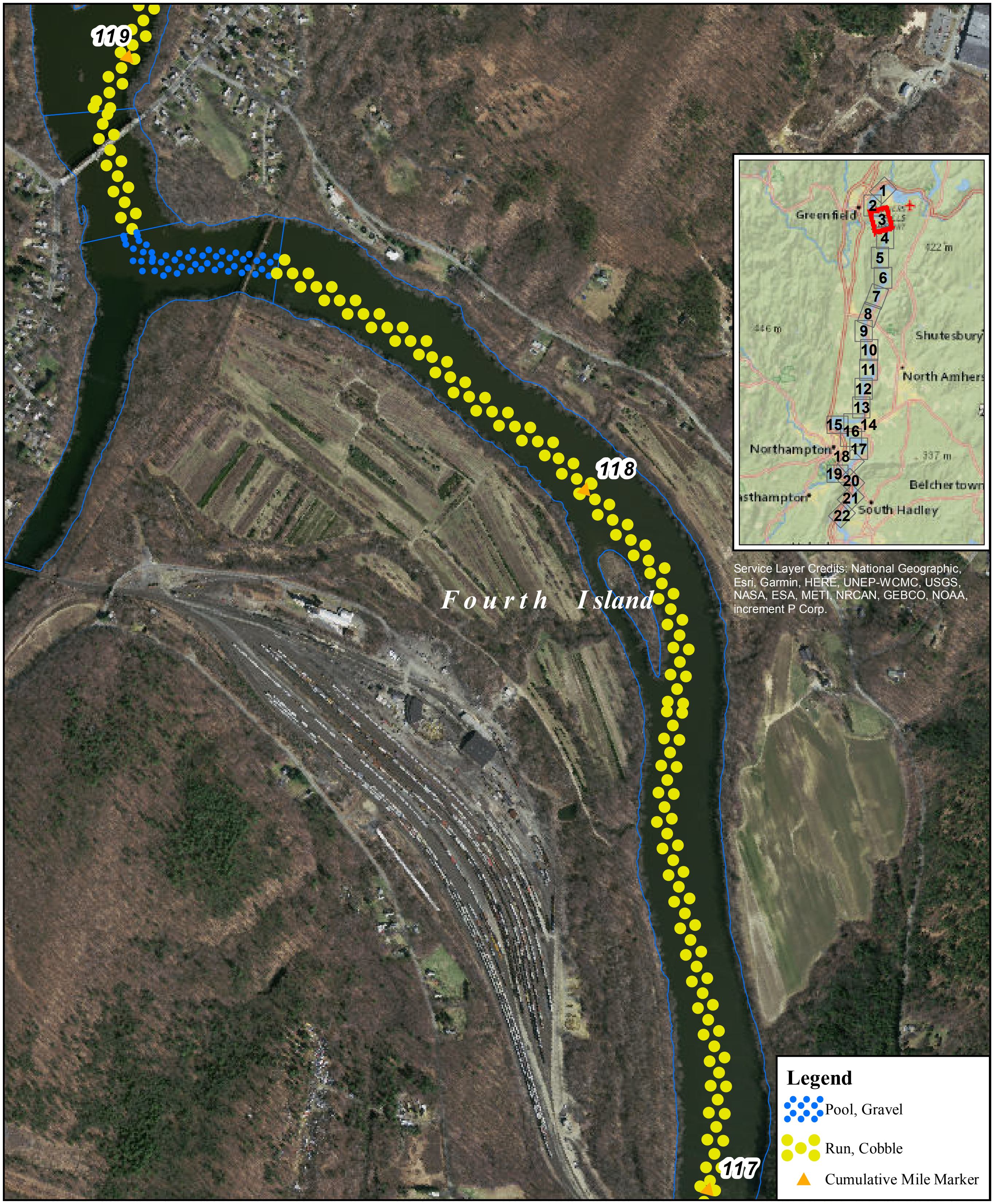

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Figure 3.3.3.1-3: Downstream Mesohabitat Linear Habitat Classification Map 3

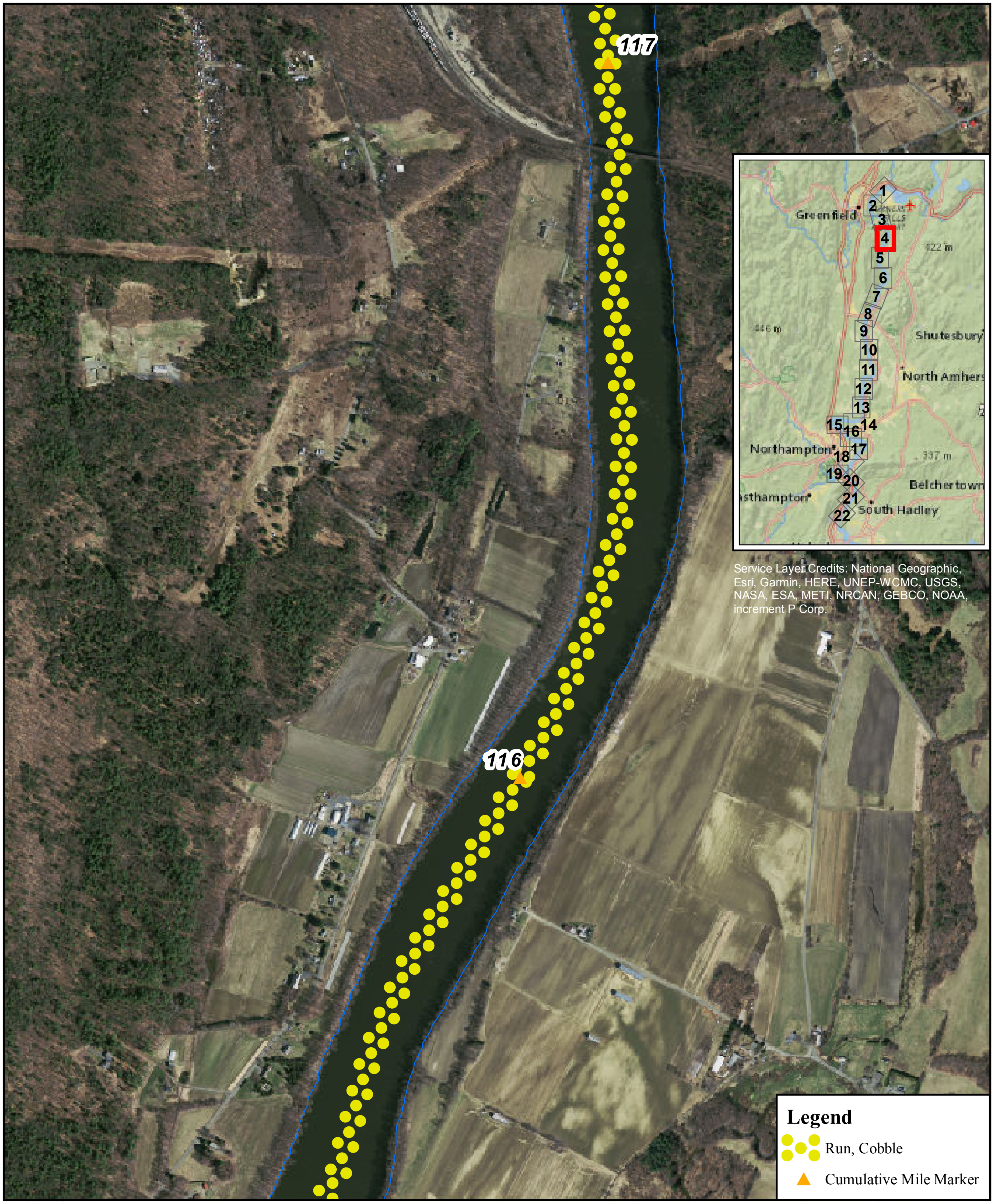

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Figure 3.3.3.1-3: Downstream Mesohabitat Linear Habitat Classification Map 4

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 5

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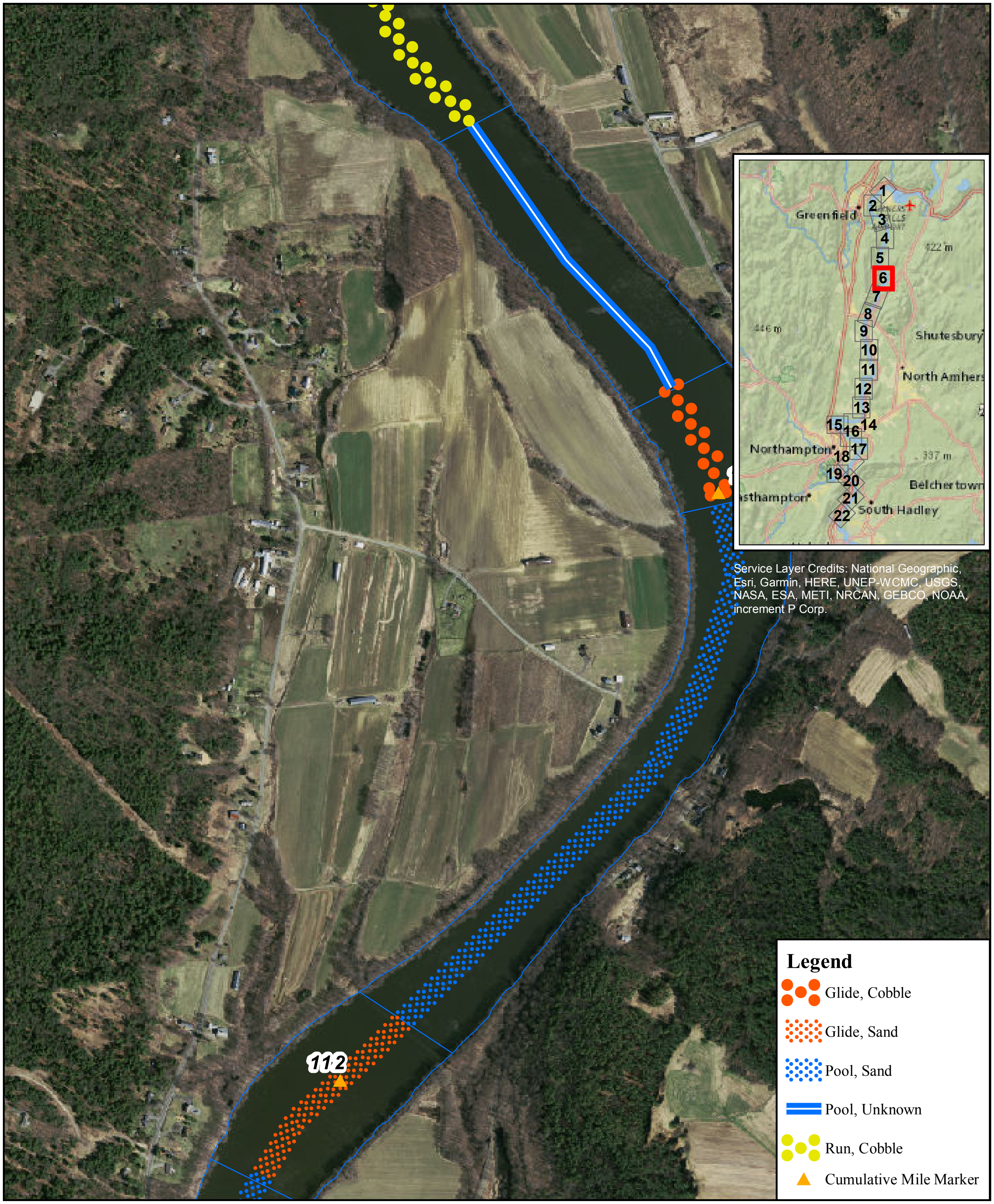

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Figure 3.3.3.1-3:
Downstream Mesohabitat Linear Habitat Classification Map 6

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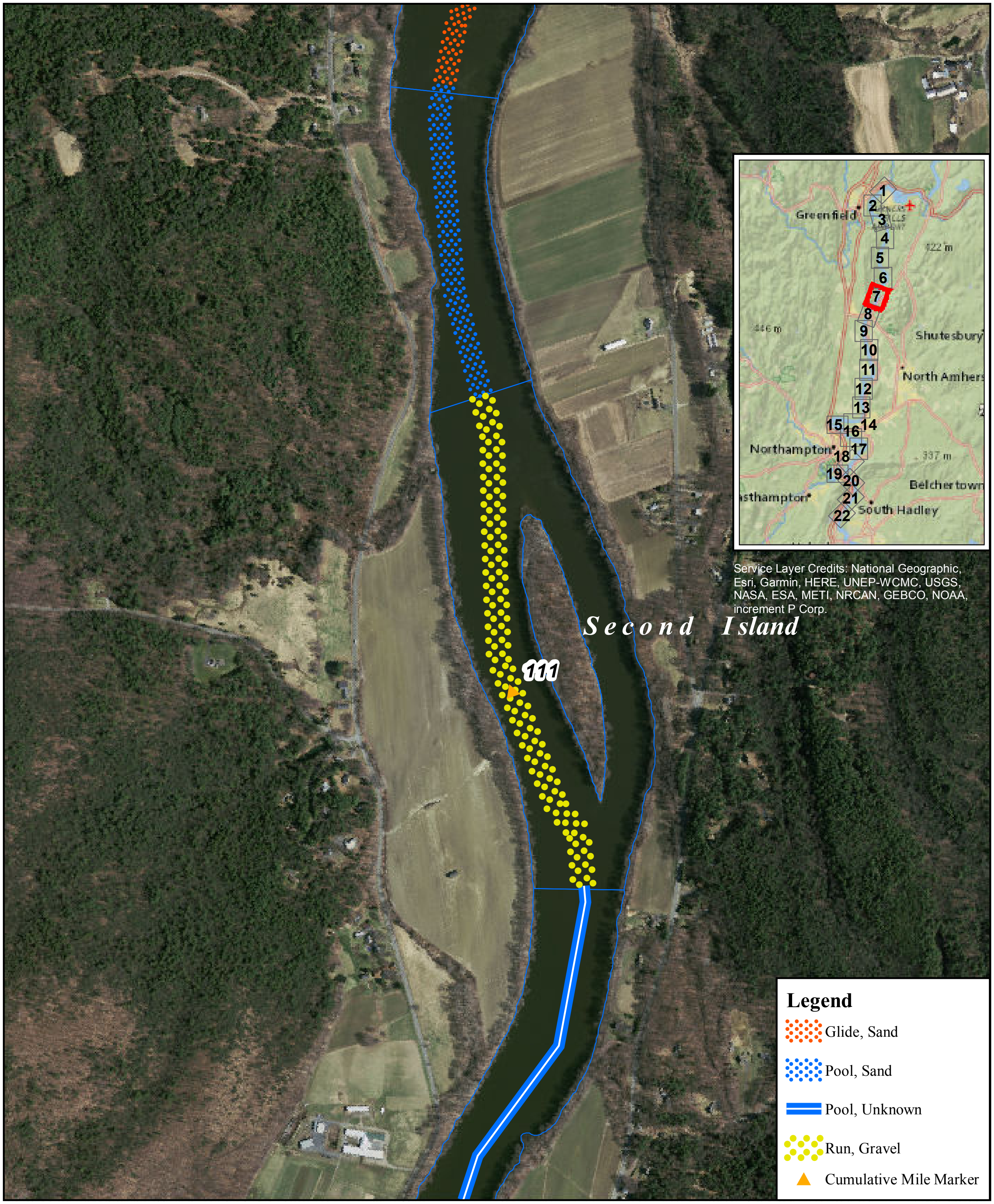

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Figure 3.3.3.1-3: Downstream Mesohabitat Linear Habitat Classification Map 7

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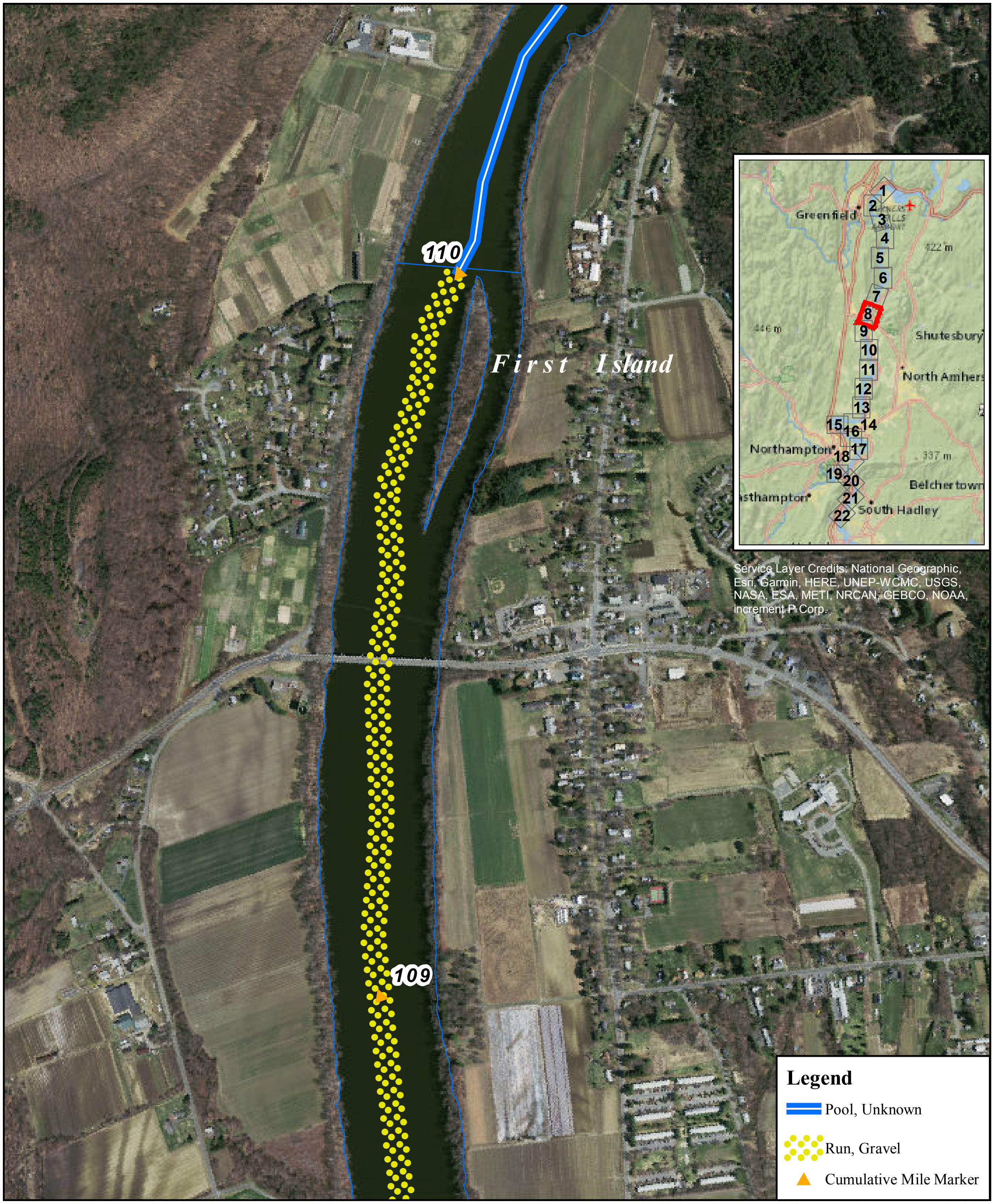

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 8

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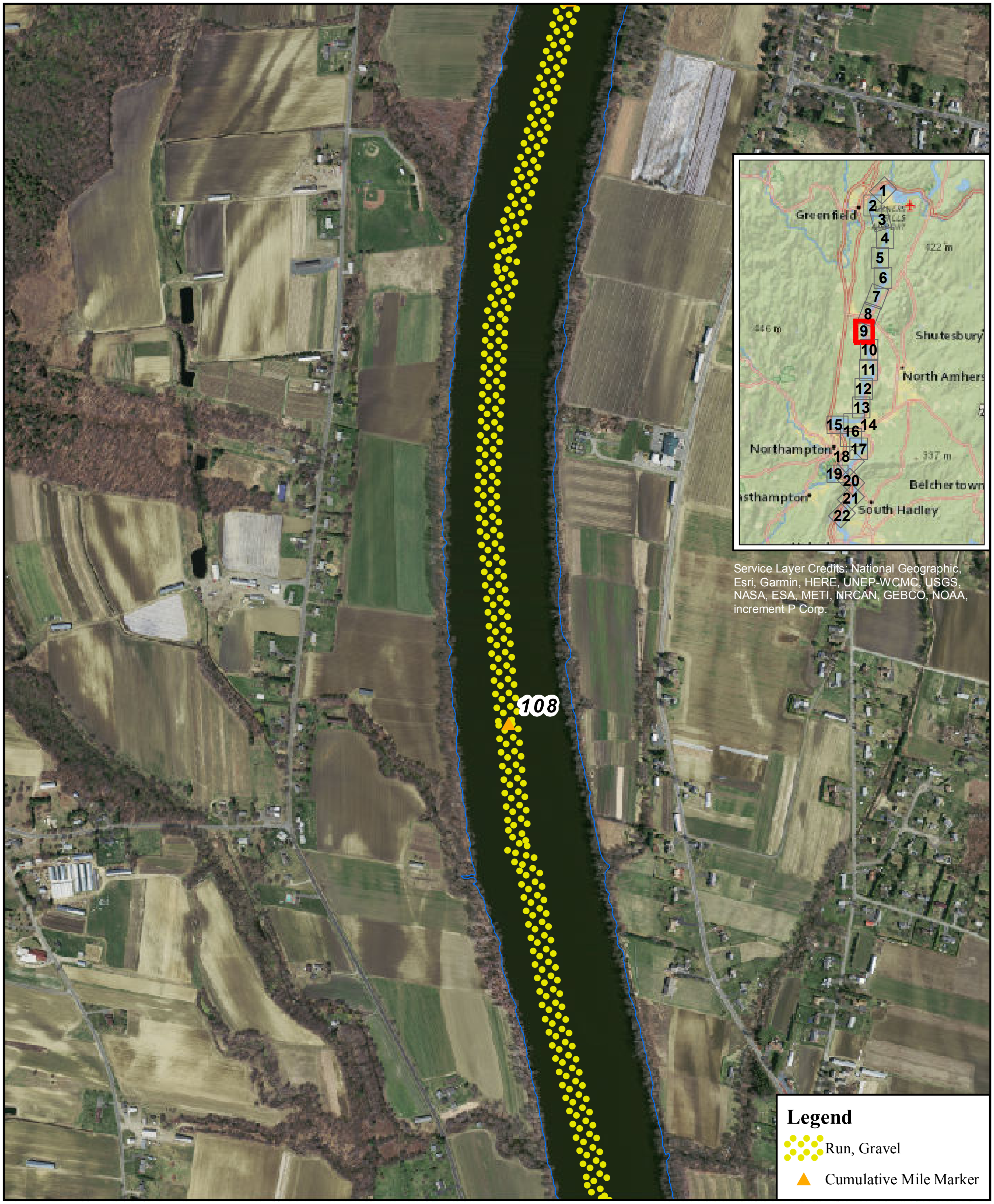

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 9

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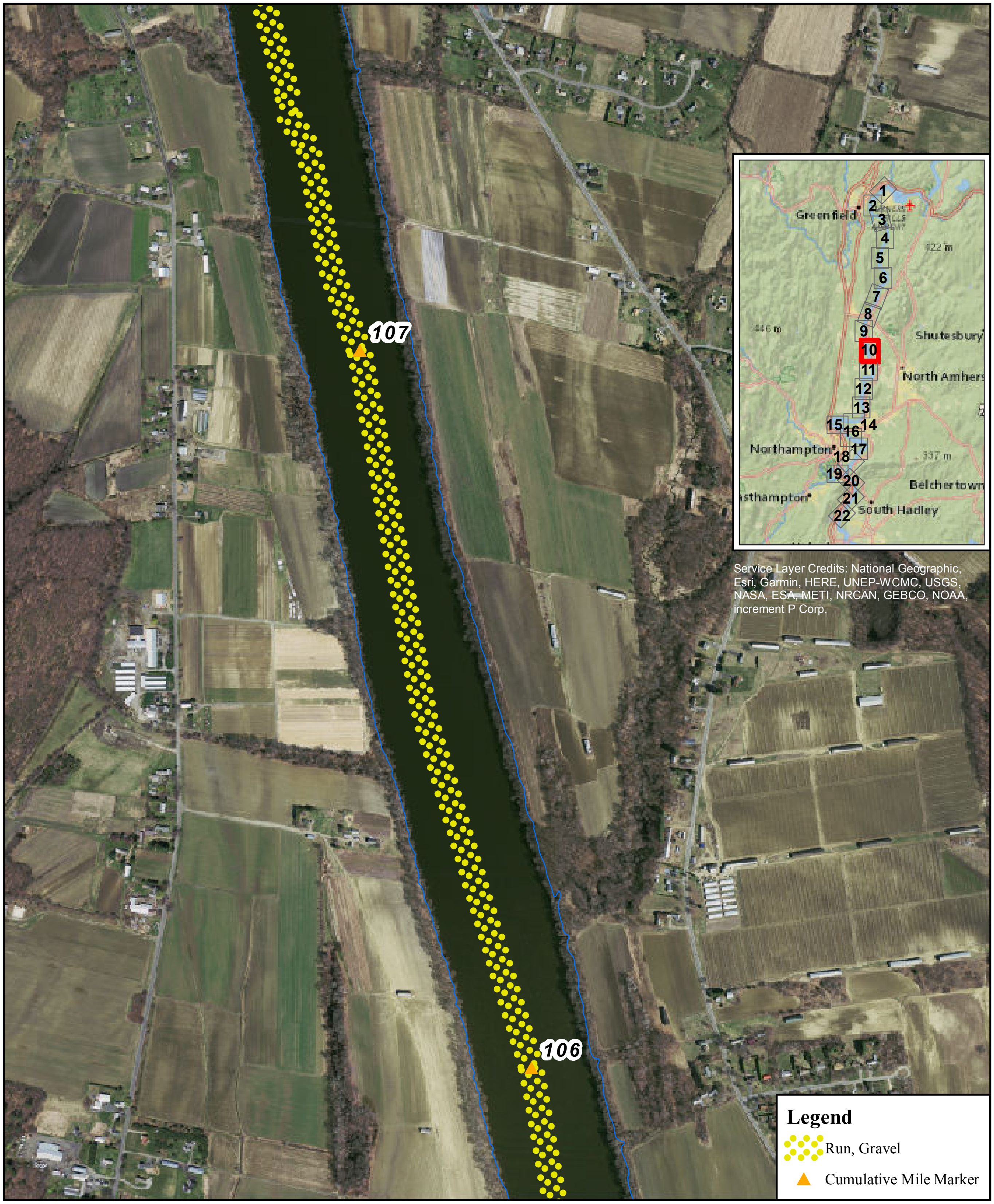

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 10

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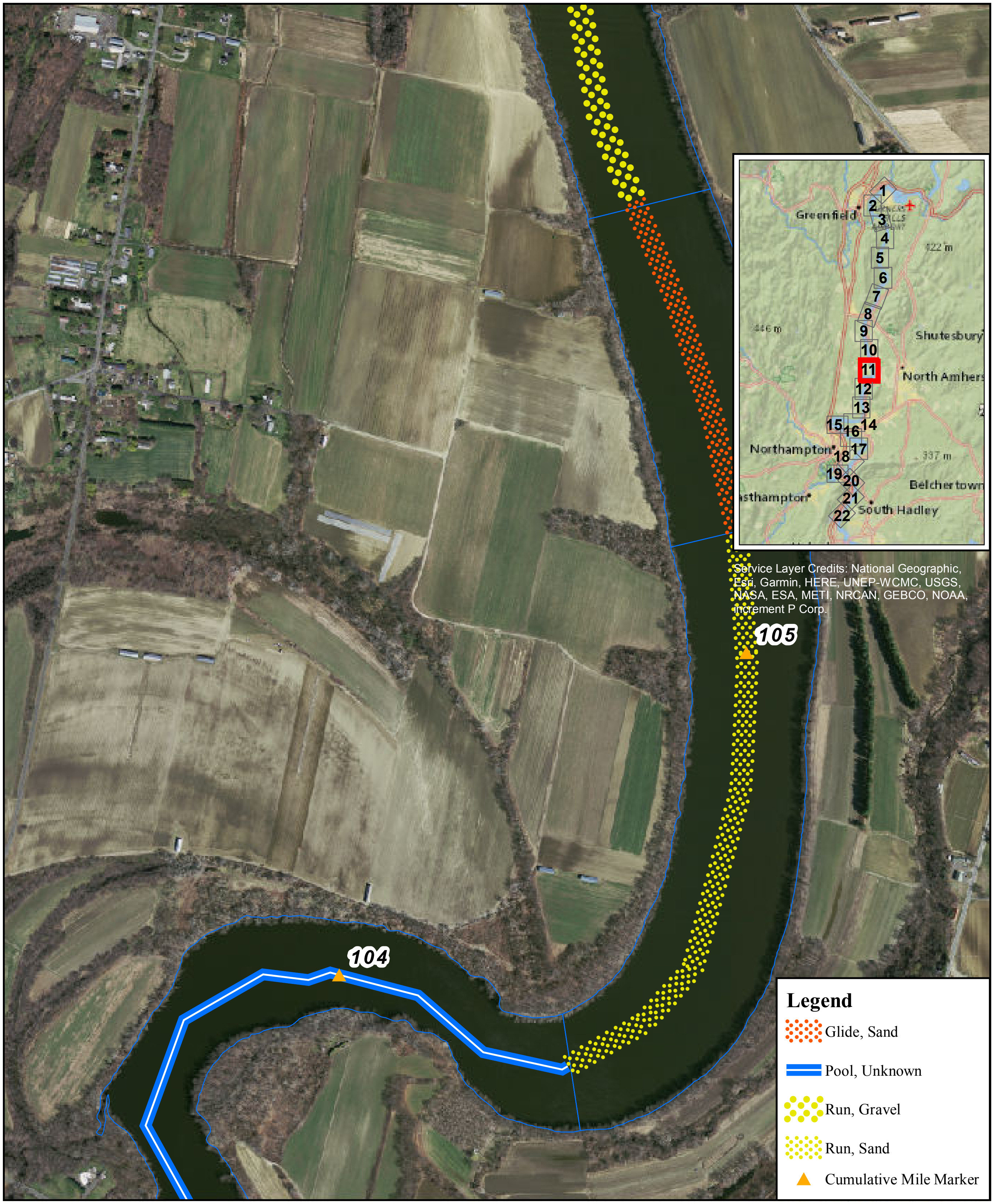

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Figure 3.3.3.1-3:
Downstream Mesohabitat Linear Habitat Classification
Map 11

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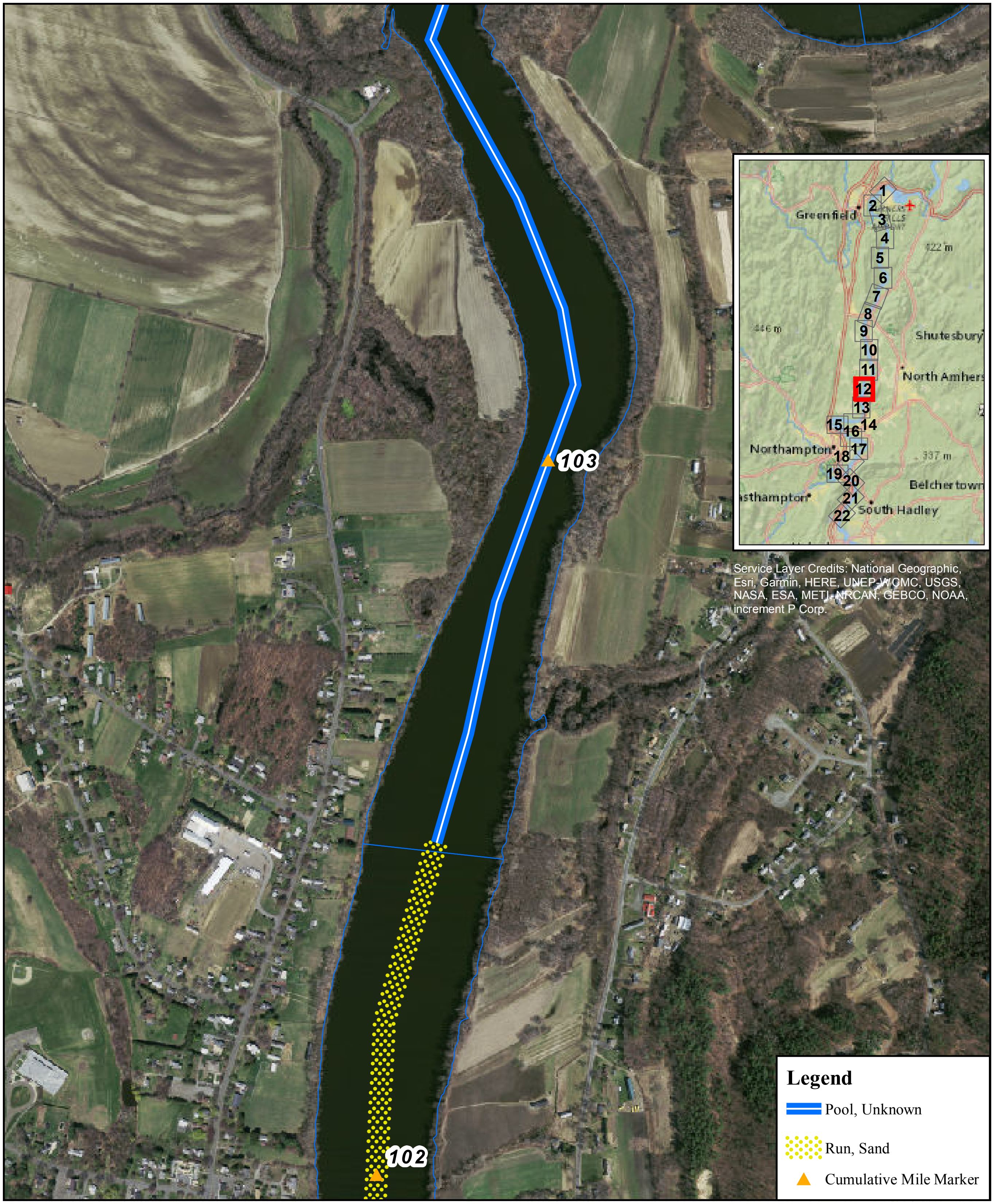

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Figure 3.3.3.1-3: Downstream Mesohabitat Linear Habitat Classification Map 12

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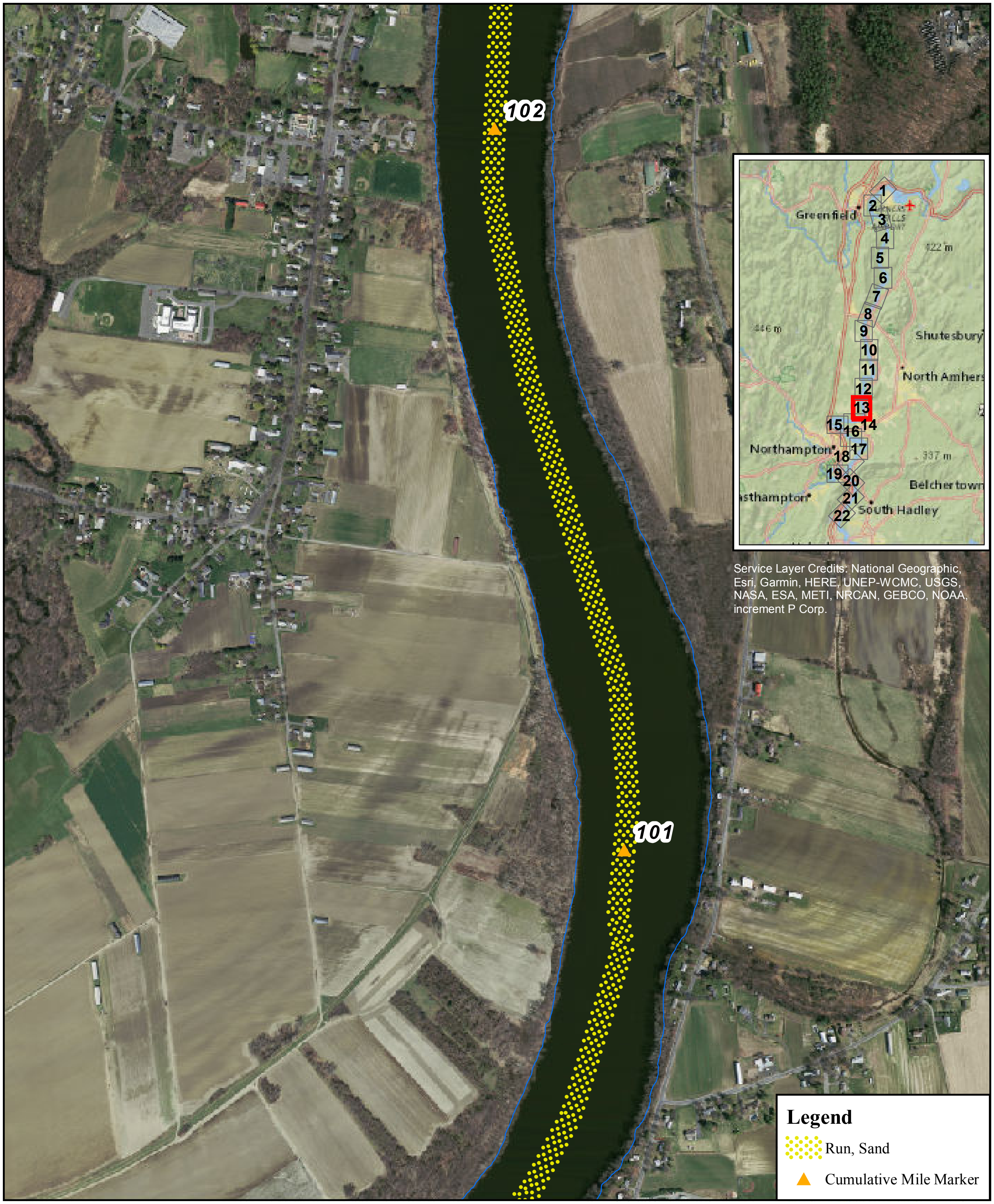

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 13

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 14

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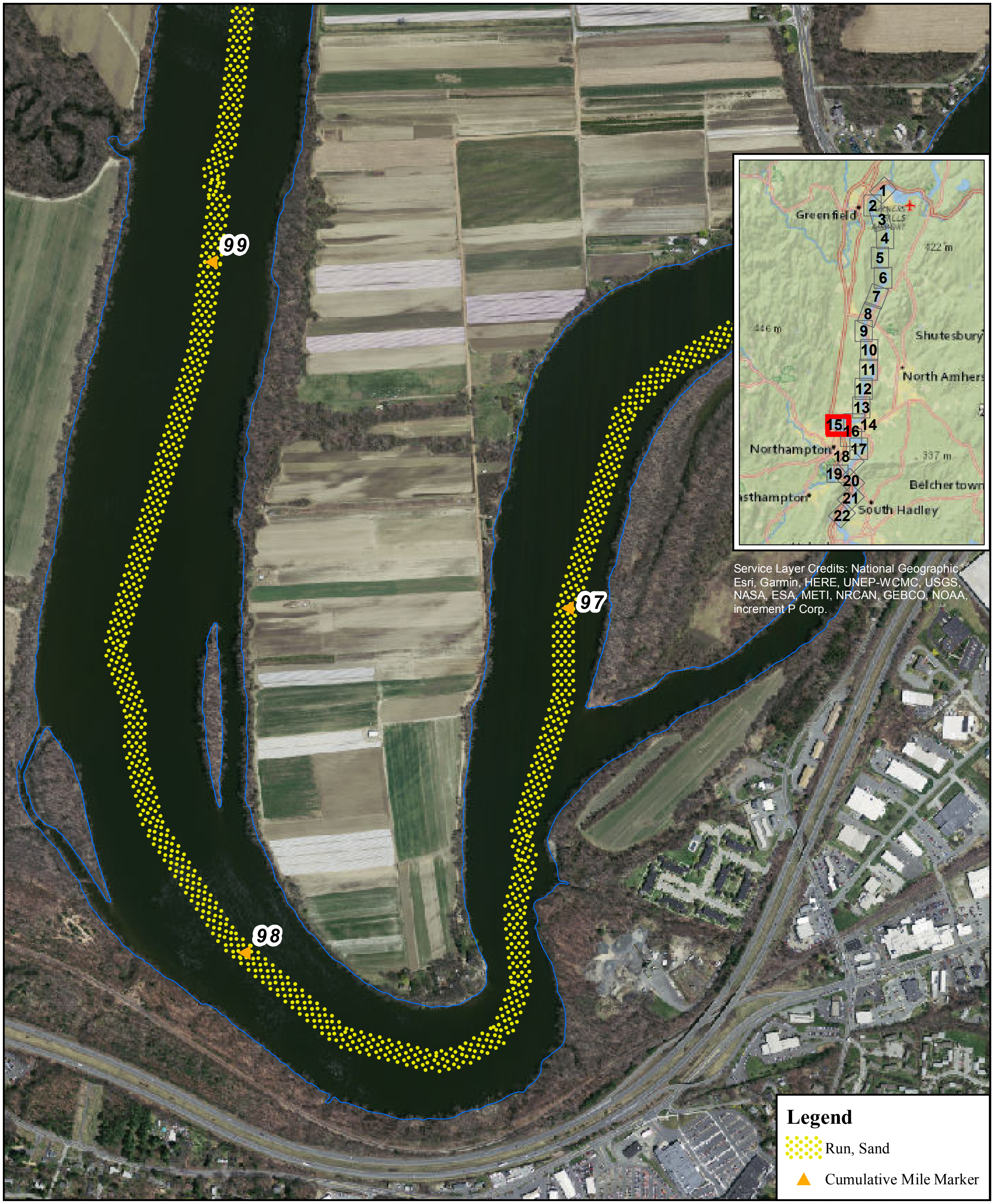

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 15

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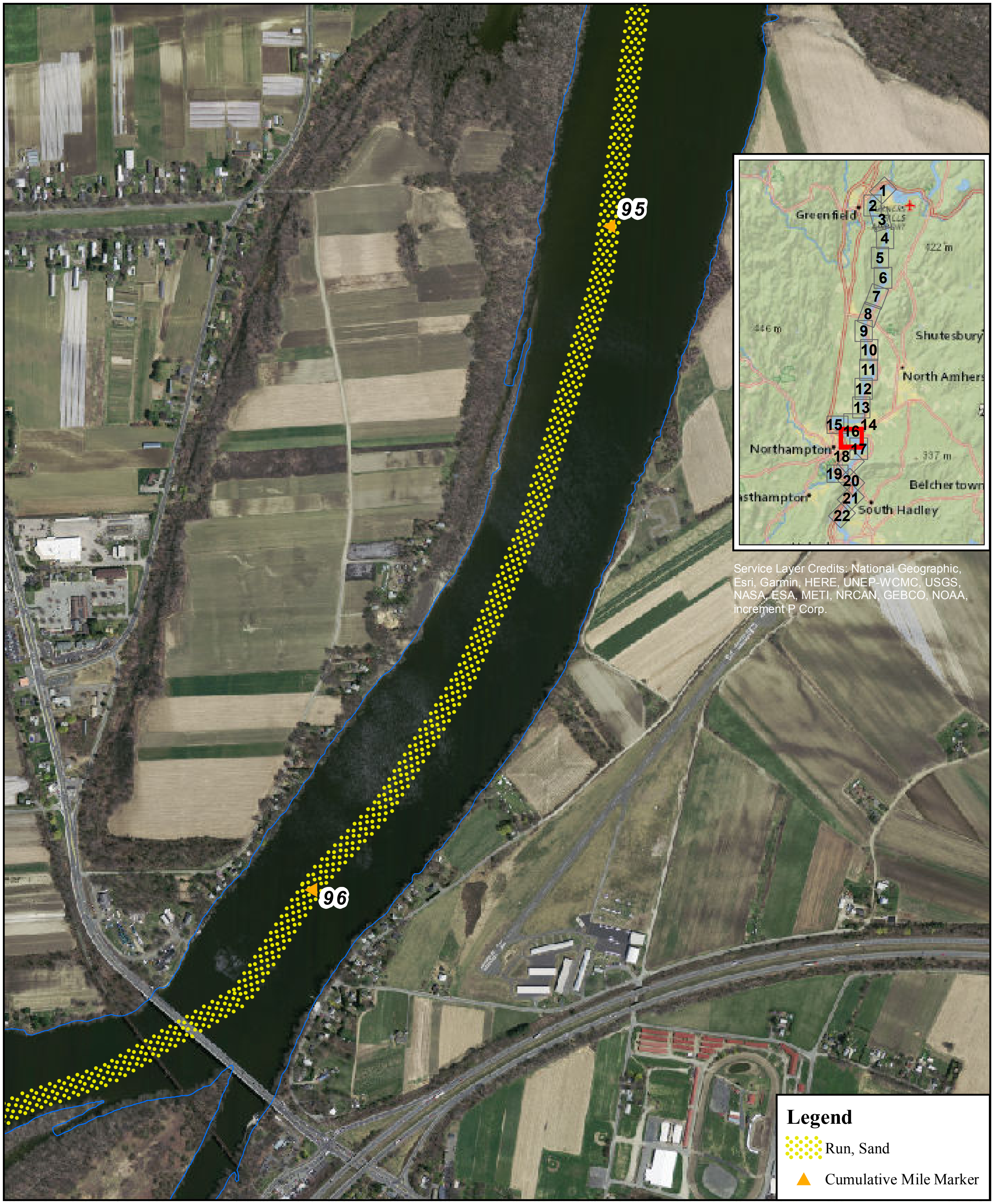

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Figure 3.3.3.1-3: Downstream Mesohabitat Linear Habitat Classification Map 16

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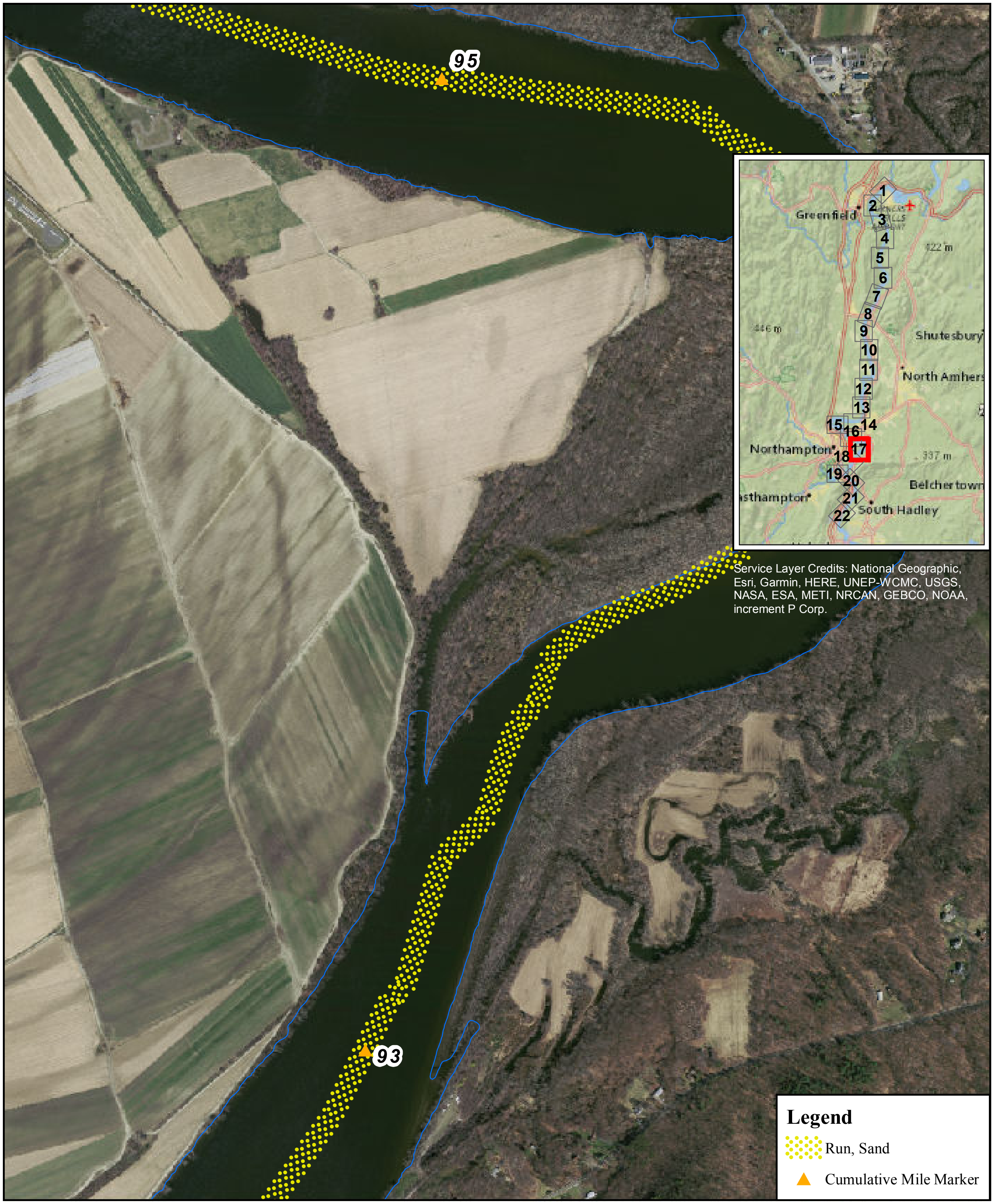

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 17

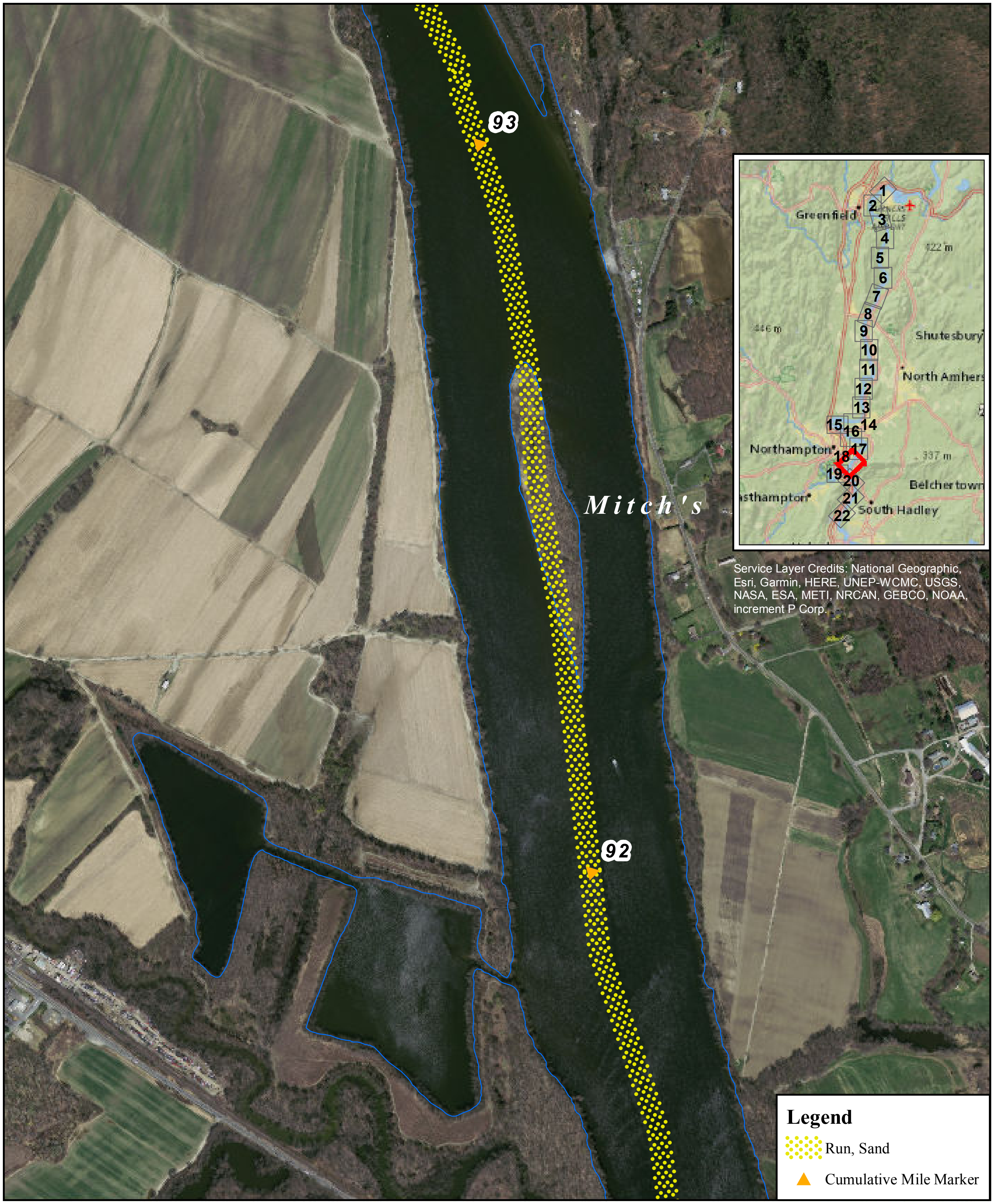

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 18

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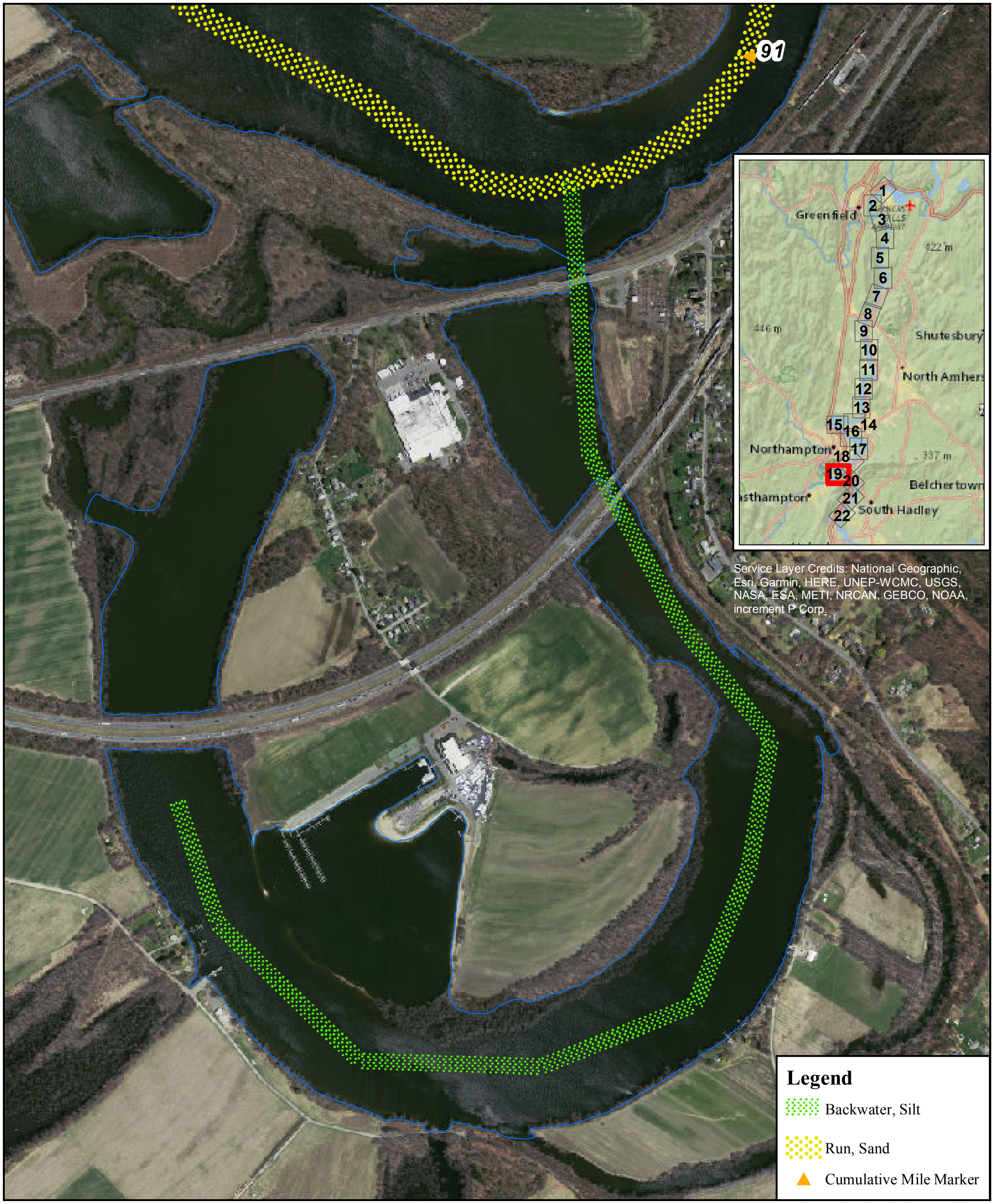

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 19

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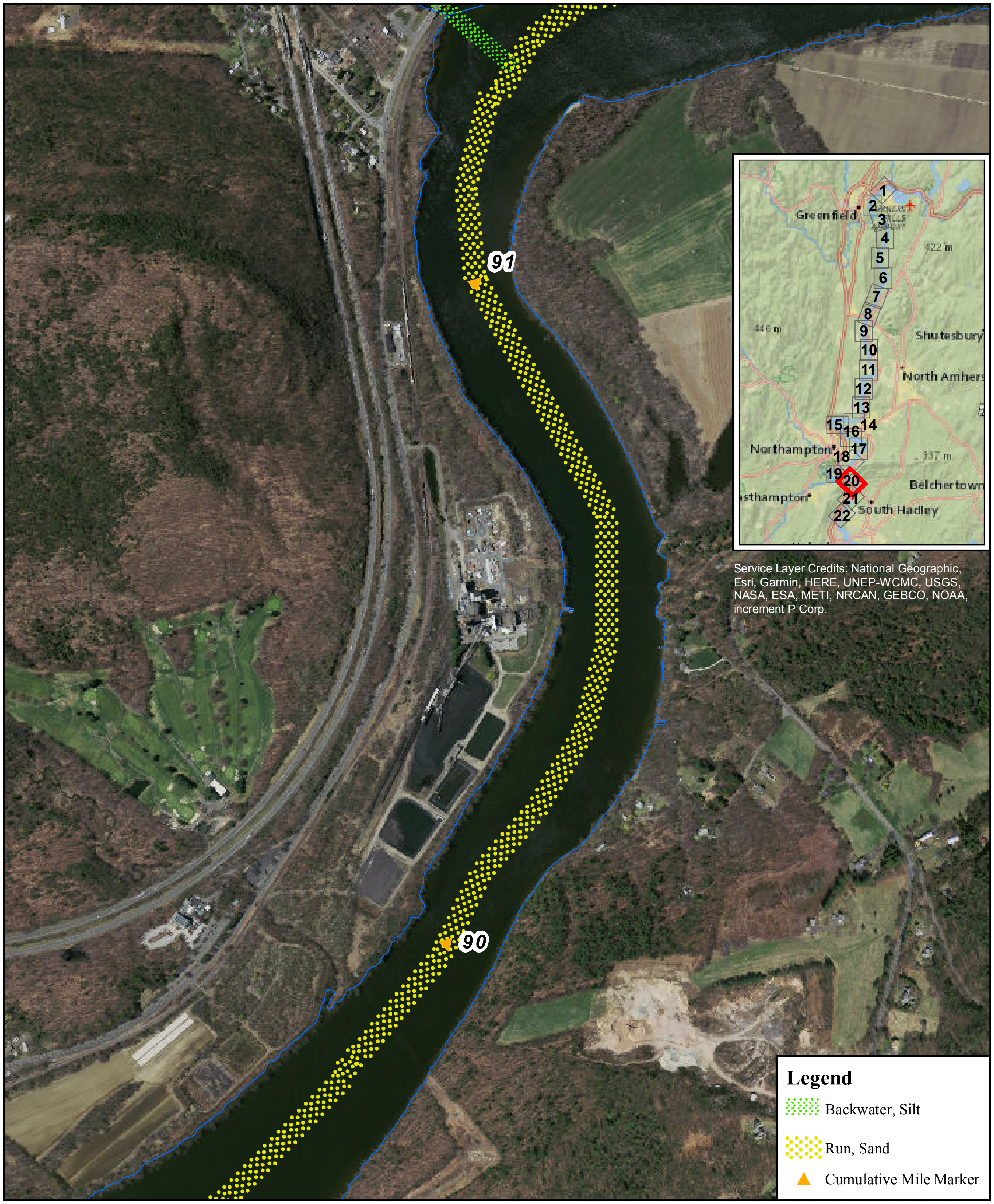

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Feet

Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 20

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 21

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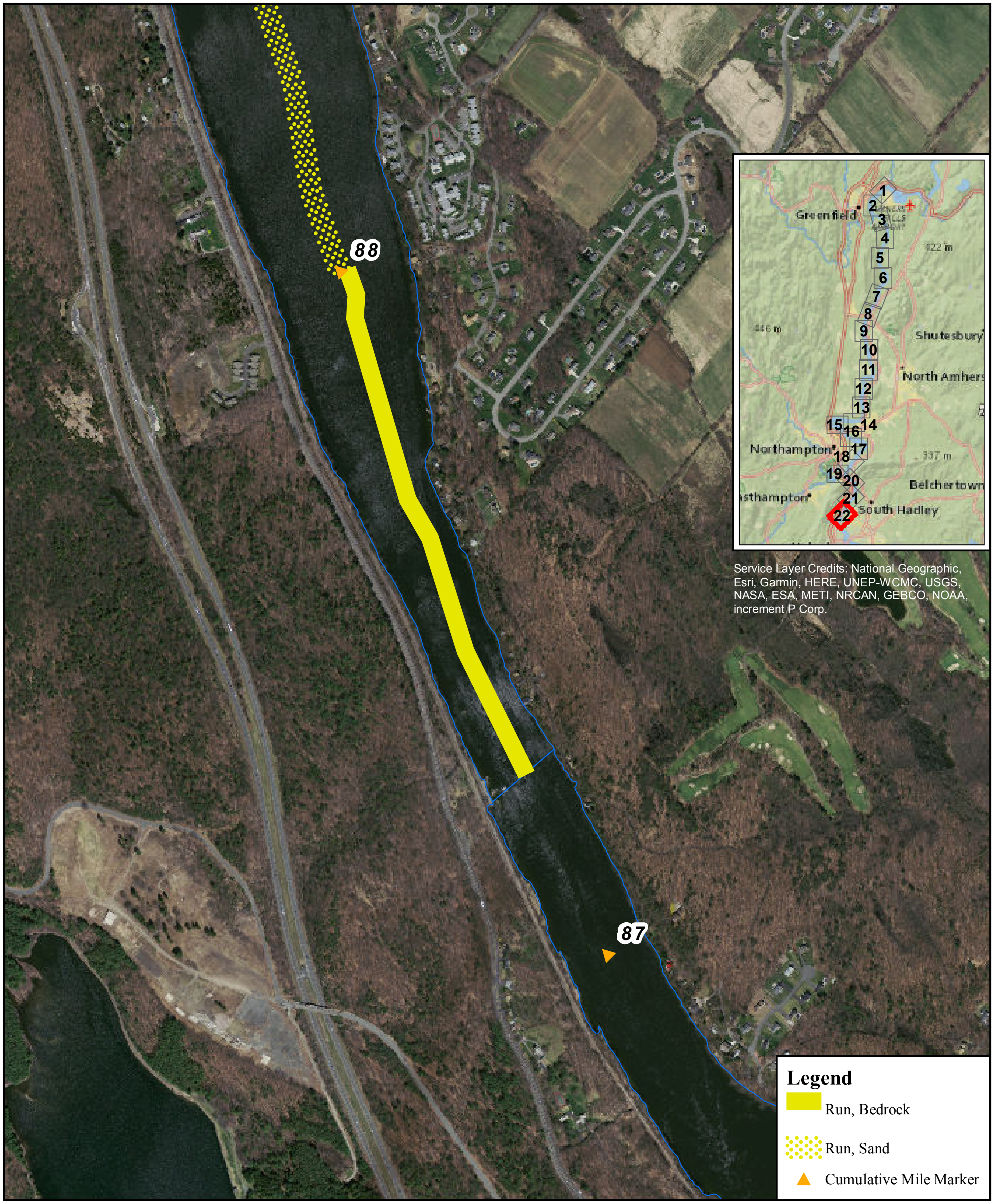

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Figure 3.3.3.1-3:
Downstream Mesohabitat
Linear Habitat Classification
Map 22

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3.3.3.1.1 Aquatic Vegetation

During the summer of 2014, submerged aquatic vegetation (SAV) beds within the TFI were mapped and dominant species were identified. Dominant species identified during the survey are shown in Table 3.3.3.1.1-1. Native species include wild celery, various pondweeds, musk grasses, and coontail. Wild celery occurs throughout the majority of the identified SAV beds. Isolated patches of SAV, emergent aquatic vegetation (EAV), and wetlands typically occur in areas with finer substrates. Areas with bedrock substrates have limited or no riparian vegetation. Beds of SAV vegetation, particularly upstream of the Otter Run confluence (near Kidd's Island about 7.5 miles upstream of the Turners Falls Dam) with the Connecticut River generally occur as narrow bands located parallel to the TFI shoreline, although in some cases, shallow shoals within the TFI, often associated with islands, support larger beds of SAV (just outside of Barton's Cove in the lower TFI). EAV, generally consisting of cattail stubs, was absent from the upper and mid TFI, except for the stand along the shoreline in the vicinity of Pauchaug Brook as well as the shoreline upstream of Kidds Island. EAV was more common in the lower TFI, which spans from the French King Bridge to the Turners Falls Dam.

Several non-native aquatic species are currently found within the Project, including variable leaf milfoil, Eurasian milfoil, curly-leaf pondweed, fanwort, and water chestnut. Most non-native species were found in the furthest downstream areas of the TFI, with fewer occurrences upstream of the French King Bridge. In general, non-native species are not as widespread and occur at lower densities upstream of the French King Bridge.

Table 3.3.3.1.1-1: Observed Submerged Aquatic Vegetation

Common Name	Scientific Name
Pondweed	*Potamogeton ssp.*
Milfoil	*Myriophylum spp.*
Coontail	*Ceratophyllum demersum*
Wild Celery (Eelgrass)	*Vallisneria americana*
Clasping Leaf Pondweed	*Potamogeton perfoliatus*
Waterweed	*Elodea nuttallii*
Eurasian Milfoil	*Myriophyllum spicatum**
Muskgrass	*Chara ssp.*
Fanwort	*Cabomba caroliniana**
Large Leaf Pondweed	*Potamogeton amplifolius*
Variable Leaf Milfoil	*Myriophylum heterophyllum**
Water Chestnut	*Trapa natans**
Curly-Leaved Pondweed	*Potomageton crispus**

*Non-native Species

3.3.3.1.2 Fisheries

3.3.3.1.2.1 Resident Fish Species

The Connecticut River in the vicinity of the Turners Falls and Northfield Mountain Projects supports several native and non-native warm water resident fish (Table 3.3.3.1.2.1-1). Dominant family groups include Centrarchidae (sunfishes), Percidae (perches) Catostomidae (suckers), and Cyprinidae (minnows). The centrarchid family includes important warmwater game fishes such as Largemouth and Smallmouth Bass, crappies and sunfish (Hartel *et al*., 2002). Among the Cyprinidae species reported in the Connecticut River are the Spottail Shiner, Fallfish and Common Shiner. Catostomids are closely related to the Cyprinids and are a highly diverse taxonomic group. Although the Longnose Sucker was historically found in the mainstem Connecticut River, recently only White Sucker have been reported in the project area. Yellow Perch and Walleye are two common Percids, and Northern Pike and Chain Pickerel are two common Esocids found in the TFI (Hartel *et al*., 2002).

Fish Assemblage Study

FirstLight conducted Study No. 3.3.11 *Fish Assemblage Study* (FirstLight, 2016j) to gather baseline information pertaining to the current population(s) within the study area. The study area included the TFI and the bypass reach down to a natural rock formation referred to as Rock Dam. In order to sufficiently sample representative habitat types throughout the study area, and the range of strata within these reaches, sampling methods included boat electrofishing, gill netting, and seining (Figure 3.3.3.1.2.1-1). Sampling was performed during the early summer in June/July 2015 in the TFI and again in the late summer (September). Sampling was performed in the bypass reach to Rock Dam during the late summer. Twenty-four (24) electrofishing stations were sampled in the TFI. Gillnets were also deployed in deep holes concurrent with electrofishing, and beach seining was conducted where feasible in the middle and lower TFI strata. In several locations where beach seining was not feasible due to snags or unwadable shorelines, supplemental boat electrofishing was conducted. In addition, the four major mesohabitats in the bypass reach were sampled by boat electrofishing.

Turners Falls Impoundment

Overall, 28 species (inclusive of hybrid sunfish) were observed during the 2015 field sampling effort (Table 3.3.3.1.2.1-1). Spottail Shiner, Smallmouth Bass, and Yellow Perch were the dominant species collected during both the early and late summer periods in the TFI. Smallmouth Bass abundance was greater in the upper reaches of the TFI as compared to the lower reaches. Other species that tended to be more dominant in the upper reaches included Fallfish, Rock Bass, Mimic Shiner, Tessellated Darter, and American Eel. Conversely, species such as Bluegill, Pumpkinseed, Largemouth Bass, Banded Killifish, White Sucker, and Yellow Perch were more abundant in the lower reaches of the TFI.

The distribution of species in the TFI generally reflected habitat conditions and species preferences. For example, the upstream stratum of the TFI was dominated by Smallmouth Bass and Fallfish, whereas the lowermost stratum of the TFI was dominated by Bluegill, Pumpkinseed and Yellow Perch. Largemouth Bass were more common than Smallmouth Bass in the lower TFI, whereas Smallmouth Bass were more common than Largemouth Bass in the upper TFI. Fallfish and Smallmouth Bass prefer habitat with gravel and cobble substrate, free of fines (Scott & Crossman, 1973), whereas Sunfish and Largemouth Bass prefer lentic conditions (Coble, 1975; Heidinger, 1975; Trial *et al*., 1983), and substrates dominated by fines, as well as aquatic vegetation and dense debris cover, which are characteristic of the lower TFI but absent further upriver. Habitat generalists, including Spottail Shiner and Yellow Perch were dominant and relatively evenly distributed throughout the TFI area.

Boat electrofishing data obtained during the 2015 effort in the TFI were compared to historical data collected during 1971-1975 (MADFG, 1978), as well as 2008-2009 (Yoder *et al*., 2010; MBI, 2014). Massachusetts Division of Fisheries and Game (MADFG) (MADFG, 1978) concluded, based on multiple consecutive years of sampling the TFI, that resident fish species composition and relative abundance were stable. MADFG observed similar spatial trends to those from the 2015 study, such as the widespread spatial dominance of Yellow Perch, and the inverse upstream to downstream distribution of Smallmouth Bass and Largemouth Bass, which appeared to be driven by preferred habitat types. This suggests that the resident fish community composition remains stable, although the number of species has increased somewhat. Fallfish were not within the top 14 dominant species and American Shad were absent during the 1971-1975 surveys but were relatively dominant in 2015 surveys. Fallfish require relatively clear water quality; it is possible that since the 1970's, reduction in pollution described by MADFG (MADFG, 1978) has decreased ambient turbidity to the extent that Fallfish can better utilize study area habitat. The relative dominance of American Shad young-of-year (YOY) likely reflects improved recruitment to the study area due to construction of fishways at Turners Falls, Cabot Station and Holyoke that were not present in the 1970's.

Yoder *et al*. (2010), MBI (2014) and the 2015 study reflect more contemporary sampling and provide more quantitative station-specific results. Both the 2008-09 and 2015 datasets exhibit similar trends relative to fish assemblage metrics. Despite the passage of more than three decades, the same general species dominance pattern and spatial distribution were evident among resident species when MADFG (1978) is compared to both of the more contemporary data sets. Salmonid species are less prevalent than in the 1970's, likely due to changes in stocking and management practices combined with the summer sampling design of the more recent studies, which coincides with warmer water temperatures.

Bypass Reach

The four major mesohabitats sampled in the bypass reach include:

- A large plunge pool at the toe of the Turners Falls Dam,
- A low-gradient riffle/run/pool complex extending from the plunge pool downstream to the Station No. 1 discharge,
- A higher-gradient riffle-run below Station No. 1 extending downstream to a pool formed by Rock Dam, and
- Rock Dam pool.

During the 2015 late summer sampling effort, 269 individuals representing 16 species (inclusive of hybrid sunfish) were observed throughout the bypass reach (Table 3.3.3.1.2.1-2). Smallmouth Bass dominated observations and accounted for nearly 63% of the total catch, followed by American Eel and Bluegill, which accounted for approximately 10% and 8% of the total catch, respectively. Species diversity was greatest at Rock Dam pool (Table 3.3.3.1.2.1-2), followed by the plunge pool below Turners Falls Dam, although the total number of fish captured was greater in the Turners Falls Dam plunge pool.

The bypass reach from the Turners Falls Dam to Cabot Station was previously sampled in 2009 (Yoder *et al*., 2010) using the same equipment and methods as the 2015 study, although sampling stations were slightly different. For purposes of comparison, the 2015 upper bypass reach stations (plunge pool and riffle/run/pool above Station No. 1) and the two stations below Station No. 1 (riffle-run below Station No. 1 and Rock Dam pool) were paired. Table 3.3.3.1.2.1-3 lists all species collected in declining order of abundance, from both 2009 (MBI, 2014) and the 2015 study. Three of the six most dominant species (Smallmouth Bass, American Eel, and White Sucker) remained the same in both 2009 and 2015. Tessellated Darter and Bluegill were more common in 2015 than in 2009. Sea Lamprey YOY were evident in both surveys but were not among the most common species. Species richness, abundance and catch per unit effort (CPUE) generally followed the same spatial trends in both studies (Table 3.3.3.1.2.1-4). The lower bypass reach had slightly greater species richness in both studies, and the upper bypass reach exhibited greater abundance and CPUE than the lower areas in both studies.

Downstream of Cabot Station

Due to concerns regarding impacts to the federally endangered SNS, no directed sampling to determine species composition downstream of Cabot Station was performed during relicensing. Historical records suggest that the resident fish assemblage of the Connecticut River downstream of Cabot Station consists of cool and warm-water species (e.g. centrarchids, esocids, catostomids, ictalurids, and percids) typical to MA waters and the Connecticut River.

Littoral Zone Fish Spawning and Spawning Habitat

In accordance with the RSP for Study No. 3.3.13 *Impacts of the Turners Falls Project and Northfield Mountain Project on Littoral Zone Fish Habitat and Spawning Habitat*, (FirstLight, 2016l) the Licensee performed a study to identify littoral zone fish spawning and spawning habitat in the mainstem, tributaries and backwater of Project-affected areas to supplement information on resident species. Prior to initiating the field surveys, a desktop review was performed to determine the typical timing of spawning, spawning habitats, and spawning behaviors for resident species (Table 3.3.3.1.2.1-5). Field sampling was then conducted by systematically traversing the littoral zone (depth less than 6 feet) of the TFI via boat and/or foot (wading) to visually identify any fish nests, egg masses/deposits, and/or spawning habitat. Identified habitats, egg deposits and nests were geo-referenced with a GPS unit, and water quality parameters, including temperature, velocity, clarity, and depth, were recorded. Other relevant information collected included sediment grain size associated with nests, presence of aquatic vegetation, occupied/abandoned nests, weather conditions, and other relevant observations or descriptive information.

The early spring survey was performed from May 4-6, 2015, after river flow had receded to safe levels. Water temperature during this period ranged from 10.1 to 11.7°C, except in the lower reaches of tributaries such as Pauchaug Brook and Millers River which were warmer (16-16.7°C). The naturally routed flow through the TFI during this period ranged from approximately 12,000 to 15,000 cfs, and water clarity was generally good (6-7.5 ft visibility), allowing clear view of the littoral zone bottom.

The late spring survey was initiated on June 1, 2015 but was aborted due to rising river flow. The survey resumed June 11 and extended to June 13, but relatively high river flow persisted, and visibility was reduced to 4-6 ft. Water temperature during late May had slowly climbed to approximately 18°C, but on June 1 was 16°C due to rains and persistent cold weather. After field work resumed on June 11 temperatures ranged from 17 to 21.5°C during the survey.

A total of 18 spawning locations were surveyed during the early spawning season and 16 locations were surveyed during the late spring season. Several spawning locations, particularly in the late spring featured multiple nests clustered near each other. Figure 3.3.3.1.2.1-2 illustrates the location and distribution of spawning sites that were identified during the two surveys.

Table 3.3.3.1.2.1-1: Species Collected During 2015 Effort for the Fish Assemblage Survey at Turners Falls Project

Common Name	Native/Non-Native Status	Scientific Name	TFI		Bypass
			June-July	September	September
American Eel	Native	*Anguilla rostrata*	X	X	X
American Shad	Native	*Alosa sapidissima*	X	X	-
Banded Killifish	Native	*Fundulus diaphanus*	-	X	-
Black Crappie	Non-Native	*Pomoxis nigromaculatus*	X	X	-
Bluegill	Non-Native	*Lepomis macrochirus*	X	X	X
Brown Bullhead	Native	*Ictalurus nebulosus*	X	X	X
Chain Pickerel	Native	*Esox niger*	X	X	-
Channel Catfish	Non-Native	*Ictalurus punctatus*	X	X	-
Common Carp	Non-Native	*Cyprinus carpio*	X	X	-
Common Shiner	Native	*Luxilis cornutus*	X	-	-
Fallfish	Native	*Semotilus corporalis*	X	X	-
Golden Shiner	Native	*Notemigonus crysoleucas*	X	X	-
Hybrid Sunfish	-	*Lepomis spp.*	-	-	X
Largemouth Bass	Non-Native	*Micropterus salmoides*	X	X	X
Longnose Dace	Native	*Rhinichthys cataractae*	-	-	X
Mimic Shiner	Non-Native	*Notropis volucellus*	X	X	X
Northern Pike	Non-Native	*Esox lucius*	X	X	X
Pumpkinseed Sunfish	Native	*Lepomis gibbosus*	X	X	X
Rock Bass	Non-Native	*Ambloplites rupestris*	X	X	-
Rosyface Shiner	Non-Native	*Notropis rubellus*	-	X	-
Sea Lamprey	Native	*Petromyzon marinus*	X	X	X
Smallmouth Bass	Non-Native	*Micropterus dolomieui*	X	X	X
Spottail Shiner	Native	*Notropis hudsonius*	X	X	X
Tessellated Darter	Native	*Etheostoma olmstedi*	X	X	X
Walleye	Non-Native	*Sander vitreus*	X	X	X
White Perch	Non-Native*	*Morone americana*	-	X	-
White Sucker	Native	*Catostomus commersonii*	X	X	X
Yellow Perch	Native	*Perca flavescens*	X	X	X

*Note: Though White Perch are native to the lower portions of the Connecticut River, they are not native to the TFI according to the USGS Nonindigenous Aquatic Species database (https://nas.er.usgs.gov/)

Table 3.3.3.1.2.1-2: Species Abundance at Each Boat Electrofishing Station within the Turners Falls Bypass Reach during Late Summer 2015

Species	Upper Bypass Reach		Lower Bypass Reach		Total	% of Total
	Plunge Pool	Riffle-Run-Pool Above Station No. 1	Riffle-Run Below Station No. 1	Rock Dam Pool		
Smallmouth Bass	48	67	30	23	168	62.5%
American Eel	16	1	7	2	26	9.7%
Bluegill	12	9	-	1	22	8.2%
Pumpkinseed	8	8	-	-	16	5.9%
White Sucker	10	-	2	1	13	4.8%
Tessellated Darter	4	2	2	4	12	4.5%
Sea Lamprey	1	-	1	1	3	1.1%
Largemouth Bass	1	-	-	-	1	0.4%
Yellow Perch	-	-	-	1	1	0.4%
Spottail Shiner	-	-	-	1	1	0.4%
Mimic Shiner	-	-	-	1	1	0.4%
Walleye	1	-	-	-	1	0.4%
Northern Pike	-	-	-	1	1	0.4%
Brown Bullhead	-	-	-	1	1	0.4%
Hybrid Sunfish	-	1	-	-	1	0.4%
Longnose Dace	-	-	1	-	1	0.4%
Total	**101**	**88**	**43**	**37**	**269**	

Table 3.3.3.1.2.1-3: Comparison of Fish Species Abundance in the Turners Falls Bypass Reach in 2009 and 2015 (list in descending order of abundance).

Upper Bypass Reach		Lower Bypass Reach	
2009	**2015**	**2009**	**2015**
Smallmouth Bass	Smallmouth Bass	Smallmouth Bass	Smallmouth Bass
Longnose Dace	American Eel	Spottail Shiner	Bluegill
American Eel	Tessellated Darter	Longnose Dace	American Eel
Atlantic Salmon	White Sucker	Tessellated Darter	Pumpkinseed
White Sucker	Sea Lamprey	White Sucker	White Sucker
Rock Bass	Yellow Perch	American Eel	Tessellated Darter
Sea Lamprey	Spottail Shiner	Brown Trout	Largemouth Bass
Tessellated Darter	Mimic Shiner	Common Carp	Walleye
	Bluegill	Rock Bass	Sea Lamprey
	Northern Pike	Bluegill	Hybrid Sunfish
	Brown Bullhead		
	Longnose Dace		
	Largemouth Bass		

Table 3.3.3.1.2.1-4: Comparison of Bypass Reach Species Richness, Abundance, and Catch-Per-Unit–Effort (CPUE) from 2009 and the Present Study

	Species Richness		Abundance		CPUE (fish/m)	
	2009	**2015**	**2009**	**2015**	**2009**	**2015**
Upper Bypass Reach stations	7	10	94	189	0.085	0.11
Lower Bypass Reach stations	9	11	78	80	0.078	0.07

Table 3.3.3.1.2.1-5: Summary of Spawning Information for Resident Species Obtained from Desktop Literature Review

Common Name	Spawning Strategy	Notes	Spawning Period	Temperature Range
Yellow Perch	Broadcast spawn in shallow weedy areas	Eggs adhesive, no guardianship	April and May	6.7-12.2°C
Pumpkinseed	Nest scoured in sand/fines	Male adult guardianship	Late spring to mid-summer	20°C
Smallmouth Bass	Sand/gravel nest near object cover	Male adult guardianship	Late spring to early summer	16.1-18.3°C
Largemouth Bass	Sand/fines nest near object cover	Male adult guardianship	Mid-spring to early summer	16.7-18.3°C
Bluegill	Sand/fines nest	Male adult guardianship	Mid-May to mid-summer	17 -31°C
Spottail Shiner	Broadcast spawn on sand at mouths of streams	No guardianship	May to mid-June	15-20°C
White Sucker	Gravel bars in tributary or shoals	No guardianship	Mid-April to May	10°C
Walleye	Cobble riffle or shoals	Broadcast spawn, no guardianship	April	7-11°C
Golden Shiner	Submerged vegetation in shallow water	Broadcast spawn, eggs are adhesive, no guardianship	May to August	20°C
Black Crappie	Nest scoured in sand/fines	Male adult guardianship	Mid-spring to early summer	19-20°C
White Perch	Broadcast spawn	Eggs planktonic	Mid-spring	11-15°C
Rock Bass	Sand/gravel nest near object cover	Male adult guardianship	June	15.6-21.1°C
Brown Bullhead	Sand/fines nest	Male adult guardianship	Late May through June	21.1°C
Chain Pickerel	Broadcast spawn glutinous egg strings in marshes	Eggs adhesive, no guardianship	March to May	8.3-11.1°C
Fallfish	Gravel in low velocity stream margins	Nest builder, no guardianship	Late April through May	12-16.6°C
Common Carp	Shallow vegetation	Broadcast spawn, no guardianship	Late spring to late summer	22-27°C

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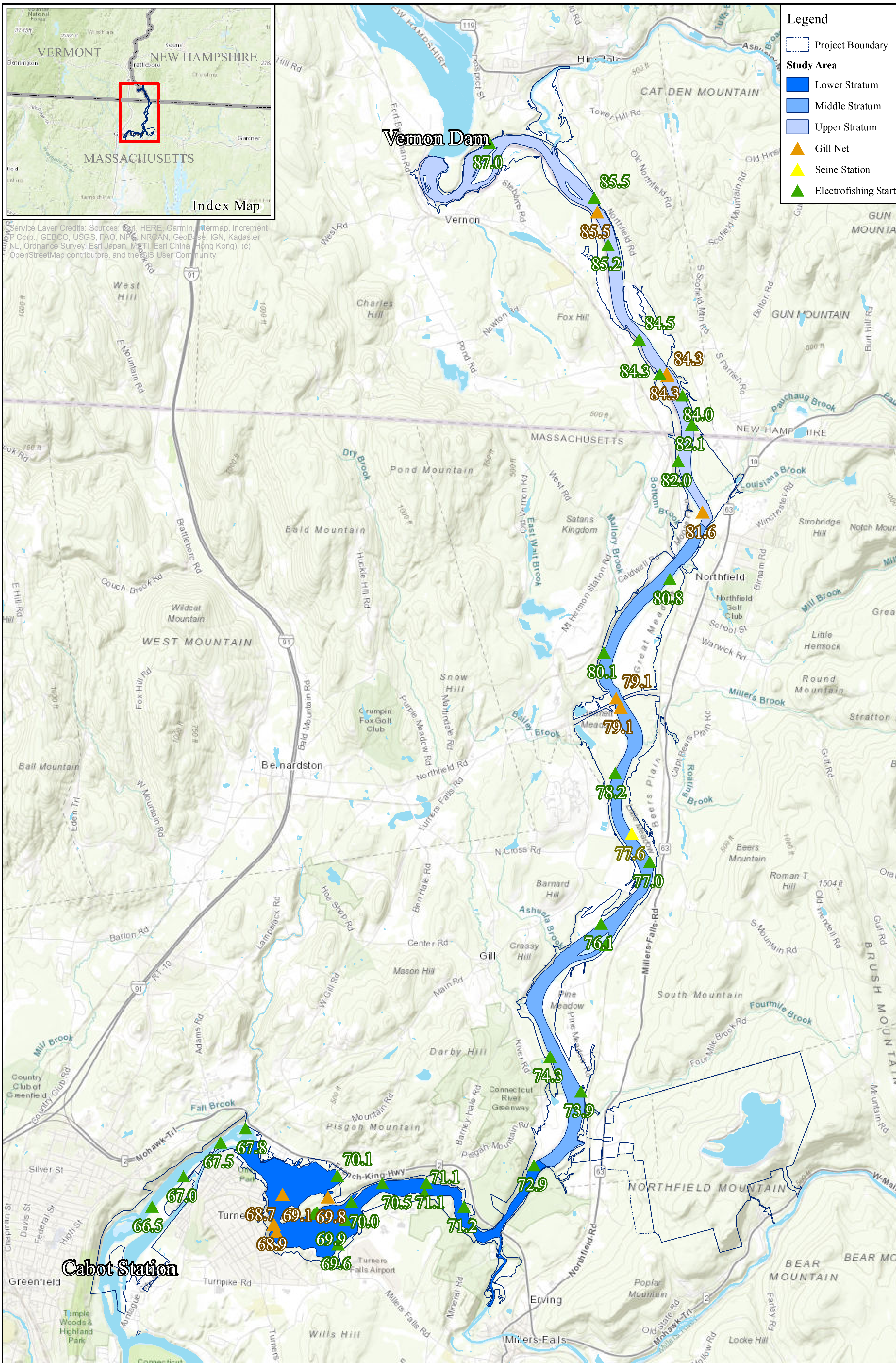

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E

0 0.5 1 2 Miles

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Figure 3.3.3.1.2.1-1:
Turners Falls Project Fish Assemblage Study Area

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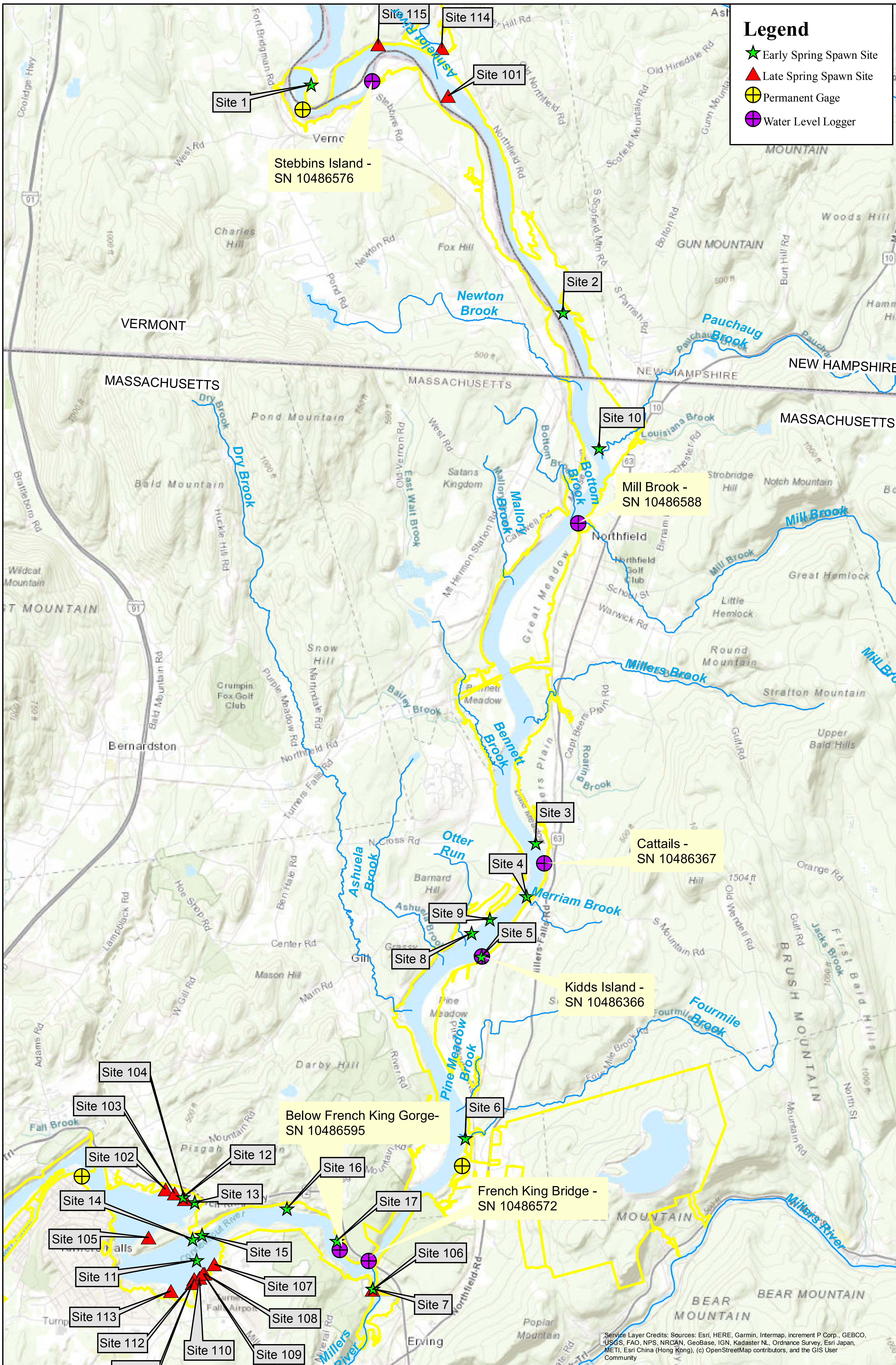

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

FirstLight

Amended Final License Application
Exhibit E

Figure 3.3.3.1.2.1-2:
Locations of Spawning Sites
Identified During Early and Late
Spring Littoral Zone Surveys

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3.3.3.1.2.2 Migratory Fish Species

The Connecticut River in the Turners Falls Project and Northfield Mountain Project vicinity supports a variety of migratory fish species (anadromous and catadromous), including American Shad, Blueback Herring, Striped Bass, Sea Lamprey, and American Eel.[4] Before reaching the Project Area, these migrants must successfully pass the hydroelectric facility at Holyoke (RM 85), where there is a fish lift and eel passage ladders. In addition, a population of Shortnose Sturgeon (SNS)is known to inhabit the Connecticut River between the Turners Falls Dam and Holyoke Dam, and over 200 sturgeon have been passed upstream at the Holyoke Dam since 2017.

3.3.3.1.2.2.1 American Shad

Life History

American Shad are anadromous, living most of their lives in oceanic environments and spawning in freshwater. Juvenile shad migrate to areas in the North Atlantic and remain at sea for four to six years before returning to their native river to spawn. American Shad can survive after spawning and potentially return to their natal rivers more than once. They migrate into the lower Connecticut River during late March or April, reaching Cabot Station in late April or early to mid- May as they move upstream to spawn. Spawning typically occurs from April into June. Males typically arrive at the spawning grounds ahead of females. Spawning activity generally occurs after sunset, continuing until midnight or later, and may also occur during the day under low light conditions (Collette and Klein-MacPhee 2002). During spawning, a group of shad, which may consist of one female and several males, exhibit behaviors that have been characterized as dashing, darting, circling, and rolling near the surface (Ross et al. 1993). These behaviors lead fish to break the surface of the water, thereby creating a series of splashes.

Female shad broadcast their eggs (about 150,000-500,000 per individual) over a variety of substrates in open water where they are fertilized (Savoy et al. 2004; Greene et al. 2009). After spawning, spent shad swim back downstream during June and July, and may survive to spawn more than once. Fertilized eggs are semi-buoyant and drift downstream with river currents for several kilometers before settling to the bottom (Savoy et al. 2004). Stier and Crance (1985) report optimal egg survival occurs at water temperatures of 15.5 to 26.0°C, with temperatures above 26.7°C unsuitable for hatching. Shad larvae hatch in three to 12 days, depending on water temperature. The yolk-sac is absorbed in another three to four days, and the larvae are transported by currents into areas of lower velocity, where they begin to feed on plankton. YOY shad abundance has been shown to be negatively correlated with river flow in June (Crecco et al. 1983), either because of physical displacement of YOY shad into unsuitable habitat, or because of fluctuations in populations of prey organisms that are related to flow. YOY shad remain in southern New England freshwater rivers throughout the summer before initiating seaward migration which typically occurs in September or October.

Implications of Fish Passage on Population Structure

To facilitate the restoration of American Shad to their historic ranges in the Connecticut River, a fish lift system at Holyoke Dam was improved in 1976 to increase the numbers of fish lifted. Fish ladders were installed since 1980 at the Turners Falls and Vernon Dams to support the restoration of extirpated Atlantic Salmon, an effort which has since been canceled. In 1982, fishways were operational at all three dams (Holyoke, Turners Falls and Vernon) on the Connecticut River (Moffitt et al. 1982), allowing American Shad to migrate much further upriver (174 miles). Generally, less than 15% of the shad passed at Holyoke proceed through the fish ladders at Turners Falls Dam based on annual fish counts. Crecco and Savoy

[4] At a meeting of the Connecticut River Atlantic Salmon Commission on July 10, 2012 the USFWS announced that it will no longer culture salmon for restoration efforts in the Connecticut River Basin. Agency representatives indicated that they supported the salmon restoration for 45 years, but low return rates and the science supporting salmon restoration have caused them to refocus efforts on other migratory fish (including American Eel).

(1987) found the relative abundance of repeat spawners declined since the lifting of large numbers of shad over Holyoke Dam began in 1976. Different authors have attributed this decline to the effects of natural mortality caused by the extension of their migratory range (Leggett et al. 2004) or delay at upstream and downstream passage facilities (Castro-Santos and Letcher 2010).

Crecco and Savoy (1987) reported post-spawning mortality in the Connecticut River never exceeded 80% between 1956 to 1975 but increased to 80-90% thereafter when high numbers of shad were lifted following improvement at the Holyoke fish lift. They calculated annual mortality rate of 80% for shad migrating past Holyoke. For adult spawning shad remaining downstream of Holyoke Dam, the annual mortality was 45%.

Connecticut River American Shad have continued to be lifted above Holyoke in large numbers with little change in the population size and continued reduction of the repeat spawner component (2% of the population repeat spawners in 2015 *per* The Connecticut River Atlantic Salmon Commission (CRASC) Connecticut River Shad Management Plan). In 2017, CRASC published a Connecticut River Shad Management Plan which continues to support the upriver relocation of the main shad spawning activity while acknowledging the importance of the proportion of repeat spawners in the population.

Rates of Arrival at the Project

Fisheries relicensing studies focused on adult American Shad migration through the Turners Falls Project and TFI. Over the course of four years, FirstLight radio tagged and tracked over 1,000 adult American Shad to understand factors that affected their upstream migration. Of interest was the low proportion of shad that migrated from Holyoke and subsequently passed through the Turners Falls Project.

In the first year of study (2015), shad were tagged and released throughout the fish passage season at Holyoke Dam. Approximately 60% of the tagged fish reached the Turners Falls Project area. Most of the tagged fish that reached the Project area were those tagged earlier in the passage season. During subsequent tagging studies, early season migrants were targeted for tagging and the percent of tagged shad reaching the Project area increased to around 80%, demonstrating that early season migrants are more likely to move further upstream.

For all study years, water temperature appeared to be an important driver of movement since fish moved through the bypass reach over a wide range of high and low flow conditions. Further, overall movement upstream in all study years began to decrease when water temperature reached 18.5°C, which coincides with peaking spawning temperature (Collette and Klein-MacPhee 2002), regardless of flow conditions. Water temperatures generally reached 18.5°C by the end of May, except in 2019 when water temperature reached 18.5 °C on June 11. The length of time that shad were expected to be in the river, as measured by Accumulated Thermal Units (ATUs) for days with temperatures greater than 10°C, was also a significant factor. These metrics are biologically important for shad, given that they do not feed while in the river, but still expend energy each day for swimming and egg maturation. As the migration season progresses and the water warms, the fitness of individual fish declines, and they stop or slow upstream movements to spawn.

Geographical Extent of Shad Spawning in Project Waters

Spawning shad prefer areas dominated by runs and glides (3- to 18-ft-deep) and have been observed to spawn over a variety of substrates with preference given to sand and gravel (Stier and Crance 1985). In the Project area, this type of habitat most closely corresponds to the habitats that dominate the reach of the Connecticut River downstream of Cabot Station.

Spawning locations of American Shad in the Connecticut River between Holyoke Dam and Turners Falls Dam were previously identified by Layzer (1974), Gilmore (1975 as cited in Kuzmeskus 1977), and Kuzmeskus (1977). Figure 3.3.3.1.2.2.1-1 depicts the locations of the historical spawning grounds identified in the reach of the Connecticut River spanning from the Cabot Station tailrace the Route 116 Bridge in Sunderland, MA. Identification of these sites was based on visual observations and collection of eggs with plankton nets (Layzer 1974; Gilmore (1975 as cited in Kuzmeskus 1977). Note the historical spawning sites were in areas of free-flowing sections of the Connecticut River dominated by runs and glides over sand, gravel, and cobble substrates.

In 2015, FirstLight surveyed spawning activity within the TFI, power canal, and in the mainstem of the Connecticut River downstream of Cabot Station. The surveys were performed during various operational conditions at Cabot Station and Station No. 1. Surveys typically commenced at sunset and observations of spawning activity were generally between 20:00 and 01:00. Field crews recorded spawning behavior as darting and grouping. In general, groups of shad appeared to congregate at a spawning location, with individuals intermittently darting upwards and breaking the water surface, thereby causing splashes.

FirstLight observed American Shad spawning downstream of Cabot Station and within the TFI in 2015. Spawning intensity was estimated with splash counts, where two independent counts over a 15-minute period were averaged. In the downstream reach, the average splash count recorded over a 15-minute interval varied, ranging from 3 to 215.5, with a mean of about 43 splashes. During the study period (May 13 to June 22, 2015), 22 unique spawning observations were documented between Cabot Station and the Route 116 Bridge during field surveys (Table 3.3.3.1.2.2.1-1 and Figure 3.3.3.1.2.2.1-1). Spawning was most frequently observed between the Deerfield River confluence and the railroad bridge near river mile 116.8, with highest concentrations between the Deerfield River confluence and Fourth Island. The 2015 surveys confirmed that fish still spawn within the vicinity of historic spawning locations identified in the 1970s. Large spawning events below Cabot Station likely explain why fewer shad arrive at the Project area than would be anticipated based on passage counts at Holyoke.

Spawning activity was also observed in the lower portion of the power canal, and in the bypass reach near Rawson Island, but at a much lesser extent than the downstream areas. Spawning activity was only observed at these areas during one site visit, later in the season, on June 18, 2015.

Above the Turners Falls Dam, seven unique spawning events were observed in the TFI (Table 3.3.3.1.2.2.1-2); however, spawning activity was only observed in one area near Stebbins Island, which is near the upstream extent of the Project just below the Vernon Dam (Figure 3.3.3.1.2.2.1-2). This site was approximately 13.7 river miles upstream of the Northfield Mountain intake. Spawning was observed over a 39-acre area at this location.

Temporal Trends of Spawning

The first recorded spawning incident during the 2015 survey occurred on May 14 directly upstream of the General Pierce foot bridge at the confluence of the Connecticut and Deerfield Rivers. This location was subsequently sampled in 2018 for the duration of the spawning season to precisely define the timing and duration of the spawning run within the Project area. FirstLight employed the same splash count method as in 2015 with two independent observers. The maximum splash count by day is depicted in Figure 3.3.3.1.2.2.1-3. Peak spawning activity was observed on May 29, 2018 with up to 229 splashes noted within a 15-minute window. This aligns with the 2015 peak noted on May 27, 2015 with 253 splashes per 15 minutes. Generally, the gatehouse ladder has passed or is nearing the 75th cumulative passage percentage

(Figure 3.3.3.1.2.2.1-4) when spawning intensity peaks. Spawning intensity decreased and counts were below 100 per 15-minute period two weeks later, on June 15, 2018.

Spawning Habitat Characteristics

American Shad are broadcast spawners and take advantage of the moderate currents found within the riverine segments for egg dispersal. Shad eggs are semi-buoyant and eventually sink. Areas predominated by sand and gravel may enhance survival because there is sufficient water velocity to remove silt and fine particles thus preventing suffocation when eggs settle to bottom (Greene et al. 2009). Spawning and egg incubation most often occurred where water velocity was approximately 1-3 fps, where a minimum velocity is needed to prevent siltation that could suffocate eggs (Greene et al. 2009).

At spawning locations studied by FirstLight, discrete water quality, depth, and velocity measurements recorded for each spawning observation are provided in Table 3.3.3.1.2.2.1-3. At the times of the surveys, water temperature ranged from 15.8 to 20.2 °C; DO ranged from 9.0 to 13.4 mg/l; pH ranged from 6.2 to 7.4; secchi depth ranged from 5.5 to 9.5 ft; depth measured from 3.3 to 16.0 ft; and velocity ranged from 0.1 to 2.8 fps.

As the spawning surveys were conducted at night, substrate type could not be accurately identified by the field crews; therefore, dominant substrate types at spawning locations were ascertained from data collection efforts related to Relicensing Study No. 3.3.1 *Conduct Instream Flow Habitat Assessment in the Bypass reach and below Cabot Station*. All of the identified spawning areas in the downstream reach predominantly consisted of cobble and/or gravel (Table 3.3.3.1.2.2.1-4). Mesohabitat classifications, also determined as part of Relicensing Study No. 3.3.1, for the spawning locations were mostly run, with pool-type habitat also present.

In the TFI, the only spawning area identified was adjacent to Stebbins Island which has a cobble and/or gravel substrate and represents the most riverine habitat area within the TFI.

Emigrating Post-Spawn Adult Shad

Following spawning, and assuming they survive, adult American Shad begin their emigration back to Long Island Sound. Once post-spawn shad begin their emigration to Long Island Sound, depending on how far upstream they have passed, they could interact with pumping and generation at the Northfield Mountain Project, and could pass the Turners Falls Project via several passage routes described in Section 3.3.3.1.2.3.

Juvenile Shad

After spawning, shad hatch and enter the larval stage for only 3 to 5 weeks (Collette and Klein-MacPhee 2002). After that, juvenile American Shad remain upstream until water temperatures reach approximately 19°C degrees (O'Leary and Kynard 1986). During that time, larval and juvenile shad are at risk of entrainment into the Northfield Mountain Project when pumping (see Section 3.3.3.2.4.2.1). Once juvenile shad begin their emigration to Long Island Sound, depending on where they are residing in the river pre-emigration, they could interact with pumping and generation at the Northfield Mountain Project, and could pass the Turners Falls Project via several passage routes described in Section 3.3.3.1.2.3.

CRASC Passage Criteria

On June 9, 2017, the CRASC approved a new Management Plan for American Shad, *Connecticut River American Shad Management Plan* (CRASC, 2017). The Plan updates the existing CRASC Management Plan for American Shad in the Connecticut River Basin (1992). The Plan establishes performance criteria to achieve goals and objectives including achieving a rate of return of 203 adults per hectare in the mainstem and 111 adults per hectare in tributaries. The Plan uses an estimate of the total amount of river habitat (with no analysis of whether habitat is good for spawning/rearing) to determine minimum target return numbers that will pass upstream of each mainstem dams, (Holyoke: 687,088 shad, Turners Falls: 397,108 shad, Vernon: 226,988 shad). The Plan was approved by the CRASC without public input.

Over the past six years, FirstLight's extensive relicensing studies have added to the knowledge of Connecticut River American Shad spawning, migration, and emigration. These studies produced results that should be considered in future management strategies. To date (1976-2019) the mean number of shad to pass upstream at Holyoke Dam is 315,369 +/- 130,335. Radio telemetry studies conducted as part of this relicensing in 2015, 2016, 2018 and 2019 indicated 30% to 40% of the migrating shad tagged at Holyoke Dam arrived in the project area annually.

Just downstream of the Turners Falls Project, there is a large area (~106 acres) where shad spawning occurs. This location was first identified as a major spawning area over 35 years ago and still remains a prime area for shad spawning. The Plan fails to account for the fact that shad spawning downstream of Turners Falls would lose their drive to continue their upstream migration and thus not available to pass upstream of Turners Falls and be counted.

FirstLight agrees that the current fish passage facilities prescribed and designed by USFWS to pass Atlantic Salmon can be improved to pass American Shad and has proposed significantly higher fish passage flow in the bypass reach and a new Spillway Fish Lift to improve shad passage. However, considering the amount of spawning that occurs downstream of the Turners Falls Project and that only 30-40% of the shad passed at Holyoke even arrive at the Turners Falls Project, the numbers of shad available to be passed upstream of Turners Falls Dam are nowhere near the passage goals of the Plan.

In 2019, CRASC developed an addendum to the 2017 Plan that provides performance criteria in support of the Plan goals which was approved by CRASC on February 28, 2020.

1. Upstream adult passage minimum efficiency rate is 75%, based on the number of shad that approach within 1 kilometer of a project area and/or passage barrier. Passage efficiency is [(# passed/# arrived)*100];
2. Upstream adult passage time-to-pass (1 kilometer threshold) is 48 hours or less based on fish that are passed (requires achieving Objective #1);
3. Downstream adult and juvenile project passage minimum efficiency and survival rates are each 95%, based on the number of shad that approach within 1 kilometer of a project area and/or passage barrier and the number that are determined alive post passage (not less than 48 hours evaluation). Passage efficiency is [(# passed/# arrived)*100] and passage survival is [(# alive downstream of project/# passed)*100].
4. Downstream adult and juvenile time-to-pass is 24 hours or less, for those fish entering the project area.

These performance criteria were based on a model, *Shadia*, developed for the Penobscot River. Unlike the 2017 shad management plan, this Addendum was publicly vetted for comments and FirstLight, along with other mainstem dam owners, commented on the use of the model as well as the performance criteria. FirstLight, along with the other dam owners, requested that a presentation or workshop be presented by the model's developer Dr. Stich to address questions regarding model design, variable inputs and outputs. CRASC responded with a copy of the program code to generate model outputs and a copy of a PowerPoint presentation. FirstLight incorporated model input code provided by CRASC and the publicly available *Shadia* model for the Connecticut River. However, model output differed significantly from that provided by CRASC. On October 9, 2019, the companies conferred with *Shadia*'s originator, Dr. Dan Stich (SUNY Oneonta), who confirmed that the publicly available model version had been revised from the version used to produce the output used by CRASC to inform the Addendum. In addition, the companies were made aware that the publicly available version of the model had not yet been fully reviewed and was not considered to be final or stable. Dr. Stich was able make available a 'legacy' version of the model code which was expected to replicate that used to inform the Addendum.

FirstLight submitted several comments to CRASC about its concerns of using the *Shadia* model for establishing performance criteria. The Addendum focused on the mean modeled population projections as indicators of the necessity of specific suites of passage performance criteria to achieve minimum Plan targets. That approach is misapplied because it undermines the inherent stochasticity of the model and considers the result as deterministic. The model incorporates environmental stochasticity and inter-annual variability by drawing from parameterized distributions for many input variables (Stich et al. 2018). It is appropriate to use the model as a tool to assess the relative population trends, but not to consider the output as deterministic. The Addendum failed to present, discuss and seemingly consider the confidence intervals around modeled population projections. In the presentation of model output provided in support of the Addendum, figures depict the annual population as an average of approximately 123 iterations per scenario, but no information regarding the variability around those projections. Wide confidence intervals indicate both the variability inherent in the model and uncertainty in population projections. The wide confidence intervals demonstrate a high level of variability and calls into question the validity of specific passage performance criteria with regards to the Plan objective. While the mean of a few scenarios approached the Plan objective, the confidence limits of many scenarios exceeded it. The trend in population growth was generally similar among scenarios (55%, 65% and 75%) with the most rapid population growth occurring over approximately the first two generations (~10 years). Similarly, output for modeled populations above Turners Falls Dam demonstrated high variability with upper confidence limits well above the targets and lower confidence limits below the targets in all scenarios.

The model currently includes an unrealistic single, common downstream passage effectiveness/survival input value for both adult and juvenile shad. It should include separate effectiveness/survival input values for each life stage.

In addition, a review of the timing of the annual shad runs from 1989 through 2019 demonstrated that the majority of the shad run occurs within a short amount of time and over 90% of the shad run had passed Holyoke by the first week of June. The upstream relocation of the shad population has resulted in higher total energy expenditure and increased adult mortality which lead to a dramatic reduction in the repeat spawning component of the population and in the mean size and age of adult fish. The loss of larger repeat spawning females is estimated to have resulted in a 20% reduction in mean population fecundity and could account for a 14% reduction in annual recruitment to the population (Leggett et al. 2004). This most likely has contributed to the failure of the population to respond numerically to the increased access to upriver spawning habitat. A prudent management strategy would be to adjust the passage of shad during the latter part of the annual run to ensure the restoration and the maintenance of an age and repeat spawning structure more consistent with historic levels. Failure to do so could further erode the proportion of repeat spawners and the number of individuals of older age classes, thereby placing the population at risk of recruitment failure in the event of a period of several years of successive poor recruitment.

FirstLight reiterates that use of modeled population projections should consider variability in output and focus on trends, rather than a deterministic interpretation of results. Model revision is necessary to incorporate the best available data and include separation of juvenile and adult downstream passage, and the model should be verified as stable and agreed upon as final for the purpose of assessing passage performance. Since the trend in population growth was similar among upstream adult passage minimum efficiency rates of 55%, 65% and 75%, the CRASC selected performance criterion of 75% is arbitrary.

Table 3.3.3.1.2.2.1-1: Summary of Conditions Observed During Shad Spawning Surveys Conducted in the Downstream Reach.

Date	Time (EDT)	Location	Cabot Discharge* (cfs)	Station No. 1 Discharge* (cfs)	Instantaneous River Discharge USGS01170500* (cfs)	Average Splash Count	Behavior
5/13/2015			13,632	0	18,200	No shad spawning observed	
5/14/2015	21:15	1	11,398	0	15,700	36.0	darting, grouping
5/14/2015	20:18	2	11,462	0	15,700	17.0	darting, grouping
5/19/2015	17:05	3	11,274	2,194	14,600	46.0	darting, grouping
5/19/2015	23:03	4	6,875	2,194	15,700	18.0	darting, grouping
5/20/2015			6,923	2,210	12,400	No shad spawning observed	
5/21/2015	21:51	5	6,824	2,201	8,780	42.0	darting
5/21/2015	22:37	6	6,751	1,664	10,600	107.0	darting, grouping
5/21/2015	23:40	7	6,939	1,212	11,000	29.0	darting, grouping
5/26/2015	20:56	8	2,336	0	8,310	76.5	darting
5/26/2015	21:34	8	4,663	0	8,150	69.0	darting
5/26/2015	22:10	9	4,614	0	8,830	215.5	darting
5/26/2015	22:51	9	2,263	0	9,000	205.0	darting
5/27/2015	22:50	10	18	1,216	11,000	37.5	darting
5/27/2015	23:40	10	2,227	1,208	9,240	25.5	darting
5/28/2015	0:15	11	2,287	1,227	8,690	56.0	darting
5/28/2015	0:50	11	18	1,242	8,190	46.0	darting
5/28/2015	20:46	12	4,530	1,223	7,710	31.5	darting
5/28/2015	22:08	12	6,950	1,230	9,240	14.0	darting
5/28/2015	23:13	13	6,976	1,212	9,760	30.0	darting
5/28/2015	23:57	13	4,714	1,227	9,150	9.5	darting
6/4/2015			13,519	2,210	23,600	No shad spawning observed	
6/8/2015			9,142	0	14,400	No shad spawning observed	
6/9/2015	20:00	14	9,102	0	12,500	36.5	darting
6/9/2015	20:43	14	9,139	0	12,700	22.0	darting
6/9/2015	23:45	15	13,665	0	16,000	9.5	darting
6/10/2015	0:30	15	9,046	0	16,200	3.0	darting
6/10/2015	22:29	16	13,432	2,205	21,300	11.0	darting
6/10/2015	23:22	16	8,973	2,157	20,900	11.5	darting
6/10/2015	23:51	17	9,153	2,194	19,400	34.5	darting
6/11/2015	0:27	17	13,499	2,209	18,400	29.0	darting
6/16/2015	22:38	18	13,514	2,210	20,400	72.0	darting
6/16/2015	23:20	18	8,987	2,210	20,400	35.5	darting
6/17/2015	0:24	19	9,961	2,210	17,600	4.5	darting
6/17/2015	0:55	19	13,421	2,172	18,700	4.0	darting
6/17/2015	22:20	20	9,124	2,210	15,800	10.5	darting
6/17/2015	23:07	20	4,554	2,210	15,600	17.5	darting
6/17/2015	23:33	21	4,585	2,210	14,100	41.5	darting
6/18/2015	0:15	21	9,055	2,198	13,500	21.5	darting
6/18/2015			3,512	0	16,100	No shad spawning observed	
6/22/2015	21:59	22	12,943	2,210	26,400	57.5	darting
		Minimum	18	0	7,710	3.0	
		Maximum	13,665	2,210	26,400	215.5	
		Average	7,646	13,29.3	13,868	42.6	

*Recorded flows were the nearest instantaneous values from the time of the survey observations. For dates when no shad spawning was observed, the maximum value occurring between 17:00 and 01:00 is reported.

Table 3.3.3.1.2.2.1-2: Summary of Conditions Observed During Shad Spawning Surveys Conducted in the Turners Falls Impoundment

Date	Time (EDT)	Average Splash Count (No./15 min.)	Water Temp. (°C)	DO (mg/l)	pH	Secchi Depth (ft)	Water Depth (ft)	Surface Velocity (ft/sec)	WSEL NGVD29 (ft)	Vernon Discharge (cfs)*
5/19/2015	20:33	8	16.4	10.1	7.4	6.8	8.0	0.1	184.39	7,944
5/20/2015	20:21	5	15.6	9.9	7.4	6.0	7.0	1.3	183.16	4,345
5/21/2015			No shad spawning observed							
5/26/2015	20:57	265	17.8	11.4	6.4	5.0	9.5	1.3	183.34	5,006
5/27/2015	22:25	253	18.7	10.5	7.3	6.8	7.5	0.8	182.89	1,942
5/28/2015			No survey conducted due to boat engine failure							
6/4/2015			No shad spawning observed; No other surveys conducted this week due to high							
6/8/2015			No shad spawning observed							
6/9/2015			No shad spawning observed							
6/10/2015			No shad spawning observed							
6/16/2015	22:00	56	18.6	10.0	8.17	7.5	11.0		185.31	17,535
6/17/2015	22:49	24	18.6	9.9	7.38	5.5	7.0	0.06	183.03	8,932
6/18/2015	22:15	89	18.8	10.3	7.55	5.4	6.8	1.6	184.61	13,279
6/22/2015			No shad spawning observed							
Average		100	17.8	10.3	7.4	6.1	8.1	0.9	183.82	8,426
Minimum		5	15.6	9.9	6.4	5.0	6.8	0.1	182.89	1,942
Maximum		265	18.8	11.4	8.2	7.5	11.0	1.6	185.31	17,535

*Recorded flows were the nearest instantaneous values from the time of the survey observations.

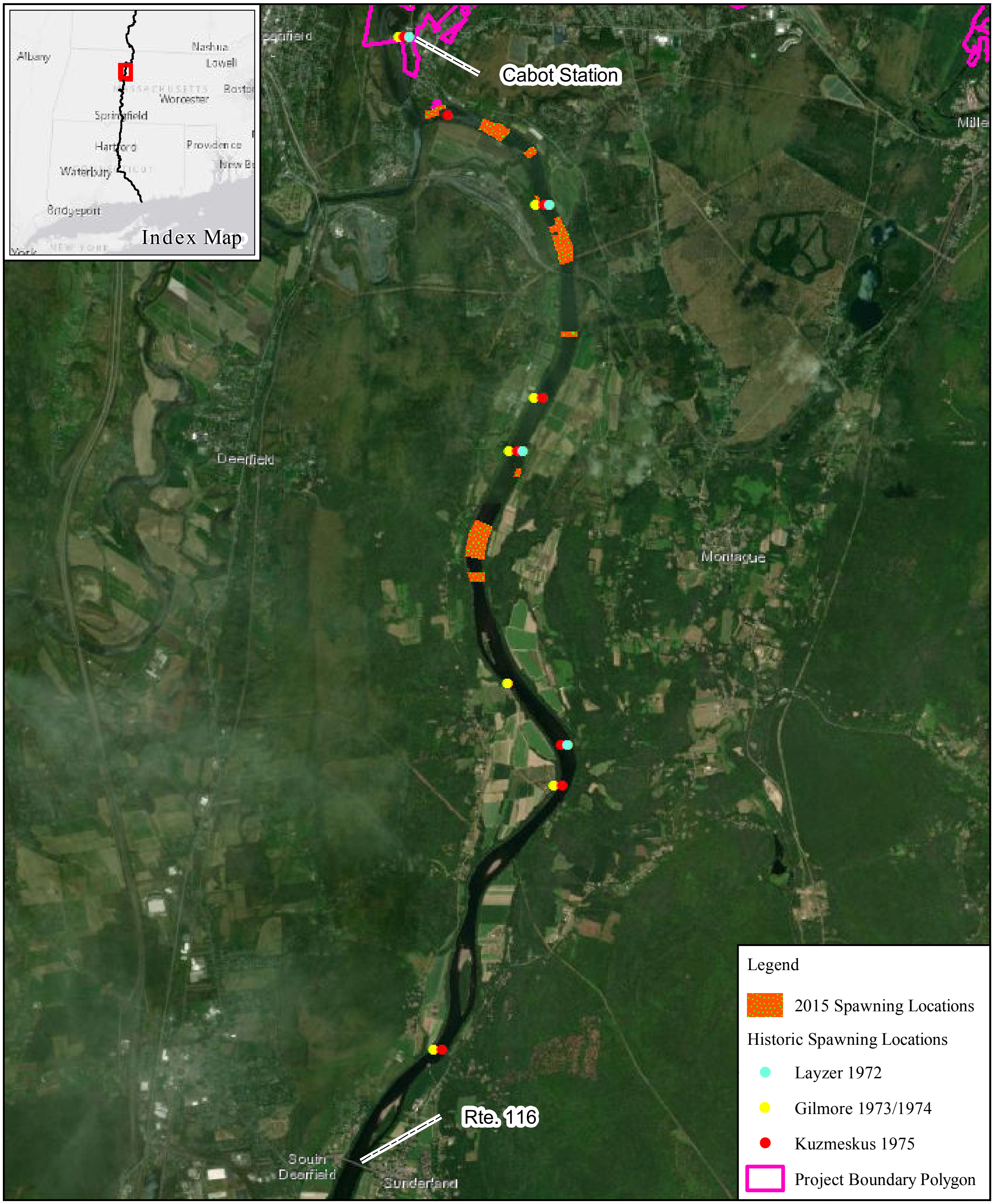
Table 3.3.3.1.2.2.1-3: Summary of Physical Measurements Recorded During Shad Spawning Surveys Conducted Downstream of Cabot Station

Date	Spawning Site ID	Estimated Area (acres)	Water Temp. (°C)	DO (mg/l)	pH	Secchi Depth (ft)	Water Depth (ft)	Surface Velocity (fps)
5/14/2015	1	1.26	16.4	10.0	6.4	9.0	14.1	2.4
5/14/2015	2	1.4	16.4	10.1	6.7	9.0	8.5	2.3
5/19/2015	3	1.21	16.3	13.4	6.2	9.5	12.8	2.3
5/19/2015	4	1.49	16.3	12.7	6.6	n/d	4.3	2.8
5/21/2015	5	7.44	15.8	10.9	6.3	9.0	8.2	1.0
5/21/2015	6	11.21	15.8	11.7	7.0	9.0	6.9	0.5
5/21/2015	7	24.42	15.8	10.6	7.2	n/d	3.3	1.0
5/26/2015	8	4.36	17.7	10.5	6.6	8.3	14.5	0.1
5/26/2015	9	4.68	17.7	10.3	6.6	n/d	6.6	1.1
5/27/2015	10	3.34	18.4	10.1	6.7	7.5	8.0	0.1
5/28/2015	11	3.41	18.8	9.9	6.7	7.5	11.0	0.8
5/28/2015	12	5.49	19.1	9.1	6.9	9.0	14.0	0.8
5/28/2015	13	4.08	18.6	9.4	7.2	n/d	4.0	1.0
6/9/2015	14	0.68	17.3	9.5	6.8	n/d	5.2	0.9
6/9/2015	15	9.15	17.2	9.5	6.5	8.5	9.0	1.0
6/10/2015	16	0.70	18.0	9.2	6.5	6.8	10.0	1.7
6/10/2015	17	4.85	18.3	9.4	7.0	7.5	14.0	1.2
6/16/2015	18	5.05	18.7	9.9	7.4	6.0	10.0	0.7
6/17/2015	19	0.42	18.6	9.1	7.4	6.0	10.0	0.7
6/17/2015	20	1.42	18.9	9.0	7.4	8.0	16.0	0.4
6/17/2015	21	3.10	18.8	9.1	7.4	8.0	10.0	0.2
6/22/2015	22	6.75	20.2	10.0	7.4	5.5	6.0	1.4
	Minimum	0.42	15.8	9.0	6.2	5.5	3.3	0.1
	Maximum	24.42	20.2	13.4	7.4	9.5	16.0	2.8
	Average	4.81	17.7	10.1	6.9	7.9	9.4	1.1

Notes: n/d = no data collected. Secchi depth was taken in areas deep enough for a reading and may have been deeper than the areas where shad were spawning.

Table 3.3.3.1.2.2.1-4: Mesohabitat Type and Dominant Substrates for the Spawning Locations identified in the Downstream Reach, 2015

Spawning Site ID	Mesohabitat Type	Dominant Substrate(s)
1	Pool/Run	Gravel/Cobble
2	Run	Cobble
3	Pool/Run	Gravel/Cobble
4	Run	Cobble
5	Run	Cobble
6	Run	Cobble
7	Run	Cobble
8	Pool	Gravel
9	Run	Cobble
10	Run	Cobble
11	Run	Cobble
12	Run	Cobble
13	Run	Cobble
14	Pool/Run	Gravel/Cobble
15	Run	Cobble
16	Pool/Run	Gravel/Cobble
17	Run	Cobble
18	Run	Cobble
19	Run	Cobble
20	Pool/Run	Gravel/Cobble
21	Run	Cobble
22	Run	Cobble



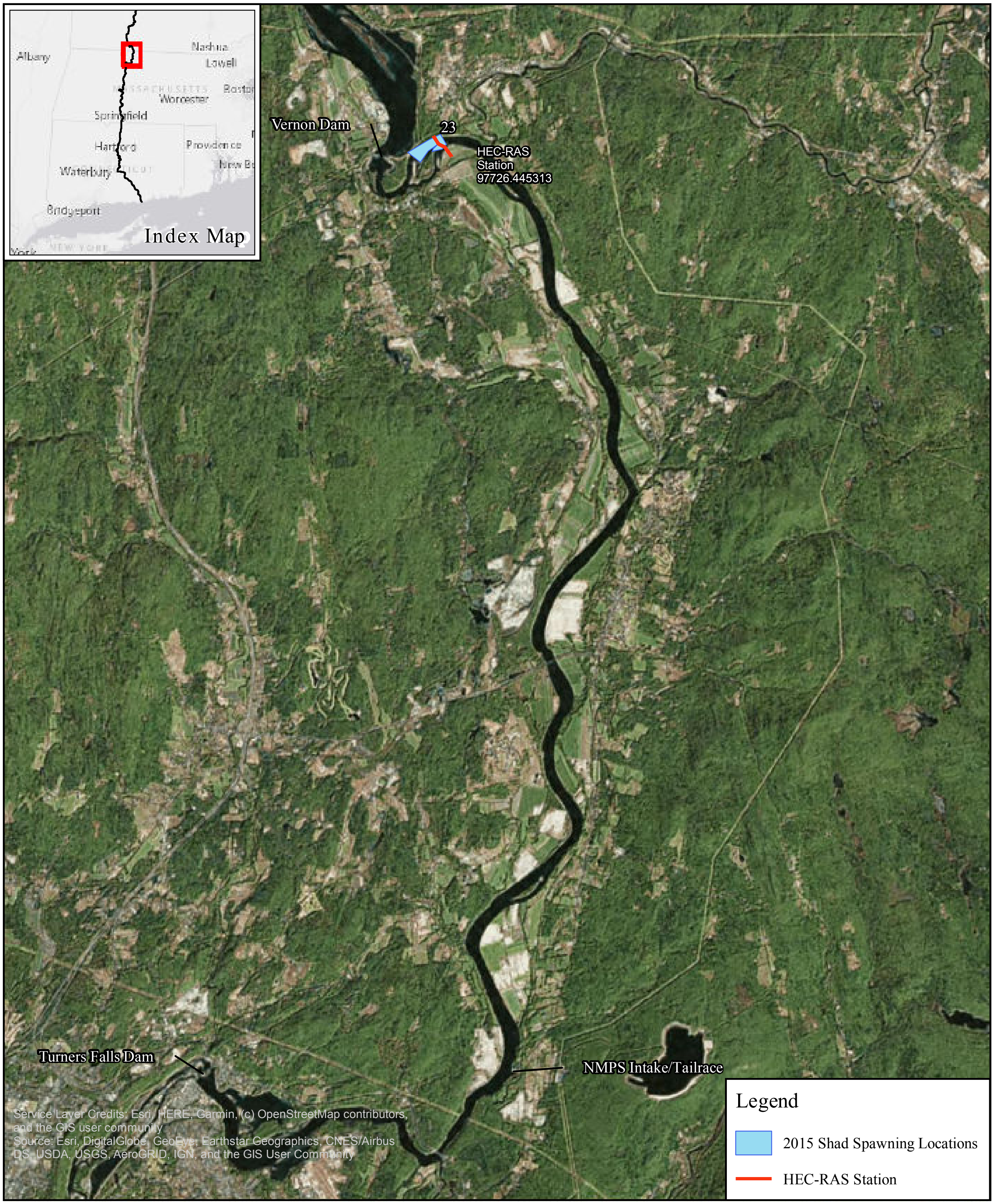
FirstLight

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E

Figure 3.3.3.1.2.2.1-1: Spawning Locations Identified in the Downstream Reach from Cabot Station tailrace to the Route 116 Bridge in Sunderland, Massachusetts.

Path: W:\gis\maps\Exhibit_E\amended_combined\figure_3_3_3_1_2_2_1-1.mxd



Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

FirstLight

Amended Final License Application
Exhibit E

Figure 3.3.3.1.2.2.1-2:
Location of Shad Spawning Activity Identified in the Turners Falls Impoundment

Path: W:\gis\maps\Exhibit_E\amended_combined\figure_3_3_3_1_2_2_1-2.mxd

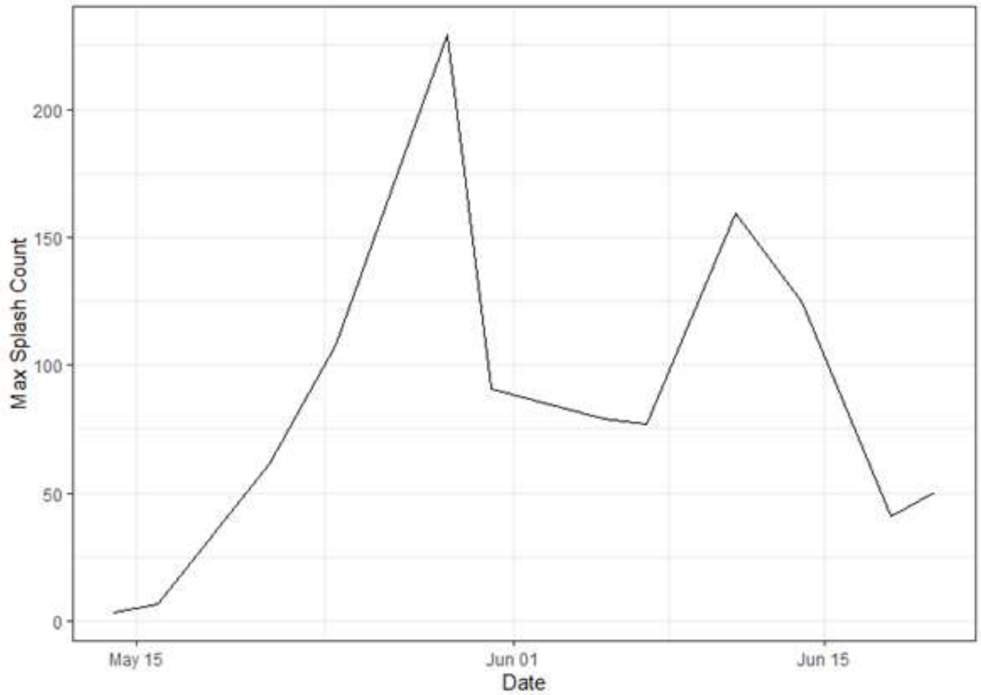


Figure 3.3.3.1.2.2.1-3. Maximum splash count by day during shad spawning survey, 2015.

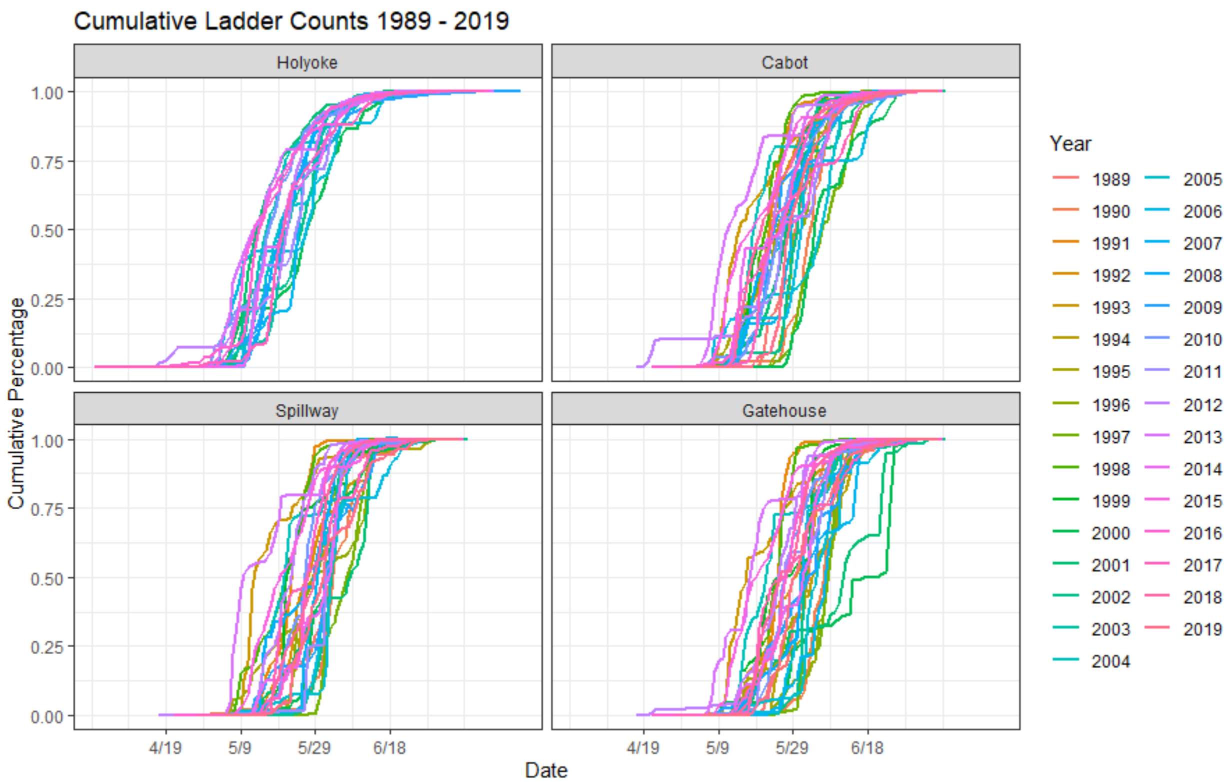


Figure 3.3.3.1.2.2.1-4: Cumulative proportion of passage over time at fishways on the Connecticut River.

3.3.3.1.2.2.2 Blueback Herring

Together Blueback Herring and Alewife are known as river herring. Alewife use the lower portion of the Connecticut River, but rarely pass above the Holyoke Dam. Thus, Blueback Herring is the only river herring found in the Project area (Hartel *et al*., 2002). Pre-spawning Blueback Herring enter the mouth of the Connecticut River at about the same time as American Shad. Blueback Herring broadcast spawn on hard substrate in swift-flowing tributaries to the lower Connecticut River. Presumably, some spawning also occurs in the mainstem Connecticut River, where swift-flowing habitats with hard substrate are available (Hartel *et al*., 2002). Females may produce 122,000 to 261,000 eggs; larger fish generally produce more eggs.

Blueback Herring elsewhere have been reported to spawn in both swift-flowing, deeper stretches and in slower-flowing tributaries and flooded low-lying areas adjacent to the main stream; substrates may vary from coarse to fine materials (Pardue, 1983). Active spawning may occur over a wide range of water velocities. FirstLight (2012a) identified that the uppermost segments of the reach below Cabot Station consist of riffle habitat with swift-flowing conditions, but swift-flowing runs are well distributed throughout the 30 mile reach downstream of Cabot Station tailrace evaluated in 2012, along with portions of the bypass reach below Turners Falls Dam. Most of the runs featuring the hard substrates (e.g., cobble and/or gravel) can be found in the first 14 miles of river below the Cabot Station tailrace. Fines such as sand dominate the substrates in the remaining downstream reaches. Eggs are initially demersal but become planktonic. Pardue (1983) reports that larvae in Chesapeake Bay remain near or slightly downstream of presumed spawning areas, and in Nova Scotia are associated with relatively shallow (depth < 6.6 ft), sandy, warm areas in and near areas of observed spawning.

Juveniles remain in the river, feeding on zooplankton, until the fall of the year then emigrate to the sea (Collette & Klein-MacPhee, 2002). These characteristics of their development parallel those of American Shad and the young of the two species are difficult to distinguish. Juvenile Blueback Herring begin their seaward migration slightly earlier and at higher water temperatures (peaking at 14 to 15°C) than American Shad. Adult Blueback Herring spend three to six years at sea before returning to spawn in their natal streams. The average length of adults is less than 300 mm (Hartel *et al*., 2002).

Blueback Herring in the Connecticut River and coast-wide experienced a decline in the mid-1990s. Few Blueback Herring have been recorded in the Project Area since the late 1990's. Since a peak of nearly 23,000 individuals passed in 1986, counts declined to fewer than 400 individuals in 1997, and less than 10 from 1998 to 2019. This is similar to the trend observed at the first barrier on the Connecticut River, the Holyoke Dam. Historical fish passage counts (1967-2018) from the Holyoke Dam show a peak of over 632,000 individuals passed in 1985, followed by a generally steady decline since. Estimates for 2019 indicate just over 5,000 individuals passed the Holyoke Dam. Causes for the decline were thought to be similar to those listed for American Shad with offshore bycatch and predation by Striped Bass likely accounting for the decline in the Connecticut River.

Blueback Herring are not an important sport or commercial species in the Connecticut River, although some are captured for use as bait in coastal fisheries, and they are harvested at sea for human consumption and animal feed.

A petition to list Blueback Herring as threatened under the federal Endangered Species Act (ESA) of 1973 (16 U.S.C. §1531 et seq., ESA) was submitted to the NMFS on August 5, 2011 by the Natural Resources Defense Council. In its 90-day review of the 2011 Petition, NMFS concluded that the Petition presented substantial scientific or commercial information indicating that the petitioned action may be warranted (76 FR 67652-67656) and initiated a status review for the species. Upon completion of the status review in August 2013, NMFS determined that listing was not warranted, though several data deficiencies were cited. Another status review was performed, with a determination issued by NMFS on June 19, 2019, which concluded that blueback herring are not in danger of extinction, nor likely to become so in the foreseeable future throughout all or a significant portion of their ranges. As such, Blueback Herring did not meet the definition of a threatened or endangered species, and listing was not warranted.

3.3.3.1.2.2.3 Striped Bass

Striped Bass are native to Atlantic coastal waters from the St. Lawrence River in Canada to the St. Johns River in Florida, moving into freshwater to spawn or feed. Major spawning areas include the Hudson River and tributaries to Chesapeake Bay, although spawning occurs in rivers from the Maritimes to the southeastern United States. They may grow to several feet in length and are highly predatory, feeding on a variety of fishes and invertebrates. Adult and juvenile striped bass in freshwater habitats feed largely on other fish, and have been shown to feed on river herring, American Shad, and American Eel. The recent declines in Connecticut River populations of these species (herring, shad, and eel) have been linked to the resurgence of the Atlantic coast Striped Bass population (Savoy & Crecco, 2004).

During the past decade Striped Bass have become abundant in the Connecticut River; over 5,700 Striped Bass have been passed into the Holyoke impoundment since 2000. From 1980 to 1999, Striped Bass were rarely noted at the upstream passage facilities at the Project. Striped bass spawning has not been documented in the Connecticut River.

A three year study supported by the Connecticut Department of Energy and Environmental Protection (CTDEEP) was begun in 2005 to assess the abundance, temporal and spatial distribution, and population structure of Alewife, Blueback Herring, and Striped Bass, and to describe predator/prey interactions between these species in the Connecticut River (Davis *et al*., 2009). The study found that Striped Bass predation is a large source of mortality for migrating adult Blueback Herring and it was estimated that over 200,000 herring were consumed by Striped Bass in the Connecticut River in May 2008.

Striped Bass supports recreational fishing in the Connecticut River. Commercial fishing is not permitted.

3.3.3.1.2.2.4 Sea Lamprey

Sea Lamprey is an anadromous species that spawns in the Connecticut River and its tributaries. Sea Lamprey spawn during the spring in shallow areas of moderate current with gravel, and rubble substrate. After the larval stage, Sea Lamprey mature into ammocoetes, which burrow into soft sediments and exist as filter feeders, emerging from the sediment surface to feed. Pre-spawn adults create a depression in the substrate by carrying larger rocks out of the nest area and by sweeping smaller particles out using rapid body movements. The female then deposits eggs, fertilized by the male, moving more rocks and gravel as necessary. Spawning in one nest, or redd, may continue for 16 hours to 3.5 days. During the spawning run, adults undergo considerable physiological change and deterioration; they die after spawning. The adults parasitize other fish species, using a sucking disc and rasping teeth and tongue to attach to and penetrate the tissues of prey species. The sucking disc is also used during spawning to construct 1 to 3-foot-diameter nests in the substrate. Similar to other anadromous species, Sea Lamprey do not feed during their upstream spawning migration and thus are not parasitic while in the river (Hartel *et al*., 2002).

During late spring and early summer 2015 (as part of Study No. 3.3.15 *Assessment of Adult Sea Lamprey Spawning within the Project Area*), the Licensee assessed spawning activity and habitat within the Project area utilizing radio telemetry techniques and visual surveys of identified redds to determine whether Project operations adversely affect spawning activity. Twenty-nine redds were GPS-located in five (5) distinct regions of the Project area as summarized in Table 3.3.3.1.2.2.4-1 and monitored weekly until water temperature exceeded 22°C. The mean depth of all 29 redds ranged from 1.5 to 4.6 ft and mean velocity ranged from 0.8 to 3.0 ft/s (Table 3.3.3.1.2.2.4-2). Substrate characteristics of the redds consisted of a circular or oval area of bare sand and/or gravel with cobble and gravel around the perimeter.

Five (5) of the 29 identified redds were capped using a 4 x 4 ft^2, weighted PVC framed collection net (1-mm mesh) that funneled into a collection jar on the downstream end to capture emerging larvae. Lamprey ammocoetes were recovered from two of the five traps set. The Hatfield S Curve cap (retrieved July 7) produced a larva measuring approximately 47 mm (total length) and the Fall River cap (retrieved July 2) produced a much smaller ammocoete measuring approximately 7.4 mm in total length. No larvae were observed in the samples from the Ashuelot River and the cap near Stebbins Island was displaced from the redd and never recovered.

All 29 redds that were monitored demonstrated the presence of lamprey and ammocoetes were recovered from two of the five capped redds. At no time were any redds dewatered during the study period and no visual differences to the redds were observed at any time.

Table 3.3.3.1.2.2.4-1: Locations of Monitored Sea Lamprey Redds in Project Area during 2015 Surveys

Location	Number of redds monitored	Number of capped redds
Connecticut River mainstem near Vernon Dam (both sides of Stebbins Island)	7	1
Ashuelot River confluence with the Connecticut River	10	1
Millers River confluence with the Connecticut River	5	1
Fall River confluence with the Connecticut River	2	1
Hatfield S curve below Rt. 116 Bridge	5	1
Total	**29**	**5**

Table 3.3.3.1.2.2.4-2: Lamprey Redd Data Recorded During 2015 Monitoring Period (X = present, XX = present and dominant)

Site*	Water Depth (ft)			Water Velocity (ft/s)			Substrate					
	Min	Max	Mean	Min	Max	Mean	Silt	Sand	Gravel	Cobble	Boulder	Bedrock
Millers571	1.5	2.9	2.08	0.82	3.24	2.1	-	X	X	XX	X	X
Millers572-1	1.5	2.8	2.04	1.57	4.25	2.6	-	X	X	XX	X	-
Millers572-2	1.2	2	1.65	0.77	3.44	2.35	-	X	X	XX	X	-
Millers572-3	1.35	2.4	1.69	0.48	3.3	1.86	-	X	X	XX	X	-
Millers572-4	1.1	2.9	2.11	0.21	1.91	1.02	-	X	X	XX	X	-
Ashuelot573	1.9	6.4	3.43	0.06	1.99	0.87	-	X	XX	XX	-	-
Ashuelot574-1	1.6	5.2	3	0.12	3.02	1.17	-	X	XX	XX	-	-
Ashuelot574-2	1.75	5.4	3.39	0.07	2.41	1.33	-	X	XX	XX	-	-
Ashuelot574-3	1	4.7	2.86	0.22	2.22	1.24	-	X	XX	XX	-	-
Ashuelot574-4	1.4	5.1	3.1	0.3	2.68	1.48	-	X	XX	XX	-	-
Ashuelot574-5	1.7	5.3	3.1	0.14	2.52	1.35	-	X	XX	XX	-	-
Ashuelot574-6	1.8	5.8	3.29	0.2	2.56	1.26	-	X	XX	XX	-	-
Ashuelot574-7	1.6	5.2	3.12	0.14	2.05	1.16	-	X	XX	XX	-	-
Ashuelot574-8	1.2	5.2	3.16	0.19	1.74	0.96	-	X	XX	XX	-	-
Ashuelot574-9	0.6	4.5	2.46	0.34	2.43	1.49	-	X	XX	XX	-	-
Ashuelot574-10	1.4	1.5	1.45	1.2	1.72	1.37	-	X	XX	XX	-	-
Hatfield130-1	2.8	7.9	4.24	1.41	2.84	2.08	-	X	X	X	-	-
Hatfield130-2	3.9	3.9	3.9	1.54	1.61	1.57	-	X	X	X	-	-
Hatfield130-3	3.5	3.5	3.5	1.7	1.75	1.72	-	X	X	X	-	-
Hatfield130-4	4.2	4.2	4.2	1.66	1.8	1.74	-	X	X	X	-	-
Stebbins182	1.3	7.3	3.7	1.08	3.65	2.68	-	X	X	XX	-	-
Stebbins217	2.6	8.8	5.24	1.77	4.43	3.11	-	X	X	XX	-	-
Stebbins219	1.7	8.6	5.03	0.11	5.6	3.2	-	X	X	XX	-	-
Stebbins219-1	1.8	8.2	4.26	0.22	4.26	2.56	-	X	X	XX	-	-
Stebbins220	2.3	8.3	5.27	0.85	6.08	3.3	-	X	X	XX	-	-
Stebbins221	2.4	7.3	4.3	2.05	4.3	3.21	-	X	X	XX	-	-
Stebbins222	2.9	7.5	4.33	1.43	4.27	2.9	-	X	X	XX	-	-
Fall1	0.7	3.4	1.15	0.11	2.38	0.83	X	X	XX	XX	-	-
Fall2	0.6	4.8	1.91	0.02	1.69	0.82	X	X	XX	XX	-	-

*Site identification based on GPS waypoint

3.3.3.1.2.2.5 American Eel

The American Eel is a catadromous species. Young eels enter estuarine or freshwater to feed and mature, and then the adults return to the sea to spawn. After spending five (5) to 20 years in fresh or coastal waters, eels migrate to spawning grounds in the Sargasso Sea of the South Atlantic Ocean (Collette & Klein-MacPhee, 2002). Eggs are released and fertilized in the water column. The eggs and larvae are pelagic, drifting via the Florida current and the Gulf Stream to coastal North America and Europe. The young eels ultimately leave these currents and move shoreward and either reside in estuarine coastal waters or move into fresh water, following cues that are not well understood.

Juvenile Eel Migration

Eels moving into the estuaries are referred to as glass eels because of their transparent appearance. Once they develop pigment, they are referred to as elvers until they gain the yellow cast typical of juvenile eels. Eels may reside in an estuary throughout their entire life or move upstream into freshwater during the first few years. At maturation, the species undergoes another transformation including a color change to the silver eel stage and migrates downstream, usually at night during fall.

Beginning in 2014, the Licensee conducted studies to assess the presence of juvenile eels in the Project area, determine locations for siting upstream passage facilities, understand the timing and route(s) of downstream passage, and determine relationships with environmental conditions and Project operations. During upstream migration, which typically spans June through October when water temperatures range from 10 to 20°C (Haro and Krueger, 1991), nighttime surveys revealed the majority of observations (94%) occurred at the base of the Turners Falls Dam as compared to other wetted structures/areas (e.g., Cabot Station discharge area and fishway, Station No. 1 discharge area, various canal discharge areas in the bypassed reach) throughout the Project area (Table 3.3.3.1.2.2.5-1).

The following year, installation of temporary eel passes and Medusa traps that were monitored from July through early October yielded similar results, with nearly 88% of observations occurring at the Turners Falls Spillway Fishway (Table 3.3.3.1.2.2.5-2). Peak observations occurred toward the end of July. Water temperature at the onset of the monitoring period was 21.7°C (July 10) and decreased to 14.9°C on the last day eels were observed (October 4). Most of the eels measured between 10 and 20 cm (total length). No correlation between the rate of eel collection and precipitation (r=-0.1962) or daily river flow (r=0.0429) was identified.

Adult Eel Emigration Timing

Radio-telemetry monitoring indicated that the majority (69%) of the eels migrated toward the power canal (i.e., follow flow) at night following rain events. DIDSON monitoring of eel passage into the canal occurred sporadically throughout the study period during both years of study, peaking in early August during 2015 and mid-October in 2016.

A petition to list American Eel as threatened under the federal ESA of 1973 (16 U.S.C. §1531 et seq., ESA) was submitted to the USFWS and NMFS on November 18, 2004. After initially finding that the petition presented substantial information indicating that listing the American Eel may be warranted, the USFWS made a final determination in February 2007 that listing of the eel under the ESA was not warranted. On April 30, 2010, the Council for ESA Reliability submitted another petition to list American Eels as threatened under ESA. Upon completion of this status review in October 2015, USFWS determined that listing was not warranted.

Table 3.3.3.1.2.2.5-1: Summary of Eel Observations during 2014 Nighttime Surveys

Station	6/11	6/26	7/2	7/10	7/17	7/31	8/7	8/21	9/4	9/16	10/9	TOTAL
Cabot Lower Gate	0	0	12	5	16	0	0	0	0	0	0	33
Cabot Emergency Spillway	0	0	0	53	173	60	33	5	6	2	0	332
Cabot Fishway	0	0	18	0	0	0	0	0	0	0	0	18
Conte Discharge	0	0	0	0	0	0	0	0	0	0	0	0
Station No. 1	0	0	2	0	1	0	0	0	0	0	0	3
Mill Hydro Discharge[a]	0	0	0	0	0	-	-	-	-	-	-	0
Outfall 1[a]	0	0	0	0	0	-	-	-	-	-	-	0
Outfall 2[a]	0	0	0	0	0	-	-	-	-	-	-	0
Outfall 3[a]	0	0	0	0	0	-	-	-	-	-	-	0
Paper Mill Discharge[a]	0	0	0	0	0	-	-	-	-	-	-	0
Spillway Attraction Water Stilling Basin	0	0	0	6	3[b]	0	0	1	0	0	0	10
Spillway Fishway	0	20	2,401	1,629	1,614[b]	64	95	23	7	12	2	5,867
Tainter Gates	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	20	2,433	1,693	1,807	124	128	29	13	14	2	6,263

[a] Discontinued surveying these locations on July 31, 2014 because of a lack of eel and safety concerns.
[b] Due to access issues, these locations were surveyed on July 21, 2014.

Table 3.3.3.1.2.2.5-2: Summary of Eel Collections at Temporary Ramps during 2015 Monitoring Period

Date of Collection	Number of Eels Trapped			
	Spillway Ladder	Cabot Emergency Spillway	Cabot Ladder	Station No. 1 Medusa Traps
July 10	2	0	0	-
July 13	117	10	15	-
July 15	702	6	23	-
July 17	182	11	17	-
July 20	280	1	29	-
July 22	602	88	51	-
July 24	520	59	13	0
July 27	135	3	7	0
July 29	119	102	10	0
July 31	308	8	24	0
August 3	264	7	29	0
August 5	89	17	19	0
August 7	148	6	1	0
August 10	187	7	1	0
August 12	130	4	0	0
August 14	162	10	0	0
August 17	135	7	14	0
August 19	7	12	10	0
August 21	10	11	15	0
August 24	155	5	0	0
August 26	116	7	0	0
August 28	137	12	2	0
August 31	173	6	0	0
September 2	178	2	4	0
September 4	35	4	2	0
September 8	197	12	15	0
September 10	38	2	2	0
September 14	14	2	3	0
September 16	6	0	1	0
September 18	9	0	0	0
September 21	6	0	1	0
September 25	11	0	0	0
September 28	1	1	0	0
September 30	5	0	0	0
October 1	45	2	4	0
October 4	10	0	1	0
October 14	0	0	0	0
October 19	0	0	0	0
October 26	0	0	0	0
November 2	0	0	0	0
Total	**5,235**	**424**	**313**	**0**

3.3.3.1.2.2.6 Shortnose Sturgeon

SNS is a federally listed endangered species that typically inhabits slow moving riverine waters or near shore marine waters and periodically migrates into faster moving freshwater areas to spawn. They are long-lived (30-40 years) and mature at late ages (5-13 years for males and 7-18 years for females) in the northern extent of their range (Dadswell *et al*., 1984; SSSRT, 2010). SNS exhibit three distinct movement patterns associated with spawning, feeding, and overwintering activities. In spring, as water temperatures rise above 8 ºC, pre-spawning SNS move from overwintering grounds to spawning areas. Spawning occurs from April to May and may last from a few days to several weeks depending upon water temperature, photoperiod (day-length) and bottom water velocity (Dadswell *et al*. 1984; Kynard *et al*., 2012. SNS migrations are characterized by rapid, directed and often extensive upstream movement (NMFS, 1998). Female SNS are thought to spawn every three to five years while males spawn every two years, but they may spawn annually in some rivers (Kieffer & Kynard, 1996). Fecundity estimates range from 27,000 to 208,000 eggs/female (Dadswell *et al*., 1984).

SNS eggs become adhesive after fertilization and larvae begin downstream migrations at about 15-mm total length (Kynard, 1997; SSSRT, 2010). Laboratory studies suggest that young SNS move downstream in two steps; a 2 to 3-day migration by larvae followed by a residency period by YOY, then a resumption of migration by yearlings in the second summer of life (Kynard, 1997).

Adults normally depart from their spawning grounds soon after spawning and movements include rapid, directed movements to downstream feeding areas in spring followed by local meandering in summer and fall (Dadswell *et al.*, 1984; Buckley & Kynard, 1985; O'Herron *et al*. 1993). Post-spawning migrations are associated with rising spring water temperature and river discharge (Kieffer & Kynard, 1993).

Historically in the Connecticut River, Turners Falls is believed to mark the extent of the upstream range of SNS due to the height of the natural falls upon which the Turners Falls Dam sits. Completion of the downstream Holyoke Dam in 1849 blocked SNS from migrating beyond RM 87. The first successful fishway to pass fish upstream, an elevator, was installed at the tailrace at Holyoke in 1955. In 1976, the existing tailrace fish lift at Holyoke was improved, and a lift was installed in the bypass area at the Holyoke Dam. These improvements allowed SNS to pass above Holyoke Dam and access the Connecticut River up to their historic limit at Turners Falls; however, over the past decade or so NMFS would not allow SNS to be lifted above Holyoke Dam until safe downstream passage was in place. When a SNS would enter the lift, it was manually removed from the fish lift flume and placed downstream of the dam. A new downstream fish passage system has been constructed at Holyoke Dam, and SNS have been passed upstream starting in 2017, with over 200 SNS passed upstream between 2017 and 2020.

Researchers have found five distinct sites used year after year by wintering SNS in the Connecticut River between Holyoke Dam and Turners Falls Dam: Whitmore (RM 113.7), Second Island (RM 111.8), S-turn (RM 105.6), Hatfield (RM 105.6), and Elwell Island (RM 98.2; SSSRT, 2010; Kynard *et al*., 2012). Among the five areas, the most prominent was the Whitmore site. This area was located near the Montague spawning site and had both the greatest numbers of adults (as observed with an underwater video camera) and the greatest concentration of pre-spawning adults (as observed with radio tracking).

During summer, the SNS population above Holyoke Dam congregates near the confluence of the Deerfield River; this group overwinters a few miles downstream from Cabot Station. The concentration area used by adult fish in the Connecticut River is in reaches where natural or artificial features cause a decrease in river flow, possibly creating suitable substrate conditions for freshwater mussels (Kieffer & Kynard, 1993), a major prey item for adult SNS (Dadswell *et al*., 1984). Both adults and juveniles have been found to use the same river reaches in the Connecticut River and have ranges of about 10 km during spring, summer and fall (Savoy, 1991; Seibel, 1991). In the winter, SNS move less than 2 km and assemble together in deep water (Seibel, 1991). The migration of juvenile and adult SNS from the Holyoke impoundment to points downstream of the Holyoke Dam appears to be a natural event coincidental with increased river discharges (Seibel, 1991; Kynard, 1997).

SNS in the upper river population spawn from the last week of April to mid-May, after the spring freshet (Taubert, 1980; Buckley & Kynard, 1985; Kynard, 1997). The spawning period is estimated to last from three to 17 days, occurring during the same 26-day period each year (April 27 – May 22), which corresponds to the time of year when photoperiod ranges from 13.9 to 14.9 h (Kynard *et al*., 2012). SNS are believed to spawn at discrete sites within the river (Kieffer & Kynard, 1993) in channel habitats containing gravel, rubble, or rock-cobble substrates (Dadswell *et al.*, 1984; NMFS, 1998). Additional environmental conditions associated with spawning activity include decreasing river discharge following the spring freshet, water temperatures ranging from 6.5-15.9°C, daily mean discharge ranged from 121-901 m^3/s (4,273-31,819 cfs), depth ranging from 1.2-5.2 m (3.9-17.0 ft), and bottom water velocities of 0.3 to 1.2 m/s (0.98-3.9 fps) (Dadswell *et al.*, 1984; NMFS, 1998; SSSRT, 2010). The SNS Status Review Team (SSSRT) (2010) indicated that while temperature and river discharge affect spawning, photoperiod was the dominant factor influencing the timing of spawning.

Successful spawning has been documented at two sites in Montague, located about 4 km (~2.5 miles) downstream of the Turners Falls Dam near the Cabot Station tailrace (SSSRT, 2010). The main site in the Cabot tailrace was estimated to be 2.7 ha (6.7 acres) and the smaller site at Rock Dam was estimated to be about 0.4 ha (1 acre) in area. These sites are just downstream of the species' historical limit in the Connecticut River at Turners Falls (RM 122) (NMFS, 2005). SNS eggs and larvae were captured at the sites in 1993, 1994, and 1995 (Vinogradov, 1997). These sites are within the 0.9 mi reach that spans from Rock Dam to 656 feet downstream of Cabot Station, where all common types of river habitat are present. Much of the river bottom in the area is rock and rubble. The 0.3-mi.-long reach downstream of Cabot Station contains rubble/boulder shoals that can be exposed briefly in spring during low river discharge and low Cabot Station generation (Kieffer & Kynard, 2007).

SNS spawning in this area typically occurs from late April to mid-May and the egg incubation period is about two weeks when water temperatures are between 8 and 12 °C. Upon hatching, larval SNS hide for about 15 days under available cover at the spawning site while absorbing the yolk-sac, before migrating downstream to deeper water between the mouth of the Deerfield River and Holyoke (SSSRT, 2010).

In August 2017, an angler reported catching and releasing an adult-sized SNS below the Vernon Dam (the upper end of the TFI). This was the first documented report of a SNS being collected upstream of the Turners Falls Dam. Since the existence of a population of ESA listed SNS in the TFI could have implications for license conditions, FirstLight worked to proactively address this reported capture. To answer the question of whether the single capture of a SNS indicated the presence of a population in the TFI, FirstLight investigated scientific methods which could determine the existence of such a population. Since SNS are federally endangered and collection requires an ESA Section 10 research permit, netting for SNS was not an option. However, environmental DNA (eDNA) is a sampling method for detecting aquatic species which can provide a measure of species presence, density and distribution without having to collect the fish. Fish release DNA into their surrounding environment via slime, scales, epidermal cells or feces.

FirstLight collected a total of 170 water samples which were filtered during the two surveys on July 18 and 19 and August 14, 2018. There were no SNS detected in the TFI; however, they were detected downstream in an area that SNS are known to occupy in the summer. The samples taken below Vernon Dam and the TFI did not detect the presence of SNS and thus there is no evidence of the existence of a population in the TFI and the best available information is that no population exists. A report entitled *Environmental DNA Sampling for Shortnose Sturgeon* summarizing the eDNA findings was filed with FERC on November 8, 2018.

3.3.3.1.2.3 Fish Passage

3.3.3.1.2.3.1 Upstream Passage of Migratory Fish

Upstream passage facilities for Connecticut River migratory fish are provided at several hydroelectric projects. Migrating fish first encounter the Holyoke Project (RM 87) where they are passed upstream through a fish lift. Turners Falls Dam is the second dam on the Connecticut, 37 miles upstream of Holyoke. The Deerfield River is a major tributary entering the Connecticut River below Cabot Station and provides an additional migration route. Fish passing the Turners Falls Project (RM 122) can continue upstream migrating through the TFI, passing the Northfield Mountain Project (RM 127) before encountering the Vernon Hydroelectric Project (RM 142), 20 miles upstream of Turners Falls Dam. Fish passage facilities at the Vernon Project allow migrants to continue upstream.

Upstream fish passage facilities began operating in 1980 at the Turners Falls Project pursuant to a Settlement Agreement signed by FirstLight's predecessor, Western Massachusetts Electric Company, state and federal resource agencies, and non-government organizations. There are three fish ladders at the Turners Falls Project: the Cabot Fish Ladder adjacent to Cabot Station; the Spillway Fish Ladder at Turners Falls Dam; and the gatehouse fish ladder at the upstream end of the power canal. The Cabot and Spillway Fish Ladders are modified "Ice Harbor" designs and the gatehouse fish ladder is a vertical slot ladder. These fish ladders were designed in consultation with state and federal resource agencies, based on Columbia River salmon fish ladder designs. The CRASC[5] establishes an annual schedule for the operation of upstream fish passage facilities at the Connecticut River dams. The schedules are based on the projected movement of migratory fish and may be adjusted in season to address actual observations.

The dates of peak passage have varied throughout the years, ranging from early to mid-May to mid to late June. American Shad and Sea Lamprey have been the dominant anadromous species observed at the passage facilities through the period of record (Table 3.3.3.1.2.3.1-1). Substantial Blueback Herring passage was recorded for the 15-year period from 1983 to 1997, but few herring have been recorded since 1997. Use of the passage facilities by Atlantic Salmon has been low since most are collected downstream at Holyoke Dam; salmon were noted in 28 of the 31 years, but few individuals were recorded (1 – 29 annually). The 31-year period of record does not show any usage of the facilities by SNS (Table 3.3.3.1.2.3.1-1).

Fish ascending the Cabot Fish Ladder enter the power canal, then pass through the gatehouse fishway into the TFI. Passage rates for this route were evaluated using radio and PIT tracking studies for American Shad, as described in Section 3.3.3.2.3.1. Additionally, FirstLight studied conditions near the Cabot fishway entrance as part of Relicensing Study No. 3.3.8 *Computational Fluid Dynamics Modeling in the Vicinity of the Fishway Entrances and Powerhouse Forebays* (FirstLight, 2016g). The study report was filed with FERC on March 1, 2016. At low flows (2-4 units operating at Cabot), velocities tended to be highest around the riffle located on river left approximately halfway downstream of Smead Island, while velocities were generally lower around the Cabot tailrace. At moderate flows (at Cabot Station capacity), velocities were high in the riffle area as well as near the Cabot Station tailrace, and the water appeared to be more turbulent near the Cabot Station tailrace and fishway entrance. At the highest modeled flows (at Cabot Station capacity and higher bypass reach flows), hydraulic controls from downstream began to backwater the riffle area, reducing water velocities through most of the study reach compared to lower flows, and the flow conditions around the Cabot Station tailrace and fishway entrance showed they were being influenced by the upstream bypass reach flows. Eddies and areas of flow circulation were observed throughout all model conditions, though the intensity and location of these areas changed with flow.

As an alternative to the Cabot Fish Ladder, fish can swim up the bypass reach to the base of the Turners Falls Dam, ascend the Spillway Fish Ladder, pass through the gatehouse collection gallery that crosses the power canal, and enter the TFI through the gatehouse fishway, along with the fish passed through the Cabot

[5] CRASC membership consists of the USFWS, NMFS, and state fishery agencies from CT, MA, NH, and VT.

Fishway. Passage rates for this route were evaluated using radio and PIT tracking studies for American Shad, as described in Section 3.3.3.2.3.1. Additionally, FirstLight studied conditions near the Spillway fishway entrance as part of Relicensing Study No. 3.3.8 *Computational Fluid Dynamics Modeling in the Vicinity of the Fishway Entrances and Powerhouse Forebays* (FirstLight, 2016g). Under low flows, with the exception of the area near Bascule Gate No. 1 (closest to the gatehouse) and the Spillway fishway entrance, water velocities were generally slower (~4 fps or less) throughout much of the study reach. Under higher discharges from Bascule Gate No. 1 the velocities increased throughout most of the reach; some areas had velocities in the 6-9 fps range. Under the highest modeled discharge[6], velocities throughout the modeled reach increased, with some areas near Bascule Gate No. 2 and Bascule Gate No. 4 approaching 20 fps. Eddies and areas of flow circulation were observed throughout all modeled conditions, though the intensity and location of these areas changed drastically with flow.

[6] The highest flow scenario included 7,500 cfs from Bascule Gate No. 1, 7,500 cfs from Bascule Gate No. 2, 4,960 cfs from Bascule Gate No. 4, 10,000 cfs from the tainter gates, and 318 cfs from the spillway fishway for a total flow of 30,278 cfs.

Table 3.3.3.1.2.3.1-1: Anadromous Fish Passage Recorded at the Turners Falls Fish Passage Facilities, Connecticut River, Massachusetts, 1980 to 2019

Year	Location	American Shad	Blueback Herring	Striped Bass	Sea Lamprey	Atlantic Salmon	Gizzard* Shad
1980	Cabot	687	0	11	187	0	
	Spillway	5	0	0	0	0	
	Gatehouse	298	0	1	66	1	
1981	Cabot	224	0	0	1,622	7	
	Spillway**	-	-	-	-	-	
	Gatehouse	200	0	0	935	8	
1982	Cabot	-	-	-	-	-	
	Spillway**	-	-	-	-	-	
	Gatehouse	11	4	0	210	0	
1983	Cabot	26,697	106	6	859	0	
	Spillway	263	1	1	649	0	
	Gatehouse	12,705	28	7	703	0	
1984	Cabot	1,831	4	0	334	1	
	Spillway	4,563	12	0	851	1	
	Gatehouse	4,333	21	0	683	1	
1985	Cabot	31,000	1,726	0	3,198	2	
	Spillway	843	243	0	3,185	3	
	Gatehouse	3,855	301	0	1,809	3	
1986	Cabot	22,144	7,091	0	1,424	5	
	Spillway	5,857	6,248	0	2,230	4	
	Gatehouse	17,858	9,578	0	1,961	10	
1987	Cabot	33,114	2,866	0	1,324	2	
	Spillway	3,679	2,841	0	2,921	3	
	Gatehouse	18,959	5,091	0	2,590	12	
1988	Cabot	28,546	349	0	335	2	
	Spillway	3,354	865	0	1,912	2	
	Gatehouse	15,787	1,079	0	1,175	7	
1989	Cabot	14,403	199	0	578	1	
	Spillway	1,494	279	0	947	0	
	Gatehouse	9,511	510	1	868	2	

Year	Location	American Shad	Blueback Herring	Striped Bass	Sea Lamprey	Atlantic Salmon	Gizzard* Shad
1990	Cabot	31,056	711	0	1,304	8	1
	Spillway	5,898	768	0	1,013	2	0
	Gatehouse	27,908	1,585	0	1,301	16	13
1991	Cabot	87,168	6,433	1	2,089	2	0
	Spillway	6,282	2,718	0	3,026	2	0
	Gatehouse	54,656	7,522	3	4,090	4	1
1992	Cabot	94,046	1,765	1	1,836	9	0
	Spillway	11,760	884	0	3,275	6	0
	Gatehouse	60,089	2,157	2	2,710	14	7
1993	Cabot	21,045	243	0	711	7	0
	Spillway	898	90	0	2,082	3	0
	Gatehouse	10,221	278	0	1,637	7	0
1994	Cabot**	-	-	-	-	-	-
	Spillway	1,507	17	0	1,740	1	0
	Gatehouse	3,729	97	0	1,702	5	0
1995	Cabot	33,938	4,234	0	1,417	2	1
	Spillway	543	31	0	1,372	0	0
	Gatehouse	18,369	2,957	0	1,813	4	4
1996	Cabot**	-	-	-	-	-	-
	Spillway	2,293	13	0	2,651	4	0
	Gatehouse	16,192	515	0	4,556	3	3
1997	Cabot	22,518	231	0	2,374	2	4
	Spillway	3,473	15	0	2,219	1	3
	Gatehouse	9,216	128	0	2,265	2	2
1998	Cabot	14,947	2	0	8,707	6	1
	Spillway	4,721	0	0	8,642	2	2
	Gatehouse	10,527	4	0	7,579	5	2
1999	Cabot	11,501	5	0	2,014	2	543
	Spillway	4,215	0	8	1,449	2	440
	Gatehouse	6,751	2	0	916	0	275
2000	Cabot	12,289	0	0	1,455	0	9

Year	Location	American Shad	Blueback Herring	Striped Bass	Sea Lamprey	Atlantic Salmon	Gizzard* Shad
	Spillway	2,240	0	0	1,962	4	358
	Gatehouse	2,590	0	0	1,350	5	199
2001	Cabot	20,933	0	0	3,678	0	0
	Spillway	2,344	0	0	5,280	0	0
	Gatehouse	1,540	0	0	2,144	0	0
2002	Cabot	7,922	0	0	14,709	0	0
	Spillway	5,372	0	0	12,367	4	7
	Gatehouse	2,870	0	0	10,160	4	2
2003**	-	-	-	-	-	-	-
2004	Cabot	5,933	0	0	13,352	0	0
	Spillway	1,980	0	0	5,821	0	0
	Gatehouse	2,192	0	0	8,418	0	0
2005	Cabot	5,404	2	7	12,974	5	0
	Spillway	1,626	0	7	9,990	1	2
	Gatehouse	1,581	2	2	215,843	5	0
2006	Cabot	11,991	1	198	5,377	4	9
	Spillway	2,577	0	153	5,133	8	0
	Gatehouse	1,810	0	46	3,005	7	0
2007	Cabot	11,130	**	**	11,061	5	0
	Spillway	1,793	**	**	5,555	3	0
	Gatehouse	2,248	**	**	15,438	5	0
2008	Cabot	15,089	**	**	**	6	**
	Spillway	627	**	**	**	5	**
	Gatehouse	3,995	**	**	32,035	10	**
2009	Cabot	13,391	**	**	**	0	**
	Spillway	919	**	**	**	5	**
	Gatehouse	3,814	**	**	8,296	8	**
2010	Cabot	30,232	**	**	**	2	**
	Spillway	2,735	**	**	**	4	**
	Gatehouse	16, 768	**	**	6,352	8	**
2011	Cabot	27,077	**	**	**	2	**

Year	Location	American Shad	Blueback Herring	Striped Bass	Sea Lamprey	Atlantic Salmon	Gizzard* Shad
	Spillway	1,966	**	**	**	6	**
	Gatehouse	16,798	**	**	2,032	7	**
2012	Cabot	51,901	**	**	**	2	**
	Spillway	10,608	**	**	**	3	**
	Gatehouse	26,727	**	**	4,503	2	**
2013	Cabot	46,886	**	**	**	0	**
	Spillway	10,571	**	**	**	1	**
	Gatehouse	35,494	**	**	6,016	0	**
2014	Cabot	40,666	**	**	**	3	**
	Spillway	24,262	**	**	**	8	**
	Gatehouse	39,914	**	**	5,553	11	**
2015	Cabot	47,588	**	**	**	1	**
	Spillway	41,835	**	**	**	1	**
	Gatehouse	58,079	**	**	8,423	0	**
2016	Cabot	34,709	0	0	**	0	0
	Spillway	19,399	0	0	**	0	0
	Gatehouse	54,760	0	0	15,128	0	0
2017	Cabot	43,269	0	0	**	0	0
	Spillway	16,741	0	0	**	0	0
	Gatehouse	48,727	0	0	9,223	0	0
2018	Cabot	24,031	0	0	**	0	0
	Spillway	32,593	0	0	**	2	0
	Gatehouse	43,146	1	0	4,010	2	0
2019	Cabot	21,804	3	0	1,151	0	0
	Spillway	13,150	4	0	7,918	1***	0
	Gatehouse	22,649	1	0	3,700	1***	0

* Observations of Gizzard Shad using ladders was first reported in 1990.
** not monitored
*** assumed to be landlocked salmon

(Slater, 2011; Robert Stira, per. comm., 2015; S. Leach, per. comm., 2019).

3.3.3.1.2.3.1.1 American Shad

FirstLight conducted a long-term frequency analysis on daily ladder counts at Holyoke and Turners Falls dams (1989 – 2019) to describe the timing, magnitude, and duration of American Shad passage on the Connecticut River. The statistic of interest was the cumulative percentage of run total, which makes it possible to compare among years. In the Connecticut River, mature adults move into the river typically during late March or April, reaching Cabot Station in late April or early to mid-May. During the upstream migration, river water temperatures generally range from 12 to 20°C, with spawning occurring from 14 to 23°C (Collette and Klein-MacPhee 2002). River flow is generally declining from the spring peak during the passage season.

Most upstream migrating American Shad are passed at the Turners Falls Project between mid-May to mid-June, at both Turners Falls and Holyoke (Figure 3.3.3.1.2.3.1.1-1). The highest median counts on average occurred in mid-May at Holyoke and two weeks later at Turners Falls (Figure 3.3.3.1.2.3.1.1-1).

Most of the American Shad passage (90%) at the Cabot Ladder has historically occurred within just 20 days, and most passage occurs between mid-May and early-June, specifically, May 21 to June 9 based on available data.

The magnitude of the run at the gatehouse ladder is related to the magnitude of the run at Holyoke (Figure 3.3.3.1.2.3.1.1-2). Generally, as the run at Holyoke gets larger, so does the run at the gatehouse ladder. Higher passage rates at the Turners Falls Project in recent years resulted from several modifications made to the Gatehouse Fishway in consultation with the resource agencies. Passage improvements at Holyoke have also resulted in more fish passing into the Connecticut River between Holyoke and Turners Falls. The proportion of Holyoke fish that passed Cabot Station has increased since 2000, and the timing of run milestones has come earlier at Cabot Station suggesting delay has been decreasing due to improved passage efforts at the Turners Falls Project. Over that 15-year range, Cabot Station went from passing just 2% of the Holyoke count to passing over 14% of the Holyoke total.

The majority of American Shad upstream passage occurs within a short amount of time at each passage facility, with the middle 50% of the run occurring over few days (Table 3.3.3.1.2.3.1.1-1; Table 3.3.3.1.2.3.1.1-2). However, the initial portion of the run takes weeks to reach 25% of the total count and the final 25% of the run also takes multiple weeks (Table 3.3.3.1.2.3.1.1-1; Table 3.3.3.1.2.3.1.1-2). On average, over the last 18 years, most of the run occurred between May 9 and June 9. Holyoke's passage season is less variable than that of the Turners Falls facilities. However, the timing of the run at Turners Falls (especially that of the gatehouse) appears to have occurred earlier in more recent years, suggesting that delay of passage at the Turners Falls Project has been decreasing with time due to management actions (Figure 3.3.3.1.2.3.1.1-2).

Based on a comparison of passage counts since 2012, over 60% of adult American Shad that have migrated upstream through the Turners Falls Project have continued upstream through the Vernon Project (Table 3.3.3.1.2.3.1.1-3).

Table 3.3.3.1.2.3.1.1-1: Identifies specific run milestones at Cabot Ladder (2000 - 2017)

	25th Percentile			25th - 50th Percentile			50th - 75th Percentile			75th - 90th Percentile			90th - 100th Percentile		
Year	**First Day**	**Last Day**	**Duration (d)**	**First Day**	**Last Day**	**Duration (d)**	**First Day**	**Last Day**	**Duration (d)**	**First Day**	**Last Day**	**Duration (d)**	**First Day**	**Last Day**	**Duration (d)**
2000	May 10	Jun 1	22	Jun 2	Jun 3	1	Jun 4	Jun 12	8	Jun 13	Jun 20	7	Jun 21	Jul 2	11
2001	May 14	May 23	9	May 24	June 28	4	May 29	Jun 1	3	Jun 2	Jun 14	12	Jun 15	Jun 25	10
2002	May 10	May 28	18	May 29	May 31	2	Jun 1	Jun 2	1	Jun 3	Jun 4	1	Jun 5	Jul 1	26
2004	May 5	May 15	10	May 16	May 18	2	May 19	May 22	3	May 23	Jun 9	17	Jun 10	Jun 26	16
2005	May 13	May 22	9	May 23	Jun 6	14	Jun 7	Jun 9	2	Jun 10	Jun 11	1	Jun 12	Jun 17	5
2006	May 6	May 29	23	May 30	May 31	1	Jun 1	Jun 9	8	Jun 10	Jun 19	9	Jun 20	Jun 29	9
2007	May 13	May 26	13	May 27	May 29	2	May 30	May 30	0	May 31	Jun 7	7	Jun 8	Jul 1	21
2008	May 14	May 18	4	May 19	May 26	7	May 27	Jun 1	5	Jun 2	Jun 6	4	Jun 7	Jun 29	24
2009	May 9	May 22	13	May 23	May 24	1	May 25	Jun 5	11	Jun 6	Jun 10	4	Jun 11	Jun 30	19
2010	May 4	May 22	18	May 23	May 26	3	May 27	May 31	4	Jun 1	Jun 7	6	Jun 8	Jul 6	28
2011	May 13	May 23	10	May 24	May 27	3	May 28	Jun 6	9	Jun 7	Jun 8	1	Jun 9	Jul 6	27
2012	Apr 18	May 19	31	May 20	May 23	3	May 24	May 26	2	May 27	May 28	1	May 29	Jun 2	34
2013	May 3	May 8	5	May 9	May 12	3	May 13	May 20	7	May 21	Jun 2	12	Jun 3	Jun 28	25
2014	May 11	May 15	4	May 16	May 26	10	May 27	Jun 5	9	Jun 6	Jun 9	3	Jun 10	Jul 1	21
2015	May 6	May 11	5	May 12	May 18	6	May 19	May 27	8	May 28	May 31	3	Jun 1	Jun 27	26
2016	Apr 26	May 14	18	May 15	May 25	10	May 26	May 30	4	May 31	Jun 3	3	Jun 4	Jul 7	33
2017	May 1	May 20	19	May 21	May 24	3	May 25	Jun 10	16	Jun 11	Jun 15	4	Jun 16	Jul 6	20
Min			4			1			0			1			5
Median			13			3			5			3			21
Mean	May-8	May-21	13.6	May-22	May-27	4.4	May-28	Jun-3	5.9	Jun-4	Jun-9	5.6	Jun-10	Jul-1	20.9
Max			31			14			16			17			34

Table 3.3.3.1.2.2.1.1-2: Identifies specific run milestones at Holyoke (2000 - 2017)

	25th Percentile			25th - 50th Percentile			50th - 75th Percentile			75th - 90th Percentile			90th - 100th Percentile		
Year	**First Day**	**Last Day**	**Duration (d)**	**First Day**	**Last Day**	**Duration (d)**	**First Day**	**Last Day**	**Duration (d)**	**First Day**	**Last Day**	**Duration (d)**	**First Day**	**Last Day**	**Duration (d)**
2000	Apr-17	May-18	31	May-19	May-26	7	May-27	Jun-2	6	Jun-3	Jun-10	7	Jun-22	Jul-7	26
2001	May-7	May-10	3	May-11	May-15	4	May-16	May-22	6	May-23	May-29	6	May-30	Jul-6	37
2003	Apr-18	May-11	28	May-12	May-25	13	May-26	May-30	4	May-31	Jun-2	2	Jun-3	Jul-11	38
2002	Apr-3	May-18	45	May-19	May-24	5	May-25	Jun-2	8	Jun-3	Jun-8	5	Jun-9	Jul-15	36
2004	Apr-21	May-12	21	May-13	May-16	3	May-27	May-20	3	May-21	Jun-3	13	Jun-4	Jul-7	28
2005	Apr-20	May-15	25	May-16	May-19	3	May-20	Jun-03	14	Jun-4	Jun-6	2	Jun-7	Jul-18	41
2006	Apr-4	May-8	34	May-9	May-27	18	May-28	May-30	2	May-31	Jun-14	14	Jun-15	Jul-14	29
2007	May-2	May-23	21	May-24	May-25	1	May-26	May-27	1	May-28	May-31	3	Jun-1	Jul-15	44
2008	Apr-29	May-15	16	May-16	May-19	3	May-20	May-25	5	May-26	May-31	5	Jun-1	Jul-11	40
2009	Apr-23	May-16	23	May-17	May-21	4	May-22	May-29	7	May-30	Jun-6	7	Jun-7	Jul-24	47
2010	Apr-9	May-13	34	May-14	May-17	3	May-18	May-23	5	May-24	May-31	7	Jun-1	Jul-13	42
2011	May-5	May-13	8	May-14	May-24	10	May-25	Jun-2	8	Jun-3	Jun-4	1	Jun-5	Jul-15	40
2012	Apr-5	May-7	32	May-8	May-19	11	May-20	May-25	5	May-26	Jun-1	6	Jun-2	Jul-8	36
2013	Apr-18	May-8	20	May-9	May-16	7	May-17	May-21	4	May-22	Jun-2	11	Jun-3	Jul-17	44
2014	Apr-25	May-16	21	May-17	May-25	8	May-26	Jun-2	7	Jun-3	Jun-7	4	Jun-8	Jul-15	37
2015	Apr-29	May-11	12	May-12	May-17	5	May-18	May-25	7	May-26	May-6	11	Jun-7	Jun-21	14
2016	Apr-1	May-12	41	May-13	May-17	4	May-18	May-25	7	May-26	May-31	5	Jun-1	Jul-15	44
2017	Apr-24	May-21	27	May-22	May-27	5	May-28	Jun-3	6	Jun-4	Jun-12	8	Jun-13	Jul-14	31
Min			3			1			1			1			14
Median			24			5			6			6			37.5
Mean	Apr-20	May-15	24.6	May-16	May-22	6.33	May-23	May-29	5.8	May-30	Jun-5	6.5	Jun-6	Jul-13	36.3
Max			45			18			14			14			47

Table 3.3.3.1.2.3.1.1-3: Total number of American Shad Passed Annually at Turners Falls and Vernon Dams

Year	Turners Falls	Vernon	Percent of Turners Falls Passed Shad that were Passed at Vernon
2012	26,727	10,386	39%
2013	35,293	18,220	52%
2014	39,914	27,706	69%
2015	58,079	39,771	68%
2016	54,069	35,513	66%
2017	48,727	28,682	59%
2018	43,146	31,725	74%
2019	22,575	12,490	55%

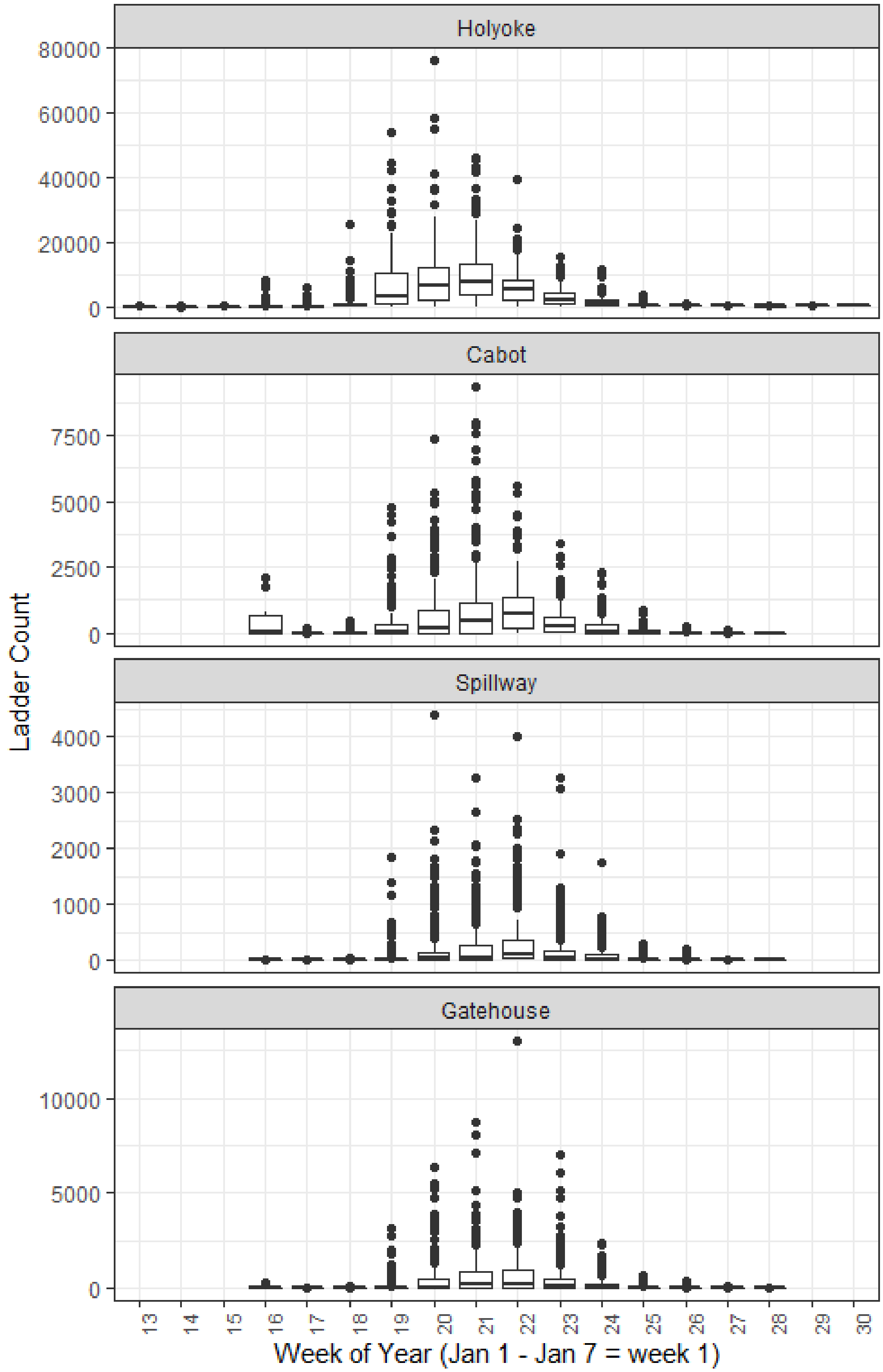


Figure 3.3.3.1.2.3.1.1-1: Box and whisker plots of count by calendar week and fishway.

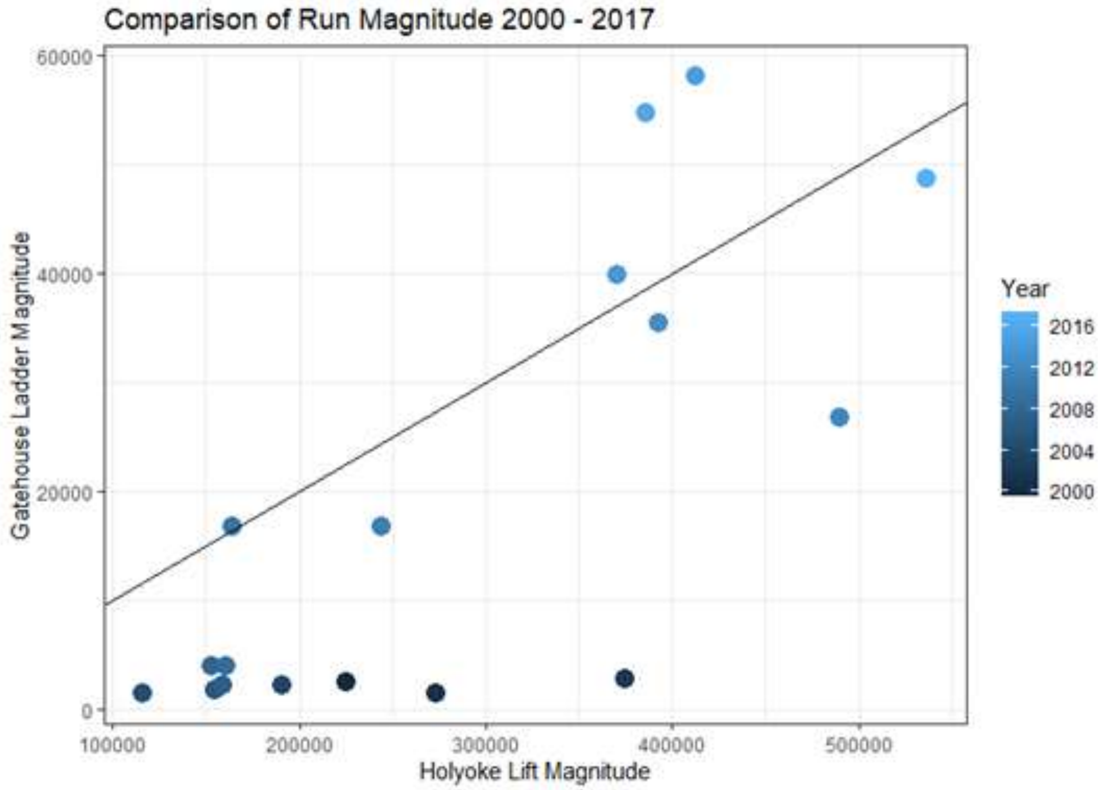


Figure 3.3.3.1.2.3.1.1-2: Gatehouse Ladder counts as a function of Holyoke counts.

Note: Diagonal solid black line represents a 10:1 relationship between Holyoke run magnitude and Gatehouse Ladder run magnitude.

3.3.3.1.2.3.1.2 Sea Lamprey

As indicated in Table 3.3.3.1.2.3.1-1, adult Sea Lamprey have been documented using the three Turners Falls fish passage facilities over the past four decades. Historical count records suggest that passage of lamprey at the gatehouse fishway exhibited an overall increasing trend through the mid-1990s, with the peak occurring in 2005, when 21,584 individuals were observed. Although no counts were recorded for Sea Lamprey in 2008, passage at gatehouse has ranged from about 2,000 to over 15,000 individuals per year since the 2005 peak.

3.3.3.1.2.3.1.3 American Eel

Upstream passage of American Eel has not historically been monitored at the Project, but the species is known to use the fish passage facilities in small numbers. With an ability to ascend damp surfaces, juvenile American Eels are also capable of transcending barriers, such as dams and gates, without the aid of passage facilities. The presence of American Eel in the TFI, as documented in 2015 and previous fish assemblage survey efforts (see Section 3.3.3.1.2.1), confirms that they are passing upstream of the Turners Falls Project.

3.3.3.1.2.3.2 Downstream Passage

Migratory fish in the TFI or entering the TFI after passing downstream of the Vernon Project move past the Northfield Mountain Project tailrace/intake, downstream through the Turners Falls Project and thence to the Holyoke Project as they migrate to the ocean. These migratory fish include post-spawning adult and juvenile American Shad, juvenile Sea Lamprey, and adult American Eel. Other possible downstream migrants include Atlantic Salmon smolts and post-spawning adults, and post-spawning adult and juvenile Blueback Herring, and post-spawning and juvenile Striped Bass, but downstream passage of these three species would be uncommon as few adults have migrated upstream of the Turners Falls Project in recent years. Resident species could also pass downstream through the Turners Falls Project or encounter the Northfield Mountain Project tailrace/intake.

Fish passing downstream leave the TFI either by passing over the Bascule Gates or beneath the Tainter gates at Turners Falls Dam to the bypass reach or by exiting through the gatehouse into the power canal. Migrants entering the power canal have three primary avenues of outmigration: 1) Station No. 1 turbines, 2) Cabot Station turbines or 3) a log sluice adjacent to the Cabot Station[7]. It is possible that fish could also pass downstream via the Spillway Fishway attraction water system, though this has not been identified as a significant route of passage.

From the power canal there is an approximate 700-foot-long by 100-foot-wide branch canal. At the end of the branch canal is the entrance to Station No. 1, consisting of eight bays, each 15 feet wide for a total intake width of 120 feet. Trashracks are angled across the entire entrance, totaling 120 feet wide by 20.5 feet high. With a normal canal elevation of approximately 173.5 feet, the effective trashrack opening is approximately 114 feet wide by 15.9 feet high, resulting in a gross area of 1,812.6 square feet (ft^2). The bar thickness is 0.375 inches, and the bars are 3 inches on center, thus the clear spacing between bars is 2.625 inches. At full hydraulic capacity (2,210 cfs), the calculated average approach velocity in front of the trashracks is approximately 1.2 feet per second (fps). More detailed information on velocities was collected for Relicensing Study 3.3.8 *Computational Fluid Dynamics Modeling in the Vicinity of the Fishway Entrances and Powerhouse Forebays* (FirstLight, 2016g) which demonstrated that, under maximum generation flow at Station No. 1, 91% of the rack face had approach velocities of less than 2.0 fps.

Cabot Station is located at the downstream terminus of the power canal. The trashrack opening is 217 feet wide by 31 feet high, resulting in a gross area of 6,727 ft^2. The trashracks are angled and include upper and lower racks. The top 11 feet of the upper racks have clear-bar spacing of 0.94 inches (15/16-inch), and the bottom 7 feet of the upper racks have clear-bar spacing of 3.5625 (3-9/16) inches. The entire 13 feet of the lower racks have clear-bar spacing of 3.5625 (3-9/16) inches. At full hydraulic capacity, the calculated approach velocity in front of the trashracks is approximately 2.0 fps. More detailed information on velocities was collected for Relicensing Study 3.3.8 *Computational Fluid Dynamics Modeling in the Vicinity of the Fishway Entrances and Powerhouse Forebays* (FirstLight, 2016g) which demonstrated that velocities across the rack were not uniform and, under maximum generation flow, 32% of the rack area had velocities less than 2.0 fps. The highest approach velocities were in front of penstock no. 6 (the most upstream area of the intake) and nearest to the bottom.

The downstream fish passage facility is located at Cabot Station, at the downstream terminus of the power canal. Assuming no spill is occurring at Turners Falls Dam, fish moving downstream pass through the gatehouse (which has no racks) and into the power canal. The downstream fish passage facilities at Cabot Station consist of: reduced bar-spacing in the upper 11 feet of the intake racks; a broad-crested weir with an elliptical floor developed specifically to enhance fish passage at the log sluice; the log sluice itself, which has been resurfaced to provide a passage route; above-water lighting; and a sampling facility. Although the log sluice gate is approximately 16 feet wide, there is an 8-foot-wide weir that is inserted in the sluice

[7] Other passage routes include the Hilton Milton, LLC hydro project (formerly PaperLogic, no FERC license) and the Turners Falls Hydro Project (FERC No. 2622) owned by Eagle Creek Renewable Energy.

opening during downstream fish passage season. The sluiceway is 6 feet high and 180 feet long. With the weir in place, the amount of flow conveyed downstream varies based on the power canal elevation, but typically ranges from 110 to 253 cfs. During fish passage season, the gate is set 3.5 feet open if/when the weir is removed, which results in a flow of approximately 130 cfs.

As described for upstream passage, the CRASC also establishes an annual schedule for the operation of downstream fish passage facilities at the Connecticut River dams (Table 3.3.3.1.2.3.2-1).

Table 3.3.3.1.2.3.2-1: Downstream Fish Passage Schedule

Development	Downstream Fish Passage Exit	Species	Life Stage	Dates of Operation	Hours of Operation
Turners Falls	Log/trash sluice	salmon salmon shad shad eels	smolt adult adult juvenile adult	Not required Oct 15-Dec 31[1] Apr 7[2]-Jul 31 Aug 1-Nov 15 Sep 1-Nov 15	24 hours/day 24 hours/day 24 hours/day 24 hours/day 24 hours/day

[1]Downstream passage operation for adults will only be required if 50 or more adults are documented as passing upstream of a dam/facility.
[2]Downstream passage measures should be operational for American Shad at the same time as upstream passage is initiated

Source: CRASC letter to FirstLight, 3/2/2020

3.3.3.1.3 Macroinvertebrates

3.3.3.1.3.1 Odonates

As part of Relicensing Study 3.3.10 – *Assess Operational Impacts on Emergence of State-Listed Odonates in the Connecticut River* (FirstLight, 2016i), several surveys over the span of three years (2014-2016) provided information on the presence and distribution of odonate species in Project-affected areas. Qualitative surveys were conducted in 2014 on June 2, 6, 9, and 20 (2014). Barton Cove and the Route 116 Bridge were also checked twice in May 2014 to determine if emergence had begun early. However, the spring of 2014 was cooler than average, river flows were higher than average, and emergence was not detected until early June. Quantitative surveys were performed in 2015 and 2016 at several locations and on multiple dates throughout the emergence season (Tables 3.3.3.1.3.1-1 and 3.3.3.1.3.1-2).

Species Assemblage

In 2014, approximately 250 exuviae were collected across the eight survey sites. A total of 622 individuals representing 16 species were collected during the 2015 season. In 2016, 156 individuals representing four species were observed during eclosure and collected. The genera and species collected from 2014 to 2016 are listed in Table 3.3.3.1.3.1-3.

<u>Barton Cove</u>

Epitheca princeps, a species common in lentic habitats, was the most common species collected in Barton Cove. The Barton Cove survey sites contain mostly lentic habitat with submerged and emergent vegetation. Other species that can tolerate this type of environment (e.g., *Perithemis tenera* and *Libellula* sp.) were found in Barton Cove, but not found at any of the survey sites in the bypass reach or downstream of Cabot Station.

<u>Bypass Reach and Downstream from Cabot Station</u>

Sites in the bypass reach and downstream of Cabot Station were riverine and generally more lotic. Species found most frequently in these areas included *Gomphus vastus* (~55% of total), *Stylurus spiniceps* (~13% of total), and *Boyeria vinosa* (~12% of total). Less common taxa include *Ophiogomphus rupinsulensis*, *Neurocordulia yamaskanensis*, *Gomphus abbreviatus*, and *Dromogomphus spinosus*. Rare taxa included *Macromia illinoiensis, Gomphus ventricosus, Stylurus amnicola, Hagenius brevistylus*, and *Basiaeschna janata*.

Timing of Emergence

In 2015, emergence was first detected early in the fourth week of May, which prompted quantitative sampling to begin on May 26. Counts were low for all species during the first round of sampling, reached a peak in early June, then dropped and remained consistent through July and early August before diminishing to very low numbers during the final two sampling events in late August and early September (Figure 3.3.3.1.3.1-1).

In 2016, surveys targeting state-listed species in late May to mid-July were performed. Sites were checked starting in mid-May to determine the onset of emergence; emergence was detected in the last week of May and peaked in early June at sites downstream from the dam, but despite fair weather, was spotty throughout the survey period. At the site in the TFI, emergence was very sparse and there were few exuviae.

Crawl Distances and Heights

This analysis focuses on 2015 and 2016 data, which included species-level identification of exuviae. In 2015, crawl distance and height data were collected for 622 individuals and 16 species, with sample sizes per species ranging from 1 to 219. In 2016, crawl distance and height data were collected for 156 individuals and four species. Crawl height is the vertical height from the water's surface to the eclosure location and crawl distance is the horizontal distance from the edge of the water to the eclosure location, both recorded at the time of the observation.

There was little difference in median crawl heights in 2015 and 2016, but median crawl distances were higher in 2016 (Table 3.3.3.1.3.1-4). For this analysis, the 2015 and 2016 crawl distance and height data are combined, which served to increase sample sizes for the four species that were observed in 2016 (*G. vastus*, *D. spinosus*, *S. amnicola*, and *S. spiniceps*). For all species combined, larvae crawled a median distance of 12.5 ft from the edge of the water and a median vertical height of 5.5 ft. There was considerable variation within and among species, as shown in Table 3.3.3.1.3.1-4.

Critical height percentiles, which represent heights protective of a given percentage of individuals within a species or species group, are shown in Table 3.3.3.1.3.1-4. The more lentic species collected in Barton Cove (i.e., *Perithemis tenera*, *Libellula* sp., *Epitheca princeps*), which tend to emerge on aquatic vegetation, crawled shorter vertical heights from the water's surface than the riverine species that were more prevalent in the bypass each and downstream of Cabot Station. Among the riverine species, crawl height was greatest for *Macromia illinoiensis*, *Gomphus abbreviatus*, and *Gomphus vastus*; each of these species crawled a median vertical height of near or above 7 ft. Riverine species that crawled the shortest median vertical height from the water's surface included *Stylurus amnicola* (2.2 ft), *Stylurus spiniceps* (3.4 ft), and *Ophiogomphus rupinsulensis* (3.5 ft).

Of the species that had a sample size of ≥ 10 individuals, *Boyeria vinosa* crawled the longest distances from the edge of the water, with a median of 16.2 ft, and one individual had crawled 58.9 ft before stopping to eclose. Average crawl distance was usually between 10 and 15 ft for most species, with maximum distances often 3-4 times greater than the average. Shortest crawl distance was for *Perithemis tenera* (a lentic species that prefers to emerge on aquatic vegetation) and *Stylurus amnicola*. Considering crawl height and crawl distance together, the riverine species that tended to eclose closest to the water were *Stylurus amnicola* and *Ophiogomphus rupinsulensis*.

Substrate Selection

In general, species eclosed on a wide variety of available surfaces. In Barton Cove, this included large amounts of emergent aquatic vegetation, detritus, rock, trees, and roots. In the bypass reach and downstream of Cabot Station, emergent aquatic vegetation was mostly absent and species eclosed on bare sediment (from silt to coarse rock); ground-level cover such as moss, roots, and detritus; and on vertical surfaces such as stems of herbaceous plants, vines, trees, and vertical rock faces.

Emergence and Eclosure Speed

With the 2015 and 2016 data combined, a total of 180 individuals, representing eight taxa, were observed during part or all of the emergence process. This included observations of two state-listed species, *Gomphus abbreviatus* (sample size = 1), and *S. amnicola* (sample size = 7). Emergence and eclosure information were gathered for various species, and were also pooled into two species groups (Table 3.3.3.1.3.1-5 and Table 3.3.3.1.3.1-6): Gomphus Group (*Gomphus* sp. and *D. spinosus*; sample size = 137) and Stylurus Group (*S. amnicola* and *S. spiniceps*; sample size = 32). For the combined 2015-2016 data, the average duration of "Start to Free" (i.e., start of eclosure to free from the larval exoskeleton) was 18 minutes (range: 7 to 30 minutes) (Table 3.3.3.1.3.1-7). The average duration of "Free to Flight" (i.e., free from larval exoskeleton to flight) was 39 minutes (range: 7 to 96 minutes). Together, these two time periods comprise the critical timeframe from when a larva stops to start eclosing to when it flies away ("Start to Flight"). The average duration of "Start to Flight" was 58 minutes and ranged from 24 to 126 minutes for all species combined. Variation among species seemed related more to sample sizes than species-specific differences. Among species or species groups with relatively large sample sizes, "Start to Flight" durations ranged from 28 to 105 minutes for *G. vastus* (sample size = 122), from 24 to 85 minutes for *S. spiniceps* (sample size = 25), from 28 to 118 minutes for the Gomphus Group (sample size = 129), and from 24 to 85 minutes for the Stylurus Group (sample size = 31).

Critical Protective Rates

Based on eclosure speeds and crawl heights, various Critical Protective Rates (CPRs) were developed for various species and groups of odonates (Table 3.3.3.1.3.1-7). Because each species had a range of heights and crawl times, the rates were based on how much of the population would be protected given a maximum hourly water level change. For example, a CPR-95 would be the water level increase (per hour) that would not affect 95% of the population, based on the distribution of crawl heights and flight times documented.

Table 3.3.3.1.3.1-1: Survey Sites and Dates for the Phase 2 Quantitative Odonate Surveys in the Connecticut River, 2015

Site	Location	Town	Date Surveyed
1	Route 116	Sunderland	May 30. June 10, 20, 25, 30. July 7, 18, 21. August 5, 20. Sept 1.
2	MADFW conservation lands upstream from the Sawmill River confluence	Montague	May 30. June 11, 23. July 6, 14, 21. August 4, 20. Sept 1.
3	Poplar Street boating access area across from Deerfield River confluence	Montague	May 29. June 12, 22. July 9, 17, 20. August 3, 19, 31
4	Rock Dam in the bypass reach; 2 transects upstream and 4 downstream from the Rock Dam	Montague	May 29. June 11, 22. July 9, 17, 20, August 3, 19, 31.
5	Barton Cove	Gill	May 27. June 8, 19. July 2, 8, 25. August 5, 18. Sept 2.

Table 3.3.3.1.3.1-2: Survey Sites and Dates for the Phase 3 Quantitative Odonate Surveys in the Connecticut River, 2016

Site	Location	Town	Date Surveyed (2016)
1	Mt. Holyoke College Crew Docks (below Cabot Station)	South Hadley	June 11
2	Hatfield Boat Ramp (below Cabot Station)	Hatfield	May 31, June 3, June 14, June 17, July 7
3	Route 116 Bridge, West Side (below Cabot Station)	South Deerfield	May 27, June 2, June 4, June 7, June 13, June 17, June 20, June 24, July 5, July 6
4	Route 116 Bridge, East Side (below Cabot Station)	Sunderland	June 4, June 7, June 20, June 22, June 24, June 27, July 7, July 13
5	MADFW Conservation Lands (below Cabot Station)	Montague	May 27, May 31, June 6, June 13, June 22
6	Poplar Street (below Cabot Station)	Montague	July 6
7	Rock Dam (Bypass Reach)	Montague	June 6, June 9, June 14, June 24, July 6
8	Mt. Hermon School (TFI)	Gill	June 4, June 9

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Table 3.3.3.1.3.1-3: Odonates Documented in the Study Areas during Odonate Surveys, 2014-2016

Species	Abbreviation	State Status	Phase 1 (2014) Survey Site								Phase 2 (2015) Survey Site					Phase 3 (2016) Survey Site								Total
			1	2	3	4	5	6	7	8	1	2	3	4	5	1	2	3	4	5	6	7	8	(2015-2016)
Arigomphus furcifer	ArFu			P							0	0	0	0	0	0	0	0	0	0	0	0	0	0
Basiaeschna janata	BaJa										0	0	0	0	2	0	0	0	0	0	0	0	0	2
Boyeria vinosa	BoVi		P			P	P	P	P	P	58	3	11	6	0	0	0	0	0	0	0	0	0	78
Cordulegaster maculata	CoMa										0	0	0	1	0	0	0	0	0	0	0	0	0	1
Dromogomphus spinosus	DrSp										3	10	1	2	2	0	1	2	0	0	0	0	0	21
Epitheca princeps	EpPr		P	P	P	P	P				0	0	0	1	101	0	0	0	0	0	0	0	0	102
Gomphus abbreviatus	GoAb	Special Concern				P	P	P	P	P	2	4	0	14	0	0	0	0	0	0	0	0	0	20
Gomphus vastus	GoVa					P	P	P	P	P	70	129	2	18	0	0	3	19	53	35	0	19	0	348
Gomphus ventricosus	GoVe	Threatened					P				0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hagenius brevistylus	HaBr										2	1	1	0	0	0	0	0	0	0	0	0	0	4
Libellula sp.	Lisp										0	0	0	0	6	0	0	0	0	0	0	0	0	6
Libellulinae (unidentified)	Li										0	0	0	0	12	0	0	0	0	0	0	0	0	12
Macromia illinoiensis	MaIl		P	P	P	P	P	P	P	P	3	2	6	2	1	0	0	0	0	0	0	0	0	14
Neurocordulia yamaskanensis	NeYa		P	P	P	P	P	P	P	P	3	8	4	6	2	0	0	0	0	0	0	0	0	23
Ophiogomphus rupinsulensis	OpRu					P	P	P	P	P	5	20	0	0	0	0	0	0	0	0	0	0	0	25
Perithemis tenera	PeTe					P	P	P	P	P	0	0	0	0	27	0	0	0	0	0	0	0	0	27
Stylurus amnicola	StAm	Endangered									3	1	5	0	0	0	0	4	0	0	0	0	0	13
Stylurus spiniceps	StSp					P					23	25	9	5	0	0	0	13	8	0	0	0	0	83
										Total	**172**	**203**	**39**	**55**	**153**	**0**	**4**	**38**	**61**	**35**	**0**	**19**	**0**	**779**

Note: 2014, 2015, and 2016 site numbers and locations differ and are included below. No quantitative surveys were performed in 2014, presence is indicated by a "P". Colors in the table indicate relative location (Blue = TFI, Orange = Bypass Reach, Green = Downstream Areas

Phase 1 (2014) surveys sites included:
- Sites 1 – 3: Barton Cove
- Site 4: Bypass Reach above and below Rock Dam
- Site 5: Downstream from Railroad Bridge at Montague
- Site 6: Between Railroad Bridge and Third Island
- Site 7: Upstream from Third Island
- Site 8: Route 116 Bridge, Boat Ramp

Phase 2 (2015) survey sites included:
- Site 1: Eastern shore near the Route 116 Bridge (Sunderland)
- Site 2: Massachusetts Division of Fisheries and Wildlife conservation lands on the eastern shore upstream from the Sawmill River confluence (Montague)
- Site 3: Area from bike path bridge to Montague City Road, opposite the Deerfield River confluence (Montague)
- Site 4: Upstream and downstream from the Rock Dam in the bypass reach (Montague)
- Site 5: Barton Cove (Gill)

Phase 3 (2016) survey sites included:
- Site 1: Near the Mt. Holyoke College crew dock (South Hadley)
- Site 2: Western shore upstream and downstream from the Hatfield Boat ramp (Hatfield)
- Site 3: Western shore near the Route 116 Bridge (Sunderland)
- Site 4: Eastern shore near the Route 116 Bridge (Sunderland)
- Site 5: MADFW conservation lands on the eastern shore upstream from the Sawmill River confluence (Montague)
- Site 6: Area from bike path bridge to Montague City Road, opposite the Deerfield River confluence (Montague)
- Site 7: Upstream and downstream from the Rock Dam in the bypass reach (Montague)
- Site 8: Mt. Hermon School crew dock, including both the western shore and the eastern shore (Gill and Northfield)

Table 3.3.3.1.3.1-4: Summary of Vertical Crawl Heights, Critical Height Percentiles, and Horizontal Crawl Distances for Odonate Species and Species Groups Collected in 2015 and 2016.

Statistic	Species														Groups			
	BaJa	BoVi	DrSp	EpPr	GoAb	GoVa	HaBr	Li	MaIl	NeYa	OpRu	PeTe	StAm	StSp	Aeshnidae	Gomphus	Libellulidae	Stylurus
Vertical Crawl Height (ft)																		
Sample Size	2	78	21	102	20	348	4	18	14	23	25	27	13	83	80	389	45	100
Average	6.5	5.9	5.2	4.2	7.1	7.4	5.7	3.1	7.1	6.6	3.3	2.5	2.4	4.0	5.9	7.2	2.8	3.9
StDev	1.27	2.88	4.37	2.17	2.69	3.33	4.53	1.59	4.88	4.66	2.45	1.31	2.39	3.57	2.85	3.39	1.45	3.51
Minimum	5.6	0.3	0.1	0.6	3.0	0.0	0.1	0.5	0.2	0.2	0.4	0.3	0.0	0.0	0.3	0.0	0.3	0.0
25th Percentile	6.1	4.2	2.4	2.4	5.2	4.8	3.3	2.2	3.4	3.3	1.2	1.9	0.4	1.6	4.3	4.7	1.9	1.2
Median	6.5	5.5	2.8	4.0	7.1	7.3	5.9	2.9	7.0	5.6	3.5	2.4	2.2	3.4	5.5	7.2	2.5	3.3
75th Percentile	7.0	7.4	8.8	5.8	8.6	9.6	8.2	3.9	10.4	9.3	4.3	2.8	2.9	5.5	7.4	9.5	3.1	5.4
Maximum	7.4	14.5	13.3	10.0	13.8	17.5	10.8	6.6	17.5	17.5	11.5	6.5	7.2	22.2	14.5	17.5	6.6	22.2
Critical Height Percentiles (ft)																		
5%	5.69	1.51	0.13	0.93	3.35	1.81	0.77	1.27	0.75	1.12	0.43	1.07	0.15	0.09	1.52	1.69	1.00	0.08
10%	5.78	2.26	0.15	1.46	3.51	3.07	1.42	1.47	1.60	1.71	0.79	1.46	0.27	0.18	2.30	2.81	1.44	0.17
20%	5.96	3.96	1.84	2.12	5.05	4.42	2.70	1.96	3.14	2.69	1.11	1.74	0.37	1.01	3.99	4.15	1.78	0.67
30%	6.14	4.53	2.50	2.60	5.22	5.59	3.99	2.41	3.67	4.03	1.31	1.92	0.75	2.24	4.58	5.26	1.94	2.14
50%	6.50	5.47	2.83	4.00	7.08	7.34	5.88	2.90	6.98	5.63	3.45	2.40	2.17	3.35	5.51	7.23	2.50	3.29
Horizontal Crawl Distance (ft)																		
Sample Size	2	77	21	102	20	348	4	18	14	23	25	27	13	83	79	389	45	96
Average	13.6	17.2	11.8	12.4	12.8	17.1	15.5	11.0	16.5	13.2	10.2	7.7	6.5	14.2	17.1	16.6	9.0	13.1
StDev	0.23	9.86	7.26	7.62	10.99	11.62	10.05	6.21	13.23	10.52	6.95	5.18	6.45	11.34	9.75	11.47	5.78	11.10
Minimum	13.5	1.5	0.3	0.3	1.0	0.2	0.5	3.6	1.3	0.7	0.0	1.3	0.0	0.0	1.5	0.2	1.3	0.0
25th Percentile	13.5	11.5	6.9	7.9	3.4	8.7	15.1	5.0	5.8	4.5	5.2	3.6	1.3	3.9	11.5	8.4	4.3	2.9
Median	13.6	16.2	11.2	11.6	8.2	14.4	20.2	11.2	13.0	12.1	8.5	6.7	4.1	12.5	16.1	13.8	7.9	11.8
75th Percentile	13.7	22.3	16.6	13.1	23.0	24.3	20.6	13.5	25.0	20.3	13.5	11.3	12.5	22.6	22.3	23.3	12.8	21.7
Maximum	13.8	58.9	24.6	39.4	33.1	49.9	21.3	24.9	43.3	37.1	28.5	20.0	18.7	58.1	58.9	49.9	24.9	58.1

Note: Aeshnidae combines Basiaeschna janata (BaJa) and Boyeria vinosa (BoVi). Libellulidae combines Libellulinae (Li) and Perithemis tenera (PeTe). Gomphus combines Gomphus vastus (GoVa), Gomphus abbreviatus (GoAb), and Dromogomphus spinosus (DrSp). Stylurus combines Stylurus amnicola (StAm) and Stylurus spiniceps (StSp)

Table 3.3.3.1.3.1-5: Eclosure Duration and Sample Sizes for Odonate Species.

Species/Statistic	**Eclosure Period**		
	Start-Free	**Free-Flight**	**Start-Flight**
Boyeria vinosa			
Sample Size	1	1	1
Min Time	0:30	0:54	1:24
Max Time	0:30	0:54	1:24
Average Time	0:30	0:54	1:24
Dromogomphus spinosus			
Sample Size	6	6	6
Min Time	0:10	0:21	0:41
Max Time	0:30	1:28	1:58
Average Time	0:22	0:47	1:10
Gomphus abbreviatus			
Sample Size	1	1	1
Min Time	0:30	0:46	1:16
Max Time	0:30	0:46	1:16
Average Time	0:30	0:46	1:16
Gomphus vastus			
Sample Size	130	122	122
Min Time	0:08	0:14	0:28
Max Time	0:30	1:34	1:45
Average Time	0:17	0:43	1:00
Libellulidae			
Sample Size	3	2	2
Min Time	0:30	0:25	0:55
Max Time	0:30	1:36	2:06
Average Time	0:30	1:00	1:30
Stylurus amnicola			
Sample Size	7	6	6
Min Time	0:09	0:15	0:29
Max Time	0:30	0:30	1:00
Average Time	0:21	0:24	0:43
Stylurus spiniceps			
Sample Size	25	25	25
Min Time	0:07	0:16	0:24
Max Time	0:30	0:55	1:25
Average Time	0:13	0:28	0:41
Ophiogomphus rupinsulensis			
Sample Size	7	7	7
Min Time	0:30	0:07	0:37
Max Time	0:30	0:52	1:22
Average Time	0:30	0:20	0:50

Table 3.3.3.1.3.1-6: Eclosure Duration and Sample Sizes for Odonate Species Groups.

Species/Statistic	Eclosure Period		
	Start-Free	Free-Flight	Start-Flight
Gomphus Group			
Sample Size	137	129	129
Min Time	0:08	0:14	0:28
Max Time	0:30	1:34	1:58
Average Time	0:17	0:43	1:01
Stylurus Group			
Sample Size	32	31	31
Min Time	0:07	0:15	0:24
Max Time	0:30	0:55	1:25
Average Time	0:14	0:27	0:42
All Species			
Sample Size	180	170	170
Min Time	0:07	0:07	0:24
Max Time	0:30	1:36	2:06
Average Time	0:18	0:39	0:58

Table 3.3.3.1.3.1-7: Critical Protective Rates Developed for Odonate Species in the Project Areas

	Critical Protective Rate	
Species/Group	**Percentile**	**ft/hr**
G. abbreviatus	CPR-95%	**1.67**
	CPR-90%	**1.76**
	CPR-80%	**2.52**
	CPR-70%	**2.61**
	CPR-50%	**3.54**
G. vastus	CPR-95%	**0.91**
	CPR-90%	**1.53**
	CPR-80%	**2.21**
	CPR-70%	**2.79**
	CPR-50%	**3.67**
Gomphus Group	CPR-95%	**0.85**
	CPR-90%	**1.41**
	CPR-80%	**2.07**
	CPR-70%	**2.63**
	CPR-50%	**3.62**
S. amnicola	CPR-95%	**0.07**
	CPR-90%	**0.13**
	CPR-80%	**0.18**
	CPR-70%	**0.37**
	CPR-50%	**1.08**
Stylurus Group	CPR-95%	**0.04**
	CPR-90%	**0.08**
	CPR-80%	**0.34**
	CPR-70%	**1.07**
	CPR-50%	**1.65**
N. yamaskanensis	CPR-95%	**0.56**
	CPR-90%	**0.86**
	CPR-80%	**1.34**
	CPR-70%	**2.02**
	CPR-50%	**2.82**

	Critical Protective Rate	
Species/Group	**Percentile**	**ft/hr**
D. spinosus	CPR-95%	**0.06**
	CPR-90%	**0.08**
	CPR-80%	**0.92**
	CPR-70%	**1.25**
	CPR-50%	**1.42**
O. rupinsulensis	CPR-95%	**0.22**
	CPR-90%	**0.40**
	CPR-80%	**0.56**
	CPR-70%	**0.65**
	CPR-50%	**1.73**
M. illinoiensis	CPR-95%	**0.38**
	CPR-90%	**0.80**
	CPR-80%	**1.57**
	CPR-70%	**1.83**
	CPR-50%	**3.49**
E. princeps	CPR-95%	**0.47**
	CPR-90%	**0.73**
	CPR-80%	**1.06**
	CPR-70%	**1.30**
	CPR-50%	**2.00**
Aeshnidae Group	CPR-95%	**0.76**
	CPR-90%	**1.15**
	CPR-80%	**1.99**
	CPR-70%	**2.29**
	CPR-50%	**2.76**
Libellulidae Group	CPR-95%	**0.50**
	CPR-90%	**0.72**
	CPR-80%	**0.89**
	CPR-70%	**0.97**
	CPR-50%	**1.25**

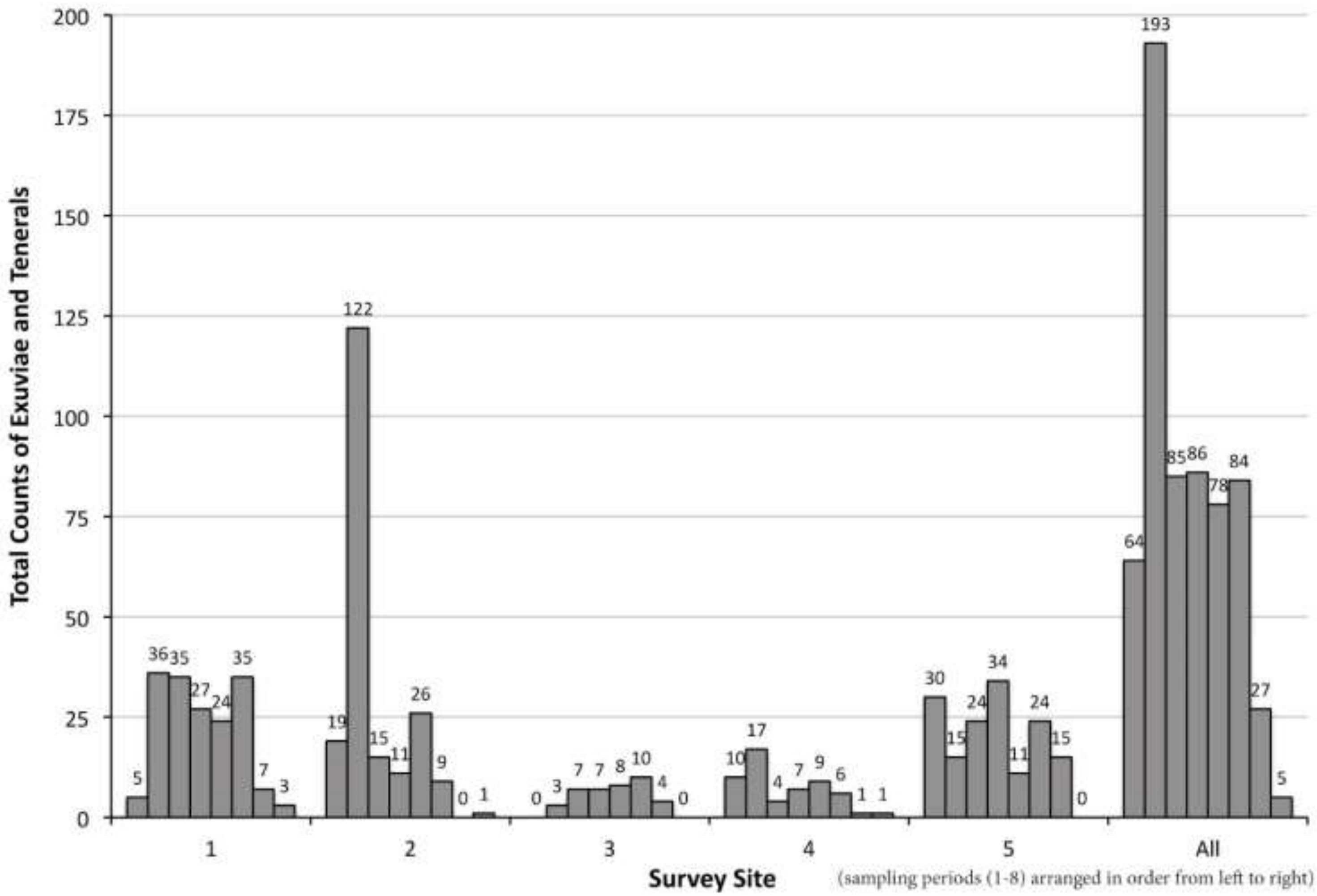


Figure 3.3.3.1.3.1-1: Total Counts of Odonate Exuviae and Tenerals for each Sampling Period, for all Transects Combined at each of the Survey Sites (2015 Data Only)

Note: The dates of each sampling period at each site is listed in Table 3.3.3.1.3.1-1.

3.3.3.1.3.2 Freshwater Mussels

Freshwater mussels are part of the benthic fauna in the TFI, bypass reach, power canal, and downstream areas. The Eastern Elliptio is the dominant species forming expansive beds along much of the TFI and in downstream areas. Recent surveys for mussels in the Project areas, and beyond, include:

- 2011 – Assessment of the distribution, abundance, and habitat of freshwater mussels in the TFI, bypass reach, power canal, and areas downstream of Cabot Station to the Deerfield River confluence.
- 2014 – Delineated populations of state-listed mussels and suitable habitat from Cabot Station downstream to the Route 116 Bridge in Sunderland.
- Freshwater mussel studies in the Holyoke Dam Impoundment over the course of several years between 2003 and 2014, from Dry Brook (Sunderland) to the Holyoke Dam.

Figure 3.3.3.1.3.2-1 shows the locations of these surveys.

Impoundment, Bypass Reach, Power Canal, and nearby Downstream Areas

In 2011, a freshwater mussel survey was conducted in a 20-mile reach of the TFI, and a 3.5-mile reach from Turners Falls Dam to the confluence with the Deerfield River (2.5 of the 3.5 miles is in the bypass reach), as well as 2.1 miles of the power canal. The study objective was to assess the distribution, abundance, and habitat of freshwater mussels. The TFI and bypass reach surveys were conducted during low flow in August and the power canal survey was conducted during the September canal drawdown. Five freshwater mussel species were found, including the Eastern Elliptio, Alewife Floater, Eastern Lampmussel, Eastern Floater, and Triangle Floater. The Eastern Elliptio was found at 96.2% of the 52 sites sampled and was 100 to 1,000 times more abundant than other species. Over 400 Alewife Floaters were found with the highest densities in the upstream end of the TFI. Of the few Eastern Lampmussel that were found, they were mostly found in the TFI and not in the bypass reach or power canal. A total of eight Eastern Floaters were found in the TFI and in the power canal. One Triangle Floater was found near the mouth of the Deerfield River. Mussels were found in a wide range of water depths, flow conditions, and substrate conditions.

The Alewife Floater was broadly distributed in the survey area but in low densities in the power canal, bypass reach, and lower two-thirds of the TFI. The Eastern Lampmussel was found in limited numbers throughout the survey area. The Triangle Floater was listed as Special Concern in MA until 2012 when it was removed from the list. Triangle Floaters are numerous in many Connecticut River tributaries including the Ashuelot and Millers Rivers which flow into the TFI. No state listed or federally threatened or endangered mussel species were found during the 2011 survey.

Cabot Station to Sunderland (Downstream Areas)

Based on surveys performed in 2014 (FirstLight, 2016n) , the mussel community in the nine-mile reach from Cabot Station to the Route 116 Bridge is strongly dominated by Eastern Elliptio, as no live mussels of other species were found (Table 3.3.3.1.3.2-1; Figure 3.3.3.1.3.2-2). Eastern Elliptio are common to abundant in a wide range of habitat types, and the presence of a relatively high proportion of juveniles (which are usually underrepresented in qualitative surveys) suggests recruitment success is high. The presence of more than 30 Alewife Floater shells suggest that live Alewife Floater may also exist within this reach, but at very low population densities and possibly confined to small patches that were undetected in the 2014 survey. Only relic shells of state listed Yellow Lampmussel (1) and Eastern Lampmussel (2) were found.

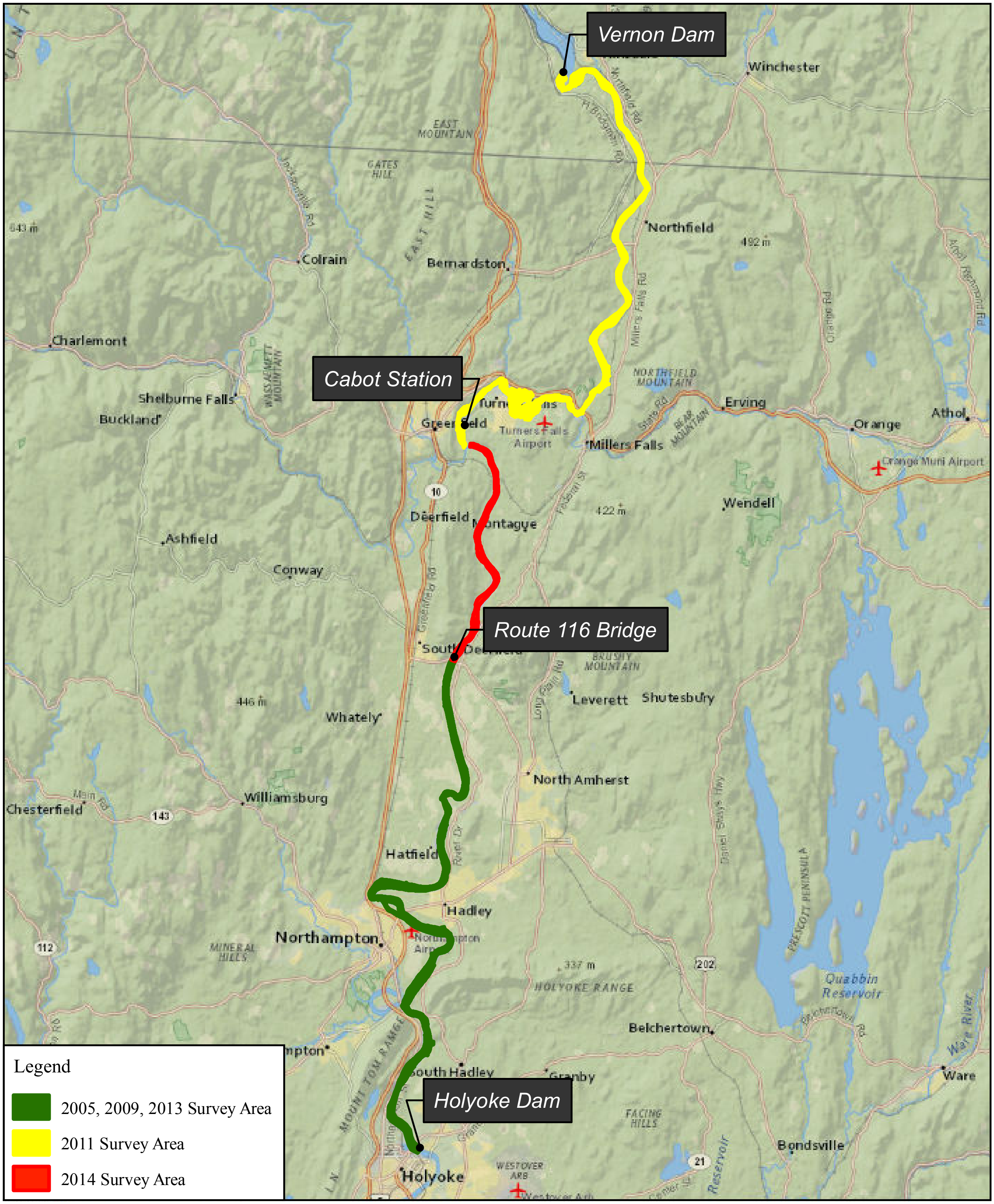
Holyoke Impoundment

Surveys for mussels in areas of the Holyoke Impoundment, between Sunderland and the Holyoke Dam, focused on state listed species. Information regarding the distribution of state listed mussel species in this area is provided in Threatened and Endangered Species section of this AFLA.

Table 3.3.3.1.3.2-1: Mussel Species Found at Each of the 26 Survey Sites below Cabot Station, 2014.

Site	Mussel Species			
	Eastern Elliptio	Eastern Lampmussel	Alewife Floater	Yellow Lampmussel
1	100s			
2	1,000s	1(S)	1(S)	
3	150			
4	64			
5	1,000s		2(S)	1(S)
6	100			
7	1,000s			
8	100s			
9	1,000s			
10	100s			
11	1,000s			
12	150			
13	100s			
14	1,000s			
15	1,000s		30(S)	
16	1,000s			
17	1,000s	1(S)		
18	1,000s			
19	1,000s			
20	1,000s			
21	1,000s			
22	1,000s			
23	1,000s			
24	100s			
25	100s			
26	53			

S=shell only



Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

FirstLight

Amended Final License Application
Exhibit E

Figure 3.3.3.1.3.2-1:
Summary Map of
Recent Mussel Survey Locations

N

0 2.5 5 10 Miles

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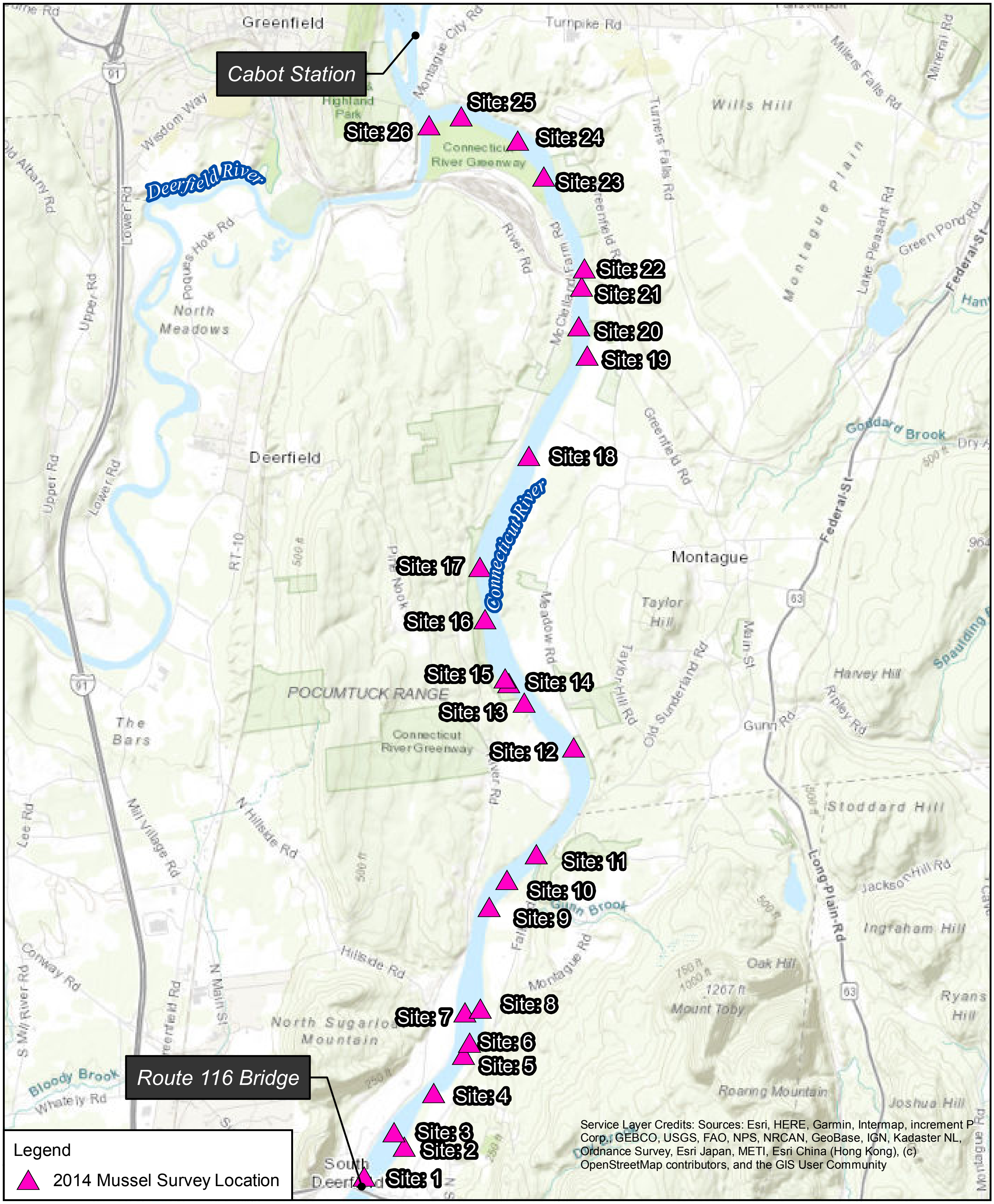

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

FirstLight

N

0 0.5 1 2 Miles

Amended Final License Application
Exhibit E

Figure 3.3.3.1.3.2-2:
2014 Mussel Survey Locations

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3.3.3.1.4 Environmental Effects

Several issues pertaining to fish and aquatic resources were identified in the scoping process for the Northfield Mountain Project and Turners Falls Project. In SD2, the following issues were identified:

- Effects of Project operations and maintenance (including fluctuations in water levels, and downstream releases) on aquatic habitat and resources in the Projects' vicinity (e.g., resident and migratory fish populations; fish spawning, rearing, feeding, and overwintering habitats; mussels and habitat).
- Effects of Project facilities and operations, (including reservoir fluctuations, and generation releases) on fish migration through and within Project fishways, canals, bypassed reaches, reservoirs, and the downstream riverine corridors.
- Effects of entrainment on fish.

3.3.3.1.5 Aquatic Habitat

Project operations affect aquatic habitat by altering flows, which affects water levels and velocities. Pumping and generation at the Northfield Mountain Project can raise and lower TFI WSELs and result in changes to river flows in the TFI. Additionally, generation and dam spillway controls at the Turners Falls Project affect water levels in TFI, along with flows in the power canal, bypass reach, and areas downstream.

3.3.3.1.5.1 Turners Falls Impoundment

The Licensee completed Study No. 3.3.14 *Aquatic Habitat Mapping of the Turners Falls Impoundment* (FirstLight, 2015a) to determine the types of aquatic habitats present within the TFI, and the distribution and abundance of those habitats, and to identify any potential effects of operations of the Turners Falls Project and Northfield Mountain Project on those habitats. Study Report No. 3.3.14 was filed on June 30, 2015. This study described how TFI WSELs fluctuate due to the inflows from the Vernon Project, tributaries, Northfield Mountain Project pumping and generation, Turners Falls Dam operations, naturally high flows, and boat wakes and the resulting effect on littoral aquatic habitat and aquatic species. The TFI was classified into two geomorphic units:

- The upstream reach (~13 miles) is riverine with alluvial substrates ranging from fines to gravels and cobbles. In general, object cover in this reach is poor and limited to occasional patches of woody debris or fringe SAV beds.
- The downstream reach (~7 miles) is bedrock controlled, with more variability relative to cover, substrate, and bed profile. Cover is generally submerged or emerging aquatic vegetation beds, boulders, and ledge crevasses and adjacent areas of deeper water that provide relatively good cover.

The Licensee completed Study No. 3.3.13 *Impacts of the Turners Falls Project and Northfield Mountain Project on Littoral Zone Fish Habitat and Spawning Habitat* (FirstLight, 2016l) which identified the timing and locations of fish spawning in the littoral zone of the TFI. This study also qualitatively described the shallow water habitat types (i.e., substrate composition, vegetation presence and type, elevation, water velocity, etc.) during field efforts of 2015.

Both of these studies used Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach, and Below Cabot* to help determine the WSEL fluctuation throughout different locations of the TFI during historic hourly modeled conditions for January 1, 2000, to September 30, 2014. As part of the process for preparation of the AFLA, the TFI Hydraulic model was used to determine the hourly WSEL variations under baseline and FirstLight's proposed operation conditions. As shown in the modeled hourly TFI elevation duration curves and histograms in Section 3.3.2 (Water Resources), only very limited differences in the fluctuations of TFI WSELs are likely under FirstLight proposed conditions as compared to baseline conditions.

3.3.3.1.5.1.1 American Shad Spawning

For the TFI, the only observed spawning of American Shad in the TFI occurred near Stebbins Island over a range of conditions. The impact of operations on American Shad spawning habitat in the Stebbins Island location were evaluated by GRH as part of its instream flow study below Vernon Dam, with a study report filed on May 20, 2019 (GRH, 2019). The habitat near Stebbins Island is a function of both Vernon Project discharges and TFI water levels (see Figure 3.3.3.2.1.1.1-1). Flows from Vernon Dam have a greater effect on habitat suitability than TFI water levels overall, and the effect of TFI water levels declines with increasing flow when flows are above 6,000 cfs. Typical spring spawning period flows would be higher than 6,000 cfs, providing a high percentage of the suitable habitat area that is driven by Vernon flow and is not heavily dependent on TFI water levels.

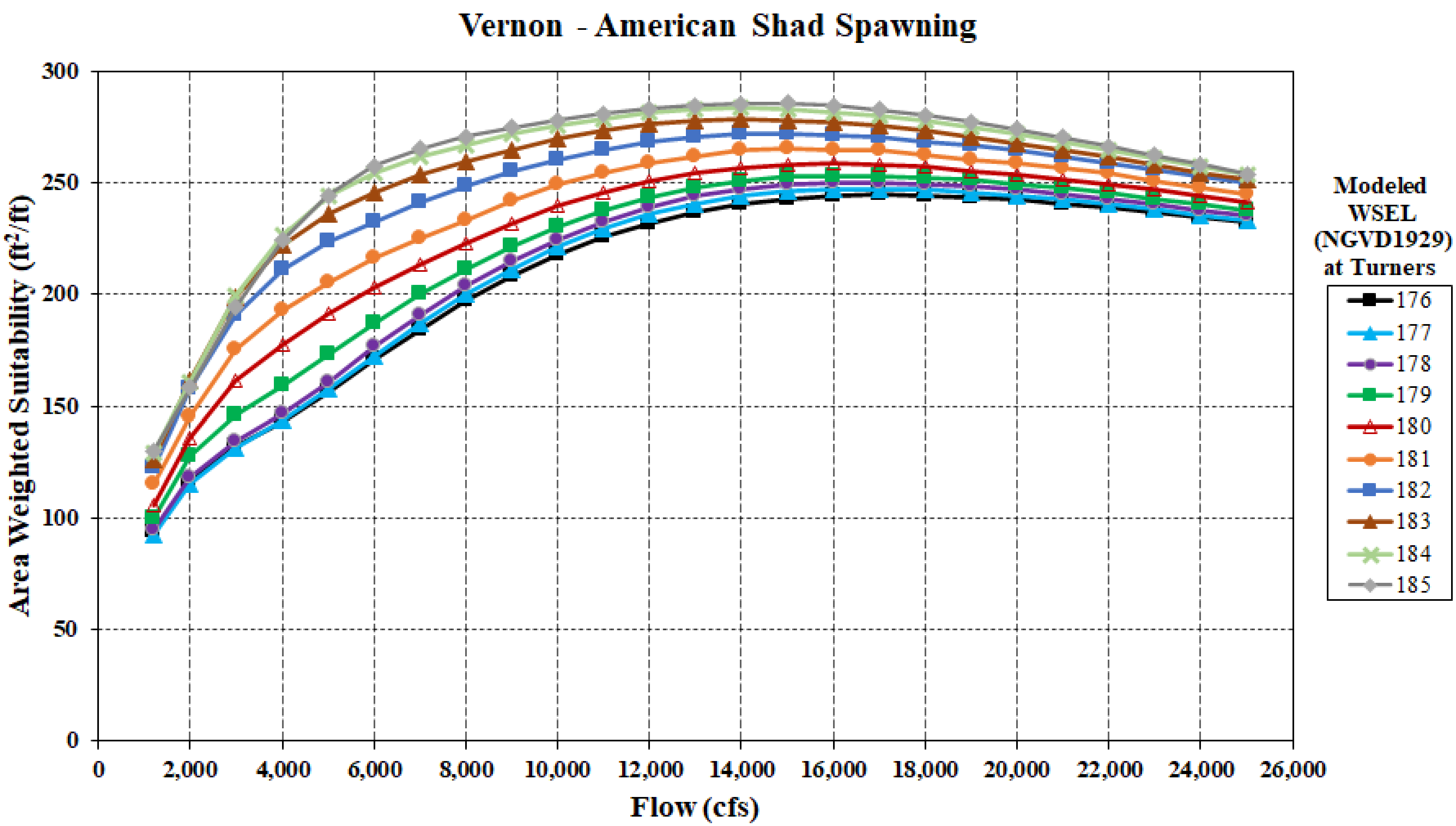

Figure 3.3.3.2.1.1.1-1: American Shad Spawning Habitat Curves for the Stebbins Island Area (Source: GRH, 2019).

3.3.3.1.5.1.2 Sea Lamprey Spawning

As indicated in Section 3.3.3.1.2.2.4, FirstLight identified spawning locations within the Project area and monitored redds in 2015 to assess whether operations of GRH's Vernon Project and the Turners Falls and Northfield Mountain Projects could potentially impact these spawning areas near Stebbins Island. Effects of operations in the TFI are evaluated below.

Habitat Suitability Criteria

Upon review of habitat suitability criteria used from the literature for habitat modeling, it was determined that Sea Lamprey spawning redds were built in 2015 at depths and velocities outside of the published habitat suitability index (HIS) recommended by the agencies and other stakeholders in Relicensing Study No. 3.3.1 *Instream Flow Habitat Assessments in the Bypass Reach and below Cabot Station* (FirstLight, 2016a). Following study report meetings conducted by FirstLight with resource agencies and other stakeholders on October 31 and November 1, 2016, the FERC issued its Determination on Requests for Study Modifications and New Studies on February 17, 2017. In its Determination Letter relative to Study No. 3.3.1, FERC discussed HSI curves for Sea Lamprey based on depth and velocity data collected at nest locations. Stakeholders requested that the HSI curves originally developed from existing literature be modified based on the site-specific depth and velocity data collected at five Sea Lamprey nesting sites in the Connecticut, Ashuelot and Millers Rivers. FERC's Determination Letter stated:

"Because this site-specific habitat data is specific to the project area and would be useful for adjusting or verifying the HSI curves taken from the literature, we recommend FirstLight consult with the agencies and use the data collected at documented sea lamprey spawning sites in study 3.3.15 to make adjustments to (or verify) the literature-based curves. If use of this data result in adjustments to the HSI curves, we recommend that FirstLight incorporate the new curves into the PHABSIM model and produce revised estimates of WUA for sea lamprey spawning in the bypassed reach and downstream of Cabot Station and file an addendum to the study by May 15, 2017".

FirstLight consulted with stakeholders on a method for developing the Sea Lamprey spawning curves and in May of 2018 submitted to FERC the Addendum No. 4 (Relicensing Study 3.3.1) *New Sea Lamprey weighted usable area curves based on agency proposed habitat suitability index curves*. The revised habitat suitability curves are provided in Figure 3.3.3.2.1.1.2-1 and Figure 3.3.3.2.1.1.2-2). There was no change to the substrate criteria (Figure 3.3.3.2.1.1.2-3).

Spawning Habitat in the Upper TFI

As part of the relicensing process for Vernon, GRH conducted an instream flow study of this area to determine suitable Vernon releases for sea lamprey spawning. The results of GRH's Instream Flow Incremental Methodology (IFIM) study were summarized in its Study 9: Instream Flow Study – Revised Final Report, filed on May 20, 2019(GRH, 2019). GRH's instream flow study of the Stebbins Island Area shows the combined effects of Vernon releases and TFI water levels on Sea Lamprey spawning habitat (Figure 3.3.3.2.1.1.2-4). Except for extremely high Turners Falls Dam water levels (i.e. 185 feet), the amount of variability in habitat suitability varies relatively little with changing Turners Falls Dam water levels in comparison to changes in flow from Vernon Dam (Figure 3.3.3.2.1.1.2-4). Further, flows during the spring spawning period are often considerably higher than 6,000 cfs, which would result in lower amounts of habitat due to higher river flows and less of an impact from Turners Falls Dam water levels (Figure 3.3.3.2.1.1.2-4). At higher flow rates, habitat is driven primarily by flow from Vernon Dam and is not dependent on TFI water levels.

Spawning Habitat in the Ashuelot and Millers River near the Connecticut River

As noted in Addendum No. 1 (Relicensing Study 3.3.15) *Assessment of Sea Lamprey Spawning Within Turners Falls Project and Northfield Project Area*, hydraulic models of the redd locations on the Ashuelot and Millers Ashuelot Rivers do not exist. However, as observed in 2015 and summarized in Study 3.3.15, the location of the Ashuelot River redds only experienced backwater conditions when Vernon discharges were 35,000 cfs and above when constrictions at the French King Gorge and elsewhere control the WSEL at the upper end of the TFI. Such high inflows are also outside of the Projects' capacity to control[8]. The Millers River redds were located about 2,150 feet upstream of the confluence with the Connecticut River and outside of backwater effects from the TFI. Redds found in both tributaries are outside of the effect of either the Northfield Mountain Project or the Turners Falls Project.

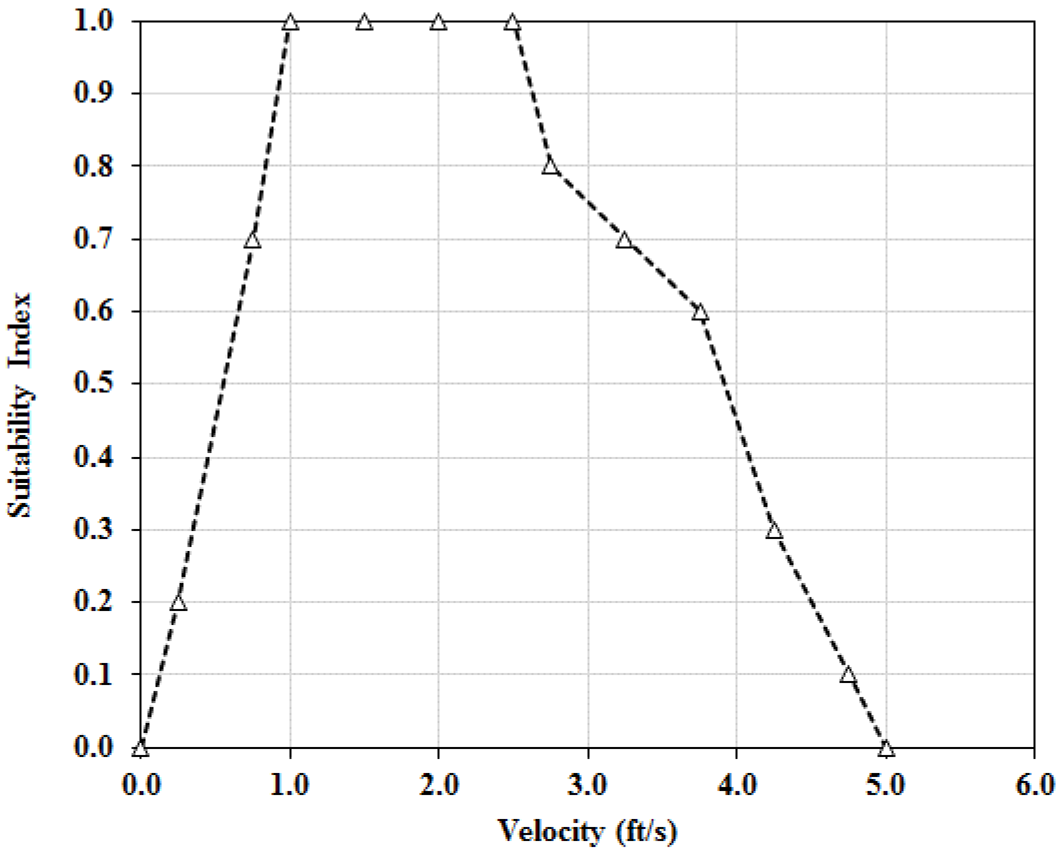

Figure 3.3.3.2.1.1.2-1 Lamprey Spawning Habitat Suitability Curve – Velocity

[8] The Turners Falls Project has a total hydraulic capacity of approximately 15,938 cfs. When inflows exceed approximately 15,938 cfs, FirstLight has less control of flows in the bypass and below Cabot Station.

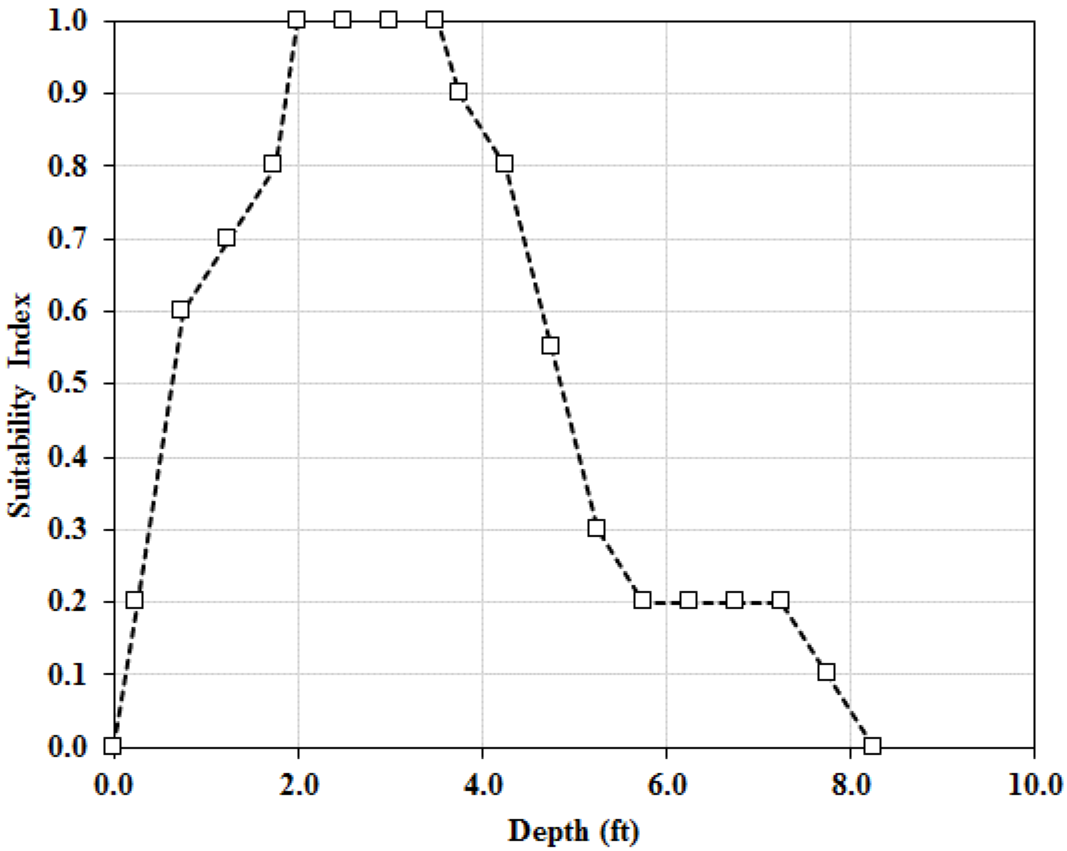

Figure 3.3.3.2.1.1.2-2 Lamprey Spawning Habitat Suitability Curve - Depth

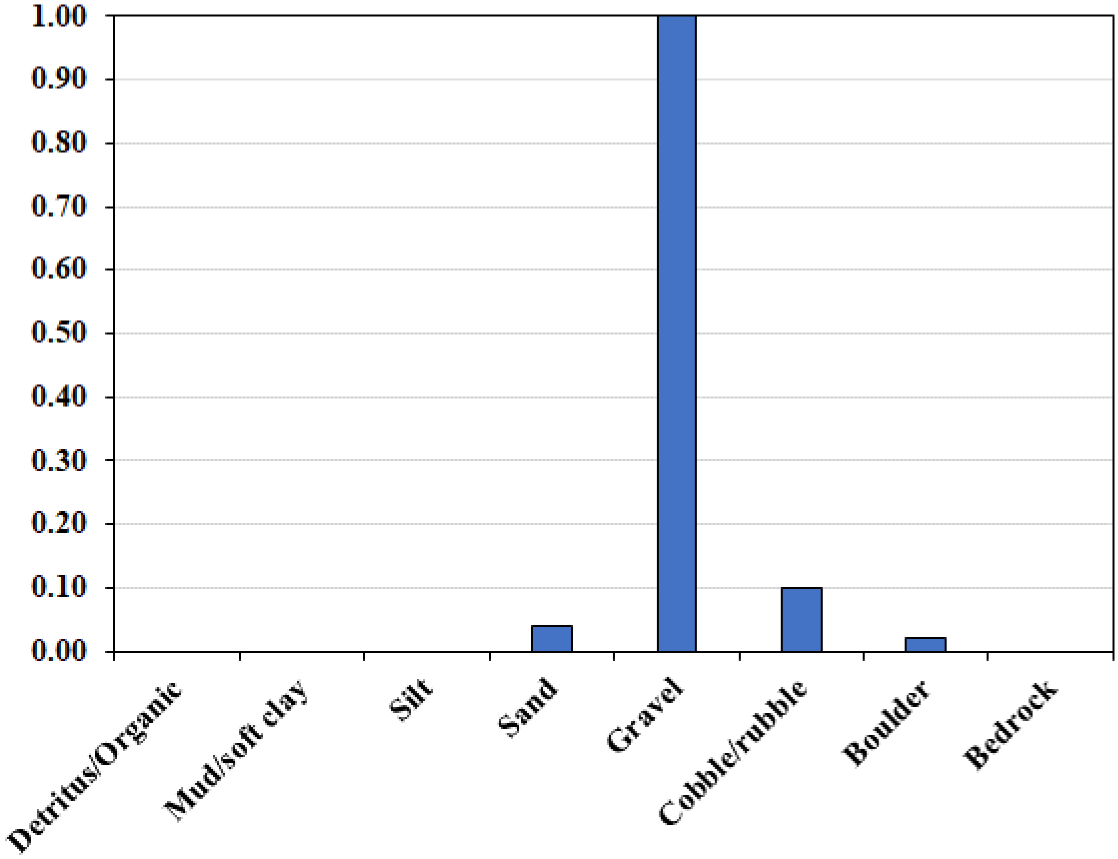

Figure 3.3.3.2.1.1.2-3 Lamprey Spawning Habitat Suitability - Substrate

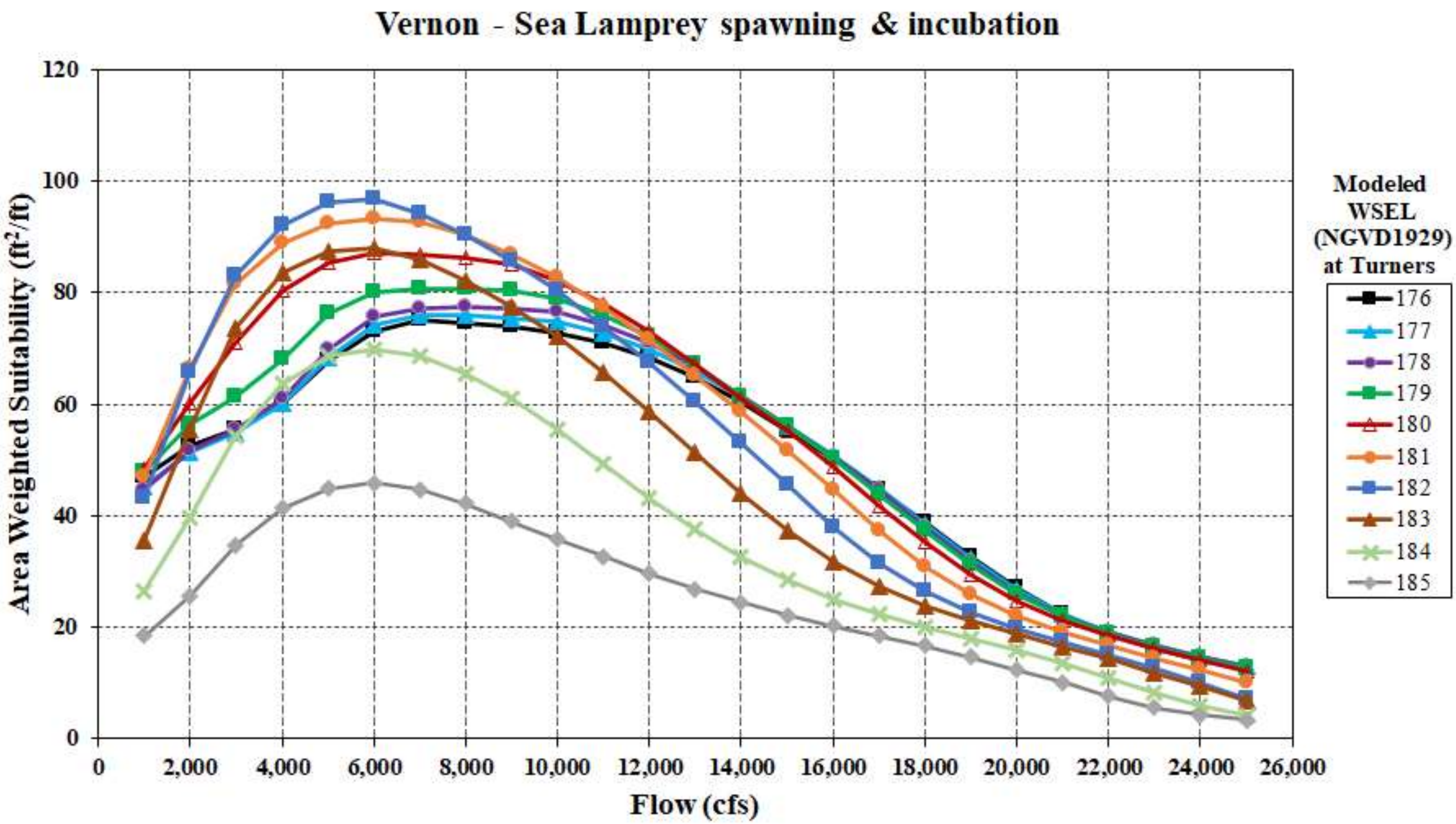

Figure 3.3.3.2.1.1.2-4: Sea Lamprey Spawning Habitat Curves for the Stebbins Island Area (GRH, 2019).

3.3.3.1.5.2 Tributary Streams

FirstLight performed systematic surveys in the spring, summer, and fall of 2014 as part of Study No. 3.3.17 *Assess the Impact of Project Operations of the Turners Falls Project and Northfield Mountain Project on Tributary and Backwater Area Access and Habitat* (FirstLight, 2015b) to assess the effects of operations of the Turners Falls Project and Northfield Mountain Project on tributary and backwater area habitat and access to that habitat under a range of hydrologic conditions.

The confluences of 19 tributaries to the Connecticut River located between Vernon Dam and the Route 116 Bridge in Sunderland, MA were surveyed to determine if water level fluctuations from the operation of the Turners Falls Project and Northfield Mountain Project resulted in reductions of available aquatic habitat. During field sampling the maximum and minimum water levels ranged from 184.2 feet to 178.33 feet as measured at the Turners Falls Dam. Potential barriers to migration/movement were observed at three of the 19 tributaries, namely Merriam Brook, Pine Meadow Brook, and Fourmile Brook; however, it appeared that the barriers were attributable to natural phenomena, such as woody debris accumulation, sediment deposition, or seasonal flow characteristics, rather than to Project-related water level fluctuations. As the observed barriers appeared temporary and localized, it appears that Project operations do not substantially impact access to and habitat within the tributaries.

3.3.3.1.5.3 Power Canal

Water levels in the power canal are operated within a narrow elevation range, though flows can vary between full Project capacity and no flow. As such, habitat in the canal can change drastically with changes in operations. However, no specific habitat evaluations were performed in the canal, given that habitat would be more limited than other reaches of the Project areas, and the canal is primarily used as a migratory pathway for species such as American Shad and American Eel.

FirstLight performs week-long annual canal drawdowns to facilitate inspections and maintenance, typically during late September or early October. The Licensee conducted a canal drawdown study during the 2014 drawdown (Study No. 3.3.18 *Impacts of the Turners Falls Canal Drawdown on Fish Migration and Aquatic Organisms*). The Canal Drawdown report was filed with FERC on March 1, 2016 (FirstLight, 2015c).

A field survey was conducted in the lower portion of the canal during the 2014 drawdown to gain an understanding of the effects of the drawdown on aquatic species. Since the upper portion of the canal, just before it widens, remains wetted for the duration of the outage, the aquatic species survey was performed only in the lower portion of the canal, where it begins to widen along Migratory Way. The topography of the lower portion of the canal varies with large areas of silt deposits, areas of exposed bedrock, and areas with fines and cobble.

A survey was performed in the soft sediments in the lower portion of the power canal during the 2014 drawdown to document the presence of ammocoetes and to determine if the annual drawdown of the canal exposes Sea Lamprey burrowing substrate. Thirty-two 1 m x 1 m quadrats were sited within soft sediments and systematically searched for the presence of lamprey ammocoetes. The quadrat sampling was performed on the day immediately following the release of water from the canal (initial survey), as well as the day prior to rewatering. Of the 64 quadrats sampled (32 during initial survey and 32 during day-prior-to-rewatering survey), only 11 ammocoetes and one transformer (individuals transitioning from ammocoete to juvenile stage) were identified, all of which were alive. The lamprey specimens were all found buried in the substrate, which likely serves to prevent desiccation and support survival until the canal is refilled.

In addition to lamprey ammocoetes, quadrat sampling identified mudpuppies and two species of mussels, Eastern Elliptio and Alewife Floaters. Almost all mussels found were Eastern Elliptio (n=534); only one Alewife Floater was observed. Mussels tended to be concentrated at sites proximal to the canal's thalweg.

All mussels observed during the sampling events were alive, and 2 of the 3 mudpuppies observed were dead.

The pools that remain in the lower portion of the canal during the drawdown were sampled by electrofishing or seining. Twenty-two fish and one amphibian species were observed in the pools. Spottail Shiner, Tessellated Darter, and juvenile American Shad were the most abundant fish species observed. All fishes captured in the pools were alive at the time of collection, suggesting that observed mortalities at the time of sample processing were likely due to handling and temporary holding associated with sampling.

Based on results of the 2014 sampling effort, it appears that the annual drawdown has little effect on Connecticut River aquatic species. As the canal drawdown is initiated, the turbine bays at Cabot Station and Station No. 1, as well as various gates within the canal allow egress for fish. Canal geometry is such that the upper portion of the canal, just before it widens, remains wetted for the duration of the drawdown, and Keith's Tunnel is open with substantial flow through it during the duration of the drawdown. This area provides a refuge area for fishes that remain following the release of water from the lower canal. In addition, a series of pools remain in the lower portion of the canal that provide wetted habitat for fishes and mussels that remain trapped within the canal for the week-long drawdown. Although the size of some of the pools decreased over the course of the week spanning the drawdown, most of the pools (11 of the 14 identified) were observed to be hydraulically connected and allowed fish to progress downstream toward a larger pool upstream of the Cabot Station intake, which remained for the duration of the drawdown.

Results of the meander survey conducted in the lower portion of the canal during the 2014 drawdown revealed an estimated 766 fish, representing nine species, were stranded following release of the canal water. American Shad and sunfish species (e.g., Bluegill, Pumpkinseed, Largemouth Bass, and Rock Bass) accounted for nearly 50% of the observed stranded fishes. Overall, these results suggest minor impacts to Connecticut River fish populations, and the absence of freshly dead mussels suggests that the drawdown does not adversely affect Connecticut River mussel populations.

3.3.3.1.5.4 Bypass Reach and below Cabot Station

Flows in the bypass reach and downstream are important for several aquatic resources and are a major focus of FirstLight's proposal. As a major part of developing the proposed flow rates, FirstLight evaluated the habitat-flow relationships of key species such as American Shad and the federally listed SNS.

Per the FERC license, a continuous minimum flow of 200 cfs is maintained in the bypass reach starting on May 1 and increases to 400 cfs when fish passage starts by releasing flow through a bascule gate. The 400 cfs continuous minimum flow is provided through July 15, unless the upstream fish passage season has concluded early in which case the 400 cfs flow is reduced to 120 cfs to provide a zone of passage for Shortnose Sturgeon. The 120 cfs continuous minimum flow is maintained in the bypass reach from the date the fishways are closed (or by July 16) until the river temperature drops below 7°C, which typically occurs around November 15.

Under the current FERC license for the Turners Falls Project, a continuous minimum flow of 1,433 cfs or inflow, whichever is less below the Turners Falls Project. FirstLight typically maintains the minimum flow requirement through discharges at Cabot Station and/or Station No. 1.

FirstLight's proposal is substantially different, with seasonal bypass reach minimum flows of:

- 6,500 cfs, or the natural routed flow (NRF[9]), whichever is less, with 4,290 cfs from Turners Falls Dam and 2,210 from Station No. 1[1] from April 1 through May 31. Minimum proposed flows downstream of the Project during this period is 6,500 cfs, or the NRF, whichever is less.

[9] The Naturally Routed Flow= Vernon Project Discharge + Ashuelot River flow + Millers River flow. The Ashuelot and Millers Rivers are equipped with USGS gages.

- 4,500 cfs, or the NRF, whichever is less, with 2,990 cfs from Turners Falls Dam and 1,510 from Station No. 1[1] from June 1 through June 15. Minimum proposed flows downstream of the Project during this period is 6,800 cfs, or the NRF, whichever is less.
- 3,500 cfs, or the NRF, whichever is less, with 2,280 cfs from Turners Falls Dam and 1,220 from Station No. 1[1] from June 16 through June 30. Minimum proposed flows downstream of the Project during this period is 5,800 cfs, or the NRF, whichever is less.
- 1,800 cfs, or the NRF, whichever is less, with 670 cfs from Turners Falls Dam and 1,130 from Station No. 1[1] from July 1 through August 31. Minimum proposed flows downstream of the Project during this period is 1,800 cfs, or the NRF, whichever is less.
- 1,500 cfs, or the NRF, whichever is less, with 500 cfs from Turners Falls Dam and 1,000 from Station No. 1[1] from September 1 through November 30. Minimum proposed flows downstream of the Project during this period is 1,500 cfs, or the NRF, whichever is less.
- 1,500 cfs, or the NRF, whichever is less, with 300 cfs from Turners Falls Dam and 1,200 from Station No. 1[1] from December 1 through March 31. Minimum proposed flows downstream of the Project during this period is 1,500 cfs, or the NRF, whichever is less.

[1] The Turners Falls Hydro (TFH) project (FERC No. 2622) and Milton Hilton, LLC project (unlicensed) are located on the power canal and discharge into the bypass reach upstream of Station No. 1. The hydraulic capacity of the TFH project and Milton Hilton, LLC project is 289 and 113 cfs, respectively. If the TFH project is operating, FirstLight will reduce its Station No. 1 discharge by 289 cfs. If the Milton Hilton, LLC project is operating, FirstLight will reduce its Station No. 1 discharge by 113 cfs.

The proposed bypass flow regime would be implemented starting in Year 1 of the license, while other operational measures (flow regime below Cabot such as up- and down-ramping) would be implemented starting in Year 4.

In addition to the bypass flows and flow below Cabot Station, FirstLight is proposing to up- and down-ramp Cabot Station at 2,300 cfs/hour, 24 hours/day, from April 1 to May 31 to protect SNS.

FirstLight has conducted instream flow studies (Study No. 3.3.1 *Instream Flow Studies in Bypass Channel and below Cabot Station*) in the following locations: a) in the bypass reach from the Turners Falls Dam to the Montague USGS Gage, and b) from the USGS Gage to the Sunderland Bridge (below Cabot Station). In addition, in the reach between the Sunderland Bridge and the Dinosaur Footprints Reservation, a habitat assessment was conducted for state listed mussels.

Aquatic habitat suitability was evaluated using IFIM techniques developed by the National Ecology Research Center of the National Biological Survey (Bovee, 1982; Bovee, *et al*., 1998; Milhouse *et al*. 1989). These techniques included standard field procedures and Physical Habitat Simulation (PHABSIM) modeling. The IFIM quantifies habitat for selected species over a range of flows using habitat suitability index (HSI) criteria that are based on depth, velocity and substrate.

The study reaches identified in consultation with stakeholders were:

- Reach 1: Turners Falls Dam downstream to the tailrace of Station Number 1 (~0.75 miles)
- Reach 2: Tailrace of Station No. 1 downstream to Rock Dam (~1 mile)
- Reach 3: Rock Dam downstream to the confluence with the Deerfield River (including Cabot tailrace) near the Montague USGS stream flow gage (~1.5 miles)
- Reach 4: USGS Montague Gage downstream to Route 116 in Sunderland, MA (~9 miles)
- Reach 5: Sunderland Bridge downstream to Dinosaur Footprint Park (~22 miles)

Based on the results of literature reviews and consultation with stakeholders, HSI criteria were established for several target species and life stages identified in consultation with resource agencies.

In Reach 1 and Reach 2, a one-dimensional model was developed to predict changes in depth and velocity as discharge varies. In addition, a two-dimensional model was developed to simulate hydraulics in the lowermost extreme of Reach 2, and also Reach 3 (the vicinity of the Cabot Station tailrace, from the upstream end of Rawson Island downstream to just below the Deerfield River confluence). Data collected to calibrate the model, included hydraulic data, bed profiles, substrate and cover data, and velocity/current data. Reaches 4 and 5 were modeled using applicable one-dimensional modeling approaches.

A summary of the effects of flows on aquatic habitat in Reaches 1-4 are provided below for target species and life stages. Analyses in Reach 5 pertained only to state-listed mussel species and are included in Section 3.3.5 Threatened and Endangered Species. Additionally, an evaluation of the effects of the Project on SNS is included Section 3.3.5 Threatened and Endangered Species.

3.3.3.1.5.4.1 Fish Spawning and Early Life Stage Habitat

The Connecticut River below Turners Falls Dam is populated by several spring-spawning species, including American Shad, Fallfish, Sea Lamprey, White Sucker, Walleye, and the federally listed SNS. The effects of the Project on Shortnose Sturgeon habitat are evaluated Section 3.3.5 Threatened and Endangered Species. When river flows are within Project control (~<15,938 cfs), habitat amounts in the upper portions of the bypass reach are consistent with that provided by the current minimum flows, which is no minimum flow in April, 200 cfs starting May 1st, and 400 cfs during the fish passage season (Table 3.3.3.2.1.4.1-1). Proposed bypass flows for the spring are substantially higher than currently licensed. Absent spillage, fish species that begin pre-spawn staging and movements, along with those that begin spawning in April or May such as White Sucker, Walleye, and the federally endangered SNS will encounter substantially higher minimum flows under proposed conditions. However, this is a time when the Turners Falls Project is often spilling due to high flows. Additionally, proposed increases to bypass flows, and proposed flow splits between Turners Falls Dam and Station No. 1 are anticipated to increase the amount of spawning and early life stage habitat in the bypass reach for several species when river flows are within the hydraulic capacity of the Project to control (Table 3.3.3.2.1.4.1-1). Specifically, American Shad and Walleye spawning habitat amounts would increase substantially under FirstLight's proposal, with some benefits to White Sucker, Fallfish, and Sea Lamprey spawning as well. These increased flows do substantially reduce habitat suitability for various species of fry, especially White Sucker fry (Table 3.3.3.2.1.4.1-1). This is not surprising, since velocities that would typically support spawning are likely too high for most fry. Declines in habitat suitability in the bypass reach are not likely to result in declines in the populations of these species, however, given that fry of these species typically swim up in the water column and drift to downstream areas. Also, high natural spill flows in the bypass reach would result in limited suitable habitat for fry during most years. In these cases, fry could drift downstream and settle into suitable habitats in downstream reaches, as is consistent with their life history.

Reach 3 habitat is complex, given the interactions between bypass reach flows and Cabot Station flows. In general, higher Cabot Station flows backwater habitats to a greater degree up to the Rawson Island Complex and Rock Dam while higher bypass reach flows would result in swifter velocities in these areas, and more flow through the various channels around Smead Island. Proposed minimum flows are expected to provide benefits to several species in this reach (Table 3.3.3.2.1.4.1-2). However, Cabot Station generation also affects habitat. Descriptions of operational effects on fish habitats that include a combination of bypass reach minimum flows and Cabot Station generation include:

- American Shad – Spawning and adult habitat amounts are highest at a combination of high bypass and high generation flows, and lowest at low bypass and low generation flows (Figures 3.3.3.2.1.4.1-1 and 3.3.3.2.1.4.1-2). Proposed minimum bypass flows, and baseloading one Cabot Station unit in June (~2,300 cfs), would substantially increase the amounts of habitat relative to existing licensed conditions.

- Fallfish – Spawning habitat is highest at approximately 1,000 cfs bypass flows and 6,000 cfs at Cabot Station (Figure 3.3.3.2.1.4.1-3). Fry habitat exhibits a similar pattern with flow (Figure 3.3.3.2.1.4.1-4). Current minimum bypass reach flows would provide lower amounts of these habitats at low and high Cabot Station flows. Higher proposed bypass flows will result in the greatest amount of fallfish spawning and fry habitat at low Cabot Station flows, with decreasing habitat amounts with increasing Cabot Station flows.
- White Sucker – Spawning habitat is relatively limited compared to the other species that could spawn in Reach 3. The greatest amounts of spawning habitat would be available at approximately 3,500 cfs and limited to no flow from Cabot Station (Figure 3.3.3.2.1.4.1-5). Higher proposed bypass flows would result in less habitat at higher Cabot Station flows than under current minimum flow conditions. Fry habitat is less affected by Cabot Station, but will be substantially lower at higher proposed bypass flows (Figure 3.3.3.2.1.4.1-6). However, there would still be relatively high amounts of habitat (> 1,000,000 ft^2) for fry at all Cabot Station and bypass reach flows.
- Walleye – Spawning habitat is highest between 6,000-8,000 cfs bypass reach flows coupled with 2,000-4,500 cfs generation flows from Cabot Station (Figure 3.3.3.2.1.4.1-7). Proposed higher bypass reach flows will increase the amount of spawning habitat for Walleye substantially, and across all Cabot Station flows. Alternatively, the amount of habitat available for Walleye fry is expected to be reduced by higher proposed bypass reach flows, given that the greatest amount of fry habitat is available at the combination of very low bypass reach flows and moderate to high Cabot Station generation flows (Figure 3.3.3.2.1.4.1-8).
- Sea Lamprey – Spawning habitat is highest at a combination of high bypass reach flows and high Cabot Station generation flows (Figure 3.3.3.2.1.4.1-9). Proposed minimum bypass flows, and base loading one Cabot Station unit in June, would substantially increase the amounts of habitat relative to existing licensed conditions.
- Shortnose Sturgeon – Spawning and rearing habitat for Shortnose Sturgeon in Reach 3 is complex and is evaluated in detail in the draft BA. Overall, the proposed bypass reach flows are expected to provide high amounts of spawning habitat in Reach 3, and the proposed downstream minimum flows that extend through June would provide high amounts of habitat for sturgeon eggs/embryos. The downstream minimum flows also protect shoal areas below the Project, where sturgeon eggs/embryos could be present, from becoming dewatered.

Reach 4 is nine miles long and covers a relatively large area. Depending on inflow, flows in Reach 4 in the spring can vary between the current minimum capacity of 1,433 cfs and considerably high flows above the Project capacity, plus flows from the Deerfield River. When flows are low, under the baseline minimum flow of approximately 1,433 cfs, there are relatively large amounts of habitat for several spring spawning species and early life stages, particularly SNS fry, White Sucker Fry, American Shad adults, American Shad spawning, Fallfish fry, and Fallfish spawning/incubation (Figure 3.3.3.2.1.4.1-10; Table 3.3.3.2.1.4.1-3). The higher minimum flows that are proposed during the spring spawning period would yield substantially greater amounts of suitable habitat for American Shad (spawning and adults), and Walleye (spawning and fry) (Figure 3.3.3.2.1.4.1-10; Table 3.3.3.2.1.4.1-2). The proposed minimum flows would, however, result in substantially less habitat for the applicable springtime life stages of White Sucker and Fallfish, with a slight reduction in Sea Lamprey spawning habitat (Table 3.3.3.2.1.4.1-1). This reduction in habitat may not apply much of the time, given that typical springtime flow rates are often higher than the current minimum flow.

Operating Cabot Station to meet peak demand would typically result in a range of flows that occur each day. When flows are within the hydraulic capacity of the Project to control, but with enough flow to operate at maximum generation capacity, habitat for most spring-spawning species would decline with increasing flow, except for American Shad (Figure 3.3.3.2.1.4.1-10). This pattern is similar for baseline and proposed conditions. However, for proposed operations, the day-to-day operational range will often be constrained due to a combination of increases in minimum flows, baseloading of a Cabot Station unit, and up- and down-ramping rate restrictions. Thus, the full range of daily Project flows would not always occur.

Table 3.3.3.2.1.4.1-1: Area of Suitable Habitat for Spring Spawning Species in the Upper Portions of the Bypass Reach

Species	Lifestage	Months Present	Area of Suitable Habitat in Reaches 1 & 2 at Minimum Flows (square feet)					
			Baseline Operations			Proposed Operations		
			April	May 1 to Passage Season*	Passage Season*	April-May	June 1-15	June 16-30
Shortnose Sturgeon	Spawning	April-May	-	255,439	419,106	1,305,646	-	-
Shortnose Sturgeon	Egg/Embryo	April-June	-	923,087	1,232,100	3,377,958	3,349,794	3,312,290
American Shad	Spawning/Incu	May-June	-	-	489,293	2,034,085	1,755,374	1,528,867
American Shad	Adult	May-June	-	-	462,866	1,594,864	1,305,009	1,109,372
Fallfish	Spawn/Incu	May-June	-	18,742	18,685	26,523	39,116	43,561
Fallfish	Fry	May-June	-	98,462	104,430	39,467	60,207	80,216
Walleye	Spawning/Incu	April-May	-	60,745	109,930	598,732	-	-
Walleye	Fry	April-May	-	15,682	17,284	10,928	-	-
White Sucker	Spawn/Incu	April-May	-	1,201	1,540	6,646	-	-
White Sucker	Fry	May-June	-	1,066,876	1,130,971	144,251	267,442	514,838
Sea Lamprey	Spawning	May-June	-	-	142,700	221,785	253,167	257,610

Note: Habitat amounts are approximate, based on models nearest to the actual flow rates, and averaged models for certain flow rates, from Study No. 3.3.1. For baseline operations, there are currently no minimum flows in April. Zero flow in the bypass reach was not modeled as part of relicensing studies. Habitat increases for the proposed condition are depicted in blue.

**The Connecticut River Atlantic Salmon Commission establishes an annual schedule for the operation of upstream fish passage facilities at the Connecticut River dams. Therefore, the exact dates of the "Passage Season" may vary from year-to-year but would typically start in May.*

Table 3.3.3.2.1.4.1-2: Minimum Area of Suitable Habitat for Spring Spawning Species in Reach 3

Species	Life Stage	Months Present	Minimum Area of Suitable Habitat in Reach 3 at Minimum Flows (square feet)					
			Existing Operations			Proposed Operations		
			April	May 1 to Passage Season*	Passage Season*	April-May	June 1-15	June 16-30
Shortnose Sturgeon	Spawning	April-May	-	42,978	54,406	143,820	-	-
Shortnose Sturgeon	Egg/Embryo	April-June	-	132,194	144,436	228,194	232,809	229,583
American Shad	Spawning/Incu	May-June	-	-	902,050	1,981,674	1,925,569	1,767,126
American Shad	Adult	May-June	-	-	1,302,531	2,300,221	2,307,139	2,139,341
Fallfish	Spawn/Incu	May-June	-	220,742	231,305	104,886	147,397	179,481
Fallfish	Fry	May-June	-	316,767	326,356	162,598	199,993	227,006
Walleye	Spawning/Incu	April-May	-	277,669	332,559	572,221	-	-
Walleye	Fry	April-May	-	140,889	128,886	120,472	-	-
White Sucker	Spawn/Incu	April-May	-	11,420	14,815	25,131	-	-
White Sucker	Fry	May-June	-	1,946,281	1,849,393	994,909	11,180,965	1,204,539
Sea Lamprey	Spawning	May-June	-	-	270,872	1,108,106	975,092	840,598

Note: Habitat amounts are approximate, based on models nearest to the actual flow rates, and averaged models for certain flow rates, from Study No. 3.3.1. For baseline operations, there are currently no minimum flows in April. Zero flow in the bypass reach was not modeled as part of relicensing studies. Habitat increases for the proposed condition are depicted in blue.

**The Connecticut River Atlantic Salmon Commission establishes an annual schedule for the operation of upstream fish passage facilities at the Connecticut River dams. Therefore, the exact dates of the "Passage Season" may vary from year-to-year but would typically start in May.*

Table 3.3.3.2.1.4.1-3: Area of Suitable Habitat for Spring Spawning Species in Reach 4 (Downstream Areas)

Species	Life Stage	Months Present	Area of Suitable Habitat in Reach 4 at Minimum Flows (square feet)			
			Baseline	Proposed		
			Minimum Flow	April-May	June 1-15	June 16-30
Shortnose Sturgeon	Fry	May-June	12,314,447	16,128,365	16,056,977	16,257,214
American Shad	Spawning/Incu	May-June	7,169,286	12,879,109	13,013,709	12,595,627
American Shad	Adult	May-June	14,884,729	24,336,843	24,569,327	23,822,383
Fallfish	Spawn/Incu	May-June	4,230,052	1,508,510	1,388,633	1,767,075
Fallfish	Fry	May-June	6,682,346	1,938,259	1,832,162	2,171,864
Walleye	Spawning/Incu	April-May	1,634,274	2,394,329	-	-
Walleye	Fry	April-May	781,469	849,060	-	-
White Sucker	Spawn/Incu	April-May	647,509	65,312	-	-
White Sucker	Fry	May-June	15,488,036	6,432,174	6,308,923	6,658,176
Sea Lamprey	Spawning	May-June	5,561,317	4,446,423	4,189,692	4,725,831

Note: Habitat amounts are approximate, based on models nearest to the actual flow rates, and averaged models for certain flow rates, from Study No. 3.3.1. Habitat increases for the proposed condition are depicted in blue. Shortnose Sturgeon spawning and rearing are not known to occur in this reach, but sturgeon fry is a critical life stage that drifts into this reach from areas near and above Cabot Station.

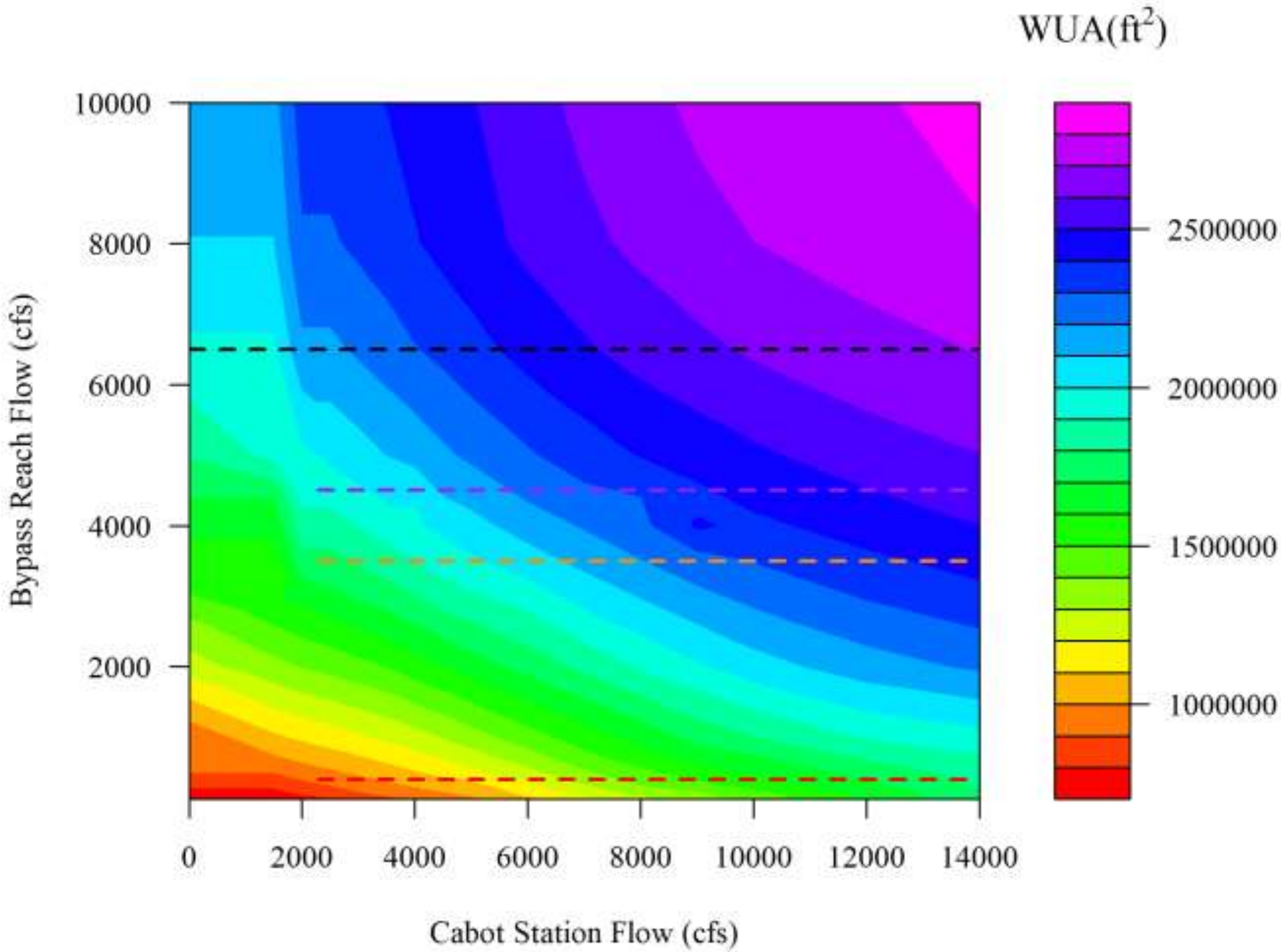

Figure 3.3.3.2.1.4.1-1: American Shad Spawning Habitat for Minimum Bypass Flows and Ranges of Cabot Station Operation in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is the current minimum flow during the fish passage season. The black dotted line indicates proposed operations in April/May, the purple dotted line indicates proposed operations in early June, and the yellow dotted line indicates proposed operations in late June.

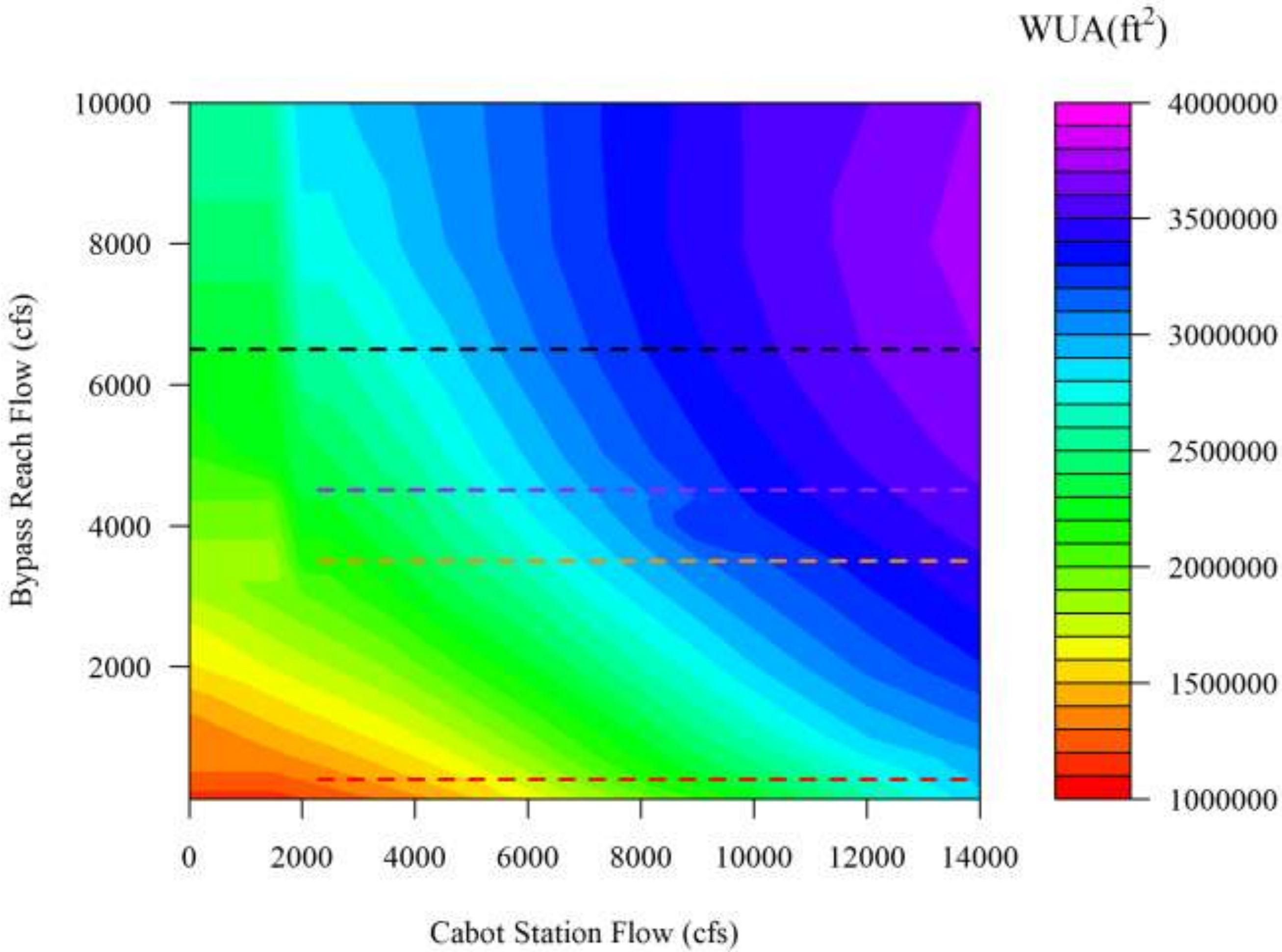

Figure 3.3.3.2.1.4.1-2: American Shad Adult Habitat for Minimum Bypass Flows and Ranges of Cabot Station Operation in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is the current minimum flow during the fish passage season. The black dotted line indicates proposed operations in April/May, the purple dotted line indicates proposed operations in early June, and the yellow dotted line indicates proposed operations in late June.

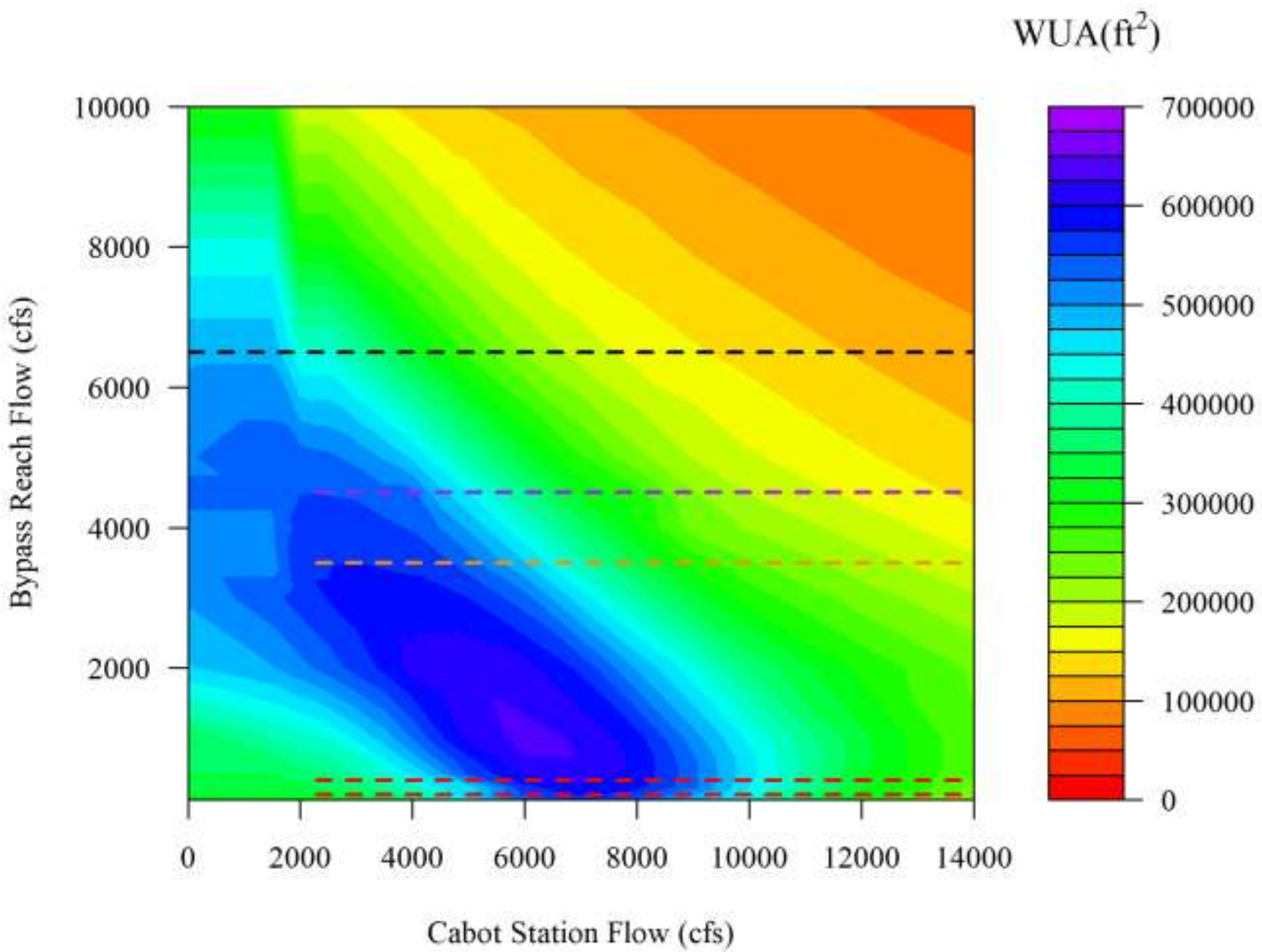

Figure 3.3.3.2.1.4.1-3: Fallfish Spawning Habitat for Minimum Bypass Flows and Ranges of Cabot Station Operation in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is the current minimum flow during the fish passage season. The black dotted line indicates proposed operations in April/May, the purple dotted line indicates proposed operations in early June, and the yellow dotted line indicates proposed operations in late June.

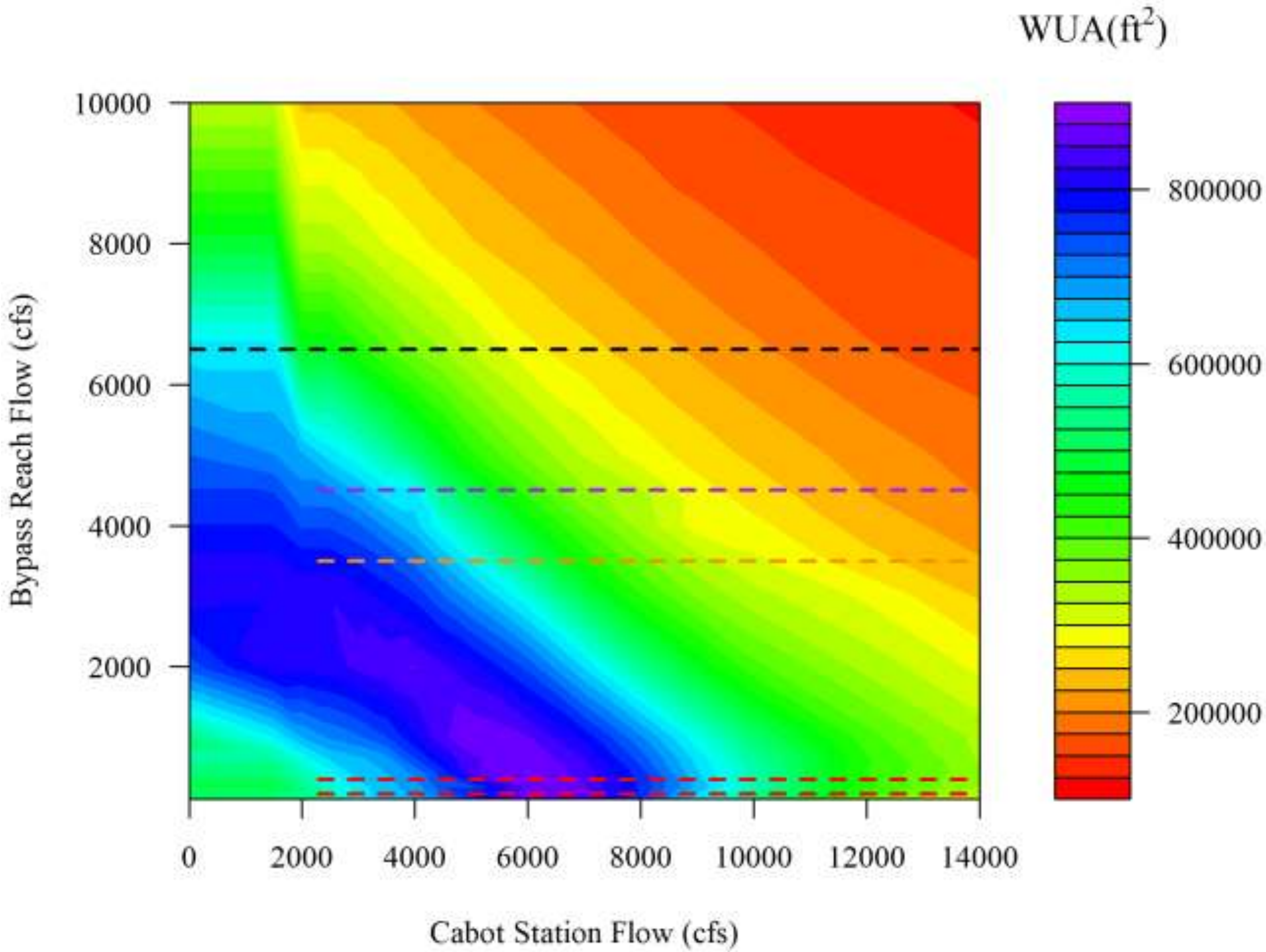

Figure 3.3.3.2.1.4.1-4: Fallfish Fry Habitat for Minimum Bypass Flows and Ranges of Cabot Station Operation in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is the current minimum flow during the fish passage season. The black dotted line indicates proposed operations in April/May, the purple dotted line indicates proposed operations in early June, and the yellow dotted line indicates proposed operations in late June.

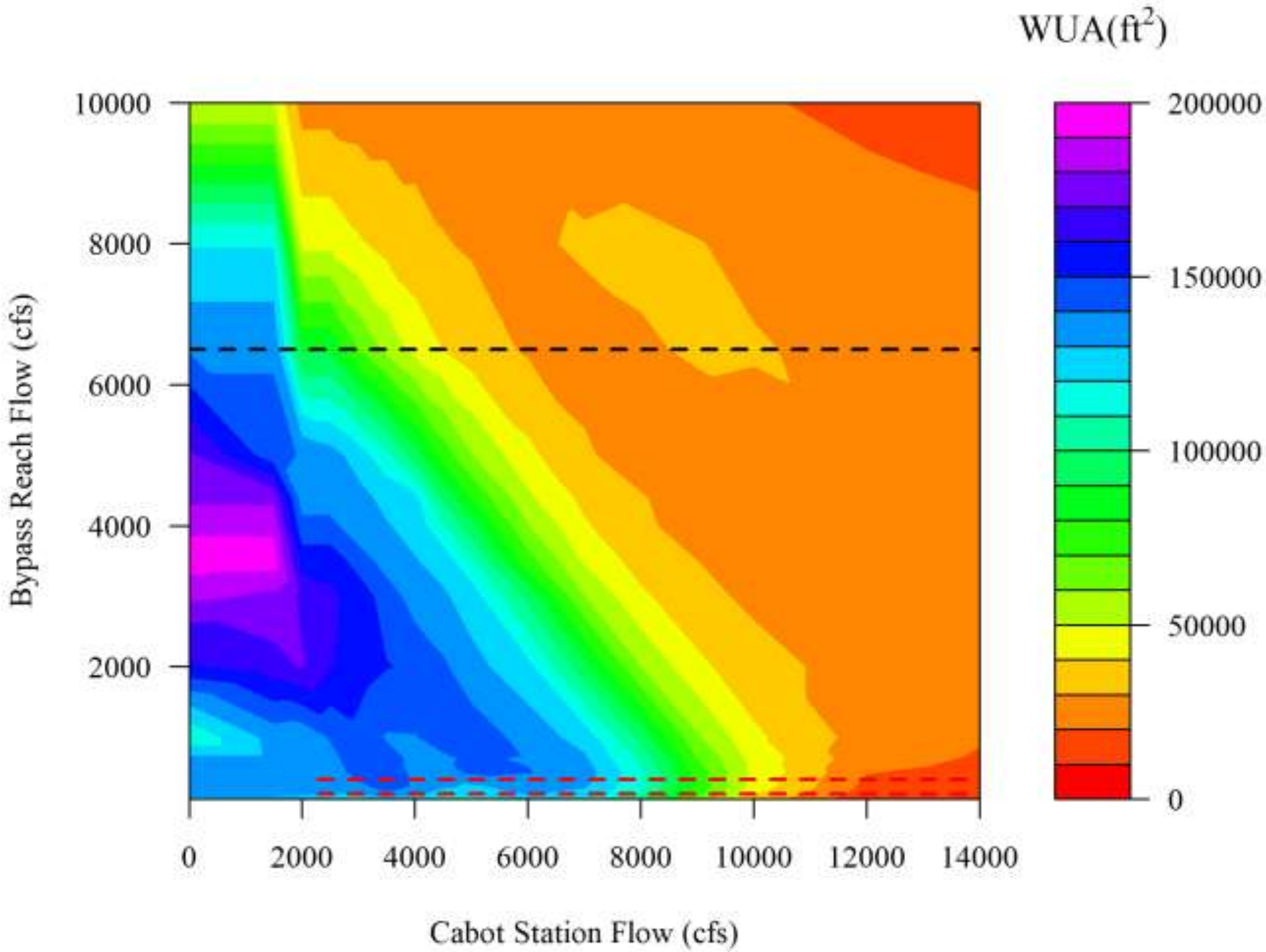

Figure 3.3.3.2.1.4.1-5: White Sucker Spawning Habitat for Minimum Bypass Flows and Ranges of Cabot Station Operation in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted lines are the current minimum flows during the April/May time period. The black dotted line indicates proposed operations in April/May.

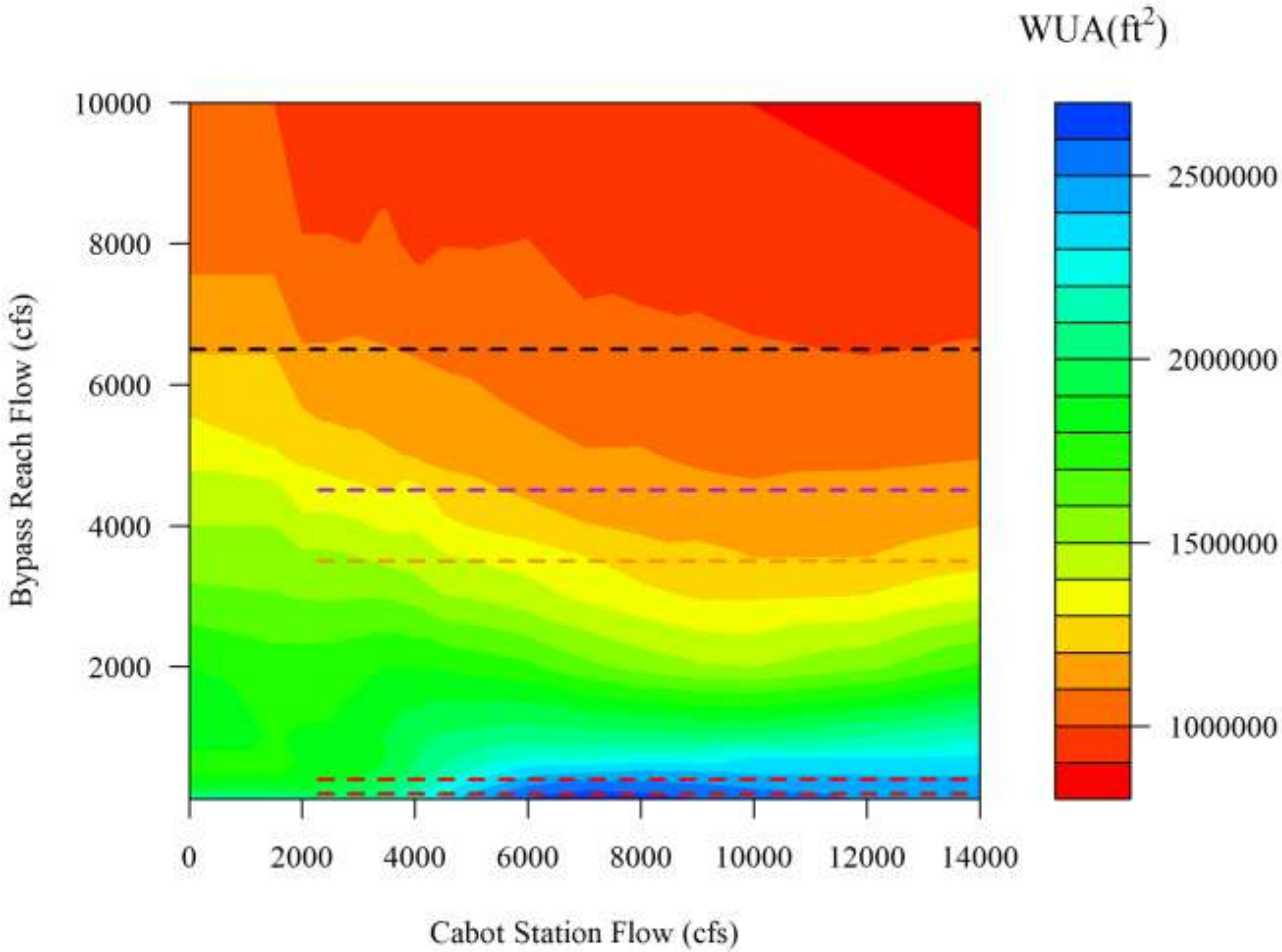

Figure 3.3.3.2.1.4.1-6: White Sucker Fry Habitat for Minimum Bypass Flows and Ranges of Cabot Station Operation in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted lines are the current minimum flows during the April/May time period. The black dotted line indicates proposed operations in April/May.

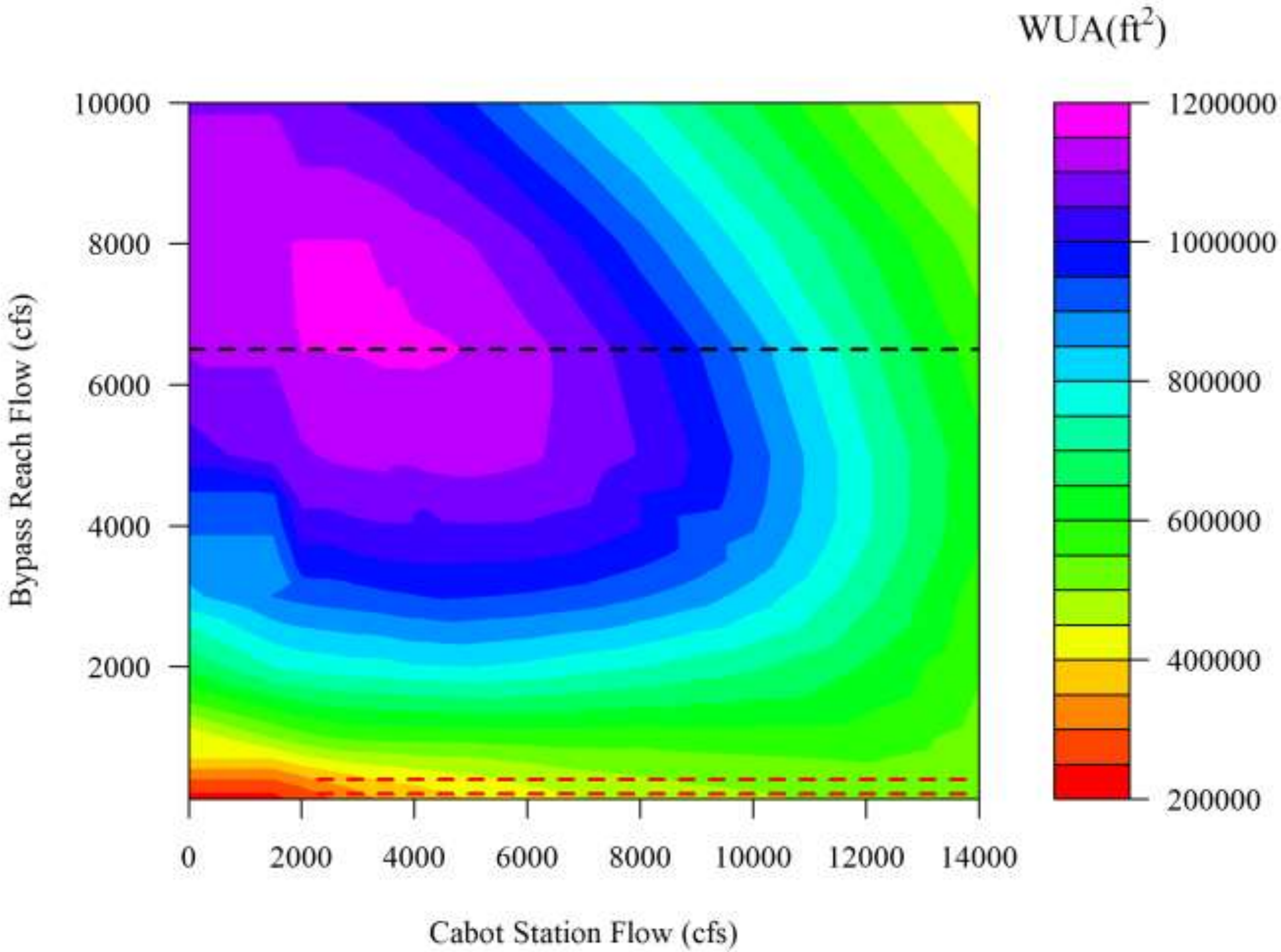

Figure 3.3.3.2.1.4.1-7: Walleye Spawning Habitat for Minimum Bypass Flows and Ranges of Cabot Station Operation in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted lines are the current minimum flows during the April/May time period. The black dotted line indicates proposed operations in April/May.

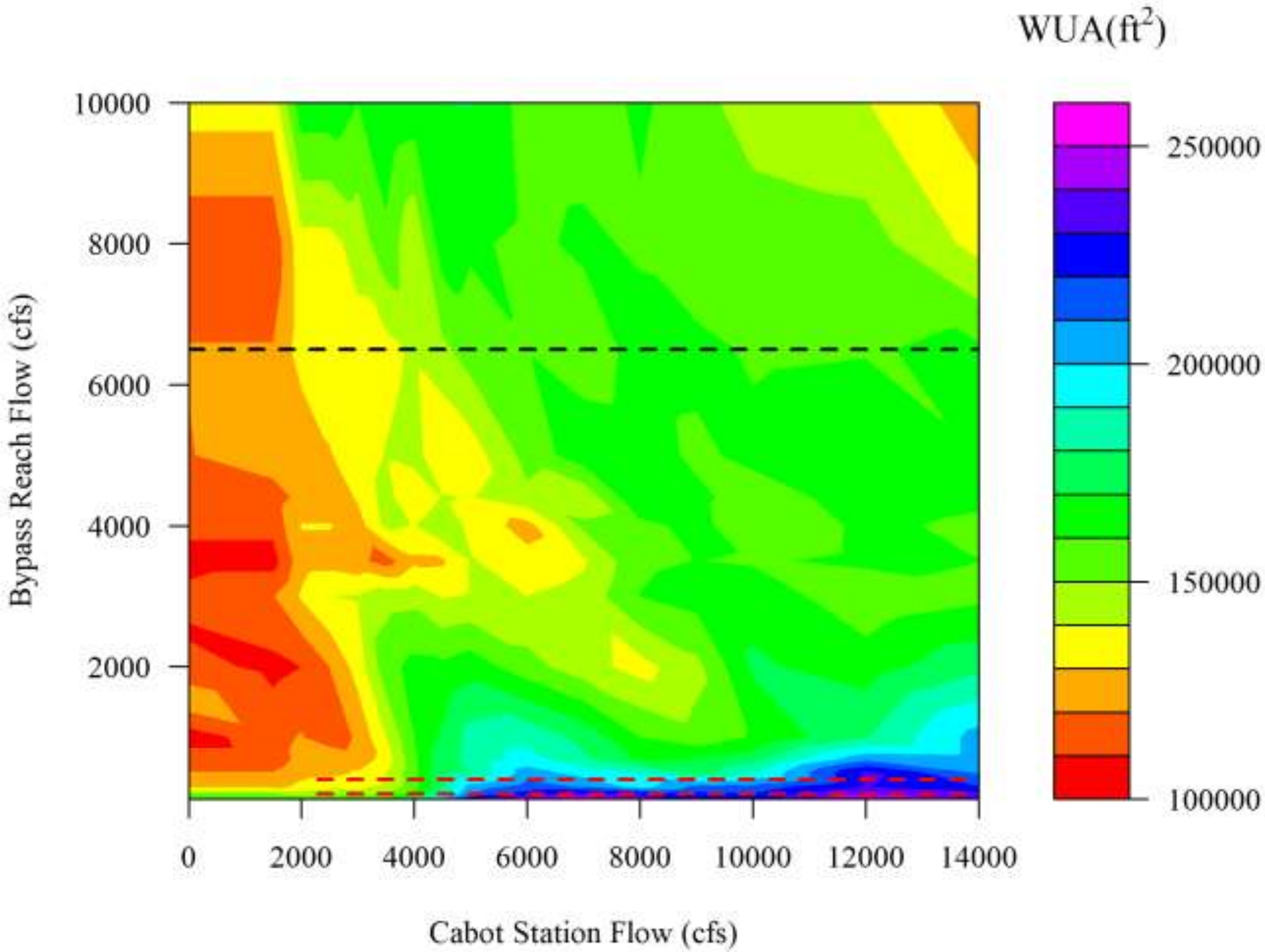

Figure 3.3.3.2.1.4.1-8: Walleye Fry Habitat for Minimum Bypass Flows and Ranges of Cabot Station Operation in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is the current minimum flow during the fish passage season. The black dotted line indicates proposed operations in April/May, the purple dotted line indicates proposed operations in early June, and the yellow dotted line indicates proposed operations in late June.

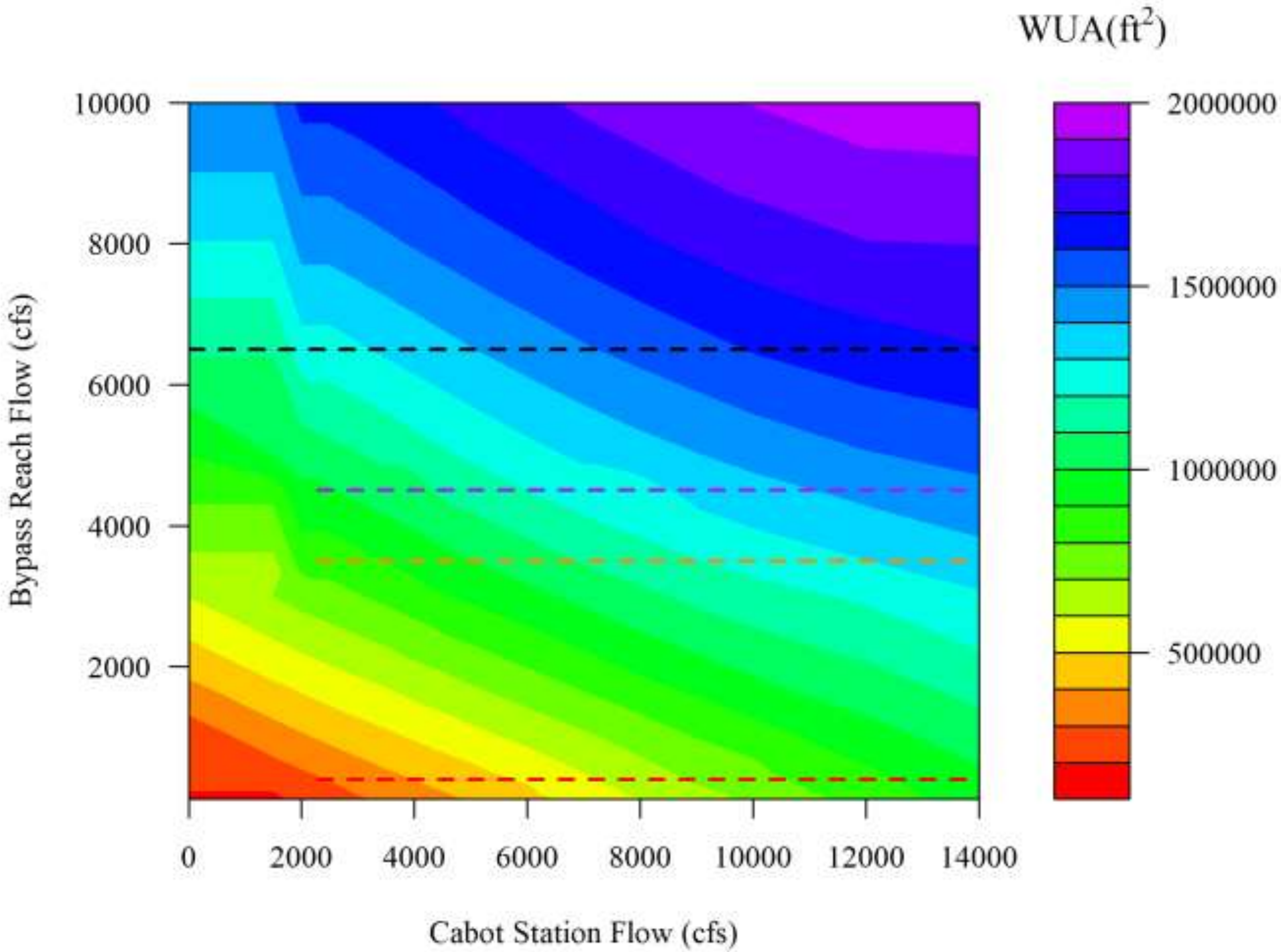

Figure 3.3.3.2.1.4.1-9: Sea Lamprey Spawning Habitat for Minimum Bypass Flows and Ranges of Cabot Station Operation in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is the current minimum flow during the fish passage season. The black dotted line indicates proposed operations in April/May, the purple dotted line indicates proposed operations in early June, and the yellow dotted line indicates proposed operations in late June.

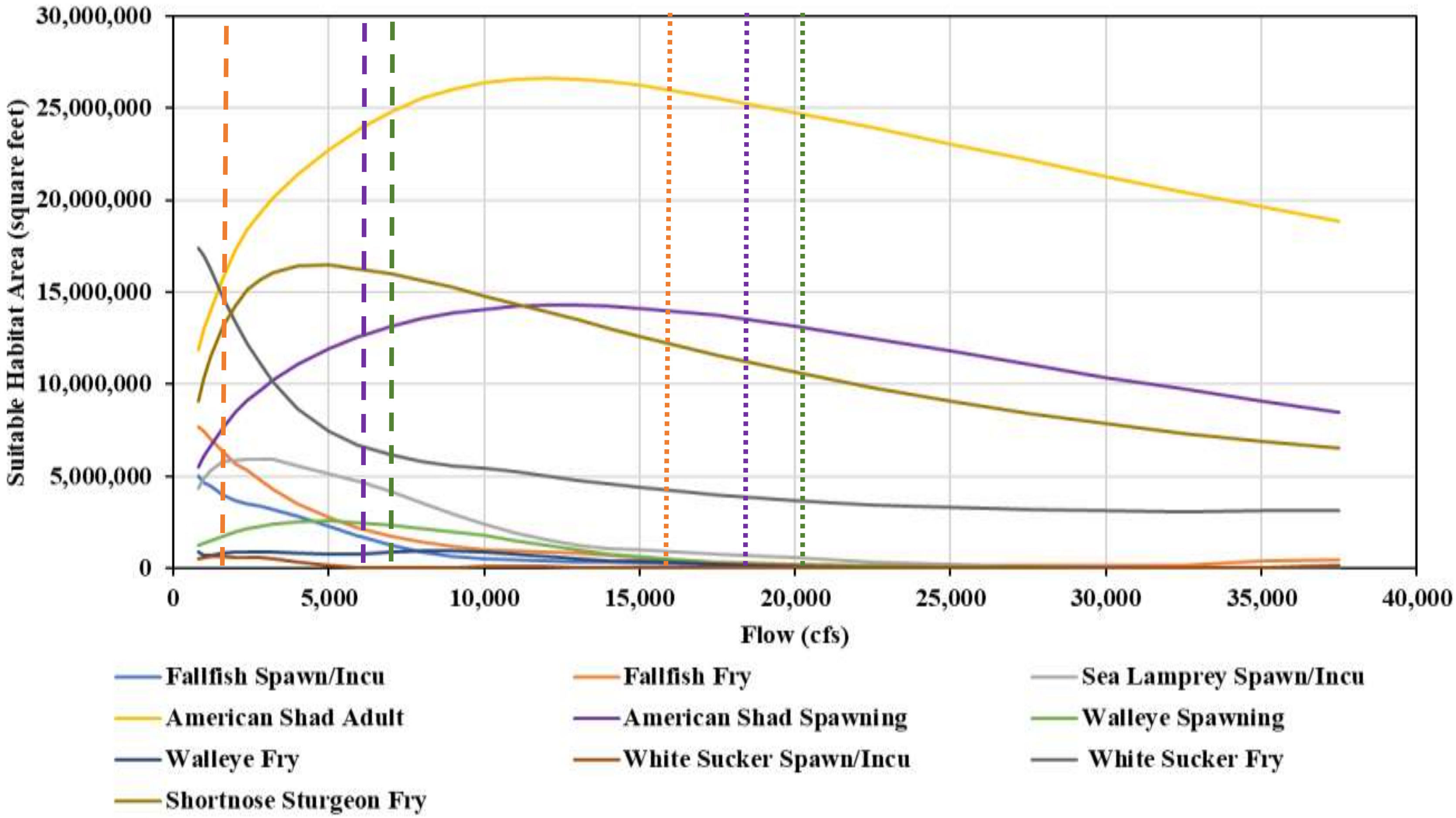

Figure 3.3.3.2.1.4.1-10: Spring Spawning/Rearing Habitat at Minimum Flows in Reach 4

Notes: Deerfield flows are not included, but could add between 200-1,445 cfs at flows within the control of Deerfield Station No. 2

The vertical dashed orange line is the current minimum flow (1,433 cfs), the vertical dashed blue line is the approximate proposed minimum flows below the Project from April through mid-June (6,500-6,800 cfs), and the vertical dashed purple line is the approximate proposed minimum flow in the second half of June (5,800 cfs). For flows within Project control, and based on combined minimum spill and maximum generation capacity, the vertical dotted orange line is the current maximum peak flow from the Project (16,338 cfs), the vertical dotted green line is the proposed maximum peak flow in April/May (20,228 cfs) and the vertical dotted purple line is the approximate proposed maximum peak flow in June (18,928 cfs in early June, 18,218 cfs in late June).

3.3.3.1.5.4.2 Effects of Operations on Sea Lamprey Redds

At no time were any of the 29 Sea Lamprey redds dewatered during the 2015 study period. Sea Lamprey die after spawning, and the same exact locations will not necessarily be used each year by other Sea Lamprey. Spawning locations chosen by Sea Lamprey could vary depending on the flow conditions encountered and the amount of habitat provided to Sea Lamprey would be consistent with the IFIM results.

Redds in the Fall River near the Turners Falls Dam

During the 2015 field study associated with Study Report 3.3.15, one redd location was observed in the Fall River, upstream of the confluence with the Connecticut River. Fall River enters Reach 1 of the Bypass Reach, just below the Turners Falls Dam. During the field study it was determined that this area is only affected by backwater during substantial spillage from Turners Dam, which occurs when river flows are above the Project's capacity to control.

Redds at the Hatfield S Curve below the Turners Falls Project

Transect and depth information of the redd location at the Hatfield S Curve about 15 miles downstream of Cabot Station is limited as described in the Study 3.3.15. As such, a habitat versus flow model was not developed for this specific area. However, this area is within Reach 4, which was evaluated as part of Relicensing Study 3.3.1 (see Section 3.3.3.2.1.4.1).

3.3.3.1.5.4.3 Effects of Operational Changes on Spawning American Shad

American Shad are broadcast, batch spawners and eggs are semi-buoyant, drifting downstream with river currents before settling to the bottom (Stira, 1976 as cited in Savoy *et al.*, 2004). This suggests that effects on spawning habitat would not necessarily impact egg deposition.

Throughout the 2015 study period, shad spawning areas comprised approximately 106 acres in the downstream reach between Cabot Station and the Route 116 Bridge. Based on the changes in Cabot Station generation that were assessed (increasing and decreasing generation by 1 and 2 units), the surface areas of the downstream spawning sites exhibited little to no changes, with an estimated maximum decrease in spawning area of 2% at Site 10. Layzer (1974) reported that although water levels fluctuated up to 6 ft throughout the 1972 spawning period, with corresponding changes in water velocity, shad continued to spawn at these sites. It should be noted that Cabot Station and Station No. 1 have no ability to regulate flow when Montague Gage readings exceed approximately 18,000 cfs as this represents the hydraulic capacity of the power canal.

WSEL, velocity and depth at the spawning sites were affected by flows from the Turners Falls Project; when flows were higher, WSEL, velocity, and depths were also higher. Depths of the spawning areas varied at the times of observation as well as throughout the spawning period. Measured depths at spawning locations, which were typically recorded closer to the banks, ranged from 5.5 to 9.5 ft and modeled mean channel depths were estimated to range from 7.0 to 25.2 ft at the downstream spawning sites. With previous research documenting spawning at a variety of depths, it is likely that depth is not a critical factor in site selection for spawning shad. Stier and Crance (1985) indicate the optimum depth range for all life stages (spawning, egg, incubation, larvae, and juvenile) is approximately 4.9 to 20 ft.

Physical habitat variables, such as depth, velocity, and substrate vary longitudinally and laterally within rivers, and spawning was documented at a wide range of physical conditions, including flow changes. Photoperiod and time since sunset were found to be more influential on spawning activity than physical changes at spawning sites related to Project operations. American Shad appeared to spawn over large areas, both longitudinally and laterally, often encompassing a range of conditions. Further, given natural variability in river flows, the locations that shad choose to spawn can vary from year-to-year.

3.3.3.1.5.4.4 Juvenile Shad, Resident Fish, Guilds, and Benthic Macroinvertebrates

During the summer and fall low flow periods, current minimum flows in the bypass reach of 120 cfs, from the end of fish passage season (or July 16) until water temperatures fall below 7°C (typically mid-November) provides habitat for various species and life stages of fish and aquatic macroinvertebrates in the upper portion of the bypass reach. Proposed flows in the bypass reach (1,800 cfs with 670 cfs from Turners Falls Dam in July/August and 1,500 cfs with 500 cfs from Turners Falls Dam in September through November) would substantially increase the amount of habitat for nearly all species and life stages in Reaches 1 and 2 evaluated during this period (Table 3.3.3.2.1.4.4-1). The only species that would not benefit from the proposed minimum flows in Reaches 1 and 2 of bypass reach is Walleye, for which suitable habitat amounts for adult Walleye would be approximately 40-45% less than for the baseline condition.

Reach 3 habitat is complex, given the interactions between bypass reach flows and Cabot Station flows. In general, higher Cabot Station flows backwater habitats to a greater degree up to the Rawson Island Complex and Rock Dam while higher bypass reach flows would result in swifter velocities of these areas, and more flow through the various channels around Smead Island. When river flows are within the capacity of the Turners Falls Project to control, Project operations could affect juvenile American Shad and several resident aquatic species, including:

- American Shad – Juvenile American Shad habitat is highest between 1,500-3,000 cfs bypass flows, when combined with high (10,000 cfs or more) generation at Cabot Station (Figure 3.3.3.2.1.4.4-1). Proposed higher bypass flow rates in the summer and fall will provide more habitat to juvenile American Shad at the range of Cabot Station generation flows.
- Fallfish – Adult Fallfish habitat is highest at approximately 1,000 cfs bypass flows, when combined with relatively high (8,000 cfs or more) generation at Cabot Station (Figure 3.3.3.2.1.4.4-2). Proposed higher bypass flow rates in the summer and fall will provide more habitat to adult Fallfish at the range of Cabot Station generation flows. Juvenile Fallfish habitat is highest at between approximately 300-2,000 cfs bypass flows, when combined with moderate (5,000-9,000 cfs) generation at Cabot Station (Figure 3.3.3.2.1.4.4-3). Proposed higher bypass flow rates in the summer and fall will provide more habitat to juvenile Fallfish at the range of Cabot Station generation flows.
- Longnose Dace – Adult Longnose Dace habitat is highest at approximately 2,000 cfs bypass flows, when combined with relatively low (6,000 cfs or less) generation at Cabot Station (Figure 3.3.3.2.1.4.4-4). Proposed higher bypass flow rates in the summer and fall will provide more habitat to adult Longnose Dace at the range of Cabot Station generation flows, with the greatest improvement at Cabot Station flows less than 8,000 cfs. Juvenile Longnose Dace habitat area is more limited in Reach 3, though habitat versus flow relationships are similar to adults; similarly, some improvements are expected under the range of Cabot Station flows for proposed conditions (Figure 3.3.3.2.1.4.4-5).
- Tessellated Darter – Tessellated Darter habitat is highest at approximately 2,000 cfs bypass flows, when combined with 2,000 cfs generation at Cabot Station (Figure 3.3.3.2.1.4.4-6). Proposed higher bypass flow rates in the summer and fall will provide slightly more habitat to Tessellated Darter at the range of Cabot Station generation flows, particularly when Cabot Station is generating between 2,000 and 4,000 cfs.
- Walleye – Adult Walleye habitat is highest at low (~400 cfs) bypass reach flows and maximum Cabot Station generation (Figure 3.3.3.2.1.4.4-7). As such, proposed increases to bypass reach flow rates is expected to decrease the amount of habitat available to adult Walleye, though the amount of habitat would remain above 300,000 ft^2 under all generation conditions. Juvenile Walleye habitat area is more limited in Reach 3, though habitat versus flow relationships are similar to adults;

similarly, decreases in habitat are expected under the range of Cabot Station flows for proposed conditions (Figure 3.3.3.2.1.4.4-8).

- White Sucker – Adult/Juvenile White Sucker habitat is highest within narrow flow ranges at low (~500 cfs) bypass reach flows and moderate to high Cabot Station generation (7,000-11,000 cfs) (Figure 3.3.3.2.1.4.4-9). Proposed increases to bypass reach flow rates are expected to provide a similar amount of habitat available to White Sucker.
- Macroinvertebrates – Macroinvertebrate habitat in Reach 3 is affected more by bypass flows than Cabot Station generation, with increases in habitat at higher bypass reach flows (Figure 3.3.3.2.1.4.4-10). Proposed increases in bypass flows would therefore provide more habitat to macroinvertebrates during the summer and fall low flow period.
- Shallow-Slow Guild – Habitat for the Shallow-Slow Guild is greatest at bypass flows of less than 1,000 cfs combined with 3,000-7,000 cfs generation flows from Cabot Station (Figure 3.3.3.2.1.4.4-11). Proposed increases to bypass reach flows are expected to slightly decrease the amount of habitat for species within this guild.
- Shallow-Fast Guild – Habitat for the Shallow-Fast Guild is greatest at bypass flows of less than 2,000 cfs combined with 4,000-7,000 cfs generation flows from Cabot Station (Figure 3.3.3.2.1.4.4-12). Proposed increases to bypass reach flows are expected to provide a similar amount of habitat for species within this guild.
- Deep-Slow Guild – Habitat for the Deep-Slow Guild is greatest at bypass flows of less than 1,000 cfs combined with high (more than 7,000 cfs) generation flows from Cabot Station (Figure 3.3.3.2.1.4.4-13). Proposed increases to bypass reach flows are expected to provide less habitat for species within this guild, though overall habitat amounts would remain high, at above 1,400,000 ft^2 at all Cabot Station flows.
- Deep-Fast Guild – Habitat for the Deep-Fast Guild is greatest at bypass flows of 4,000 cfs combined with moderate amounts of generation flow from Cabot Station (Figure 3.3.3.2.1.4.4-14). Proposed increases to bypass reach flows are expected to provide more habitat for species within this guild.

Because the minimum flows below Cabot Station would not be considerably different than current conditions, low flow habitat conditions below Cabot Station in Reach 4 would be similar for the various species and life stages evaluated (Figure 3.3.3.2.1.4.4-15). Additionally, reductions in habitat for most species during Cabot Station peaking conditions would occur in a similar manner under proposed conditions as currently, given that the overall capacity of the Project would not have changed considerably. For example, the current capacity of the Project, including minimum bypass flows, is 16,058 cfs whereas the proposed capacity during the summer would be 16,608 cfs (670 cfs from Turners Falls Dam, 2,210 cfs from Station No. 1, and 13,728 cfs from Cabot Station).

Table 3.3.3.2.1.4.4-1: Area of Suitable Habitat for Fish Species the Bypass Reach during Summer/Fall

Species	Lifestage	Months Present	Area of Suitable Habitat in Reaches 1 & 2 at Minimum Flows (square feet)		
			Baseline	Proposed	
			July-Nov	July-August	Sept-Nov
American Shad	Juvenile	June-Oct	454,252	1,395,470	1,285,773
Fallfish	Juvenile	Year Round	312,914	741,635	690,959
Fallfish	Adult	Year Round	554,982	1,191,536	1,221,745
Longnose Dace	Juvenile	Year Round	125,890	329,355	266,447
Longnose Dace	Adult	Year Round	180,939	600,235	483,130
White Sucker	Adult/Juvenile	Year Round	364,156	589,979	690,899
Walleye	Juvenile	Year Round	10,897	11,844	11,865
Walleye	Adult	Year Round	100,504	54,960	60,228
Tessellated Darter	Adult/Juvenile	Year Round	66,938	244,305	191,878
Macroinvertebrates	Larvae	Year Round	96,841	777,118	552,044
Shallow Slow	Shallow Slow	Year Round	623,916	1,494,525	1,529,471
Shallow Fast	Shallow Fast	Year Round	262,058	820,671	691,944
Deep Slow	Deep Slow	Year Round	786,435	1,128,612	1,418,195
Deep Fast	Deep Fast	Year Round	44,388	334,433	272,511

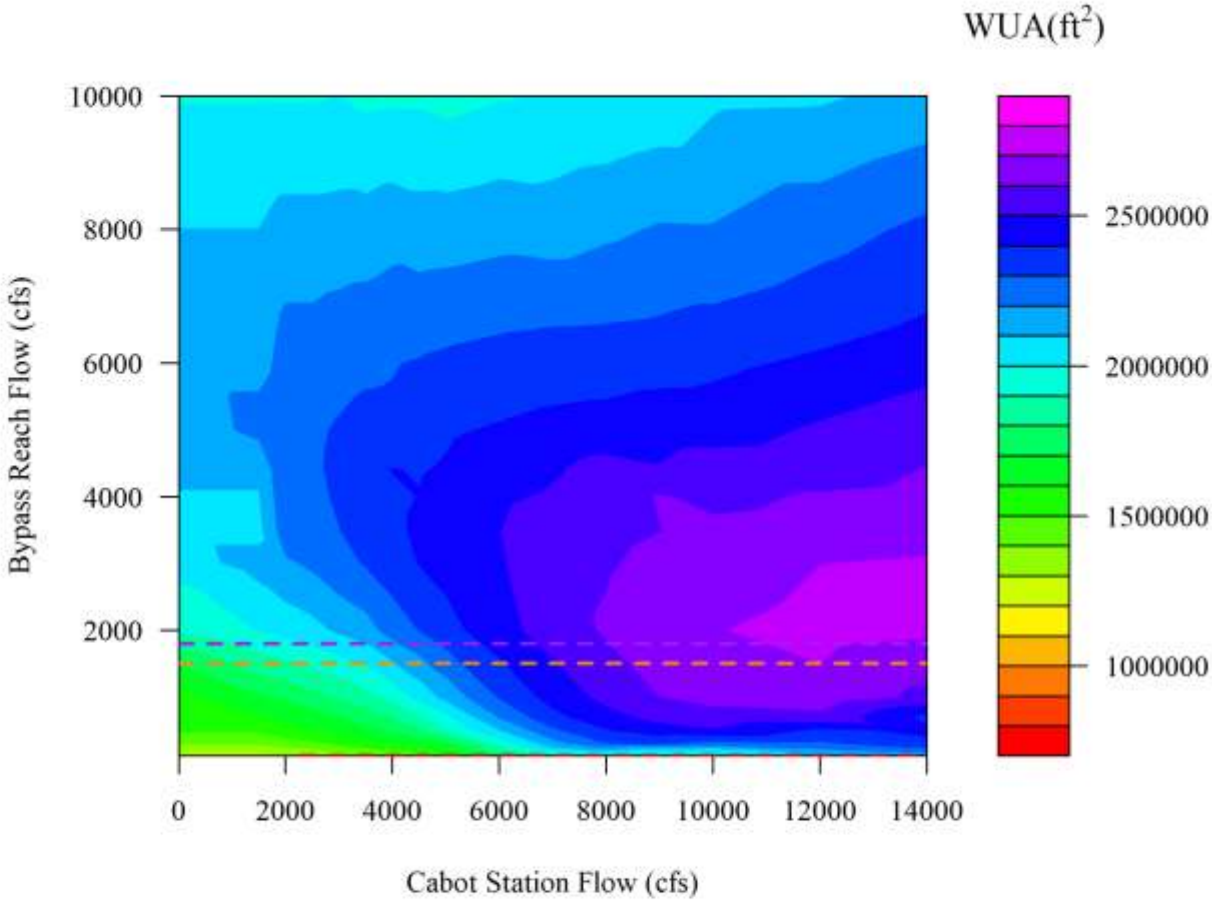

Figure 3.3.3.2.1.4.4-1: Summer/Fall Habitat for Juvenile American Shad in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

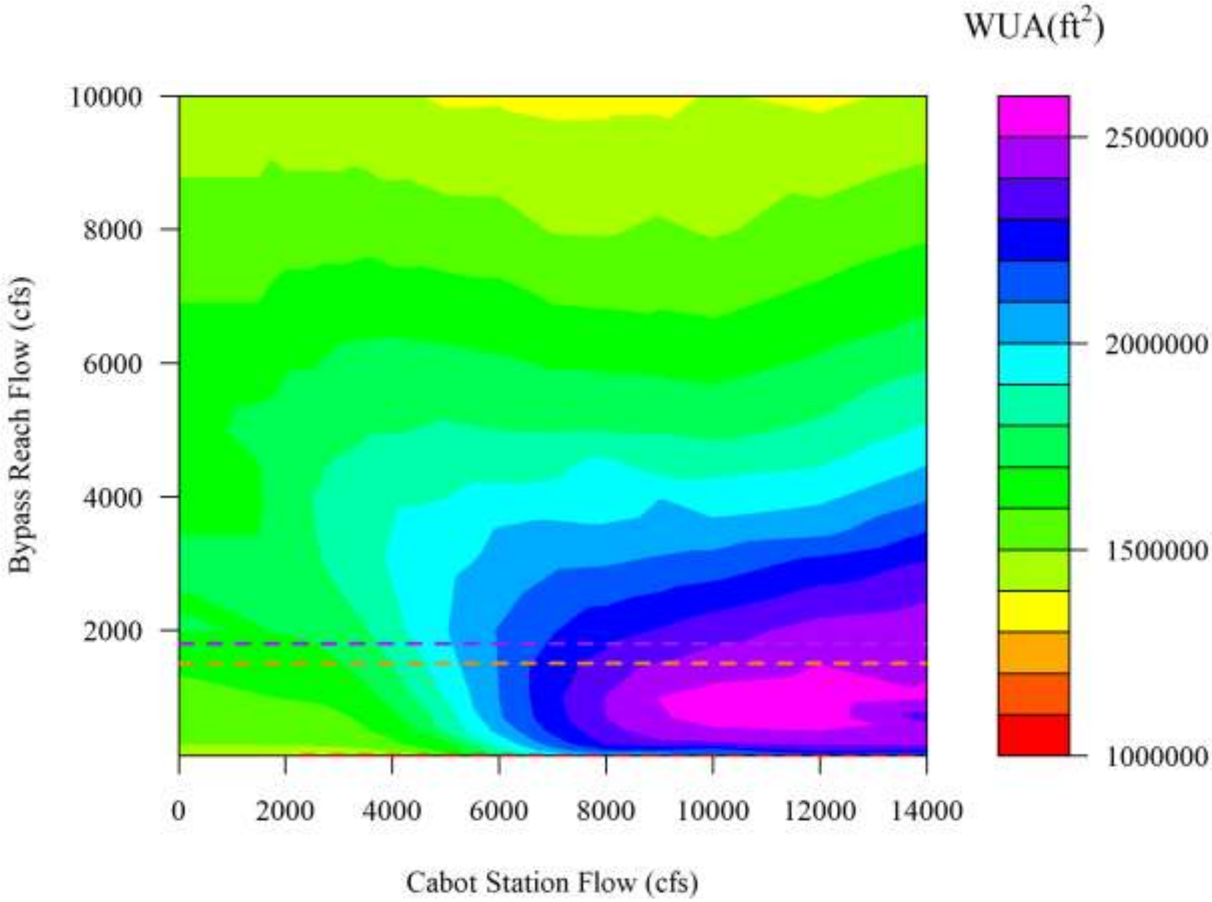

Figure 3.3.3.2.1.4.4-2: Summer/Fall Habitat for Adult Fallfish in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

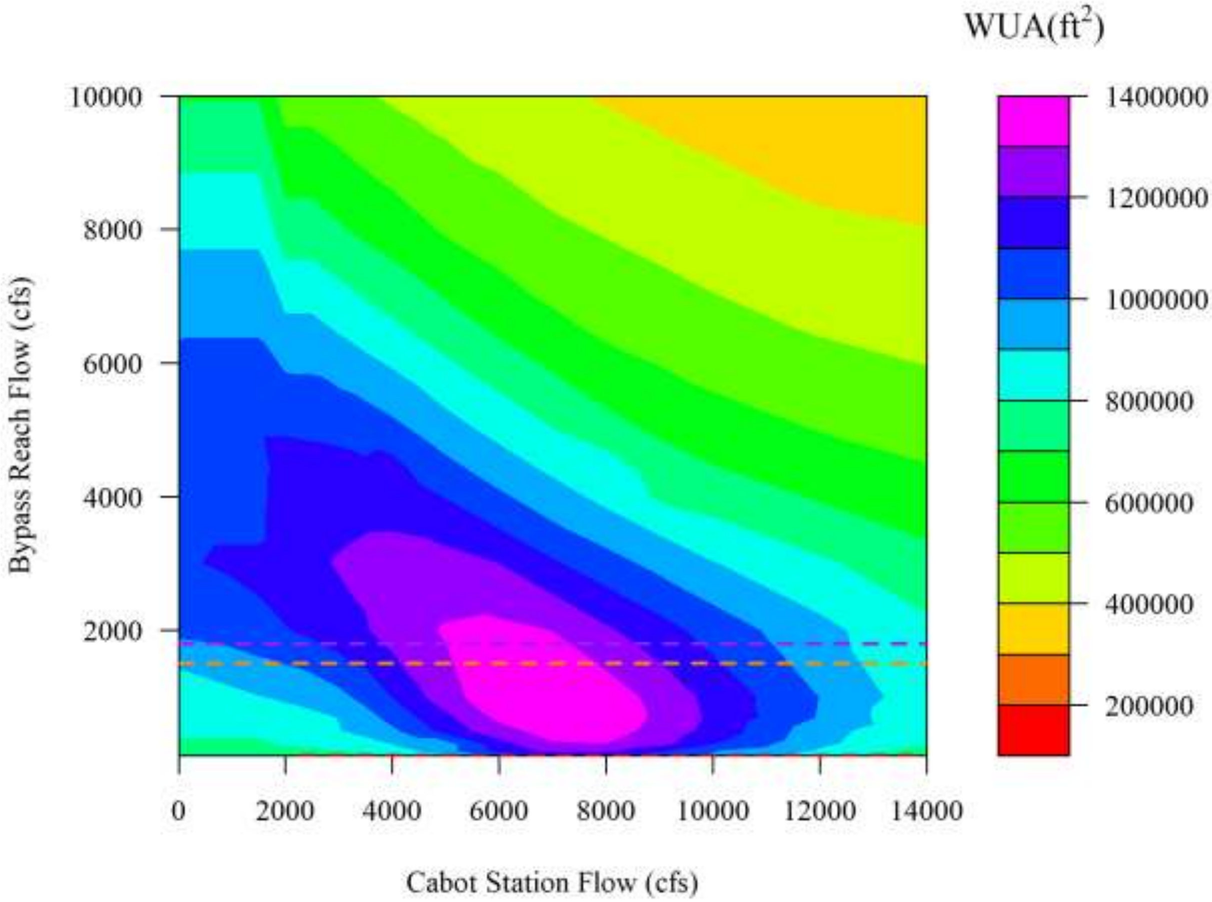

Figure 3.3.3.2.1.4.4-3: Summer/Fall Habitat for Juvenile Fallfish in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

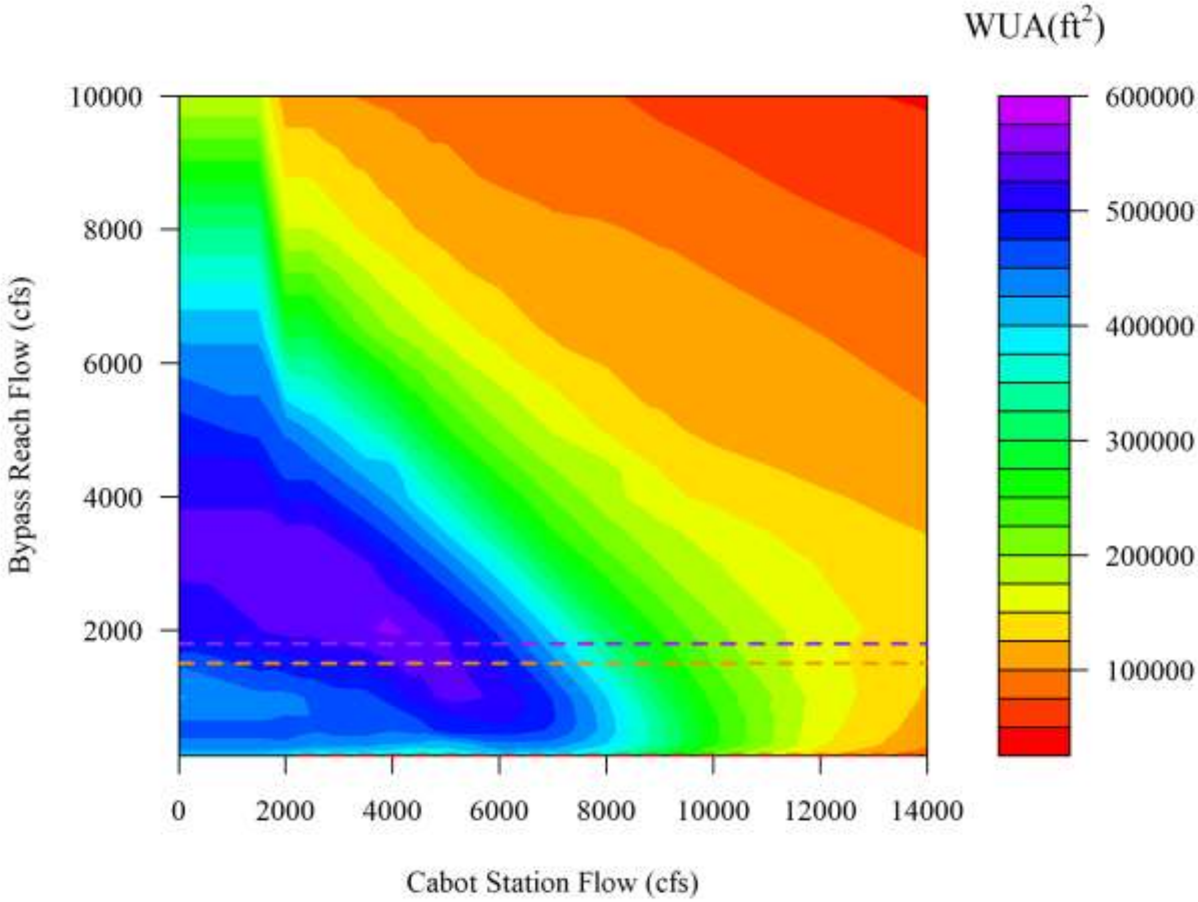

Figure 3.3.3.2.1.4.4-4: Summer/Fall Habitat for Adult Longnose Dace in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

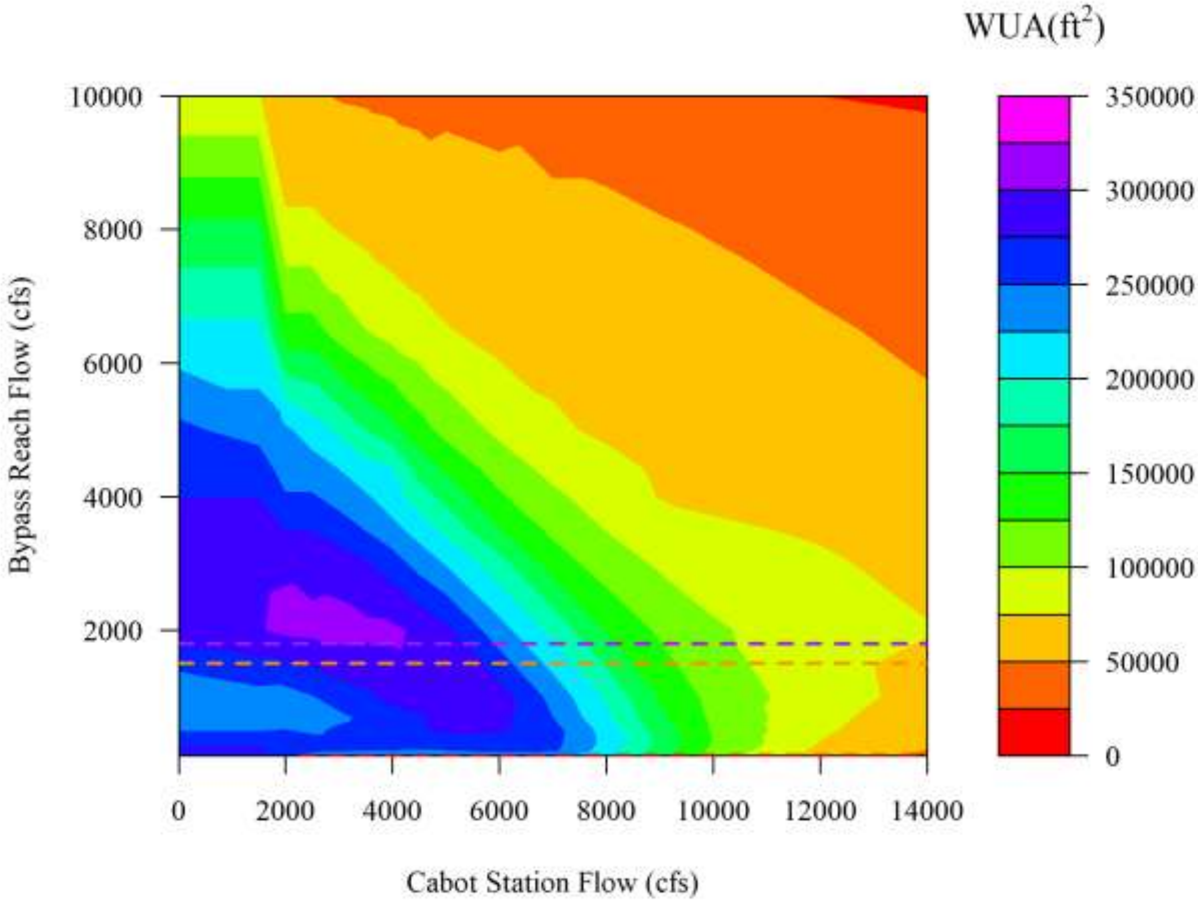

Figure 3.3.3.2.1.4.4-5: Summer/Fall Habitat for Juvenile Longnose Dace in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

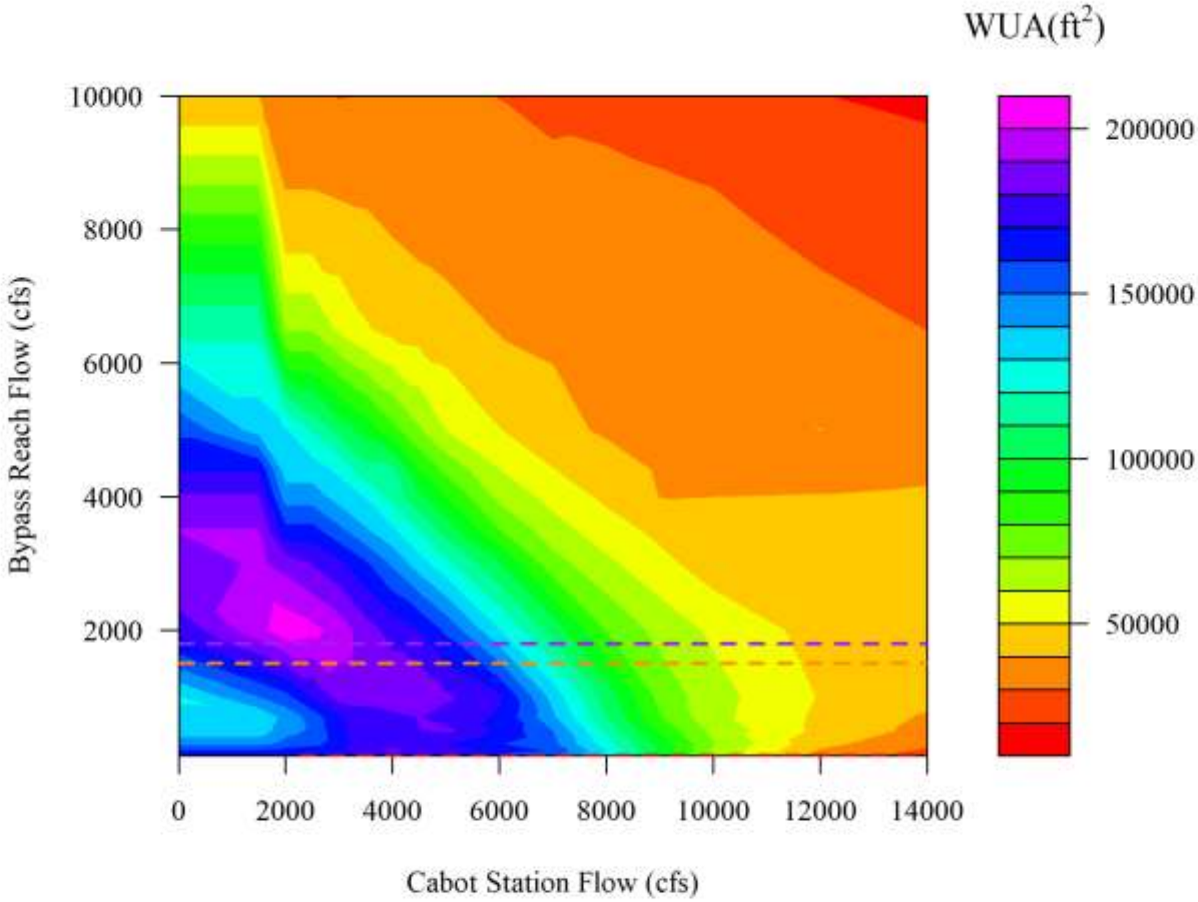

Figure 3.3.3.2.1.4.4-6: Summer/Fall Habitat for Adult/Juvenile Tessellated Darter in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

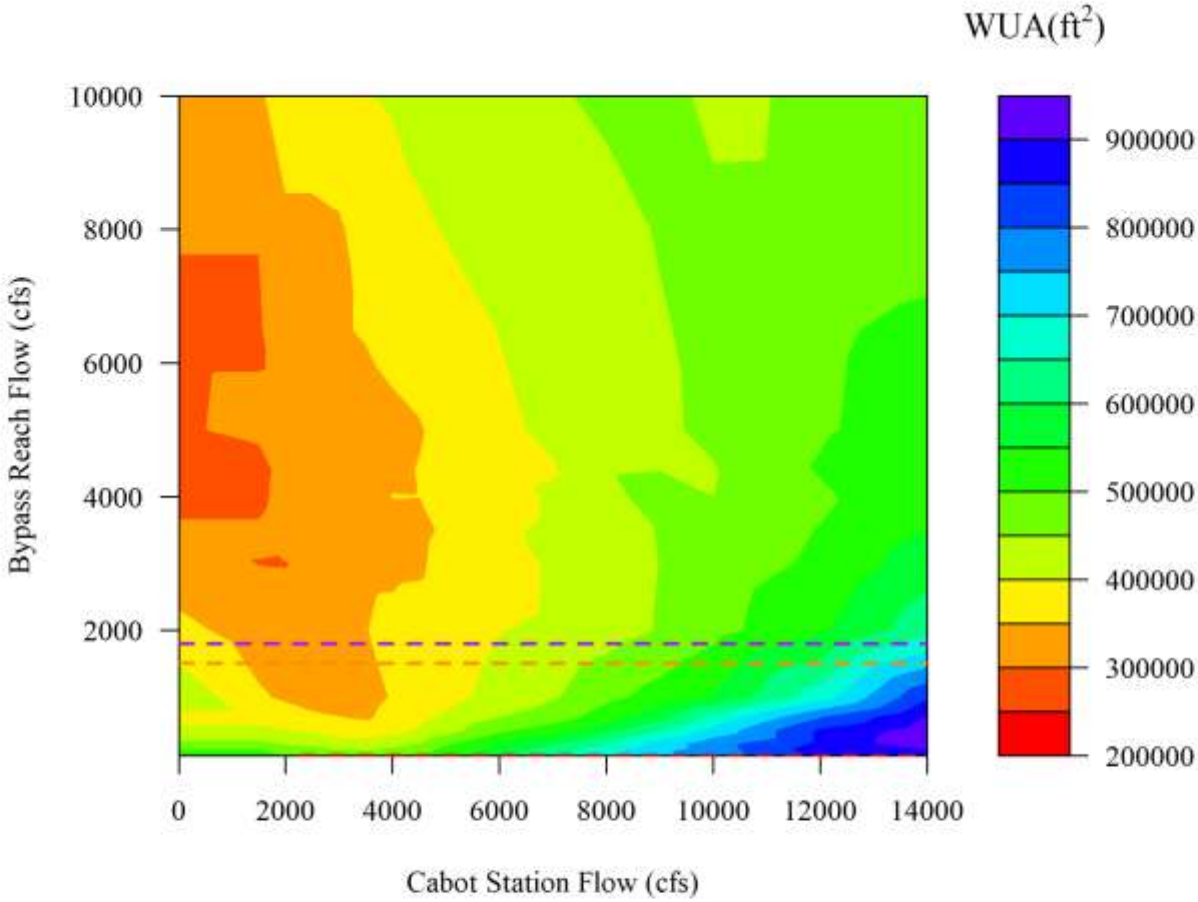

Figure 3.3.3.2.1.4.4-7: Summer/Fall Habitat for Adult Walleye in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

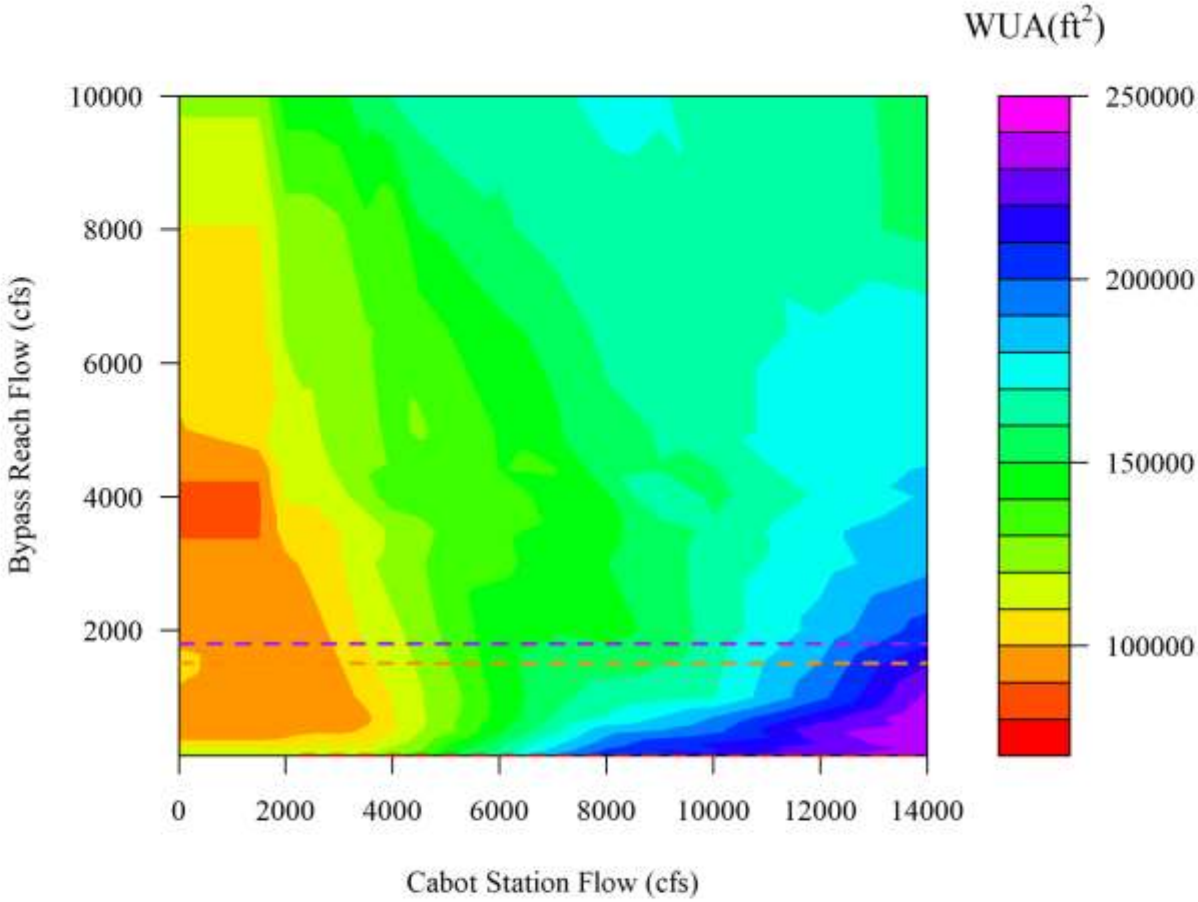

Figure 3.3.3.2.1.4.4-8: Summer/Fall Habitat for Juvenile Walleye in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

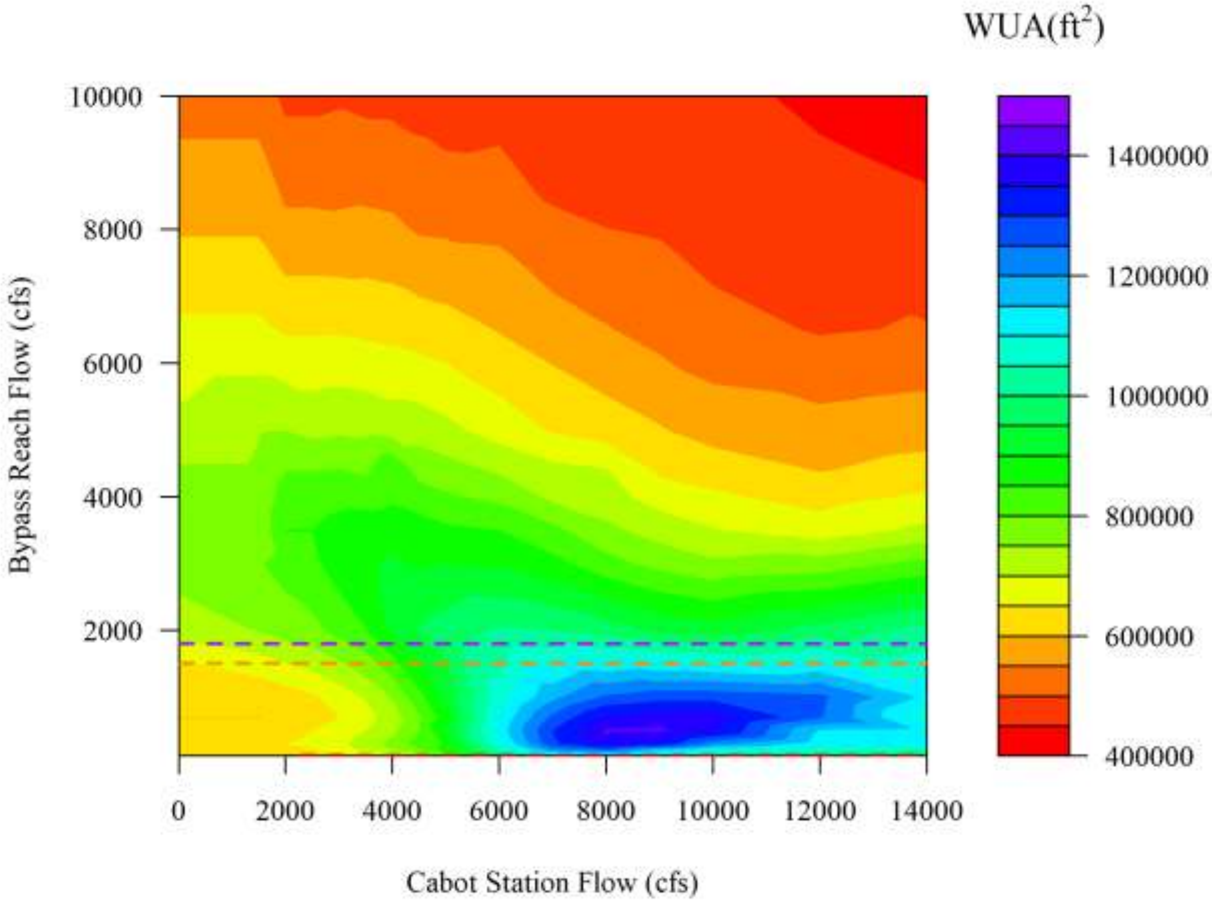

Figure 3.3.3.2.1.4.4-9: Summer/Fall Habitat for Adult/Juvenile White Sucker in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

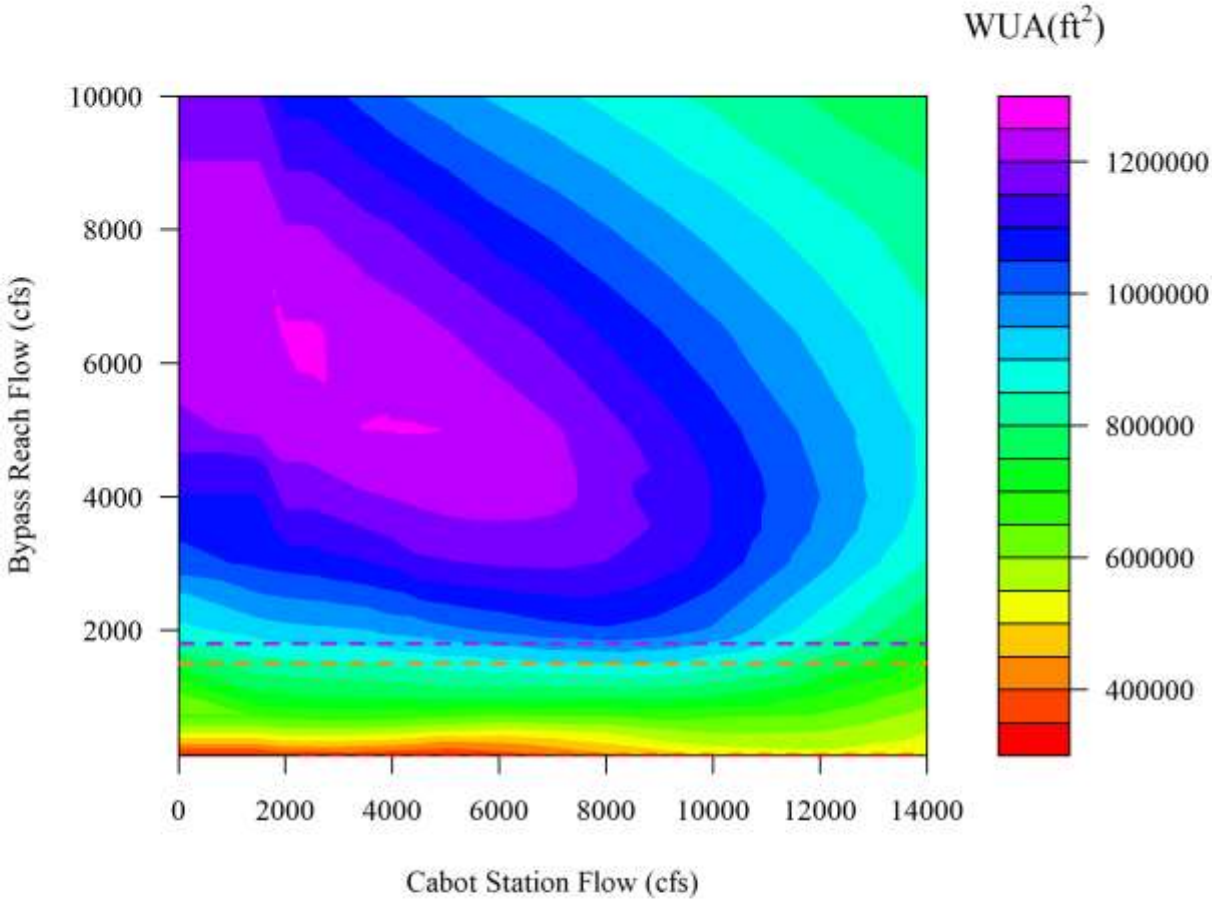

Figure 3.3.3.2.1.4.4-10: Summer/Fall Habitat for Benthic Macroinvertebrates in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

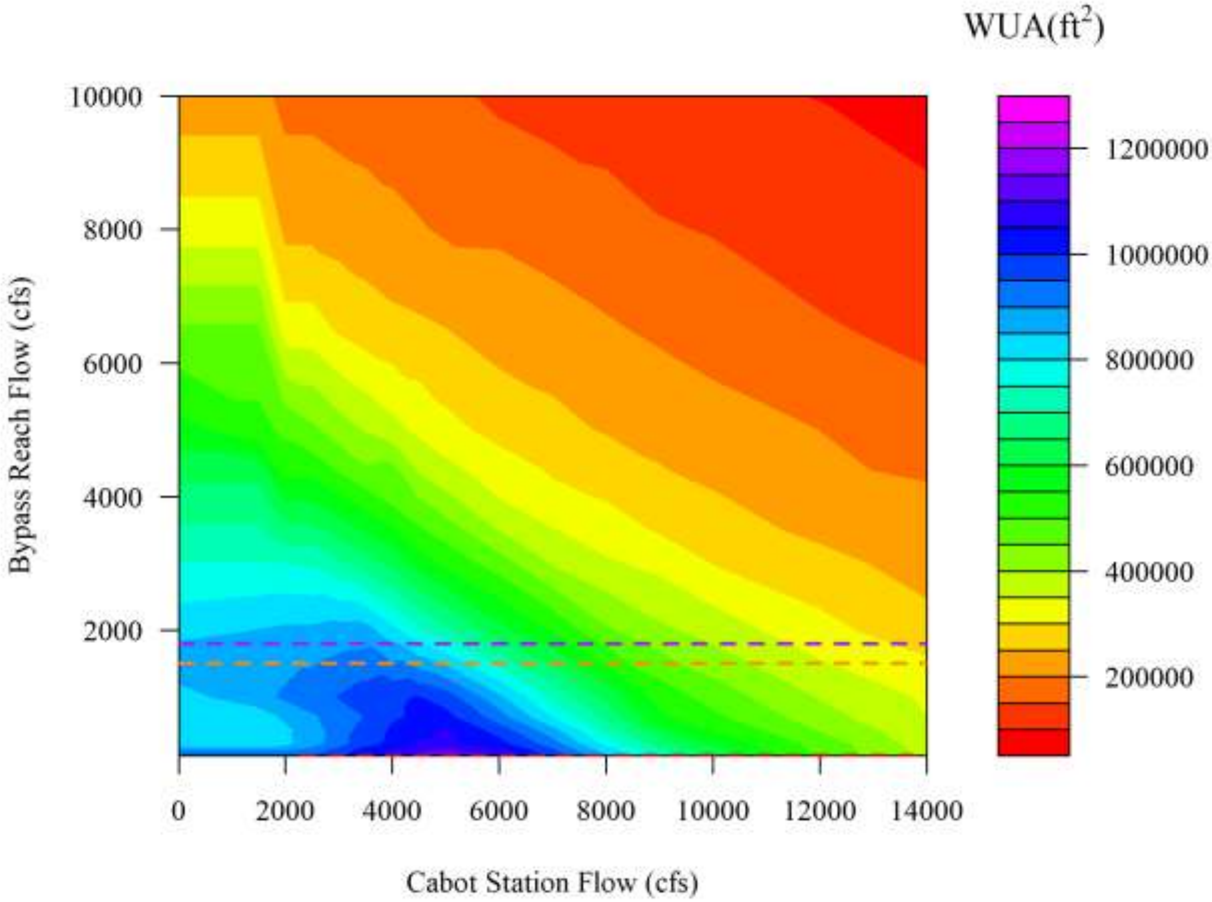

Figure 3.3.3.2.1.4.4-11: Summer/Fall Habitat for the Shallow Slow Guild in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

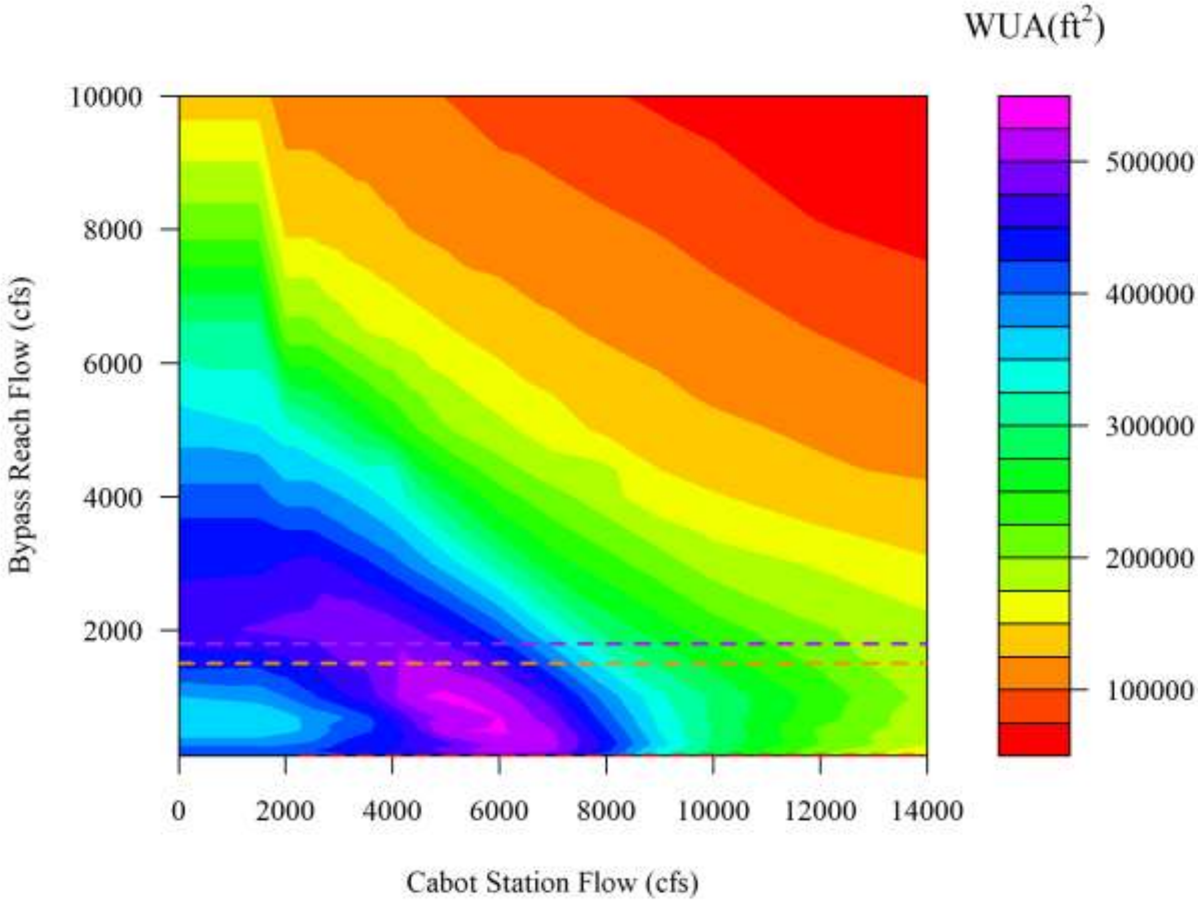

Figure 3.3.3.2.1.4.4-12: Summer/Fall Habitat for the Shallow Fast Guild in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

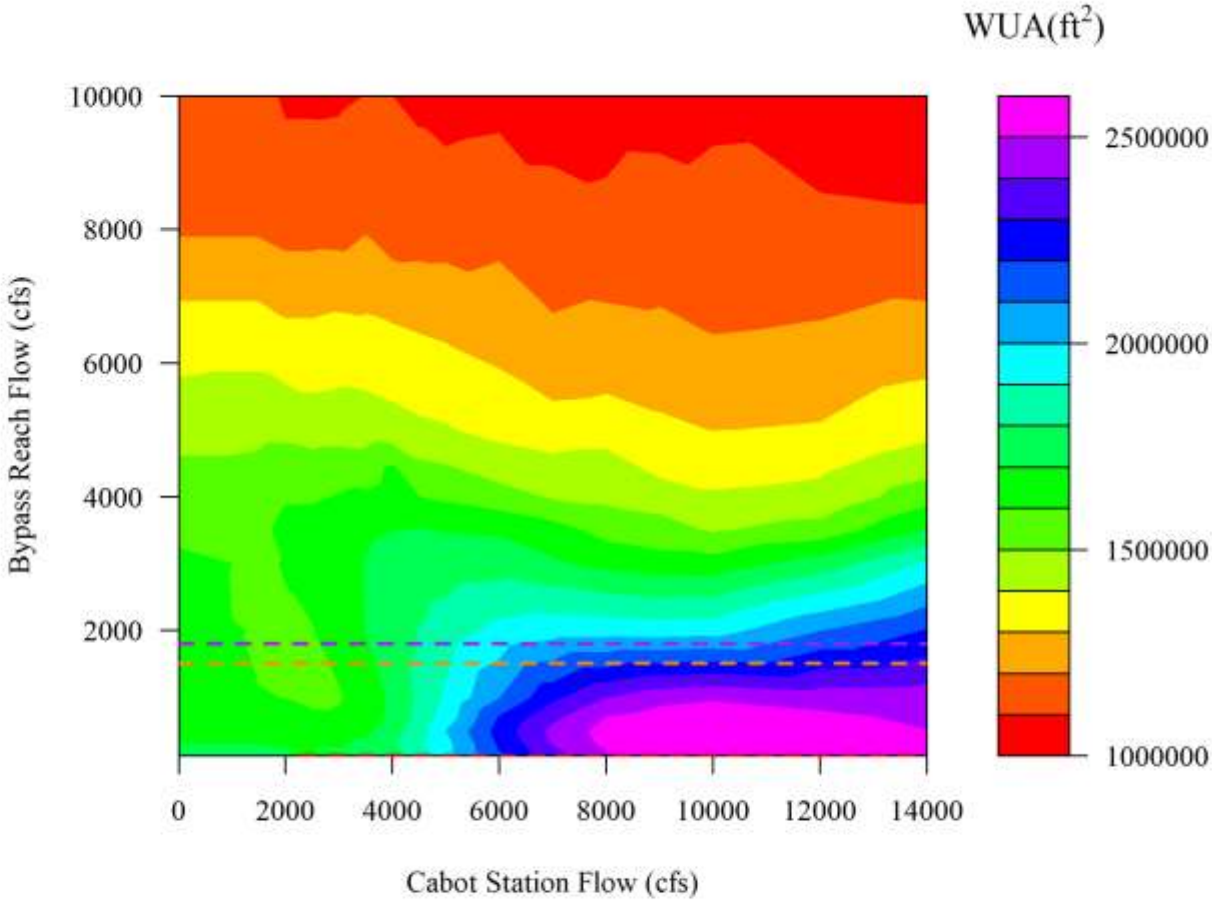

Figure 3.3.3.2.1.4.4-13: Summer/Fall Habitat for the Deep Slow Guild in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

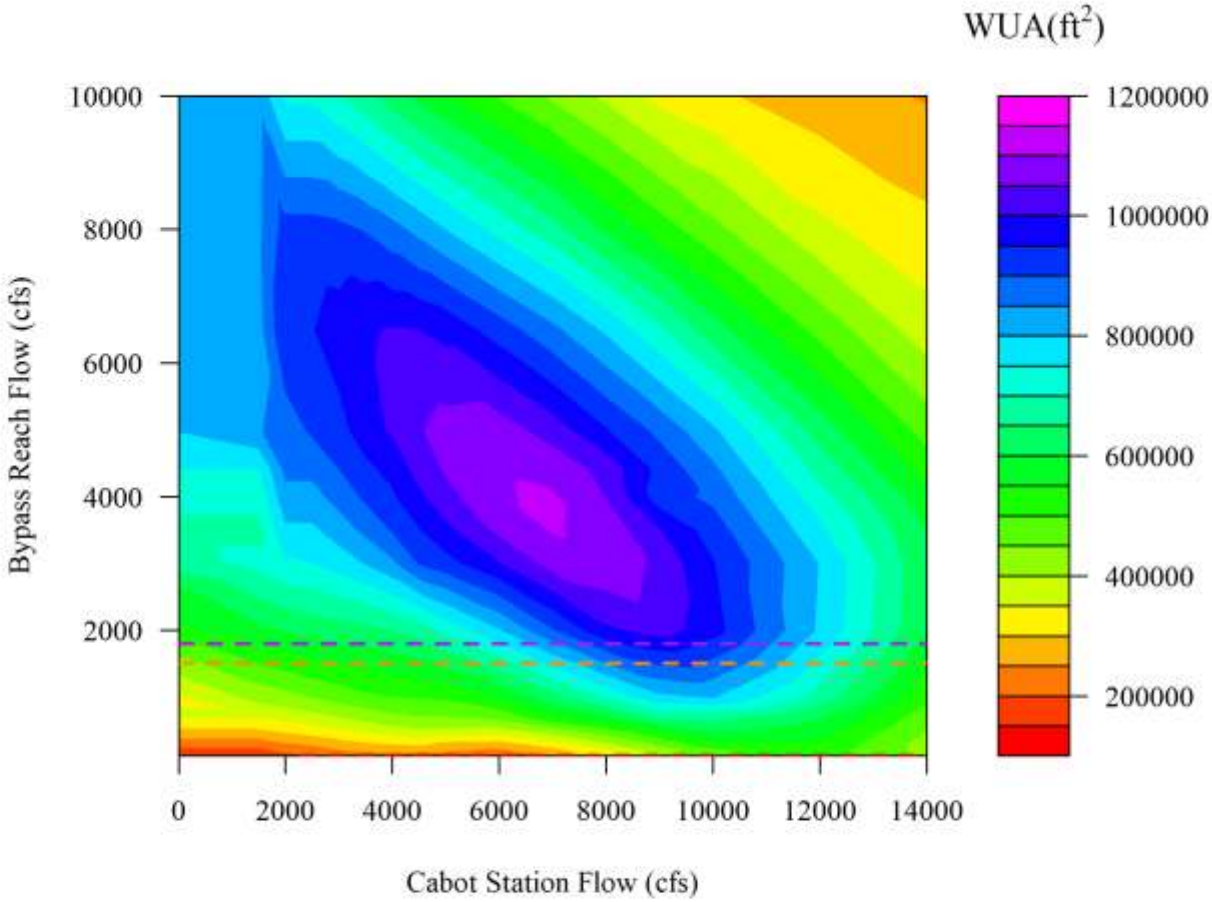

Figure 3.3.3.2.1.4.4-14: Summer/Fall Habitat for the Deep Fast Guild in Reach 3

Note: Model includes Deerfield River at 200 cfs. The red dotted line is operations given the current minimum flow during the summer (120 cfs). The purple dotted line indicates operations given proposed bypass flows in July and August (1,800 cfs), and the orange dotted line indicates operations given proposed bypass flows in September through November (1,500 cfs).

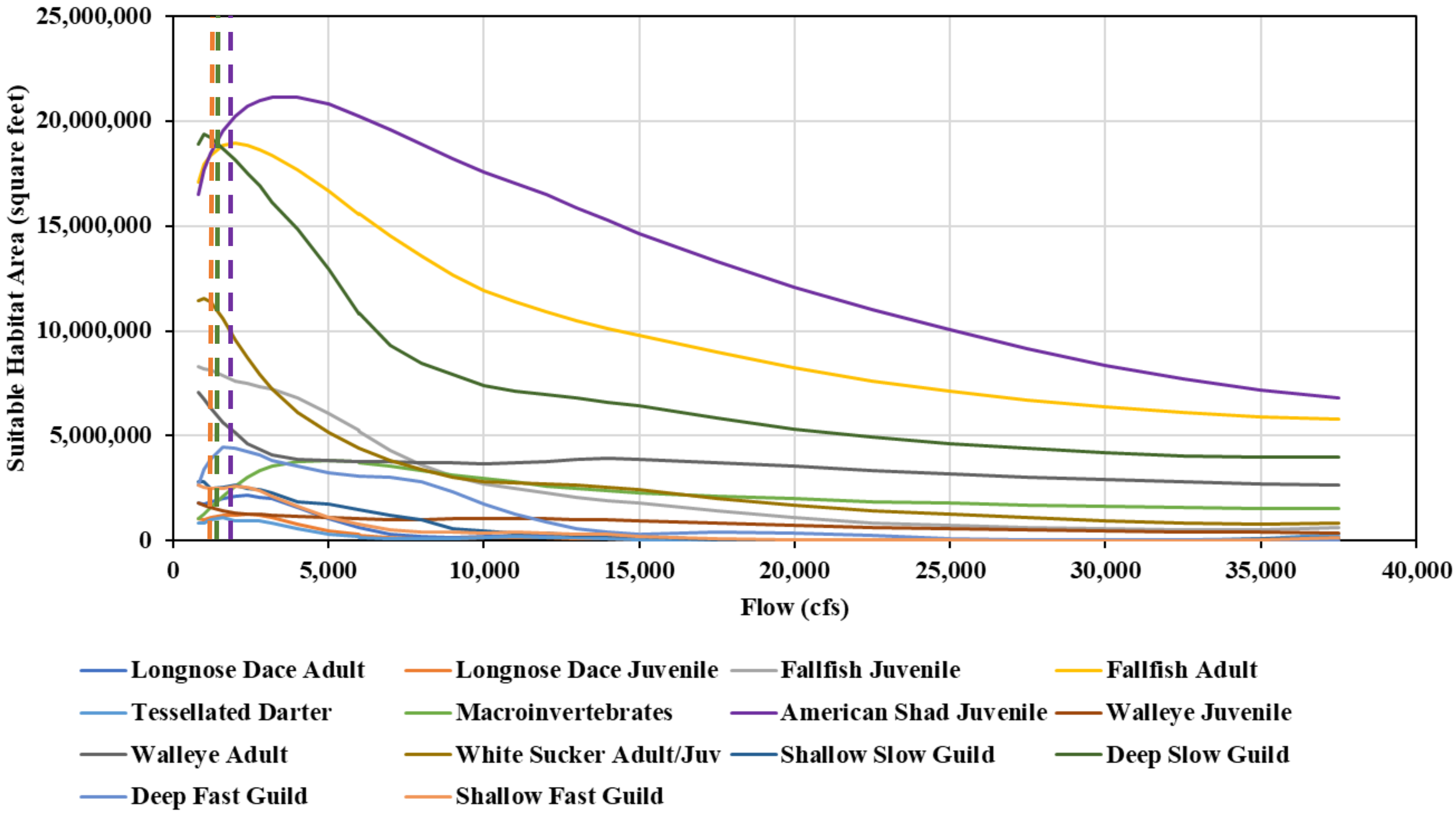

Figure 3.3.3.2.1.4.4-15: Summer/Fall Habitat for Aquatic Species in Reach 4

Note: The vertical dashed orange line is the current minimum flow (1,433 cfs), the vertical dashed purple line is the approximate proposed minimum flows below the Project in July and August (1,800 cfs), and the vertical dashed green line is the approximate proposed minimum flow (1,500 cfs) from September through November.

3.3.3.1.5.4.5 Winter Habitat

In New England rivers, base flows during the winter tend to be relatively low, with much of the precipitation in the watershed being retained as snowpack. Habitat suitability criteria for various species and life stages during the warmer months do not apply during winter, and relatively little is known about the habitat needs of many aquatic species and life stages during the winter months. Therefore, no habitat versus flow relationships were developed for the winter period as part of FirstLight's instream flow studies. Generally, fish that reside in flowing waters will move to areas of deeper, slow water in the winter. Smaller fish will typically seek out crevices in the substrate where they can hide.

There is currently no minimum flow in the bypass reach during the winter. Without flow in the bypass reach, there would be little, if any, velocity in most places within the bypass reach. Further, areas of the upper bypass reach with standing water would likely exhibit ice cover during no-flow conditions, which would then change rapidly at the onset of spill conditions at the Turners Falls Dam during winter and springtime thaw events.

Proposed minimum flows would represent a substantial change, with 300 cfs spilling over Turners Falls Dam and 1,200 cfs released from Station No. 1. Based on an analysis of cross-sections surveyed and water levels modeled in Reaches 1 and 2 (Figure 3.3.3.2.1.4.5-1), these flows would maintain riverine habitat characteristics, with flow through the main channel and consistent inundation of off-channel areas (Figures 3.3.3.2.1.4.5-2 through 3.3.3.2.1.4.5-12). The proposed flows would therefore be anticipated to provide more heterogeneous lotic habitat than would be present during the current minimum flow in upper bypass reach areas. Passing this flow rate would prevent many areas from freezing and would be beneficial to overwintering fish and aquatic macroinvertebrate species by maintaining depth and wetted area where they could find shelter in slower, deeper habitats or take shelter within the inundated substrate.

Proposed minimum flow conditions would result in additional heterogeneity in the lower bypass reach, between the Rawson Island Complex and Cabot Station, which would have been subjected primarily to backwatering from Cabot Station operations in the absence of flow from the upper bypass reach. Downstream of Cabot Station, the overall minimum winter flow is not substantially different between baseline (1,433 cfs) and proposed (1,500 cfs) conditions; therefore, no substantial changes in winter minimum flows would be expected in downstream areas.

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.3.2.1.4.5-1:
Reach 1 and 2 Transect Locations

Legend

1-D Transect

Habitat Transect

N

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

0 200 400 800 Feet

1 inch = 400 feet

FirstLight

Path: W:\gis\maps\Exhibit_E\amended_combined\figure_3_3_3_2_1_4_5-1.mxd

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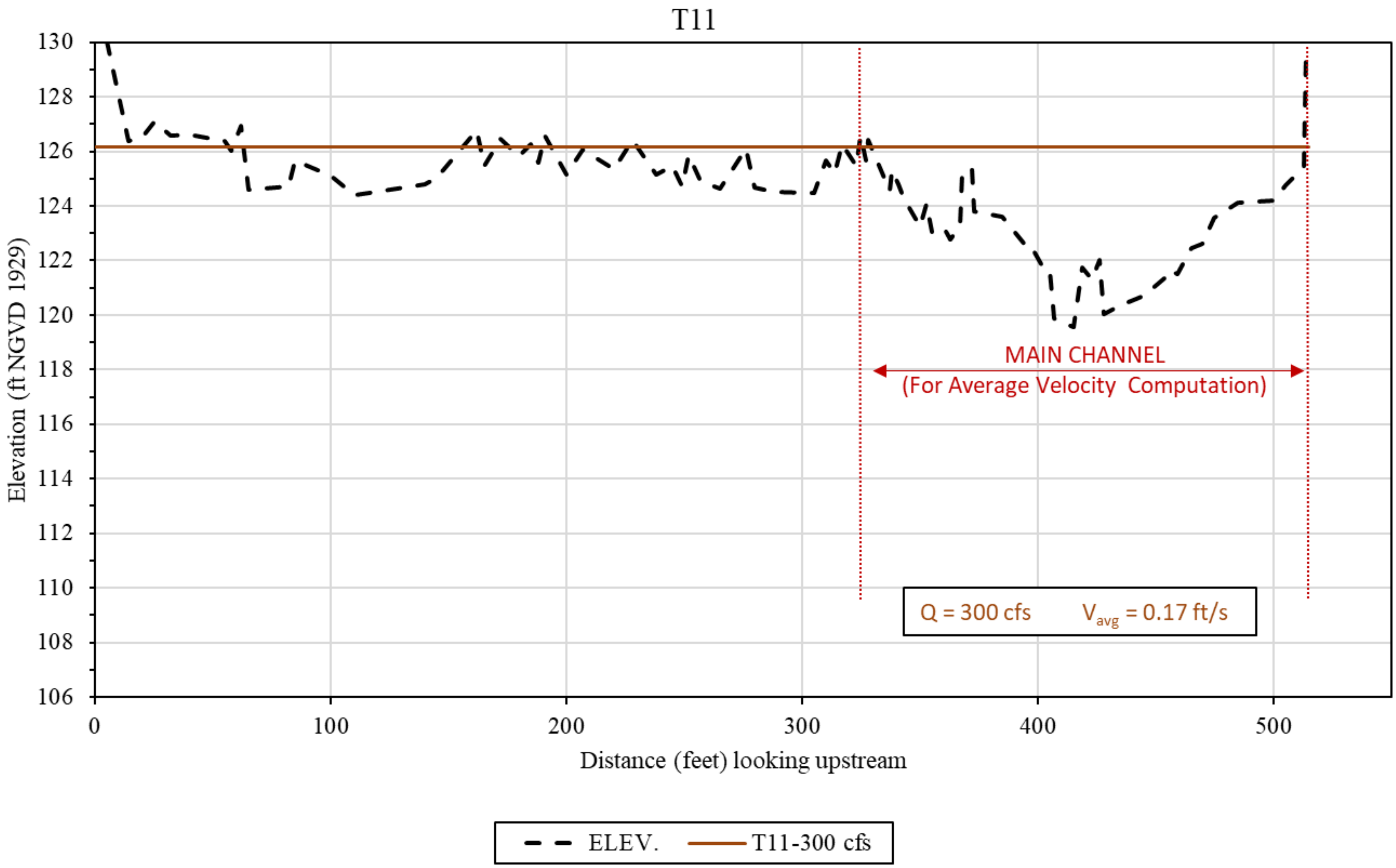

Figure 3.3.3.2.1.4.5-2: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T11

Note: Models assumed backwatering from Station No. 1, which will result from proposed minimum flows also being released from Station No. 1.

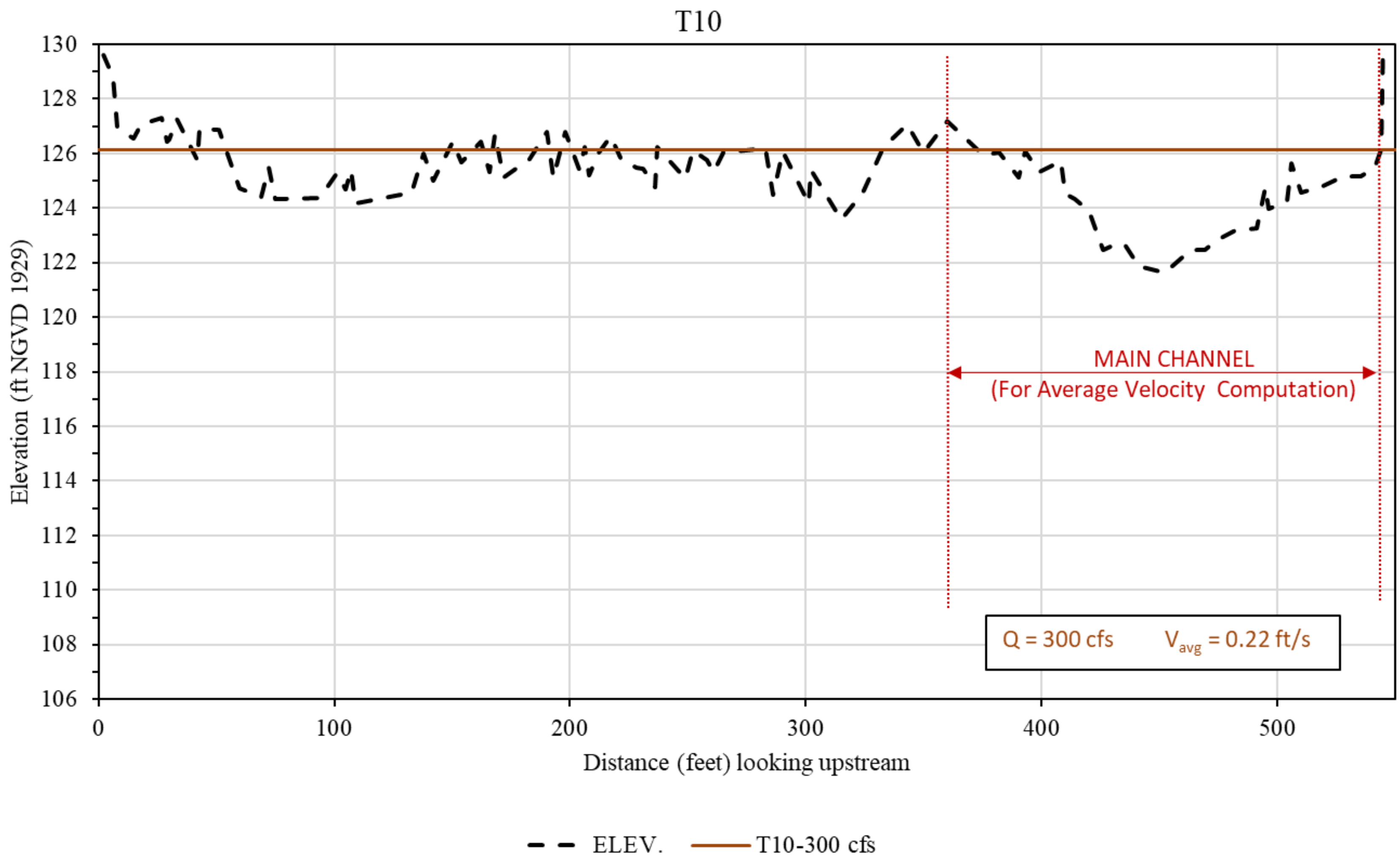

Figure 3.3.3.2.1.4.5-3: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T10

Note: Models assumed backwatering from Station No. 1, which will result from proposed minimum flows also being released from Station No. 1.

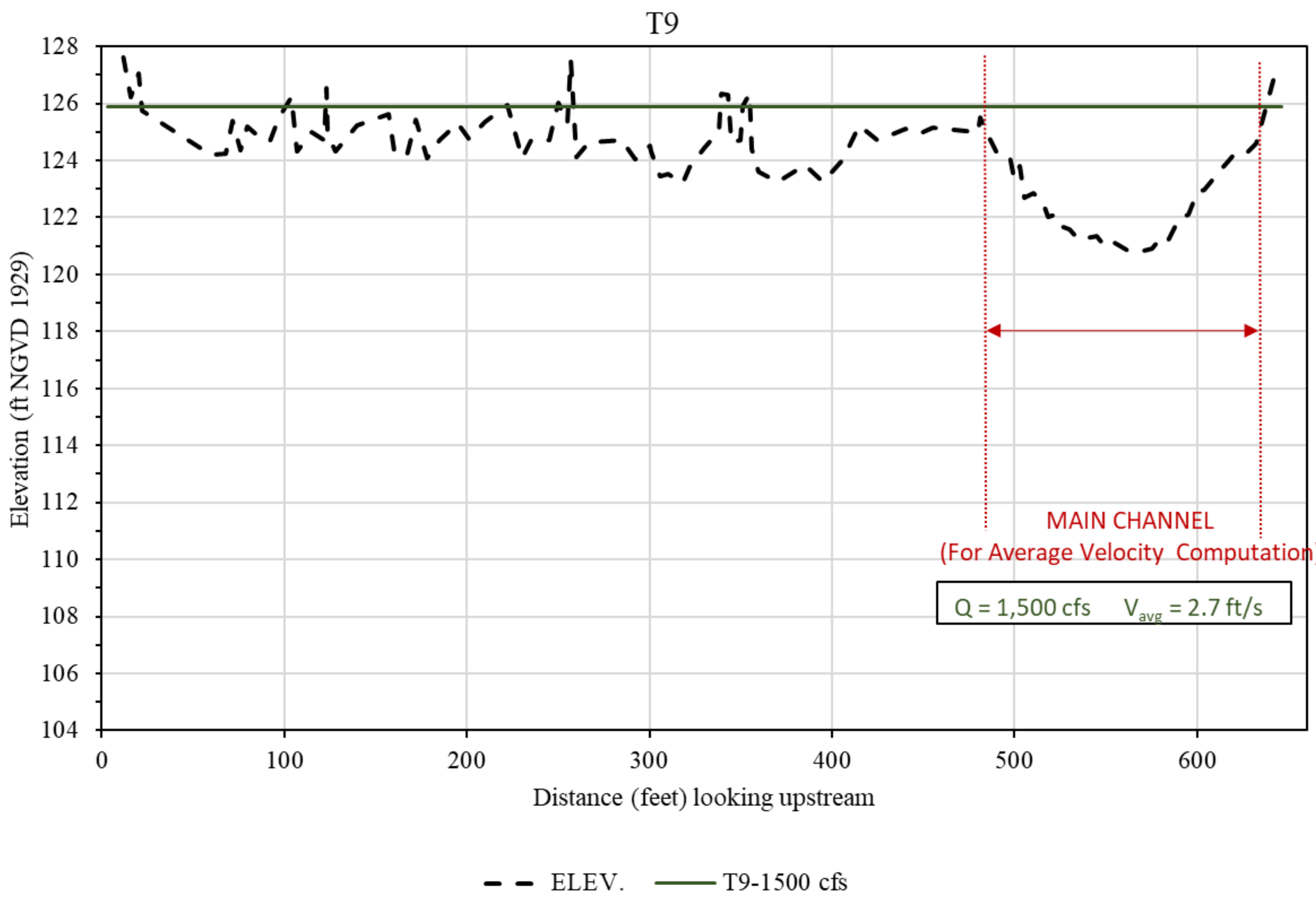

Figure 3.3.3.2.1.4.5-4: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T9

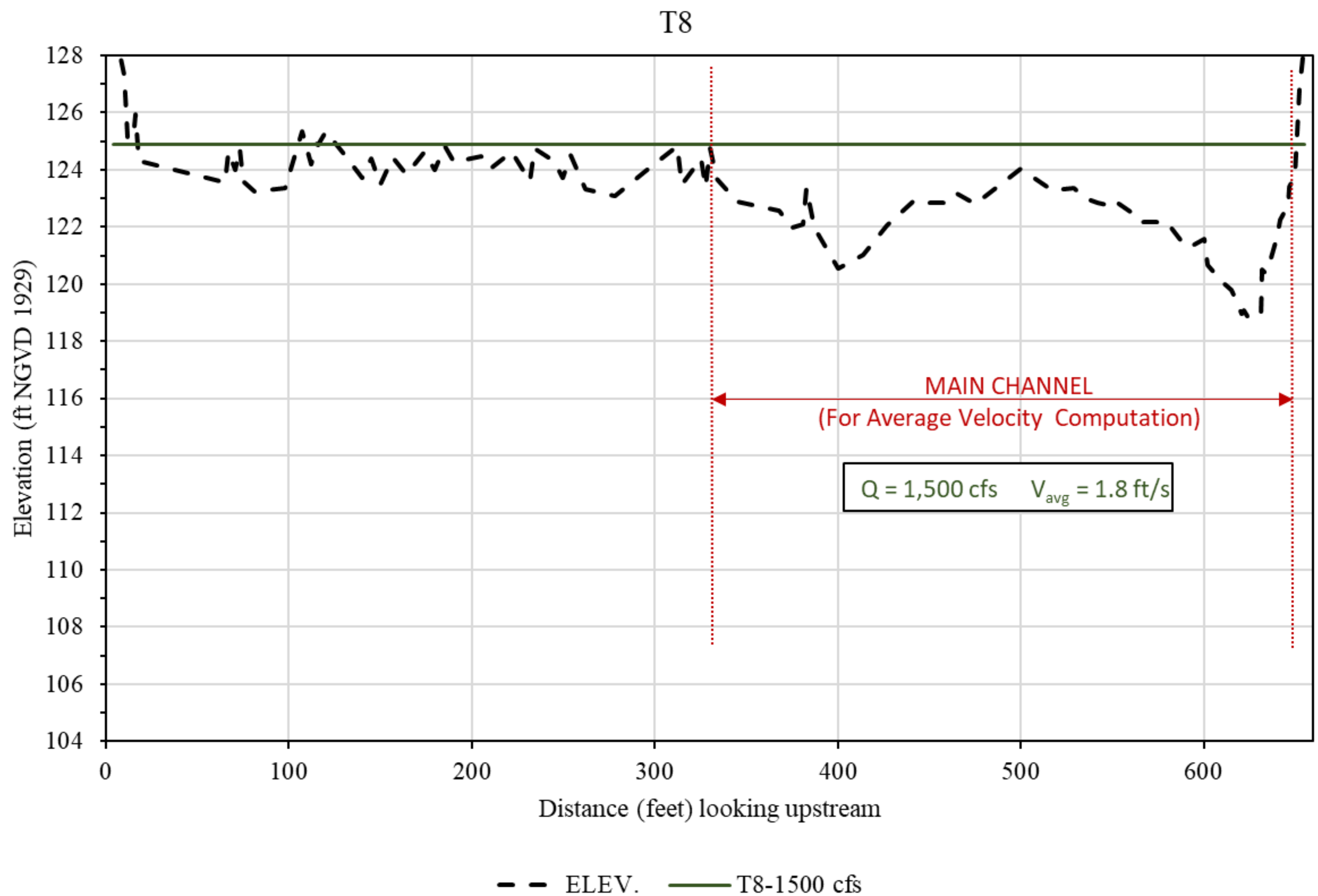

Figure 3.3.3.2.1.4.5-5: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T8

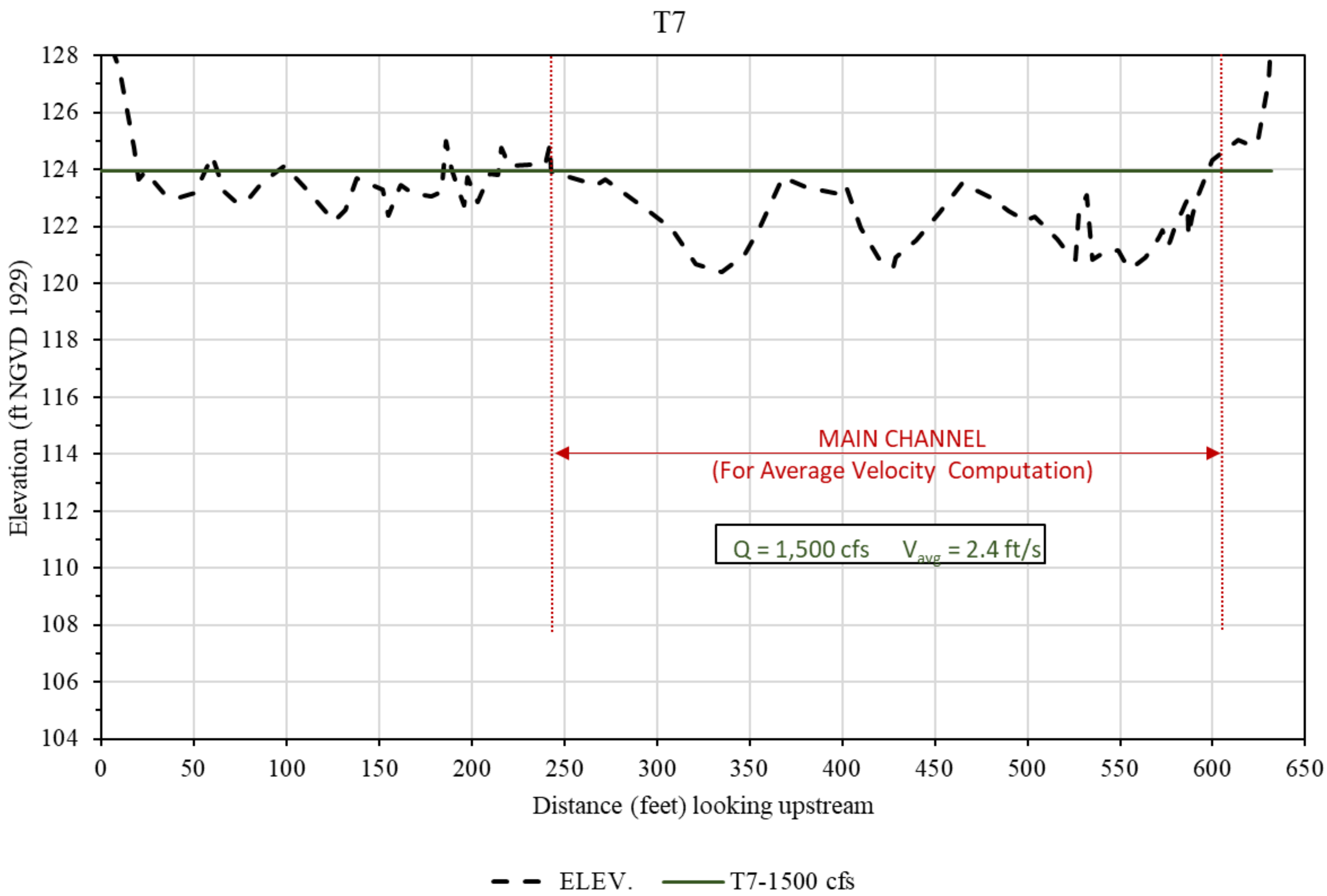

Figure 3.3.3.2.1.4.5-6: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T7

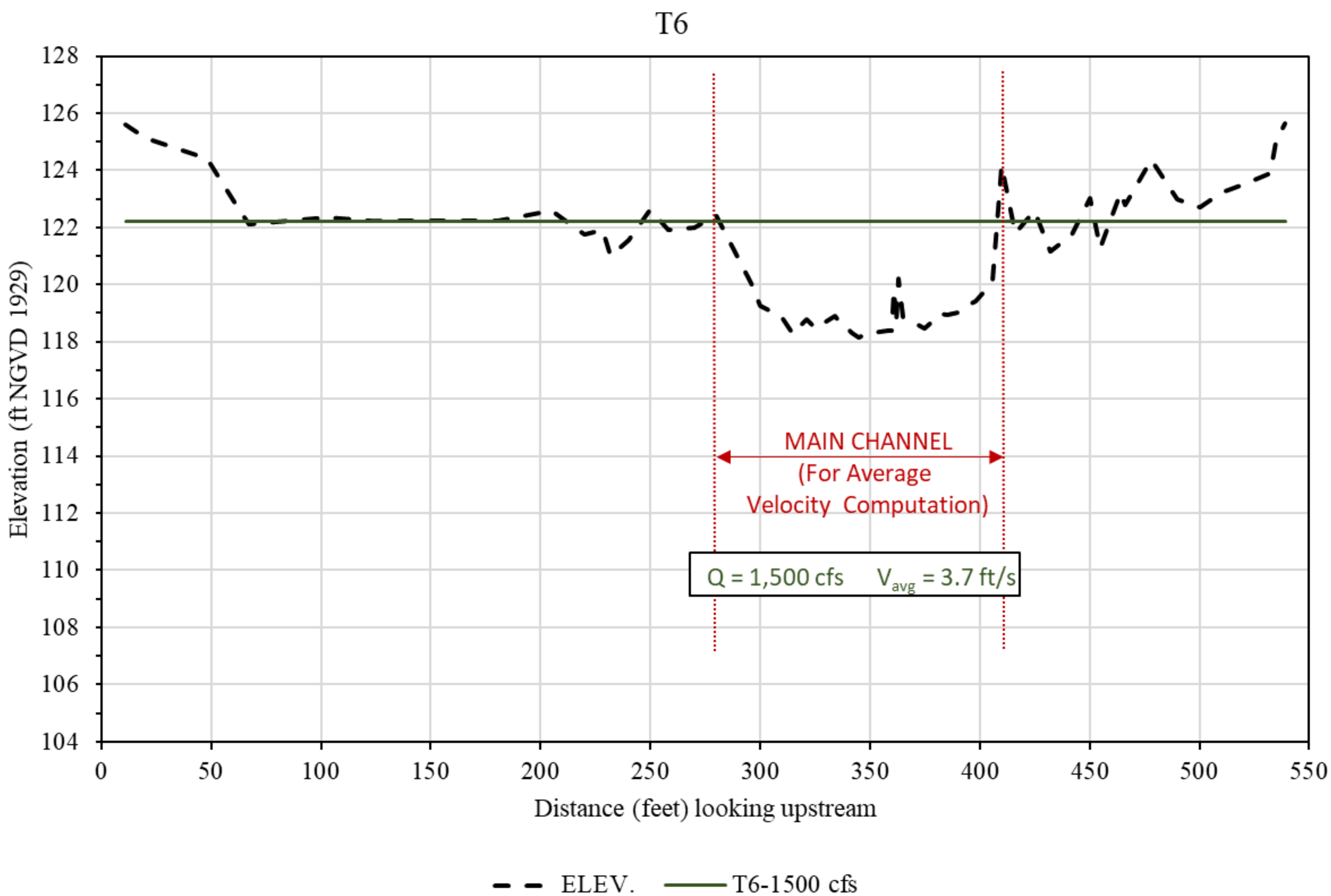

Figure 3.3.3.2.1.4.5-7: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T6

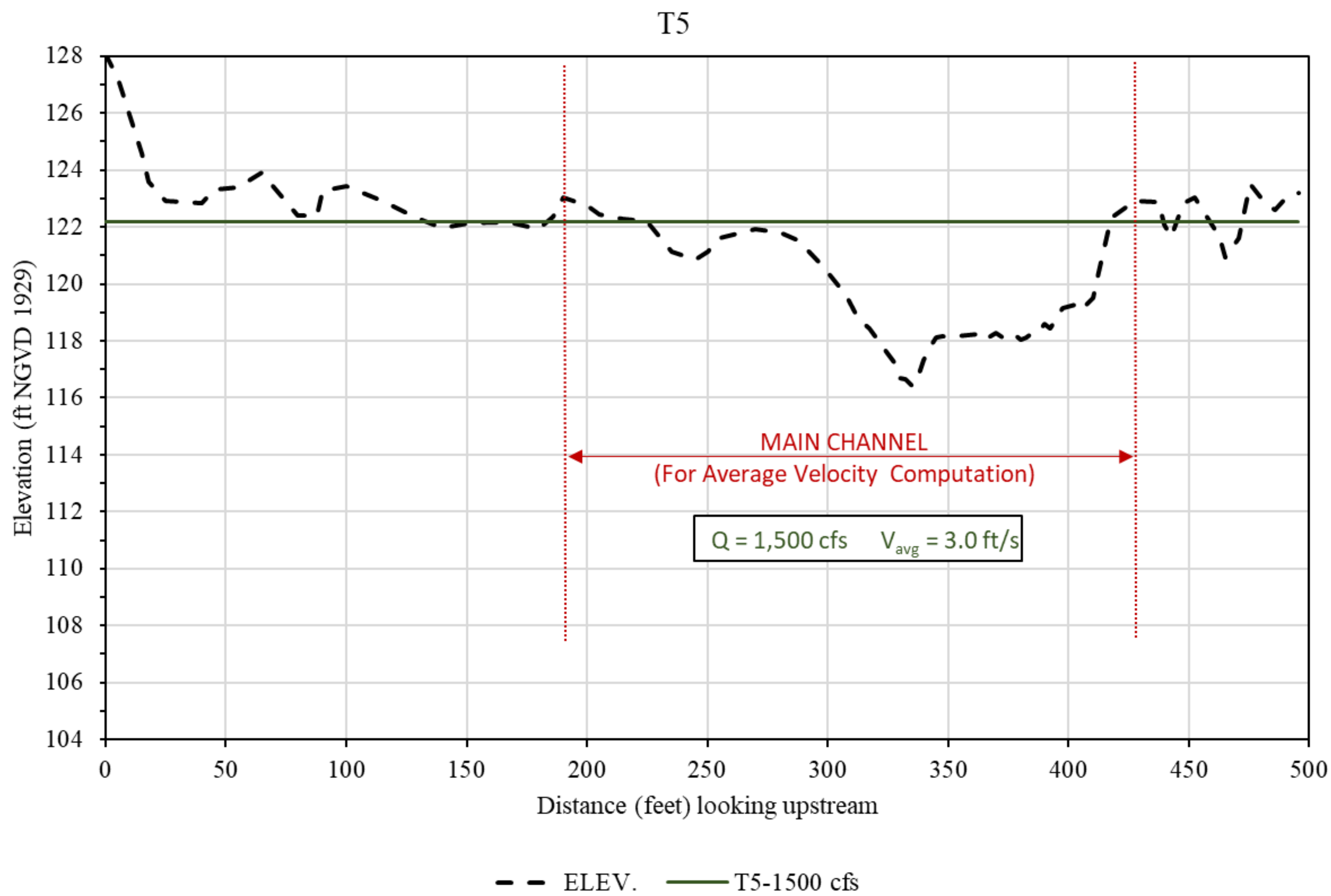

Figure 3.3.3.2.1.4.5-8: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T5

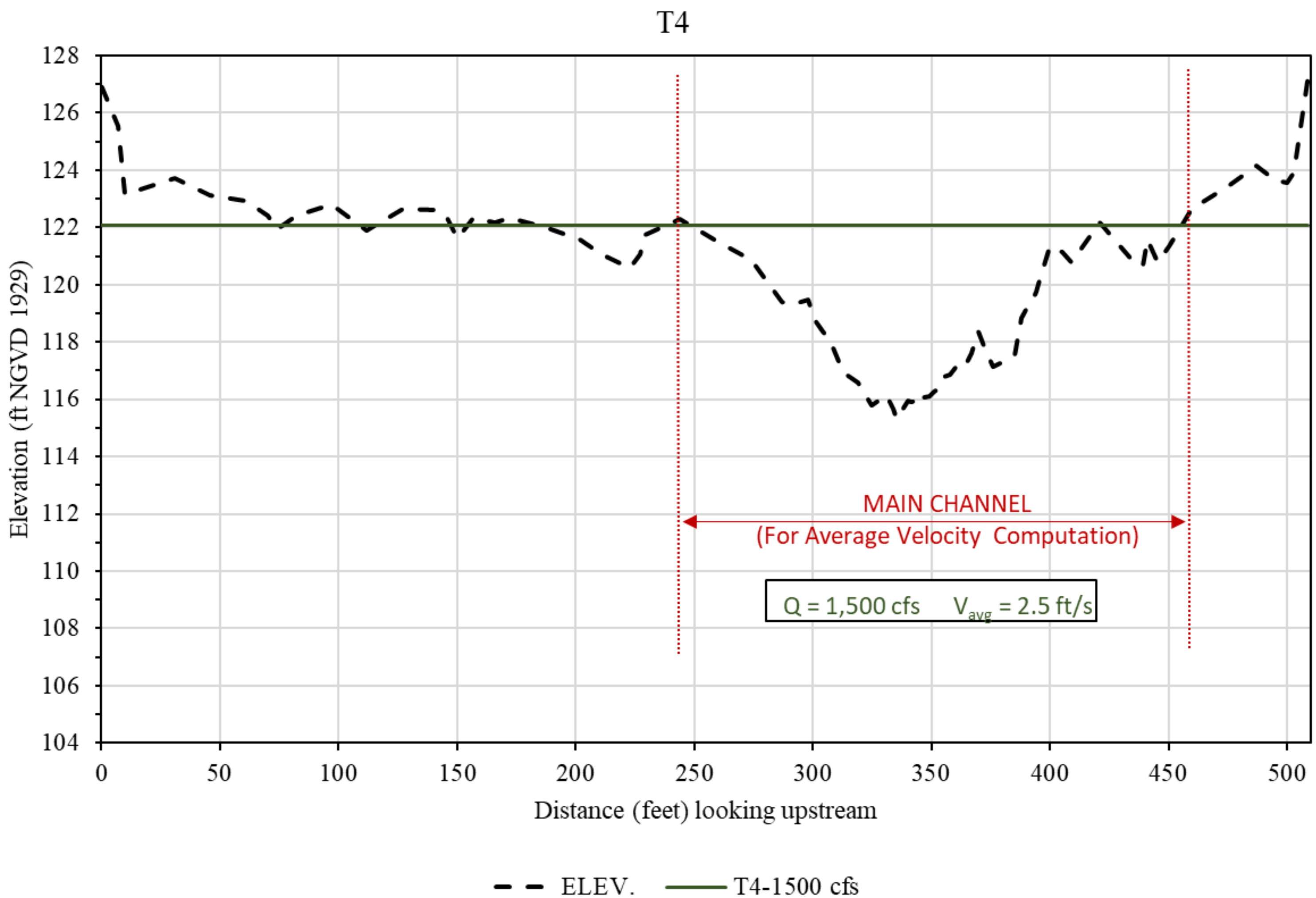

Figure 3.3.3.2.1.4.5-9: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T4

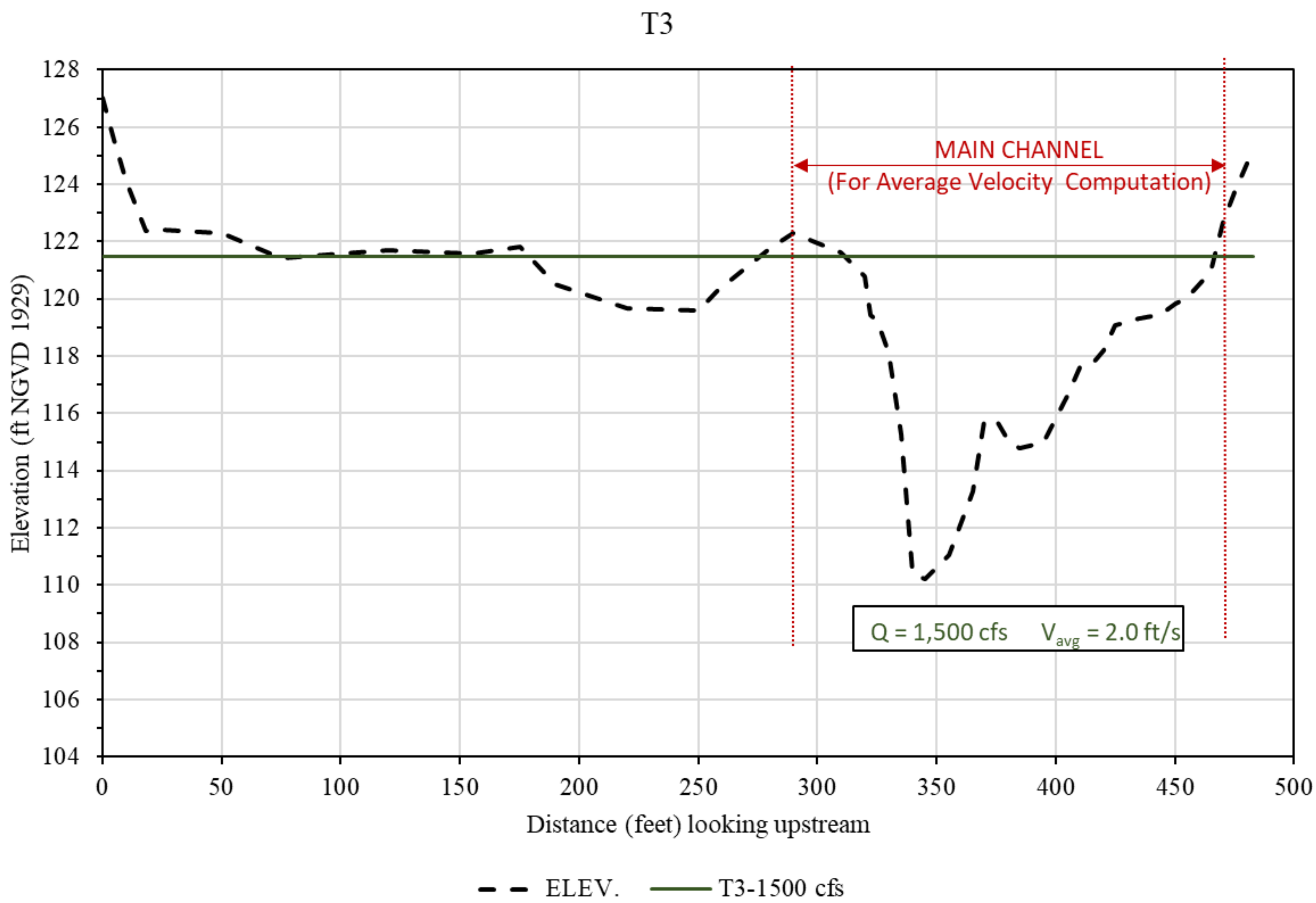

Figure 3.3.3.2.1.4.5-10: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T3

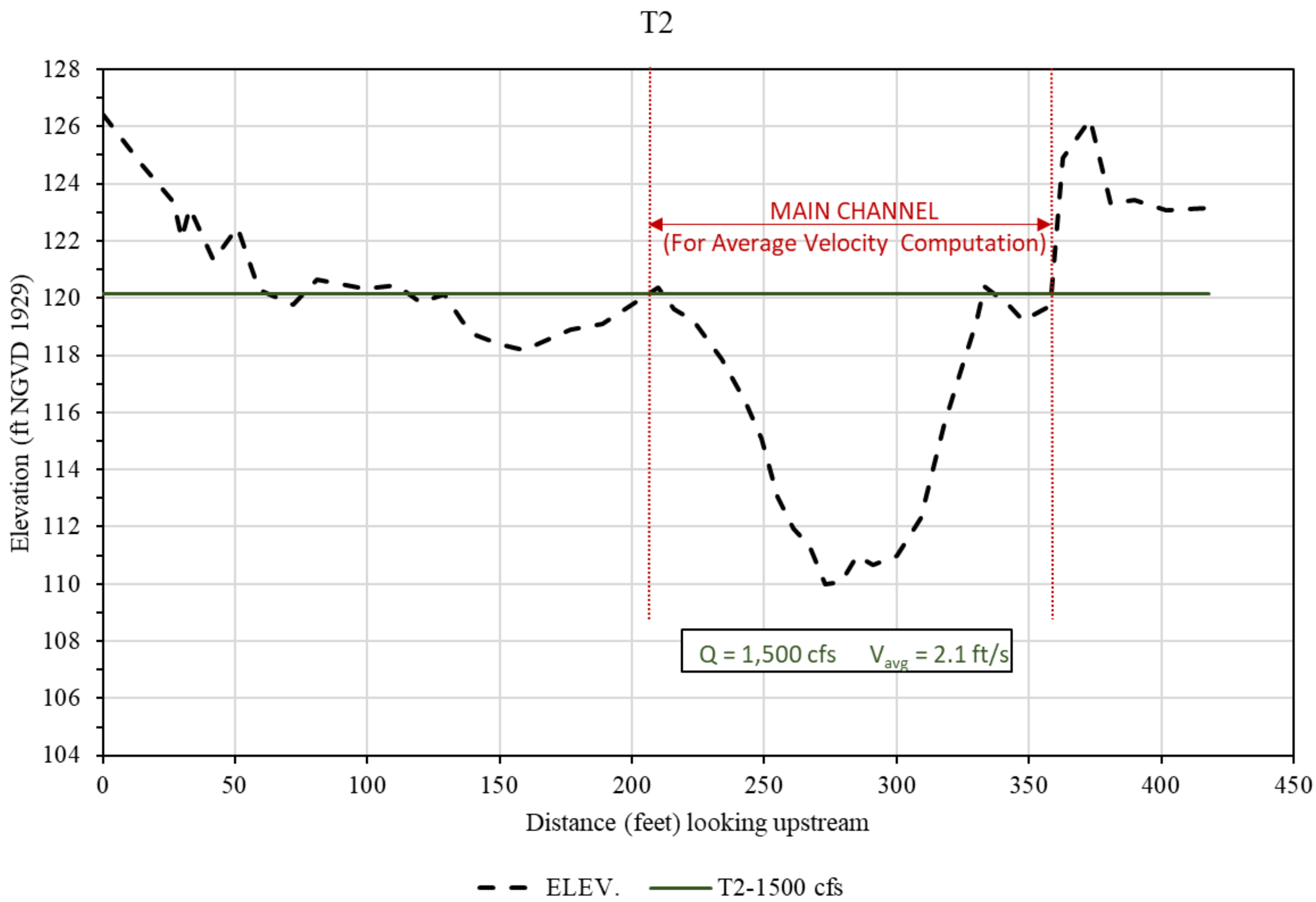

Figure 3.3.3.2.1.4.5-11: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T2

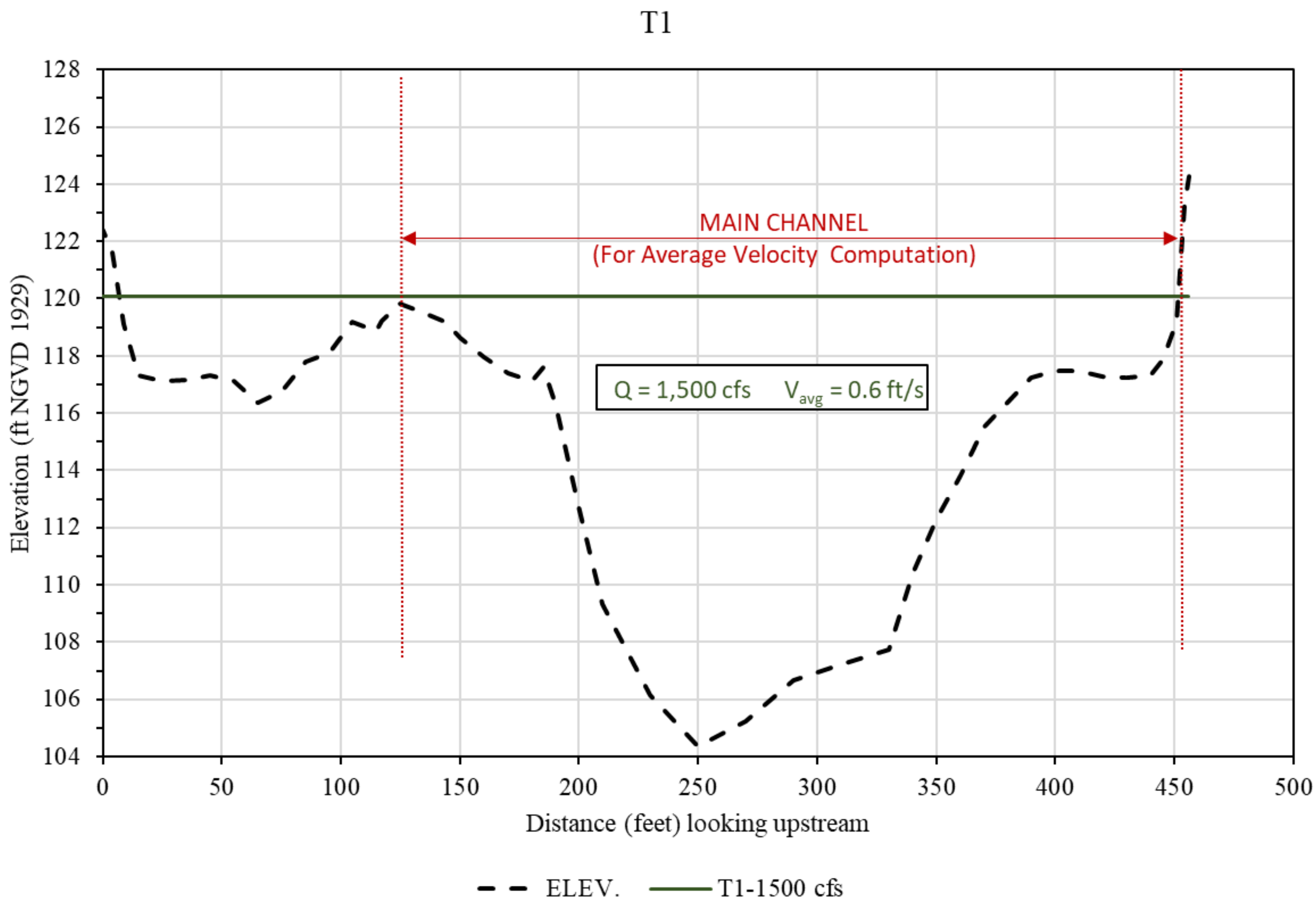

Figure 3.3.3.2.1.4.5-12: Wetted Area and Average Main Channel Velocities during Proposed Winter Flow in the Bypass Reach at T1

3.3.3.1.6 Fish Passage of Resident Species

Current Project operations have no documented impacts on upstream passage of resident fish species. Any proposed PM&E measures or flow release changes are assumed to have no adverse effects on the passage of resident species through and within Project facilities.

3.3.3.1.7 Fish Passage of Migratory Species

Migratory fish species in Connecticut River moving in the vicinity of the project area include juvenile and adult stages of American Shad, Sea Lamprey, and American Eel. Movement within the Project area includes upstream migration and downstream emigration, which vary with seasonality and life stage. Along with the various consideration to providing aquatic habitat, FirstLight is proposing several measures pertaining to fish passage that would allow more migrating fish to pass through the Project areas.

3.3.3.1.7.1 Upstream Fish Passage

Along with providing fish habitat, flows at the Turners Falls Project are an important component of providing fish passage. FirstLight studied upstream fish passage of American Shad extensively at the Project. Upstream migrating shad were a key species identified at the Project that also required specific amounts of flow to encourage passage to and into the Project fishways.

3.3.3.1.7.1.1 American Shad

FirstLight performed several years of study regarding upstream passage of American Shad. This included:

- 2015 – As part of Relicensing Study No. 3.3.2 – *Evaluate Upstream and Downstream Passage of Adult American Shad* (FirstLight, 2016b) FirstLight tagged 397 adult shad with both radio and PIT tags, plus an additional 396 fish with only PIT tags. These fish were released in multiple locations to satisfy several goals and objectives regarding upstream and downstream passage at and around the Turners Falls and Northfield Mountain Projects. Additionally, 154 adult shad were released by TransCanada (now GRH), into and upstream of the Project areas. A total of 551 shad were detected by FirstLight during the 2015 study efforts. The study report was filed with FERC on October 14, 2016. Addendum 1 to the study was filed with FERC on May 1, 2017, with several analyses superseding those in the original report.

- 2016 – As part of Relicensing Study No. 3.3.19 – *Evaluate the Use of an Ultrasound Array to Facilitate Upstream Movement to Turners Falls Dam by Avoiding Cabot Station Tailrace* (FirstLight, 2017b), FirstLight tagged 118 adult shad at Holyoke Dam with both radio and PIT tags. Additional fish were tagged by Normandeau Associates and released upstream and downstream of Holyoke Dam. The purpose of the study was to evaluate the potential for an ultrasound array installed at Cabot Station to reduce delay for fish attracted to Cabot Station, and to promote passage into the bypass reach. As such, most telemetry receivers were between Montague and the lower portions of the bypass reach, though some antennae were placed in various locations at the Turners Falls Dam (i.e. spillway and gatehouse areas). A total of 58 fish were detected in the Project areas, which was a lower percentage than anticipated (18.65% of available fish), though useful data were gathered from these fish that guided future evaluations of the ultrasound array. The study report was filed with FERC on March 1, 2017.

- 2018 – As part of a continuation of Relicensing Study No. 3.3.19, FirstLight radio tagged 250 adult shad and 137 entered the Project area. The focus of the study was on passage from Cabot Station into the bypass reach, given the ultrasound array in place, though information was also gathered pertaining to passage through the bypass reach. The study report was filed with FERC in March 2019.

- 2019 – As part of a continuation of Relicensing Study No. 3.3.19, FirstLight radio tagged 463 adult shad, of which 241 were released at Holyoke, 198 were released into the Turners Falls canal alive, and 24 euthanized shad were released into the Cabot Station forebay. The goals in 2019 included evaluating passage beyond Cabot Station without the ultrasound array in place, along with providing a better understanding of upstream passage through the bypass reach and downstream mortality through Cabot Station. As such, the overall telemetry network deployed was more extensive than in 2016 and 2018, with additional receivers added in the bypass reach and in downstream areas. The study report was filed with FERC on March 31, 2020.

These various tagging and tracking efforts have resulted in detailed understanding of fish passage through the Project areas.

Cabot Ladder, Power Canal, and Gatehouse Fishway

The probability that a tagged adult American Shad will ascend the Cabot Ladder was quantified in 2015 via radio and Passive Integrated Transponder (PIT) telemetry with a Cormack Jolly Seber (CJS) live recapture model. The entrance efficiency passage rate between the tailrace and entrance antenna was 66.8%. All shad that entered passed to the next antenna upstream in the ladder (T29), but only 15.3% passed through the remainder of the ladder between T29 and ladder exit. The overall efficiency of passage at the Cabot Ladder, including entrance efficiency, was 10.2%.

In 2015, FirstLight assessed movement within the canal via dual tagged fish released from Holyoke or into the canal. Overall passage through the canal to downstream of the gatehouse was estimated at 40.7% (Table 3.3.3.2.3.1.1-1). Areas within the lower and mid-canal appear to contain bottlenecks to passage. Further, shad will make multiple attempts to move upstream in the canal, falling back all the way to the forebay at times before making another attempt at upstream movement. This results in delay for fish that make multiple attempts in the canal. For perspective, the fastest fish to traverse the canal to the gatehouse ladder did so in 0.20 hours, but other fish took up to 8.1 days to traverse the canal. The reasons for this behavior are not known.

Once at the head of the canal, 61% of the shad that had traversed the canal successfully entered the gatehouse fishway. For those that entered the gatehouse fishway, approximately 87% passed (internal efficiency), though the sample size was relatively small and confidence intervals were wide. A broader analysis of the internal efficiency of gatehouse ladder was estimated at 76.9% with a CJS mark recapture model. Overall, only 21% of fish passed at Cabot Station would be expected to pass into the TFI (Figure 3.3.3.2.3.1.1-1)

A series of Cox Proportional Hazard regression models were fit to the upstream canal movement data to assess the factors that may be contributing or inhibiting movement for fish passing through the canal into the gatehouse ladder. Shad that passed from the canal to the gatehouse ladder did so throughout the day with a peak in the late afternoon (Figure 3.3.3.2.3.1.1-2, top left panel). Shad approached the ladder at canal flows ranging between 0 and 14,000 cfs, which encompasses most of the typical canal flow operating range (Figure 3.3.3.2.3.1.1-2, bottom left panel). The most movement from the canal into the gatehouse ladder occurred when flows were around 4,000 cfs.

Given the low passage rates through the Cabot Ladder, passage bottlenecks and delay in the canal, and continued issues with entrance efficiency of the gatehouse ladder, FirstLight is proposing to decommission the Cabot Ladder, which would preclude fish from needing to traverse the canal and enter the gatehouse ladder to reach suitable spawning areas further upstream in the TFI and beyond. Instead, FirstLight proposes to install an ultrasound array in the Cabot Station tailrace to move adult shad into the bypass and to construct a new state-of-the-art Spillway Lift, as described in the following subsection.

Bypass Reach, Spillway Ladder, and Gatehouse Fishway

The proportion of shad arriving at the Project that continue through the bypass to the Turners Falls Dam spillway was consistent among years. Although bypass flows greatly differed among years, there was no difference between the percent that entered the bypass reach in 2019 (30.6%) or 2015 (30.8%) in the absence of an ultrasound array system. Cabot Station tailrace flows can attract upstream migrating shad, resulting in delay prior to entry into the bypass reach. However, there are also flow conditions that facilitate attraction toward and movement into the bypass reach. Radio telemetry data and associated modeling from 2019 suggests that most fish moving from Cabot Station tailrace into the bypass reach did so when Cabot Station flows were less than 2.5 times the magnitude of the bypass reach flow.

After passing Cabot Station tailrace, shad need to traverse the heterogeneous bypass reach to reach the Turners Falls Dam and Spillway area. FirstLight tracked the movements of American Shad within the bypass reach in 2015, 2016, 2018 and 2019. Each year, the fixed telemetry monitoring station upstream of the Conte discharge (Conte receiver) was designated as the entrance to the bypass reach. Raw telemetry data suggested that 37%, 46%, 35% and 50% of fish detected at the Conte receiver reached the Turners Falls Dam spillway in 2015, 2016, 2018, and 2019, respectively. The median transit time for all fish that moved from Conte receiver to the Spillway was 19.8 hours, with a minimum of 2.24 hours and a maximum of 307.8 hours.

The single covariate model that best described the aggregated dataset of movement within the bypass reach included accumulated thermal units (ATU) (10°C). The model incorporating ATU had the lowest Akiki Information Criteria (AIC) (993.8) and was highly significant ($p<0.001$) with a hazard ratio of 0.57, suggesting that the number of days that water temperatures increase past 10°C, the likelihood of fish moving up to the Spillway area decreases significantly. Because shad would typically enter the river at around 10°C, this is relevant to the biology of the species as an approximate measure of how long fish would have been expected to be in the river and moving upstream.

Given the potentially difficult terrain that shad would encounter in the bypass reach, FirstLight studied passage at specific study flow rates, along with available flows that would occur as the result of spill. Seasonality and temperature appear to be more important than specific flows, with multiple years of telemetry studies show fish moving through the bypass reach at various flows and temperatures (Figure 3.3.3.2.3.1.1-3). Further, analyses of test flows at 400 cfs, 3,500 cfs, 4,500 cfs, and 6,500 cfs showed slight increases in the proportion of shad passing through the bypass reach to the spillway, in slightly less time, with increased flow, though passage at these test flows was statistically similar (Figure 3.3.3.2.3.1.1-4)

At the upper end of the bypass reach is the Turners Falls Dam and the Spillway Ladder. In 2015, FirstLight assessed the overall efficiency of the Spillway Ladder with a CJS mark recapture model. The spillway entrance efficiency (of the dual tagged and PIT tagged only fish known to be in the spillway) was estimated at 91.5%. The passage rate from the entrance to the first PIT reader (P23SL) was 64.7%. The rate from P23SL to the turning pool (P23TP) was 61.3%. Ninety percent of the fish arriving at the turning pool passed to P24, and from P24 to P25, passage rate was 100%. The internal efficiency of the ladder was 35.7%. Overall, the ladder had an efficiency of 32.7% including entrance efficiency (Table 3.3.3.2.3.1.1-2).

At the upper end of the Spillway Ladder, fish enter the internal portions of the gatehouse ladder. The internal efficiency of gatehouse ladder was estimated at 76.9% with a CJS mark recapture model.

Much has been learned about shad movement and behavior at the Turners Falls Project and specifically in the bypass reach since 2015. Based on study findings, FirstLight is proposing PME measures that will lead to positive effects for upstream migrating adult American Shad as listed below.

- **Install and operate a permanent Ultrasound Array in the Cabot Station Tailrace**. In 2016 and 2018, an ultrasound array was employed as a deterrent from the Cabot Station tailrace and to encourage movement further upstream into the bypass reach. Testing of the ultrasound array in 2016 showed reduced counts at the Cabot ladder in the hours directly following activation. However, counts would increase after a short period, suggesting that shad were becoming acclimated to the sound. The ultrasound array was tested again in 2018 using an arrangement of devices across the tailrace with an 'always-on' configuration. The results of the 2018 study indicated that the ultrasound array was effective in preventing a proportion of migrating shad from entering the Cabot Station tailrace and facilitating movement into the bypass reach. However, two elements (additional flow in the bypass reach and the ultrasound array) were both added as part of the 2016 and 2018 studies, and it was not possible to ascertain which contributed to the increased number of fish that moved upstream and entered the bypass reach. As a result, a 2019 study was conducted to test varying flows in the bypass reach without an ultrasound array present. FirstLight compared the movement data from the four years of telemetry and ultrasound studies to understand movement from the Cabot Station tailrace and upstream through the bypass reach. Based on data from the combined study years, FirstLight determined that when the ultrasound array was present in the Cabot Station tailrace, fish were more than 3.82 times more likely to move into the bypass reach. Most fish that passed from the Cabot Station tailrace to the bypass reach in less than five hours did so when the ultrasound array was operational. Additional information pertaining to the Ultrasound Array can be found in the 2019 Report for Study No. 3.3.19 (*Ultrasound Array Control and Cabot Station Shad Mortality Study*).

- Release higher minimum flows in the bypass reach. FirstLight is also proposing higher minimum flows within the bypass reach during the upstream migration season. From April 1 – May 31, FirstLight proposes to release 6,500 cfs or inflow, whichever is less, in the bypass reach. This period would cover approximately 75% of the shad run. Given that shad are attracted to the bypass reach when the Cabot Station to bypass reach flow ratio is 2.5 or less, this flow in the bypass reach would be attractive to shad, as it would provide a ratio of no more than 2.1. From June 1 – June 15, FirstLight proposes to lower the bypass release to 4,500 cfs or inflow, whichever is less. By the end of this period, historical run timing suggests that the run would be approximately 90% complete. Flows of 4,500 cfs were tested in 2015, 2016, 2018 and 2019, and a viable zone of passage for American Shad in the bypass reach was demonstrated. In 2018, a combination of proposed bypass flows and the ultrasound array led to the first ever observation of a higher count at the Spillway Ladder as compared to the Cabot Ladder. When compared to the current minimum flow release of 400 cfs, all proposed releases will result in more shad expecting to reach the spillway in a shorter amount of time (Figure 3.3.3.2.3.1.1-4).

- **Construct a new Spillway Lift with Palisade Entrance.** The Spillway Lift will include a single hopper that will lift fish approximately 39 feet to an exit trough that connects into the top of the existing Spillway Fish Ladder for fish to exit into the headpond through the existing gatehouse fish ladder. The lift will also utilize the existing entrance structure of the Spillway Fish Ladder for the entrance to the lift. A V-trap and brail system will be used instead of a crowder channel to capture fish in the hopper.

These proposed measures would benefit adult American Shad as they migrate past the project. The array reduces delay within the Cabot Station tailrace, which means that fish will move upstream into the bypass reach sooner, and in better physiological condition for the migratory challenges that lay ahead within the bypass reach. Proposed bypass reach minimum flows will provide for a combination of attraction from Cabot Station tailrace to the bypass reach, along with passage routes through the reach to the spillway. Once fish arrive in the spillway area, FirstLight's proposed Spillway Lift would provide safer, more efficient passage with less delay. This means that adult American Shad will arrive at upstream spawning habitats in better physiological condition than they currently do.

Turners Falls Impoundment

Adult shad radio telemetry studies conducted by FirstLight and TransCanada (now GRH) in 2015 demonstrate high rates of passage through the TFI. Data from 105 shad from multiple release cohorts that passed upstream of the lower TFI areas were determined to be migrating non-fallback fish. The shad tracked within the TFI were from three different release locations: Holyoke, Cabot Canal and the TFI, with the majority having been released directly into the TFI.

One hundred of the tagged fish (95.2%) were detected at Shearer Farms (Table 3.3.3.2.3.1.1-3). Most of these fish had passed beyond the Northfield Mountain Project intake/tailrace without being detected there, indicating that they were traversing the area on the opposite side of the river. Eighteen (17.1%) were detected at the Northfield Mountain Project intake/tailrace (Table 3.3.3.2.3.1.1-3), most of which were also detected further upstream at Shearer Farms. Those 18 fish made a total of 47 transitions into the Northfield Mountain Project intake/tailrace area from the lower TFI or from Shearer Farms (Table 3.3.3.2.3.1.1-4), indicating some degree of attraction for fish that encountered the area, though generally these fish moved there relatively few times and did not remain for extended periods. Sixty-two of the 100 fish at Shearer Farms made movements to the lower TFI before returning to reach Shearer Farms, suggesting that shad were making some larger-scale back-and-forth movements within the TFI (Table 3.3.3.2.3.1.1-4). The median transition time from the lower TFI to Shearer Farms was 0.90 days; therefore, passage to areas upstream of Northfield Mountain Project intake/tailrace from the Turners Falls Project would typically take less than a day for upstream migrating shad. Shad that encountered the Northfield Mountain Project intake/tailrace area typically did so between the hours of 6:00 and 12:00, when Northfield was not pumping, and no upstream migrating adult shad were entrained at the Northfield Mountain Project.

Additionally, radio telemetry monitoring performed by TransCanada (now GRH) indicated that 75% of the tagged shad released above Turners Falls Dam into the TFI successfully arrived at the Vernon Dam fishway. (Normandeau, 2016, ILP Study 22) This reduction from the number that reached Shearer Farms could be explained by spawning activity documented near Stebbins Island.

The percentages of tagged shad reaching Vernon Dam are likely underestimates compared to the actual migrating population, given the potential for some tagging effects and imperfect detection. Therefore, despite the presence of spawning areas near Stebbins Island, a large proportion of fish passed at the Turners Falls Dam are reaching Vernon Dam.

Table 3.3.3.2.3.1.1-1: CJS estimated survival between canal reaches (ϕ), 95% confidence intervals, and cumulative arrival probabilities for shad migrating upstream through the Power Canal.

Reach	ϕ	Lower 95%	Upper 95%	Cumulative Arrival Probability
Release: Lower Canal	1.00	0.96	1.00	1.000
Lower Canal: Mid Canal	0.64	0.51	0.76	0.633
Mid Canal: d/s Station No. 1	0.85	0.71	0.95	0.541
d/s Station No. 1: Upper Canal	0.82	0.65	0.93	0.444
Upper Canal: d/s Gatehouse	0.92	0.76	0.99	0.407
d/s Gatehouse: Gatehouse Ladder	0.61	0.39	0.81	0.247
Gatehouse Ladder: Impoundment	0.87	0.47	1.00	0.214

Table 3.3.3.2.3.1.1-2: Spillway Fishway passage estimates.

Parameter	Passage (%)	Standard Error (%)	Lower 95% Confidence Interval	Upper 95% Confidence Interval
Spillway - Entrance+T30	91.5	13.5	69.5	100
Entrance -P23SL	64.7	11.6	45.8	84.2
P23SL - P23TP	61.3	10.0	42.0	82.7
P23TP - P24	90.0	9.5	62.8	99.4
P24 -P25	100	0	88.7	100
P25 -Passage	100	0	88.7	100
Passage through the Spillway Fishway	32.7			

Table 3.3.3.2.3.1.1-3: Counts of dual tagged shad detected within each state by release date

Release Date	Release Location	Lower Turners Falls Impoundment	Northfield Mountain Project Intake/ Tailrace	Shearer Farms
5/6/2015	Holyoke	5	-	5
5/12/2015	Holyoke	2	1	2
5/13/2015	Cabot	5	-	5
5/15/2015	Impoundment	22	4	22
5/16/2015	Impoundment	20	5	19
5/19/2015	Cabot	2	1	2
5/19/2015	Holyoke	1	-	1
5/22/2015	Impoundment	23	1	20
5/23/2015	Impoundment	24	6	23
6/8/2015	Holyoke	1	-	1
Total		**105**	**18**	**100**

Table 3.3.3.2.3.1.1-4: Total number of movements (m) by all fish between reaches, the number of fish (n) that made those movements and the expected number of movements that a fish will make for each transition. The diagonal counts the number of fish detected within each reach.

To->	Lower Turners Falls Impoundment	Northfield Mountain Project Intake/ Tailrace	Shearer Farms
From			
Lower Turners Falls Impoundment	n: 105	n: 16 m: 29 Min: 1 Median: 1.5 Max: 5	n: 99 m: 219 Min: 1 Median: 2 Max: 11
Northfield Mountain Project Intake/ Tailrace	n: 14 m: 28 Min: 1 Median: 2 Max: 4	n: 18	n: 14 m: 19 Min: 1 Median: 1 Max: 4
Shearer Farms	n: 62 m: 131 Min: 1 Median: 2 Max: 8	n: 9 m: 18 Min: 1 Median: 2 Max: 4	n: 100

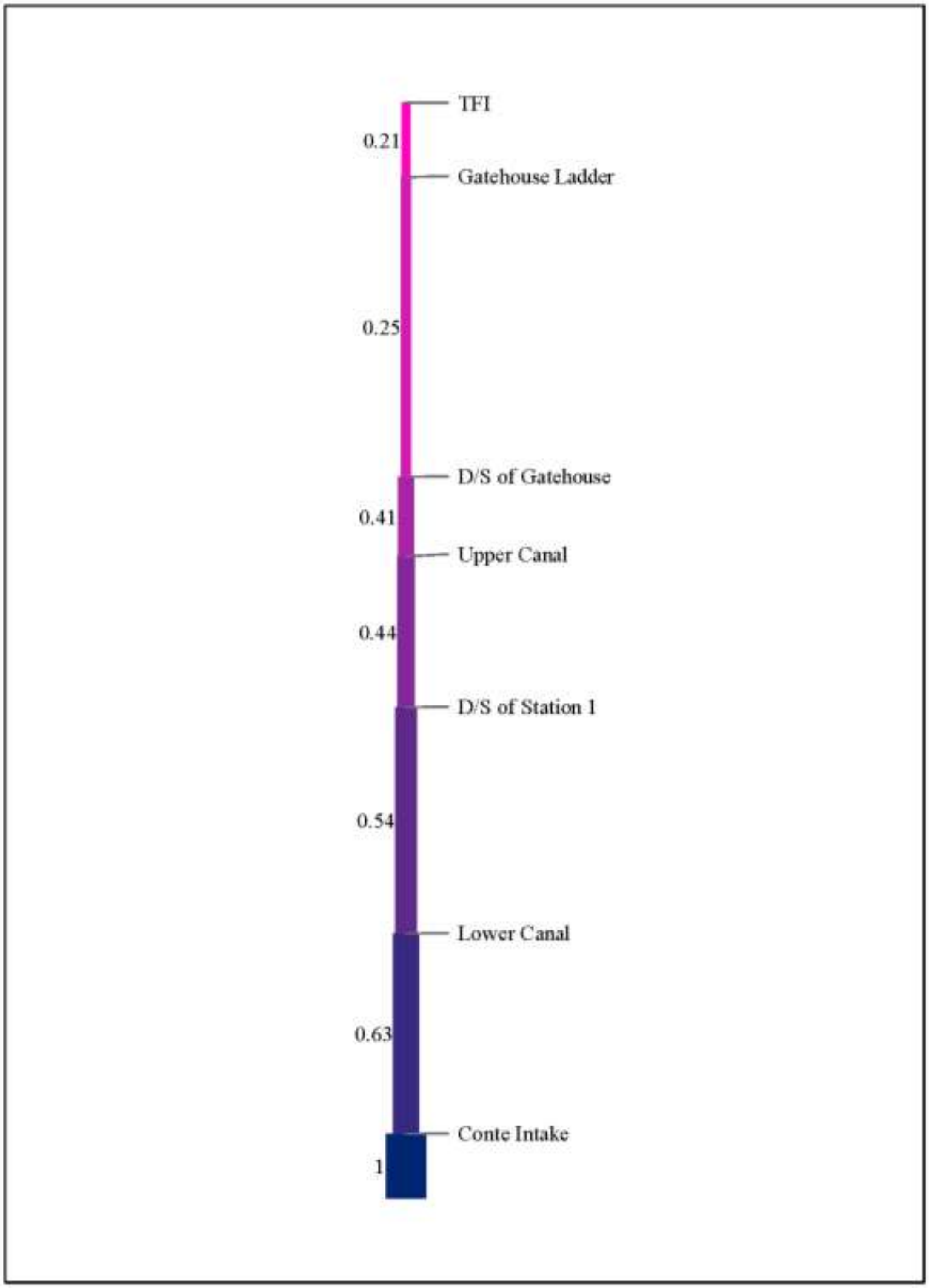

Figure 3.3.3.2.3.1.1-1: Overall probability of upstream passage through the Power Canal for all release cohorts combined.

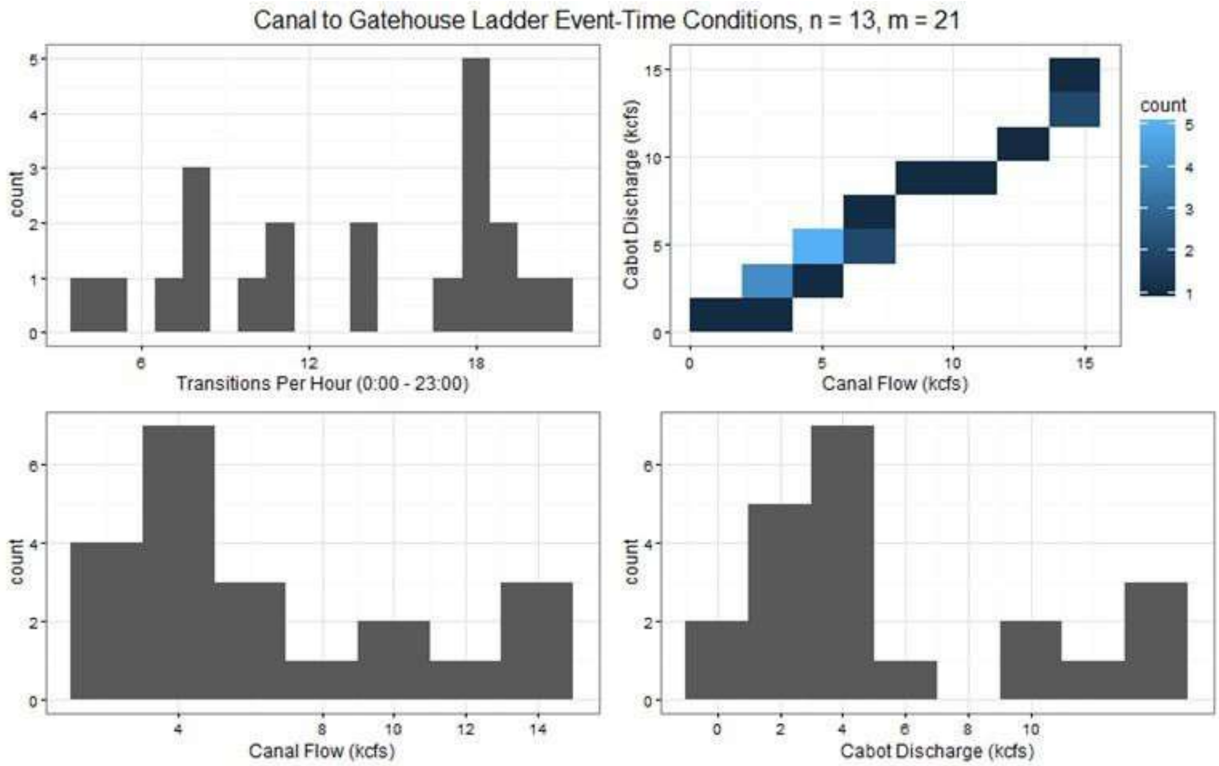

Figure 3.3.3.2.3.1.1-2: The environmental conditions at event time for fish (n = 13) moving between the Canal and Gatehouse Ladder (m = 21).

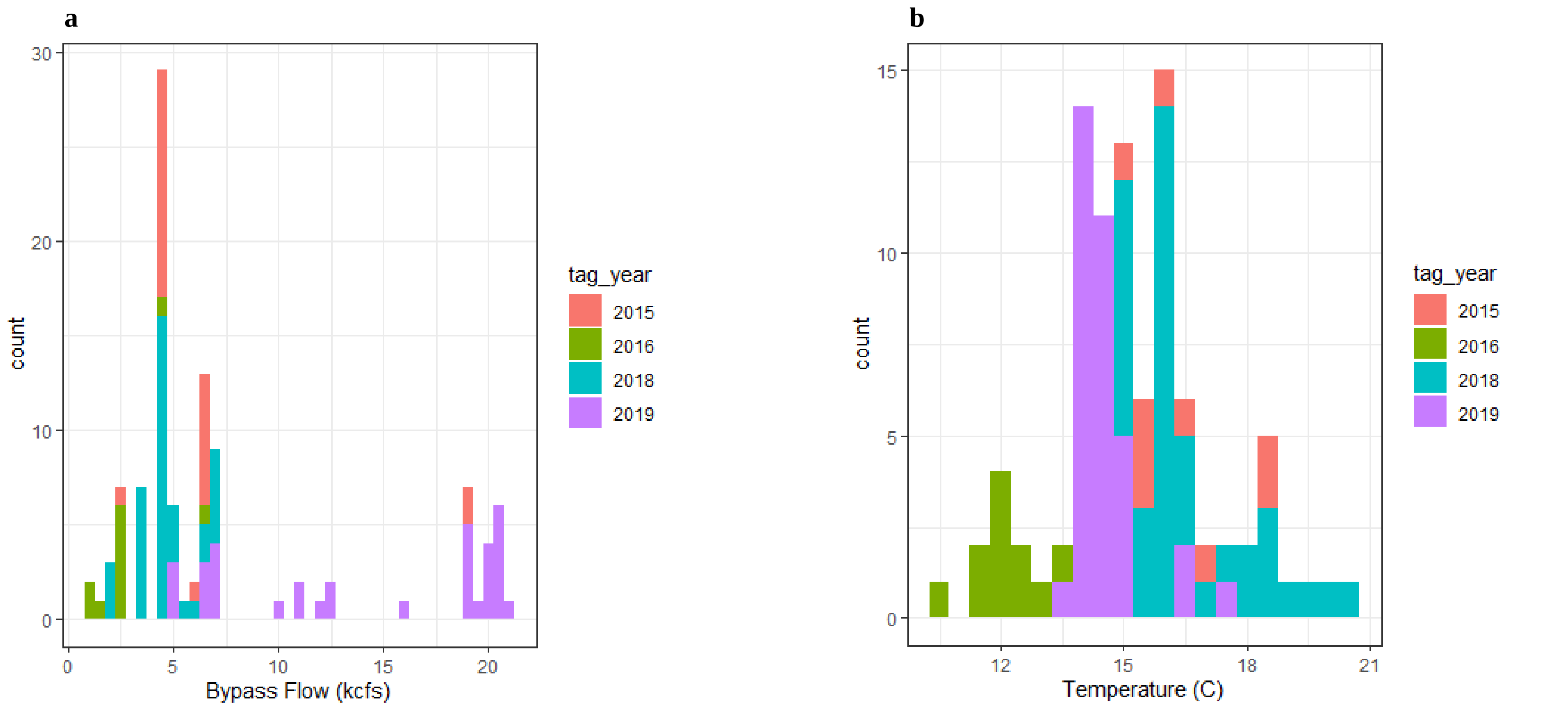

Figure 3.3.3.2.3.1.1-3: Instantaneous Bypass flow (kcfs)(a) and Instantaneous water temperature (°C) (b) during movement of tagged shad from Conte to TFD Spillway

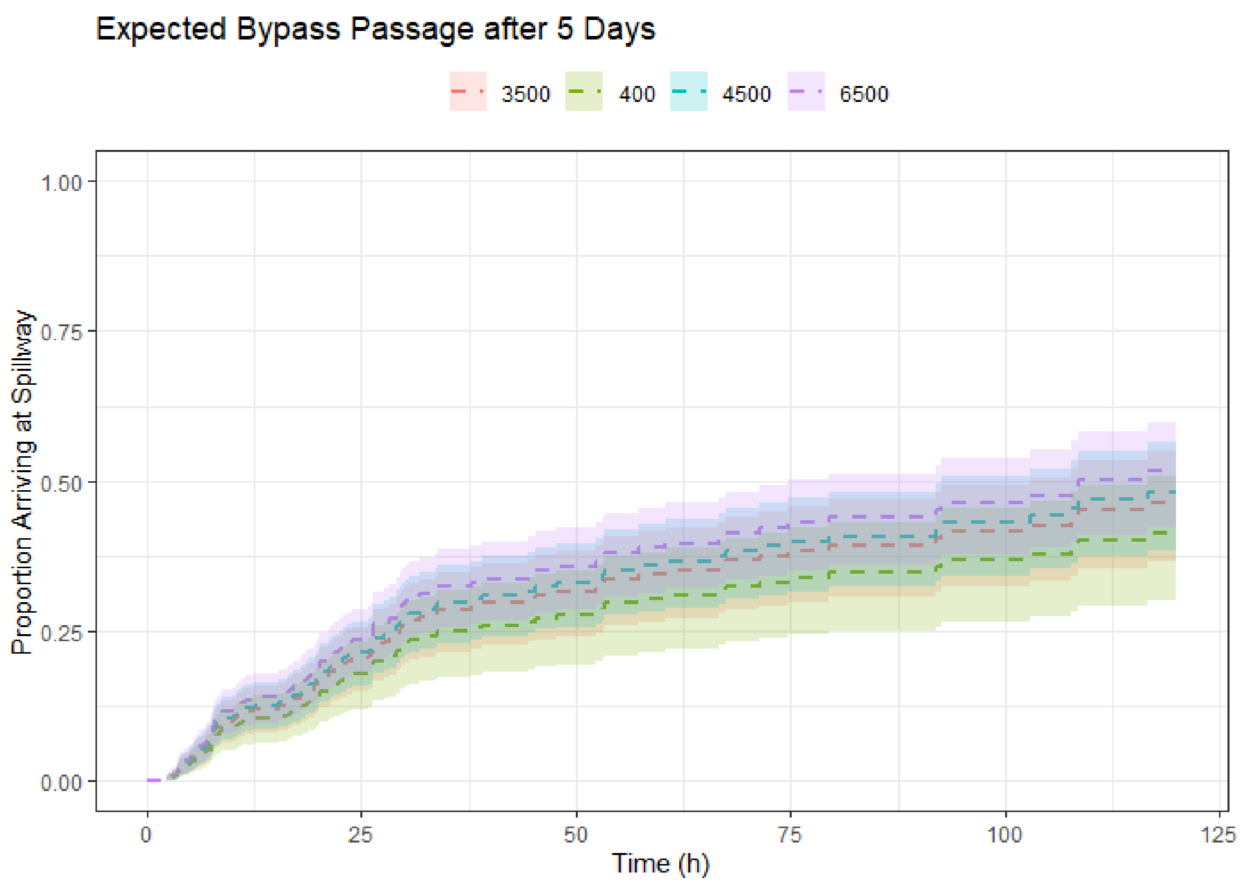

Figure 3.3.3.2.3.1.1-4: Expected passage through the Bypass to Spillway after 5 days given Total Bypass Flow Rates.

3.3.3.1.7.1.2 Sea Lamprey

Sea Lamprey populations migrating upstream through the Connecticut River are some of the largest found on the east coast (Beamish 1980). Lamprey have benefited from the construction of multiple fish passage facilities designed for other species on the Connecticut River. Currently, there are no restoration programs in place to increase lamprey populations (USFWS 2010). According to the USFWS historic fish count data, the number of Sea Lamprey passing through Holyoke Dam and Turners Falls Dam has remained stable in recent years. Proposed measures such as a new Spillway Lift will likely lead to increased passage of upstream migrating adult Sea Lamprey.

3.3.3.1.7.1.3 American Eel

Currently, there are no passage facilities for American Eel at the Turners Falls Project although some young eels apparently enter the TFI by ascending the fishways or other wetted structures associated with the Project. In 2014, the Licensee performed a study to assess the likely location of upstream American eel passage at the Turners Falls Project, described above in Section 3.3.3.1.2. Nighttime visual surveys revealed that the majority (94%) of observed juvenile American eels were congregating at the base of the Turners Falls Dam. The following year, temporary eel traps were installed at three locations (within the Turners Falls Dam Spillway fishway, within the Cabot Station fishway, and at Gate No. 10 of the emergency spillway that is adjacent to the Cabot powerhouse) to assess whether eels could be passed, and which site(s) would be viable for permanent passage structures. The traps generally consisted of a wooden ramp (incline ranging from 34 to 43 degrees depending on location) overlain with 1-inch Milieu substrate, a collection tank, and an attraction/conveyance flow system. In addition, 2 Medusa-style traps were positioned in the Station No. 1 tailrace to assess recruitment to this area. The traps were installed in July and monitored every few days through November 2, 2015. All eels were released into the TFI about 1,500 feet upstream of the Turners Falls Dam.

Results confirmed the 2014 nighttime survey findings, with about 88% (n=5,235) of eel collections occurring at the Turners Falls Dam Spillway fishway, followed by 7% at the Cabot Station fishway, and 5% at the emergency spillway trap. Eels were observed in the traps as soon as they became operational in early July. Therefore, the upstream migration of juvenile eels commenced earlier than study efforts. Available literature suggests that migration is triggered when water temperatures increase to between 10 and 14°C (Greene et al., 2009). Data collected at the Project revealed that water temperature reached 10-14°C in early to mid-May. Given this, it is likely that migration began in May at the Project. The peak period of migration during the 2015 trapping effort at Turners Falls was mid-July. Monitoring at Holyoke in 2015 revealed that peak migration occurred in July as well, with a secondary peak occurring in mid-September (Normandeau Associates, Inc. 2016).

Based on the observations and data collected, FirstLight is proposing to construct a permanent eelway adjacent to the Turners Falls Dam Spillway fishway following completion of other upstream and downstream passage facilities proposed. The eelway will consist of similar components as the traps that were deployed during the 2015 assessment of upstream passage at the Project. The proposed eelway will be "permanent" in that it will be installed and operated every season following installation, yet it is likely that some components of the structure will need to be removed annually at the end of the upstream passage season to avoid potential damage or weathering during winter conditions.

In addition to the existing fishways and wetted structures throughout the Project, the new eelway will provide juvenile American Eel access to the TFI and habitat that exists between the Turners Falls Dam and Vernon Dam. To maximize eel passage, the Licensee proposes to operate the eelway from May 1 through October 31 annually. The eelway will extend the opportunity for upstream eel passage beyond the time in which fishways designed for other species are operational, with the intent of passing eels in greater numbers for a longer period of time.

3.3.3.1.7.2 Downstream Fish Passage

3.3.3.1.7.2.1 Adult American Shad

Turners Falls Impoundment

Based on radio telemetry data, adult shad that were tracked to areas upstream of the Northfield Mountain Project intake/tailrace are finding their way downstream to the lower portions of the TFI quickly during their post-spawn emigration, suggesting the fish are motivated to move downstream. Based on radio telemetry data collected in 2015, shad emigrating from upstream of the Northfield Mountain Project to Turners Falls Dam, over 95% of tagged fish successfully passed downstream, and 75% of them did so in half of a day or less (Table 3.3.3.2.3.2.1-1; Table 3.3.3.2.3.2.1-2). Most emigrating shad moved to the lower portions of the TFI in the early morning and late afternoon, into the evening (Figure 3.3.3.2.3.2.1-1). Tagged shad also had a greater likelihood of moving downstream at higher river flows.

Relatively few emigrating shad were detected at the Northfield Mountain Project intake/tailrace (Table 3.3.3.2.3.2.1-1). Those that were detected near the intake tended to approach the area during the early morning hours when the Northfield Mountain Project was pumping (Figure 3.3.3.2.3.2.1-2). As pumping flow increased, they were more likely to be attracted to the intake; however, as river flow increased, the likelihood of movement to the intake area decreased. Despite some potential attraction to the intake area that was exhibited by a relatively small number of individual fish, no downstream migrating adult shad were entrained at Northfield Mountain Project intake/tailrace. There were two fish last detected at the intake monitoring station with no subsequent detections at any telemetry stations to follow, meaning they were at risk of entrainment, but their fate was unknown.

Turners Falls Project

Once downstream migrating shad reach Turners Falls Dam, they can pass into the bypass reach via spill or enter the power canal. Tagged shad were identified passing via both routes, favoring the power canal, though the probability of choosing one route versus another depended on flow, with fish more likely to pass via a given route at higher flows (Tables 3.3.3.2.3.2.1-3 through 3.3.3.2.3.2.1-5).

Passage via Dam Spillway

Though relatively few emigrating adult shad passed via the dam spillway, passage there is possible, especially if spill flows are high. FirstLight is proposing to construct a plunge pool below Bascule Gate No. 1. The plunge pool will include two concrete walls to create an approximately 110-foot-wide by 65-foot-long box below Bascule Gate No. 1 – one wall parallel to flow between Bascule Gate No. 1 and Bascule Gate No. 2, and one wall perpendicular to the flow from the end of the first wall to the fish lift entrance. Flow will pass from the pool either through a palisade structure adjacent to the fish lift entrance or by spilling over the downstream wall of the box. The flow from the palisade structure will also be used for attraction flow to the Spillway Lift.

This measure will reduce the chance of injuries and increase survival rates for adult shad during their emigration over the dam spillway at the Turners Falls Project.

Passage via Power Canal

Downstream migrating shad were tagged and tracked as they migrated downstream through the canal in 2015. Passage through the bypass log sluice accounted for 41 fish (~49%), followed by 30 fish (~36%) that escaped via the Cabot Station powerhouse, 8 fish (~10%) escaped via unknown avenues, and 4 fish (~5%) remained in the canal (Table 3.3.3.2.3.2.1-6). Shad exited the canal relatively quickly, with a median passage time of 0.32 days for fish passed through the powerhouse and 0.42 days for fish passed through the log sluice (Table 3.3.3.2.3.2.1-7). However, the maximum times for escapement through the powerhouse, bypass log sluice and unknown routes were 23.63, 18.84 and 29.51 days respectively, meaning some emigrating fish were present for nearly a month in the canal before passing downstream. These fish were a small portion of the fish tagged and could have been exhibiting symptoms of spawning stress and tagging effects. As such, passage through the canal is expected to occur swiftly for most emigrating adult shad.

A series of Cox Proportional Hazards regression models identified that the tagged shad were more likely to pass through the powerhouse as discharge in the canal and at Cabot Station increased, and less likely to use the log sluice as Cabot Station flows was increasing (Table 3.3.3.2.3.2.1-8 and Table 3.3.3.2.3.2.1-9).

In 2019, FirstLight released 198 fish into the canal to further evaluate delay within the forebay, choice of route of passage, and downstream passage survival. FirstLight also conducted a dead drift study of euthanized fish injected into the penstock at Cabot Station Unit 2, to aid in identification of dead fish that could drift. The dead drift study determined that dead shad do not drift swiftly or far from Cabot Station, typically settling between the Cabot Station tailrace and the Deerfield River confluence, and occasionally reaching the Fourth Island area. Patterns of movement for dead drift fish were distinctly different from live fish for fish passed through both routes (Cabot Station and log sluice) in the lower canal (Figure 3.3.3.2.3.2.1-3 and Figure 3.3.3.2.3.2.1-4)

The survival estimates generated from the live recapture-dead recovery (LRDR) modeling are an improvement over those generated with traditional CJS modeling because information from known mortalities are incorporated. With traditional CJS modeling, it is not possible to distinguish if a fish has died or if it has emigrated from the study area. By incorporating information from dead recoveries, survival can be more accurately estimated. The LRDR mark recapture estimates were generated in MARK (software package). Three LRDR models were constructed: (1) powerhouse passage survival, (2) log sluice passage survival, and (3) overall canal downstream survival. The MARK input files are provided in Appendix D of the 2019 Report for Study No. 3.3.19 *Ultrasound Array Control and Cabot Station Shad Mortality Study*.

Mortality was observed in the Cabot Station forebay with 58 of the 198 fish released (29%) exhibiting an 11-second mortality pulse rate before transitioning into the tailrace; these fish were excluded from the initial and latent survival analysis as there is no way to determine if they died from natural or handling mortality.

In total, 76 fish were known to have passed through the powerhouse alive, 38 passed via the log sluice, and 26 of the tagged fish went undetected after release. The proportion of fish exiting via the canal or the log sluice varied between the 2015 and 2019 data. This suggests that there could be some variability in route selection choice depending on the conditions encountered by emigrating fish in the canal upon reaching the Cabot Station forebay.

For the 2019 study, no fish were recovered dead within one week in the stretch of river from Fourth Island to the Hatfield Wastewater Treatment Plant (WWTP). During mobile tracking, six fish that passed via the powerhouse were recovered dead including four in the Deerfield River confluence and two between the Montague WWTP and Fourth Island. Once turbine-passed fish entered the tailrace, the median travel time to Montague WWTP was only 0.62 hours (37.2 minutes). Approximately 69% of turbine-passed fish survived to reach Montague WWTP. Of those fish that survived until reaching Montague, 96% survived to the southern tip of Fourth Island at Nourse Farms; half of these fish traversed the distance in 18 minutes or less. The LRDR model also found that 99% of the fish that survived to Nourse Farms survived to reach Hatfield WWTP, nearly 15 miles downriver from the Project.

Overall, the cumulative survival rate (48-hr after passage) of fish known to pass via the powerhouse was 65.6% (Table 3.3.3.2.3.2.1-10). Additionally, passage downstream for fish that survived turbine passage was relatively swift. Thirty-eight shad in the canal passed via the log sluice, which is considered the downstream bypass fishway. Cumulative survival (48-hr) via the log-sluice (n = 38) was 89.2% (Table 3.3.3.2.3.2.1-10).

The cumulative canal downstream survival estimate for adult shad was 65%, given that more shad had passed through the turbines where mortality was lower in comparison to the log sluice (Table 3.3.3.2.3.2.1-

10). However, if more fish had passed through the log sluice as had the tagged fish in 2015, the survival estimate would have been higher.

Though emigrating adult shad were not identified as using Station No. 1 as a route of passage out of the canal, there is the potential for greater mortality there than at other locations given the turbine configuration (higher revolutions per minute), as has been shown for other migratory species. FirstLight proposes to install a bar rack, with ¾-inch clear spacing, at the location where flow from the main power canal is diverted into the Station No. 1 forebay. The rack will be approximately 58 feet wide across the entrance of the forebay and 21 feet tall. The bar rack will exclude outmigrating adult shad from entering the forebay and being entrained through the Station No. 1 units. By excluding them from entrainment at Station No. 1, overall survival rates for fish passing downstream through the canal would be reflective of current condition, as described above.

Several of FirstLight's proposed operational changes are expected to work together to improve the likelihood of downstream migrating shad finding the log sluice and passing there instead of through Cabot Station. Releasing substantially higher minimum flows to the bypass reach at Turners Falls Dam and Station No. 1 will reduce the total flow available to be passed through Cabot Station. Additionally, FirstLight's operational proposal of up- and down-ramping Cabot Station at 2,300 cfs/hour, 24/7, from April 1 to May 31, baseloading of one Cabot Station unit in June, along with up-ramping Cabot Station at 2,300 cfs/hour for odonates in June (8:00am to 2:00pm), will provide fewer periods where flow through Cabot Station is increasing rapidly. These combined limitations on Cabot Station operation during periods when adult post-spawn shad would be emigrating through the canal would increase the attraction of the log sluice relative to Cabot Station. More shad would therefore be anticipated to pass via the log sluice, where survival is highest.

Table 3.3.3.2.3.2.1-1: Raw recaptures within each state from the impoundment by release date

Release Date	Release Location	Upper Turners Falls Impoundment	Northfield Mountain Project Intake/ Tailrace	Lower Turners Falls Impoundment	Unknown Intake
5/6/2015	Holyoke	2	1	2	-
5/12/2015	Holyoke	1	-	1	-
5/13/2015	Cabot	2	2	2	-
5/15/2015	Impoundment	15	4	15	-
5/16/2015	Impoundment	14	3	14	-
5/19/2015	Cabot	1	-	1	-
5/19/2015	Holyoke	1	-	1	-
5/22/2015	Impoundment	13	2	12	1
5/23/2015	Impoundment	16	6	15	1
Total		**65**	**18**	**63**	**2**

Table 3.3.3.2.3.2.1-2: Descriptive statistics of event times (days) from the upper Turners Falls Impoundment to the lower Turners Falls Impoundment or the Northfield Mountain Project intake/tailrace area

Event	Min	25%	Median	75%	Max
Lower Turners Falls Impoundment	0.000046	0.0427	0.19	0.50	30.67
Northfield Mountain Project Intake	0.0087	0.015	0.016	0.084	0.22

Table 3.3.3.2.3.2.1-3: Raw recaptures within each state from the Route Choice at the Turners Falls Dam by release date

Release Date	Release Location	Lower Turners Falls Impoundment	Canal	Bypass Reach (Spill)	Did Not Pass
5/6/2015	Holyoke	2	2	0	0
5/12/2015	Holyoke	1	0	1	0
5/13/2015	Cabot	2	1	0	1
5/15/2015	Impoundment	15	8	3	4
5/16/2015	Impoundment	16	13	1	2
5/19/2015	Cabot	1	1	0	0
5/19/2015	Holyoke	1	0	1	0
5/22/2015	Impoundment	15	6	3	6
5/23/2015	Impoundment	15	8	3	4
Total		**68**	**39**	**12**	**17**

Table 3.3.3.2.3.2.1-4: Cox Proportional Hazards output for Time-to-Canal route selection

Model ID	Covariates	AIC	LR Test	Hazard Ratio	SE	p	(+/-)
1	Diurnal (day)	274.69	0.86	0.95	0.33	0.865	(0.49, 1.80)
2	Canal Flow (kcfs)	264.09	0.001	1.10	0.03	0.001	(1.04, 1.16)
3	TFD Spill (kcfs)	274.51	0.64	1.02	0.04	0.64	(0.94, 1.10)

Table 3.3.3.2.3.2.1-5: Cox Proportional Hazards output for Time-to-Bypass route selection

Model ID	Covariates	AIC	LR Test	Hazard Ratio	SE	p	(+/-)
1	Diurnal (day)	63.58	0.07	3.10	0.68	0.10	(0.82, 11.75)
2	Turners Falls Dam Spill (kcfs)	59.78	0.006	1.18	0.06	0.006	(1.05, 1.32)
3	Canal Flow (kcfs)	65.15	0.21	1.07	0.06	0.22	(0.96, 1.20)

Table 3.3.3.2.3.2.1-6: Raw recaptures within each state from the Canal by release date

Release	Release Location	Canal	Powerhouse	Bypass Sluice	Remained in Canal	Unknown Escapement
5/6/2015	Holyoke	3	1	1	0	1
5/13/2015	Cabot	21	5	14	1	1
5/15/2015	Impoundment	9	5	2	1	1
5/16/2015	Impoundment	14	6	3	2	3
5/19/2015	Cabot	21	7	13	0	1
5/19/2015	Holyoke	1	0	1	0	0
5/22/2015	Impoundment	6	3	3	0	0
5/23/2015	Impoundment	8	3	4	0	1
Total		**83**	**30**	**41**	**4**	**8**

Table 3.3.3.2.3.2.1-7: **Descriptive statistics of event times (days) from the Canal to Downstream**

Event	Min	25%	Median	75%	Max
Powerhouse	0.03	0.16	0.32	1.49	23.63
Bypass Sluice	0.01	0.11	0.42	2.68	18.84
Unknown Route	0.03	0.27	1.03	13.39	29.51

Table 3.3.3.2.3.2.1-8: **Cox Proportional Hazards output for time-to-Powerhouse passage**

Model ID	Covariates	AIC	LR Test	Hazard Ratio	SE	p	(+/-)
1	Diurnal (Day)	214.55	0.61	1.22	0.40	0.61	(0.55, 2.68)
2	Cabot Ops (kcfs)	203.72	<0.001	1.17	0.05	0.002	(1.06, 1.29)
3	Canal (kcfs)	201.85	<0.001	1.16	0.04	0.001	(1.07,1.27)
4	Delta Cabot Ops (ft^3/s^2)	204.32	0.48	0.81	0.29	0.47	(0.46, 1.43)

Table 3.3.3.2.3.2.1-9: Cox Proportional Hazards output for time-to-Sluiceway passage

Model ID	Covariates	AIC	LR Test	Hazard Ratio	SE	p	(+/-)
1	Diurnal (Day)	291.16	0.22	0.68	0.32	0.22	(0.37, 1.26)
2	Cabot Ops (kcfs)	292.32	0.58	1.02	0.03	0.58	(0.95, 1.10)
3	Canal (kcfs)	292.25	0.56	1.02	0.03	0.56	(0.96, 1.10)
4	Delta Cabot Ops (ft^3/s^2)	289.61	0.08	0.74	0.14	0.04	(0.56, 0.98)

Table 3.3.3.2.3.2.1-10: Survival estimates for LRDR downstream survival Mark Recapture model

	Whole Project (Canal)	Powerhouse	Log Sluice
Forebay - Tailrace	0.95 (0.87 – 1.0)	1 (0.97 – 1.0)	1 (1.0 – 1.0)
Tailrace - Confluence	0.71 (0.61 – 0.81)	0.69 (0.57 – 0.88)	0.92 (0.81 – 0.98)
Confluence - Montague	0.97 (0.91 – 0.99)	0.96 (0.89 – 0.99)	0.97 (0.88 – 0.99)
Nourse Farms - Hatfield	1 (0.0 – 1.0)	0.99 (0.0 – 0.99)	1 (1.0 – 1.0)
Cumulative	**0.654265**	**0.655776**	**0.8924**

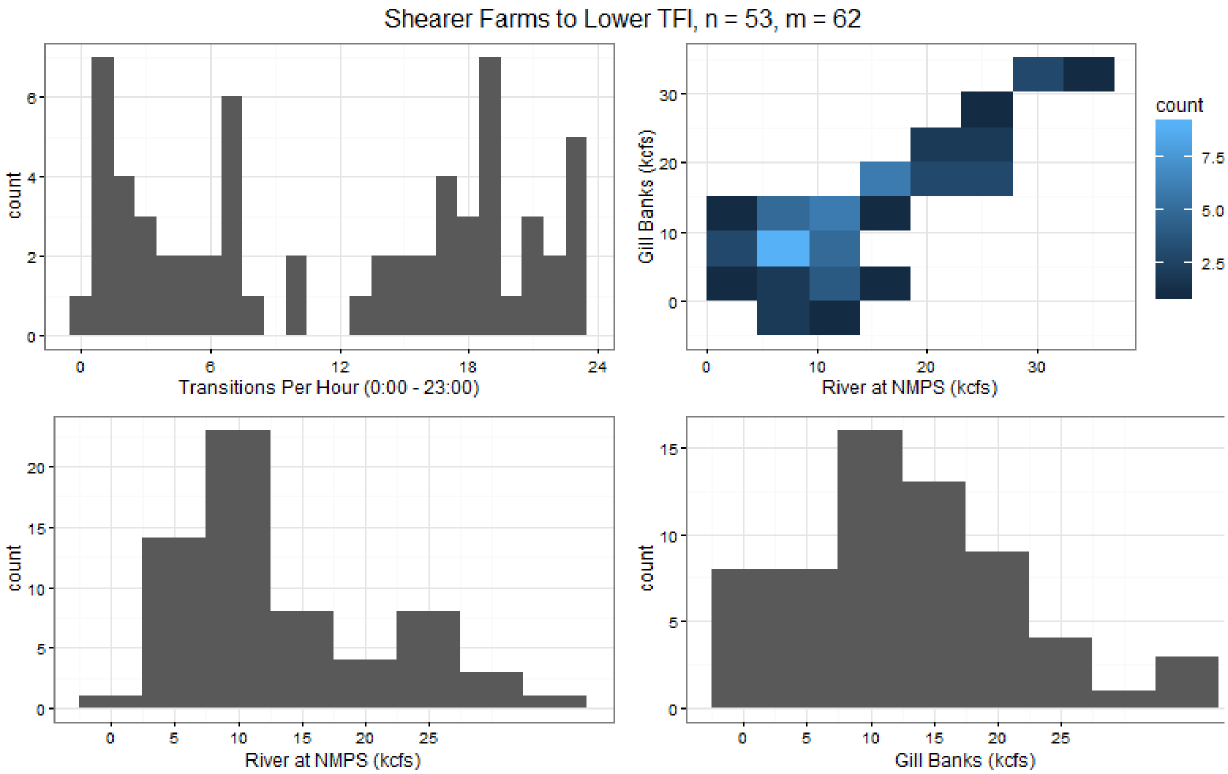

Figure 3.3.3.2.3.2.1-1: The environmental conditions at event time for fish (n = 53) moving between the Shearer Farms and the lower Turners Falls Impoundment (m = 62).

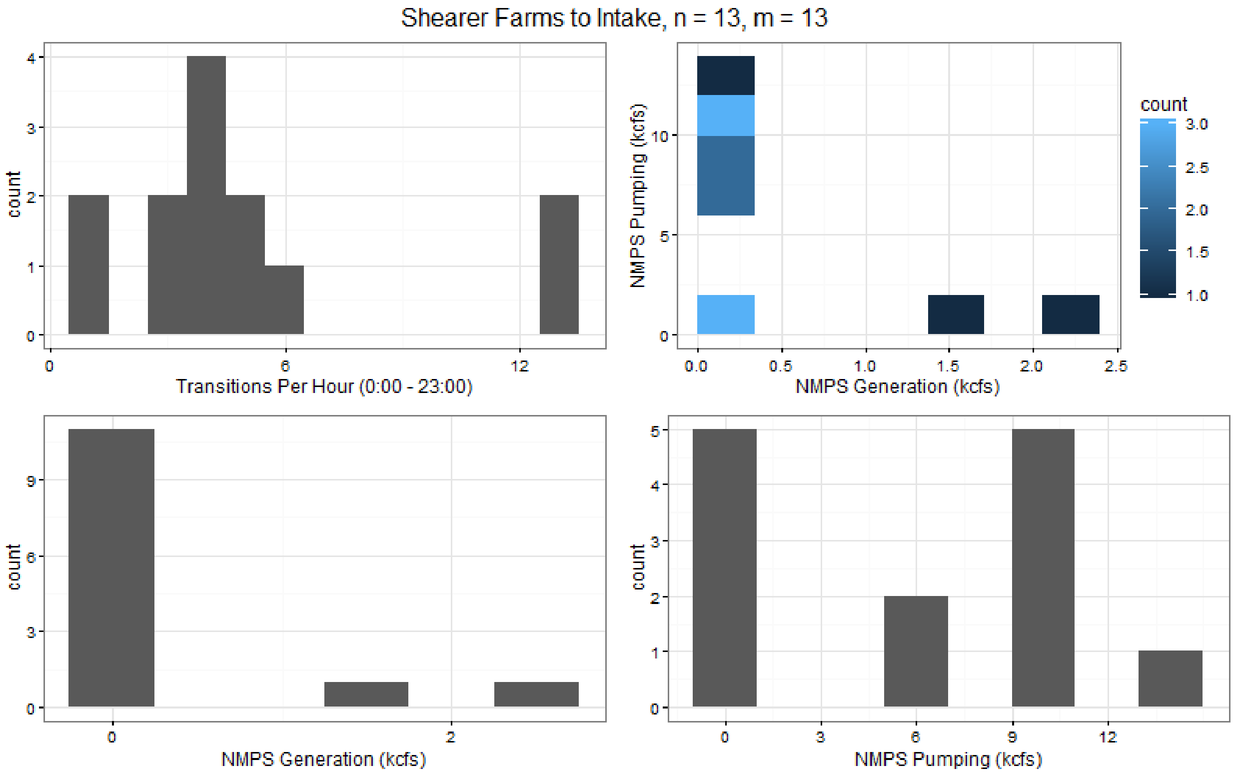

Figure 3.3.3.2.3.2.1-2: The environmental conditions at event time for fish (n = 13) moving between the Shearer Farms and the Northfield Mountain Project intake/tailrace (m = 13).

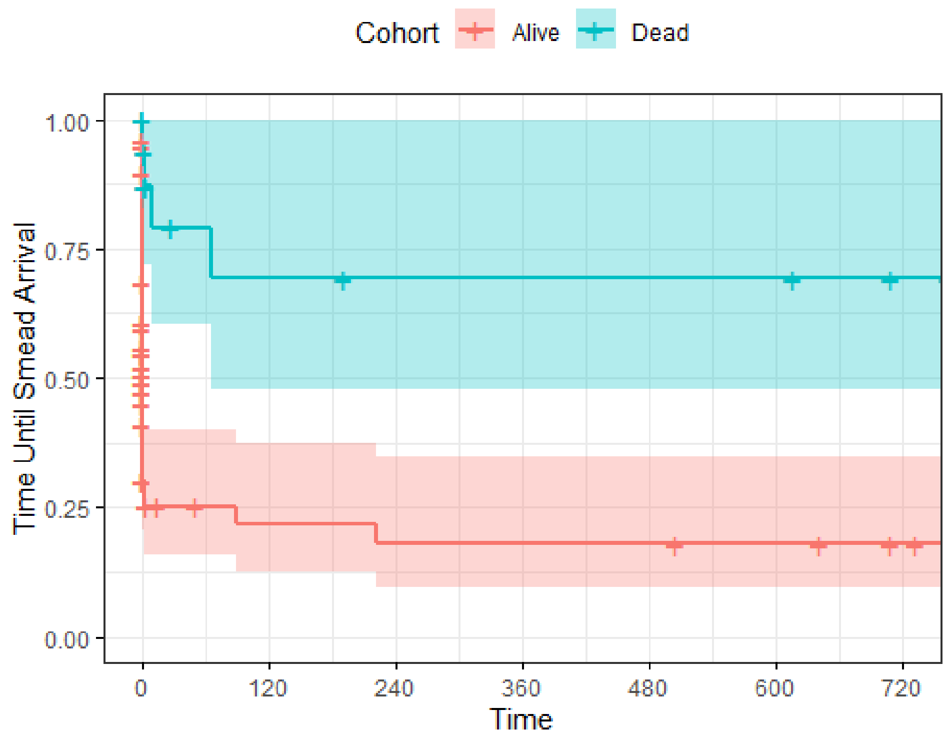

Figure 3.3.3.2.3.2.1-3: Time until Smead Island arrival for fish with known status when passing downstream via Cabot powerhouse

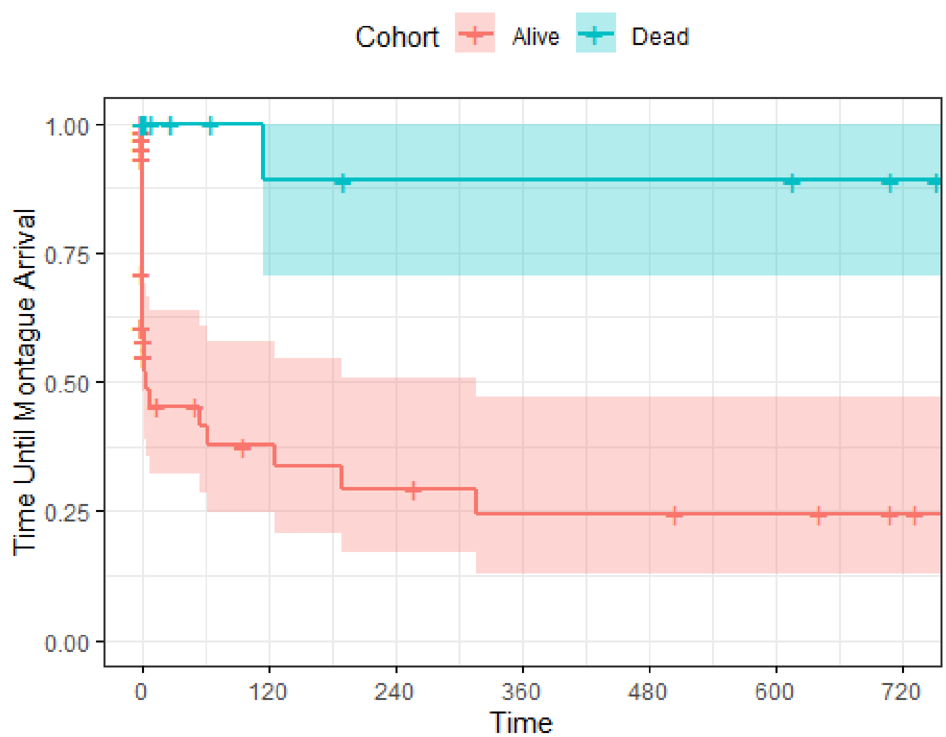

Figure 3.3.3.2.3.2.1-4: Time until Montague arrival for fish with known status when passing downstream via Cabot powerhouse

3.3.3.1.7.2.2 Juvenile American Shad

Turners Falls Impoundment

Juvenile American Shad begin their emigration out of the river in the fall, when water temperatures reach approximately 19°C degrees, with peak emigration between 14-9°C degrees and ending somewhere around 10-8°C (O'Leary and Kynard, 1986). Emigrating shad in the TFI pass the Northfield Mountain Project intake/tailrace and continue downstream by either spilling over the Turners Falls Dam into the bypass reach or entering the power canal for subsequent downstream passage through Station No. 1, through Cabot Station powerhouse, or via the log sluice bypass.

FirstLight attempted to track the downstream movements of juvenile shad in the TFI using radio telemetry technology in 2015. Juvenile shad are notoriously sensitive to stress; and transporting, handling, holding, and tagging are problematic. A tagging control study was performed that revealed tagging mortality was high and tagged fish swam irregularly. The results of the juvenile shad telemetry study were deemed invalid and there was no way to definitively determine downstream route choice selection and travel times. In addition, FirstLight used split beam sonar at the Northfield Mountain Project intake/tailrace structure but it was not optimal for estimating entrainment since installing the equipment behind the trash racks was not an option. While fish attributes such as size, three-dimensional position and direction of travel were quantified, it is not certain that fish detected passed through the trashracks and were subjected to entrainment. FirstLight held study report meetings on October 31 and November 1, 2016 indicating that the radio tagging and hydroacoustic components of the juvenile shad study did not provide enough information to satisfy the study objectives.

In a FERC determination letter on requests for study modifications dated May 31, 2018, FirstLight suggested that data collected during an entrainment study conducted at Northfield Mountain Project intake/tailrace in 1992 (LMS, 1993) would be suitable for evaluating juvenile shad entrainment at the Project under current operating conditions. FirstLight indicated that the LMS (1993) entrainment estimate is likely conservative (i.e., that more fish were entrained in 1992 than would be under current conditions) because a similar number of adult shad migrated upstream of the Turners Falls Dam in 1992 and 2015, and because the Northfield Mountain Project operated in pumping mode frequently in 1992. As such, FERC deemed the LMS study sufficient for an analysis of the rate of juvenile shad entrainment at the NMPS during downstream emigration. Juvenile American Shad entrainment impacts at the Northfield Mountain Project were deemed negligible by the study (LMS, 1993).

Despite negligible impacts on juvenile shad, FirstLight is proposing the installation of a barrier net at the Northfield Mountain Project intake/tailrace intake to prevent entrainment impacts to juvenile shad during pumping operations. FirstLight proposes to have the barrier net in place from August 1 to November 15 each year to coincide with the downstream migration season of juvenile American Shad and silver phase American Eel. Previous barrier net efficiency studies at other intake facilities have proven effective in reducing fish passage and subsequent impingement and entrainment impacts, given continual maintenance, cleaning and repair (Patrick et al. 2014, EPRI 2006).

Turners Falls Project

As juvenile shad pass further downstream, they face a route choice to either spill over the Turners Falls Dam or enter the power canal and move downstream through Station No.1, Cabot Station, or the Cabot Station log sluice.

Passage via Dam Spillway

Survival of juveniles spilling over the Bascule Gates of the Turners Falls Dam was assessed by Normandeau Associates in 2015 using Hi-Z tagging technology. The 1-hour direct survival rate of juvenile shad passing over the Turners Falls Dam via Bascule Gate No. 1 (BG 1) was 69.4%, 47.7% and 75.6% during flow releases of 1,500 cfs, 2,500 cfs and 5,000 cfs, respectively, with an overall survival rate of 63% (FirstLight, 2016f). The study suggested that the shallower depth of water below the spillway at BG 1 under low flow conditions (1,500 cfs) does not provide much protection for fish passing over BG 1.

FirstLight is proposing the installation of a plunge pool below BG 1 that will provide enough water depth for fish to safely spill over the dam without directly contacting any rock or concrete structures at all flows. These measures will likely increase the survival of juvenile shad and other species/lifestages passing downstream into the bypass reach via spill over BG 1.

Passage via Power Canal

If juvenile shad enter the power canal during downstream passage, they will subsequently pass downstream through Station No.1, Cabot Station powerhouse, or the log sluice (fish bypass) at Cabot Station. Historical studies that investigated downstream passage of Atlantic Salmon smolts and juvenile Clupeids (Harza & RMC 1992a, 1992b, 1994a, 1994b; Nguyen & Hecker, 1992; NUSCO 1994, 1995, 1998a, 1998b; RMC, 1994, 1995) indicated that 90% of juvenile Clupeids that entered the power canal exited through the log sluice and would not have been subjected to entrainment.

Survival rates (1 hr) for juvenile shad passing through the Francis units at Station No. 1 were 67.8% and 76.6%, respectively (Study Report 3.3.3). FirstLight is proposing to install an ¾-inch spaced angled bar rack at the entrance of the Station No. 1 forebay to reduce the likelihood of entrainment of juvenile shad during their emigration and encourage shad to migrate further downstream through the canal where downstream passage survival rates are higher at Cabot Station and the log sluice. Juvenile shad that pass downstream through Cabot Station exhibited 95% survival (1 hr) through the Francis turbine at Cabot Station Unit 2, which was near the median value of 94.7% for juvenile herring and shad obtained for 19 studies conducted at other hydroelectric projects (FirstLight, 2016f).

3.3.3.1.7.2.3 American Eel

After spending five (5) to 20 years in riverine habitat, maturing American Eel, referred to as silver phase eels, begin migrating downstream to reach spawning grounds in the Atlantic Ocean, somewhere in or near the Sargasso Sea. Downstream migration usually occurs at night from August through November. Outmigrating eels encounter obstacles including potential entrainment at the Northfield Mountain Project, and several route selections at the Turners Falls Dam, through the power canal, and past the Station No. 1 and Cabot Station powerhouses.

Downstream passage of outmigrating silver eels has not been historically monitored at the Project. As such, the Licensee conducted a study to assess downstream passage of adult outmigrating silver American Eel (Study No. 3.3.5 *Evaluate Downstream Passage of American Eel*) to better understand migration timing as it relates to environmental factors and operations at Turners Falls and Northfield Mountain Projects.

Turners Falls Impoundment

Based on radio telemetry data, silver phase American Eel migrating downstream are susceptible to entrainment at the Northfield Mountain Project intake during pumping operations. Pumping at this facility typically occurs nightly. A total of 164 eels were tracked in the TFI, two of which were identified as becoming entrained at the Northfield Mountain Project intake. Cox Proportional Hazard regression models revealed that another 34 eels were lost while near the Northfield Mountain Project intake, indicating possible entrainment. Cox Proportional Hazards regression indicated that those 34 fish were lost at night when the Northfield Mountain Project was in pumping mode, supporting the theory that these fish had become entrained. Susceptibility for eel entrainment increased with increasing pumping (i.e., as more pumps are engaged), particularly when intake flow surpassed river flow.

FirstLight is proposing the installation of a barrier net in front of the Northfield Mountain Project intake/tailrace to prevent downstream migrating eels from being entrained during pumping operations. FirstLight proposes to install the barrier net from August 1 to November 15 each year to coincide with the downstream migration season of juvenile American Shad and silver phase American Eel. The barrier net will prevent downstream migrating eels from becoming entrained at the Northfield Mountain Project, which will increase their survival during downstream passage as they pass the Northfield Mountain Project.

Turners Falls Project

Once past the Northfield Mountain Project migrating eels are faced with two possible egress pathways past the Turners Falls Dam: over the Turners Falls Dam with spill to the bypass reach, or through the gatehouse and into the power canal. Radio-telemetry monitoring documented 69% of eels passing into the power canal.

Passage via Dam Spillway

Though most eels were documented passing into the canal, rainy nights triggered eels to pass over the Turners Falls Dam spillway into the bypass reach. For eels that pass via the Turners Falls Dam spillway instead of entering the canal, HI-Z Turb’N Tag testing found high 48-h survival rates of 86.8% and 88.4% for eels passing through BG 1and BG 4, respectively.

FirstLight is proposing the construction of a plunge pool below BG 1 to improve survival of emigrating adult eels passing over the Turners Falls Dam.

Passage via Power Canal

Once in the power canal, emigrating adult silver-phased American Eel can select multiple routes to pass downstream of the Project. They can exit the canal via either the Station No. 1 powerhouse, the Cabot Station powerhouse, or the adjacent downstream bypass sluice. Radio-telemetry tracking revealed that fish overwhelmingly (~83%) exited the canal through the Cabot Station powerhouse, followed by the downstream bypass sluice (~10%) and then the Station No. 1 powerhouse (~4%). Most fish moved through the canal quickly and exited within 6 hours of entering the canal. Statistical analysis suggested that the most important factors influencing escapement from the canal via the Cabot Station powerhouse were diurnal cues and canal flow as eels were more likely to escape the canal via Cabot Station powerhouse for every 1,000 cfs increase in canal flow at night. Rapid flow changes (i.e., acceleration of flow or ramping effects due to Cabot Station operations) did not appear to be a significant factor influencing migration time through the canal.

Based on HI-Z Turb'N Tag testing, turbine passage survival estimates were greatest when passing via the Cabot Station powerhouse (96% based on 48-hour survival) as opposed to Station No. 1 (90% for Unit 1 and 62% for Units 2 and 3). The lower survival estimate for Units 2 and 3 at Station No. 1 is due to the station configuration and higher turbine rpms. A common penstock leads to Units 2 and 3, with Unit 2 being much smaller and having a faster runner speed than Units 1 and 3.

FirstLight proposes to install a ¾-inch spaced bar rack at the entrance of the Station No. 1 forebay. The bar rack will prevent outmigrating eels in the canal from entering the Station No. 1 forebay and encourage movement downstream to Cabot Station where passage survival rates are higher. This measure will reduce the likelihood of injuries and increase survival rates for adult American eel during their emigration through the power canal at the Turners Falls Project.

3.3.3.1.8 Entrainment and Impingement

Resident and migratory fish may be subject to entrainment and turbine passage. At the Turners Falls Project, fish may pass through the turbines at Station No. 1 or Cabot Station. At the Northfield Mountain Project, fish entrained during pumping operations pass through the intake tunnel and turbine(s) before being discharged to the Upper Reservoir. Features that determine the likelihood of entrainment include the velocity at the intakes, and the fish species and habitat available in the area. As fish pass through the turbines, mortality may occur due to (1) collision with blades, wicket gates, or vanes; (2) shear forces; and/or (3) pressure changes. Turbine passage mortality of resident fish was assessed in studies approved by FERC and by using empirically validated blade strike models to estimate potential mortality (Franke *et al.*, 1997). The results of these analyses are provided below, with additional details provided in the report for Relicensing Study 3.3.7 – *Fish Entrainment and Turbine Passage Mortality Study*, which was filed with FERC on October 14, 2016. Field studies of adult American Eel and adult and juvenile American Shad provided empirical data regarding entrainment rates and survival at the Projects.

Turners Falls Project

Fish passing downstream leave the TFI either by passing over the spillway (Bascule Gates) or via the Tainter gates at Turners Falls Dam to the bypass reach or by exiting through the gatehouse into the power canal. Fish entering the power canal have three avenues of downstream passage: 1) Entrainment through Station No. 1 turbines, 2) Entrainment through Cabot turbines or 3) Passage via a log sluice adjacent to the Cabot Station.

From the power canal there is an approximate 700-foot-long by 100-foot-wide branch canal. At the end of the branch canal is the entrance to Station No. 1, consisting of eight bays, each 15 feet wide for a total intake width of 120 feet. Trashracks are angled across the entire entrance, totaling 120 feet wide by 20.5 feet high. With a normal canal elevation of approximately 173.5 feet, the effective trashrack opening is approximately 114 feet wide by 15.9 feet high, resulting in a gross area of 1,812.6 square feet (ft^2). The bar thickness is 0.375 inches, and the bars are 3 inches on center, thus the clear spacing between bars is 2.625 inches. At full hydraulic capacity (2,210 cfs), the calculated average approach velocity in front of the trashracks is approximately 1.2 feet per second (fps). More detailed information on velocities was collected for Study No. 3.3.8 *Computational Fluid Dynamics Modeling in the Vicinity of the Fishway Entrances and Powerhouse Forebays* which demonstrated that, under maximum generation flow at Station No. 1, 91% of the rack face had approach velocities of less than 2.0 fps.

Cabot Station is located at the downstream terminus of the power canal. The trashrack opening is 217 feet wide by 31 feet high, resulting in a gross area of 6,727 ft^2. The trashracks are angled and include upper and lower racks. The top 11 feet of the upper racks have clear-bar spacing of 0.94 inches, and the bottom 7 feet of the upper racks have clear-bar spacing of 3.5625 inches. The entire 13 feet of the lower racks have clear-bar spacing of 3.5625 inches. At full hydraulic capacity, the calculated approach velocity in front of the trashracks is approximately 2.0 fps. More detailed information on velocities was collected for Study No. 3.3.8 *Computational Fluid Dynamics Modeling in the Vicinity of the Fishway Entrances and Powerhouse Forebays* which demonstrated that velocities across the rack were not uniform and, under maximum generation flow, 32% of the rack area had velocities less than 2.0 fps. The highest approach velocities were in front of penstock no. 6 (the most upstream area of the intake) and nearest to the bottom.

Northfield Mountain Project

The Northfield Mountain Project tailrace serves as the intake during pumping and is located inshore from the Connecticut River. An excavated 700-feet-long channel serves as a forebay/tailrace. The channel lacks instream cover, providing limited fish habitat. When operating in a pumping mode, the approximate hydraulic capacity of the station is 15,200 cfs (3,800 cfs/pump). Alternatively, when operating in a generation mode, the approximate hydraulic capacity is 20,000 cfs (5,000 cfs/turbine).

The trashrack opening is trapezoidal in shape and has a gross area opening of 4,400 ft^2. The bar thickness is 0.75 inches, with a clear-spacing of 6 inches. Under maximum pumping conditions of 15,200 cfs, the calculated velocity in front of the rack is 3.5 fps. Velocities were field measured in this area as part of Relicensing Study No. 3.3.9 *Two-Dimensional Modeling of the Northfield Mountain Pumped Storage Project Intake/Tailrace Channel and Connecticut River Upstream and Downstream of the Intake/Tailrace*. The results indicated that during four units pumping, velocities across the channel were typically 3-4 ft/s.

3.3.3.1.8.1 Resident Species

Some resident fish in the Project areas may be subject to impingement and entrainment at Cabot Station, Station No. 1, or the Northfield Mountain Project (during pumping). Most resident species are littoral, shoreline- and cover-oriented, and due to the paucity of these habitat features in the Northfield Mountain Project intake/tailrace channel, the likelihood of entrainment or impingement of these fishes is reduced. In addition, these resident species do not typically undertake large river-wide movements that require passing downstream at the Turners Falls Project where they would encounter either the Cabot Station or Station No. 1 intakes. Such fish reside or forage locally within the intake area and encounter velocities that may exceed their sustained swim speed. Some localized movements of individuals, or small schools during foraging or random exploration in the immediate vicinity of the project intake could result in periodic, small-scale entrainment events.

Impingement feasibility for each species was identified based on fish size relative to trashrack spacing (Table 3.3.3.2.4.1-1). In general, larger species could be impinged, particularly at the upper narrow-spaced racks at Cabot Station, but these fish would also generally have greater swim speeds than smaller fish that could pass through the racks and become entrained. A qualitative scale of entrainment potential ranging from "Low" to "High" was developed for each resident fish species documented in the TFI during the baseline fish assemblage assessment. Overall entrainment risk to resident species is slightly higher at Cabot Station than at Station No. 1 (Tables 3.3.3.2.4.1-2 and 3.3.3.2.4.1-3). The primary factor that raises the Cabot Station risk level is the proximity of habitat that is attractive to some species. Fringe shoal areas exist upstream from the Cabot Station intake featuring a limited amount of object cover such as logs and debris, as well as scattered rooted and submerged aquatic vegetation beds. These features are absent from the Station No. 1 forebay area. Although not in the immediate vicinity of the Cabot Station intake, these habitat pockets may provide shelter for cover-oriented species. Residents of these areas may approach the Cabot Station intake during localized foraging or exploration movements.

Most resident species are at moderate to low risk at Cabot Station at the individual animal level, and none are at a high risk. Species scoring as low risk included Bluegill, Pumpkinseed and Smallmouth Bass. Five species are at moderate risk to entrainment loss at Station No. 1 at the individual animal level, and the remainder are at a low risk; none are at a high risk. Entrainment of resident fish is confined to individual movements of a limited number of fishes, and therefore is not expected to materially affect spawning or YOY recruitment. In general, most resident fish entrainment loss has been shown to be dominated by YOY and small juvenile fish that exhibit swimming speeds less than intake velocities (EPRI, 1997). However, turbine survival of smaller fish tends to be relatively high when compared to adults, as smaller fish are less likely to encounter blades, vanes and get caught in shear zones than larger fish (Franke *et al*., 1997). Natural mortality rates generally exert a more significant effect on YOY and juveniles than does entrainment mortality (Franke *et al*., 1997; EPRI, 1997).

Operation of the Northfield Mountain Project may impact fishes due to entrainment. However, pumping operations generally only occur over short periods, on the order of a few hours at a time, limiting the timeframe that fish could be subjected to entrainment. All species evaluated are at low or moderate risk to entrainment loss at the individual level and although intake velocities are generally greater than swimming capabilities of many of the species in the TFI, the lack of habitat features likely limits the frequency of fish entering the intake/tailrace channel (Table 3.3.3.2.4.1-4).

Overall, entrainment is not anticipated to affect the populations of resident species (Tables 3.3.3.2.4.1-2 through 3.3.3.2.4.1-4). However, PM&E measures designed for migratory species such as the barrier net at the Northfield Mountain Project and the ¾-inch spaced angled bar rack at the entrance of the Station No. 1 would protect individuals of resident species from entrainment.

Table 3.3.3.2.4.1-1: Feasibility of resident fish impingement based on comparison of mean fish body width and trashrack spacing.
Minus sign indicates less susceptible to impingement and plus sign indicates a species is susceptible.
TL = total length; BW = body width

	Smith 1985 (mm)			Measured TL (mm)			Estimated BW (mm)			Impingement Feasibility			
Common Name	**TL**	**BW**	**BW:TL**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Northfield (152.4 mm)***	**Station No. 1 (66.7 mm)***	**Cabot Station (upper, 23.9 mm)***	**Cabot Station (lower, 90.5 mm)***
Banded Killifish	120.1	14.2	0.118	47.5	30	67	5.6	3.5	7.9	-	-	-	-
Black Crappie	133.8	13.3	0.099	223.4	87	280	22.2	8.6	27.8	-	-	-	-
Bluegill	126.8	16.8	0.132	159.9	30	225	21.2	4.0	29.8	-	-	-	-
Brown Bullhead	123.8	20.6	0.166	340.0	325	355	56.6	54.1	59.1	-	-	+	-
Chain Pickerel	116.5	10.3	0.088	431.8	410	477	38.2	36.2	42.2	-	-	+	-
Channel Catfish	121.3	22.7	0.187	330.0	76	622	61.8	14.2	116.4	-	-	+	-
Common Carp	125.9	20.4	0.162	735.3	585	930	119.1	94.8	150.7	-	+	+	+
Common Shiner	124.1	13.3	0.107	37.5	30	45	4.0	3.2	4.8	-	-	-	-
Fallfish	124.7	16.1	0.129	139.7	56	430	18.0	7.2	55.5	-	-	-	-
Golden Shiner	123.3	13.0	0.105	98.0	57	212	10.3	6.0	22.4	-	-	-	-
Largemouth Bass	123.4	16.5	0.134	128.4	25	410	17.2	3.3	54.8	-	-	-	-
Longnose Dace	123.3	17.2	0.139	57.0	57	57	8.0	8.0	8.0	-	-	-	-
Mimic Shiner	125.5	12.7	0.101	58.4	53	64	5.9	5.4	6.5	-	-	-	-
Northern Pike	118.6	9.2	0.078	355.6	197	780	27.6	15.3	60.5	-	-	+	-
Pumpkinseed	129.8	16.1	0.124	152.9	75	205	19.0	9.3	25.4	-	-	-	-
Rock Bass	124.6	19.4	0.156	142.3	32	257	22.2	5.0	40.0	-	-	-	-
Rosyface Shiner	115.3	11.0	0.095	61.0	61	61	5.8	5.8	5.8	-	-	-	-
Smallmouth Bass	123.6	15.8	0.128	152.2	29	470	19.5	3.7	60.1	-	-	-	-
Spottail Shiner	128.4	18.0	0.140	92.0	45	165	12.9	6.3	23.1	-	-	-	-
Tessellated Darter	121.6	16.9	0.139	53.2	19	85	7.4	2.6	11.8	-	-	-	-
Walleye	120.2	15.0	0.125	261.5	146	530	32.6	18.2	66.1	-	-	+	-
White Perch	123.5	17.6	0.143	109.0	109	109	15.5	15.5	15.5	-	-	-	-
White Sucker	121.9	17.8	0.146	117.8	35	530	17.2	5.1	77.4	-	-	-	-
Yellow Perch	123.4	14.1	0.114	143.6	15	360	16.4	1.7	41.1	-	-	-	-

* Indicates trashrack spacing.

Table 3.3.3.2.4.1-2: Entrainment risk scores for resident species at Cabot Station.

Species	Habitat & Biology	Swim Speed	Survival	Likelihood	Population Impact	Risk Score*
Banded Killifish	1	2	2	1	0	6
Black Crappie	1	2	1	2	0	6
Bluegill	1	2	1	1	0	5
Brown Bullhead	1	2	3	2	0	8
Chain Pickerel	1	2	1	2	0	6
Channel Catfish	1	0	3	2	0	6
Common Carp	3	2	2	2	0	9
Common Shiner	1	2	2	2	0	7
Fallfish	1	2	2	1	0	6
Golden Shiner	2	2	2	2	0	8
Largemouth Bass	1	2	1	1	0	5
Longnose Dace	1	2	2	2	0	7
Mimic Shiner	1	2	2	2	0	7
Northern Pike	1	0	0	2	0	3
Pumpkinseed	1	2	1	1	0	5
Rock Bass	1	2	1	2	0	6
Rosyface Shiner	1	2	2	2	0	7
Smallmouth Bass	1	2	1	1	0	5
Spottail Shiner	1	2	2	2	0	7
Tessellated Darter	1	2	2	1	0	6
Walleye	1	2	2	2	0	7
White Perch	2	2	1	2	0	7
White Sucker	2	0	1	2	0	5
Yellow Perch	1	2	2	1	0	6

Score	Habitat & Biology	Swim Speed	Survival	Likelihood	Population Impact
0		greater than intake velocity	90-100%		no impact
1	"unlikely"	equal to intake velocity	80-90%	"unlikely"	"minimal"
2	"habitat preference present"	less than intake velocity	70-80%	"moderate"	may significantly reduce spawning
3	"very likely"		<70%	"likely"	may significantly impact YOY

*Note: Category scores were summed to generate an entrainment risk score on a scale of 0 to 15. Summed scores of 0-5 represent "low" entrainment risk, scores of 6-10 represent "moderate" risk and 11-15 equate to "high" risk.

Table 3.3.3.2.4.1-3: Entrainment risk scores for resident species at Station No. 1.

Species	Habitat & Biology	Swim Speed	Survival	Likelihood	Population Impact	Risk Score*
Banded Killifish	1	2	1	1	0	5
Black Crappie	2	2	1	2	0	7
Bluegill	1	0	1	1	0	3
Brown Bullhead	1	0	2	1	0	4
Chain Pickerel	1	2	1	1	0	5
Channel Catfish	1	0	3	1	0	5
Common Carp	2	0	2	1	0	5
Common Shiner	1	0	2	1	0	4
Fallfish	1	0	2	1	0	4
Golden Shiner	1	0	2	1	0	4
Largemouth Bass	1	1	1	1	0	4
Longnose Dace	1	2	2	1	0	6
Mimic Shiner	1	2	2	1	0	6
Northern Pike	1	0	0	1	0	2
Pumpkinseed	1	0	1	1	0	3
Rock Bass	1	2	1	1	0	5
Rosyface Shiner	1	2	2	1	0	6
Smallmouth Bass	1	1	1	1	0	4
Spottail Shiner	1	0	2	1	0	4
Tessellated Darter	1	2	2	1	0	6
Walleye	1	0	2	1	0	4
White Perch	1	0	1	1	0	3
White Sucker	2	0	1	1	0	4
Yellow Perch	1	0	2	1	0	4

Score	Habitat & Biology	Swim Speed	Survival	Likelihood	Population Impact
0		greater than intake velocity	90-100%		no impact
1	"unlikely"	equal to intake velocity	80-90%	"unlikely"	"minimal"
2	"habitat preference present"	less than intake velocity	70-80%	"moderate"	may significantly reduce spawning
3	"very likely"		<70%	"likely"	may significantly impact YOY

*Note: Category scores were summed to generate an entrainment risk score on a scale of 0 to 15. Summed scores of 0-5 represent “low” entrainment risk, scores of 6-10 represent “moderate” risk and 11-15 equate to “high” risk.

Table 3.3.3.2.4.1-4. Entrainment risk scores for resident species at the Northfield Mountain Project.

Species	Habitat & Biology	Swim Speed	Survival	Likelihood	Population Impact	Risk Score*
Banded Killifish	1	2	3	1	0	7
Black Crappie	1	2	3	1	0	7
Bluegill	1	2	3	1	0	7
Brown Bullhead	1	2	3	1	0	7
Chain Pickerel	1	2	3	1	0	7
Channel Catfish	1	2	3	1	0	7
Common Carp	1	2	3	1	0	7
Common Shiner	1	2	3	1	0	7
Fallfish	1	2	3	1	0	7
Golden Shiner	1	2	3	1	0	7
Largemouth Bass	1	2	3	1	0	7
Longnose Dace	1	2	3	1	0	7
Mimic Shiner	1	2	3	1	0	7
Northern Pike	1	2	3	1	0	7
Pumpkinseed	1	2	3	1	0	7
Rock Bass	2	2	3	1	0	8
Rosyface Shiner	1	2	3	1	0	7
Smallmouth Bass	2	2	3	1	0	8
Spottail Shiner	1	2	3	1	0	7
Tessellated Darter	1	2	3	1	0	7
Walleye	1	2	3	1	0	7
White Perch	2	2	3	1	0	8
White Sucker	2	2	3	1	0	8
Yellow Perch	1	2	3	1	0	7

Score	Habitat & Biology	Swim Speed	Survival	Likelihood	Population Impact
0		greater than intake velocity	90-100%		no impact
1	"unlikely"	equal to intake velocity	80-90%	"unlikely"	"minimal"
2	"habitat preference present"	slightly less than intake velocity	70-80%	"moderate"	may significantly reduce spawning
3	"very likely"		<70%	"likely"	may significantly impact YOY

*Note: Category scores were summed to generate an entrainment risk score on a scale of 0 to 15. Summed scores of 0-5 represent “low” entrainment risk, scores of 6-10 represent “moderate” risk and 11-15 equate to “high” risk.

3.3.3.1.8.2 Migratory Species

3.3.3.1.8.2.1 American Shad

Northfield Mountain Project

Ichthyoplankton

Entrainment of American Shad eggs and larvae was estimated after site specific ichthyoplankton sampling at the Northfield Mountain Project in 2015 and 2016. Based on the entrainment estimates and published survival fractions, the number of equivalent juvenile and adults lost to entrainment as eggs and larvae at the Northfield Mountain Project was estimated to be 696 juvenile shad or 94 adult American Shad in 2015 and 2,093 juvenile shad or 578 adult American Shad in 2016. To put these numbers into perspective, the number of American Shad passed annually in 2015 and 2016 at the Turners Falls gatehouse fishway were 58,079 and 54,069, respectively and the Vernon fishway were 39,771 and 35,807, respectively. Equivalent adult lost to entrainment in 2015 and 2016 at the Northfield Mountain Project ranged from 0.1% to 1.1% of the Turners Falls gatehouse passage. Though entrainment of shad eggs and larvae is occurring, the effects of entrainment on the population of shad is minimal.

Juvenile Emigration

Determining the rate of entrainment at the Northfield Mountain Project was an objective of Relicensing Study 3.3.3 *Evaluate Downstream Passage of Juvenile American Shad (*FirstLight, 2016c). Hydroacoustic and radio telemetry methods were used to achieve this objective. However, the objective was not fully met due to a high level of milling observed in the hydroacoustic data and poor survival and tag retention for radio-tagged control fish.

FirstLight's estimates of juvenile shad entrainment at the Northfield Mountain Project are therefore based on a previous robust netting study conducted in 1992. The numbers of adult shad that passed Turners Falls at the time of the study were similar to current passage numbers, and the Northfield Mountain Project pumping was also similar. Therefore, FirstLight believes the previous entrainment study conducted at the Northfield Mountain Project in 1992 is still applicable.

In 1991 and 1992, a number of methods were used to assess the impact of the operation of the Northfield Mountain Project on juvenile American Shad in the Connecticut River, including trawls, seining, electrofishing, and netting in the Upper Reservoir (LMS 1993). The objectives were to determine the temporal and spatial distribution of juvenile American Shad in the vicinity of the Northfield Mountain Project intake and to estimate entrainment of juvenile shad during pumping operations. Of the study methods, netting in the Upper Reservoir was used to determine an entrainment estimate.

The netting study had a robust sampling scheme with 23 entrainment samples collected from August 9 to October 27, 1992 by deploying a 5' x 34' framed net at the opening of the discharge tunnel in the Upper Reservoir during pumping operations. The area of the net represented about 11% of the area of the tunnel opening, such that only a portion of the total volume of water pumped was filtered through the net. The net was maintained at the same elevation for the duration of the sampling program. The net was deployed after pumping began (typically near 23:30) and continued to sample for up to 5.5 hours. Eight flow meters mounted in the mouth of the frame allowed the volume of sampled water to be calculated.

The efficiency of the net frame was also assessed based on 13 sampling events in which marked juveniles (both alive and dead) were introduced into plant flow and the number recaptured was recorded. The net efficiency calculation accounted for the percentage of water that was sampled by the net relative to total volume pumped and was ultimately used to adjust the juvenile entrainment estimate.

Throughout the entrainment sampling events, it was determined that the net sampled about 6.5-13.9% of the pumping cycle flow. During the 80.2 hours and 8,204,756 m^3 of water sampled, 331 juvenile shad were collected during sampling events from August to late October. For net efficiency testing, 262 shad overall, or 8.2% of the marked fish released, were recaptured in the entrainment net during the 13 efficiency sampling events. The extrapolation of counts based on the total volume of water pumped and net efficiency yielded an estimate of 37,260 juvenile shad that were entrained during the late summer to fall migration season of 1992.

The overall mean volume of water filtered through the net (11.7%) was close to the percent of the outlet area occupied by the net frame, indicating that the net was fishing effectively. While there was variability in the weekly entrainment net catch rate, the peak catch rate coincided with the expected seasonal peak of the shad migration. Juvenile catch was greatest in mid-October corresponding to a period of decreasing water temperatures, consistent with O'Leary and Kynard (1986). The estimated entrainment of juvenile shad at the Northfield Mountain Project was 37,260 individuals (standard error = ±11,900), which included a 74% adjustment for net efficiency. The sampling design consisted of several sampling events over the duration of the migration period and allowed for a reduction of bias in the sampling results. The consistency of the net recovery results and the volume of the Northfield Mountain Project flow that was filtered during each sampling event supports the reliability of the entrainment estimate for juvenile shad at the Northfield Mountain Project.

To demonstrate that the 1992 juvenile shad entrainment estimate at the Northfield Mountain Project described above is still applicable today, the numbers of adult American Shad in the TFI and the Northfield Mountain Project operations were compared between the two periods. The juvenile entrainment assessment of 1992 occurred during August, September and October, which included the typical period of outmigration of juvenile shad from rearing areas in rivers to the ocean. Mean monthly discharge of the Connecticut River as reported for USGS Gage No. 01170500 (Connecticut River at Montague City, MA) ranged from 5,545 cfs in August to 6,926 cfs in October 1992 and between 4,975 cfs in September and 10,100 cfs in October 2015.

Additionally, the numbers of adult American Shad that passed into the TFI were similar in 1991-1992 (54,656 and 60,089) and 2015-2016 (58,079 and 54,069). This would most likely result in comparable numbers of juvenile shad passing the Northfield Mountain Project tailrace during these two periods, assuming similar larval and juvenile survival.

FirstLight has filed information (*Supplemental Information Relevant to U.S. Fish and Wildlife Service Notice of Study Dispute at 2, Project Nos. 1889-081 and 2485-063, filed Mar. 28, 2014*) into the record to clarify that there has been less overall utilization of the Northfield Mountain Project since the 1992 study was conducted and consequently a decrease in the amount of pumping, and that there has been no significant change in pump discharge since the Project was constructed. Overall pumping between 1992 and 2015 during the emigration of juvenile American Shad (August through October) was higher in 1992 than 2015. In 1992, pumping typically extended approximately an hour further into the morning, and also occurred occasionally with one-unit during the daytime hours. Alternatively, no pumping occurred during the day in August-October 2015. Using the 1992 study results thus provides an estimate of entrainment that overstates the actual amount of entrainment at the Project today and is conservative.

Since the number of adult shad in the TFI was similar and the Northfield Mountain Project generation in 2015 as compared to 1992 was less, assessing the impact of the operation of the Northfield Mountain Project on emigrating juvenile American Shad using the 1992 study results would provide a conservative estimate of juvenile American Shad entrainment. FERC agreed in a letter dated May 31, 2018.

FirstLight proposes to install a barrier net at the Northfield Mountain Project intake/tailrace annually between August 1 to November 15. The barrier net will prevent entrainment of juvenile American shad emigrating downstream past the Project. Barrier net technology has been considered an acceptable industry standard for successfully reducing the risk of impingement at other pumped storage facilities including the Ludington plant (Patrick et al. 2014). The effectiveness of the barrier net in previous studies is contingent on-site specific applications and the importance of continual maintenance of the net due to potential biofouling.

Adult Migration

During upstream passage, a large proportion of migrating adult American Shad that entered the TFI have successfully migrated through the project area to the Vernon Dam. A small percentage are attracted towards the Northfield Mountain Project intake, but they proceed through that area relatively quickly. No adult shad (upstream or downstream migrating) were documented in the Northfield Mountain Project Upper Reservoir.

Turners Falls Project

Juvenile Emigration

Juvenile shad that migrate down the canal have multiple avenues of escapement. They can pass downstream via the entrainment at Cabot Station or Station No. 1, or via the log sluice, avoiding entrainment. Historical studies that investigated downstream passage of Atlantic Salmon smolts and juvenile Clupeids (Harza & RMC 1992a, 1992b, 1994a, 1994b; Nguyen & Hecker, 1992; NUSCO 1994, 1995, 1998, 1999; RMC, 1994, 1995) indicated that 90% of juvenile Clupeids that entered the power canal exited through the log sluice and were not subjected to entrainment.

Impacts to juvenile shad outmigration at the Turners Falls Project were evaluated using a combination of methodologies and technologies including hydroacoustics, radio telemetry and HI-Z Turb'N tags. Analysis of hydroacoustic data collected at the Cabot Station intakes from August 1 to November 14, 2015 suggested 1,660,166 juvenile shad were entrained at Cabot Station. Impacts to these fish are likely far less substantial because of high turbine passage survival; NAI reported a 95.0% immediate survival of juvenile shad passed through Cabot Station Unit 2 and recaptured using HI-Z Turb'N tags (FirstLight, 2016f). Units 1, 3, 4, 5 and 6 are identical to Unit 2, so similarly high survival is expected at these units as well. The immediate survival rates for the smaller Francis units at Station No. 1 (67.8% and 76.6%) were lower, but radio telemetry results (Study 3.3.3) suggest that a proportionally small number of the shad that enter the canal passed via Station No. 1, as evidenced by the fact that of the 16 radio tagged juvenile shad that emigrated through the power canal, only one was detected at the Station No. 1 forebay and was not entrained during the 2015 monitoring study (FirstLight, 2016c).

Under FirstLight's flow proposal, more consistent flows would be released to the bypass reach via Station No. 1 than historically, which would increase their potential for entrainment and mortality there. FirstLight proposes the installation of a bar rack, with ¾-inch clear spacing, at the entrance to the Station No. 1 forebay where flows are diverted from the main power canal. The bar rack will deter outmigrating juvenile shad from entering the forebay and being entrained through the Station No. 1 units. The location of the bar rack will encourage shad movement downstream to Cabot Station where passage via the bypass log sluice and higher entrainment survival rates through the Cabot Station units would provide a greater success rate for shad exiting the canal.

Adult Emigration

Adult post-spawn shad tended to pass downstream via the Turners Falls power canal, within which there are multiple downstream passage routes. They can pass downstream via the entrainment at Cabot Station or Station No. 1, or via the log sluice, avoiding entrainment. As described in Section 3.3.3.2.3.2.1, the proportion of tagged shad passed via the log sluice and Cabot Station varied depending on the flow through Cabot Station, and none passed through Station No. 1. Their 48-hour survival was highest through the log sluice (89.2%), relative to Cabot Station (65.6%). Though emigrating adult shad were not identified as using Station No. 1 as a route of passage out of the canal, there is the potential for greater mortality there than at other locations given the turbine configuration, as has been shown for other migratory species.

Under FirstLight's flow proposal, more consistent flows would be released to the bypass reach via Station No. 1 than historically, which would increase their potential for entrainment and mortality there. FirstLight proposes the installation of a bar rack, with ¾-inch clear spacing, at the entrance to the Station No. 1 forebay where flows are diverted from the main power canal. The bar rack will exclude outmigrating adult shad from entering the forebay and being entrained through the Station No. 1 units. The location of the bar rack will encourage shad movement downstream to Cabot Station where a bypass log sluice and higher survival rates through the units would provide a greater success rate for shad exiting the canal.

3.3.3.1.8.2.2 Sea Lamprey

Once hatched, Sea Lamprey larvae, known as ammocoetes, will burrow into muddy, sandy/silty bottoms of streams or rivers (Beamish 1980, Moser et al. 2007). Once settled in the substrate, ammocoetes can remain in this sedentary life stage for up to 3-7 years (Moser et al. 2007). Ammocoetes undergo several stages of metamorphosis during their sedentary stage before emerging from silt beds to begin feeding parasitically and transitioning into their adult life stage (Auer, 1982). Due to their unique life history characteristics, it is unlikely that Sea Lamprey are susceptible to the risk of entrainment or impingement at the Project facilities until they emigrate from the river during the "transformer" stage. However, at this stage they are relatively small and would likely exhibit high survival rates. Because adults that return to the river die after spawning, entrainment effects are not an issue for this life stage.

3.3.3.1.8.2.3 American Eel

Northfield Mountain Project

Entrainment of outmigrating adult silver American Eel at the Northfield Mountain Project intake was estimated using radio telemetry techniques in fall of 2015. Tagged eels were released about 5 km upstream of the Northfield Mountain Project intake/tailrace just before pumping began, as well as about 6 km upstream of the Turners Falls Dam. Releases occurred in batches over a range of operating conditions. Eel were subsequently tracked by fixed station receivers and mobile receivers until tagged eel left the area or water temperatures dropped to 5°C.

FirstLight tagged and released 132 eels with radio telemetry tags at two sites in the TFI, one site above (n=72) and one below (n=60) the Northfield Mountain Project intake. TransCanada (now GRH) released an additional 165 eel above Vernon Dam as part of a concurrent relicensing study. A series of fixed radio telemetry stations were installed to monitor the downstream movements of tagged eel from just upstream of the Northfield Mountain Project intake, through project features, and down to the Montague WWTP, which is located downstream of Cabot Station tailrace. A CJS mark recapture model revealed 164 eels were recaptured in the TFI, two of which were entrained at the Northfield Mountain Project intake. Cox Proportional Hazard regression models revealed that another 34 eels were lost while at the Northfield Mountain Project intake, indicating possible entrainment.

The Licensee proposes to install a barrier net at the Northfield Mountain Project intake/tailrace annually between August 1 to November 15. The barrier net will prevent entrainment of silver phase American Eels migrating downstream past the Project.

Turners Falls Project

Impacts to adult silver American eels outmigrating at the Turners Falls Project were evaluated using a combination of technologies including radio telemetry and HI-Z Turb'N tags. Turbine passage survival evaluations were conducted in the fall of 2015. HI-Z Turb'N tags were used to evaluate passage survival of 50 adult eels at Cabot Station Unit 2 and 60 adult eels were injected into the turbines of Station No. 1. Testing revealed high 48-h survival rate of 96% for eel passing through Cabot Station powerhouse. Eels also fared well (approximately 90% survival and little injury) passing the larger of the Francis units at Station No. 1. However, results indicate that the units with a common penstock leading to both a larger and smaller unit at Station No. 1 inflict up to 40% mortality.

Eels used in these studies were imported from a commercial fisher in Newfoundland in accordance with state and Federal law and as stipulated in Permit Number 088.15LP issued by MADFW on October 20, 2015. Eels were held at each project in tanks, continuously supplied with ambient river water. Water temperature ranged from 7.5 to 9.1°C during the study. Fish tagging, release, and recapture techniques were similar to those used for adult fish in numerous other passage survival studies.

The treatment eels ranged from 400-960 mm in total length with a mean of 692 mm. Control eels ranged from 560-920 mm with a mean of 715 mm. Recapture rates for the treatment eels at Cabot Station Unit 2, Station No. 1 Unit 1, and Units 2/3, were 98.0, 86.7, and 63.3%, respectively. The estimated immediate (1 h) survivals for Cabot Station Unit 2 and Station No. 1 Units 1 and 2/3 were 98.0, 90.0, and 62.1%, respectively.

The estimated 48-h survivals for Cabot Station Unit 2 and Station No. 1 Units 1 and 2/3 were 96.0, 90.0, and 62.1%, respectively. All the post-turbine passage recaptured treatment fish were examined for injuries. The total treatment fish that had visible injuries for Cabot Station Unit 2 and Station No. 1 Units 1 and 2/3 were 2, 0, and 3, respectively. None of the control fish had visible injuries. Fish free of visible injuries and loss of equilibrium, were designated a malady-free status. Malady-free estimate rates were adjusted by any maladies incurred by control fish. The adjusted malady-free estimates for recaptured fish at Cabot Station Unit 2, Station No. 1 Unit 1 and Units 2/3, and BG 1 and BG 4 at 1,500, 2,500, and 5,000 cfs were generally greater than 95%, with the exception of Units 2/3 of Station No. 1 (malady-free estimate of 79.0%). The study results indicate that adult eels should incur little mortality or injury passing the Francis units except for the smaller units at Station No. 1.

Under the proposed condition, more consistent flows would be released to the bypass reach via Station No. 1 than historically, which would increase their potential for entrainment and mortality there. FirstLight proposes the installation of a bar rack, with ¾-inch clear spacing, at the entrance to the Station No. 1 forebay where flows are diverted from the main power canal. The bar rack will exclude outmigrating silver phase eels from entering the forebay and being entrained through the Station No. 1 units. The location of the bar rack will encourage eel movement downstream to Cabot Station where a bypass log sluice and higher survival rates through the units would provide a greater success rate for eels exiting the canal.

3.3.3.1.9 Odonates

The speed with which odonate larvae ascend the riverbanks, find a spot to eclose, complete the eclosure process, and take flight is important for understanding potential effects of water level fluctuations. Once the eclosure process begins, the insect is susceptible to rising water levels, wind, waves, and predators. Species that select eclosure sites far enough or high enough from the water to avoid inundation will be more successful at avoiding inundation and potential mortality. If larvae select eclosure sites within the zone that may be inundated as water levels rise, then it would need to complete the process and fly away prior to inundation.

In terms of understanding potential effects of water level fluctuations, the concern is for those species and individuals that remain close to the water's edge, especially in areas of the river where daily and hourly water level fluctuations and rates of change are greatest. Water level fluctuations and rates of change, resulting from Project operations, may affect odonate emergence.

Although most other riverine odonate species did, on average, crawl far enough and high enough from the water to escape risks of fluctuating water levels, a small proportion of all species eclosed close enough that inundation during eclosure was a risk to some individuals.

Turners Falls Impoundment

In the Barton Cove area of the TFI, the most abundant species documented was *Epitheca princeps*, a species common in lentic habitats. Based on water level timeseries data, developed from the operations model and the hydraulic model in the TFI, water level increases that could occur when the NRF is within Project control and when this species is eclosing are always below the CPR-90 level, and reaches the CPR-95 level 3.6% of the time under baseline conditions (Figure 3.3.3.2.5-1). Given that the CPR-95 level would protect 95% of eclosing individuals, the probability of water levels affecting eclosing *Epitheca princeps* has been minimal. The second-most abundant species documented in Barton Cove was *Perithemis tenera*. CPRs for this species, along with some other less-common species found in the TFI, were represented by the Libellulidae group. Similarly, water levels would reach the CPR-95 level for this group only 2.2% of the time under baseline conditions, with minimal effects on this odonate group (Figure 3.3.3.2.5-2).

FirstLight is proposing to limit the rate of water level rise in the TFI, as measured at the Turners Falls Dam to 0.9 feet/hr, subject to certain exceptions discussed in Section 2.2. Though this magnitude of increase does not typically occur in the TFI today, the limitation will prevent increases that could affect odonates in the future. Given the similarities between the baseline and proposed water level changes in the TFI relative to the eclosure characteristics of odonates residing there, effects of proposed operations on odonates in the TFI will also be minimal (Figure 3.3.3.2.5-1 and Figure 3.3.3.2.5-2).

Bypass Reach

In the bypass reach, the most abundant species documented were from the Gomphus group, specifically *Gomphus vastus* and the state listed *Gomphus abbreviatus*. The Gomphus group exhibits high climbing behaviors relative to many of the other species/groups. Changes in flows to the bypass reach primarily result from changes in spill over the Turners Falls Dam. Station No. 1 is operated for relatively long periods, either on or off, and is not a peaking plant; therefore, increases in water levels that could affect odonates would occur only during brief periods when Station No. 1 is turned on or re-set at a higher flow rate. When the river flows are within the Turners Falls Project capacity, it is in FirstLight's interest to pass the water through Cabot Station, when possible, and avoid spilling. Therefore, increases in flows to the bypass reach that could affect odonates would typically occur under natural high flow events when spill flows over the dam increase. Proposed whitewater flow releases would occur during periods when odonates would be emerging (i.e. once in July, and once in August), and would reflect an increase of 1,000 cfs or less from the proposed minimum flows at these times.

Downstream Areas

In the downstream areas, the most abundant odonates observed were in the Gomphus group. Based on water level timeseries data at Montague (River Mile 118.5), which were developed from the operations model and the hydraulic model below Cabot Station, water level increases that could occur when this species is eclosing reaches the CPR-95 level 17.6% of the time under baseline conditions (Figure 3.3.3.2.5-3). This suggests that 5% of the Gomphus group population could be susceptible to impacts periodically.

FirstLight is proposing to limit Cabot Station upramping to 2,300 cfs/hr from 8:00am to 2:00pm, from June 1 through August 15 to protect odonates, subject to certain exceptions discussed in Section 2.2. Further, other operational conditions such as increased bypass flow rates would be expected to lower the extent of water level increases during periods when Gomphus may be eclosing. Water level analyses show less impacts on Gomphus under proposed operations, with the CPR-95 level being reached approximately 3.5% of the time at Montague. Effects would be even less downstream, given flow attenuation. Therefore, the probability of water levels affecting eclosing Gomphus under proposed operations will be minimal, which is an improvement upon the baseline condition.

The second-most abundant odonate species documented downstream were in the Stylurus group. Members of this group tend to eclose between mid-June through mid-August, which tends to be later than Gomphus. This group does not tend to climb as high as Gomphus and could be more susceptible to water level increases due to Project operations. Water level analyses suggest that water level increases from Cabot Station would not affect 70% of Stylurus individuals most of the time. However, individuals within the Stylurus group that do not climb as high could be affected, especially the 10% of the population that barely climbs above the water surface, which could be affected approximately 30% of the time given baseline operations, between Cabot Station and the Route 116 Bridge, approximately 9 miles downstream (Figure 3.3.3.2.5-4 through Figure 3.3.3.2.5-8). Proposed operational conditions are anticipated to affect this small (10%) proportion of the population 5-10% less of the time across the nine-mile river reach (Figure 3.3.3.2.5-4 through Figure 3.3.3.2.5-8).

Though the Project currently has infrequent effects on the few individuals of this species that barely climb above the water surface, these effects would likely occur even in the absence of peaking operations. The 10% of Stylurus individuals at the most risk of operational-related effects only climbed 0.08 feet (approximately one inch). Given their proximity to the water while eclosing, these individuals would also be prone to inundation from natural water level increases, natural waves/chop, and boat wakes.

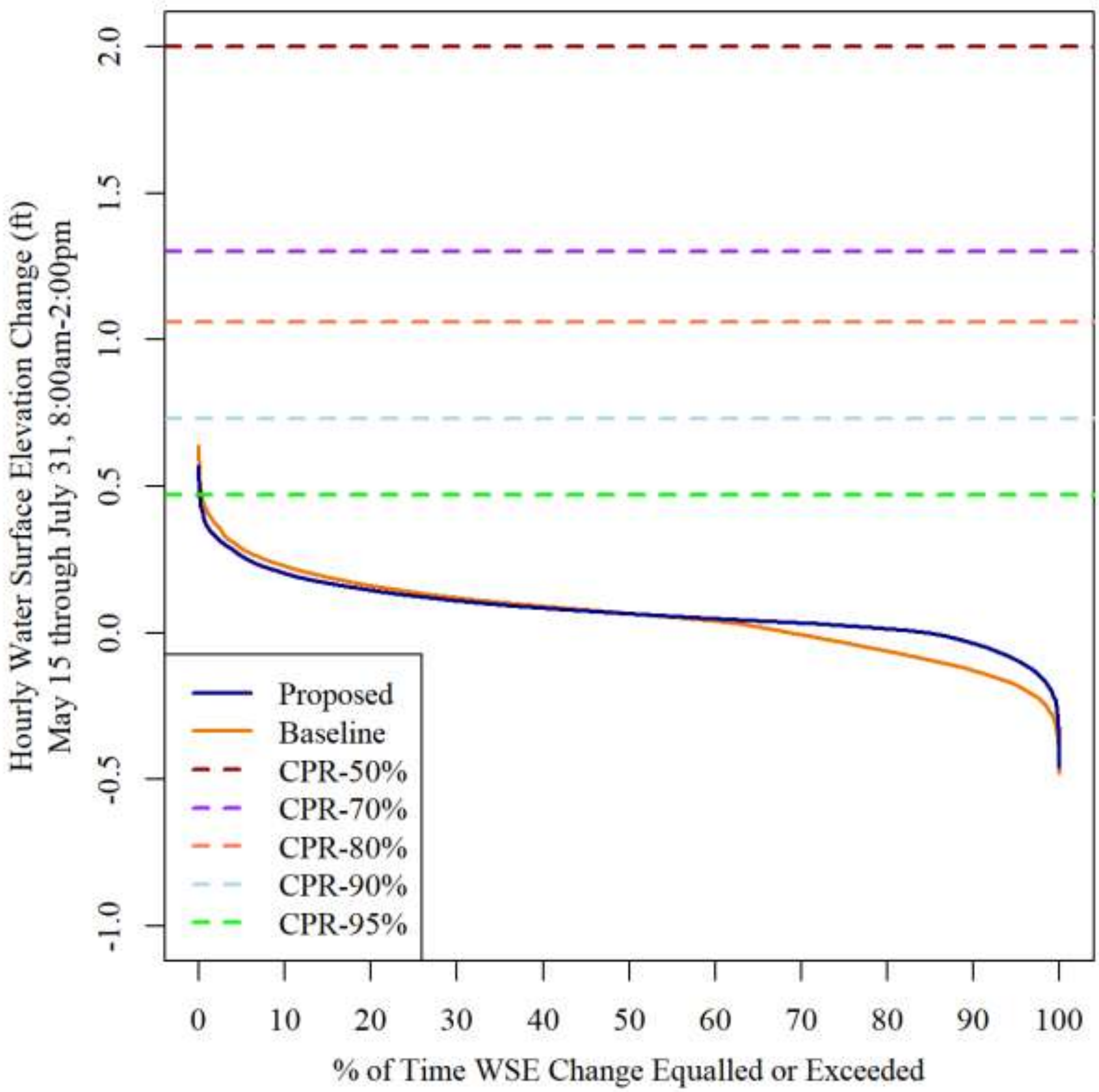

Figure 3.3.3.2.5-1: Water Level Duration Curves Compared to Critical Protective Rates for E. princeps in the Turners Falls Impoundment

Note: Data were filtered to include average daily naturally routed flows within Turners Falls Project of less than 16,000 cfs. Data were also filtered to include periods when most individuals of this species would be emerging/eclosing, between 8:00am and 2:00pm, May 15 through July 31.

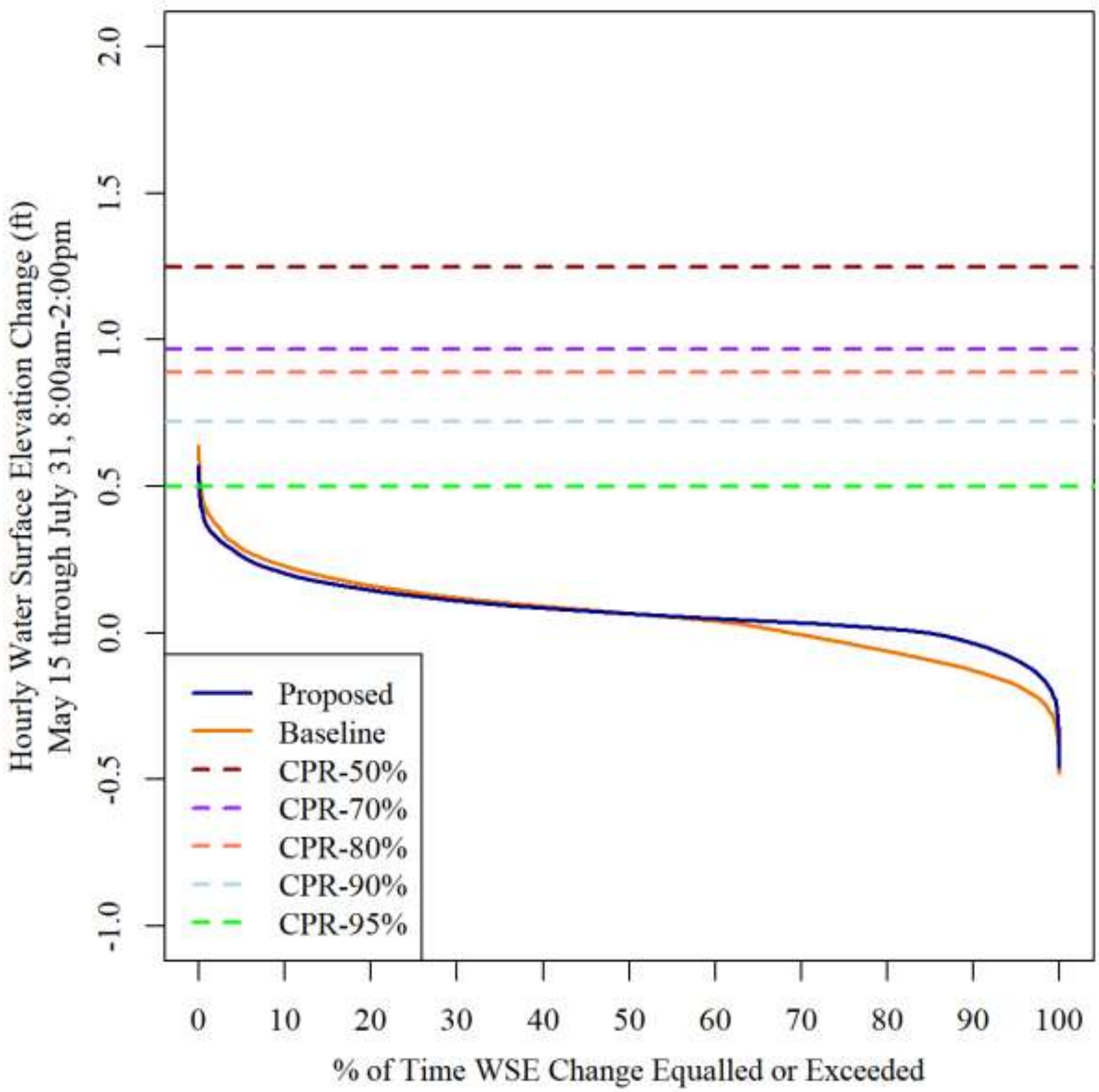

Figure 3.3.3.2.5-2: Water Level Duration Curves Compared to Critical Protective Rates for Libellulidae in the Turners Falls Impoundment

Note: Data were filtered to include average daily naturally routed flows within Turners Falls Project of less than 16,000 cfs. Data were also filtered to include periods when most individuals of this species would be emerging/eclosing, between 8:00am and 2:00pm, May 15 through July 31.

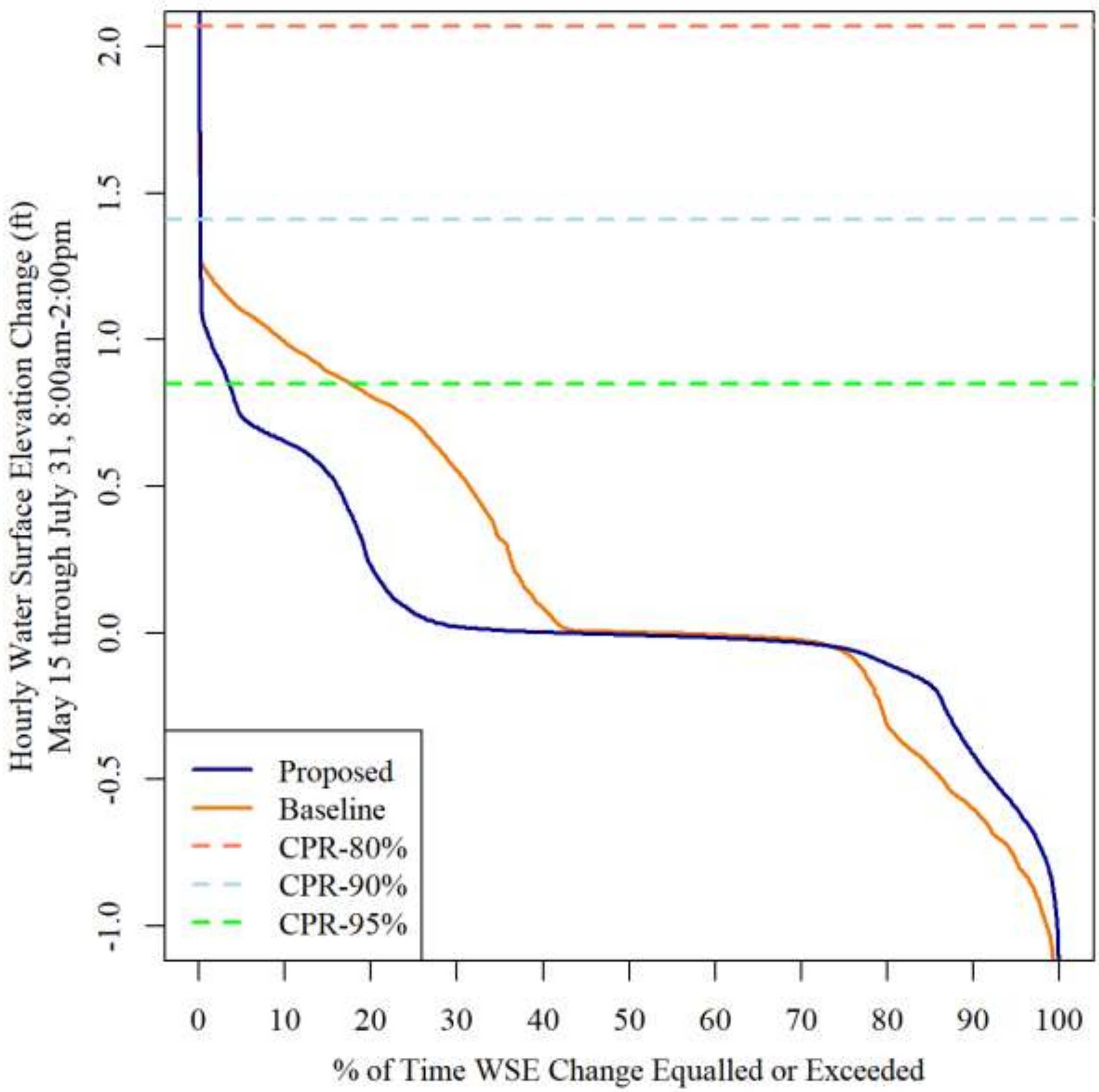

Figure 3.3.3.2.5-3: Water Level Duration Curves Compared to Critical Protective Rates for Gomphus spp. Below Cabot Station at Montague (River Mile 118.5)

Note: Data were filtered to include river flows within Turners Falls Project generating capacity plus the design generating capacity from Deerfield River Project No. 2 of 1,450 cfs and other smaller inflows. (Avg. Daily Montague Flow < 18,000 cfs). Data were also filtered to include periods when Gomphus spp. would be emerging/eclosing, between 8:00am and 2:00pm, May 15 through July 31.

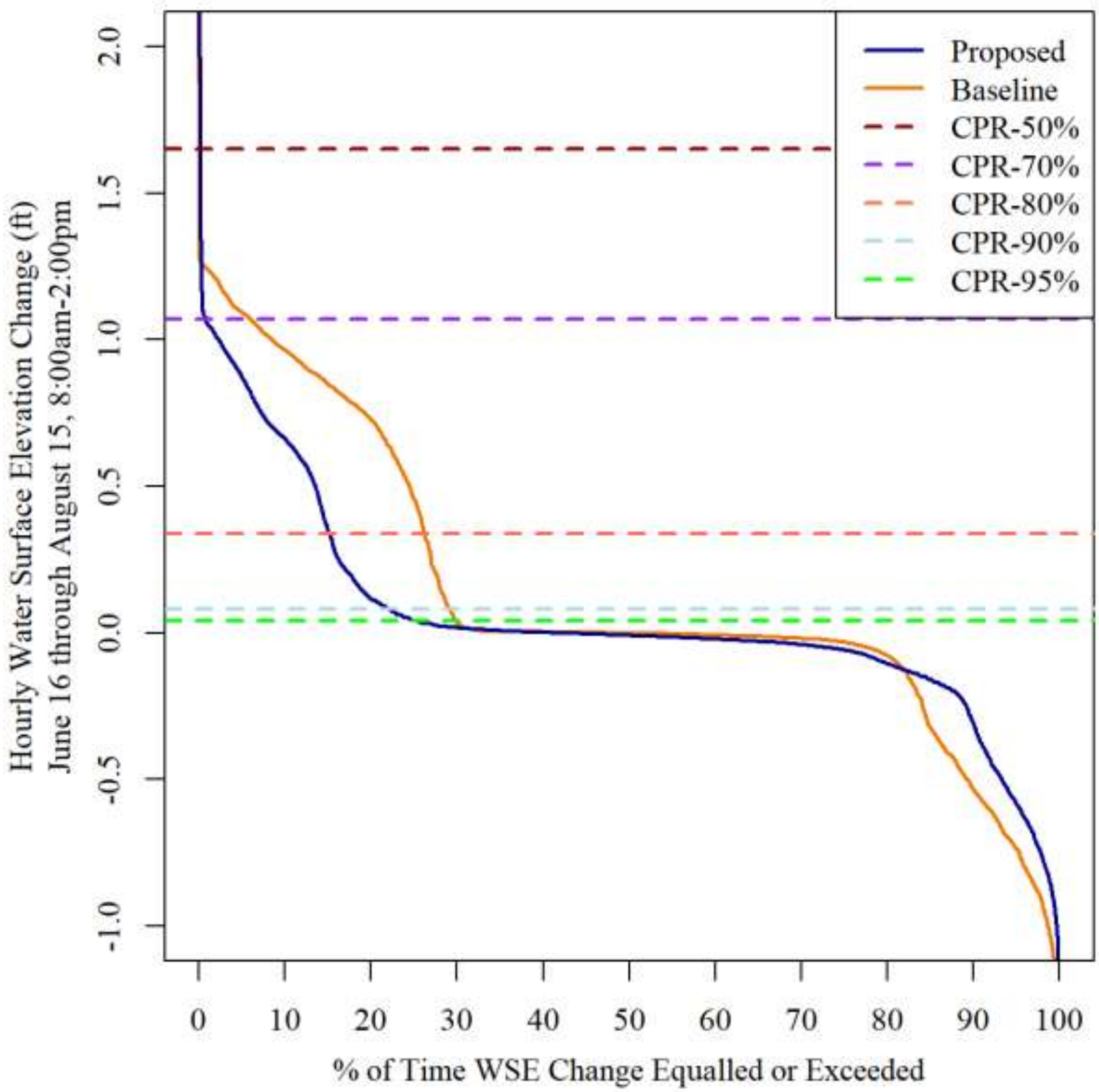

Figure 3.3.3.2.5-4: Water Level Duration Curves Compared to Critical Protective Rates for Stylurus spp. Below Cabot Station at Montague (River Mile 118.5)

Note: Data were filtered to include river flows within Turners Falls Project generating capacity plus the design generating capacity from Deerfield River Project No. 2 of 1,450 cfs and other smaller inflows. (Avg. Daily Montague Flow < 18,000 cfs). Data were also filtered to include periods when Stylurus spp. would be emerging/eclosing, between 8:00am and 2:00pm, June 16 through August 15.

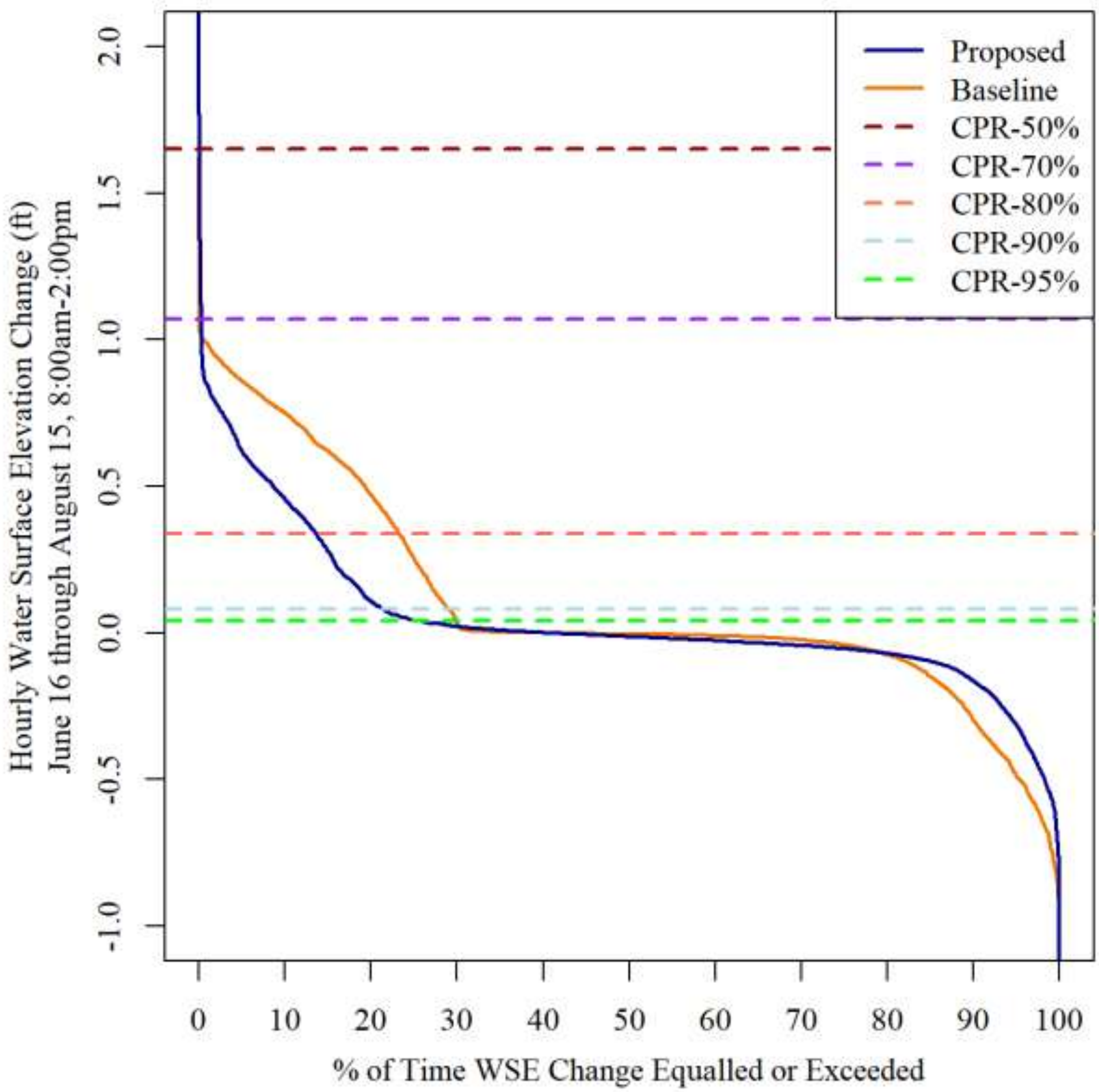

Figure 3.3.3.2.5-5: Water Level Duration Curves Compared to Critical Protective Rates for Stylurus spp. Below Cabot Station at River Mile 116.8

Note: Data were filtered to include river flows within Turners Falls Project generating capacity plus the design generating capacity from Deerfield River Project No. 2 of 1,450 cfs and other smaller inflows. (Avg. Daily Montague Flow < 18,000 cfs). Data were also filtered to include periods when Stylurus spp. would be emerging/eclosing, between 8:00am and 2:00pm, June 16 through August 15.

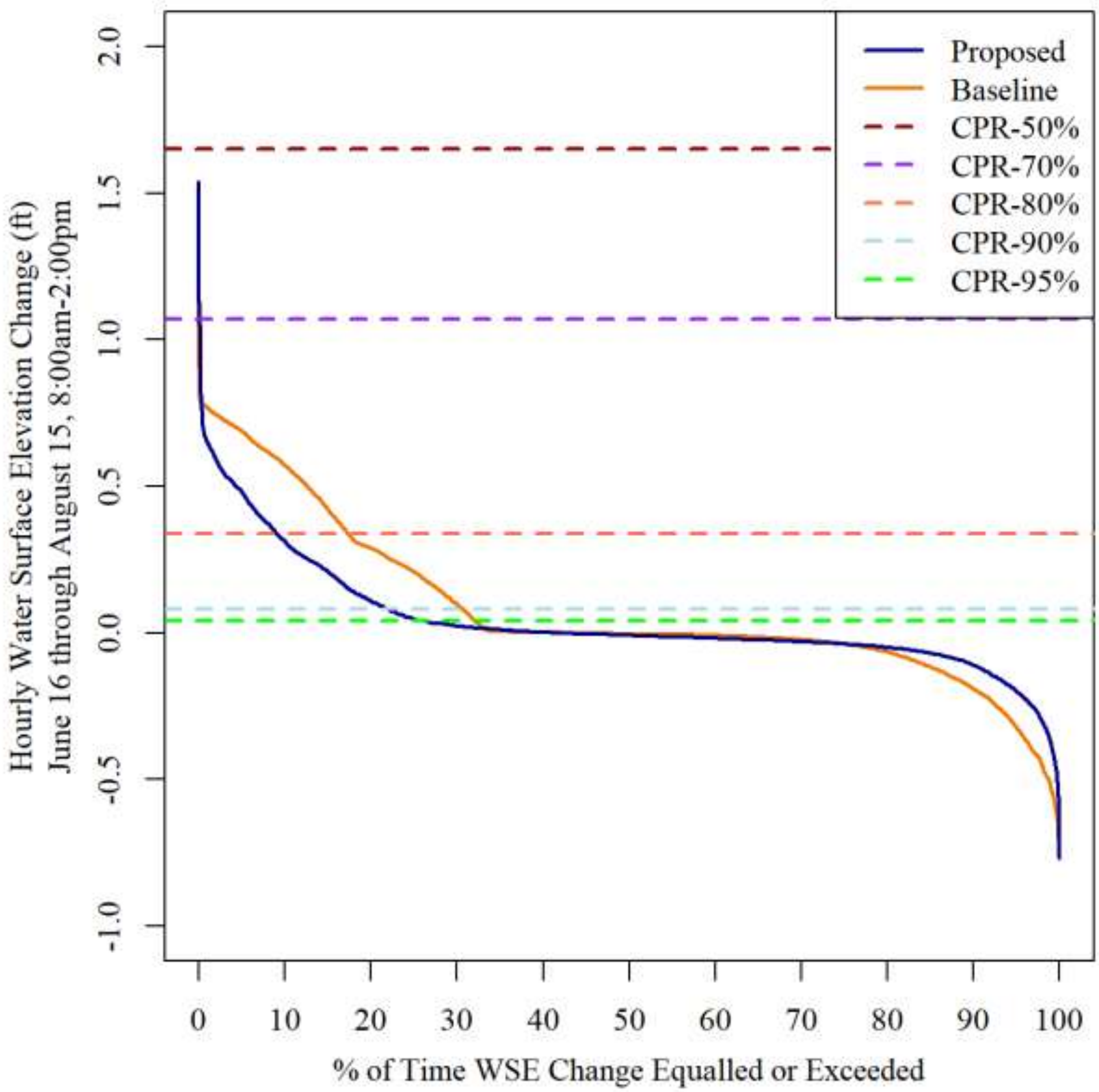

Figure 3.3.3.2.5-6: Water Level Duration Curves Compared to Critical Protective Rates for Stylurus spp. Below Cabot Station at River Mile 115.07

Note: Data were filtered to include river flows within Turners Falls Project generating capacity plus the design generating capacity from Deerfield River Project No. 2 of 1,450 cfs and other smaller inflows. (Avg. Daily Montague Flow < 18,000 cfs). Data were also filtered to include periods when Stylurus spp. would be emerging/eclosing, between 8:00am and 2:00pm, June 16 through August 15.

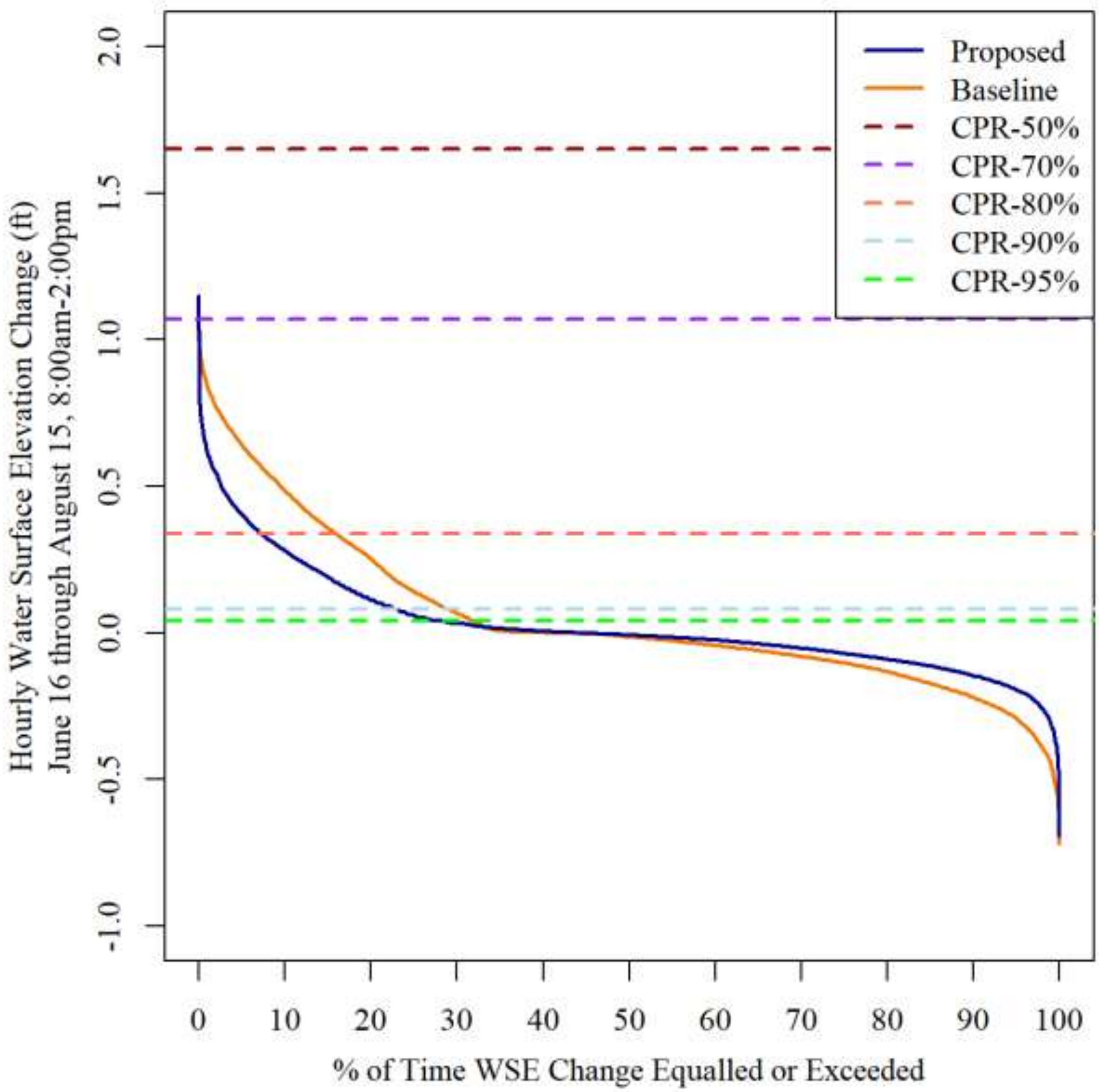

Figure 3.3.3.2.5-7: Water Level Duration Curves Compared to Critical Protective Rates for Stylurus spp. Below Cabot Station at River Mile 113.17

Note: Data were filtered to include river flows within Turners Falls Project generating capacity plus the design generating capacity from Deerfield River Project No. 2 of 1,450 cfs and other smaller inflows. (Avg. Daily Montague Flow < 18,000 cfs). Data were also filtered to include periods when Stylurus spp. would be emerging/eclosing, between 8:00am and 2:00pm, June 16 through August 15.

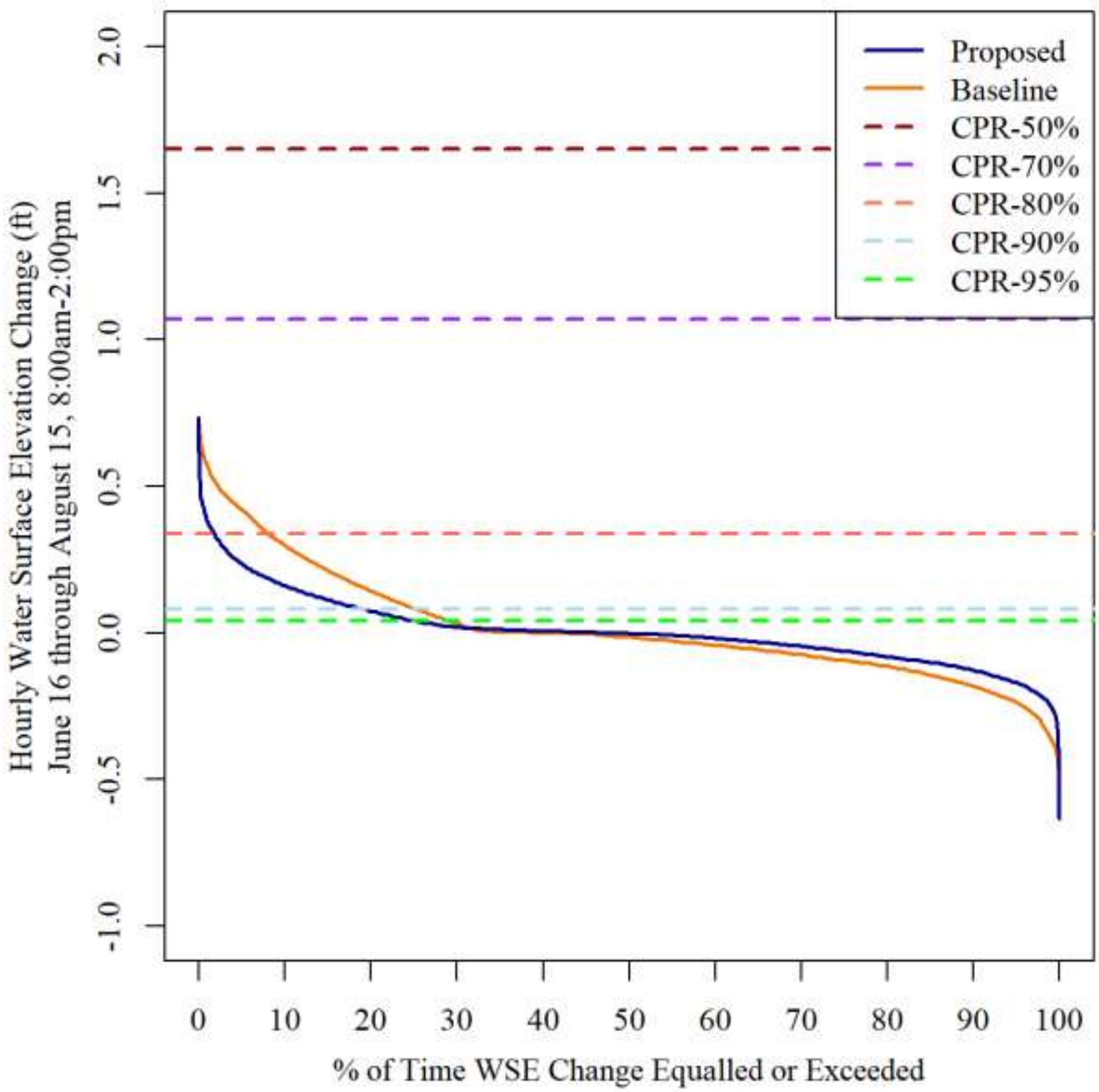

Figure 3.3.3.2.5-8: Water Level Duration Curves Compared to Critical Protective Rates for Stylurus spp. Below Cabot Station at River Mile 109.52

Note: Data were filtered to include river flows within Turners Falls Project generating capacity plus the design generating capacity from Deerfield River Project No. 2 of 1,450 cfs and other smaller inflows. (Avg. Daily Montague Flow < 18,000 cfs). Data were also filtered to include periods when Stylurus spp. would be emerging/eclosing, between 8:00am and 2:00pm, June 16 through August 15.

3.3.3.1.10 Freshwater Mussels

Studies and associated analyses of Project effects of freshwater mussels focused on state listed species, which are included in the Threatened and Endangered Species section of the AFLA.

3.3.3.2 Cumulative Effects

Cumulative effects for the Projects that were identified in FERC's Scoping Document 2 include:

- Effects of Project operations and maintenance (including fluctuations in water levels, and downstream releases) on aquatic habitat and resources in the Projects' vicinity (e.g., resident and migratory fish populations; fish spawning, rearing, feeding, and overwintering habitats; mussels and macroinvertebrate populations and habitat).

- Effects of Project facilities and operations, (including reservoir fluctuations, and generation releases) on fish migration through and within project fishways, canals, bypassed reaches, reservoirs, and the downstream riverine corridors.

- Effects of entrainment on fish.

The cumulative impact of the Project on aquatic habitat occurs within the context of the presence of a series of hydroelectric facilities that have the potential to collectively affect the water quantity of the Connecticut River. The Project contributes to the alternation of the Connecticut River's hydrology, particularly in terms of water levels and flow regime. As such, habitats are not only affected directly by the Projects, but are affected cumulatively given inflow from upstream projects and water level changes occurring downstream at Holyoke Dam.

Cumulative effects of hydropower dams in the context of migratory fish species has been well-documented. Even with fish passage measures in place, upstream passage at dams' results in some degree of reduced passage success, along with delays and effects to fish health. These effects can be encountered at varying degrees at consecutive dams. As the second dam upstream on the Connecticut River, the fish passing upstream at the Turners Falls Project have initially passed Holyoke Dam, having encountered stressors and delay there. The species that could then pass upstream through Turners Falls include American Shad, Blueback Herring, American Eel, and Sea Lamprey. Once above the Turners Falls Project, they could then pass upstream through the Vernon, Bellows Falls, and Wilder Projects. Downstream migration could then occur as post-spawned fish (American Shad and Blueback Herring), progeny (American Shad, Blueback Herring, and Sea Lamprey), or mature adults (American Eel). During downstream migration, cumulative impacts would also include reductions in numbers, delays, and reductions in fitness of individual fish at each dam. Entrainment mortality and injuries could be part of these cumulative impacts to migratory species. Several measures proposed by FirstLight to improve upstream and downstream fish passage would result in more individuals with better fitness reaching the next dam. If other projects on the river also improve fish passage, these proposed measures would be cumulatively beneficial.

In general, the effects of Project maintenance are minimal for aquatic resources. The primary effects of maintenance result from the annual drawdown of the Turners Falls power canal each year. The primary cumulative effect of the canal drawdown would pertain to migratory species, such as American Shad (juveniles), American Eel, and Sea Lamprey, which could be residing in or migrating through the canal during drawdown. As described above, given the migratory life history of these species, losses or delays due to canal drawdown could result in cumulative impacts during emigration through Holyoke Dam and out of the Connecticut River. Based on data collected, loss of these species due to the drawdown would be minimal, as many would have passed downstream or remained in pool areas. However, some delays to passage could occur for those that become stranded in the drawn-down canal.

3.3.3.3 Proposed Environmental Measures

3.3.3.3.1 Habitat

Turners Falls Impoundment

FirstLight will limit the rate of rise of the TFI water level, as measured at the Turners Falls Dam, to be less than 0.9 feet/hour from May 15 to August 15 between the hours of 8:00 am and 2:00 pm for the protection of odonates.

Turners Falls Bypass Reach

Proposed increases to bypass reach flows that vary seasonally will provide more spawning and rearing habitat to migratory fish species, including the federally endangered SNS, along with habitat for several resident fish species and macroinvertebrates during the remainder of the year.

Downstream of Cabot Station

Proposed increases to minimum flows below the Turners Falls Project during the spring will provide more spawning and rearing habitat to American Shad, Walleye, and Sea Lamprey when flows are within the capacity of the Turners Falls Project to control.

3.3.3.3.2 Fish Passage

Upstream Migration

Proposed increases to bypass reach flows during the upstream migration season will promote passage of American Shad, and possibly other migratory species such as Sea Lamprey, into and through the bypass reach to the Turners Falls Dam. The proposed spillway lift will provide improved passage at Turners Falls Dam, and the upstream passage route through the Cabot ladder and canal will be discontinued. In general, promoting passage through the bypass reach to a lift at the spillway is anticipated to be a major improvement to fish passage relative to current conditions.

Downstream Migration

Proposed installation of a plunge pool below BG 1 at the Turners Falls Dam will provide a safe route of passage for fish that choose to pass via spill, which may become more common during proposed conditions given the higher proposed minimum flows from Turners Falls Dam.

Proposed installation of a bar rack, with ¾-inch clear spacing, at the entrance to the Station No. 1 forebay, will deter emigrating adult and juvenile American Shad, and American Eels from becoming entrained in Station No. 1. This will encourage them to move downstream to the lower canal, where they can pass via routes with higher survival (i.e. Cabot Station or log sluice).

Proposed continuation of measures in place at Cabot Station will provide for downstream passage at the lower end of the canal. Fish migrating down the canal to Cabot Station will encounter an existing 31-foot high rack structure. The top 11 feet of the upper racks have clear bar spacing of 0.94 inches (15/16-inch), and the bottom 7 feet of the upper racks have clear bar spacing of 5 inches. The entire 13 feet of the lower racks have clear bar spacing of 5 inches. Cabot Station is already outfitted with a downstream fish passage facility with a state of the science uniform flow acceleration weir and an attraction flow varying between 110 and 253 cfs depending on the power canal elevation.

Proposed installation of a barrier net at the Northfield Mountain Project will limit entrainment of emigrating juvenile American Shad and adult American Eel. Data gathered at the Project provided the foundation for CFD models, which were used to inform the design and feasibility of the barrier net.

3.3.3.3.3 Entrainment/Impingement

Proposed installation of a barrier net at the Northfield Mountain tailrace from August 1 through November 15 will prevent entrainment of emigrating American Eel and juvenile American Shad.

Proposed installation of a bar rack, with ¾-inch clear spacing, at the entrance to the Station No. 1 forebay, will deter emigrating adult and juvenile American Shad, and American Eels from becoming entrained in Station No. 1. This would also reduce entrainment of resident fish at Station No. 1.

3.3.3.3.4 Odonates

FirstLight is proposing restrictions that limit the rate of water level increases at the Project to protect state-listed odonates (Section 3.3.5), subject to certain exceptions discussed in Section 2.2. These include:

- Downstream: Up to 2,300 cfs per hour up-ramping at Cabot Station from 8:00am to 2:00pm, June 1 through August 15
- Impoundment: A limit on the rate of rise of the TFI, as measured at the Turners Falls Dam, to less than 0.9 feet/hr from May 15 to August 15 between the hours of 8:00am to 2:00pm

These measures would be anticipated to benefit a variety of odonate species by providing suitable eclosing conditions.

3.3.3.4 Unavoidable Adverse Impacts

To provide benefits to specific species in the bypass reach via proposed increases in bypass flow rates, other species will be impacted by a decline in habitat suitability relative to current operations. Particularly, those that prefer areas with low water velocities, such as fry life stages and Walleye. Further, proposed minimum flows are on an "or inflow, whichever is less" basis, meaning that if the NRF is lower than the minimum flows, the NRF would be released. The Projects cannot control river inflow from upstream. Upstream storage and hydropower projects affect inflows to the Turners Falls Project. The Vernon Project is one of three GRH projects also undergoing relicensing in parallel to the Turners Falls and Northfield Mountain Projects. The other two projects are the Bellows Falls and Wilder Projects which are located immediately upstream of the Vernon Project. All three GRH facilities are used to meet peak demand and, thus, control the inflows to the Turners Falls and Northfield Mountain Projects. Upstream of the Wilder Project is the Fifteen Mile Falls Project including the Moore, Comerford and McIndoes Developments which are also owned by GRH and were licensed in April 2002. These developments have significant storage capacity and their operations influence flows to the Wilder Project and eventually to the Turners Falls and Northfield Mountain Projects.

Similarly, the Holyoke Project is downstream of the Turners Falls Project, and affects water levels over many miles of river upstream of the Holyoke Dam. Water level fluctuations at Holyoke Dam have been demonstrated to affect PTB habitat.

Cabot Station peaking operations, under FirstLight's proposed action, would continue to alter flow on an intra-daily time step in the Connecticut River below Cabot Station. These effects would be most apparent during summer/fall low flow periods, when the range of Project operations could be widest. The amount of habitat available to certain aquatic species would be reduced during periods of Cabot Station peaking, though specific PM&E measures have been taken to prevent negative effects to several aquatic resources.

Entrainment of migratory and resident fish through Cabot Station will continue to occur, though likely at lower frequencies due to proposed increases in bypass flows and other operational changes that will reduce the amount of flow passed through Cabot Station and increase attraction toward the log sluice. Though mortality from entrainment was found to be low at Cabot Station for each species evaluated, mortality and injuries will occur.

References

Auer, N. A. (1982). Identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan drainage. Ann Arbor, MI: Great Lakes Fishery Commission.

Beamish, F. W. H. (1980). Biology of the North American anadromous sea lamprey, Petromyzon marinus. *Canadian Journal of Fisheries and Aquatic Sciences*, *37*(11), 1924-1943.

Bovee, K.D. (1982). A guide to stream habitat analysis using the instream flow incremental methodology. (Office of Biol. Service FWS/OBS-82-26). Washington, DC. USFWS, U.S. Dept. of Interior.

Bovee, K.D., Lamb, B.L., Bartholow, J.M., Stalnaker, C.B., Taylor, J. & Henriksen, J. (1998). Stream habitat analysis using the instream flow incremental methodology. (Biological Resources Division Information and Technology Report USGS/BRD-1998-0004/ viii). U.S. Geological Survey.

Buckley, J. & Kynard, B. (1985). Yearly movements of Shortnose Sturgeons in the Connecticut River. Transactions of the American Fisheries Society 114, 813-820.

Castro-Santos, T and B. H. Letcher. 2010. Modeling migratory energetics of Connecticut River American Shad (Alosa sapidissima): implications for the conservation of an iteroparous anadromous fish. Canadian Journal of Fisheries and Aquatic Science, 67: 806-830.

Collette, B. B. & Klein-MacPhee, G. (Eds.). (2002). *Bigelow and Schroeder's fishes of the Gulf of Maine*. Washington, D.C.: Smithsonian Institution Press.

CRASC (Connecticut River Atlantic Salmon Commission) 2017. Connecticut River American Shad Management Plan.14 pages.

Coble, D.W. (1975). Smallmouth bass. In R.H. and H. Clepper (Eds.), *Black bass biology and management: National Symposium on the Biology and Management of the Centrarchid Basses, Tulsa, Oklahoma* (pp. 21-33). Washington DC: Sport Fishing Inst.

Crecco, V. A., Savoy, T., & Gunn, L. (1983). Daily mortality rates of larval and juvenile American shad (*Alosa sapidissima*) in the Connecticut River with changes in year-class strength. *Canadian Journal of Fisheries and Aquatic Sciences* 40(10), 1719-1728.

Crecco, V. A., and T. F. Savoy. 1987. Review of recruitment mechanisms of the American shad: the critical period and match mismatch hypotheses revisited. Pages 455–468 *in* M. J. Dadswell, R. J. Klauda, C. M. Moffitt, R. L. Saunders, R. A. Rulifson, and J. E. Cooper, editors. Common strategies of anadromous and catadromous fishes. American Fisheries Society, Symposium 1, Bethesda, Maryland.

CRASC (Connecticut River Atlantic Salmon Commission) 2017. Connecticut River American Shad Management Plan.14 pages.

Dadswell, M.J., Taubert, B.D., Squires, T.S., Marchette, D. & Buckley, J. (1984). Synopsis of biological data on Shortnose Sturgeon, *Acipenser brevirostrum* LeSueur 1818. FAO *Fish. Synop. 140,* 1-45.

Davis, J., Schultz, E., & Vokoun, J. (2009). Assessment of river herring and Striped Bass in the Connecticut river: abundance, population structure, and predator/prey interactions. Final Report submitted to the Connecticut Department of Environmental Protection.

EPRI (Electric Power Research Institute). 1997. Guidelines for Hydro Turbine Fish Entrainment and Survival Studies. EPRI, Report 107229, Palo Alto, California.

EPRI (Electric Power Research Institute). 2006. Design considerations and specifications for fish barrier net deployment at cooling water intake structures. EPRI, Report 1013309, Palo Alto, California.

FirstLight. (2016a). Relicensing Study 3.3.1 Conduct Instream Flow Habitat Assessments in the Bypass Reach and Below Cabot Station. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2016b). Relicensing Study 3.3.2 Evaluate Upstream and Downstream Passage of Adult American Shad. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author

FirstLight (2016c). Relicensing Study 3.3.3 Evaluate Downstream Passage of Juvenile American Shad. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2016d). Relicensing Study 3.3.4 Evaluate Upstream Passage of Juvenile American Eel at the Turners Falls Project. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2017a). Relicensing Study 3.3.5 Evaluate Downstream Passage of American Eel. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA. Author.

FirstLight (2016e). Relicensing Study 3.3.6 Impact of Project Operations on Shad Spawning, Spawning Habitat, and Egg Deposition in the Area of the Northfield Mountain and Turners Falls Projects. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2016f). Relicensing Study 3.3.7 Fish Entrainment and Turbine Passage Mortality Study. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2016g). Relicensing Study 3.3.8 Computational Fluid Dynamics Modeling in the Vicinity of the Fishway Entrances and Powerhouse Forebays. Prepared by Gomez and Sullivan Engineers. Northfield, MA: Author.

FirstLight (2015a). Relicensing Study 3.3.9 Two-Dimensional Modeling of the Northfield Mountain Pumped Storage Project Intake/Tailrace Channel and Connecticut River Upstream and Downstream of the Intake/Tailrace. Prepared by Gomez and Sullivan Engineers. Northfield, MA: Author.

FirstLight (2016i). Relicensing Study 3.3.10 Assess Operational Impacts on Emergence of State-Listed Odonates in the Connecticut River Prepared by Gomez and Sullivan Engineers and BioDrawversity. Northfield, MA: Author.

FirstLight (2016j). Relicensing Study 3.3.11 Fish Assemblage Assessment Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2016k). Relicensing Study 3.3.12 Evaluate Frequency and Impact of Emergency Water Control Gate Discharge Events and Bypass Flume Events on Shortnose Sturgeon Spawning and Rearing Habitat in the Tailrace and Downstream from Cabot Station. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2016l). Relicensing Study 3.3.13 Impacts of the Turners Falls Project and Northfield Mountain Project on Littoral Zone Fish Habitat and Spawning Habitat. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2012a). Aquatic Mesohabitat Assessment and Mapping Report. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA. Author.

FirstLight (2016m). Relicensing Study 3.3.15. Assessment of Adult Sea Lamprey Spawning within the Turners Falls Project and Northfield Mountain Project Area. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2016n). Relicensing Study 3.3.16. Habitat Assessment, Surveys, and Modeling of Suitable Habitat for State-listed Mussel Species in the CT River below Cabot Station. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight. (2015a). Study No. 3.3.14 Aquatic Habitat Mapping of the Turners Falls Impoundment. . Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight. (2015b). Relicensing Study 3.3.17. Assess the Impacts of Project Operations on the Turners Falls Project and Northfield Mountain Project on Tributary and Backwater Area Access and Habitat. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2017b). Relicensing Study 3.3.19. Evaluate the Use of an Ultrasound Array to Facilitate Upstream Movement to Turners Falls Dam by Avoiding Cabot Station Tailrace. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight (2016o). Relicensing Study 3.3.20 Northfield Mountain Project American Shad Ichthyoplankton Entrainment Assessment. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA. Author.

FirstLight (2015c). Relicensing Study 3.3.18. Impacts of the Turners Falls Canal Drawdown on Fish Migration and Aquatic Organisms. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

Flow Science. (2012). FLOW-3D Documentation, Release 10.1.0, November 2, 2012.

Franke, G.F., Webb, D.R., Fisher Jr., R.K., Mathur, D., Hopping, P.N., March, P.A., & Sotiropoulos, F. (1997). Development of Environmentally Advanced Hydropower Turbine System Design Concepts. Idaho Falls, ID: Idaho National Engineering Laboratory.

Great River Hydro. 2019. ILP Study 9 – Instream Flow. Revised Final Study Report. Filed with FERC on May 20, 2019.

Greene, K. E., Zimmerman, J. L., Laney, R. W., & Thomas-Blate, J. C. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission Habitat Management Series No. 9. Washington, D.C.

Grote, Ann, Baily, Michael, Zydlewski, Joseph 2014. Movements and Demography of Spawning American Shad in the Penobscot River, ME, prior to Dam Removal.

Haro, A. J., and W. H. Krueger. 1991. Pigmentation, otolith rings, and upstream migration of juvenile American eels (*Anguilla rostrata*) in a coastal Rhode Island stream. Canadian Journal of Zoology 69: 812-814.

Hartel, K.E., Halliwell, D.B., & Launer, A.E. (2002). Inland Fishes of Massachusetts. Lincoln, MA: Massachusetts Audubon Society.

Harza Engineering Company (Harza) & RMC Environmental Services (RMC). (1992a). Turners Falls downstream fish passage studies: Downstream passage of juvenile clupeids, fall 1991. Chicago, IL: Author. Report to Northeast Utilities Service Company.

Harza Engineering Company (Harza) & RMC Environmental Services (RMC). (1992b). Turners Falls downstream fish passage studies: Downstream passage of Atlantic Salmon smolts, spring 1991. Chicago, IL: Author. Report to Northeast Utilities Service Company.

Harza Engineering Company (Harza) & RMC Environmental Services (RMC). (1994a). Turners Falls downstream fish passage studies: Downstream passage of Atlantic Salmon smolts, spring 1992. Chicago, IL: Author. Report to Northeast Utilities Service Company.

Harza Engineering Company (Harza) & RMC Environmental Services (RMC). (1994b). Turners Falls downstream fish passage studies: Downstream passage of Atlantic Salmon smolts, spring 1993. Chicago, IL: Author. Report to Northeast Utilities Service Company.

Heidinger, R.C. (1975). Life history and biology of the largemouth bass. In R.H. and H. Clepper (Eds.), *Black bass biology and management: National Symposium on the Biology and Management of the Centrarchid Basses*, Tulsa, Oklahoma (pp. 11-20). Washington DC: Sport Fishing Inst.

Kieffer, M.C. & Kynard, B. (1993). Annual movements of shortnose and Atlantic sturgeons in the Merrimack River, Massachusetts. *Transactions of the American Fisheries Society 122,* 1088-1103.

Kieffer, M. & Kynard, B. (1996). Spawning of shortnose sturgeon in the Merrimack River, Massachusetts. *Trans Amer. Fish. Soc. 125*, 179-186

Kieffer, M. & Kynard, B. (2007). Effects of Water Manipulations by Turners Falls Dam Hydroelectric Complex Rearing Conditions for Connecticut River Shortnose Sturgeon Early Life Stages. S.O. Turners Falls, MA: Conte Anadromous Fish Research Center.

Kuzmeskus, D. M. 1977. Egg production and spawning site distribution of American Shad, Alosa sapidissima, in the Holyoke Pool, Connecticut River, Massachusetts. Master of Science Thesis. Amherst, MA: University of Massachusetts, Amherst, MA.

Kynard, B. (1997). Life history, latitudinal patterns, and status of the Shortnose Sturgeon, *Acipenser brevirostrum*. *Environmental Biology of Fishes*, *48*, 319-334.

Kynard, B., Bronzi, P., and Rosenthal, H. (2012). Life history and behavior of Connecticut River Shortnose and other sturgeons. World Sturgeon Conservation Society. Special Publication No. 4. 320 pp.

Layzer, J.B. (1974). Spawning Sites and Behavior of American shad, *Alosa sapidissima* (Wilson), in the Connecticut River between Holyoke and Turners Falls, Massachusetts, 1972. Master of Science Thesis. Amherst, MA: University of Massachusetts, Amherst, Massachusetts.

Lawler, Matusky, and Skelly Engineers (LMS). 1993. Northfield Mountain Pumped Storage Facility– 1992 American Shad Studies. February 1993. Northeast Utilities Service Company, Berlin, CT.

Leggett, W. C., T. F. Savoy, and C. A. Tomichek. 2004. The impact of enhancement initiatives on the structure and dynamics of the Connecticut River population of American Shad. Pages 391-405 *in* P. M. Jacobson, D. A. Dixon, W. C. Leggett, B.C. Marcy, Jr., R.R. Massengill, editors. The Connecticut River Ecological Study (1965-1973) revisited: ecology of the lower Connecticut River 1973-2000. American Fisheries Society, Monograph 9, Bethesda, Maryland.

Massachusetts Division of Fisheries and Game (MDF&G). (1978). Northfield Mountain Pumped Storage Hydroelectric Project Resident Fish Survey 1971 through 1976. Final report to Northeast Utilities Service Company. 99 pp.

Midwest Biodiversity Institute (MBI) (2014). Unpublished data. Electrofishing data Holyoke MA to Vernon, VT. Columbus, OH

Milhouse, R. T., Updike, M. A, & Schneider, D. M. (1989). Physical habitat simulation system reference manual: version 2, Instream flow information paper 26 (Biological Report 89(16)). Washington, D.C.: U.S. Fish and Wildlife Service.

Moffit, C. M., B. Kynard, and S. G. Rideout. 1982. Fish passage facilities and anadromous fish restoration in the Connecticut River basin. Fisheries 7(6):2–11.

Moser, M. L., Butzerin, J. M., & Dey, D. B. (2007). Capture and collection of lampreys: the state of the science. *Reviews in Fish Biology and Fisheries*, *17*(1), 45-56.

National Marine Fisheries Service (NMFS). (1998). Recovery Plan for the Shortnose Sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland.

National Marine Fisheries Service (NMFS). (2005). National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion for New License for the Holyoke Hydroelectric Project (FERC P-2004). Submitted to the Federal Regulatory Commission. Northeast Regional Office. 116 pp.

Normandeau Associates, Inc. (2015). ILP Study 7 Aquatic Habitat Mapping Final Study Report. Prepared for TransCanada Hydro Northeast, Inc.

Northeast Utilities Service Company (NUSCO). (1994). Downstream passage of Atlantic Salmon (*Salmo salar*) smolts at Cabot Station, Turners Falls Project, Turners Falls, Massachusetts, 1994.

Northeast Utilities Service Company (NUSCO). (1995). Downstream passage of Atlantic Salmon (*Salmo salar*) smolts at Cabot Station, Turners Falls Project, Turners Falls, Massachusetts, 1995.

Northeast Utilities Service Company (NUSCO). (1998). Movement of Atlantic Salmon (*Salmo salar*) Smolts through the Turners Falls Project, Connecticut River, Turners Falls, Massachusetts, 1998.

Northeast Utilities Service Company (NUSCO). (1998b). Downstream passage of Atlantic Salmon (*Salmo salar*) smolts at Cabot Station, Turners Falls Project, Turners Falls, Massachusetts, 1997.

Northeast Utilities Service Company. (NUSCO) (1999). The Effect of a Guide Net on the Movements of Radio tagged Atlantic Salmon (*Salmo salar*) Smolts at the Intake of the Northfield Mountain Pumped Storage Facility, Connecticut River, 1999. Author.

Nguyen, T. D. & Hecker, G. E. (1992). *Hydraulic model study of the Cabot Station log sluice fish sampler*. Holden: MA: Alden Research Laboratory. Sponsored by Northeast Utilities Service Company.

O'Herron, J.C., Able, K.W. & Hastings, R.W. (1993). Movements of Shortnose Sturgeon (*Acipenser brevirostrum*) in the Delaware River. *Estuaries, 16,* 235-240.

O'Leary, J. A. and B. Kynard. 1986. Behavior, length, and sex ratio of seaward migrating juvenile American shad and blueback herring in the Connecticut River. Transactions of the American Fisheries Society Volume 115, Issues 4, pages 529-536.

Pardue, G.B. (1983). Habitat suitability index models: alewife and Blueback Herring. U.S. Dept. Int. Fish Wildlife Service FWS/ OBS-82/l.0.58.

Patrick, Paul, Mason, Elaine, Powell, Jennifer, Milne, Scott & Poulton (2014) Evaluating the Effectiveness of the Pickering Nuclear Generating Station Fish Diversion System Barrier Net, North American Journal of Fisheries Management, 34:2, 287-300

RMC Environmental Services (RMC). (1994). Emigration of juvenile clupeids and their responses to light conditions at the Cabot Station, Fall 1993. (Draft). Brattleboro, VT: Author. Report to Northeast Utilities Service Company.

RMC Environmental Services (RMC). (1995). Log sluice passage survival of juvenile clupeids at Cabot hydroelectric station Connecticut River, Massachusetts. Drumore, PA: Author. Report to Northeast Utilities Service Company.

Ross, R. R., T. W. H. Backman, & R. M. Bennett. (1993). Evaluation of habitat suitability index models for riverine life stages of American Shad, with proposed models for premigratory juveniles. Biological Report #14. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Savoy, T. (1991). Sturgeon status in Connecticut waters. Final Report to the National Marine Fisheries Service, Gloucester, Massachusetts: Author.

Savoy, T.F. & Crecco, V.A. (2004). Factors Affecting the Recent Decline of Blueback Herring and American Shad in the Connecticut River. In P.M. Jacobson, D.A. Dixon, W.C. Leggett, B.C. Marcy, Jr. and R.R. Massengill (Eds.) *The Connecticut River Ecological Study (1965-1973) Revisited: Ecology of the Lower Connecticut River 1973-2003* (pp. 361-378). Bethesda, Maryland: American Fisheries Society, Monograph 9.

Savoy, T.F. & Crecco, V.A., & Marcy, B.C., Jr. (2004). American Shad Early Life History and recruitment in the Connecticut River: a 40-year Summary. In P.M. Jacobson, D.A. Dixon, W.C. Leggett, B.C. Marcy, Jr. and R.R. Massengill (Eds.) *The Connecticut River Ecological Study (1965-1973) Revisited: Ecology of the Lower Connecticut River 1973-2003* (pp. 407-417). Bethesda, Maryland: American Fisheries Society, Monograph 9.

Scott, W.B. & Crossman, E.J. (1973). Freshwater fishes of Canada. Bulletin 184. Fish Res. Bd. Canada.

Seibel, D. (1991). *Habitat selection, movements, and response to illumination of Shortnose Sturgeons in the Connecticut River*. (Unpublished Master of Science thesis) Amherst, MA: University of Massachusetts.

Stier, D. J., & Crance, J.H. (1985). Habitat suitability index models and American Shad instream flow suitability curves: U.S. Fish Wildl. Serv. Biol. Rep. 82(10.88).

Stich, D. S., T. F. Sheehan, and J. D. Zydlewski. 2018. A dam passage performance standard model for American Shad. Canadian Journal of Fisheries and Aquatic Science. Published at www.nrcresearch press.com/cjfas on 30 July 2018.

Shortnose Sturgeon Status Review Team (SSSRT). (2010). A Biological Assessment of Shortnose Sturgeon (*Acipenser brevirostrun*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010.

Taubert, B.D. (1980). *Biology of Shortnose Sturgeon (Acipenser brevirostrum) in the Holyoke Pool, Connecticut River, Massachusetts*. (Unpublished doctoral dissertation) Amherst, MA: University of Massachusetts.

Trial, J.G., Wade, C.S., Stanley, J.G., & Nelson, P.C. (1983). Habitat Suitability information: fallfish (FWS/OBS-82/10.48). Washington, DC: USFWS.

Vinogradov, P. (1997). *The impact of Holyoke Dam on Shortnose Sturgeon, Acipenser brevirostrum, spawning and migration*. (Unpublished Master of Science thesis) Amherst, MA: University of Massachusetts Amherst.

Yoder, C.O., Hersha, L.E., & Apell, B.R. (2010). Fish Assemblage and Habitat Assessment of the Upper Connecticut River. A Preliminary Report and Presentation of Data. MBI Technical Report MBI/2009-8-3. Final Project Report to U.S. USEPA, Region I.

U.S. Fish and Wildlife Service. (2010). Fish Facts - Sea Lamprey. Retrieved from http://www.fws.gov/r5crc/Fish/zi_pema.html.

3.3.4 Terrestrial Resources

The Project provides habitat for a variety of wildlife and botanical species. Studies of the terrestrial resources in the Project area provide information on the type and quantity of habitat potentially affected by Project operations. Biologists collected information on the distribution of invasive species, characterized habitats, and developed a plant census in 2014 and 2015 to determine if Project operations affect existing wildlife and botanical resources. As part of the relicensing process, three terrestrial resources studies were conducted as follows:

- Study No. 3.4.1 Baseline Inventory of Terrestrial, Wildlife and Botanical Resources (FirstLight, 2016a)
- Study No. 3.4.2 Effects of Northfield Mountain Project-Related Land Management Practices and Recreation use on Terrestrial Habitats (FirstLight, 2015a)
- Study No. 3.5.1 Baseline Inventory of Wetland, Riparian and Littoral Habitat in the Turners Falls Impoundment and Assessment of Operation Impacts on Special-Status Species[10] (FirstLight, 2016b)
    - Addendum 1: October 2016
    - Addendum 2: April 2017
    - Addendum 3: March 2019

A report for Study No. 3.4.2 was filed with FERC on September 14, 2015. Reports for Study Nos. 3.4.1 and 3.5.1 were filed with FERC on March 1, 2016.

3.3.4.1 Affected Environment

Background
The physiographic settings of the Project, with its relatively large tracts of undisturbed terrestrial habitats, provide a wide variety of habitats for terrestrial wildlife. There are several parks and conservation lands in and around the Project area. Notable areas include (but are not limited to): Connecticut River Greenway State Park, Westwood Wildlife Sanctuary, Rocky Mt. Park, King Phillips Hill, Brush Mt. Conservation area, Pauchaug Brook area, Bennett Meadow Wildlife Management Area (WMA), Cabot Woods, the Erving State Forest, and the Northfield State Forest. FirstLight also manages recreational resources at the Project as part of its FERC license and agreement with the State of MA. The Northfield Mountain Project has many recreational features (e.g., a trail system with over 26 miles of trails, observation area, picnic areas) that are available for public use.

The study area for the Project covers the following areas:

- Upland areas along the TFI including areas within the Project Boundary and areas up to 200 feet from shore where the Project Boundary is along the shoreline;
- Upland areas adjacent to the bypass reach, defined as extending from the Turners Falls Dam to the Cabot Station tailrace;
- The Connecticut River from the Cabot Station tailrace to the Route 116 Bridge in Sunderland; and
- Approximately 2,011 acres of land of Northfield Mountain, of which approximately 405-407 acres constitute the Upper Reservoir.

[10] On October 14, 2016 FirstLight filed Addendum 1 which addressed comments on Puritan and Cobblestone Tiger Beetles and state-listed plants. On April 3, 2017, FirstLight filed Addendum 2 which addressed comments on Puritan and Cobblestone Tiger Beetles, state-listed plants and invasive plant species. On March 1, 2019 FirstLight filed Addendum 3, which addressed Puritan and Cobblestone Tiger Beetles,

FERC Relicensing Studies
As noted above, FirstLight has conducted several studies to gather information necessary to understand the potential effects of land management practices and recreational use on wildlife and botanical resources within the Turners Falls Project and Northfield Mountain Project study area. The goal of these studies was to characterize and describe the terrestrial wildlife and botanical resources that use representative upland habitats within and adjacent to the Project boundary. Specific objectives were:

- Survey and inventory overall upland wildlife habitats;
- Note the occurrence of wildlife sighting during the course of the surveys;
- Survey and inventory vegetation communities and land use; and
- Survey and inventory the nature and extent of upland invasive, exotic vegetation species.

Wildlife

Mammals
Table 3.3.4.1-1 provides a list of the 35 mammal species that were directly and indirectly observed in the Project area during 2014 field surveys, as well as species that are likely to exist in the study area. The list of mammals likely to occur is inferred from available habitat types documented in the study area cross referenced with life history of mammals that are known to occur within the region as referenced by DeGraaf and Yamasaki (2001). The diverse vegetated communities within the study area provide a range of habitat niches for species typical of the highlands of central to western MA and the Connecticut River valley. The majority of the species are habitat generalists with a known tolerance for habitat modifications and adaptations.

Some of the furbearing animals that are known to inhabit the study area include beaver, red fox, gray fox, muskrat, Virginia opossum, and striped skunk. Aquatic furbearers like beaver and muskrat primarily use inundated habitats and the immediately surrounding areas, whereas generalists like opossum and skunk use a wider range of terrestrial habitat types such as woodland, wetland, scrub-shrub or early successional areas, and grassland areas. Use of these areas may shift during different life stages and/or times or year.

Reptiles and Amphibians
According to the MADFW, 45 inland native species of amphibians and reptiles are known to occur in MA (Cardoza & Mirick, 2009). Of these, 23 species of amphibians and reptiles were observed during 2014 field surveys or are likely to occur within the study area. Included are nine frogs and toads, four salamanders, three turtles, and seven snakes. These inland native species include terrestrial and semi-aquatic amphibians and reptiles. A list of reptiles and amphibians recorded or likely to occur in the study area is provided in Table 3.3.4.1-2.

Avian Species
The Connecticut River provides important habitat to a variety of bird species. During the spring and summer, many species (including those observed during this survey) breed and nest along the river. In spring and fall, the river is a major migratory flyway, and, generally, in the winter, it provides habitat for species of waterfowl that nest further north. Throughout the year the river is a source of food for foraging birds.

Sixty-four (64) species of birds were observed on or near the river (Table 3.3.4.1-3). Most species were found in the surrounding upland floodplain, rather than utilizing aquatic habitat. Species associated with the river include: Double-crested Cormorant, Canada Goose, Common Merganser, Mallard, Mute Swan, Wood Duck, Bank Swallow, Northern Rough-winged Swallow, Spotted Sandpiper, and Belted Kingfisher.

Fifty-nine (59) species of birds were observed within the study area of Northfield Mountain (Table 3.3.4.1-3). The northwest slope had the greatest species richness, with 47 species, while the northeast slope had only 17 observed species. This is likely a reflection on the relative sizes of the various sections, rather than differing habitats. A few open habitat species occurred only in the mowed areas and power line right-of-ways of the northwest slope, but the majority of species were found in more than one slope section (e.g., Ovenbird).

Vegetative Communities
The region encompassing the study area is characterized by a diversity of terrestrial botanical resources that are influenced by geological features, soil type, hydrology, climate, and historic and current land use. Biologists documented 390 plant species within the study area in 2014 and 2015. An overall plant census list of all recorded plant species identified during the 2014 and 2015 field season is provided in Table 3.3.4.1-4. Field surveys were conducted in September 2015 to confirm vegetative communities. One plant community, the calcareous rock cliff community, was identified during survey work, but this habitat was not mapped as the aerial signature and habitat size did not allow for identification using available aerial imagery. Four disturbed or mostly unvegetated cover types; agricultural, development, bypass reach, and transmission right-of-way, were mapped, but these are not described by the Natural Heritage and Endangered Species Program (NHESP). Located in the Connecticut River valley, with adjacent high elevations of Northfield Mountain, the study area has characteristics of both Northeastern Highlands and Northeastern Coastal Zone ecoregions (Swain & Kersey, 2011).

The Connecticut River, during its course between Vernon Dam and Turners Falls Dam (the TFI), regains the appearance of a river even though it is impounded. The wide and fertile plains on both sides of the Connecticut River are terminated by terraces rising to forest uplands to the east and west. Examples of geologic and geomorphic features influencing the area's botanical communities include:

- the Connecticut River valley and remnant floodplains;
- the confluence of the Connecticut River and major tributaries (e.g., Millers River);
- bedrock and alluvial islands within the Connecticut River; and
- the high elevations of Northfield Mountain.

The primary upland plant communities (Table 3.3.4.1-5) include:

- Remnant/transitional floodplain forest
- Northern hardwoods-hemlock-white pine forest
- Successional northern hardwood forest
- Hemlock ravine
- White pine - oak forest
- Calcareous rock cliff (not mapped)
- Circumneutral rock cliff (not mapped),
- Oak - hickory forest (not mapped),
- Agricultural lands (not described by NHESP)
- High-energy shore (not described by the NHESP)
- Development (not described by NHESP)
- Right of way (not described by NHESP)

Remnant/Transitional Floodplain Forests
Soils in this zone generally experience annual flooding and are either silt loams or very fine sandy loams, and soil mottling is generally present within two feet of the soil surface. A surface organic layer is typically

absent. Silver maple, sycamore, cottonwood, red maple, ash, American elm, and willow are the dominate tree species. A shrub layer is generally lacking; however, saplings of overstory trees are common. The herbaceous layer is typically an even mixture of wood-nettle, ostrich fern, sensitive fern and false nettle. Within the study area, these transitional floodplain forests are the dominant forest type present along the main stem of the Connecticut River, islands, and its major tributaries (Figure 3.3.4.1-1).

Successional Northern Hardwoods

Successional northern hardwoods in the study area vary from forest communities with thick young sprouts and little diversity to mature, diversifying forests with undergrowth of more shade-tolerant trees. The canopy is seldom completely closed, and undergrowth may be dense or open. Areas of successional forest are associated with past disturbance such as cutting or blow-down/ storm damage. Aspen, white birch, black birch, red maple, and /or black cherry tend to be common throughout the community. The understory of more mature successional forests is comprised of young, more shade-tolerant trees (typically less than 10" at diameter at breast height). Shrubs and herbaceous species are variable and includes species common to edge habitat and open areas such as sumac, goldenrod, Joe-pye weed and blackberry (Figure 3.3.4.1-2). Successional northern hardwood forests are found intermingled throughout the study area and are typical of transition areas and edge habitat around developed areas and agricultural lands.

Northern Hardwoods-Hemlock-White Pine Forest

Northern hardwoods - hemlock - white pine forest is the dominant vegetated community along the shoreline from Barton Cove upstream to the French King Bridge and on the northwestern and northeastern slopes of Northfield Mountain. This forest type is associated with a closed canopy forest of a mixture of deciduous and evergreen trees, with sparse shrub and herbaceous layers (Figure 3.3.4.1-3). The forest is dominated by a mix of sugar maple, American beech, yellow birch, and red oak in variable proportions, with eastern hemlock and white pine intermingled throughout. American beech tends to dominate in upland areas. Black cherry, white birch, red maple, and other early successional tree species are often scattered, with occurrences in the subcanopy with stripped maple, and sometimes ironwood. The shrub layer is usually open, with clumps of hobblebush, honeysuckle and Japanese barberry. The diverse but sparse herb layer includes Christmas fern, Canada mayflower, club mosses, asters, and false nettle.

Hemlock Ravine

Hemlock ravine communities are dominated by the dense overstory canopies of eastern hemlock trees. These cool moist habitats are located in topographic draws and drainage ways in the landscape. In the Project area, this heavily shaded habitat is characterized by little growth in the understory. The forest floor typically has little vegetation and is covered by needles, twigs, and small branches of hemlocks. Occasionally deciduous trees that grow along with hemlock occur at very low percentages and include; a mixture of oak species, (red, white and black), yellow birch, and red maple. Generally, the shrub layer is sparse, with occasional individuals of the canopy species and small patches of mountain laurel. Hemlock ravines communities attract wildlife that depend on mature dense evergreen forests and typically host a variety of songbirds that nest high in the canopy. Several hemlock forested areas and ravines are found along hillsides and lowlands at Barton Cove campgrounds and throughout the northern and southern slopes of Northfield Mountain (Figure 3.3.4.1-4). As with other parts of MA and adjacent states to the south and west, hemlock is in poor health and declining in the study area due to hemlock woolly adelgid and is in the process of being replaced by other species.

White Pine- Oak Forest

The white-pine oak forests within the study area are limited. The forest has a partial closed canopy with sporadic understory shrub coverage. The overstory is dominated by white pine and red oak with the shrub layer dominated by red maple, low bush blueberry, and mountain laurel. Herbaceous vegetation includes bracken fern, Canada mayflower, and wintergreen. White pine – oak forests are found at lower elevations of the northwest and southern slope of Northfield Mountain (Figure 3.3.4.1-5).

Calcareous Rock Cliff Community

Rock Cliff Communities all occur on a more or less vertical bedrock cliff faces. They have extremely sparse scattered vascular plants on ledges and in crevices. Calcareous rock cliffs have vegetation that is more distinct and specific to the habitat. Purple cliff brake, maidenhair spleenwort, blunt-lobed cliff-fern, and columbine are characteristic of calcareous cliffs. Of these species, purple cliff brake and columbine were both seen within the Project area. Surrounding vegetation tends to be northern hardwood forest. This is a more uncommon community in MA and is host to several unusual plants. A Calcareous Rock Cliff community exists on the western bank of the TFI extending upstream and downstream of the French King Bridge (Figure 3.3.4.1-6).

Circumneutral Rock Cliff Community

This community type is found along the summit and higher elevations of the southeastern slope of Northfield Mountain (Figure 3.3.4.1-7). Rose ledge and the Farley ledges are notable examples where sparse, scattered vascular plants are found in ledges and small crevices within vertical cliff faces. Lichens are occasionally dense on cliff faces. These communities can be variable in moisture, but generally consist of areas of significant rock outcroppings that are well shaded by trees of the surrounding forest. Species of dry open areas, including pale corydalis, bearberry, plantain-leaved pussytoes, columbine, marginal wood-fern little bluestem grass, ebony spleenwort, rusty cliff fern, and mosses. In the area, chestnut oak, scrub oak, and witch hazel are sporadically observed.

Oak – Hickory Forest

This community consists of hardwood forests dominated by a mixture of oaks, with hickories mixed in at a lower density. The canopy is dominated by one or several oak species including red, white, and black oak. Mixed in are lower densities of one or several hickory species. Other trees include ash, birch, sassafras, and red maple. The subcanopy commonly includes ironwood, flowering dogwood, shadbush, and witch-hazel. Low shrubs are common and often diverse; blueberries, dogwoods, and viburnums are characteristically present. The herbaceous layer is also richer than in many oak forests. Plants typical of the herbaceous layer include hepatica, goldenrod, tick-trefoil, wild sarsaparilla, and false Solomon's seal. This variable forest community is found at higher elevations on the Northfield Mountain range, most notably in a strip of deciduous forest between the northwestern slope and southeast slope, and adjacent to the upper elevations to Rose ledge (Figure 3.3.4.1-8).

Agricultural Lands

Land use along the corridor of the Connecticut River is primarily rural and agricultural. In the study area, approximately 25% of the land use is classified as agricultural/open field habitat. These lands are managed and transition through several vegetative changes within a growing season. The edge habitat of agricultural lands can be vulnerable to the introduction of invasive species. Invasive species also favor these edges as a result of abundant sunlight which promotes favorable growing conditions. Most agricultural land within the study area is a mosaic of various croplands, with few lands used for active livestock pasture. There were relatively few instances where agricultural fields were cleared to the river's edge. Typically, there exists a narrow buffer of forested land which offers erosion protection along the shoreline (Figure 3.3.4.1-9).

High-energy Shore

High-energy riverbank communities are associated with steep gradient, fast-moving water, alluvial deposition, and scour. These environments have limited plant growth and cover and were observed in the bypass reach and on the upstream ends of riverine islands – specifically, Sunderland Islands in Deerfield, MA (Figure 3.3.4.1-10). The upper reaches of some island communities transitioned into a band of invasive shrubs and vines, then transitioned further upland into floodplain and hardwood communities, previously described.

The bypass reach is approximately 2.5 miles long. Fall River, located near the head of the bypass channel, discharges into the bypass reach. Station No. 1 discharges into the bypass reach approximately 0.9 miles downstream of the TFD. The bypass is a unique habitat comprised of a mosaic of high-energy shoreline and exposed bedrock. The eastern side of the bypass is occupied by historic industrial developments with numerous discharge locations that supported the historic industries that were built on the canal. The western side of the bypass is steeply sloping woodlands of Rocky Mountain Park. Rocky Mountain Park is part of the Pocumtuck Ridge and is the northernmost subrange of the Metacomet Ridge mountain range of southern New England known for its continuous high cliffs, scenic vistas, and microclimate ecosystems containing species common to the northern hardwoods' ecosystem types. Hemlock crowd narrow ravines, blocking sunlight and creating damp, cool growing conditions with associated cool climate plant species. Talus slopes are especially rich in nutrients and support several calcium-loving plants uncommon in the region.

Development
Portions of the upland habitat within the study area are dominated by maintained spaces (i.e., residential, commercial, or transportation corridors) and sporadic shrub or overstory vegetation, such as solitary white pines or other species. The primary vegetation in these areas is comprised of shrub and herbaceous layer vegetation. Herbaceous vegetation is dominated by mowed areas of Kentucky bluegrass. Shrub layer vegetation may include glossy buckthorn, Russian olive, and several species of northern hardwood saplings.

Right-of-Way
This community was identified within the portion of the study area that is crossed by electric transmission right-of-ways. These areas are maintained by periodic vegetation management which limits the growth of large woody vegetation. The dominant communities are shrub and herbaceous communities. Shrub layer vegetation is dominated by white pine saplings, glossy buckthorn, red cedar, and meadowsweet. The herbaceous community is extensive and includes several weedy species such as chicory, mullein, and pearly everlasting. Additional herbaceous vegetation includes bracken fern, sensitive fern, Joe pye weed, and milkweed. Portions of these areas include gravel access roads (Figure 3.3.4.1-11).

<u>Wetlands</u>
Biologists led by a Professional Wetland Scientist field-verified National Wetland Inventory (NWI)-mapped wetlands within the Northfield Mountain Project study area. These areas were not formally delineated, but the boundaries were refined to provide a better level of detail. Thirty (30) NWI-mapped wetlands were field verified, and an additional 18 non-NWI mapped wetlands were also identified and mapped. Dominant wetland communities within the study area include:

- Hemlock swamp
- Red maple swamp
- Woodland vernal pool

In 2014 and 2015, NWI wetlands within the TFI study area were verified. If new wetlands (not occurring in the mapped NWI data) were located, the approximate boundaries were identified. Verified wetlands account for approximately 1,382 acres of wetland and include emergent, scrub-shrub, and forested wetland types. Biologists also identified an additional 55.7 acres of wetlands that were not captured in current NWI wetland mapping. In total, the TFI study area includes approximately 1,438 acres of wetland habitat with shrub dominated wetlands and freshwater ponds being most common. In general, the principle functions and services of wetlands within the study area are flood attenuation, wildlife habitat, shoreline stabilization, fish and shellfish habitat, visual quality, and recreation.

Hemlock Swamp

Hemlock is a major or co-dominant canopy species in hemlock swamps within the study area. In some cases, hemlock forms dense stands, but more commonly hemlock is associated with a mixture of white pine, red maple and yellow birch. The understory tends to be sparse to moderately vegetated with highbush blueberry, winterberry, and mountain laurel. Ferns are common, especially cinnamon fern, along with a hummocky floor covered with sphagnum moss. Notable hemlock swamp habitat is found down gradient of the Farley ledges situated in a well -defined saddle in the landscape. These areas can provide year-round habitat and breeding (i.e. vernal pools) for amphibian species (Figure 3.3.4.1-12).

Red Maple Swamp

Red maple dominates the overstory of red maple swamps in the study area and can often provide up to 90% of the canopy cover. A variable mixture of subordinate tree species co-occurs with red maple, including yellow birch, black gum, white ash, white pine, elm, hemlock, pin oak, and swamp white oak. The shrub layer of red maple swamps is usually dense and well developed with greater than 50% cover, but it can be variable. Sweet pepperbush, highbush blueberry, winterberry, spicebush, alder and viburnum species often dominant the shrub stratum. The herbaceous stratum can be variable, but ferns are unusually abundant. Cinnamon fern is common with other ferns including but not limited to; sensitive fern, royal fern and marsh fern. Gaminoides are common, mixed in with a variety of other herbaceous species commonly including; skunk cabbage, false hellebore, spotted touch-me-not, swamp dewberry, and marsh marigold (Figure 3.3.4.1-13).

Palustrine Emergent Wetlands

Palustrine emergent wetlands within the study area occur, primarily, as fringe wetlands along the shoreline. The largest examples of these wetlands occur near the Turners Falls Dam and the Barton Cove area. Large expanses of emergent and deep emergent marshes occur in these areas. Dominant species within these wetlands include American bulrush, sweet flag, soft-stem bulrush, arrowhead, pickerelweed, bur-reed, and cattail. Palustrine emergent wetlands within the study area provide several functions, primarily as wildlife habitat and also through sediment and toxicant retention (FirstLight, 2016a).

Palustrine Scrub-Shrub Wetlands

Generally, palustrine scrub-shrub wetlands occur in association with larger emergent or forested wetland complexes. These wetlands occur along the fringes of emergent wetlands or intermixed in open canopy areas adjacent to or within forested communities. Dominant shrub vegetation within these wetlands includes alder, button bush, winterberry, red-osier dogwood, elderberry, silky dogwood, highbush blueberry, and saplings of over story species. Herbaceous vegetation varies depending on light penetration, but may include sensitive fern, horsetails, jewelweed, ostrich fern, royal fern, cinnamon fern, and interrupted fern. Functionally these wetlands provide primarily wildlife habitat. Depending upon landscape position, these wetlands may also aid in flood storage, shoreline stabilization, and sediment retention (FirstLight, 2016a).

Palustrine Forested Wetlands

Palustrine forested wetlands within the study area are primarily forested floodplains. Excellent examples of these forested wetland systems are present near the Pauchaug boat launch. Dominant overstory species include silver maple, red maple, American basswood, American elm, willow, and cottonwood. The shrub layer in these systems is limited, but occasional alders and dogwoods occur. Herbaceous vegetation includes sensitive fern, ostrich fern, skunk cabbage, blue flag iris, clearweed, false nettle, and stinging nettle. Several islands within the study area also contain similar forested floodplains. In some cases, Japanese knotweed has invaded the understory of these systems. Forested wetland systems within the study area provide several important functions and services, most importantly flood storage, wildlife habitat, shoreline stabilization, and sediment retention (FirstLight, 2016a).

Woodland Vernal Pool

Woodland vernal pools are typically small, shallow depressions that are isolated from other surface waters. They usually flood in spring and sometimes in fall, and generally hold water for a minimum of two months but are dry in summer. Because vernal pools are temporary bodies of water, they do not support fish populations. When dry, woodland vernal pools can be often be recognized by a layer of water-stained gray leaves covering the pool's basin and distinct waterline marks on the base of tree buttresses. These temporarily flooded areas provide important breeding habitat for amphibians. Due to prolonged standing water, woodland vernal pools often have sparse-to-little shrub and herbaceous vegetation within the pool basin. Red maple and hemlock, along with lesser quantities of various wetland tree species, are found in the canopy cover, similar to hemlock swamp and red maple swamp communities. Vernal pools are tracked as a separate community type because of the important habitat they provide for amphibians and invertebrates.

Biologists located and documented 13 woodland vernal pools in the Northfield Mountain study area (Figure 3.3.4.1-14) and one vernal pool along the TFI (Table 3.3.4.1-6). Commonly observed egg masses of obligate vernal pool indicator species included spotted salamanders and wood frogs. Wood frogs and four local species of mole salamanders have evolved breeding strategies intolerant of fish predation on their eggs and larvae; the lack of fish populations is essential to the breeding success of these species. Other amphibian species use vernal pools, but they do not depend on them including American toads, green frogs, and red-spotted newts. It should be noted that green frogs and red-spotted newts feed on obligate vernal pool species eggs and larval and can have negative effects on other amphibian population dynamics. Vernal pools also support a diverse invertebrate fauna, including obligate indicator species like fairy shrimp which complete their entire life cycle in vernal pools (Burne, 2001).

Invasive Species

Biologists identified 25 invasive plants in the Turners Falls Project and Northfield Mountain Project study areas including:

The MA Invasive Plant Advisory Group (MIPAG) listed non-native invasive plants, one MIPAG watch list species (coltsfoot), one United States Department of Agriculture (USDA) Forestry Service early detection species (Spotted knapweed), and, for consistency with other studies, European alder (see Table 3.3.4.1-7). Locations of invasive species within the study area observed during 2014 field reconnaissance surveys are shown in Figure 3.3.4.1-15. This figure illustrates the relative abundance and distribution of invasive plants along the TFI using estimated cover classes of <5%, 6-25%, 26-50%, > 50%. The following five (5) exotic and invasive plant species were found to be common within the study area during the 2014 field surveys:

- Oriental Bittersweet - found throughout the study area, particularly ubiquitous along the edge of the river where there is abundant sunlight. Highest concentrations were noted in the TFI north of Pauchaug Brook where the TFI transitions to a more dynamic riverine environment. In the upper reaches of the TFI, Oriental bittersweet can be found covering at least 50% of the trees and shrubs along the shoreline.
- Japanese Knotweed - typically confined to discrete patches along the immediate shoreline and, in some instances, in small stands along the edge habitat of previously disturbed areas.
- Multiflora Rose - scattered throughout the study area, particularly along edges of field habitat and along shoreline/transition areas that abut agricultural lands.
- Japanese Barberry - throughout the study area, a common forest understory shrub that forms monoculture thickets. Particularly found in low lying lands and on upland islands within the river.

- Black Swallowwort – found throughout study area, particularly on the banks of the river and the TFI.

3.3.4.2 Environmental Effects

The occurrence and distribution of wildlife and botanical resources in the study area are generally unrelated to the Turners Falls Project and Northfield Mountain Project and/or its operations. There is no evidence of any on-going adverse effects on upland wildlife and botanical resources. The majority of invasive species found at the Project are upland species located outside the range of water level fluctuations. However, fluctuating water levels from Project operations may cause disturbances allowing the establishment of invasive species such as common reed and Japanese knotweed (MADCR 2002; USFWS 2017). These disturbances would likely be contained to areas within and just below the bypass reach. Recreational activities at the Projects indirectly affect habitats (paths through the forested habitats, cleared/mowed areas from recreational activities) but do not directly harm wildlife. Habitat generalists may benefit from the recreational features whereas habitat specialists like forest interior birds (e.g., ovenbird) would experience insignificant indirect effects. These effects are considered insignificant because sufficient forest-interior habitat remains elsewhere in the study area. In some cases, wildlife that utilizes the shoreline may be temporarily impacted as water levels rise and fall, but generally these species are able to move freely.

Wildlife and botanical resources within the study area may be impacted by vegetation management and maintenance of development lands around the TFI, the Northfield Mountain Upper Reservoir, power canal and the maintenance of development-related access ways. Specifically, there is some potential for ground disturbing activities (i.e., land clearing construction activities) which may result in the spread or propagation of invasive species as well as degradation of existing habitat. In addition, recreational facilities (i.e., boat launches) may allow for the movement or introduction of invasive vegetation (both terrestrial and aquatic). However, such effects will be minimized through implementation of FirstLight's proposed Invasive Plant Species Management Plans - see Appendix A-Terrestrial-Turners Falls- Invasive Plant Species Management Plan (Exhibit E, Part 3 of 3) and Appendix-B Terrestrial- Northfield Mountain- Invasive Plant Species Management Plan (Exhibit E, Part 3 of 3).

Palustrine Emergent Wetlands

Under the current FERC license, the TFI water surface elevation (WSEL), as measured at the Turners Falls Dam, may fluctuate between 176.0 and 185.0 feet NGVD 1929. FirstLight proposes to limit the rate of rise of the TFI, as measured at the Turners Falls Dam, to less than 0.90 feet/hour from May 15 to August 15 between the hours 8:00 am to 2:00 pm, subject to certain exceptions identified in Section 2.2 of the AFLA. This would reduce the rate of rise in the WSEL during the growing season.

Palustrine Scrub-Shrub Wetlands

All the scrub-shrub wetlands are located in the TFI with the exception of one small wetland in the bypass reach (~0.7 acres). Under FirstLight's proposal, the velocity and depth of water in the bypass reach would increase compared to baseline conditions year-round. The small scrub shrub wetland within the bypass reach may be inundated during the growing season which could promote the growth of emergent, herbaceous vegetation and reduce the establishment of woody vegetation.

Palustrine Forested Wetlands

Forested wetland systems are typically more stable habitats; therefore, habitat availability for forested wetlands that occur in the TFI and downstream of the bypass will likely remain similar under FirstLight's proposal. However, there are several forested wetlands on islands within Reach 2 and 3 of the bypass reach (~22.5 acres). Higher flows within the bypass reach may reduce the suitability of these areas for forested wetlands. These areas would remain wetlands; however, the species composition may change to reflect a wetter hydrology.

3.3.4.3 Cumulative Effects

Operation and maintenance of the Northfield Mountain and Turners Falls Projects may, to a limited degree, have a cumulative effect on the spread of invasive species. Commercial, residential and agricultural development within and adjacent to the Project boundaries potentially introduce invasive species to terrestrial habitat within the Project boundaries. Other potential vectors for invasive species include a transmission line right-of-way maintained by Eversource in the western portion of the Northfield Mountain study area, the Northfield Mountain trail system, which includes over 25 miles of trail, and recreational activities (e.g., boating) within the TFI that could disturb the shoreline or introduce aquatic invasive species from other locations.

3.3.4.4 Proposed Environmental Measures

FirstLight proposes to implement a project-specific Invasive Plant Species Management Plan for each Project during the term of the new licenses as noted above.

3.3.4.5 Unavoidable Adverse Impacts

Vegetation management activities including mowing, are necessary in areas around the Northfield Mountain Upper Reservoir which are maintained for safety and surveillance as part of its Dam Safety Surveillance and Monitoring Program. Vegetation management also occurs for maintenance associated with the power canal. Vegetation management activities associated with the Projects represent a minor, unavoidable adverse impact to terrestrial resources, but are necessary for public safety and the integrity of Project facilities.

References

Burne, M.R (2001). Massachusetts aerial photo survey of Potential Vernal Pools. Natural Heritage and Endangered Species Program, Massachusetts Division of fisheries and Wildlife. Westborough, MA

Cardoza, J.E. & Mirick, P.G. (2009). State Reptiles & Amphibians List. [Online] Retrieved October, 7, 2015 from http://www.mass.gov/eea/agencies/dfg/dfw/fish-wildlife-plants/state-reptiles-and-amphibians-list.html.

DeGraaf, R.M & Yamasaki, M. (2001). New England wildlife: habitat, natural history, and distribution. Lebanon, NH: The University Press of New England.

DeGraaf, R. M. (2001). NeS&Aw England Wildlife: Habitat, Natural History, and Distribution. Northeast Forest Experiment Station, General Technical Report NE-108.

FirstLight. (2015a). Relicensing Study No. Study No. 3.4.2 Effects of Northfield Mountain Project-Related Land Management Practices and Recreation use on Terrestrial Habitats. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight. (2016a). Relicensing Study 3.3.1 Conduct Instream Flow Habitat Assessments in the Bypass Reach and Below Cabot Station. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

FirstLight. (2016b). Relicensing Study No. 3.5.1 Baseline Inventory of Wetland, Riparian and Littoral Habitat in the Turners Falls Impoundment and Assessment of Operation Impacts on Special-Status Species. Prepared by Gomez and Sullivan Engineers and Kleinschmidt Associates. Northfield, MA: Author.

Massachusetts Department of Conservation and Recreation (MADCR) 2002. Common Reed: An Invasive Wetland Plant, *Phragmites australis*. www.mass.gov/lakesandponds. 3 pages.

Swain, P.C., & Kersey, J.B. (2011). Classification of the Natural Communities of Massachusetts: Draft. [Online] Retrieved January 2, 2015 from http://www.mass.gov/dfwele/dfw/nhesp/natural_communities/natural_community_classification.htm.

U.S. Fish and Wildlife Service (USFWS) 2017. Common reed/*Phragmites australis*. Wetland Assessment, Restoration and Management. National Conservation Training Center. Willows, CA 6 pages.

Table 3.3.4.1-1: List of Mammals Observed or Likely to Occur in Study Area

Common Name	Scientific Name
Beaver*	*Castor canadensis*
Black bear**	*Ursus americanus*
Bobcat	*Felix rufus*
Coyote**	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Eastern chipmunk*	*Tamias striatus*
Eastern mole	*Scalopus aquaticus*
Fisher	*Martes pennanti*
Gray fox	*Urocyon cinereoargenteus*
Gray squirrel*	*Sciurus carolinensis*
Hairy-tailed mole	*Parascalops breweri*
Hoary bat	*Lasiurus cinereus*
House mouse	*Mus musculus*
Long-tailed shrew	*Sorex dispar*
Masked shrew	*Sorex cinereus*
Meadow jumping mouse	*Zapus hudsonius*
Meadow vole	*Microtus pennsylvanicus*
Muskrat*	*Ondatra zibethicus*
New England cottontail	*Sylvilagus transitionalis*
Northern short-tailed shrew	*Blarina brevicauda*
Norway rat	*Rattus norvegicus*
Porcupine**	*Erethizon dorsatum*
Raccoon*	*Procyon lotor*
Red bat	*Lasiurus borealis*
Red fox**	*Vulpes*
Red squirrel*	*Tamiasciurus hudsonicus*
Silver-haired bat	*Lasionycteris noctivagans*
Star-nosed mole	*Condylura cristata*
Striped skunk	*Mephitis*
Virginia opossum*	*Didelphis virginiana*
White-footed mouse	*Peromyscus leucopus*
White-tailed deer*	*Odocoileus virginianus*
Woodchuck	*Marmota monax*
Woodland jumping mouse	*Napaeozapus insignis*
Woodland vole	*Microtus pinetorum*

* Denotes Direct Observation

**Denotes Indirect Observation

Table 3.3.4.1-2: List of Reptiles and Amphibians Observed or Likely to Occur in Study Area

Common Name	Scientific Name
Frogs & Toads	
American bullfrog*	*Lithobates catesbeiana*
American toad*	*Anaxyrus americanus*
Fowler's toad	*Bufo fowleri*
Gray treefrog	*Hyla versicolor*
Green frog*	*Lithobates clamitans*
Northern leopard frog	*Lithobates pipiens*
Pickerel frog*	*Lithobates palustris*
Spring peeper*	*Pseudacris crucifer*
Wood frog*	*Lithobates sylvatica*
Salamanders	
Eastern-red-backed salamander*	*Plethodon cinereus*
Northern dusky salamander*	*Desmognathus fuscus*
Red-spotted newt*	*Notophthalmus viridescens*
Spotted salamander*	*Ambystoma maculatum*
Snakes	
Common ribbon snake	*Thamnophis sauritus*
Eastern garter snake*	*Thamnophis sirtalis*
Eastern ratsnake	*Pantherophis alleghaniensis*
Northern black racer	*Coluber constrictor*
Northern red-bellied snake	*Storeria occipitomaculata*
Northern ring-necked snake	*Diadophis punctatus edwardsii*
Northern watersnake*	*Nerodia sipedon*
Turtles	
Painted turtle*	*Chrysemys picta*
Snapping turtle*	*Chelydra serpentina*
Spotted turtle*	*Clemmys guttata*

*Denotes direct observation

Table 3.3.4.1-3: Avian Species Found in the Study Area

Common Name	Scientific Name	TF[1]	Northfield Mountain					
			Total area	NW Slope	NE Slope	SE Slope	SW Slope	Reservoir
American Crow	*Corvus brachyrhynchos*	X	X	X		X		X
American Goldfinch	*Carduelis tristis*	X	X	X		X		
American Redstart	*Setophaga ruticilla*	X	X	X		X		
American Robin	*Turdus migratorius*	X	X	X		X		X
Bald Eagle	*Haliaeetus leucocephalus*	X	X					X
Baltimore Oriole	*Icterus galbula*	X						
Bank Swallow	*Riparia riparia*	X	X					X
Barn Swallow	*Hirundo rustica*	X						
Belted Kingfisher	*Megaceryle alcyon*	X						
Black and White Warbler	*Mniotilta varia*	X	X	X	X	X	X	
Black-billed Cuckoo	*Coccyzus erythropthalmus*	X	X	X				
Blackburnian Warbler	*Setophaga fusca*		X	X	X	X		
Blacked-capped Chickadee	*Poecile atricapillus*	X	X	X		X	X	
Black-throated Blue Warbler	*Setophaga caerulescens*		X	X	X	X	X	
Black-throated Green Warbler	*Setophaga virens*	X	X	X	X	X	X	
Blue Jay	*Cyanocitta cristata*	X	X	X	X	X	X	
Blue-headed Vireo	*Vireo solitarius*		X	X		X	X	
Blue-winged Warbler	*Vermivora cyanoptera*	X						
Broad-winged Hawk	*Buteo platypterus*	X						
Brown Creeper	*Certhia americana*		X	X		X		
Brown-headed Cowbird	*Molothrus ater*	X						
Canada Goose	*Branta canadensis*	X						
Cedar Waxwing	*Bombycilla cedrorum*	X	X	X	X		X	X

Common Name	Scientific Name	TF[1]	Northfield Mountain					
			Total area	**NW Slope**	**NE Slope**	**SE Slope**	**SW Slope**	**Reservoir**
Chestnut-sided Warbler	*Setophaga pensylvanica*	X	X	X				
Chimney Swift	*Chaetura pelagica*	X						
Chipping Sparrow	*Spizella passerina*		X	X		X	X	X
Common Grackle	*Quiscalus quiscula*	X						
Common Merganser	*Mergus merganser*	X						
Common Raven	*Corvus corax*	X	X			X		
Common Yellowthroat	*Geothlypis trichas*	X	X	X				X
Coopers Hawk	*Accipiter cooperii*	X						
Double-crested Cormorant	*Phalacrocorax auritus*	X						
Downy Woodpecker	*Picoides pubescens*	X	X	X				
Eastern Wood-Pewee	*Contopus virens*		X	X	X	X	X	
Eastern Bluebird	*Sialia sialis*		X					X
Eastern Kingbird	*Tyrannus tyrannus*	X						
Eastern Phoebe	*Sayornis phoebe*	X	X	X	X	X	X	
Eastern Towhee	*Pipilo erythrophthalmus*		X	X				
European Starling	*Sturnus vulgaris*		X	X				
Field Sparrow	*Spizella pusilla*		X					X
Gray Catbird	*Dumetella carolinensis*	X	X	X				
Great Blue Heron	*Ardea herodias*	X						
Great Crested Flycatcher	*Myiarchus crinitus*	X	X	X		X	X	
Greater Yellowlegs	*Tringa melanoleuca*	X						
Green Heron	*Butorides virescens*	X						
Hairy Woodpecker	*Leuconotopicus villosus*		X	X		X	X	
Hermit Thrush	*Catharus guttatus*		X	X		X	X	

Common Name	Scientific Name	TF[1]	Northfield Mountain					
			Total area	NW Slope	NE Slope	SE Slope	SW Slope	Reservoir
Indigo Bunting	*Passerina cyanea*	X	X	X	X	X		X
Killdeer	*Charadrius vociferus*	X	X					X
Least Flycatcher	*Empidonax minimus*	X						
Louisiana Waterthrush	*Parkesia motacilla*	X						
Mallard	*Anas platyrhynchos*	X						
Mute Swan	*Cygnus olor*	X						
Northern Cardinal	*Cardinalis cardinalis*	X	X	X				
Northern Mockingbird	*Mimus polyglottos*		X	X				
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	X						
Northern Flicker	*Colaptes auratus*		X				X	X
Orchard Oriole	*Icterus spurius*	X						
Osprey	*Pandion haliaetus*	X						
Oven Bird	*Seiurus aurocapilla*		X	X	X	X	X	
Peregrine Falcon	*Falco peregrinus*		X			X		
Pileated Woodpecker	*Hylatomus pileatus*	X	X	X	X	X	X	
Pine Warbler	*Setophaga pinus*		X	X		X	X	
Prairie Warbler	*Setophaga discolor*		X	X				
Red-breasted Nuthatch	*Sitta canadensis*		X	X		X		
Red-eyed Vireo	*Vireo olivaceus*	X	X	X	X	X	X	X
Red-tailed Hawk	*Buteo jamaicensis*	X	X		X	X		
Red-winged Blackbird	*Agelaius phoeniceus*	X						
Rock Pigeon	*Columba livia*	X						
Rose-breasted Grosbeak	*Pheucticus ludovicianus*		X	X		X		
Ruby-throated Hummingbird	*Archilochus colubris*		X	X			X	
Scarlet Tanager	*Piranga olivacea*	X	X	X	X	X	X	

Common Name	Scientific Name	TF[1]	Northfield Mountain					
			Total area	**NW Slope**	**NE Slope**	**SE Slope**	**SW Slope**	**Reservoir**
Song Sparrow	*Melospiza melodia*	X	X	X				X
Spotted Sandpiper	*Actitis macularius*	X	X					X
Tree Swallow	*Tachycineta bicolor*	X	X					X
Tufted Titmouse	*Baeolophus bicolor*	X	X	X		X	X	
Turkey Vulture	*Cathartes aura*	X	X	X				X
Veery	*Catharus fuscescens*	X	X	X	X	X	X	
Warbling Vireo	*Vireo gilvus*	X						
White-breasted Nuthatch	*Sitta carolinensis*	X	X	X	X	X	X	
Wild Turkey	*Meleagris gallopavo*		X	X		X	X	X
Winter Wren	*Troglodytes hiemalis*		X	X		X		
Wood Duck	*Aix sponsa*	X						
Wood Thrush	*Hylocichla mustelina*	X	X	X	X	X	X	
Yellow Warbler	*Setophaga petechia*	X						
Yellow-bellied Sapsucker	*Sphyrapicus varius*	X	X			X	X	
Yellow-billed Cuckoo	*Coccyzus americanus*	X						
Yellow-throated Vireo	*Vireo flavifrons*		X	X				
Total Number Observed		**64**	**59**	**47**	**17**	**36**	**26**	**18**

[1]TF= Turners Falls Project (Includes the shoreline of TFI, the Bypass Reach, and below Cabot Station to the Route 116 Bridge in Sunderland)

Table 3.3.4.1-4: Botanical Species Found in the Study Area

Common Name	Scientific Name	NFM[1]	TF[2]
alternate-leaf dogwood	*Swida alternifolia*		X
American basswood	*Tilia americana*		X
American beech	*Fagus grandifolia*	X	X
American chestnut	*Castanea dentata*	X	
American elm	*Ulmus americana*		X
American hazelnut	*Corylus americana*	X	
American hornbeam	*Carpinus caroliniana*	X	X
American pokeweed	*Phytolacca americana*	X	
American speedwell	*Veronica americana*		X
American witch-hazel	*Hamamelis virginiana*	X	X
anise-scented goldenrod	*Solidago odora*		X
arrow arum	*Peltandra virginica*		X
arrow-leaved tearthumb	*Persicaria sagittata*		X
arrowwood	*Viburnum dentatum*		X
Asian bush honeysuckle	*Lonicera sp.*	X	
Asiatic dayflower	*Commelina communis*		X
asparagus	*Asparagus officinalis*		X
autumn olive	*Elaeagnus umbellata***	X	X
balsam fir	*Abies balsamea*	X	
barberpole sedge	*Scirpus microcarpus*	X	
bearberry	*Arctostaphylos uva-ursi*	X	
bedstraw	*Gallium spp.*		X
bee balm	*Monarda didyma*		X
big bluestem	*Andropogon gerardii*		X
big-star sedge	*Carex rosea*		X
bigtooth aspen	*Populus grandidentata*	X	
bird's-foot trefoil	*Lotus corniculatus*	X	
bittersweet nightshade	*Solanum dulcamara*	X	X
black cherry	*Prunus serotina*		X
black chokeberry	*Aronia melanocarpa*		X
black elderberry	*Sambucus nigra*		X
black gum	*Nyssa sylvatica*		X
black locust	*Robinia pseudoacacia***		X
black oak	*Quercus velutina*	X	X
black swallow-wort	*Cynanchum louiseae***		X
black-eyed Susan	*Rudbeckia hirta*	X	X
bladder campion	*Silene sp.*	X	
bladder sedge	*Carex intumescens*	X	
bloodroot	*Sanguinaria canadensis*		X
blue flag iris	*Iris versicolor*	X	X
blue vervain	*Verbena hastata*		X
blue-eyed grass	*Sisyrinchium angustifolium*	X	
bluejoint grass	*Calamagrostis canadensis*		X
blue-stemmed goldenrod	*Solidago caesia*		X
bluets	*Houstonia sp.*		X
blunt spikerush	*Elocharis obtusa*		X
blunt-lobed cliff-fern	*Woodsia obtusa*		X
boneset	*Eupatorium perfoliatum*	X	X
box elder	*Acer negundo*	X	
bracken fern	*Pteridium aquilinum*	X	X

Common Name	Scientific Name	NFM[1]	TF[2]
broad-leaved cattail	*Typha latifolia*		X
broad-leaved dock	*Rumex obtusifolius*		X
broom sedge	*Carex scoparia*	X	
burning bush	*Euonymus alatus***	X	X
burred	*Sparganium americanum*		X
bush honeysuckle	*Diervilla lonicera*	X	X
butter-and-eggs	*Linaria vulgaris*	X	X
buttonbush	*Cephalanthus occidentalis*		X
calico aster	*Symphyotrichum lateriflorum*		X
Canada mayflower	*Maianthemum canadense*	X	X
Canada rush	*Juncus canadensis*		X
Canada St. John's wort	*Hypericum canadense*	X	
Canada thistle	*Cirsium arvense*		X
Canada yew	*Taxus canadensis*		X
cardinal flower	*Lobelia cardinalis*		X
carrion flower	*Smilax herbacea*		X
chestnut oak	*Quercus montana*	X	
chickweed	*Stellaria media*		X
chokecherry	*Prunus virginiana*	X	
christmas fern	*Polystichum acrostichoides*	X	X
cinnamon fern	*Osmundastrum cinnamomeum*	X	X
clasping dogbane	*Apocynun cannabinum*		X
clearweed	*Pilea pumila*		X
club moss	*Huperzia sp.*	X	
coltsfoot	*Tussilago farfara****	X	X
common blackberry	*Rubus allegheniensis*		X
common buckthorn	*Rhamnus cathartica***		X
common burdock	*Arctium minus*	X	X
common chicory	*Cichorium intybus*	X	X
common cinquefoil	*Potentilla simplex*	X	X
common cocklebur	*Xanthium strumarium* var. *glabratum*		X
common cow-wheat	*Melampyrum pratense*	X	
common dewberry	*Rubus flagellaris*	X	X
common evening primrose	*Oenothera biennis*		X
common greenbrier	*Smilax rotundifolia*		X
common jewelweed	*Impatiens capensis*	X	X
common milkweed	*Asclepias syriaca*	X	X
common mugwort	*Artemisia vulgaris***		X
common mullein	*Verbascum thapsus*	X	X
common plantain	*Plantago major*	X	
common ragweed	*Ambrosia artemisiifolia*	X	X
common reed	*Phragmites australis***	X	X
common shadbush	*Amelanchier arborea*		X
common spikerush	*Eleocharis palustris*		X
common threesquare	*Schoenoplectus pungens*		X
common water plantain	*Alisma subcordatum*		X
common woodsorrel	*Oxalis montana*		X
cow vetch	*Vicia cracca*	X	X
creeping jenny	*Lysimachia nummularia***		X
creeping spearwort	*Ranunculus repens*		X
curled dock	*Rumex crispus*	X	

Common Name	Scientific Name	NFM[1]	TF[2]
dandelion	*Taraxacum officinale*		X
daylily	*Hemerocallis sp.*	X	
deer berry	*Vaccinium stanimeum*		X
deer-tongue grass	*Dichanthelium clandestinum*	X	X
deptford pink	*Dianthus armeria*	X	
devil's beggar-ticks	*Bidens frondosa*	X	X
Dewey's sedge	*Carex deweyana*		X
downy rattlesnake plantain	*Goodyera pubescens*	X	X
early lowbush blueberry	*Vaccinium vacillans*	X	
early saxifrage	*Micranthes virginiensis*		X
eastern cottonwood	*Populus deltoides*	X	X
eastern hemlock	*Tsuga canadensis*	X	X
eastern serviceberry	*Amelanchier canadensis*	X	X
eastern teaberry	*Gaultheria procumbens*	X	X
eastern white pine	*Pinus strobus*	X	X
ebony spleenwort	*Asplenium platyneuron*	X	X
enchanter's nightshade	*Cerastium fontanum*	X	X
European alder	*Alnus glutinosa*	X	
false baby's breath	*Galium mollugo*		X
false dragonhead	*Physostegia virginiana*		X
false hellebore	*Veratrum viride*	X	X
false indigo	*Amorpha fruticosa*		
false nettle	*Boehmeria cylindrica*		X
false Solomon's seal	*Maianthemum racemosum*	X	X
field penny-cress	*Thlaspi arvense*	X	
field pepperweed	*Lepidium campestre*	X	
flattened oatgrass	*Danthonia compressa*		X
flat-top goldentop	*Euthamia graminifolia*	X	
flat-top white aster	*Doellingeria umbellata*		X
fleabane	*Erigeron spp.*	X	X
flowering dogwood	*Benthamidia florida*		X
foam flower	*Tiarella cordifolia*	X	X
forget-me-not	*Myosotis scorpioides*		X
fox grape	*Vitis labrusca*		X
Frank’s lovegrass	*Eragrostis frankii**	X	
fringe loosestrife	*Lysimachia ciliata*		X
fringed sedge	*Carex crinita*	X	
garlic mustard	*Alliaria petiolata***		X
gaywings	*Polygala paucifolia*		X
giant goldenrod	*Solidago gigantica*		X
glossy buckthorn	*Frangula alnus***	X	X
golden alexanders	*Zizua ayrea*		X
golden ragwort	*Packera aurea*		X
goldenrod	*Solidago spp.*	X	X
goldthread	*Coptis trifolia*	X	X
grass-leaf flat-topped goldenrod	*Euthamia graminifolia*		X
grass of Parnassus	*Parnassia glauca*		X
gray birch	*Betula populifolia*	X	
gray goldenrod	*Solidago nemoralis*		X
great blue lobelia	*Lobelia siphilitica**		X
great Solomon’s seal	*Polygonatum biflorum*		X

Common Name	Scientific Name	NFM[1]	TF[2]
green ash	*Fraxinus pennsylvanica*	X	X
green bulrush	*Scirpus atrovirens*	X	
gill over the ground	*Glechoma hederacea*	X	X
groundnut	*Apios americana*		X
ground pine	*Lycopodium obscurum*	X	X
hair-cap moss	*Polytrichum juniperinum*		X
hairy bush clover	*Lespedeza hirta*	X	
hairy Solomon's seal	*Polygonatum pubescens*		X
harebell	*Campanula rotundifolia*		X
hawkweed	*Hieracium caespitosum*	X	
hawthorn	*Crataegus sp.*		X
hay-scented fern	*Dennstaedtia punctilobula*	X	
heart-leaved aster	*Symphyotrichum cordifolium*		X
hepatica	*Hepatica nobilis*	X	
highbush blueberry	*Vaccinium corymbosum*	X	X
hobblebush	*Viburnum lantanoides*	X	X
hog peanut	*Amphicarpaea bracteata*	X	X
hop hornbeam	*Ostrya virginiana*		X
hop trefoil	*Trifolium campestre*	X	
Indian cucumber	*Medeola virginiana*	X	X
Indian grass	*Sorghastrum nutans*		X
Indian pipe	*Monotropa uniflora*	X	X
Indian tobacco	*Lobelia inflata*		X
intermediate spike-sedge	*Eleocharis intermedia**		X
interrupted fern	*Osmunda claytoniana*	X	X
Jack in the pulpit	*Arisaema triphyllum*		X
Japanese barberry	*Berberis thunbergii***	X	X
Japanese honeysuckle	*Lonicera japonica***		X
Japanese knotweed	*Fallopia japonica***	X	X
Japanese privet	*Ligustrum obtusifolium***		X
Japanese stiltgrass	*Microstegium vimineum****		X
Jerusalum artichoke	*Helianthus tuberosus*		X
joe-pye weed	*Eutrochium purpureum*	X	X
jump seed	*Persicaria virginiana*		X
leafy spurge	*Euphorbia esula***		X
lesser celandine	*Ranunculus ficaria***		X
lily-of-the-valley	*Convallaria majalis*		X
little bluestem grass	*Schizachyrium scoparium*	X	X
lowbush blueberry	*Vaccinium angustifolium*	X	X
mad dog skullcap	*Scutellaria lateriflora*		X
maiden-hair fern	*Adiantum pedatum*		X
maidenhair spleenwort	*Asplenium trichomanes*		X
mannagrass	*Glyceria sp.*	X	
marginal wood-fern	*Dryopteris marginalis*	X	
marsh fern	*Thelypteris palustris*	X	X
marsh horsetail	*Equisetum palustre*	X	
marsh marigold	*Caltha palustris*	X	X
marsh speedwell	*Veronica scutellata*		X
marshpepper knotweed	*Persicaria hydropiper*		X
mayapple	*Podophyllum peltatum*		X
mint	*Mentha arvensis*		X

Common Name	Scientific Name	NFM[1]	TF[2]
monkey flower	_Mimulis ringens_		X
morning glory	_Ipomoea purpurea_		X
Morrow's honeysuckle	_Lonicera morrowii_**		X
mountain alder	_Alnus viridis_ ssp. _Crispa_*		X
mountain laurel	_Kalmia latifolia_	X	X
mouse-ear-chickweed	_Cerastium fontanum_		X
multiflora rose	_Rosa multiflora_**	X	X
naked-flowered tick trefoil	_Hylodesmum nudiflorum_		X
nannyberry	_Viburnum lentago_		X
narrowleaf cattail	_Typha angustifolia_	X	
New England aster	_Symphyotrichum novae-angliae_		X
New England sedge	_Carex novae-angliae_		X
New York aster	_Symphyotrichum novi-belgii_		X
New York fern	_Parathelypteris noveboracensis_	X	
nodding smartweed	_Persicaria lapathifolia_		X
northern bayberry	_Morella pensylvanica_		X
northern bugleweed	_Lycopus uniflorus_	X	X
northern catalpa	_Catalpa speciosa_		X
northern red oak	_Quercus rubra_	X	X
Norway maple	_Acer platanoides_**		X
Norwegian cinquefoil	_Potentilla norvgica_		X
Olney's three-square bulrush	_Schoenoplectus americanus_	X	
orangegrass	_Hypericum gentianoides_	X	
Oriental bittersweet	_Celastrus orbiculatus_**	X	X
ostrich fern	_Matteuccia struthiopteris_	X	X
ovate spikerush	_Eleocharis ovata_*		X
oxeye daisy	_Leucanthemum vulgare_	X	
pale corydalis	_Corydalis sempervirens_	X	
panicled aster	_Symphyotrichum lanceolatum_		X
partridge berry	_Mitchella repens_	X	X
path rush	_Juncus tenuis_		X
pearly everlasting	_Anaphalis margaritacea_		X
pickerelweed	_Pontederia cordata_		X
pin cushion moss	_Leucobryum albidum_		X
pin oak	_Quercus palustris_	X	
pinkweed	_Persicaria pensylvanica_		X
pippsissewa	_Chimaphila umbellata_		X
pale dogwood	_Swida amomum_ var. _schueltzeana_		X
plantain-leaved pussytoes	_Antennaria plantaginifolia_	X	
plantain-leaved sedge	_Carex plantaginea_		X
poison ivy	_Toxicodendron radicans_	X	X
prickly lettuce	_Lactuca serriola_		X
princess pine	_Dendrolycopodium obscurum_		X
purple chokeberry	_Aronia x floribunda_		X
purple cliff brake	_Pellaea atropurpurea_		X
purple leaved willow herb	_Epilobium ciliatum_		X
purple loosestrife	_Lythrum salicaria_**	X	X
purple osier willow	_Salix purpurea_±		X
purple-flowering raspberry	_Rubus odoratus_		X
quaking aspen	_Populus tremuloides_	X	
Queen Anne's lace	_Daucus carota_	X	X

Common Name	Scientific Name	NFM[1]	TF[2]
quillwort	*Isotes spp.*		X
rabbit-foot clover	*Trifolium arvense*		X
red cedar	*Juniperus virginiana*	X	
red chokeberry	*Aronia arbutifolia*		X
red clover	*Trifolium pratense*	X	X
red fescue	*Festuca rubra*		X
red maple	*Acer rubrum*	X	X
red mullberry	*Morus alba*		X
red pine	*Pinus resinosa*		X
red trillium	*Trillium erectum*	X	
red-osier dogwood	*Swida sericea*		X
reed canary grass	*Phalaris arundinacea***		X
Rhododendron	*Rhododendron sp.*	X	
rice cutgrass	*Leersia oryzoides*		X
river bank grape	*Vitis riparia*	X	X
rock polypody	*Polypodium virginianum*	X	X
rough bedstraw	*Galium asprellum*	X	
rough-fruited cinquefoil	*Potentilla novegica*	X	
rough-leaved goldenrod	*Solidago patula*		X
round-leaved dogwood	*Swida rugosa*		X
rough-stemmed goldenrod	*Solidago rugosa*		X
round-lobed hepatica	*Anemone americana*		X
royal fern	*Osmunda regalis*	X	X
Russian olive	*Elaeagnus angustifolia*		X
rusty cliff-fern	*Woodsia ilvensis*	X	
sandbar cherry	*Prunus pumila var. depressa**		X
sandbar willow	*Salix exigua**		X
sassafras	*Sassafras albidum*	X	X
saxifrage	*Micranthes sp.*		X
scouring rush	*Equisetum hyemale*	X	
scrub oak	*Quercus ilicifolia*	X	X
seedbox	*Ludwigia alternifolia*		X
self-heal	*Prunella vulgaris*	X	X
sensitive fern	*Onoclea sensibilis*	X	X
shagbark hickory	*Carya ovata*	X	
shallow sedge	*Carex lurida*	X	
shaved sedge	*Carex tonsa*		X
sheep laurel	*Kalmia angustifolia*	X	
silky dogwood	*Swida amomum*	X	X
silver maple	*Acer saccharinum*		X
silver rod	*Solidago bicolor*		X
silver vein	*Parthenocissus henryana*		X
skunk cabbage	*Symplocarpus foetidus*		X
slender gerardia	*Agalinis tenuifolia*		X
slender rattlesnake root	*Nabalus altissimus*		X
smartweed	*Persicaria sp.*	X	X
smooth alder	*Alnus serrulata*		X
smooth sumac	*Rhus glabra*	X	
soft rush	*Juncus effusus*	X	X
soft-stem bulrush	*Schoenoplectus tabernaemontani*		X
speckled alder	*Alnus incana*	X	X

Common Name	Scientific Name	NFM[1]	TF[2]
sphagnum	*Sphagnum sp.*	X	
spinulose woodfern	*Dryopteris carthusiana*	X	
spotted joe-pyeweed	*Eutrochium maculatum*		X
spotted knapweed	*Centaurea maculosa****	X	
spreading dogbane	*Aposynum androsaemifolium*	X	X
squashberry	*Viburnum edule*	X	
St. John’s wort	*Hypericum perforatum*		X
staghorn sumac	*Rhus hirta*	X	X
starflower	*Lysimachia borealis*	X	X
steeplebush	*Spiraea tomentosa*	X	X
stiff aster	*Lonactis linariifolia*		X
stinging nettle	*Urtica dioica*		X
striped maple	*Acer pensylvanicum*	X	X
striped wintergreen	*Chimaphila maculata*	X	X
sugar maple	*Acer saccharum*		X
swamp azalea	*Rhodoendron viscosum*		X
swamp candles	*Lysimachia terrestris*		X
swamp dewberry	*Rubus hispidus*	X	X
swamp honeysuckle	*Lonicera oblongifolia*	X	
swamp rose	*Rosa palustris*	X	
swamp white oak	*Quercus bicolor*	X	
sweet fern	*Comptonia peregrina*	X	X
sweet flag	*Acorus calamus*	X	X
sweetgale	*Myrica gale*		X
switchgrass	*Panicum vigatum*		X
sycamore	*Platanus occidentalis*		X
tall blue lettuce	*Lactuca biennis*		X
tall meadow rue	*Thalictrum puescens*		X
Tartarian honeysuckle	*Lonicera tatarica****		X
three-leaved blackberry	*Rubus parvifolius*		X
three seed mercury	*Acalypha rhomboidea*		X
three-way sedge	*Dulichium arundinaceum*		X
tick-trefoil	*Desmondium glutinosum*	X	
tiger lily	*Lilium lancifolium*		
tower mustard	*Arabis glabra*	X	
Tradescant’s aster	*Symphyotrichum tradescantii*		X
trident maple	*Acer rubrum* var. *trilobum*	X	
trillium	*Trillium sp.*	X	
turtle head	*Chelone glabra*		X
tussock sedge	*Carex stricta*		X
tufted hairgrass	*Deschampia cespitosa spp. glauca*		X
twig sedge	*Cladium mariscoides*		X
twisted stalk	*Streptopus amplexifolis*	X	
thyme-leaved speedwell	*Veronica serpyllifolia*		X
upland white aster	*Oligoneuron album**		X
violet	*Viola sp.*	X	X
viper's bugloss	*Echium vulgare*	X	
Virginia creeper	*Parthenocissus quinquefolia*	X	X
virgin's bower	*Clematis virginiana*	X	X
water hemlock	*Cicuta maculata*		X
water horehound	*Lycopus americanus*	X	X

Common Name	Scientific Name	NFM[1]	TF[2]
water horsetail	*Equisetum fluviatile*		X
water parsnip	*Sium suave*	X	X
water pennywort	*Hydrocotyle sp.*	X	
water purslane	*Ludwigia palustris*		X
water-chestnut	*Trapa natans*		X
watercress	*Nasturtium officinale*		X
white ash	*Fraxinus americana*		X
white avens	*Geum canadense*		X
white birch	*Betula papyrifera*	X	X
white clover	*Trifolium repens*	X	
white meadowsweet	*Spiraea alba var. latifolia*	X	X
white oak	*Quercus alba*	X	
white ricegrass	*Leersia virginica*		X
white snakeroot	*Ageratina altissima*		X
white sweet clover	*Melilotus albus*	X	X
white vervain	*Verbena urticifolia*		X
white wood aster	*Eurybia divaricata*		X
whorled loosestrife	*Lysimachia quadrifolia*	X	X
whorled wood aster	*Oclemena acuminata*		X
wild columbine	*Aquilegia canadinsis*	X	X
wild madder	*Rubia peregrina*	X	
wild oats	*Avena fatua*		X
wild oats	*Uvularia sessilifolia*		X
wild raisin	*Viburnum nudum*		X
wild sarsaparilla	*Aralia nudicaulis*	X	X
wild strawberry	*Fragaria virginiana*	X	
winterberry	*Ilex verticillata*	X	X
wood nettle	*Laportea canadensis*		X
woodfern	*Dryopteris sp.*		X
woolgrass	*Scirpus cyperinus*		X
yarrow	*Achillea millefolium*	X	X
yellow birch	*Betula alleghaniensis*	X	X
yellow iris	*Iris pseudacorus***	X	
yellow nutsedge	*Cyperus esculentus*		X
yellow woodsorrel	*Oxalis stricta*	X	

[1]NFM= Northfield Mountain Project Area
[2]TF= Turners Falls Project Study Area (Includes the shoreline of TFI, the Bypass Reach, and below Cabot Station to the Route 116 Bridge in Sunderland)
* Denotes RTE
**Denotes Invasive according to MIPAG
***Denotes Likely Invasive according to MIPAG
± Denotes Non-native species of interest

Table 3.3.4.1-5: Mapped Habitats, Dominant Vegetation, and Percent Occurrence within the Study Area

Habitat Type	Dominant Overstory	Dominant Shrub	Dominant Herbaceous[1]	NFM[1]		TF[1]	
				Acres	% of Area	Acres	% of Area
Transitional Floodplain Forest	Silver maple (51-75%), sycamore (10-15%), cottonwood (10-15%), red maple (10-15%), ash (5-10%), American elm (5-10%), and willow (5-10%)	Silver maple (trace), sycamore (trace), cottonwood (trace), red maple (trace), ash (trace), American elm (trace), and willow (trace)	wood-nettle (5-10%), ostrich fern (6-25%), sensitive fern (5-10%) and false nettle (5-10%)	0	0	547.9	7.8
Northern hardwoods-hemlock-white pine forest	hemlock (75-100%), yellow birch (10-15%), American beech (5-10%)	hemlock (trace), hobblebush (trace), striped maple (trace)	sarsaparilla (trace), Canada mayflower (trace), wood fern (trace)	127.8	6.4	1,107.9	15.7
Successional Northern Hardwood Forest	red maple, American beech, white birch, quaking aspen (51-75%)	striped maple (6-25%) witch hazel (6-25%)	sarsaparilla (6-25%), twisted stalk (6-25%), starflower (6-25%)	666.8	33.2	2.9	.05
Hemlock Ravine	eastern hemlock (76-100%)	mountain laurel (6-25%)	starflower (trace), wintergreen (trace)	621.5	30.9	0	0
White Pine - Oak Forest	white pine (75-100%), red oak (6-25%), overcup oak (6-25%)	red maple (25%), low bush blueberry (10%), white oak (10%)	Canada mayflower (6-25%), partridge berry (6-25%)	70.1	3.5	0	0
Agricultural Lands	N/A	N/A	N/A	0	0	1,624.7	23.0

Habitat Type	Dominant Overstory	Dominant Shrub	Dominant Herbaceous[1]	NFM[1]		TF[1]	
				Acres	% of Area	Acres	% of Area
High-energy Shore	N/A	silky dogwood (trace), sandbar willow (trace), sandbar cherry (trace)	Beggartick (6-25%), dogbane (6-25%)	0	0	5.17	.07
Development	white pine (trace)	N/A	Kentucky bluegrass (76-100%)	284.8	14.2	317.3	4.5
Right of Way	N/A	white pine (6-25%), glossy buckthorn (6-25%)	goldenrod spp. (6-25%), interrupted fern (6-25%), sweetfern (6-25%), bracken fern (6-25%), mullein (6-25%)	14.3	0.7	4.8	.07
Wetlands	See Section 3.3.4.1	See Section 3.3.4.1	See Section 3.3.4.1	N/A	N/A	342.2	4.8
Water	N/A	N/A	N/A	225.5	11.1	3,112.4	44.1
Total				**2010.8**	**100**	**7,065.2**	**100**

[1]NFM=Northfield Mountain, TF=Turners Falls (Includes the shoreline of Turners Falls Impoundment, the Bypass Reach, and below Cabot Station to the Route 116 Bridge in Sunderland

Table 3.3.4.1-6: Vernal Pool Field Notes

Pool ID	Egg Masses		Pool Dimensions (Feet)	Water Depth (Feet)	Comments
	Spotted Salamander	Wood Frog			
VP-1	0	0	80x30	1.0	Only VP found in TF project area.
VP-2	0	0	200x50	3.0	Spotted salamander (*Ambystoma maculatum*) spermatophores man-made rock-quarry
VP-3	>66	40	45x72	1.5	
VP-4	25	0	120x30	2.0	
VP-5	50	25	100x40	1.0	
VP-6	32	0	100x45	1.0	
VP-7	25	0	125x75	2.0	
VP-8	18	6	75x40	2.0	
VP-9	12	2	20x20	2.0	
VP-10	12	0	-	3.0	
VP-11	52	18	45x25	2.0	
VP-12	15	>30	-	-	red spotted newts (*Notophthalmus viridescens*) feeding on egg masses
VP-13	25	>500	250x50	4.0	red spotted newts (*Notophthalmus viridescens*) feeding on egg masses
VP-14	5	6	120x45	2	

Table 3.3.4.1-7: Invasive Species found in the Study Area

Common Name	Scientific Name	Lifeform Type	NFM	TF	Notes
autumn olive	*Elaeagnus umbellata*	Shrub	X	X	Grows in full sun, berries spread by birds, aggressive in open areas
black locust	*Robinia pseudoacacia*	Tree		X	Occurs in uplands, grows in full sun to full shade, aggressive in areas with sandy soils
black swallow-wort	*Cynanchum louiseae*	Perennial vine		X	Grows in full sun to partial shade, forms dense stands, deadly to Monarch butterfly larvae
burning bush	*Euonymus alatus*	Shrub	X	X	Capable of germinating in full sun to full shade. Escapes from cultivation and can form dense thickets and dominate the understory
coltsfoot	*Tussilago farfara**	Perennial herb	X		Occurs in lowland and upland woods, grows in full sun to full shade, spreads vegetatively and by seed, forms dense stands
common buckthorn	*Rhamnus cathartica*	Shrub-tree		X	Occurs in uplands and wetlands, grows in full sun to full shade.
common reed	*Phragmities australis*	Perennial grass	X	X	Grows in uplands and wetlands, full sun to full shade, forms dense stands, flourishes in disturbed areas
creeping jenny	*Lysimachia nummularia*	Perennial herb		X	Occurs in uplands and wetlands, grows in full sun to full shade, forms dense mats
European alder	*Alnus glutinosa***	Shrub	X		Rapidly growing shrub that establishes nonspecific stands displacing natives
garlic mustard	*Alliaria petiolatea*	Biennial Herb		X	Widespread, grows in full sun to full shade, spreads by seed, especially in wooded areas
glossy buckthorn	*Frangula alnus*	Shrub-tree	X		Occurs in uplands and wetlands, grows in full sun to full shade, forms thickets
Japanese barberry	*Berberis thunbergii*	Shrub	X	X	Wooded uplands and wetlands, grows in full sun to full shade, spread by birds, forms dense stands
Japanese honeysuckle	*Lonicera japonica*	Perennial vine	X	X	Widespread, grows full sun to full shade, climbs vegetation, seeds dispersed by birds
Japanese knotweed	*Fallopia japonica*	Perennial Herb-subshrub	X	X	Widespread, grows in full sun to full shade, spreads vegetatively and by seed, forms dense thickets
leafy spurge	*Euphorbia esula*	Perennial herb		X	Aggressive, grows in full sun, occurs in grasslands
lesser celandine	*Ranunculus ficaria*	Perennial herb		X	Occurs in lowland and upland woods, grows in full sun to full shade, spreads vegetatively and by seed, forms dense stands

Common Name	Scientific Name	Lifeform Type	NFM	TF	Notes
multiflora rose	*Rosa multiflora*	Shrub	X	X	Widespread, grows in full sun to full shade, forms thorny thickets, dispersed by birds.
Morrow's honeysuckle	*Lonicera morrowii*	Shrub		X	Widespread, grows full sun to full shade, dispersed by birds, can hybridize with other honeysuckle species
Norway maple	*Acer platanoides*	Tree		X	Common in woodlands with colluvial soils, grows full sun to full shade dispersed by water, wind and vehicles
Oriental bittersweet	*Celastrus orbiculatus*	Perennial vine	X	X	Grows in full sun to partial shade, berries spread by birds and humans
purple loosestrife	*Lythrum salicaria*	Perennial herb	X	X	Occurs in uplands and wetlands, grows in full sun to partial shade, high seed production, overtakes wetlands
reed canary grass	*Phalaris arundinacea*	Perennial grass		X	Occurs in uplands and wetlands, grows full sun to partial shade, can form large colonies, common in agricultural settings
spotted knapweed	*Centaurea maculosa**	Perennial herb	X	X	Occurs in full sun, spreads rapidly in artificial corridors, agricultural fields, and margins.
yellow iris	*Iris pseudacorus*	Perennial herb	X		Occurs in wetland habitat, grows in full sun to partial shade, out-competes native plant communities.

NFM=Northfield Mountain, TF=Turners Falls (Includes the shoreline of Turners Falls Impoundment, the Bypass Reach, and below Cabot Station to the Route 116 Bridge in Sunderland)
** Denotes Likely Invasive according to MIPAG*
*** Not on MIPAG list, but noted for consistency with other studies*

Figure 3.3.4.1-1: Example of Remnant Floodplain Forest Along Shoreline Downstream of Cabot

Figure 3.3.4.1-2: Example of Successional Northern Hardwoods

Figure 3.3.4.1-3: Example of Northern Hardwoods-Hemlock-White Pine Forest on Northwest Slope of Northfield Mountain

Figure 3.3.4.1-4: Example of Hemlock Ravine Community

Figure 3.3.4.1-5: View Through the Interior of the White Pine-Oak Forest

Figure 3.3.4.1-6: Calcareous Cliff Habitat

Figure 3.3.4.1-7: Circumneutral Rock Cliff Community- Farley Ledges (formed from granitic gneiss)

Figure 3.3.4.1-8: Example of Oak - Hickory Forest

Figure 3.3.4.1-9: Example of Agricultural Land in the Study Area

Figure 3.3.4.1-10: Typical Habitat of Bypass During Low-Flow in Late Summer

Figure 3.3.4.1-11: Representative View of the Right-of-Way Community.

Figure 3.3.4.1-12: Example of Hemlock Swamp Near the Base of the Farley Ledges

Figure 3.3.4.1-13: Example of Red Maple Swamp on Southeast Slope of Northfield Mountain

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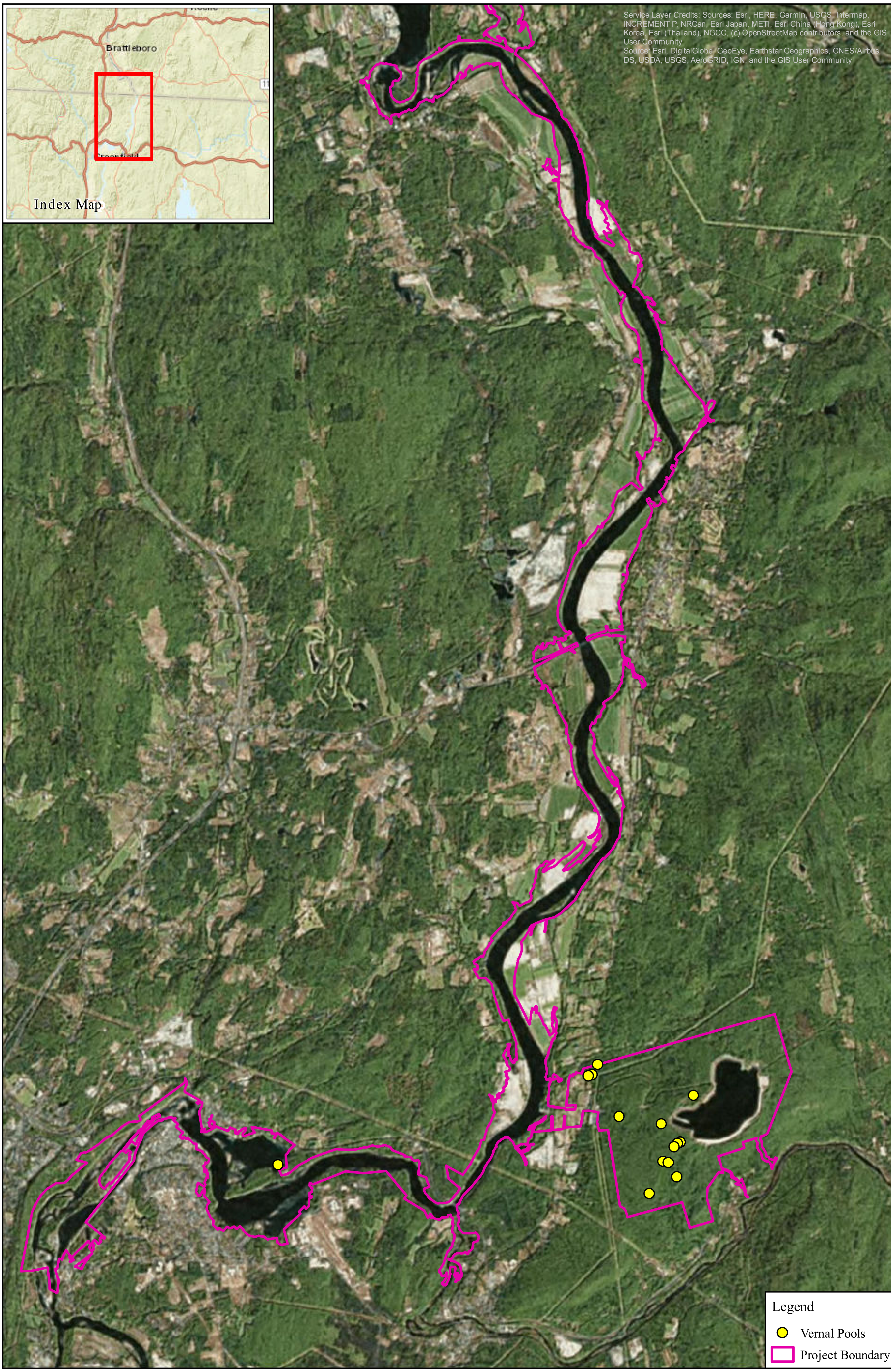

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E

N

0 0.5 1 2
Miles

Figure 3.3.4-1-14:
Locations of Identified
Vernal Pools

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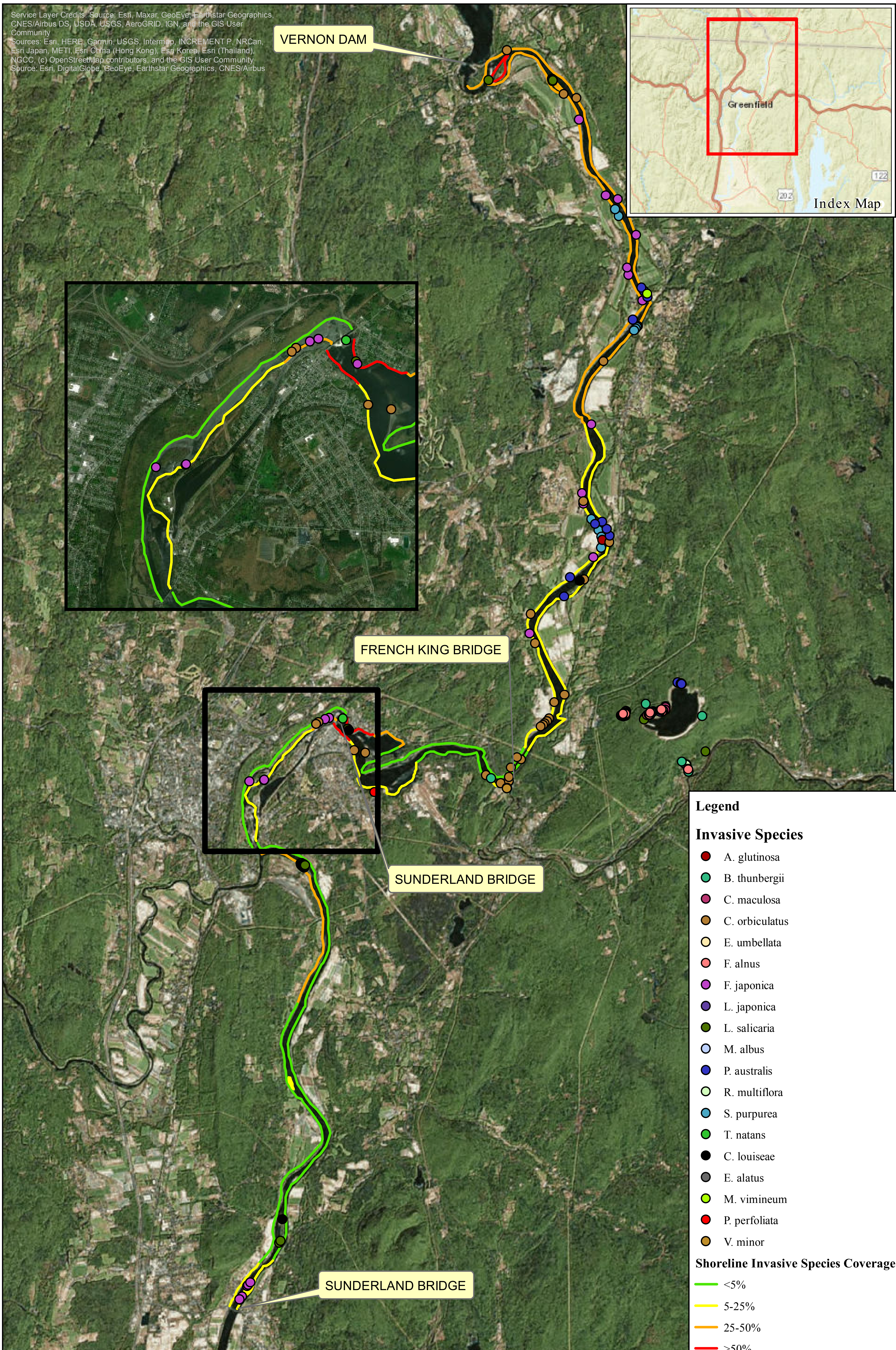

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

FirstLight

N

Amended Final License Application
Exhibit E

0 0.75 1.5 3 Miles

Figure 3.3.4.1-15:
Locations of Identified
Invasive Plants in 2014

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3.3.6 Recreation Resources

3.3.6.1 Affected Environment

3.3.6.1.1 Regional Recreation

The Project is located on the Connecticut River, within the states of MA, NH and VT. The majority of the Project lands are located within the county of Franklin, MA, specifically in the towns of Erving, Gill, Greenfield, Montague, and Northfield. Northern sections of the TFI extend into the towns of Vernon, VT and Hinsdale, NH. Turners Falls Dam is located at RM 122 (above Long Island Sound) of the Connecticut River, in the towns of Gill and Montague, MA. The TFI is approximately 20 miles long, with 5.7 miles located within the states of NH and VT.

Recreation sites and facilities in the vicinity of the Project include hiking trails, fishing access, picnic areas, camping, wildlife management areas, boat launches, hunting, observation areas, and bike trails. There are recreation sites in near proximity to the Project that provide hiking and nature observation opportunities, as well as numerous state lands for hiking, hunting and enjoyment of the outdoors. Some of the nearby recreation sites include the King Philip's Hill Trail, Brush Mountain Conservation Area, Stacy Mountain Preserve and the Erving State Forest. The Connecticut River Greenway State Park in MA is a linear state park paralleling the river for the 69 mile portion flowing through the state and connects key recreational areas including boat launches and other public lands. The park includes over 12 miles of permanently protected shoreline. The Connecticut River is also a National Blueway; and although the program was dissolved in 2014, the Connecticut River has retained its designation.

There are several other FERC licensed hydroelectric projects located near the Project that also provide a variety of recreation opportunities for the public. These projects include the Holyoke Hydroelectric Project (FERC No. 2004), approximately 35 miles downstream of the Turners Falls Dam and the Vernon Hydroelectric Project (FERC No. 1904), approximately 20 miles upstream of the Turners Falls Dam. In addition, the nearby Deerfield River Project (FERC No. 2323) is located nearby on the Deerfield River. Recreation resources and opportunities in the general vicinity of the Project are discussed in more detail in FirstLight's Pre-Application Document (FirstLight, 2012d), and in several of the recreation studies conducted by FirstLight, including Study No. 3.6.1 *Recreation Use/User Contact Survey* (FirstLight, 2015b), Study No. 3.6.*2 Recreation Facilities Inventory and Assessment Report* (FirstLight, 2014b) and Addendum (FirstLight, 2015c), 3.6.3 *Whitewater Boating Evaluation* (FirstLight, 2015d), 3.6.4 *Assessment of Day Use and Overnight Facilities Associated with Non-motorized Boating* (FirstLight, 2015e), and 3.6.7 *Recreation Study at Northfield Mountain, including Assessment of Sufficiency of Trails for Shared Use* (FirstLight, 2015f). All of these reports and addendums have been filed with the Commission[15].

In addition to recreation sites and facilities in the vicinity of the Project, there are also whitewater boating opportunities in the region including several reaches of the Deerfield River, the Ashuelot River, the West River, and the Millers River. Some of these opportunities are subject to natural flows while others are supported by scheduled whitewater releases. Whitewater boating opportunities in the Turners Falls Project region are discussed in detail in Study Report 3.6.3 *Whitewater Boating Evaluation* (FirstLight, 2015d).
Recreation facilities providing access to the Project, or are immediately adjacent to the Project, were inventoried as part of Study 3.6.2 *Recreation Facilities Inventory and Assessment Report* (FirstLight, 2014b) and Addendum (FirstLight, 2015c). Existing recreation sites and trails at the Turners Falls Project and Northfield Mountain Project are identified on Figure 3.3.6.1.1-1. The current licenses for the Northfield Mountain Project and Turners Falls Project require FirstLight to operate and maintain certain public

[15]The report for Study No. 3.6.1 was filed with FERC as part of an Updated Study Report (USR) on March 1, 2016. The report for Study No. 3.6.2 was filed with FERC as part of the Initial Study Report on September 15, 2014 and an addendum to the report was filed with FERC on June 15, 2015. The reports for Study Nos. 3.6.3, 3.6.4, and 3.6.7 were filed with FERC as part of a USR on September 14, 2015.

recreation facilities. These sites are included in the Projects' respective Recreation Plans (Exhibit R) and are therefore considered Project Recreation Sites. In addition to these Project Recreation Sites, there are several other public recreation sites located in the immediate vicinity of the Project, many of which provide access to the Project lands and waters. Some of these sites are formal recreation sites that FERC has previously approved as non-project use of Project lands. Some of the sites are informal areas where no improvements have been made, and no facilities exist, but where the public is provided access to Project lands and waters and are using that access for recreational purposes. Such areas are common at hydropower projects and often include such activities as informal access paths for shoreline fishing, footpaths to the water's edge for carry-in boat launching, or local swimming holes accessed via footpath, bridge or roadway. The more significant of these informal access areas located within the Project boundaries were inventoried as part of Study 3.6.2 *Recreation Facilities Inventory and Assessment* (FirstLight, 2014b) and Addendum (FirstLight, 2015c).

There are also private recreation facilities at the Project, such as boat docks, piers, picnic areas, or campsites. Some private facilities are located within the Project boundaries, and may be on property owned by FirstLight, and have been approved as "non-project use of project lands" as allowed under the standard land-use articles in the existing FERC licenses. There are several such approved facilities and uses on the TFI, mostly associated with residences or camps located along the shoreline of the TFI, some of which are on permitted FirstLight lands. There are also a small number of private clubs or organizations that also maintain approved recreation facilities on the TFI. There are no commercially operated recreation facilities at the Project.

3.3.6.1.2 Project Recreation Sites

Turners Falls Project
Table 3.3.6.1.2-1 lists the Commission approved Project Recreation Sites for the Turners Falls Project. Below is a summary of the Commission approved Project Recreation Sites. Additional information can be found in the Study 3.6.2 *Recreation Facilities Inventory and Assessment Report* (FirstLight, 2014b) and Addendum (2015c).

Gatehouse Fishway Viewing Area. The Gatehouse Fishway Viewing Area is located on the north side of 1st Street across from the town operated Unity Park in Montague, MA. The viewing area is owned and managed by FirstLight. The site consists of a visitor center which provides the public an opportunity to view fish when the Gatehouse fishway is operating. The first floor of the visitor center is ADA accessible with a closed-circuit TV feed from the viewing window to a TV monitor that allows for ease of access for those with limited mobility. There are interpretive panels that provide information about anadromous fish, along with bathrooms, and benches on the outside of the facility. The site also contains a picnic area on the north side of 1st Street with picnic tables, grills, a bike rack, and parking for approximately 29 vehicles.

Turners Falls Branch Canal Area. The Turners Falls Branch Canal Area is located off of Power Street in Montague, MA. This site is owned and managed by FirstLight. The site provides fishing access and has benches for anglers to use while fishing.

Cabot Woods Fishing Access. Cabot Woods Fishing Access is located on Migratory Way in Montague, MA. This site is owned and managed by FirstLight and is open to day use activities. Amenities at this site include picnic tables, parking areas, and informal angler access trails. The two (2) parking areas provide approximately 17 parking spaces and two (2) ADA parking spaces. The first parking area is located outside of a gate at the northerly terminus of Migratory Way where it joins G Street. The second lot is located roadside along Migratory Way, inside of the gate.

Turners Falls Canoe Portage. The Turners Falls canoe portage operation provides boaters with a means of circumventing the Turners Falls Dam. Boaters wishing to proceed downriver of Barton Cove call FirstLight for vehicular portage. They are then picked up and driven downstream of the Turners Falls Dam to the Poplar Street Access site in Montague, where they can continue their trip. (The Poplar Street Access is currently outside the Turners Falls Project boundary, but FirstLight is proposing to add to the Project Boundary. Signs explaining the canoe portage operation procedures and providing the portage request call-in number are located at the following recreation sites: Munn's Ferry Boat Camping Recreation Area, Boat Tour and Riverview Picnic Area, Barton Cove Nature Area and Campground, Barton Cove Canoe and Kayak Rental Area, and at the Poplar Street Access site. Instructions are to paddle to the Barton Cove Canoe and Kayak Rental Area, unload gear, and then call (413) 659-3761 to request a pick up. Typically, a vehicle for the portage will arrive within 15 to 90 minutes of the telephone call. Barton Cove Canoe and Kayak Rental Area has a phone that boaters can use from Memorial Day through Labor Day. During the off-season, boaters need to use their own phones to make the portage request.

Northfield Mountain Project
Table 3.3.6.1.2.2 lists the Commission approved Project Recreation Sites for the Northfield Mountain Project. Below is a summary of the Commission approved Project Recreation Sites. Additional information can be found in the Study 3.6.2 *Recreation Facilities Inventory and Assessment Report* (FirstLight, 2014b) and Addendum (2015c).

Bennett Meadow Wildlife Management Area (WMA). Bennett Meadow WMA is located on the western shore of the Connecticut River, south of the Route 10 Bridge in Northfield, MA. The site is owned by FirstLight and is managed primarily by the MADFW for wildlife management. A portion of the lands within the WMA are managed for agricultural purposes. While there are no developed recreation facilities, existing agricultural roads provide access for walking and hiking, as well as hunting.

Munn's Ferry Boat Camping Recreation Area (Munn's Ferry). Munn's Ferry is located on the east side of the Connecticut River in Northfield, MA. This site is owned and managed by FirstLight. This site provides four to five tent campsites with platforms all complete with trash can, picnic table, grill, and, in some cases, a fire ring. Pit toilets are available at the site. A dock and bank fishing opportunities are also available at the site.

Boat Tour and Riverview Picnic Area. The Boat Tour and Riverview Picnic Area is accessed by Pine Meadow Road in Northfield, MA. This site is owned and managed by FirstLight and provides a picnic area and riverboat tours. Amenities include picnic tables, a pavilion that can be rented for events, as well as restroom facilities that are ADA compliant. There are two parking areas with a total of approximately 54 parking spaces with two ADA signed spaces. Riverboat tours are conducted on the Heritage, which travels along the Connecticut River between Barton Cove and the Riverview Picnic Area.

Northfield Mountain Tour and Trail Center (NMTTC). Northfield Mountain Tour and Trail Center is located off Rt. 63 in Northfield, MA. FirstLight owns and manages this site. Amenities include an ADA accessible Visitor Center with public restrooms, picnic tables, grills, a fire ring, and interpretive displays. There are approximately 25 miles of trails (Northfield Mountain Trail System) accessible from the NMTTC Visitor Center that can be used for hiking, biking, horseback riding, snowshoeing, cross-country skiing, and other non-motorized multi-use activities. The site has a parking area with approximately 50 parking spaces and three ADA parking spaces.

Barton Cove Nature Area and Campground. This campground is located north of the Turners Falls Dam in Barton Cove, on Barton Cove Road in Gill, MA. The Nature Area and Campground are owned and managed by FirstLight. The campground has two group campsites, two trailer sites, and 27 tent sites, one of which is considered ADA accessible. Each campsite has a picnic table and fire ring. There are community trash containers in the campground. The group sites have a grill and additional picnic tables. The Nature Area and Campground has a set of flush toilets, two showers, along with vault and portable restrooms.

Barton Cove Canoe and Kayak Rental Area. The Barton Cove Canoe and Kayak Rental Area is located on the northern shore of the Connecticut River, off of Route 2 in Gill, MA. This rental area is owned and managed by FirstLight and offers paddling and picnicking. Site amenities include a natural gravel carry-in canoe/kayak launch, picnic tables, and a portable toilet. There is also the option for a paddlecraft rental, which includes a personal flotation device and a paddle or oar. The parking area holds approximately 28 vehicles.

3.3.6.1.3 Other Formal Recreation Sites

Other formal recreation sites that provide access to the Project are summarized below. Most of these sites are fully or partially within the Project boundaries, although one site is fully outside the Project boundaries. Additional information regarding the recreation sites can be found in the Study No. 3.6.2 *Recreation Facilities Inventory and Assessment Report* (FirstLight, 2014b) and Addendum (2015c).

Governor Hunt Boat Launch and Picnic Area. This site is located immediately downstream of the Vernon Hydroelectric Project (Project No. 1904) dam in Vernon, Vermont and is owned and managed by the Licensee of that project. While this recreation site is within the Vernon Project boundary, a portion of the site along the shoreline, which includes the boat launch is also located within the Project boundaries.

Fort Hill Rail Trail. The Fort Hill Rail Trail is a multiple use trail, located in Hinsdale, New Hampshire. The trail is nine miles long and travels from Route 63 along the Connecticut River to the old bridge on Route 119. A small portion (approximately 190 feet) of the trail crosses through the Project boundaries, over the Ashuelot River. The trail is owned and maintained by the State of New Hampshire.

Pauchaug Wildlife Management Area (WMA). The Pauchaug WMA is located on the eastern side of the Connecticut River in Northfield, Massachusetts. This WMA is owned and managed by MADFW. The site is open for hunting and is also used for walking/hiking, bird-watching, and bank fishing. The site is located within the Project boundaries. There are no formal amenities within the WMA.

Pauchaug Boat Launch. This site is owned and managed by the MADFW as part of the Pauchaug WMA. The boat launch is located on state owned property on the eastern shore of the Connecticut River, upstream of the Schell Bridge in Northfield, Massachusetts. Facilities at this site include a hard surface boat launch with two launching lanes, parking, informational signage, and portable sanitation (seasonal). This site lies within the Project boundaries.

Northfield Connector Bikeway. The Northfield Connector Bikeway is an 11-mile shared roadway route connecting the Canalside Trail Bike Path (also known as the Canalside Rail Trail) with the Town of Northfield. There is a spur off the main route to the Northfield Mountain Trail System. The route travels along the shoulders of existing roads from the East Mineral Road Bridge along Dorsey Road, River Road, Pine Meadows Road, Ferry Road, and finally onto Route 63, in Northfield, Massachusetts. The bikeway is part of the public roadway and signage is maintained by the Franklin Regional Council of Governments. Approximately 4,580 feet of the 11-mile trail passes through the Project boundaries near the NMTTC Visitor Center.

Cabot Camp Access Area. This area is located within the Project boundaries at the end of Mineral Road in Montague, Massachusetts. The site is owned and managed by FirstLight and is open to the public for shoreline access and bank fishing. A parking area which provides parking for approximately 15 vehicles is available at the site.

State Boat Launch. This launch is located upstream of the Turners Falls Dam. A portion of this site is within the Project boundaries, off of Route 2 in Gill, Massachusetts. A portion of this site is owned by FirstLight, and a portion is owned by the Commonwealth of Massachusetts. The boat launch site is managed by the Commonwealth of Massachusetts and is open to the public free of charge. The site offers boat launching, and bank fishing opportunities. There is a hard surface boat ramp with two launching lanes, a dock and portable sanitation facility (seasonal) at the site.

Canalside Trail Bike Path. This hard surface trail begins within the Gatehouse Fishway Viewing Area and ends at McClelland Farm Road in northeast Deerfield, Massachusetts. The trail is 3.27 miles long, with approximately 1.5 miles within the Project boundaries. The trail runs along the Turners Falls Power Canal in Montague, Massachusetts and along the Connecticut River. The trail property is owned by FirstLight and is leased to, and managed by, the Massachusetts Department of Environmental Management (now the Massachusetts Department of Conservation and Recreation).

Poplar Street Access Site. The Poplar Street Access site is located outside the Project boundaries, downstream of Cabot Station, on Poplar Street in Montague, Massachusetts. This site is owned by FirstLight and is utilized for carry-in boat access, fishing and as the downstream put-in location for the Canoe Portage. A parking area that can hold approximately 16 vehicles, a FERC Part 8 sign, and a trash can are available at the site.

3.3.6.1.4 Informal Recreation and Access Areas

Informal areas within the Project boundaries provide various recreation opportunities. Informal fishing access, whitewater boating access, climbing areas, and campsites make up a majority of these opportunities. These areas have been created through repeated use by the public and have not been improved by the Licensee or other authorized entities.

Ashuelot River Informal Campsite. The informal campsite is located just downstream of the confluence of the Ashuelot River with the Connecticut River on the east side of the Connecticut River. The site is located on private property and FirstLight maintains flowage rights over the property. The area appears to be used for camping and picnicking.

Schell Bridge Informal Fishing and Swimming Access. The Schell Bridge informal fishing and swimming access is located on the western shore of the Connecticut River just south of the Pauchaug Boat Launch in Northfield, MA. This site is located partially within the Project boundaries on private property and FirstLight holds flowage rights to the property. The area appears to be used for fishing and swimming.

Informal Multi-Use Access. This informal multi-use access area is located on the western shore of the Connecticut River, in Northfield, MA, upstream of the Route 10 Bridge. The access area is located on property owned by FirstLight within the Project boundaries. It appears that this access area is used as an informal fishing access and campsite.

Informal Munn's Ferry Fishing Access. This informal access area is partially located within the Project boundaries on the west side of the river in Gill, MA across from the Munn's Ferry Boat Camping Recreation Area. The access area is located on private property and FirstLight has flowage rights for the property. The area appears to be utilized for informal fishing access.

Turners Falls Station No. 1 Fishing Access. Station No. 1 is located in Montague, MA. The area is owned by FirstLight and is used as an informal fishing access. There is a parking lot associated with Station No. 1, which is maintained by FirstLight.

Turners Falls Dam Downstream Put-in. This informal area is located within the Project boundaries immediately downstream of the Spillway Ladder on river left. The area is owned by FirstLight and appears to be used informally for angling and launching of carry-in boats.

Rose Ledge Climbing Area. This area is an informal climbing area located within the Project boundaries on land owned by FirstLight. The area consists of a 40'- 60' cliff line that is used for rock-climbing. There are no formal amenities associated with the Rose Ledge Climbing area. Access to the area is via an informal foot path stemming from the NMTTC Trail System's Lower Ledge Trail. Climbers may park at the parking lot located at the NMTTC. Additional parking for the climbing area is located outside of the Project boundaries on private property.

Farley Ledge Climbing Area. This informal climbing area is located partially within the Project boundaries. A loop trail encompasses the climbing ledges associated with Farley Ledge and provides access to the crags. The Western Massachusetts Climbing Coalition (WMCC) owns property that provides parking and access to the loop trail. The total area encompassed by the trail along with the property that provides access to the site is approximately 51 acres. Approximately 46% of this land is located within the Project boundaries. Farley Ledge is part of a larger chain of ledges (Farley Ledges) utilized for rock-climbing. There are no formal amenities associated with this area within the Project boundaries. There are two (2) parking areas associated with the climbing area, the WMCC parking area and another parking area located on private property outside the Project boundaries.

3.3.6.1.5 Use at Formal Recreation Sites

FirstLight conducted an in-depth study from January 2014 to December 2014 to assess the type and level of use at formal recreation sites in the Project boundaries (Study No. 3.6.1 *Recreation Use/User Contact Survey*, FirstLight, 2015b). Data collection objectives included the determination of the amount of recreation use and demand at Project recreation sites and user opinions with regard to existing recreation sites and perceived adequacy of recreation facilities. The data regarding the type and amount of use was obtained using spot counts, calibration counts, traffic counters, and when applicable, FirstLight registration data. Using these methods, FirstLight was able to determine the type and amount of use at sites based in recreation days, a recreation day being defined by FERC as each visit by a person to a development for recreational purposes during any portion of a 24-hour period. Data regarding user opinions were obtained through the recreation user survey, the residential abutters' survey, and the Northfield Mountain trail user survey. Spot counts, calibration counts, the recreation user survey, and the Northfield Mountain trail user survey were conducted at parking locations associated with the formal recreation sites.

Based on data collected between January 2014 and December 2014, the total annual recreation use of surveyed recreation sites at the Project in 2014 was estimated to be 152,769 recreation days. Recreation use records from 2018 and recreation growth factors, along with population trends in the three counties in which 91% of recreationists live, were used to update recreation use at the formal recreation sites. Based on this update, recreation use in 2018 at the Project was estimated to be 153,647.

Table 3.3.6.1.5-1 provides a breakdown of estimated 2018 use by season. As shown, approximately half of the recreation use occurred during the summer with 53% of recreation days. Recreation use was lowest in winter (8%) with moderate use in spring (16%) and fall (23%).

Table 3.3.6.1.5-2 shows a breakdown of recreation use by activity type per recreation site surveyed. As shown, recreationists participated in a wide variety of activities at the Project. Project-wide, walking, hiking, and jogging were found to be the most popular recreation activity at the Project with 32% of recreation days. Motor boating was the second most popular activity (12%), followed by fishing (7%), bike riding (6%)[16], picnicking (5%), climbing (4%), non-motorized boating (4%), fishway viewing (4%), camping (2%), riverboat tours (2%), sightseeing (1%), and hunting (1%). Cross-county skiing, snowshoeing, ice fishing, ice skating, whitewater boating, riding horses, and birding each received fewer than 1% of recreation days.

In addition to determining the type and amount of use at each of the surveyed recreation sites, the degree to which each recreation site had the capacity to sustain the recreation activity occurring at a site was estimated. Table 3.3.6.1.5-3 provides a breakdown of percent capacity utilized for each site. Percent capacity was determined by the available amount of parking at each site versus the average number of parking spaces that were occupied during surveys during each site's peak recreation season.

Governor Hunt Boat Launch: Annual recreation use at the boat launch was estimated to be 1,856 recreation days in 2018. The portion of the site within the Project boundaries is estimated to be utilized at about 50% of capacity on summer weekends. Motor boating (53%) was the most popular recreation use at the boat launch followed by non-motor boating (16% of the use) and fishing (12% of the use).

Pauchaug WMA: There were an estimated 1,002 recreation days spent at the WMA in 2018. The site was estimated to be utilized at approximately 10% of capacity on weekends in the fall (peak season). Forty-four percent (44%) of the recreation use at the WMA was for hunting followed by walking, hiking and jogging at 33% of use.

Pauchaug Boat Launch: In 2018, annual recreation use at the boat launch was estimated to be 9,832 recreation days. The site is utilized at approximately 20% of capacity on summer weekends. Motor boating accounted for 49% of the recreation use at this site, followed by "other" at 20% of use. Fishing (12% of the use) and non-motorized boating (10%) were also popular.

Bennett Meadow WMA: There were an estimated 3,750 recreation days spent at the WMA in 2018. The site is utilized at roughly 40% capacity on weekends in the fall (peak season). Walking, hiking and jogging accounted for 42% of the use. Hunting was also a popular activity at this site, particularly during the fall, accounting for 24% of the annual use and 89% of fall use.

Munn's Ferry Boat Camping Recreation Area: Annual recreation use at the camping area in 2018 was 1,564 recreation days. The campsites were utilized at 35% capacity during summer weekends in 2018. Motor boating and camping were the most popular uses of this area and accounted for 44% and 23%, respectively.

Boat Tour and Riverview Picnic Area: Annual recreation use at the area was estimated to be 13,762 recreation days in 2018. The site is utilized at approximately 15% capacity on fall weekends (peak season). On an annual basis, 20% of the use was for riverboat trips on the Heritage (2,765 riverboat trips). Other popular recreation activities included walking, hiking, and jogging at 29% of use, followed by picnicking at 18%. Based on data maintained by FirstLight, use of the boat tour has declined since the 1980's (FirstLight, 2015f).

Northfield Mountain Tour and Trail Center (NMTTC): The total number of recreation days at the NMTTC during 2018 was estimated to be 18,226. This included recorded use of the Visitor Center, registered programs, and trail use, as well as estimated use during times when the Visitor Center is closed. Trail use was the most popular recreation activity at the NMTTC, which includes hiking, biking, horseback riding, snowshoeing and cross-country skiing. The NMTTC is utilized at 10% capacity on weekends in the summer (peak season).[17] The NMTTC is discussed in more detail in section 3.3.6.1.11.

[16] Bike riding includes both biking on hardened surfaces and mountain biking.
[17] This is based on parking lot capacity.

Cabot Camp Access Area: Annual recreation use at the area was estimated to be 5,387 recreation days in 2018. The site was utilized at 15% capacity on summer weekends. The most popular recreational activities were fishing (26% of the use at the site) and walking, hiking, and jogging (19% of the use).

Barton Cove Nature Area and Campground: In 2018, the total number of recreation days at the nature area was estimated to be 8,607, while the campground had a total of 3,200 recreation days. The most popular recreation activities at the nature area were walking, hiking, and jogging (31%) and fishing (23%). Camping was the most popular recreation activity at the campground. Based on parking area usage levels, the Nature Area was utilized at 35% on weekends in the summer. Utilization of the campground was based on campsite use and was estimated to be utilized at roughly 45% on summer weekends in 2018.

Barton Cove Canoe and Kayak Rental Area: Annual recreation use during 2018 at the rental area was estimated to be 4,141 recreation days. The area was utilized at approximately 25% capacity on summer weekends. Sixty percent (60%) of the use at the site was by individuals who were participating in non-motorized boating. Twelve percent (12%) of the use was picnicking.

State Boat Launch: The total number of recreation days during 2018 at the boat launch was estimated to be 15,501. While the launch is utilized at 65% on average during summer weekends, there are times when use exceeds 100% capacity, such as fishing tournaments. Boating (motorized at 74% of use and non-motorized boating at 11%) is the most popular recreation activity at this site.

Gatehouse Fishway Viewing Area: Data collected for the Gatehouse Fishway Viewing Area recreation site include the actual fishway viewing area and the portion of Unity Park located north of 1st Street, which includes a picnic area and associated parking area. In addition, the Canalside Trail Bike Path is adjacent to the site and use on the portion of the trail in the immediate vicinity of the fishway viewing area was also counted. Annual recreation use during 2018 at the fishway viewing area was estimated to be 28,548 recreation days. This includes individuals touring the fishway (5,912 recreation days) and those utilizing the picnic area and Canalside Trail Bike Path along the river (22,636 recreation days). During the fish passage season, typically during May and June, the fishway viewing facility is open to the public. The parking lot serving the Gatehouse Fishway Viewing Area, which includes the picnic area was at 25% capacity in the fall, which was observed to be peak season. The parking lot is also heavily used during the fish passage season.

Fishway viewing is the most popular activity at the site during the fish passage season, when the fishway viewing area is open. On an annual basis, walking/hiking/jogging accounted for 35% of use at the site, while seasonal fishway viewing accounted for 21% of use.

Turners Falls Branch Canal Area: The total number of recreation days spent at this area and Station No. 1, combined, in 2018 was estimated to be 1,121. Parking for this area is available at Station No. 1. Percent capacity utilization at Station No. 1 was approximately 10% during winter weekends (peak season). The area was primarily utilized for walking, hiking, and jogging (29% of use), fishing (24% of use), bike riding (24% of use), and cross-country skiing (4% of use).

Cabot Woods Fishing Access: There were an estimated 18,367 recreation days spent at the fishing access during 2018. The site was utilized at 30% capacity on weekends in the spring (peak season). The most popular recreation activities included walking, hiking, and jogging (58% of use), fishing (11% of use) and bike riding (10% of use). There are two parking areas associated with the fishing access, as well as 3,100 feet of Migratory Way, which links the two parking areas. This helps to account for the primary use of the access being attributable to walking, hiking, and jogging, and bike riding.

Turners Falls Canoe Portage: FirstLight typically provides portage around the Turners Falls dam to approximately 60 boaters per year from May through November.[18]

Canalside Trail Bike Path: An estimated 6,489 recreation days were spent at the site in 2018. Biking accounts for 56% of recreation use, with walking, hiking, and jogging accounting for 41% of annual use. There is no parking associated with the site.

Poplar Street Access Site: Annual recreation use during 2018 at this access area was estimated to be 1,907 recreation days. The site was utilized at 15% capacity on weekends in the summer (peak season).The site was utilized at 10% capacity for fishing (41% of use), walking, hiking, and jogging (23%), and non-motorized boating (21%).

Of the formal recreation sites for which percent capacity utilization was calculated, only one site was used at greater than 40% capacity on weekends during the site's peak season – the State Boat Launch)(65% capacity on summer weekends). Observed capacity utilization was lowest at Pauchaug WMA (10%) and Turners Falls Branch Canal/Station No. 1 (10%).

Project-wide, the formal recreation sites have sufficient capacity to meet recreational demands, with several of the sites having significant excess capacity.

3.3.6.1.6 Use of Informal Recreation Areas

Use of the informal recreation areas was estimated based on field observations of compaction, litter and other indicators noted during site visits, as well as spot counts and calibration counts made at Station No. 1 Fishing Access, Rose Ledge parking area, and at Farley Ledge's Wells Street and Route 2 parking lots.[19] It appeared that the majority of the informal recreation areas received low to moderate use with a few exceptions.

Ashuelot River Informal Campsite. This site is located on private property and appears to receive moderate use based on physical improvements and compaction at the site.

Schell Bridge Informal Fishing and Swimming Access. This area appears to see moderate use based on the amount of compaction along the shoreline. Individuals appear to use this area for informal fishing access and swimming.

Informal Multi-Use Access. This informal multi-use access area appears to have been used for informal fishing access and camping. This use appears to vary from moderate to minimal. Site indicators were compaction and erosion.

Informal Munn's Ferry Fishing Access. This area appears to be utilized for informal fishing access; however, this use appears to be minimal based on site indicators such as compaction and vegetation.

Station No. 1 Fishing Access. This area appears to see minimal use based on parking area information. The area is used as an informal fishing access.

Turners Falls Dam Downstream Put-in. This area appears to receive minimal use with some individuals participating in kayaking or bank fishing. There was no compaction noted, however the area does appear to receive some unauthorized improvements such as an informal fire ring.

[18] Average is based on FirstLight records from 2015-2017.
[19] Turners Falls Station No. 1 Fishing Access is utilized for parking by recreationists utilizing the Turners Falls Branch Canal Area and is discussed in section 3.3.6.1.5.

Rose Ledge Climbing Area: While the climbing area itself was not surveyed for use, the parking area, which is located on private property outside of the Project boundaries, is estimated to be utilized at 60% capacity on summer (peak) weekends.

Farley Ledge Climbing Area: This climbing area appears to receive moderate to heavy use based on compaction and anecdotal information. There are two parking areas associated with Farley Ledge Climbing Area, which are located on lands owned by others outside of the Project boundaries. The Route 2 parking area is frequently used and is estimated to be at 90% capacity on weekends in the spring (the peak season for the parking area).[20] The Wells St. parking area is estimated to be at 30% capacity during summer weekends (peak season for the parking area).

3.3.6.1.7 Recreationist's Opinions of Project Recreational Opportunities

As part of Study 3.6.1 *Recreation Use/User Contact Survey*, recreationists were asked their opinions regarding the recreational opportunities offered in connection with the Project. Based on the results of the survey of recreationists, visitors traveled an average of 23 miles to utilize recreation sites within the Project. The majority (69%) of the recreationists were from 10 or fewer miles away, while 2% of the people traveled 100 or more miles. Respondents agreed that the overall quality of the Project recreational opportunities was excellent (41%), fair to excellent (44%), or fair (12%). Two percent (2%) of respondents considered the overall quality to be less than fair.[21]

Surveyed visitors were asked to rate their perception of the level of use at the Project on a scale of 1 ("not crowded") to 5 ("extremely crowded"). Recreationists perceived the amount of use at the Project recreation sites to be "not crowded" (39%), "somewhat crowded" (21%), and between "not crowded" and "somewhat crowded" (19%). Only six (6) percent perceived the use at the Project sites to be "extremely crowded."
The majority of recreationists (93%) responded that they were satisfied (37%), moderately satisfied (43%), or extremely satisfied (13%) with water levels in the river when asked: Overall, how satisfied were you with the river water level during your trip?

Recreationists were also asked about their levels of satisfaction with the number of facilities at the Project. Ninety-six percent (96%) of recreationists surveyed were satisfied (3), moderately satisfied (4), or extremely satisfied (5) with the number of recreation facilities at the Project. Extremely satisfied (36% of responses) was the most frequently given rating for the number of recreation facilities available. Thirty-one percent (31%) reported being moderately satisfied (4), with 29% being satisfied.

Visitors were asked their opinions of the Project with respect to several recreation attributes and conditions. Parking received very positive responses. Eighty percent (80%) of respondents rated the parking as excellent (46%) or between fair and excellent (35%), while fourteen percent (14%) rated the parking as fair. Facility conditions also received very positive responses, with 42% rating the facility conditions as excellent (the most common response), 40% rating the facility conditions as between fair and excellent, and 14% rating the conditions as fair. Regarding the variety of amenities, 88% rated the existing variety of amenities as fair or better. Only 12% of respondents felt that the variety was poor or between poor and fair. With respect to river access, survey respondents had positive perceptions, with 43% of respondents rating the access to be excellent (the most common response), 36% between fair and excellent, and 14% fair. Restrooms were the one area in which visitors had more mixed responses, with 50% rating the restrooms as fair or better and the remaining 50% rating the restrooms as poor or between poor and fair.

[20] The Route 2 and Wells Street parking areas were surveyed to capture individuals utilizing Farley Ledges. Climbers utilizing the overflow parking would likely utilize the Route 2 area for access.
[21] Percentages shown do not sum to 100% due to rounding.

3.3.6.1.8 Residential Abutters' Opinions of Project Recreational Opportunities

As part of Study 3.6.1 *Recreation Use/User Contact Survey*, a mail survey of the 211 residential landowners abutting the Project boundaries and within the Project boundaries was conducted. While some of these properties directly abut the Connecticut River, there are residences that do not. The residential abutters' survey intended to capture recreation users at the Project who access through private lands, as opposed to through the formal recreation sites at the Project. Of the 211 surveys mailed to residential landowners, 95 surveys (or 45%) were completed and returned. The majority of the residential abutters who responded to the survey were year round residents. The residential abutters were asked: Overall, how satisfied were you with the river water level during your trip? Forty-three percent (43%) responded that they were satisfied, moderately satisfied, or extremely satisfied with water levels in the river; 19% indicated that they were slightly satisfied, while the remaining 39% gave water levels a rating of 1, indicating that they were "not satisfied at all".

Fifty-eight percent of the 95 respondents stated that they access the Connecticut River from their property for recreation purposes. When asked if they ever use the recreation sites associated with the Project, 42 (47%) of the 89 respondents answering the question stated yes. The majority of the respondents (81 of 89) stated that they utilized the Connecticut River or amenities at the Project for recreation purposes. Of these respondents, the majority (60%) use the Connecticut River or amenities at the Project for recreation purposes approximately 1-25 days per year. Respondents utilized a variety of recreation sites within the Project boundaries including Barton Cove Nature Area and Campground, the NMTTC, the Gatehouse Fishway Viewing Area, Boat Tour and Riverview Picnic Area, the State Boat Launch, and the bike paths. The most popular recreation activities reported by the residents include walking and nature observation, in all four seasons.

3.3.6.1.9 Recreation Use of the Bypass Reach for Whitewater Boating

The bypass reach of the Connecticut River begins at the Turners Falls Dam and extends downstream 2.5 miles to Cabot Station. The bypass reach is created by the power canal, which parallels the river on the east side, and is used to divert river flows to Cabot Station and Station No. 1. Flows in the bypass reach vary depending on time of year, operational needs and constraints, tributary inflows, and weather events. Flows range from leakage to extremely high flows when the river flow exceeds the hydraulic capacity of the power canal (approximately 18,000 cfs). Under current operation of the Turners Falls Project, the availability of flow in the bypass reach is dependent on river flows, which are largely determined by hydrologic conditions in the basin and discharge from the upstream hydropower projects on the river.

Under the current FERC license, FirstLight is required to release a continuous minimum flow of 1,433 cfs or inflow, whichever is less below the Turners Falls Project. This is typically maintained through discharges at Cabot Station (located at the downstream terminus of the power canal) and/or Station No. 1 which is located approximately 0.9 miles down the bypass reach. The FERC license also requires a continuous minimum flow of 200 cfs in the bypass reach starting on May 1 and increasing to 400 cfs when fish passage starts. This flow is provided through July 15 unless the upstream fish passage season has concluded early, in which case the 400 cfs flow is reduced to 120 cfs to provide a zone of passage for Shortnose Sturgeon. The 120 cfs continuous minimum flow is maintained in the bypassed reach from the date the fishways are closed (or by July 16) until the river temperature drops below 7°C, which typically occurs around November 15th.

The 2.5 mile bypass reach from the Turners Falls Dam to Cabot Station exhibits variable boating characteristics that include whitewater features interspersed with longer stretches of flat water or riffles, depending on the flow. The first approximately 2,500 feet of the bypass reach is characterized by a series of rock ledges and outcroppings, which create a whitewater play area under a range of flows. Further downstream the reach is characterized by a series of riffles and some flat water just before the Station No. 1 powerhouse tailrace, located about 4,000 feet downstream of the Turners Falls Dam. Below Station No.

1 is an area of riffles and small rapids, interspersed with flat water. Approximately 4,000 feet downstream of Station No. 1 is Rawson Island. There are boatable channels on both sides of the island, although the larger left channel contains a feature consisting of a natural bedrock vertical drop in the river gradient known as Rock Dam. The right channel contains a series of riffles and rapids. The remainder of the bypass reach is a mixture of flat water and riffle areas. The bypass reach is accessible to whitewater boaters from three locations: the informal put-in area downstream of Turners Falls Dam, Station No. 1 Fishing Access, and Cabot Woods Fishing Access.

To evaluate the potential of the bypass reach to support whitewater boating, FirstLight conducted a controlled release whitewater boating study (FirstLight, 2015d). The study was designed to provide information on the boating conditions at various flows in the bypassed reach. A total of six flows (2,500, 3,500, 5,000, 8,000, 10,000 and 13,000 cfs) were evaluated over a three-day period in the summer of 2014. Participants paddled a variety of watercraft including kayaks, closed canoes, open canoes, rafts and a stand-up paddleboard. During the study, boaters utilized the International Scale of River Difficulty to rate whitewater in the bypassed reach under each flow. Boaters rated the bypassed reach Class I to Class IV, depending on the type of boat, the magnitude of flow, and the features of the bypassed reach. For most evaluation flows, the Class IV rating was assigned to a single feature, Rock Dam. The reach was found to be boatable at all six evaluation flows i.e., between 2,500 cfs and 13,000 cfs.

When Connecticut River flows exceed about 18,000 cfs, the excess flow is spilled into the bypassed reach at the Turners Falls Dam, under normal Project operations. Bypass flows above 2,500 cfs naturally occur during the spring but may also occur occasionally during the summer and fall. Based on a review of the hydrologic record (Table 3.3.6.1.9-1), flows in excess of 2,500 cfs typically occur in the bypass an estimated 43 days between April and November, under current Project operations. The study evaluation flows of 2,500 cfs to 13,000 cfs typically occur in the bypass an estimated 19-20 days between April and November, again under current Project operations. The spring (April 1 through June 30) is a period when the federally endangered SNS could be utilizing the bypass reach for spawning and incubation which could be disturbed by whitewater boaters. Additional boating flow days may occur in the bypass reach when the power canal is shut down for maintenance or other reasons.

Current use of the bypass reach for boating is limited, even though the reach is available for boating during periods of spillage from Turners Falls Dam. This may be indicative of low demand or may be due to a general lack of knowledge of periods of spill into the bypass reach. Anecdotal information collected from boaters in preparation for the boating study indicated whitewater boaters have run the bypass reach when there is water available but no information specifically correlating bypass flows with recreational boating opportunities in the bypass reach was found. In fact, research found that existing published boating guides (Appalachian Mountain Club, AMC) and other resources (American Whitewater, AW, national river database) contained very limited information on the bypass reach. This research suggested that although existing USGS gage data are available and can be used to estimate flows in the bypass reach, boaters may not be aware that it exists or do not know how to use it (FirstLight, 2015d).

Although the boaters who participated in the study found the bypass reach to provide an acceptable boating experience for most watercraft, other regional rivers were rated more desirable. Other regional whitewater boating opportunities identified include several reaches of the Deerfield River, the Ashuelot River, the West River and the Millers River (Figure 3.3.6.1.9-1). Scheduled releases occur on the West River, Millers River, and two reaches of the Deerfield River. These releases provide whitewater boating opportunities throughout the recreation season including in the summer and on weekends.

3.3.6.1.10 Recreational Use of the Project for Boating

The Project waters are utilized for both motorized and non-motorized boating. Public motorized boating use is generally accessed by launching at the Governor Hunt Boat Launch, the State Boat Launch, and

Pauchaug Boat Launch, which provide trailered boating access. An estimated 18,866 recreation days, or 13% of the total number of recreation days at the Project, were spent participating in motor boating.

The Project is also used for non-motorized boating, which had an estimated 6,632 recreation days in 2018. Non-motorized boating at the Project is supported through several Project recreation sites. Barton Cove Canoe and Kayak Rental Area rents kayaks and is open from Memorial Day weekend to Labor Day weekend. Hours of operation on weekdays are from 9:00 a.m. to 5:00 p.m., while on weekends the rental area is open from 9:00 a.m. to 6:00 p.m. Based on FirstLight's records, an estimated 2,492 recreation days were spent participating in non-motorized boating from the Barton Cove Canoe and Kayak Rental Area. In addition, non-motorized boating access within the Project boundaries is available at the Governor Hunt Boat Launch and Picnic Area (operated by Great River Hydro (GRH) as part of the Vernon Hydroelectric Project); Pauchaug Boat Launch; the Boat Tour and Riverview Picnic Area; the Cabot Camp Access Area, the Barton Cove Nature Area and Campground; and the State Boat Launch. These sites are located approximately 1.3 to 8.2 miles apart.

The TFI is part of the Connecticut River Paddlers' Trail. According to the National Park Service (NPS) a water trail (paddlers' trail) is defined as a recreational route on a waterway with a network of public access points supported by broad-based community partnerships. Initially developed in 1992, the Connecticut River Paddlers' Trail is a series of primitive campsites and river access points extending from the headwaters of the Connecticut River to the NH/VT/MA state line. In 2012, partnerships were formed to establish a "southern" trail chapter to extend the river trail to Long Island Sound (FirstLight, 2015e). With respect to the TFI, a 2013 Friends of the Connecticut River Paddlers (FCRPT) report stated that "in general, most access points are well maintained, well-spaced, and are in adequate condition" (Pollock, 2013).

Numerous stakeholders requested a study of Project facilities that support multi-day non-motorized boating trips. In response, Study No. 3.6.4 *Assessment of Day Use and Overnight Facilities Associated with Non-Motorized Boats* was conducted in 2014 (FirstLight, 2015e). The focus of the study was to determine the number of existing overnight and access facilities that support self-powered boating trips and the adequacy of the spacing. The study also included the feasibility of alternate walkable canoe portages and the need for additional future facilities. The study area was the Connecticut River from Vernon Dam to the Sunderland Bridge (Route 116) in Sunderland, MA; a distance of approximately 32.5 miles, of which approximately 9 miles of river downstream of Cabot Station, which is outside the Project boundaries.

There are three existing campsites and, as described above, seven access sites along the approximate 20-river miles between the Turners Falls Dam and the Vernon Dam that can be used by paddlers traversing the Connecticut River Paddlers' Trail. Campsites are located on Stebbins Island operated by GRH as part of the Vernon Hydroelectric Project (FERC No. 1904); and at FirstLight's Munn's Ferry Boat Camping Recreation Area and Barton Cove Nature Area and Campground. The distance between the existing campsites within the Project boundaries ranges from 6.8 to 10.4 miles.

Water access camping is available from Memorial Day through Columbus Day at the Munn's Ferry Boat Camping Recreation Area and from Memorial Day through Labor Day at the Barton Cove Nature Area and Campground. Combined there are a total of 36 campsites along the TFI, five of which are water access only. There are an additional four to five camping areas at Stebbins Island, which is owned by GRH. The island is located approximately one (1) mile downstream of Vernon Dam.

Existing camping use at the Munn's Ferry Boat Camping Recreation Area and Barton Cove Nature Area and Campground are below capacity. Annual use declined significantly at both sites from 2010 to 2014 but has been rising in recent years. Weekend use at Munn's Ferry Boat Camping Recreation Area dropped from 38.6% in 2010 to 28.4% in 2013 but rose back to 37.7% in 2018. Weekend use at Barton Cove Nature Area and Campground has also had significant fluctuations, declining from an occupancy rate of 67.1% in 2010 to 37.6% in 2014. In 2018, occupancy at the area was 43.5%.

In the reach of river from downstream of the Turners Falls Dam to the Sunderland Bridge, there are three access sites for use by paddlers. One of these is the Poplar Street access located downstream of Cabot Station, which serves as both a take-out location for boaters utilizing the Turners Falls bypassed reach and as a put-in location for the canoe portage and boaters traveling downstream. In addition, the Sunderland Bridge Boat Launch, an unimproved boat launch located on river left (looking downstream) at the Route 116 Bridge crossing, is provided by the Town of Sunderland. Individuals also utilize the Sunderland Bridge access located on river right across from the Sunderland Bridge Boat Launch. This is a carry-in access site, located within a State right-of way. There are no formal campsites in the 9.5 mile stretch of the study area below the Project boundaries, although there are several informal campsites on private and state property.

Canoe Portage Use

FirstLight operates and maintains a canoe portage around the Turners Falls Dam during daylight hours for the paddling season, which is typically mid-May to mid-November. The existing canoe portage is comprised of a free vehicular shuttle service from Barton Cove Canoe and Kayak Rental Area to the Poplar Street Access Site. Portage is provided, by request, on an as-needed basis, for groups with four or fewer boats. Larger groups are asked to provide FirstLight with a one month advance notice. A telephone number to arrange a portage is provided on the FirstLight website and is posted on sign kiosks at several of the Project Recreation Sites located on the TFI. The telephone number is also posted in several regional and local recreational guides.

Use of the Turners Falls portage is light as previously discussed. In recent years, FirstLight provided portage around the dam to an average of 60 boaters per year (2015-2017[22]). Study No. 3.6.4 also examined the feasibility of developing a walkable portage trail around Turners Falls Dam utilizing the Canalside Trail Bike Path and public side streets. It was found, that using existing access areas and side streets would result in a portage of approximately three (3) miles. Overall, the study concluded that the existing vehicle portage provided by FirstLight also provides sufficient portage around Turners Falls Dam (FirstLight, 2015e).

3.3.6.1.11 Recreational Use of the Northfield Mountain Tour and Trail Center

The NMTTC is a four-season facility that provides many on-site recreational opportunities, environmental and educational programs. The NMTTC also serves as a base for management and oversight of other FirstLight Project recreation facilities. Public recreation facilities and amenities at the NMTTC include a Visitor Center, Trail System, Mountain Top Observation Area located on the Upper Reservoir, and several additional amenities such as picnic tables, grills, informational kiosks and a yurt.

The NMTTC, located on Route 63 in Northfield, MA, offers a variety of public and school programs through the Visitor Center. Public programs are both educational and recreational in nature, and are scheduled and offered year-round, many at no charge to participants. Programs include such activities as guided hikes, animal track identification, and winter tree identification. School programs are scheduled during the school year and offer opportunities for hands-on environmental education and recreation.

Individuals utilize the NMTTC and associated amenities for a variety of activities including hiking, mountain biking, horseback riding, cross-country skiing, snowshoeing and access to informal climbing opportunities. Individuals can also use the hiking trails to reach the Mountain Top Observation Area which has views of the Upper Reservoir.

[22] Recorded portages in 2018 were unusually light and, therefore, not included in the average presented here.

At the request of stakeholders, FirstLight conducted a study to evaluate the number of existing recreation facilities and amenities associated with the NMTTC including a review of the trail system. Study No. 3.6.7 *Recreation Study at Northfield Mountain, Including Assessment of Sufficiency of trails for Shared Use* was conducted in 2014. The study found that the NMTTC is a well-utilized regional recreation resource that provides a wide variety of opportunities, programs and amenities, which supported an estimated 20,024 recreation days in 2014 (FirstLight, 2015f). Visitors to the NMTTC participated in environmental and recreation programs and used the trail network for a variety of recreational activities.

Based on NMTTC records and patterns of additional use at times when the Center is closed, an estimated 18,226 recreation days were spent in 2018, down approximately 9% from the 2014 estimate. Much of the decline was related to skiing and snowshoeing, but a 15% decline was also recorded with program attendance. Registration and use records available demonstrate that over the long-term, NMTTC environmental program use has declined. This long-term decline appears to reflect a change in interest and participation, and is not a result of reduced program offerings, which have remained relatively constant. Over the past several years, however, with a few exceptions due to unusual circumstances (such as snow conditions the past several years), recreation use associated with the NMTTC, as well as environmental program registrations, have remained relatively consistent (FirstLight, 2015f).

Surveyed visitors were overwhelmingly satisfied with the amenities provided at the NMTTC. One hundred percent (100%) of respondents to the survey question asking about their overall satisfaction with the NMTTC said they were extremely satisfied (46%), moderately satisfied (33%), or satisfied (21%). Visitors' responses to the question "What did you like most about your recreational experience today?" included "world class touring center", the trails, the Visitor Center exhibits and the variety of programs. Visitors also reported liking most that the NMTTC was not crowded and was quiet. Surveyed visitors were asked to rate the variety of amenities at the NMTTC on a scale of 1 ("poor") to 5 ("Excellent"). Eighty-one percent (81%) of those who responded rated that the variety of amenities available at the NMTTC was a 4 or 5. In addition, there were many more responses to the two positive open-ended questions ("what did you like most about your recreation experience today?" and "what, if anything, enhanced your recreation experience today?") than responses to the two open-ended negative questions ("what did you like least about your recreation experience today?" and "what, if anything, detracted from your recreation experience today?").

3.3.6.1.12 Recreational Use of the Northfield Mountain Tour and Trail Center Trail System

The NMTTC Trail System is an approximately 25-mile network of trails that supports cross-country skiing, snowshoeing, hiking, biking, and horseback riding. The Trail System includes approximately 25 individually named trails (Figure 3.3.6.1.12-1). The NMTTC Trail Systems receives moderate use, and Study No. 3.6.7 *Recreation Study at Northfield Mountain, Including Assessment of Sufficiency of Trails for Shared Use* found that the NMTCC Trail System supported an estimated 16,123 recreation days in 2014 (FirstLight, 2015f). A review of FirstLight records for the period 2010 through 2014 show that, after adjusting for special events and closures in various years, trail use remained relatively consistent over the 2010-2014 period. In 2018, the NMTTC Trail System supported 11,516 recreation days. The decline in trail use between 2014 and 2018 was directly related to the decline in skiing and snowshoeing due to snow conditions.

Study No. 3.6.7 also found that the Trail System is well designed, well maintained and with few exceptions, in good condition. The trails were designed and built to a very high standard at the time that they were constructed in the 1970's. Although the trails were designed primarily for hiking and cross-country skiing, the trail assessment (Study No. 3.6.7) found that the cross-country ski trails are well adapted to handle mountain biking and can also accommodate horseback riding use, while remaining in good condition. The hiking and snowshoe trails are not as suitable for mountain biking or horseback riding use (FirstLight, 2015f).

The vast majority of visitors to the NMTTC Trail System are very satisfied with the number of trails and with the difficulty of the trails. Ninety-four percent (94%) of respondents strongly agreed or agreed that the trails are in good condition, with 95% strongly agreeing or agreeing that the trails are well maintained. Surveyed visitors also disagreed or strongly disagreed (61% of responses) that more trails are needed while another 26% of respondents remained neutral. The majority of respondents (85%) either agreed or strongly agreed that the grooming of winter trails is sufficient. The majority of respondents (96%) also agreed or strongly agreed that the hours of operations are adequate, while the remaining 4% were neutral. When asked how any of the trail variables could be improved, only nine (9) users chose to respond while an additional 23 recreationists chose not to respond.

In addition to the trails provided at the NMTTC System, there are 133 properties with hiking and/or mountain biking trail opportunities within 25 miles of the NMTTC. Of the 133 properties, 64 provide both hiking and mountain bike trails, 62 provide only hiking trails, and seven provide only mountain bike trails. The properties are owned and managed by a variety of federal, state, and local agencies, land trusts, and private entities. All but two of the properties are open to the public on a year-round basis.

3.3.6.2 Environmental Effects

The continued operation of the Project, as proposed, will have a beneficial effect on existing recreational use of the Project, the recreation opportunities provided by the Project, or use of the Project recreation sites. There are four (4) Commission approved Turners Falls Project Recreation Sites (listed in Table 3.3.6.1.2-1) and six (6) Commission approved Northfield Mountain Project Recreation Sites (listed in Table 3.3.6.1.2-2), which provide the public with a variety of recreational opportunities including boating, fishing, camping, swimming, picnicking, hiking, cross-country skiing, snowshoeing, horseback riding, rock-climbing, and mountain biking.

Recreation-related studies conducted by FirstLight as part of the relicensing process demonstrate that the existing Project recreation sites, combined with other public recreation sites and facilities, as well as informal access areas, provide the public with a diversity of recreation opportunities, and an abundance of options for accessing and utilizing Project lands and waters for recreation. An inventory of both Projects and other improved recreation sites found that with few exceptions all of the sites and their associated facilities and amenities are well maintained and are functioning as designed. A survey of site users also found that users felt that the existing sites were generally well operated and maintained. The major recreation facilities at the most popular Project Recreation Sites received favorable marks from most users, including the Barton Cove Campground, the Barton Cove Canoe and Kayak rental area, the Gatehouse Fishway Viewing Area, and most notably, the NMTTC and NMTTC Trail System. Continued operation of these Project Recreation Sites will ensure that the public continues to benefit from the recreational opportunities afforded by Project lands and waters.

The continued operation and maintenance of the existing Project Recreation Sites is supportive of current recreation use and demand levels. Use surveys conducted as part of Study No. 3.6.1 demonstrate that current facility capacities do not exceed 50% with one exception. A portion of the Gatehouse Fishway Viewing Area building was utilized at 90% capacity during the fishway viewing season. In addition, the State Boat Launch, which is a non-Project recreation site, was estimated to be utilized at 65% capacity during summer weekends in 2018. However, even these two sites are expected to provide adequate use capacity for the foreseeable future. Two informal recreation sites also saw capacity use exceed 50% on weekends during the peak recreation season: Rose Ledge (60% capacity on summer weekends) and Farley Ledge-Route 2 (90% on spring weekends).

Cabot Woods Fishing Access was estimated to be the most popular of the Project Recreation Sites receiving year-round use in 2018, with 18,367 recreation days. The site has the capacity to continue to serve visitors in the future, being utilized at only 30% capacity on weekends in the spring (peak season). Despite its designation as a fishing access, the most popular recreation activity at the site is walking, hiking, and jogging (58% of use).

The NMTTC was estimated to be the second most popular of the Project Recreation Sites in 2018, with 18,226 recreation days. In addition to the facilities and amenities provided at the NMTTC, the Visitors Center also serves as the base of operations for some of the other Project recreation facilities, including the Heritage riverboat tour, and the fishway viewing area. Study No. 3.6.7 results found that visitors to the NMTTC consistently gave it favorable marks for its facilities and amenities, as well as for how the facilities are operated and maintained by FirstLight. Continued operation of the NMTTC will continue to provide the region with a recreational resource offering a variety of recreational experiences, including the provisions of educational and recreational programs offered through the NMTTC. Study No. 3.6.7 results also found that users of the NMTTC Trail system consistently gave it favorable remarks and there were almost no negative comments. Study No. 3.6.7 found the trails overall, to be well maintained and in good condition. The Trail System will continue to operate year-round and provide hiking, mountain biking and horseback riding opportunities in the spring, summer and fall, as well as skiing and snowshoeing opportunities in the winter. The Trail System will also continue to provide parking and access for those wishing to access the New England National Scenic Trail, and the popular Rose Ledge climbing site. Continued maintenance of the trails by FirstLight will ensure that the trails remain in good repair, functional and sustainable for existing uses well into the future.

Continued operation of the Project, as proposed, including the operation and maintenance of the existing Project recreation sites will also be supportive of the Connecticut River Paddlers' Trail's goals of expanding the Connecticut River Trail to include the TFI and Project areas downstream of Turners Falls Dam. Study No. 3.6.4 found that existing access and camping opportunities located throughout the TFI are located and spaced consistent with water trail design standards and practices. FirstLight's proposed maintenance of its existing campsites and access areas will ensure that these facilities will be available for water trail users and multi-day through paddlers in the future. FirstLight also proposes to continue to operate the Turners Falls Dam vehicle portage between Barton Cove (take-out), as it does currently, which will also support water trail users and through-paddlers. In addition, as set forth in Section 3.3.6.4, FirstLight proposes to improve the Poplar Street Access Site (put-in) and improve Cabot Camp Access Area as a hand put-in take/out, which also will support water trail users and through-paddlers.

Continued operation of the Project will also continue to support existing recreational use of the bypass reach for recreation. The bypass reach will continue to receive seasonally variable minimum flows from May 1 to November 15. Periodically, the bypass reach will receive higher flows, if the canal is shut down for maintenance or other reasons, as well as when river flows exceed the hydraulic capacity of the canal (>18,000 cfs). Study No. 3.6.3 demonstrated that the bypass reach is suitable for whitewater boating at the evaluated range of flows (2,500 cfs – 13,000 cfs). In addition, although not evaluated, flows in excess of 13,000 may also be suitable for whitewater boating. Bypassed reach flows in excess of 2,500 cfs, would be expected to occur most frequently in the spring, but the evaluated flows (between 2,500 and 13,000 cfs) can be expected to provide boatable conditions in the bypassed reach approximately 19-20 days between April and November, in an average hydrologic year. Flows in excess of 2,500 cfs (and greater than 13,000 cfs) can be expected to occur approximately 43 days between the months of April and November in an average hydrologic year, i.e., additional days which may also be suitable for boating. Study No. 3.6.3 also found that there are numerous other regional whitewater boating opportunities, including several reaches of the Deerfield River, the Ashuelot River, the West River, and the Millers River. Some of these boating opportunities are dependent on natural flows, but several of these opportunities are available through the recreation season through scheduled flow releases, including reaches on the Deerfield River, the West River, and Millers River. Scheduled releases at these rivers provide regional boaters with significant whitewater boating opportunities, including in the summer and weekends. Access for whitewater boaters wishing to utilize the bypassed reach is available for "put-in" at an informal area below the Turners Falls

Dam, at the Cabot Woods Fishing Access; and for "take-out" at the Station No. 1 Fishing Access and at the Poplar Street Access Site. FirstLight's proposal to continue to operate and maintain these sites, and to continue to allow public access to the informal access areas will ensure that the bypassed reach can continue to be utilized for whitewater boating, whenever flow conditions allow.

Continued operation of the Project will also continue to support boating use of Project waters. Boat launching for trailered boats is currently provided at two formal recreation sites: the Pauchaug Boat Launch and the State Boat Launch. The Pauchaug Boat Launch is owned and managed by the Commonwealth of Massachusetts. The boat launch is located on state property on the eastern shore of the TFI, and within the Project boundaries. Both the boat launch and parking lot are maintained by the state. The boat launch itself is a hard surface ramp with two launch lanes. The State Boat Launch site is on property partially owned by the state, and partially by FirstLight, and the site is operated and maintained by the state. Both boat launches provide trailered boats access to Project waters and are expected to remain functional under the proposed operation of the Project.

The continued operation of the Project will have no impact on the recreational use of the Northfield Mountain Project's Upper Reservoir. For both safety and security reasons, public recreational use of the Upper Reservoir is currently restricted to the observation platform, which is maintained as part of the NMTTC, and which is accessed via the NMTTC Trail System. There is no boating, fishing or swimming allowed on the Upper Reservoir, and therefore no boat launches or recreation access sites, other than the viewing platform. Because there is no boating allowed on the Northfield Mountain Project's Upper Reservoir, proposed modifications of the operation of the Upper Reservoir will also have no impact on recreational use of that reservoir.

Existing Project Recreation Sites and facilities are currently meeting recreation demand and are adequate to meet demand in the reasonably foreseeable future.

3.3.6.3 Cumulative Effects

In Scoping Document 2 FERC identified that recreational uses may be cumulatively affected by the proposed operation and maintenance of the five Connecticut River Projects. The presence of the dams may have a cumulative effect on recreation for multi-day paddling trips on the Connecticut River. During licensing studies, it was determined that the availability and types of recreation facilities along the Connecticut River within the Project adequately support multi-day paddling trips and are also consistent with plans for Connecticut River water trail expansion.

3.3.6.4 Proposed Environmental Measures

FirstLight proposes to implement a project-specific Recreation Management Plan (RMP) for each Project during the term of the new licenses, which will provide for the operation and maintenance of proposed Project Recreation Sites (see Appendix A-Recreation- Turners Falls Recreation Management Plan, Exhibit E, Part 3 of 3 and Appendix B-Recreation- Northfield Recreation Management Plan , Exhibit E, Part 3 of 3). The RMPs are included as part of the license filing for each Project. These proposed Project Recreation Sites consist of the existing Commission approved Project Recreation Sites as well as the following at the Turners Falls Project and Northfield Mountain Project.

Turners Falls Project- Proposed Recreation Sites

Formal Access Trail and Put-In just below Turners Falls Dam. Stakeholders have requested a put-in just below the Turners Falls Dam to kayak/canoe/raft the bypass reach. There is an existing informal pathway leading to the base of the Turners Falls Dam just downstream of the existing Spillway Ladder. The proposed access would be provided via the existing bridge (aka the "IP Bridge") spanning the power canal. Once over the canal, a formal 12-ft wide path would lead recreationists to the base of the dam. The path would include a sign (Project name and FERC No.) just after exiting the IP bridge, and directional signs along the formalized path.

FirstLight also proposes to establish a weblink that would report the forecasted Turners Falls Dam discharge each day during the daylight hours from July 1 to October 15 to benefit whitewater boaters. FirstLight is not proposing to post the Turners Falls Dam discharge from April 1 to June 30 because it is a period when the federally endangered Shortnose Sturgeon could be utilizing the bypass reach for spawning and incubation which could be disturbed by whitewater boaters.

Formal Access Trail and Stairs for Take-out at Poplar Street. There is an existing take-out at Poplar Street; however, it is extremely steep. FirstLight has limited options due to steep topography and land ownership. FirstLight proposes to use the existing gravel parking lot leading to 20-foot wide timber stairs with a boat slide railing leading to a 5-foot long, 20-foot wide concrete landing/abutment. A 32-foot long gangway would be anchored to the concrete abutment and lead to a floating dock in the Connecticut River to accommodate fluctuations in the river elevation. The site would include a sign (Project name and FERC No.) at the top of the timber stairs. The land necessary for the site will be included within the proposed Turner Falls Project boundary (see Exhibit G).

Conceptual level drawings of the proposed recreation features are included in the Recreation Management Plan developed for the Turners Falls Project (see Appendix A-Recreation- Turners Falls Recreation Management Plan, Exhibit E, Part 3 of 3).

<u>Turners Falls Project- Proposed Bypass Flows and Whitewater Releases</u>

FirstLight proposes to provide higher bypass flow throughout the year as shown in the table below.

Date	Total Bypass Flow[2]	Turners Falls Dam	[3]Station No. 1
01/01-03/31	1,500 cfs or the Naturally Routed Flow (NRF), whichever is less	300 cfs	1,200 cfs[4]
04/01-05-31[1]	6,500 cfs or the NRF, whichever is less	4,290 cfs	2,210 cfs[4]
06/01-06/15[1]	4,500 cfs or the NRF, whichever is less	2,990 cfs	1,510 cfs[4]
06/16-06/30[1]	3,500 cfs or the NRF, whichever is less	2,280 cfs	1,220 cfs[4]
07/01-08/31	1,800 cfs or the NRF, whichever is less	670 cfs	1,130 cfs[4]
09/01-11/30	1,500 cfs or the NRF, whichever is less	500 cfs	1,000 cfs[4]
12/01-12/31	1,500 cfs or the NRF, whichever is less	300 cfs	1,200 cfs[4]

[1]The flow split during these periods is approximately 67% from the Turners Falls Dam and 33% from Station No. 1. If FirstLight conducts further testing, in consultation with the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS) and Massachusetts Department of Fish and Wildlife (MADFW), and determines that migratory fish are not delayed by passing a greater percentage of the bypass flow via Station No. 1, it may increase the percentage through Station No. 1 upon written concurrence of those agencies.

[2]If the NRF is less than 6,500 cfs (04/01-05/31), 4,500 cfs (06/01-06/15) or 3,500 cfs (06/16-06/30) the flow split will still be set at approximately 67% of the NRF from the Turners Falls Dam and 33% of the NRF from Station No. 1. If the NRF is less than 1,800 cfs (7/1-8/31), 1,500 cfs (9/1-11/30), or 1,500 cfs (12/1-3/31), the Licensee shall maintain the Turners Falls Dam discharges at 670 cfs, 500, cfs, and 300 cfs, respectively.

[3]To maintain the flow split, Station No. 1 must be automated, which will not occur until Year 3 of the license. FirstLight proposes to maintain the flow split such that the Turners Falls Dam discharge will be as shown above, or higher flows will be spilled, in cases where the additional flow cannot be passed through Station No. 1.

[4]The Turners Falls Hydro (TFH) project (FERC No. 2622) and Milton Hilton, LLC project (unlicensed) are located on the power canal and discharge into the bypass reach upstream of Station No. 1. The hydraulic capacity of the TFH project and Milton Hilton, LLC project is 289 and 113 cfs, respectively. If the TFH project is operating,

Date	Total Bypass Flow[2]	Turners Falls Dam	[3]Station No. 1
FirstLight will reduce its Station No. 1 discharge by 289 cfs. If the Milton Hilton, LLC project is operating, FirstLight will reduce its Station No. 1 discharge by 113 cfs.			

FirstLight proposes to provide the whitewater flows below, or the NRF, whichever is less, from the Turners Falls Dam as shown in the table below.

Date	Turners Falls Dam Magnitude of Discharge	Turners Falls Dam Release Duration
1 Saturday in July	2,500 cfs or the NRF, whichever is less	4 hours
1 Saturday in August	2,500 cfs or the NRF, whichever is less	4 hours
3 Saturdays in September	3,500 cfs or the NRF, whichever is less	4 hours
1 Saturday in October	3,500 cfs or the NRF, whichever is less	4 hours
2 Saturdays in October	5,000 cfs or the NRF, whichever is less	4 hours

<u>Northfield Mountain Project- Proposed Recreation Sites</u>

Relocation of the Boat Tour Dock at Riverview. The proposed barrier net would be in place from August 1 to November 15 during a portion of the summer recreation season. The current layout of the barrier net encloses the existing Boat Tour Dock. Given this, FirstLight proposes to relocate the dock further upstream of its current location. It would entail extending the existing paved road further north.

Create a New Access Trail with Stairs for a Put-In at Riverview. A new put-in would be located off of Pine Meadow Road, where Fourmile Brook discharges into the TFI. The site would entail establishing a 6-foot wide stone path to timber and concrete stairs leading to a put-in on the northern bank along the brook. Pine Meadow Road would be widened to add approximately seven (7) parking spots and a sign (Project Name and FERC No.) would be installed near the stone path.

Formal Access Trail and Put-In at Cabot Camp. FirstLight proposes to create a 200-foot long, 10-foot wide formal path leading from the Cabot Camp parking area to an access point on the Millers River just upstream of the confluence with the Connecticut River. There is currently an informal path in this area. A sign (Project Name and FERC No.) and directional portage sign would be installed along the formal path leading the public from the parking lot directly to the 10-foot-wide gravel path leading to the water's edge.

Conceptual level drawings of the proposed recreation features are included in the Recreation Management Plan developed for the Northfield Mountain Project (see Appendix B-Recreation- Northfield Recreation Management Plan, Exhibit E, Part 3 of 3).

<u>Northfield Mountain Project- Modifications to Existing Recreation Sites</u>

FirstLight is also proposing that the Bennett Meadow WMA, which currently is a Commission approved (Northfield Mountain Project) recreation site be considered as a non-Project recreation site. The site is primarily a wildlife management area that is managed by MADFW. It is also managed for agriculture purposes, although the WMA does provide recreation opportunities for hunting, walking, and hiking. The WMA contains steep banks, which makes access to Project waters difficult. There are no recreational facilities at the site. The proposal to consider the Bennett Meadows WMA as a non-Project recreation site will not have an adverse impact on recreational use and opportunities in the Project vicinity because the WMA is managed for other purposes, does not provide direct access to Project waters, has no recreational facilities, and receives low usage

At the Northfield Mountain Tour and Trail Center, FirstLight proposes to eliminate operating a cross-country equipment rental shop during the winter due to low rental usage, high overhead cost, and reduced snow amounts in recent years.

The continued operation and maintenance of the existing and proposed Project Recreation Sites will continue to provide multiple recreational opportunities at the Project and is supportive of anticipated recreation use and demand levels over the term of a new license. Although FirstLight is proposing to eliminate operating a cross-country equipment rental shop during the winter at the Northfield Mountain Tour and Trail Center, the trails will remain open for recreationists for cross country skiing use.

3.3.6.5 Unavoidable Adverse Impacts

No unavoidable adverse impacts are expected to recreational resources in the Project. Implementation of the RMPs would assure that the effects of the Projects on recreational resources will be taken into account.

References:

FirstLight. (2012d). Pre-Application Document (PAD) for FERC Project Nos. 2485 and 1889. Northfield, MA: Author.

Pollock, N. (2013). Connecticut River Paddlers' Trail. MA-CT Expansion Feasibility. Montpelier, VT: Vermont River Conservancy.

FirstLight. (2014b). Initial Study Report (ISR) Study No. 3.6.2. Prepared by Gomez and Sullivan and TRC Solutions. Northfield, MA: Author.

FirstLight. (2015b) Relicensing Study 3.6.1 Recreation Use/User Contact Survey. Prepared by Gomez and Sullivan and TRC Solutions. Northfield, MA: Author. FirstLight. (2015c). Relicensing Study 3.6.2 Recreation Facilities Inventory and Assessment Addendum. Prepared by Gomez and Sullivan and TRC Solutions. Northfield, MA: Author.

FirstLight. (2015d). Relicensing Study No. 3.6.3 Whitewater Boating Evaluation. Prepared by Gomez and Sullivan and TRC Solutions. Northfield, MA: Author.

FirstLight. (2015e). Relicensing Study No. 3.6.4 Assessment of Day Use and Overnight Facilities Associated with Non-Motorized Boats. Prepared by Gomez and Sullivan and TRC Solutions. Northfield, MA: Author.

FirstLight. (2015f). Relicensing Study 3.6.7 Recreation Study at Northfield Mountain, including Assessment of Sufficiency of Trails for Shared Use. Prepared by Gomez and Sullivan and TRC Solutions. Northfield, MA: Author.

Table 3.3.6.1.2-1: Commission Approved Recreation Facilities at the Turners Falls Project (FERC No. 1889)

Recreation Site Name	Recreation Facilities/Amenities
Gatehouse Fishway Viewing Area	• parking area (approximately 27 single vehicle spaces; 2 ADA spaces) • picnic area (approximately 6 tables) • bike rack • trail • fishway viewing visitor center (ADA accessible) • restrooms (ADA accessible) • interpretive sign
Turners Falls Branch Canal Area	• overlook (approximately 4 benches)
Cabot Woods Fishing Access	• parking areas (approximately 17 single vehicle spaces; 2 ADA spaces) • picnic area (approximately 3 tables)
Turners Falls Canoe Portage	• canoe portage take-out (at Barton Cove Canoe & Kayak Rental area) • canoe portage put-in (at Poplar Street Access Site) • On-call vehicular canoe & kayak transport service

Table 3.3.6.1.2-2: Commission Approved Recreation Facilities at the Northfield Mountain Project (FERC No. 2485)

Recreation Site Name	Recreation Facilities/Amenities
Bennett Meadow Wildlife Management Area	• hunting area
Munn's Ferry Boat Camping Recreation Area	• water access only campsites (approximately 4-5 tent platform sites) • pedestrian foot bridge • restrooms • picnic area (1 table) • dock
Boat Tour and Riverview Picnic Area	• parking area (approximately 54 single vehicle spaces; 2 ADA) • restroom (ADA compliant) • picnic area (approximately 10 tables) • pedestrian foot bridge • picnic pavilion (approximately 8 tables) • boat tour • dock
Northfield Mountain Tour and Trail Center	• parking area (approximately 50 single vehicle spaces; 3 ADA) • restroom • picnic area (approximately 7 tables) • overlook • visitor center and interpretive displays • winter area • trail system
Barton Cove Nature Area and Campground	• nature area parking area (approximately 26 single vehicle spaces) • campground parking (approximately 28 single vehicle spaces) • showers • restroom facilities (2 facilities; ADA compliant) • picnic area (approximately 15 tables) • overlook • interpretive sign • walk-in campground (2 group sites; 28 campsites; 1 ADA campsite) • nature trail • dock
Barton Cove Canoe and Kayak Rental Area	• parking area (approximately 28 single vehicle spaces) • picnic area (approximately 6 tables) • seasonal restroom • paddlecraft rental service • canoe put-in and take-out (serves as portage take-out) • on-call vehicular canoe & kayak transport service

Table 3.3.6.1.5-1: Estimated Use of Surveyed Sites by Season

Recreation Site	Estimated Annual Use (2018)	Estimated Winter Use (2018)	Estimated Spring Use (2018)	Estimated Summer Use (2018)	Estimated Fall Use (2018)
Governor Hunt Boat Launch	1,856	13%	11%	67%	9%
Pauchaug WMA	1,002	15%	0%	23%	62%
Pauchaug Boat Launch	9,832	1%	7%	68%	23%
Bennett Meadow WMA	3,750	2%	14%	40%	44%
Munn's Ferry Boat Camping Recreation Area	1,564	0%	3%	68%	29%
Boat Tour and Riverview Picnic Area	13,762	17%	23%	39%	21%
Northfield Mountain Tour and Trail Center	18,226	15%	11%	42%	31%
Cabot Camp Access Area	5,387	4%	10%	62%	24%
Barton Cove Nature Area	8,607	15%	22%	38%	25%
Barton Cove Campground	3,200	0%	7%	84%	8%
Barton Cove Canoe and Kayak Rental Area	4,141	2%	0%	98%	0%
State Boat Launch	15,501	1%	2%	74%	23%
Canalside Trail Bike Path	6,489	1%	13%	54%	31%
Gatehouse Fishway Viewing Area	28,548	7%	28%	46%	20%
Turners Falls Branch Canal/Station No. 1 Fishing Access	1,121	27%	29%	20%	24%
Cabot Woods Fishing Access	18,367	17%	19%	38%	27%
Poplar Street Access	1,907	14%	5%	56%	25%
Rose Ledge Climbing Area Parking	1,812	2%	27%	54%	17%
Farley Ledge Climbing Area—Wells Street Parking	2,371	7%	51%	29%	13%
Farley Ledge Climbing Area—Route 2 Parking	6,206	4%	22%	48%	25%
Total Project Recreation Site Use	153,647	8%	16%	53%	23%

Note: Percentages of estimated use by season at each recreation site may not sum to 100% due to rounding.

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Table 3.3.6.1.5-2: Percent of Recreation Use by Activity at Each Site

Recreation Site	Walk/ Hike/ Jog	Motor Boat	Fish	Ride Bikes	Picnic	Climb	Non Motor Boat	Fishway	Camping (excl. Barton Cove)	Riverboat	Sightsee	Hunt	Birding	Ice Fish	Ride Horses	X-C Ski	Whitewater Boat (Bypass) Only)	Snow Shoe	Ice Skate/ Boat	Other Rec Use
Governor Hunt Boat Launch/Picnic Area	0%	53%	12%	0%	0%	0%	16%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	19%
Pauchaug WMA	33%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	44%	0%	0%	0%	0%	0%	0%	0%	23%
Pauchaug Boat Launch	4%	49%	12%	0%	1%	0%	10%	0%	0%	0%	2%	2%	0%	0%	0%	0%	0%	0%	0%	20%
Bennett Meadow WMA	42%	0%	1%	0%	1%	0%	1%	0%	0%	0%	4%	24%	0%	0%	0%	0%	0%	0%	0%	27%
Munn's Ferry Boat Camping Recreation Area	0%	44%	0%	0%	5%	0%	10%	0%	23%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	18%
Boat Tour and Riverview Picnic Area	29%	3%	2%	2%	18%	0%	1%	0%	0%	20%	1%	0%	0%	0%	0%	0%	0%	0%	0%	24%
Northfield Mountain Tour and Trail Center	60%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	3%	3%	0%	1%	0%	32%
Cabot Camp Access Area	19%	1%	26%	2%	1%	0%	2%	0%	0%	0%	8%	0%	0%	0%	0%	0%	3%	0%	0%	39%
Barton Cove Campground	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Barton Cove Nature Area	31%	0%	23%	6%	5%	0%	4%	0%	0%	0%	1%	0%	1%	9%	0%	0%	0%	0%	1%	19%
Barton Cove Canoe and Kayak Rental Area	0%	8%	4%	0%	12%	0%	60%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	14%
State Boat Launch	1%	74%	2%	0%	1%	0%	11%	0%	0%	0%	1%	0%	2%	0%	0%	0%	0%	0%	0%	8%
Canalside Trail Bike Path	41%	0%	0%	56%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Gatehouse Fishway Viewing Area[1]	35%	0%	6%	8%	14%	0%	0%	21%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	0%	15%
Turners Falls Branch Canal/Station No. 1 Fishing Access	29%	0%	24%	24%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	0%	0%	0%	19%
Cabot Woods Fishing Access	58%	0%	11%	10%	3%	0%	0%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	0%	17%
Poplar Street Access	23%	0%	41%	3%	0%	0%	21%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	11%
Rose Ledge Climbing Area Parking	20%	0%	0%	0%	0%	75%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	4%
Farley Ledge Climbing Area—Wells Street Parking	73%	0%	0%	0%	0%	26%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
Farley Ledge Climbing Area—Route 2 Parking	20%	0%	0%	0%	0%	77%	0%	0%	0%	0%	1%	0%	0%	0%	1%	1%	0%	0%	0%	1%
Total Project-Wide Use of the above Sites.	32%	12%	7%	6%	5%	4%	4%	4%	2%	2%	1%	1%	1%	1%	0.5%	0.4%	0.1%	0.1%	0.1%	17%

[1] *Use includes visitors utilizing the Visitor Center and the associated picnic area, which includes a portion of the Canalside Trail Bike Path.*

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Table 3.3.6.1.5-3: Capacity Utilization by Site

Site	Recreation Days	Percent Capacity Utilized, Weekends, Peak Season	Peak Season
Governor Hunt Boat Launch	1,856	50%	Summer
Pauchaug WMA	1,002	10%	Fall
Pauchaug Boat Launch	9,832	20%	Summer
Bennett Meadow WMA	3,750	40%	Fall
Munn's Ferry Boat Camping Recreation Area	1,564	35%	Summer
Boat Tour and Riverview Picnic Area	13,762	15%	Fall
Northfield Mountain Tour and Trail Center	18,226	10%	Summer
Cabot Camp Access Area	5,387	15%	Summer
Barton Cove Nature Area	8,607	35%	Summer
Barton Cove Campground	3,200	45%	Summer
Barton Cove Canoe and Kayak Rental Area	4,141	25%	Summer
State Boat Launch	15,501	65%	Summer
Canalside Trail Bike Path	6,489	NA	N/A
Gatehouse Fishway Viewing Area/Unity Park	28,548	25%	Fall
Turners Falls Branch Canal/Station No. 1 Fishing Access	1,121	10%	Winter
Cabot Woods Fishing Access	18,367	30%	Spring
Poplar Street Access	1,907	15%	Summer
Rose Ledge Climbing Area Parking	1,812	60%	Summer
Farley Ledge Climbing Area—Wells Street Parking	2,371	30%	Summer
Farley Ledge Climbing Area—Route 2 Parking	6,206	90%	Spring
Annual Total	153,647		

Table 3.3.6.1.9-1: Average Number of Days Per Month Spill Flows Equal or Exceed Boating Evaluation Flows[1]

Month	Total No. of Days per Month (flow between 2,500 and 13,000 cfs)	Total No. of Days in the Month (flow between 2,500 and 13,000 cfs)	%	Average No. of Days per Month (flow between 2,500 and 13,000 cfs)	Total No. of Days per Month (flow greater than 13,000 cfs)	%	Average No. of Days per Month (flow greater 13,000 cfs)	Total No. of Days per Month (flow greater than 2,500 cfs)	%	Average number of Days per Month (flow greater 2,500 cfs)
April[2]	579	2,160	26.8%	8.0	1,052	48.7%	14.6	1,631	75.5%	22.7
May[2]	489	2,232	21.9%	6.8	394	17.7%	5.5	883	39.6%	12.3
June[2]	129	2,160	6.0%	1.8	67	3.1%	0.9	196	9.1%	2.7
July	49	2,232	2.2%	0.7	28	1.3%	0.4	77	3.4%	1.1
August	39	2,232	1.7%	0.5	22	1.0%	0.3	61	2.7%	0.8
September	32	2,160	1.5%	0.4	22	1.0%	0.3	54	2.5%	0.8
October	103	2,232	4.6%	1.4	92	4.1%	1.3	195	8.7%	2.7
Total	1,420	15,408	9.2%	19.7	1,677	10.9%	23.3	3,097	20.1%	43.0

[1] Based on period of record 1941-2018

[2] April 1 to June 30 is a period when the federally endangered Shortnose Sturgeon could be utilizing the bypass reach for spawning and incubation which could be disturbed by whitewater boaters.

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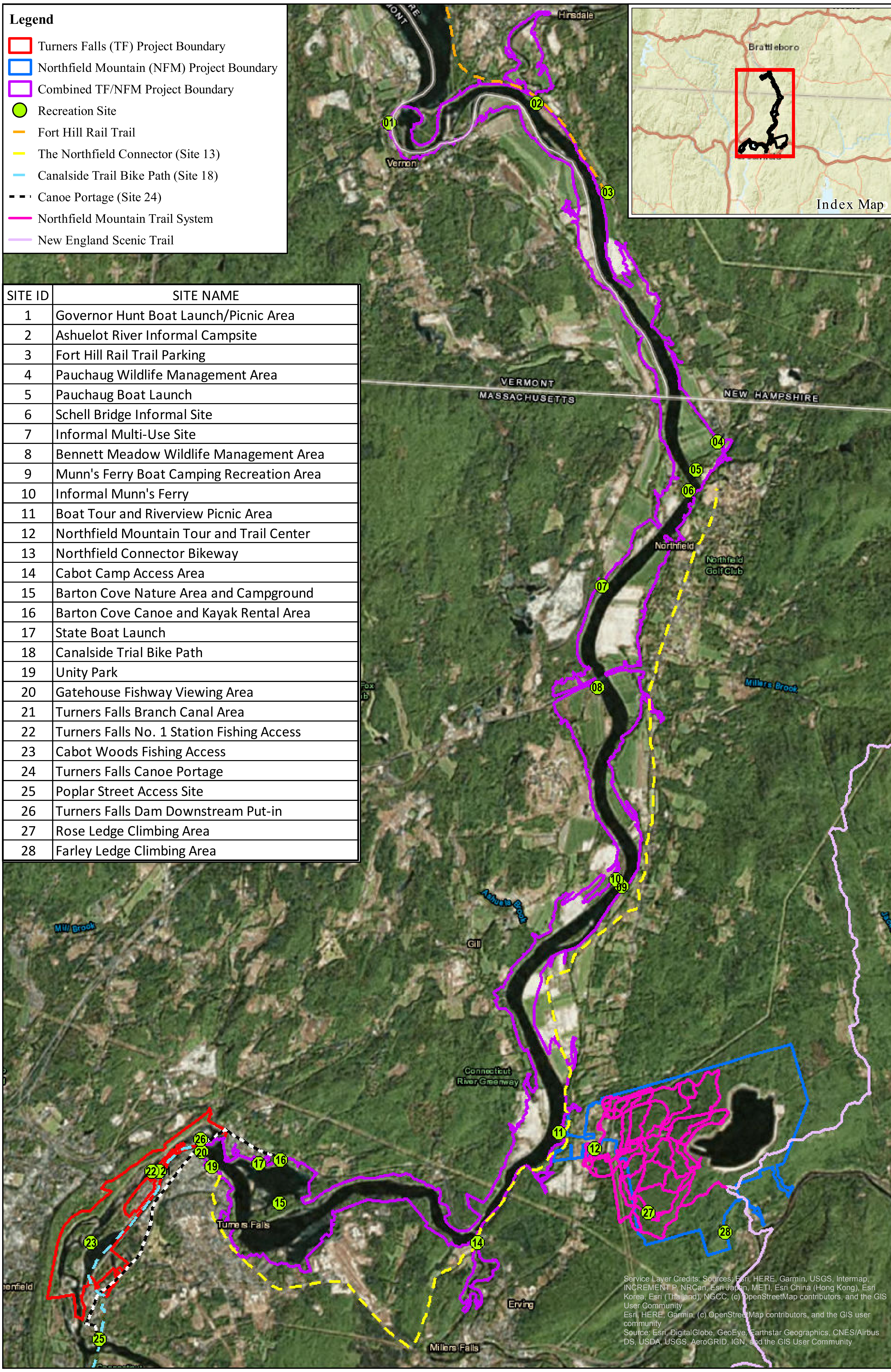

SITE ID	SITE NAME
1	Governor Hunt Boat Launch/Picnic Area
2	Ashuelot River Informal Campsite
3	Fort Hill Rail Trail Parking
4	Pauchaug Wildlife Management Area
5	Pauchaug Boat Launch
6	Schell Bridge Informal Site
7	Informal Multi-Use Site
8	Bennett Meadow Wildlife Management Area
9	Munn's Ferry Boat Camping Recreation Area
10	Informal Munn's Ferry
11	Boat Tour and Riverview Picnic Area
12	Northfield Mountain Tour and Trail Center
13	Northfield Connector Bikeway
14	Cabot Camp Access Area
15	Barton Cove Nature Area and Campground
16	Barton Cove Canoe and Kayak Rental Area
17	State Boat Launch
18	Canalside Trial Bike Path
19	Unity Park
20	Gatehouse Fishway Viewing Area
21	Turners Falls Branch Canal Area
22	Turners Falls No. 1 Station Fishing Access
23	Cabot Woods Fishing Access
24	Turners Falls Canoe Portage
25	Poplar Street Access Site
26	Turners Falls Dam Downstream Put-in
27	Rose Ledge Climbing Area
28	Farley Ledge Climbing Area

FirstLight

N

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E

0 0.5 1 2
Miles

Figure 3.3.6.1.1-1:
Existing Recreation Sites
and Facilities

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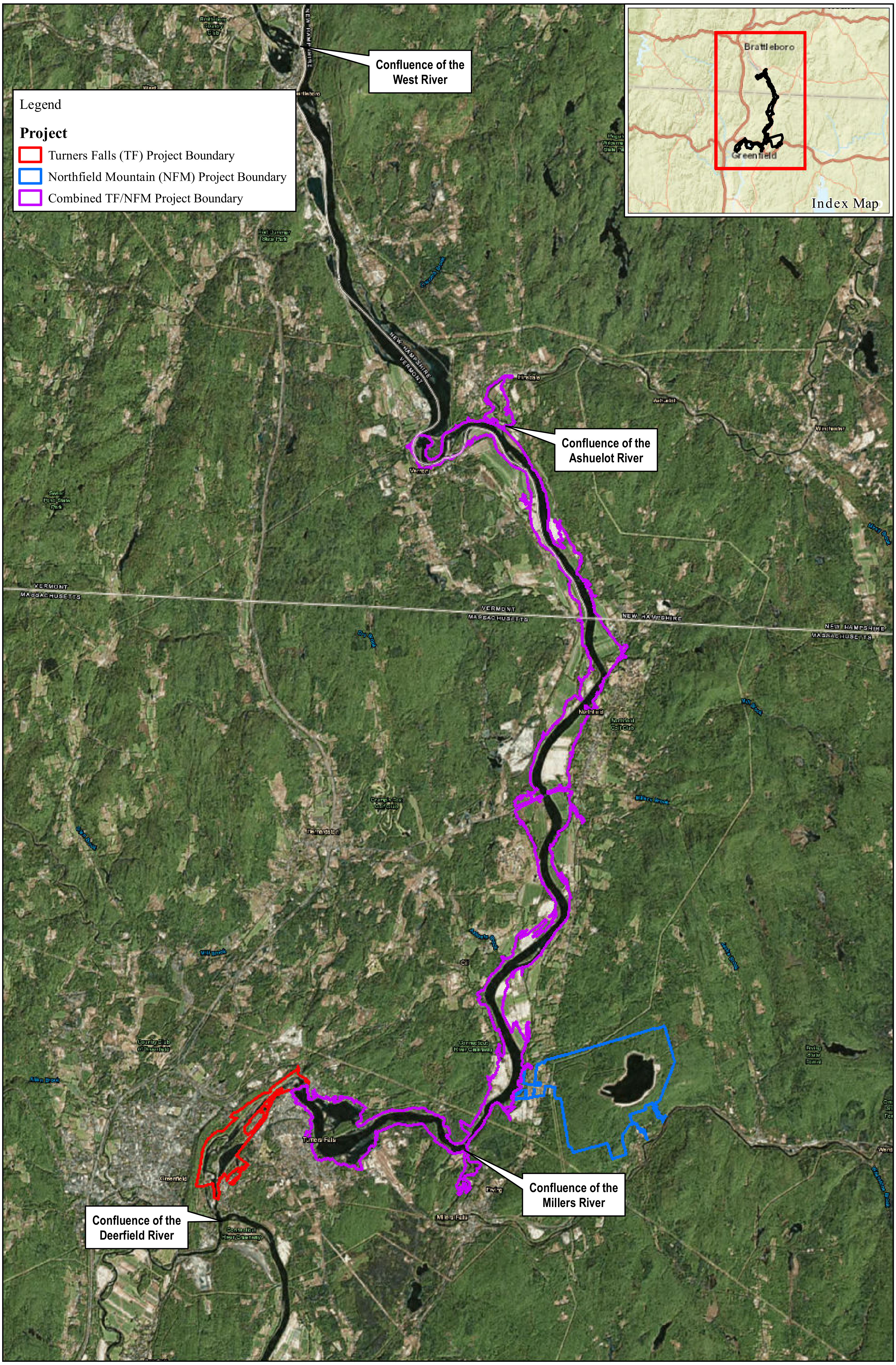

FirstLight

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E

Figure 3.3.6.1.9-1:
Regional Rivers Containing Whitewater Boating Opportunities

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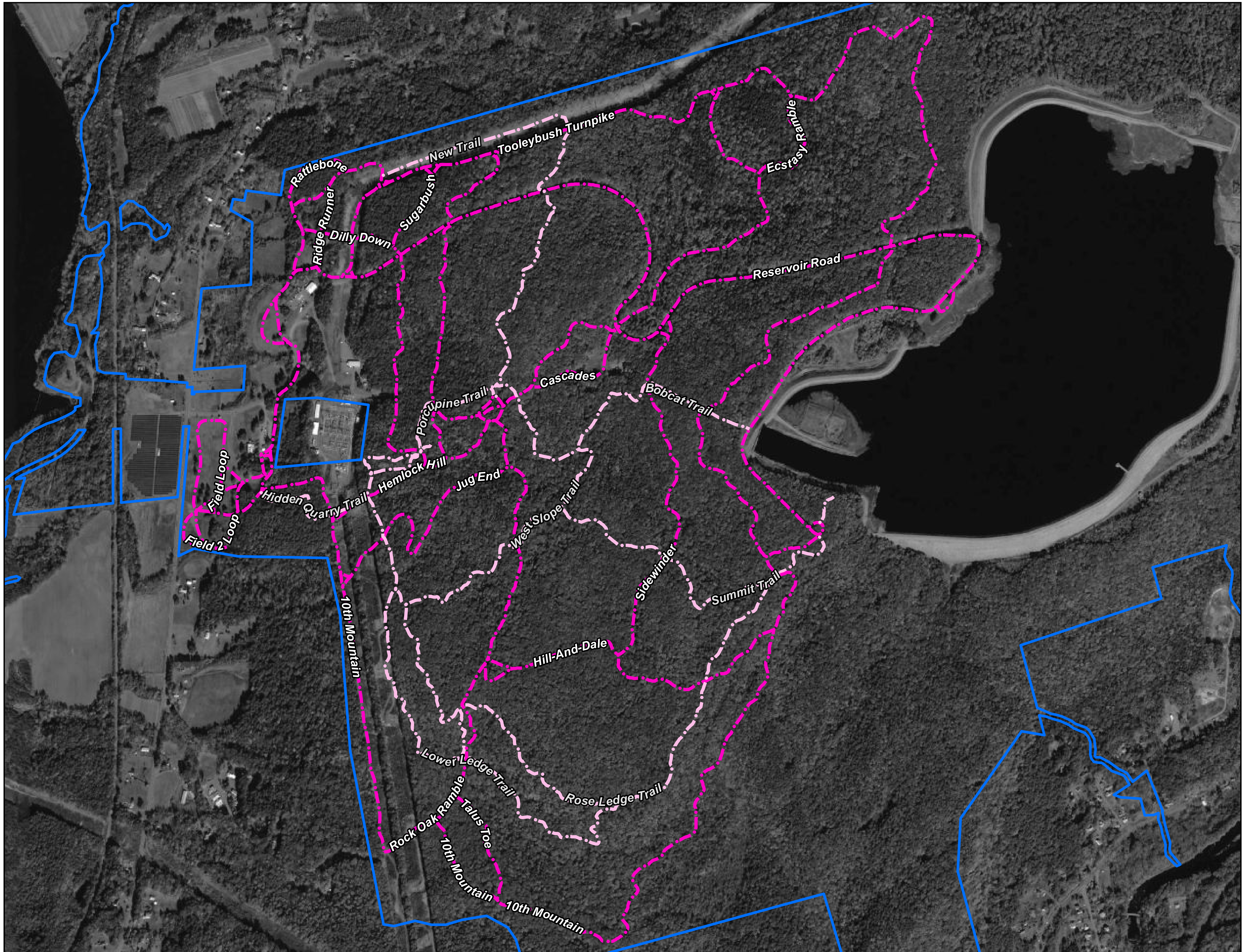

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E

Figure 3.3.6.1.12-1:
Northfield Mountain Trail System

Legend

N

FERC Project Boundary

NFM Trail Type

Ski Trail

Snowshoe Trail

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

0 500 1,000 2,000
Feet

1 inch = 1,000 feet

FirstLight

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3.3.7 Land Use

3.3.7.1 Affected Environment

3.3.7.1.1 Project Lands

The Project is situated on the Connecticut River, within the states of MA, NH, and VT. The Project is comprised of the Turners Falls Project and the Northfield Mountain Project. The Turners Falls Dam is located at RM 122 of the Connecticut River, (above the Long Island Sound) in the towns of Gill and Montague, MA. The TFI is approximately 20 miles long, with 5.7 miles located in the towns of Vernon, VT and Hinsdale, NH. The Northfield Mountain Project is located approximately 5.2 miles upstream of the Turners Falls Dam and utilizes the TFI as its lower reservoir. The Upper Reservoir is located atop Northfield Mountain to the east of the TFI. With the exception of the northern portion of the TFI extending into VT and NH, Project lands are located within the county of Franklin, MA, specifically in the towns of Erving, Gill, Greenfield, Montague, and Northfield.

An overview of the existing Project boundaries is shown in Figure 3.3.7.1.1-1. As shown, the boundary extends upstream along the Connecticut River approximately 20 miles to GRH's Vernon Hydroelectric Project Dam, located in the towns of Vernon, VT, and Hinsdale, NH. The Project extends to the east up to Northfield Mountain, to include the Northfield Mountain Upper Reservoir, north of State Route 2. The Project extends downstream of the Turners Falls Dam to Cabot Station, a hydroelectric generating facility, which is part of the Turners Falls Project.

The existing Project boundaries encompasses 7,246 acres: 2,238 acres of flowed land and 5,008 acres of upland, at minimum flow conditions.[23] When the river is at maximum flow (50 year flood) conditions, there are 3,981 acres of flowed land and 3,265 acres of upland.[24] There are no federal lands within the Project boundaries, with the exception of land associated with the Conte Fish Lab, which is owned and operated by the USGS, and which is not necessary for Project purposes. As discussed in more detail in Section 3.3.7.4, FirstLight is proposing to remove the lands associated with the Conte Fish Lab from the existing Project boundaries (see Exhibit G).

The land use in and around the Project boundaries consists primarily of recreation, agricultural, and forested lands. There are pockets of developed areas around the Project that consist of roads, industrial buildings and residences. There are also a variety of wetland areas along the banks of the river and in low lying areas within the Project area. There is a distinct difference in land uses between the lands north of the NMTTC and the lands surrounding the Turners Falls Dam. The land in and around the northern portion of the Project is mostly rural and there is very little developed land. Land that is developed consists of residential areas, roads and farming complexes. The lands surrounding the southern portion of the Project are more developed in nature, consisting primarily of residences and industrial lots with pockets of parks and greenspace. There are recreational use areas that are dispersed throughout the Project area with boat launches, hunting areas and fishing areas.

3.3.7.1.2 Land Use Designation of Lands within the Project Boundaries

As part of Study No. 3.6.5 (*Land Use Inventory*), lands within the existing Project boundaries were classified and mapped in eight (8) proposed land use designations (Figure 3.3.7.1.2-1- 11 maps) (FirstLight, 2015h). National Land Cover Database (NLCD) layers were utilized in combination with Massachusetts Geographic Information System (MassGIS) layers to develop the land use designations. This information was then reviewed and refined by utilizing information gathered from Study No. 3.4.1 *Baseline Study of Terrestrial Wildlife and Botanical Resource* (FirstLight, 2015g); Study No. 3.5.1 *Baseline Inventory of*

[23] The minimum flow represents the minimum flow required to maintain elevation 176.0 feet throughout the TFI.
[24] The maximum flow condition represents the 50 year flood scenario of 126,000 cfs.

Wetland, Riparian and Littoral Habitat in the TFI, and Assessment of Operational Impacts on Special Status Species (FirstLight, 2015c); Study No. 3.7.1 *Phase IA (Reconnaissance) Archaeological Surveys* (Sara *et al*. 2014a, 2014b) and Study No. 3.7.2 *Historic Architectural Resources Survey & National Register Evaluation* (FirstLight, 2014c, 2015j), as appropriate.

The eight (8) proposed land use designations for lands within the Project boundaries are:

- **Agricultural – Crops**: generally tilled land used to grow row crops. Boundaries follow the shape of the fields and include associated buildings (e.g. barns). This category also includes turf farms that grow sod.
- **Agricultural – Pasture/Grass**: Fields and associated facilities (barns and other outbuildings) used for animal grazing and for the growing of grasses for hay.
- **Natural/Undeveloped**: Vacant land, idle agriculture, rock outcrops, and barren areas. Vacant land is not maintained for any evident purpose and it does not support large plant growth. This designation also includes shrub cover, and some immature tress not larger or dense enough to be categorized as forested. It also includes areas that are more permanently shrubby.
- **Developed**: areas with a mixture of constructed materials and vegetation that is mostly in the form of grass.
- **Forested**: areas where tree canopy covers at least 50% of the land. Both coniferous and deciduous forests belong to this class.
- **Wetland**: Areas of vegetation, where the soil or substrate is periodically saturated with or covered with water.
- **Open Water**: areas of open water.
- **Recreation:** Lands managed for developed public recreational facilities and activities. This includes recreational sites described in the report for Study No. 3.6.2 *Recreation Facilities Inventory and Assessment Addendum* (FirstLight, 2015c) and recreation facilities managed by private landowners.[25]

Table 3.3.7.1.2-1 provides a summary of the acreages of lands within the existing Project boundaries for each land use designation. As shown, the majority of land within the Project boundaries is Recreation (1,835 acres), Agricultural-Crops (1,010 acres), and Forested (951 acres).

3.3.7.1.3 Conservation Lands within 200 feet of the Project Boundaries

As part of Study No. 3.6.5, several different types of protections were identified on lands within the Project boundaries and within 200 ft of the Project boundaries using publicly available information (FirstLight, 2015h). These protections include agricultural preservation restrictions and conservation restrictions. Approximately 715 acres of conserved land in the State of MA were identified as either within the Project boundaries (approximately 414 acres) or within 200 ft of the Project boundaries (approximately 301 acres). The purpose of the conservation protections fall into four categories: wildlife management; recreation; natural, undeveloped, and scenic; and agricultural preservation. The majority of the land conserved within the Project boundaries is conserved for agriculture and wildlife management while the majority of the land conserved within 200 ft of the Project boundaries is conserved for agriculture and recreation. This information was obtained from the MassGIS Protected and Recreational Open Space data layer. There were no conserved lands identified within the Project boundaries or within 200 ft of the Project boundaries in NH or VT. This information was based on data collected from the National Conservation Easement Database. An online search of land trusts and land conservation organizations working in the vicinity of the Projects did not identify any additional conserved lands within the Project boundaries or within 200 ft of the Project boundaries.

[25] Recreation facilities managed by private landowners are the Turners Falls Rod and Gun Club, the Franklin County Boat Club, and Turners Falls Schuetzen Verein.

3.3.7.1.4 Special Designated Areas

Portions of land within and adjacent to the Project are designated under various national and statewide programs dedicated to promoting outdoor recreation needs, as well as conservation and protection of the natural environment.

National Trails System

The National Trail System Act of 1968 authorized creation of a trail system comprised of National Recreational Trail, National Scenic Trails, and National Historic Trails. National Recreation Trails may be designated by the Secretary of Interior or the Secretary of Agriculture to recognize exemplary trails of local and regional significance in response to an application from the trail's managing agency or organization. There is one National Scenic trail passing through the Project boundary. The New England National Scenic Trail (NET) is a 220-mile hiking trail travelling through 39 communities in CT and MA. Approximately 6,600 feet of the trail passes through the Northfield Mountain Project boundary near the southern edge of the Northfield Mountain Project's Upper Reservoir. The portion of the NET lying within the Project boundary is not operated or maintained by FirstLight. However, there is a connector trail providing access to the NET from the NMTTC Trail System that is maintained by FirstLight.

Massachusetts Natural Heritage and Endangered Species Program

The MA Natural Heritage and Endangered Species Program (NHESP) focuses on protecting and conserving vertebrate and invertebrate animals, as well as native plants, that are officially listed as Endangered, Threatened, or of Special Concern in the state of MA. NHESP gathers and provides information on priority habitat for all rare listed state species of plants and animals. Rattlesnake Mountain, which includes Farley Ledge, sits on the southern border of the Northfield Mountain Project boundary and is identified as priority habitat.

Wild and Scenic Rivers

The Federal government has developed a scenic and wild river program intended to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The Project is not located within or adjacent to a river designated as part of the National Wild and Scenic River System.

National Natural Landmarks

The National Natural Landmarks Program administered through the National Park Service recognizes and encourages the conservation of sites containing outstanding biologic and geologic resources. Though there are National Natural Landmarks in the state, there are none within or adjacent to the Project boundaries.

3.3.7.1.5 Non-Project Uses of Project Lands

FirstLight has an established Permit Program through which it administers non-project uses of lands within the Project boundaries including lands it owns in fee, or in which it has an interest (Howard, 2008). Under its Permit Program it is FirstLight's policy to "protect the scenic, recreational, and other environmental values of the Project, consistent with safe, efficient operation." The Permit Program follows the requirements of the Standard Land Use Articles in the current licenses for the Project.

Consistent with the Standard Land Use articles, FirstLight's Permit Program recognizes four categories of proposed uses of Project lands that require varying levels of FERC notification and control requirements:
Category A: Miscellaneous uses and/or conveyances of interests not addressed in subsequent categories which may require FERC approval. For Category A uses, FirstLight assesses the proposed use, and determines on a case-by-case basis the best method of processing the proposed use/conveyance request such as processing the proposed use under Category B, C, or D, or obtaining prior FERC approval prior to granting permission. Category A uses are typically temporary use of non-project lands for one-time events, such as running races, state cross-country meets, horseback riding, and triathlons.

Category B: Uses associated with single-family residential dwellings abutting the Project boundaries such as (1) landscape planting; (2) non-commercial piers, landings, boat docks or similar facilities; and (3) embankments, bulkheads, retaining walls, or similar structures for erosion control to protect the existing shoreline. For Category B uses, FirstLight has an established program for issuing permits without prior FERC approval or notification for the specified types of use and occupancy of Project lands and waters, which may be subject to the payment of a reasonable fee to cover the costs of administering the permit program. For proposed uses in this category, FirstLight places an emphasis on multiple use and occupancy of facilities for access to Project lands or waters. FirstLight also ensures, to the extent practical, that the uses and occupancies for which it grants permission are maintained in good repair and comply with applicable State and local environmental, health, and safety requirements. Before granting permission for construction of bulkheads or retaining walls, FirstLight inspects the site to consider whether planting vegetation, grading or the use of riprap would be adequate to control erosion at the sites, and to determine that the proposed construction is needed and would not change the basic contour of the reservoir.

Category C: Municipal and utility uses such as (1) replacement, expansion, realignment, or maintenance of bridges and roads for which all necessary State and Federal approvals have been obtained; (2) storm drains and water mains; (3) sewers that do not discharge into project waters; (4) minor access roads; (5) telephone, gas and electric distribution lines; (6) non-project overhead electric transmission lines that do not require erection of support structures within the project boundary; (7) submarine, overhead, or underground major telephone distribution cables or major electric distribution lines (69-kV or less); and (8) water intake or pumping facilities that do not extract more than one million gallons per day from a project reservoir. For Category C uses, consistent with the Standard Land Use articles, no later than January 15 of each year, FirstLight prepares a report for the Project, which is filed with FERC, that briefly describes each conveyance made during the calendar year.

Category D: Uses such as (1) construction of new bridges or roads for which all necessary State and Federal approvals have been obtained; (2) sewer or effluent lines that discharge into project waters, for which all necessary Federal and State water quality certificates or permits have been obtained; (3) other pipelines that cross project lands or waters but do not discharge into project waters; (4) non-project overhead electric transmission lines that require erection of support structures within the project boundary, for which all necessary Federal and State approvals have been obtained; (5) private or public marinas that can accommodate no more than 10 watercraft at a time and are located at least one-half mile from any other private or public marina; (6) recreational development consistent with an approved Exhibit R or approved report on recreational resources of an Exhibit E; and (7) other uses, if: (i) the amount of land conveyed or a particular use is five acres or less: (ii) all of the land conveyed is located at least 75 feet, measured horizontally, from the edge of the project reservoir at normal maximum surface elevation: and (iii) no more than 50 total acres of project lands for each project development acres conveyed under this category in any calendar year. For Category D uses, prior to conveying any interest in Project lands or waters, FirstLight conducts an internal review of the proposed use, and prepares information about the proposed use, including the location of the lands to be conveyed, the nature of the proposed use, and the identity of any Federal or State agencies consulted or approvals needed. At least 45 days prior to conveyance, FirstLight files the information on the proposed use and conveyance with FERC. Unless FERC, within 45 days from the filing date, requires FirstLight to file an application for prior approval, FirstLight then conveys the intended interest at the end of that period.

For both Category C and D uses, before notifying FERC, FirstLight consults with Federal and State fish and wildlife agencies, as appropriate, and the State Historic Preservation Officer.
For all categories of uses, FirstLight also reviews the proposed use/conveyance to ensure that it is not inconsistent with any FERC approved recreational resources.

Proposed uses of Project lands in all categories of uses are, to the extent practical, reviewed by FirstLight to ensure that the proposed use or conveyance of rights will not adversely affect the operation of the Project. Permits granted by FirstLight under its Permit Program for non-Project use of Project lands are generally in the form of a 5-year revocable license agreement. The license agreements regulate such use and occupancy through numerous provisions protecting Project and natural resources and thus are consistent with the "protection and enhancement of the project's scenic, recreation, or other environmental values…"[26] License agreement terms can vary, and all can be terminated upon 6 months' notice by either party. The license agreements also expressly state that they are "subject to the terms and conditions as imposed by the FERC Project Licenses or to be imposed by FERC in connection with any order relative to the Projects." As a result of this provision, the ability of the Commission to further condition or even prohibit such authorized use and occupancy in order to meet the public interest standard of Section 10(a) of the Federal Power Act is fully preserved by FirstLight. All license agreements have in common the provisions below:

- The license holder must allow unobstructed use of the property by the public without regard to race, color, religious creed or national origin.
- The license is not transferable.
- The license holder must obtain all necessary federal, state, and local permits.
- Excavation, clearing, grading or filling of property is prohibited.
- Docks, piers, walls or other waterway improvements are prohibited unless all state and federal approvals have been obtained.
- Construction of any structures, fixtures or improvements on the property is prohibited without prior written approval by FirstLight.
- Parking or storage of vehicles or equipment on Project Property is prohibited, unless expressly authorized by conditions of the license.
- Hazardous materials may not be used or stored on the property unless otherwise authorized by the conditions of the license.
- Removal of timber, vegetation or plantings is prohibited without prior written permission from FirstLight.
- FirstLight reserves its right to flood and flow water on the property.
- The application of any fertilizer, pesticides and herbicides is prohibited (applicable to vegetated shoreline sites).
- FirstLight may require the license holder to plant and maintain native vegetation to reduce or prevent erosion and run-off into the Connecticut River (applicable to vegetated shoreline sites).

These requirements provide a comprehensive regulatory structure that assures that the granting of permission for non-project uses does not adversely affect the Project's scenic, recreational and environmental values.

Non-project uses at the Project generally include camps (24) within the Project boundary, docks (46[27]), landscape uses for abutters (8), and water withdrawals (8). Thirty-three of the 46 docks are located either in Barton Cove or just upstream of Barton Cove. In addition, FirstLight annually grants a number of permissions for temporary use of non-project lands for one-time events, such as running races, state cross-country meets, horseback riding, and triathlons. The camps and associated docks located within the Project boundary are a historic use with most dating to the 1920s. Most of the landscape uses date from 1972 through 1984. Five of the water withdrawals date from 2002 through 2011 and three water withdrawals date from 1990 or before. The Turners Falls Rod and Gun Club (sporting club with two docks) was

[26] Article 52(a) of the Northfield Mountain Project License and Article 43(a) of the Turners Falls Project License.
[27] Of these 46 docks, four are associated with Project Recreation Sites that are available for public use. These include the docks at the State Boat Launch, Barton Cove Nature Area, Boat Tour and Riverview Picnic Area and Munn's Ferry Boat and Camping Recreation Area.

constructed in the 1920s-1930s and the boat docks have been in place for 40 years. The Franklin County Boat Club (public marina with four boat docks) has been in existence at the current location within the Project boundary since 1971.

3.3.7.2 Environmental Effects

FirstLight's management of lands within the Project boundaries has been consistent with the land use categories developed for the Project and has been protective of sensitive resources. Continued operation of the Project, as proposed, will enable Project lands or the land uses surrounding the Project to continue. Project lands will continue to be a mix of forested, developed and agricultural lands which, for the most part, will remain available for public use for recreation. Non-project uses of Project lands will continue to be approved and managed by FirstLight in accordance with the terms of the standard land use articles that are anticipated to be included in the new licenses. As they do currently, under the new licenses FirstLight will carefully manage non-project use of Project lands by issuing short-term license agreements/leases (typically 5 years) to ensure that uses of the lands are consistent with Project purposes, that non-project uses of the lands are limited to the uses specified under the terms of the license agreement/lease, and that disturbance to the land, vegetation, and any other natural features are minimized. FirstLight will revoke or will not renew license agreements or leases for such non-project use of Project lands if terms of those license agreements/leases are violated. For requested non-project uses of Project lands that have the potential to impact significant resources, including wetlands, historic properties, traditional cultural sites, RTE species or their habitats, or other important habitats, FirstLight will consult with the appropriate agencies before approving the requested non-project use of Project lands. For requested non-project uses of Project lands that require prior FERC approval, FirstLight will consult with the appropriate agencies and then prepare a request package for FERC that includes the results of the consultation and information about the proposed use of the lands. Overall, the continued operation of the Project, as proposed, will maintain the character of surrounding lands and will promote public interaction with the surrounding nature through the NMTTC, parks, trails and campgrounds. Use of adjacent lands is not anticipated to be affected by FirstLight's proposal for relicensing the Project.

3.3.7.3 Cumulative Effects

There are no cumulative effects identified for land use in the Project.

3.3.7.4 Proposed Environmental Measures

As described in Exhibit G for the Turners Falls Project and Exhibit G for the Northfield Mountain Project, FirstLight is proposing changes to each Project boundary as summarized below. Maps showing the proposed changes to the Project boundaries are contained in Exhibit G.

Turners Falls Project and Northfield Mountain Project Overlapping Project Boundary Changes

- The removal of a 0.2 acre parcel of land at 39 Riverview Drive in Gill, MA. FirstLight has no ownership rights on this residential parcel and land rights are not needed for Project operations or any other Project purpose. None of the lands FirstLight proposes to exclude from the Project boundary contains historic properties eligible or potentially eligible for the National Register of Historic Places.

Turners Falls Project Boundary Changes

- The removal of a 20.1 acre parcel of land currently occupied by the United States Geological Survey's (USGS) Silvio Conte Anadromous Fish Laboratory located at One Migratory Way, P.O Box 796, in Turners Falls, MA 01376. The Conte Lab lands are located just north of Cabot Station. The Conte Lab does not serve any Project purpose and is not necessary to fulfill any license requirements. Nor are there any significant natural or recreational resources located on Conte Lab property. The Phase

IA Study identified several previously recorded archaeological resources on this parcel, which have not been investigated for NRHP eligibility. Nonetheless, because the parcel will remain under the ownership of USGS (a federal governmental entity), which is subject to Section 106 requirements, there will be no adverse effect as a result of removing the Conte Lab parcel from the Project. FirstLight's historical structures survey did not identify any eligible historic structures on this parcel. There are two parking lots owned by FirstLight, within the vicinity of the Conte Lab, which can be utilized for recreational access to the Cabot Woods Fishing Access site. These parking lots will remain within the Turners Falls Project boundary.

- The addition of an 0.8 acre parcel of land owned by FirstLight at 21 Poplar Street (end of street) in Montague, MA. These lands are needed for recreational purposes (take-out or put-in. As discussed in Section 3.3.6, FirstLight is proposing to develop a formal access trail and stairs for a take-out at Poplar Street, which is currently a non-Project recreation site with an existing steep take-out.

Northfield Mountain Project Boundary Changes

- The removal of an 8.1 acre parcel of land referred to as Fuller Farm located near 169 Millers Falls Road in Northfield, MA. This parcel has a land use designation of Developed, Agricultural – Pasture/Grass, and Forested. The 8.1-acre farm property includes residential and agricultural structures, and the underlying lands are not necessary for power generation, recreation, or any other Project purpose. FirstLight's historical structures survey found that the buildings (house, barn, and outbuildings) located on the 8.1 acre parcel are not eligible for listing on the NRHP due to lack of historic/architectural significance and lack of integrity.[28] While FirstLight's Phase IA reconnaissance level archaeological survey included the Fuller Farm parcel in its recommendations for Phase IB survey, the parcel is not in a location that is susceptible to erosion or in an area that suggests there are Project-related effects on the property .

- The addition of 135.5 acres[29] of land south of the Northfield Switching Station located in the Towns of Northfield and Erving, MA. Some of these lands are currently owned by Eversource and are necessary to include recreation trails associated with the Northfield Mountain Trail and Tour Center that are not currently enclosed in the Project boundary.

FirstLight has developed land use designations, which will be used by FirstLight via GIS mapping (including a non-public sensitive resources overlay map) to aid in land management activities, including vegetation management. FirstLight will continue to make land management decisions that are consistent with these land use designations and to be protective of sensitive resources. There are no other environmental measures related to land uses proposed at this time.

3.3.7.5 Unavoidable Adverse Impacts

No unavoidable adverse impacts are expected to land use in the Project.

References:

FirstLight. (2014c). Relicensing Study 3.7.2 Historic Architectural Resources Survey and National Register Evaluation. Prepared by Gomez and Sullivan Engineers & TRC Solutions. Northfield, MA: Author.

[28] Historic Architectural Resources Survey & National Register Evaluation at V-35, Project Nos. 2485 and 1889 (filed Jan. 21, 2015).

[29] The removal of a 20.1 acre parcel of land currently occupied by the United States Geological Survey's (USGS) Silvio Conte Anadromous Fish Laboratory located at One Migratory Way, P.O Box 796, in Turners Falls, MA 01376. The Conte Lab lands are located just north of Cabot Station.

FirstLight. (2015g). Relicensing Study 3.4.1 Baseline Study of Terrestrial Wildlife and Botanical Resources. Northfield, MA: FirstLight.

FirstLight. (2015h). Relicensing Study 3.6.5 Land Use Inventory. Prepared by Gomez and Sullivan Engineers and TRC Solutions. Northfield, MA: Author.

FirstLight. (2015c). Relicensing Study 3.6.2 Recreation Facilities Inventory and Assessment Addendum. Prepared by Gomez and Sullivan Engineers and TRC Solutions. Northfield, MA: Author.

FirstLight. (2015j). Relicensing Study 3.7.2 Historic Architectural Resources Survey & National Register Evaluation Report Addendum. Prepared by Gomez and Sullivan Engineers and TRC Solutions. Northfield, MA.

Howard, J. (2008). FERC Permit Program. Northfield, MA: FirstLight.

Sara T. R., Moore, E. Mundt, J. Walters, P. & Will, R. (2014a). Relicensing Study 3.7.1 Phase IA (Reconnaissance) Archaeological Survey. Prepared by TRC Environmental Corporation. Prepared for FirstLight Hydro Generating Company. Northfield, MA: FirstLight.

Sara T. R., Moore, E. Mundt, J. Walters, P. & Will, R. (2014b). Relicensing Study 3.7.1 Phase IA Archaeological Survey. TRC Environmental Corporation. Prepared for FirstLight Hydro Generating Company. Northfield, MA: FirstLight.

Table 3.3.7.1.2-1: Land Use Designations within the Project Boundaries

Land Use Designation	No. of Acres Within the Project Boundaries	% of Land within the Project Boundaries
Agricultural – Crops	1,010[1]	13.9
Agricultural - Pasture/Grass	37	0.5
Natural/Undeveloped	37	0.5
Developed	333	4.6
Forested	951	13.1
Open Water	2,647	36.5
Wetland	396	5.5
Recreation	1,835[2]	25.3
Total	**7,246**	**100**

[1] The majority of the agricultural cropland within the Project boundaries is on lands which FirstLight does not own in fee.

[2] Approximately 1,673 of these acres are the Northfield Mountain Tour and Trail Center.

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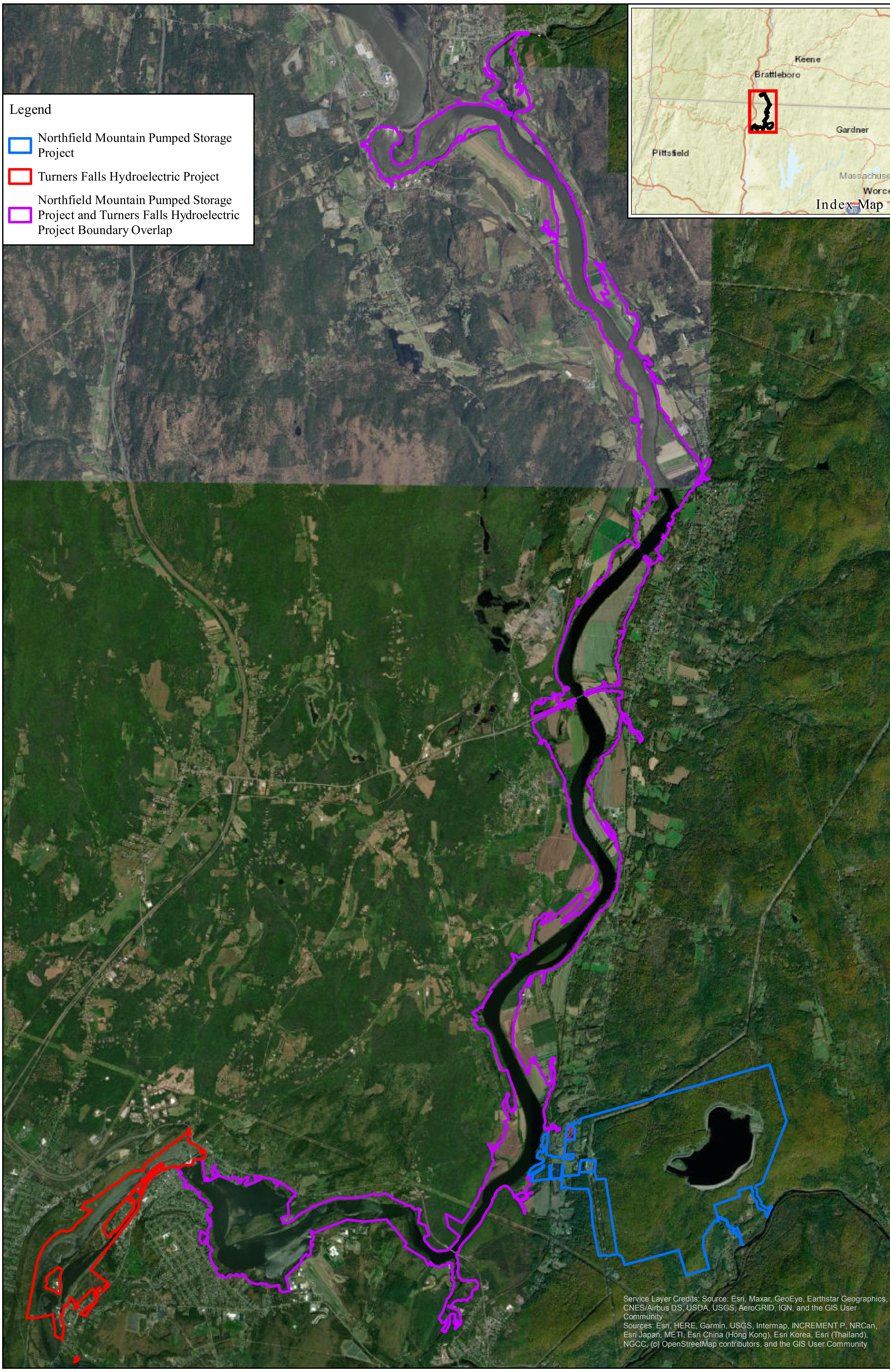

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Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E

Figure 3.3.7.1.1-1:
Existing Project Boundary

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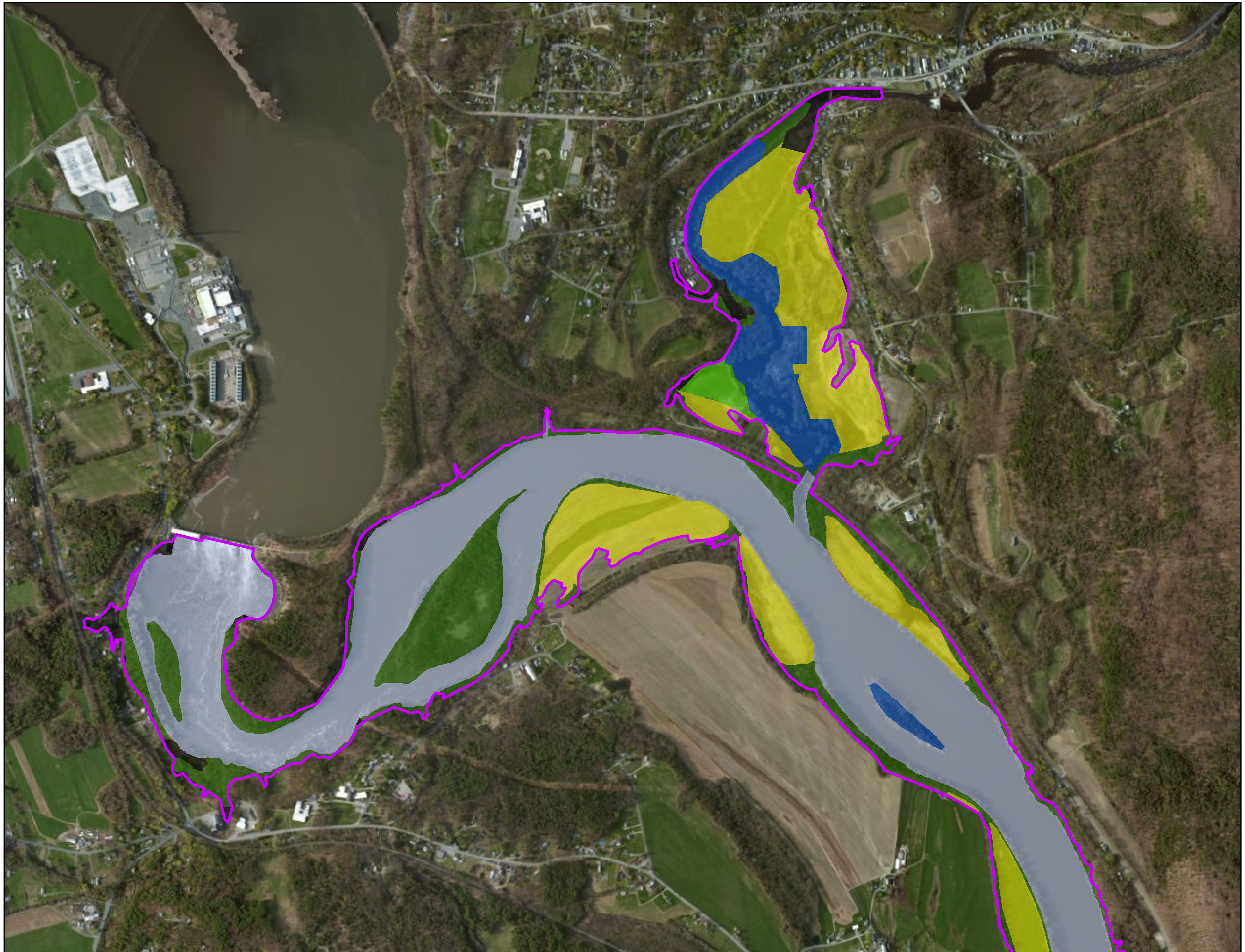

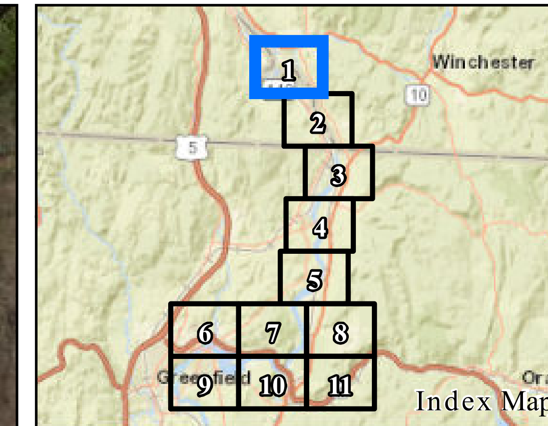

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 1

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project
- Northfield Mountain Pumped Storage Project and Turners Falls Hydroelectric Project Boundary Overlap

Land Use

- Agricultural - Crops
- Agriculture - Pasture/Grass
- Developed
- Forest
- Natural/Undeveloped
- Open Water
- Recreation
- Wetland

N

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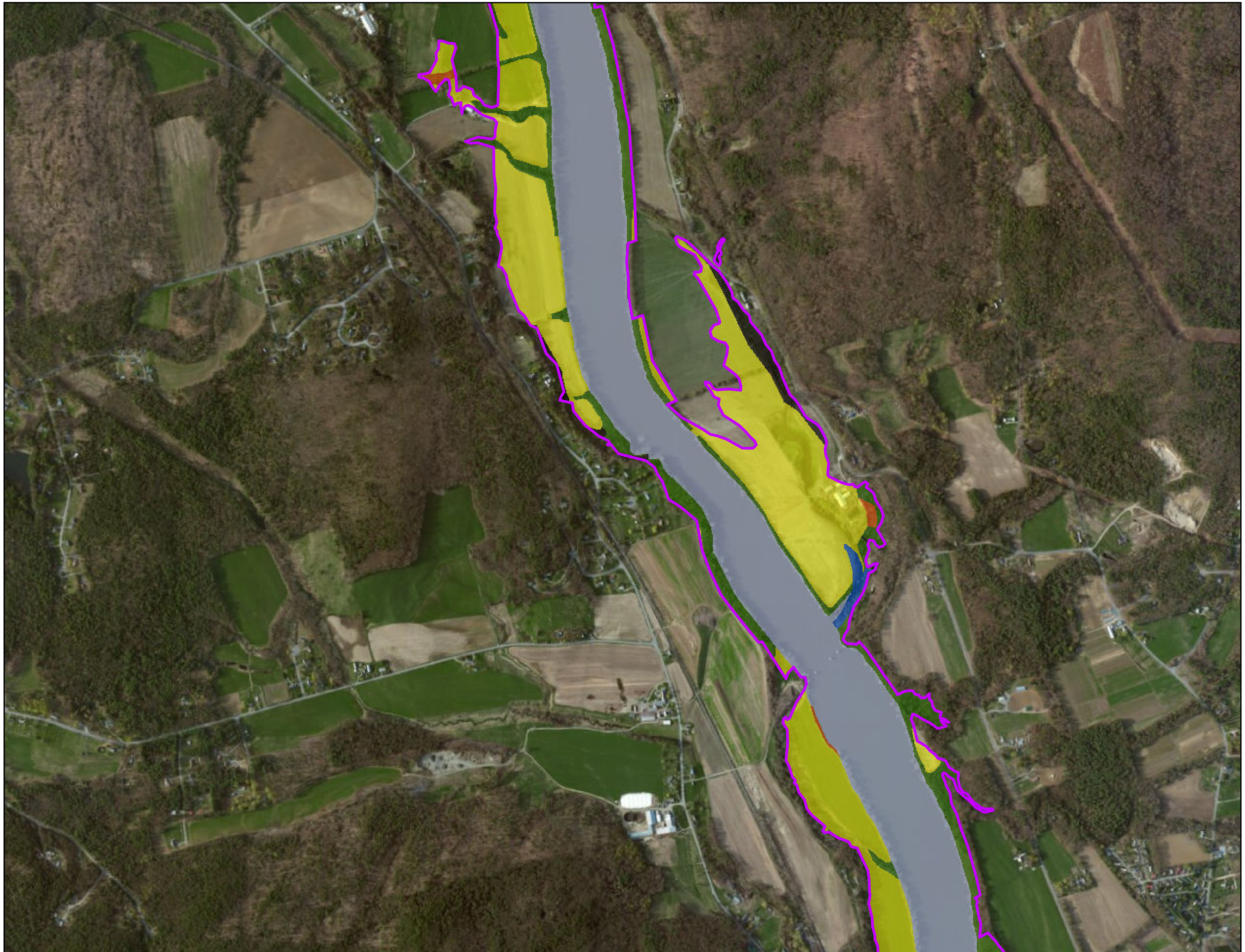

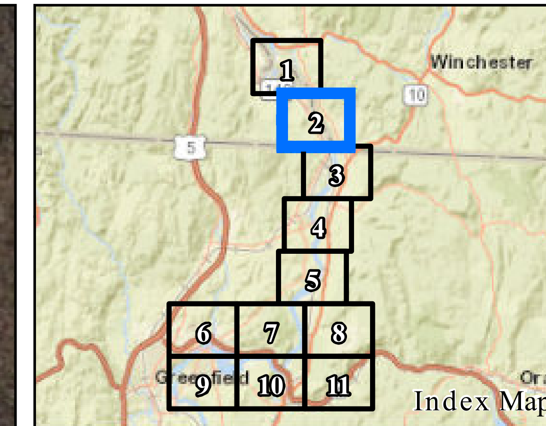

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 2

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project
- Northfield Mountain Pumped Storage Project and Turners Falls Hydroelectric Project Boundary Overlap

Land Use

- Agricultural - Crops
- Developed
- Forest
- Natural/Undeveloped
- Open Water
- Wetland

N

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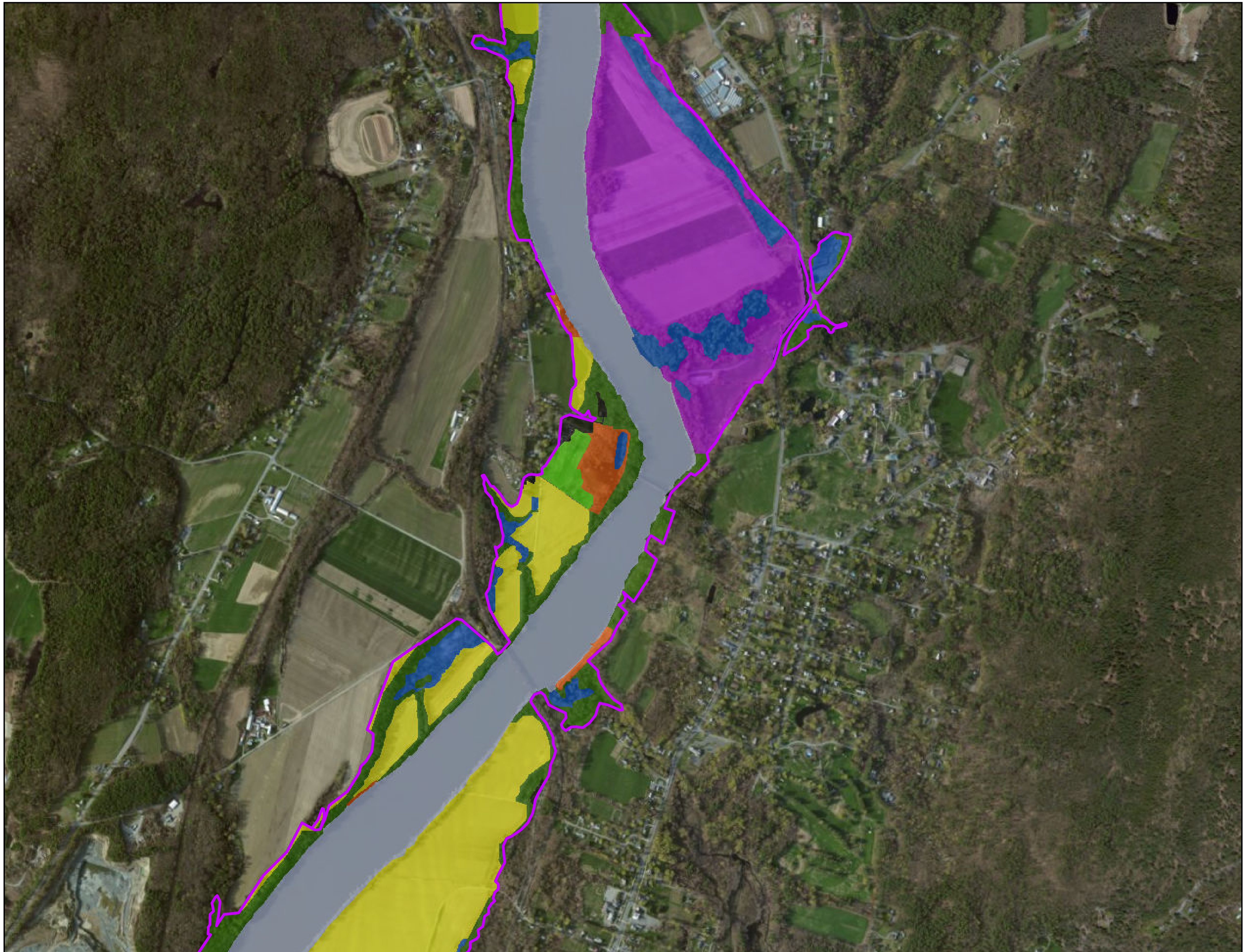

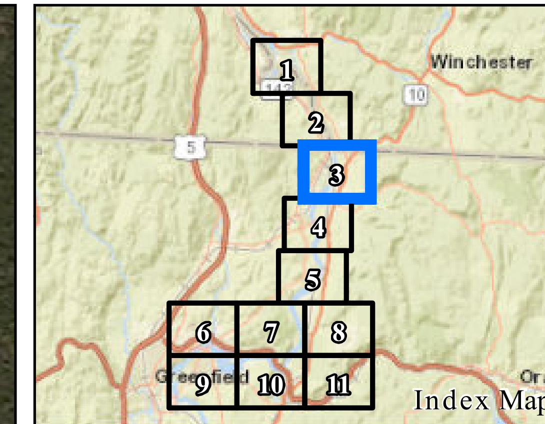

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 3

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project
- Northfield Mountain Pumped Storage Project and Turners Falls Hydroelectric Project Boundary Overlap

Land Use

- Agricultural - Crops
- Agriculture - Pasture/Grass
- Developed
- Forest
- Natural/Undeveloped
- Open Water
- Recreation
- Wetland

N

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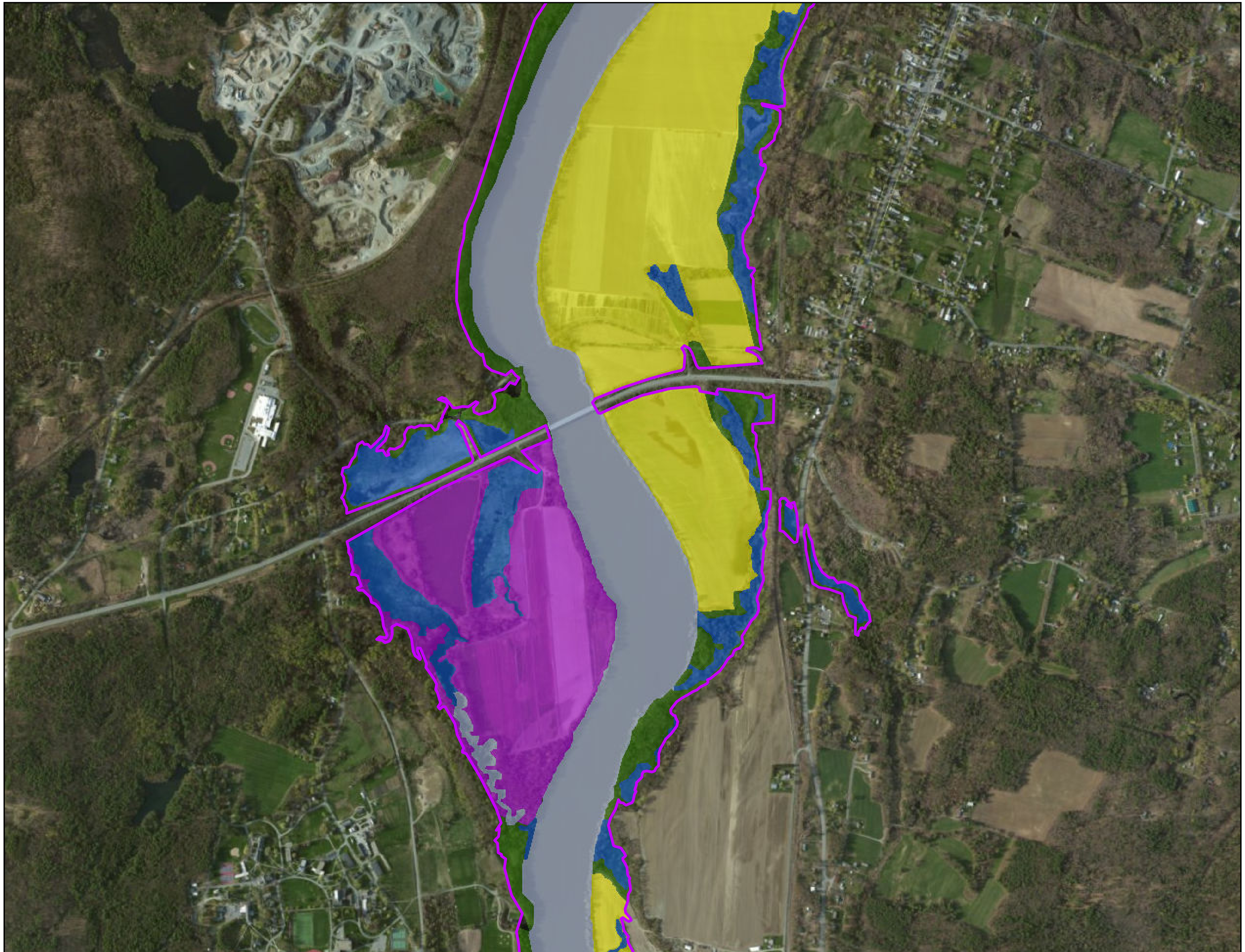

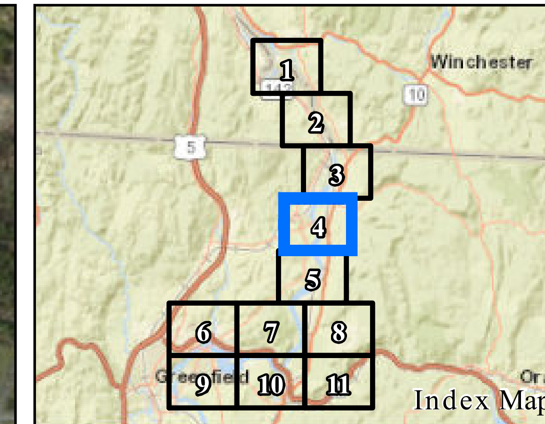

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 4

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project
- Northfield Mountain Pumped Storage Project and Turners Falls Hydroelectric Project Boundary Overlap

Land Use

- Agricultural - Crops
- Developed
- Forest
- Open Water
- Recreation
- Wetland

N

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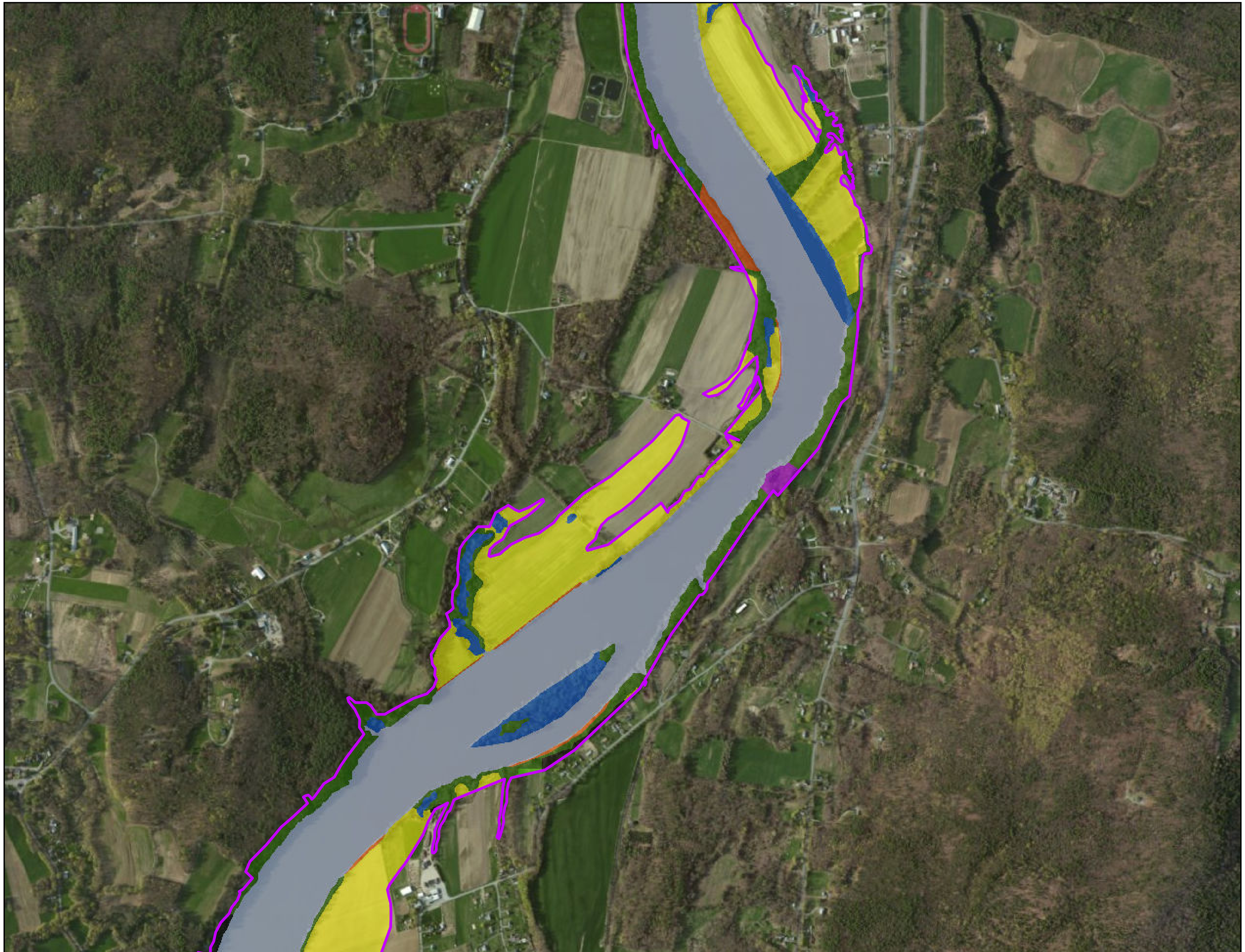

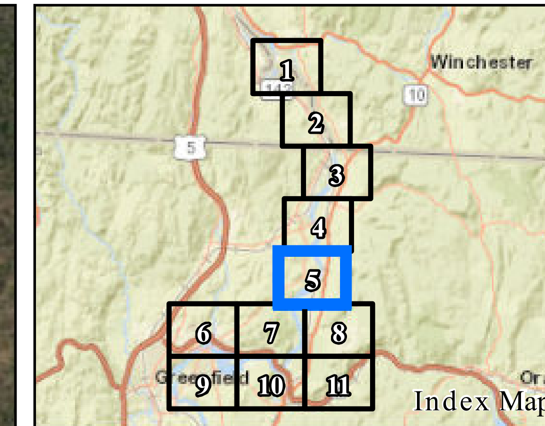

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 5

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project
- Northfield Mountain Pumped Storage Project and Turners Falls Hydroelectric Project Boundary Overlap

Land Use

- Agricultural - Crops
- Agriculture - Pasture/Grass
- Developed
- Forest
- Natural/Undeveloped
- Open Water
- Recreation
- Wetland

N

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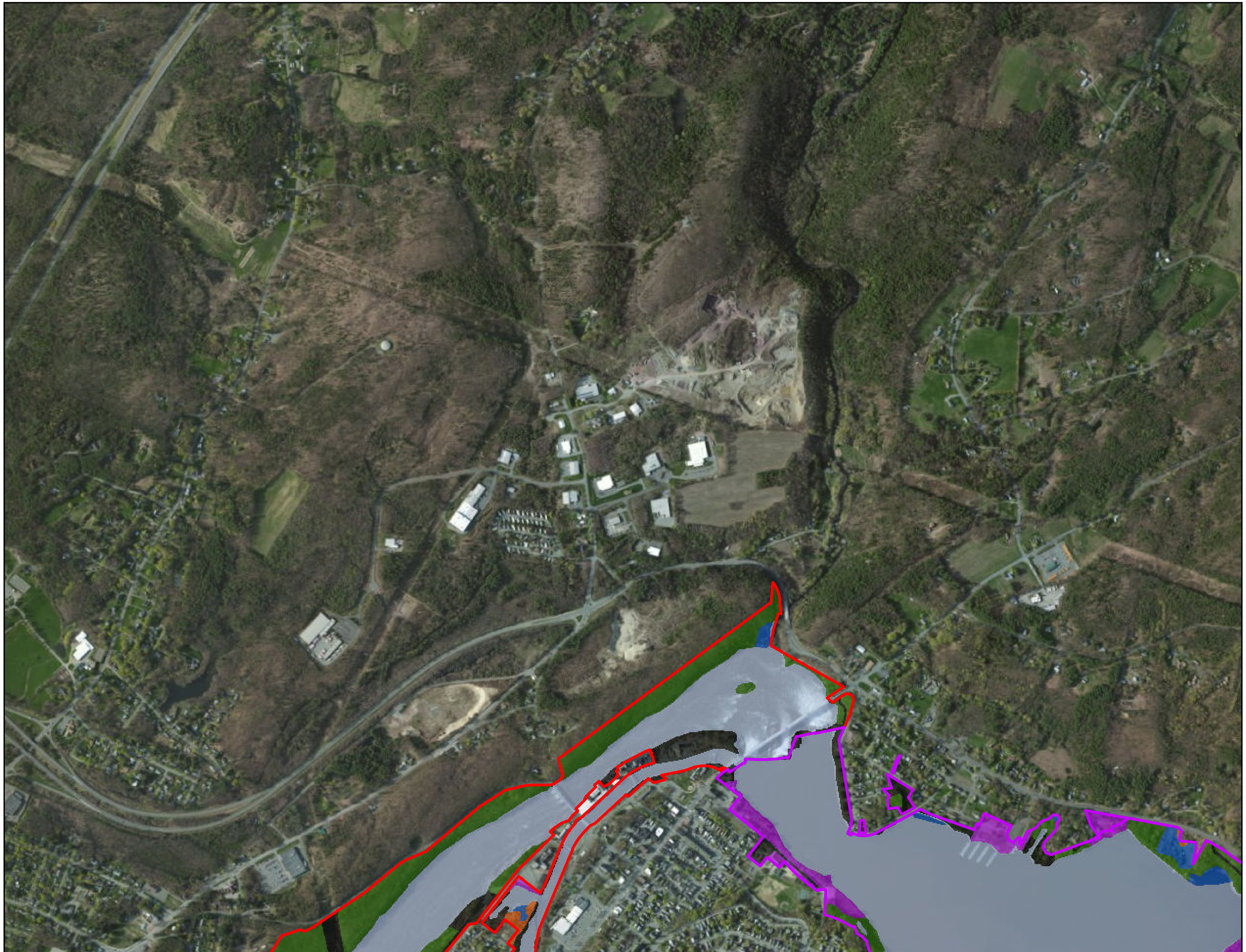

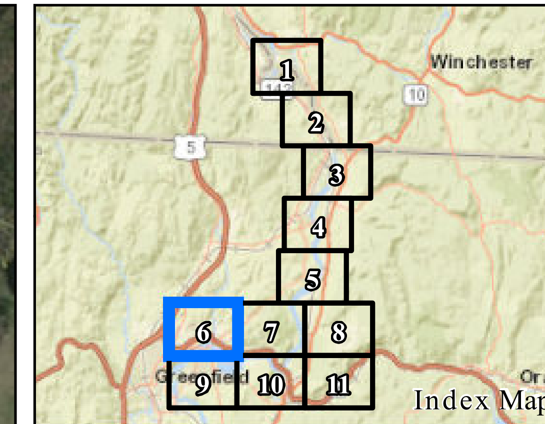

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 6

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project
- Northfield Mountain Pumped Storage Project and Turners Falls Hydroelectric Project Boundary Overlap

Land Use

- Developed
- Forest
- Natural/Undeveloped
- Open Water
- Recreation
- Wetland

N

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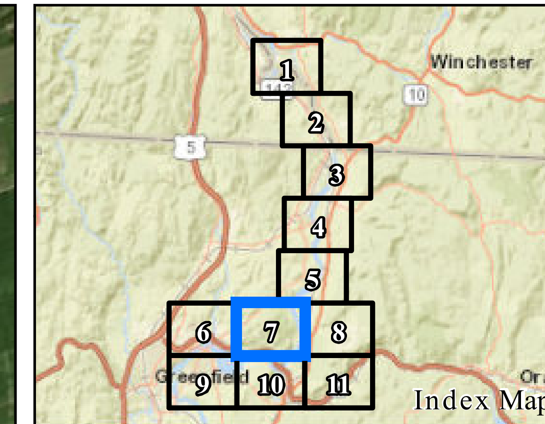

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 7

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project
- Northfield Mountain Pumped Storage Project and Turners Falls Hydroelectric Project Boundary Overlap

Land Use

- Agricultural - Crops
- Developed
- Forest
- Natural/Undeveloped
- Open Water
- Recreation
- Wetland

N

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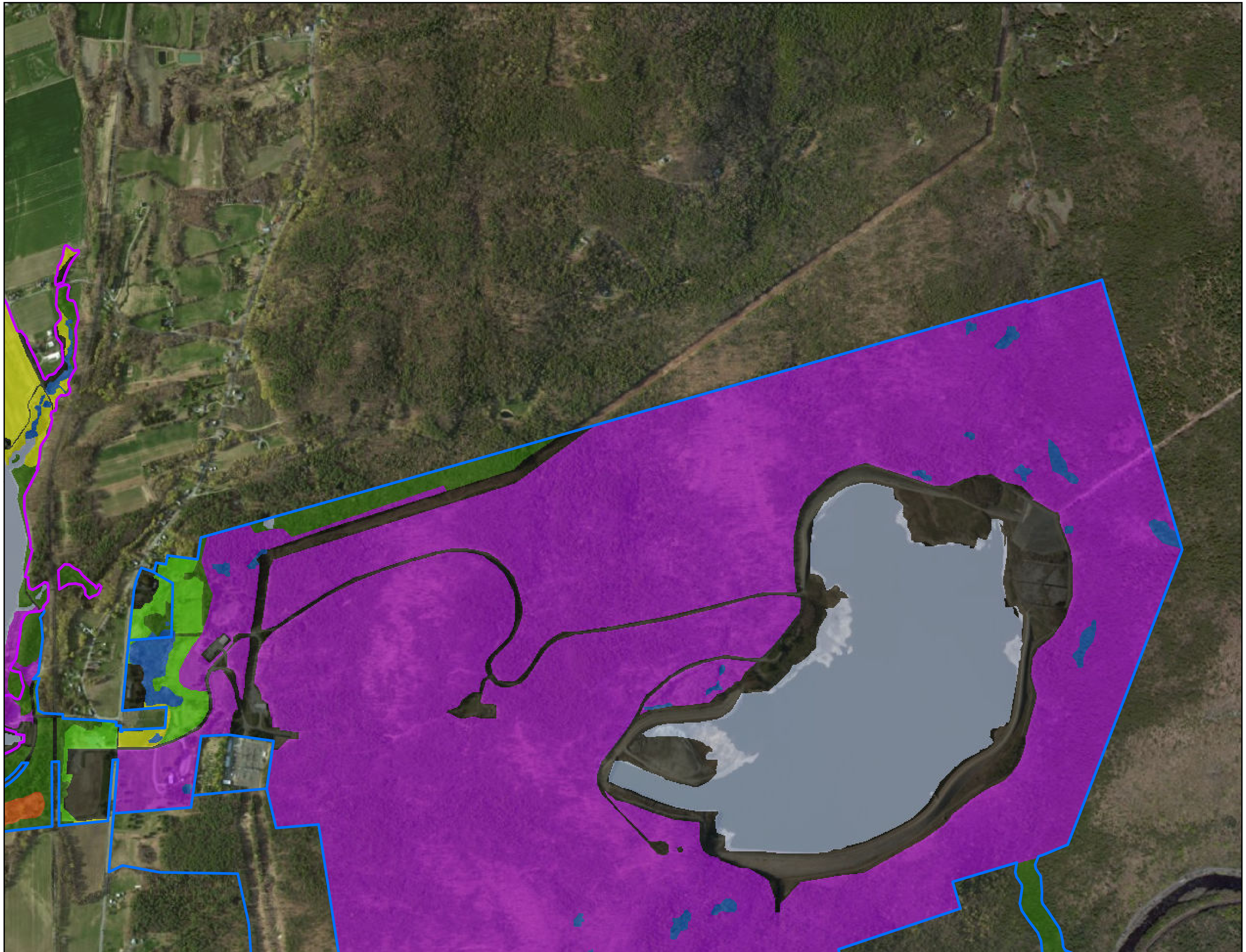

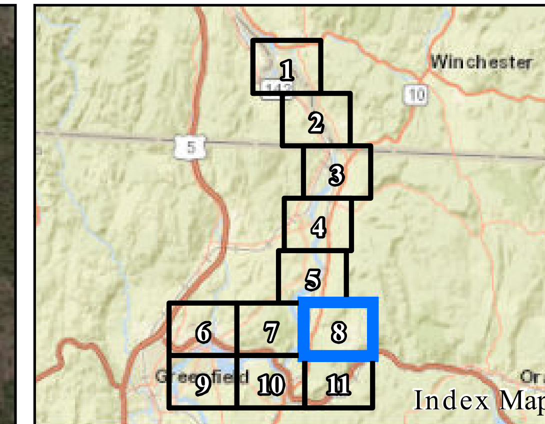

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 8

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project
- Northfield Mountain Pumped Storage Project and Turners Falls Hydroelectric Project Boundary Overlap

Land Use

- Agricultural - Crops
- Agriculture - Pasture/Grass
- Developed
- Forest
- Natural/Undeveloped
- Open Water
- Recreation
- Wetland

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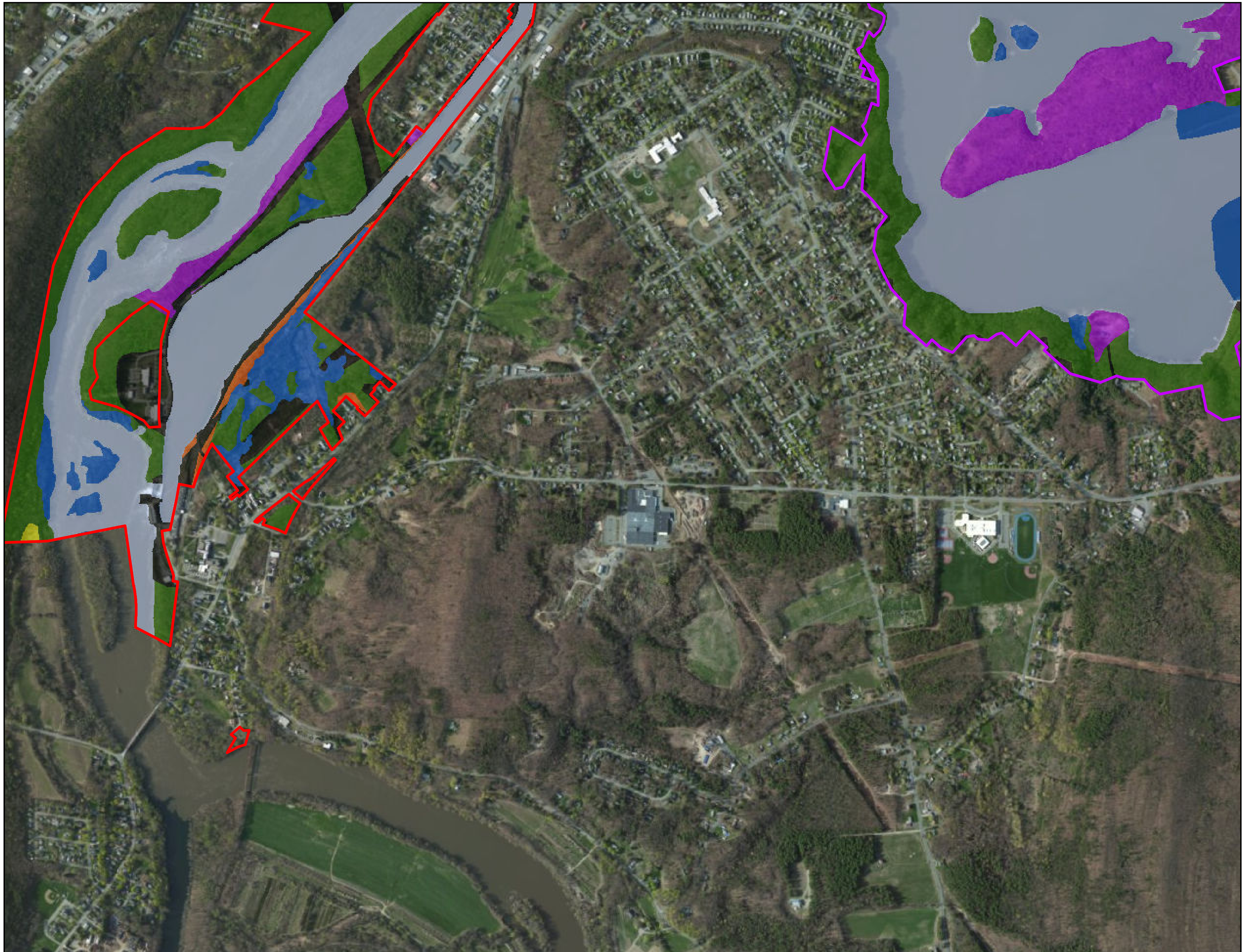

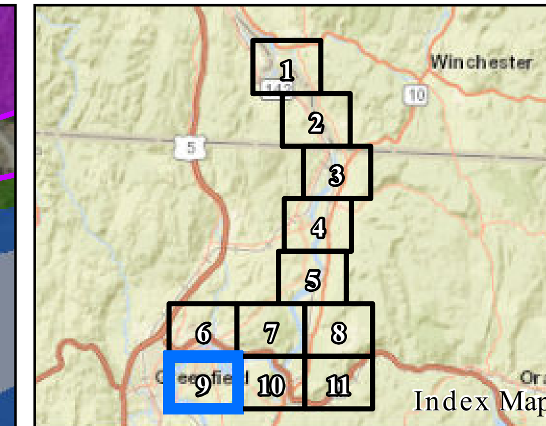

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 9

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project
- Northfield Mountain Pumped Storage Project and Turners Falls Hydroelectric Project Boundary Overlap

Land Use

- Agricultural - Crops
- Developed
- Forest
- Natural/Undeveloped
- Open Water
- Recreation
- Wetland

N

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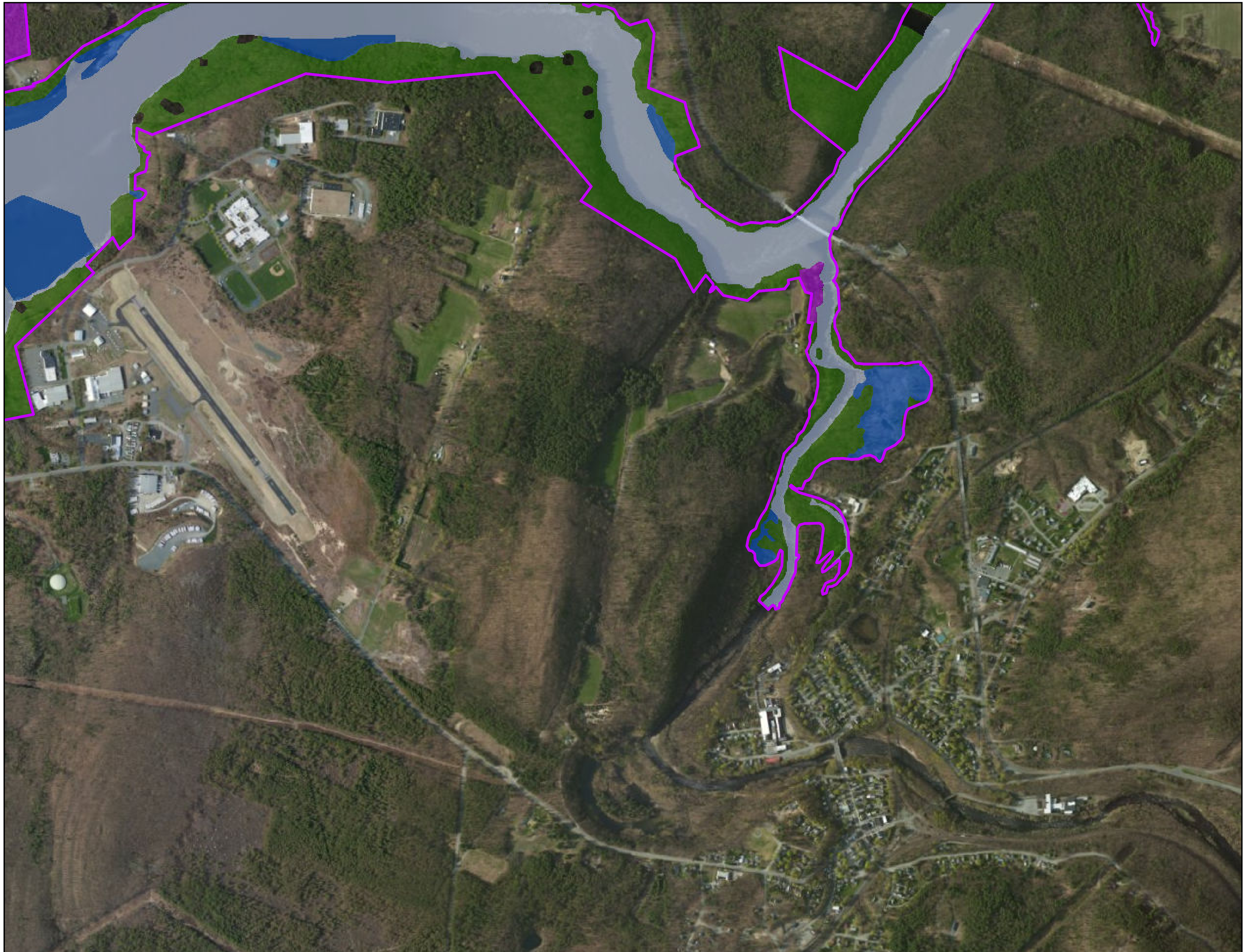

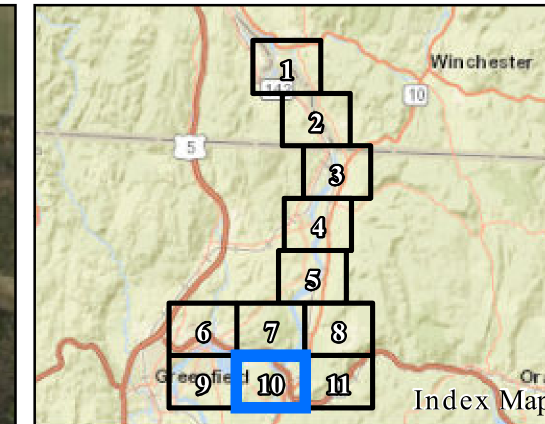

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 10

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project
- Northfield Mountain Pumped Storage Project and Turners Falls Hydroelectric Project Boundary Overlap

Land Use

- Agricultural - Crops
- Developed
- Forest
- Open Water
- Recreation
- Wetland

N

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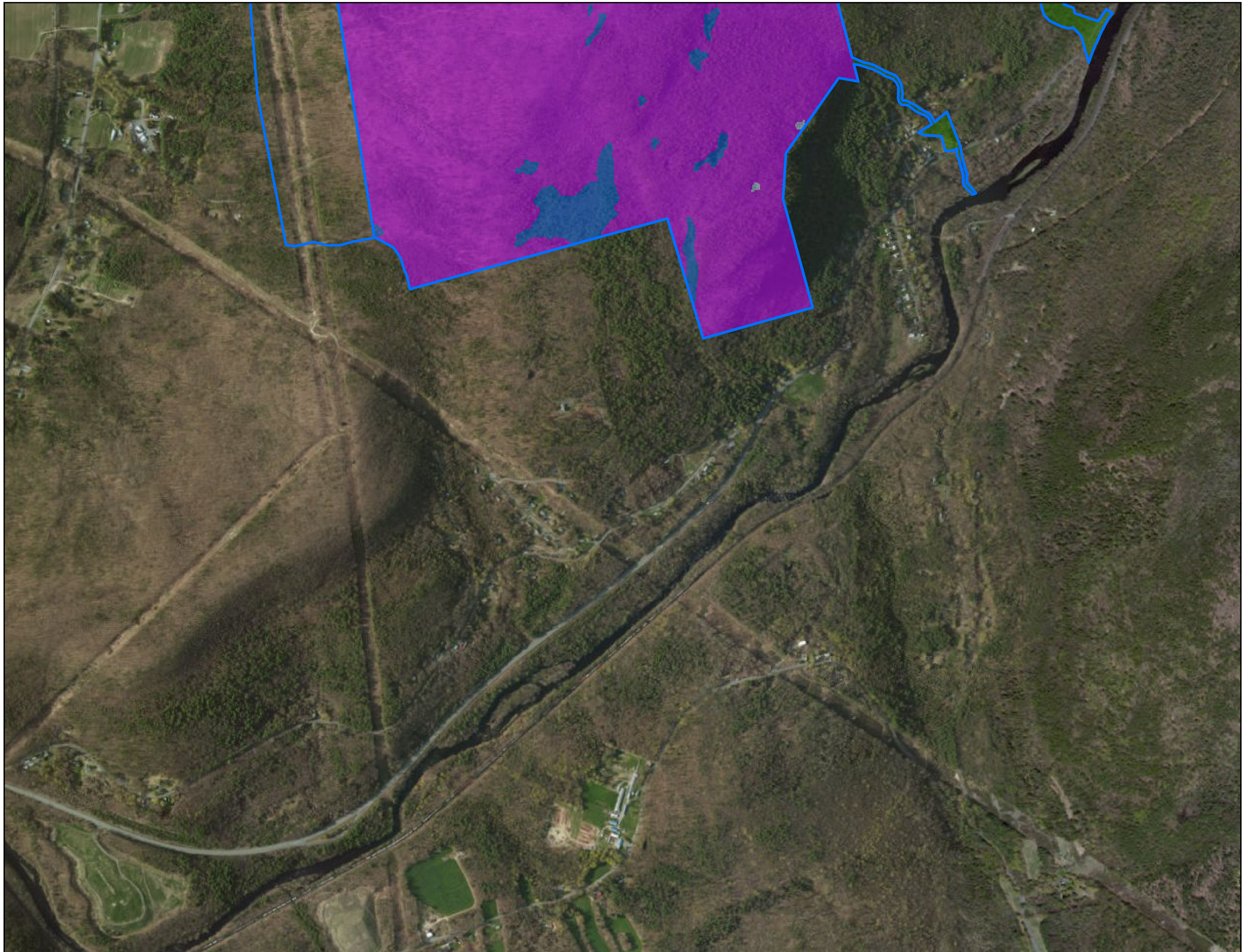

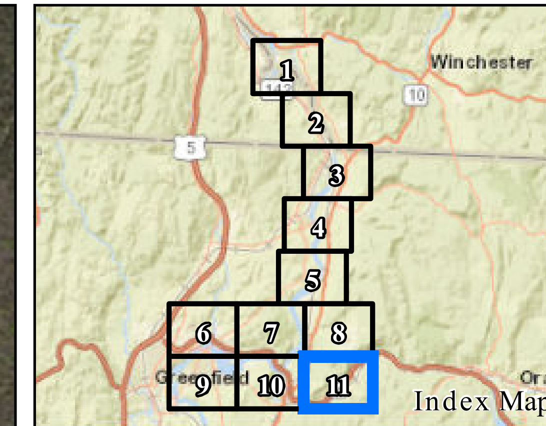

Northfield Mountain Pumped Storage Project (No. 2485)
Turners Falls Hydroelectric Project (No. 1889)

Amended Final License Application
Exhibit E

Figure 3.3.7.1.2-1:
Land Use withing the Project Boundary
Map 11

Legend

- Northfield Mountain Pumped Storage Project
- Turners Falls Hydroelectric Project

Land Use

- Developed
- Forest
- Natural/Undeveloped
- Open Water
- Recreation
- Wetland

N

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1 inch = 1,155 feet

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Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

FirstLight

N

Amended Final License Application
Exhibit E

0 150 300 600 Feet

Figure 3.3.7.4-1:
Proposed Removal of the
USGS Owned and Operated
Conte Fish Lab

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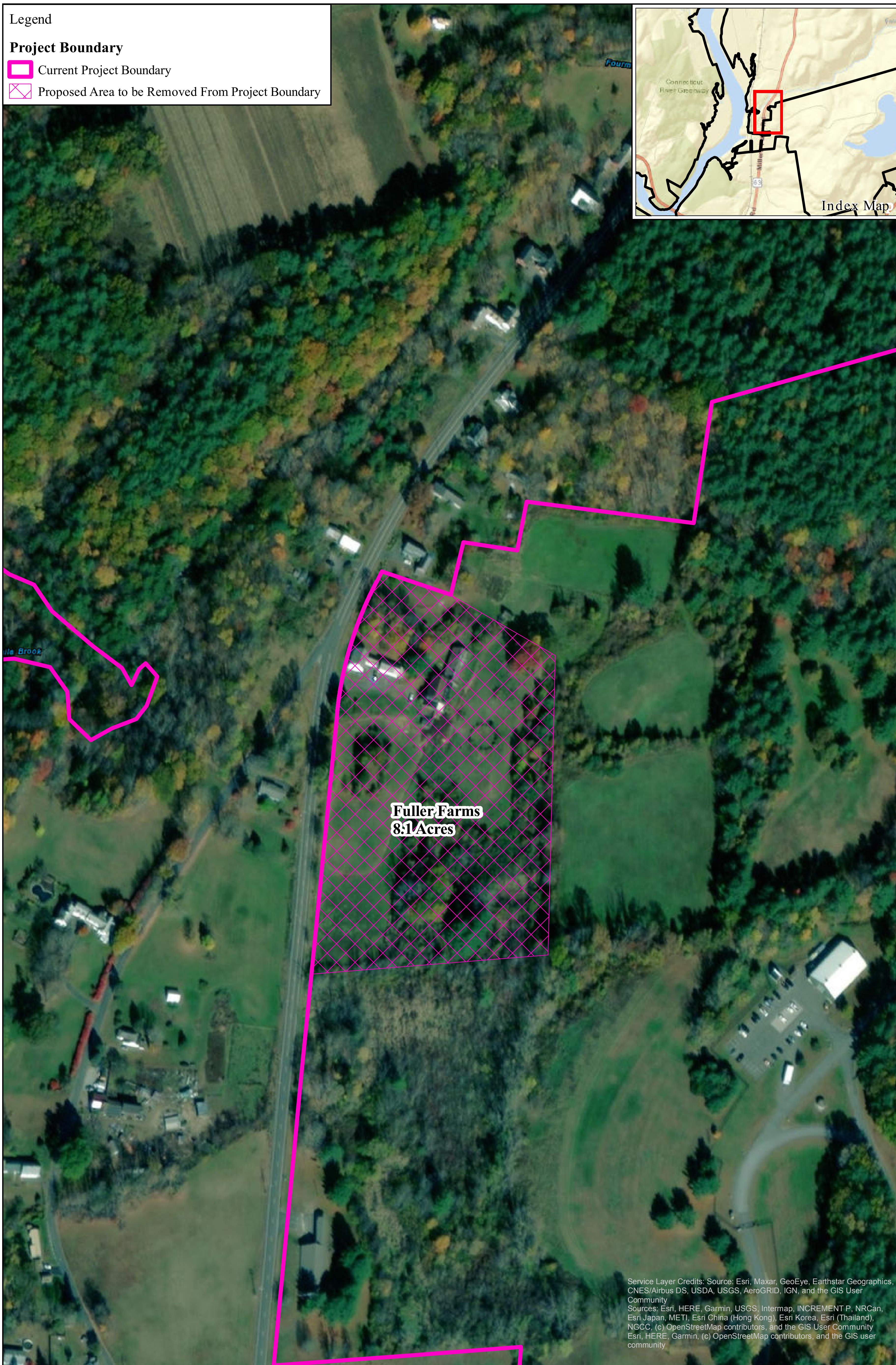

FirstLight

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E

N

0 100 200 400 Feet

Figure 3.3.7.4-2:
Proposed Removal of the
8.1 Acre Fuller Farm Property

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3.3.8 Cultural Resources

Section 106 of the National Historic Preservation Act (NHPA) of 1966 (Section 106), as amended, requires the Commission to evaluate the potential effects of continued operation of the Project on properties listed in or eligible for listing in the NRHP within the Project Areas of Potential Effects (APE). Properties listed in or eligible for listing in the NRHP are called historic properties. Section 106 also requires FERC to seek concurrence with the State Historic Preservation Offices (SHPO) on any finding of effects and allow the Advisory Council on Historic Preservation an opportunity to comment before acting on a license application.

If Native American Traditional Cultural Properties (TCP) have been identified, Section 106 also requires the Commission to consult with interested Indian tribes that might attach religious or cultural significance to such properties.

3.3.8.1 Affected Environment

3.3.8.1.1 Area of Potential Effects

On November 27, 2013, FERC defined the APEs for the Project in accordance with Section 106 and in consultation with the three SHPOs for the states included within the Project boundaries: the MA Historical Commission (MHC), the NH Division of Historical Resources (NHDHR), and the Vermont Division for Historic Preservation (VDHP), along with the Narragansett Indian Tribe, and the Nolumbeka Project. The Project APEs for both archaeological and historic architectural resources is defined as *"…all lands within the current FERC Project Boundary of the two projects in addition to any other lands outside the FERC Project Boundary where historic properties could be affected by project-related adverse effects. The Projects' APEs include lands within Franklin County, Massachusetts, Windham County, Vermont, and Cheshire County, New Hampshire. On lands adjacent to the project boundaries, the APEs would also include an additional 10 meters (33 feet) of lands inland from the top of banks of the Connecticut River and associated tributaries."* The APEs for the Projects are shown on Figure 3.3.8.1.1-1.

3.3.8.1.2 Precontact and Historic Period Background

Geographic Background. The Turners Falls Project and Northfield Mountain Project are located on the Connecticut River in the states of MA, NH, and VT. The greater portion of the Turners Falls Project, including developed facilities and most of the lands within the Project boundaries, are located in Franklin County, MA; specifically, in the towns of Erving, Gill, Greenfield, Montague, and Northfield. The northern reaches of the Project boundaries extend into the towns of Hinsdale, in Cheshire County, NH, and Vernon, in Windham County, VT.

Precontact Period Context (ca. 12,000 B.P. – ca. 500 B.P.)

The precontact period archaeological record of the Connecticut River Valley dates back more than 10,000 years (Johnson, 2007). Archaeologists have divided this record into three major periods known as the Paleoindian, Archaic, and Woodland periods. Further subdivisions within these periods are based on similarities in artifact forms and cultural adaptations over broad regions of the northeast. It is important to note that these divisions may be useful as archaeological constructs, and that their boundaries may represent changes perceived as culturally significant by archaeologists in the region.

Paleoindian Period (ca. 12,000-10,000 Years B.P.). The earliest recognized precontact period inhabitants in the Connecticut River Valley, and throughout North America, are referred to as Paleoindians. Paleoindians are believed to be the first people to migrate into North America and, in their pursuit of large game, rapidly colonized the continent (Martin, 1973). Throughout North America, the hallmark of Paleoindian people is the fluted spear point, which presumably was used to hunt down large game species, some of which are now extinct. These spear points are characterized by a lanceolate form and exhibit a long, groove-like flake struck from their base on both faces. In the northeast, Paleoindians are believed to have been highly mobile hunters and gatherers reliant mainly on caribou and their site locations tend to be associated with elevated landforms that may have provided prominent overlooks for migrating caribou herds (Spiess *et al*., 1998).

In the Connecticut River Valley, very little is known of the Paleoindian period. Only a few sites have been found in the region and these occur in a variety of settings. For example, the DEDIC/Sugarloaf site in Deerfield is situated on the surface of Lake Hitchcock bottom deposits and overlooks the modern floodplain (Ulrich, 1978); the Hadley Site is located on a low rise in a broad alluvial plain (Curran & Dincauze, 1977, p. 344-345); and the Hannemann Site is located on the sandy, well-drained Montague Plain near the Turners Falls airport (Hasenstab, 1987). The lack of Paleoindian sites is somewhat perplexing as the valley would have been a natural corridor for travel over great distances. Boisvert (1999) suggests Paleoindian occupation of northern NH often correlates with river valleys in order to provide ease of travel and communication with other regions. As suggested by Curran and Dincauze (1977), it might be that the environment of Lake Hitchcock was not favorable for Paleoindian occupation due to its limited resources and this is supported by the fact that the few resources recovered to date are found within the former margins of the lake. This would suggest that the environment became more favorable after drainage of the lake. The lack of Paleoindian sites may also reflect sampling biases, or the possibility that sites favored by Paleoindians have long since been destroyed by erosion processes and development. Regardless, the Paleoindian resources in the valley share a common trait with other Paleoindian sites of the northeast. This trait is the use of high quality cherts and other cryptocrystalline materials to manufacture stone tools.

The end of the Paleoindian period and subsequent transition into the Early Archaic period is poorly understood with no clearly defined correlation between the two periods. The beginning of the Archaic period within the Connecticut River Valley is marked only by the presence of bifurcate projectile points that are typically out of context. These points are best known in more southern regions and they suggest a different material culture than the preceding Paleoindian period.

Archaic Period (ca. 10,000-3,000 Years B.P.). The Archaic period represents the longest cultural period in the region, spanning around 7,000 years. This time frame is indicative of persistent cultural adaptations, as inferred from artifact assemblages, which lasted over several millennia. As noted earlier, Early Archaic period occupation is poorly represented in the valley and not well understood. The scant evidence comes from a few bifurcate points representative of the Early Archaic period recovered from the Riverside Archaeological District (Johnson & Krim, 2007; Nassaney, 1999). The lack of Early Archaic period remains may be due to the fact that sites dating to this period have been deeply buried in alluvial deposits and therefore not adequately sampled. Another possibility is that sites dating to the Early Archaic period have gone unrecognized due to the absence of chipped stone projectile points. Research in northern New England has revealed Early Archaic assemblages consisting of crudely fashioned flake and unifacial tools made on cobbles and locally available stone (Robinson, 1992). These Early Archaic assemblages are commonly found in stratified riverine settings and reveal an adaptation to aquatic resources, particularly beaver, muskrat, and fish. It is presumed that similar resources and settings would have been available in the Connecticut River Valley as well.

By the Middle Archaic period, sites are somewhat more numerous, but still relatively scarce within the Connecticut River Valley. Middle Archaic period sites are marked by an increase in chipped stone spear points, particularly those of the Neville and Stark variety. These points have been found in a variety of settings, including river and stream margins in both upland and lowland areas (Johnson, 2007). They are believed to have affiliations with forms in the mid-Atlantic region suggesting broad regional influences during the Middle Archaic period (Dincauze *et al.*, 1976). The variety of settings where Middle Archaic sites are found led some researchers to hypothesize the establishment of seasonal scheduling of subsistence activities and increased recognition of territories (e.g., Dincauze *et al*., 1977, Thomas, 1980).

By the Late Archaic period, sites are more frequent and larger in size, possibly suggesting an increase in population density (Nassaney, 1999). The sites also tend to occur in a wider variety of settings with large sites occurring where resources could be seasonally procured in abundance (e.g., Turners Falls) and smaller sites occurring in upland areas where specific resources were exploited. Quarrying of diabase and steatite from sources within the valley also becomes more widely recognized during the Late Archaic period and is believed to be part of a groundstone industry that likely emerged during the earlier Archaic period (Robinson, 1992; Johnson & Krim, 2007). The Late Archaic is divided into three major traditions that include the Laurentian, Small-Stemmed, and Susquehanna traditions. These traditions are largely inferred from different point styles that range from side-notched forms (e.g., Otter Creek and Brewerton), crudely fashioned stemmed forms made of local materials (Small-Stemmed Point), and broad-bladed forms (Susquehanna). As in most areas of the northeast, the Laurentian and Small-Stemmed Traditions tend to predate the Susquehanna Tradition. In particular, it is uncertain whether the various archaeological assemblages of the Late Archaic reflect local, long-term cultural adaptations or movement of people into the region with a different culture and way of life. The expansion of sites and variety of point styles during the Late Archaic period, particularly those of the Susquehanna, may relate to environmental changes that led to decreases in aquatic resources and increases in the habitat of terrestrial animals.

Woodland Period (ca. 3,000-500 Years B.P.). The introduction of pottery manufacture signals the beginning of what archaeologists call the Woodland period in the Connecticut River Valley. Woodland period sites are the best represented in the valley and occur in a variety of sizes and habitats, as well as show a diverse range of activities (Johnson, 2007). The Connecticut River Valley played a significant role in the development of the Woodland period due to its fertile bottomlands, which were favorable for horticulture, and its exposures of Lake Hitchcock bottom sediments, which provided a readily available source of clay for pottery manufacture. The period is divided into Early, Middle, and Late subdivisions.

During the Early Woodland period, adaptations established during the Late Archaic continue with most Early Woodland components found in similar settings to Late Archaic sites. Diagnostic tool forms during the Early Woodland include Vinette I pottery, Meadowood projectile points, and blocked end tube pipes suggestive of influence from Adena cultures in the Midwest. The first real evidence for mortuary activity containing Adena-like artifacts, also appears during this time and is believed to be representative of wide-spread exchange system recognized over a broad region of eastern North America (Johnson, 2007). The Middle Woodland period is defined largely by the presence of different pottery styles. Long established patterns of seasonal exploitation of resources, and concomitantly congregation of people, at favored locations such as Turners Falls, continue. However, by the end of the Middle Woodland period, horticulture became established as a part of the subsistence pattern. The emergence of horticulture certainly would have affected settlement patterns to some degree with occupation increasing in areas where fertile soils were prevalent. The Late Woodland period is marked by the continued development of horticulture, evolving pottery styles, and the presence of diagnostic triangular projectile points known as Levanna.

The picture that emerges from Woodland period sites is one showing a long-standing cultural adaptation to the diversified use of local resources. In addition, the nature of artifact forms present, and certain types of stone recovered from Woodland period sites indicate trade and communication with people from far-off regions. By the end of the period, historical evidence suggests core settlement areas had developed in the lowlands of the valley with peripheral areas occupied during certain times of the years for hunting and gathering. The Woodland period ends with European contact around 500-450 years ago. At this time, referred to as the contact period, many of the artifacts attributable to precontact period inhabitants disappear from the archaeological record and trade goods, such as copper and beads, emerge in the record.

Historic Period Context (1500-1973)

Contact Period (1500 – 1620). The contact period (1500-1620) in the Connecticut Valley is defined by direct and indirect interaction between Native American populations and Europeans. It is unclear when initial contact between these populations took place in the region, but most likely occurred to the south of the study area in the early seventeenth century. Contact between these populations (direct and indirect) was intermittent and it is thought that little material culture of European origin was utilized by Native Americans.

Plantation Period (1620 – 1675). The Plantation period (1620-1675) witnessed the development of a number of European settlements including those in the town of Northfield. During this period, direct contact between Europeans and the Native American population increased in part due to mutual involvement in the fur trade. This contact led to widespread epidemics and resulted in the decimation of Native American populations and the abandonment of Native American settlements.

Colonial Period (1675-1775). Colonial settlement of the Project area (present-day towns of Gill, Greenfield, Montague, Erving and Northfield, MA; Vernon, VT; and Hinsdale, NH) in the seventeenth century was scattered and short-term and is for the most part poorly documented. Turners Falls gained its name from the historic “Falls Battle” of 1676, when Captain William Turner attacked a group of Pocumtucks, and members of other tribes camped at the falls of the Connecticut River. More than 300 Indians died in the battle before they counter-attacked, killing Turner and 40 of his men (Jenkins, 1980, p. 8.1).

Considered a northern outpost of colonial settlement, the Vernon and Northfield areas were largely abandoned during King Philip's War and only lightly re-settled after the conclusion of Queen Anne's War in 1714. Confusion over the town boundaries of Northfield in relation to the NH colony to the north resulted in several inconclusive surveys that muddied settlement claims in the area for many years (NHDOT, 2007, p. 4). A 1753 decree by NH’s Royal Governor created two towns north of Northfield on either side of the Connecticut River, both named Hinsdale (Holmes *et al*., 1991, p. 56).

Federal Period (1775-1830). VT, contested among NY, NH and MA in the years before the Revolution, enjoyed a population boom in the late 1700s. In 1783, the province had a population of 10,000; by 1790, it had increased to 55,425. On March 4, 1791 VT gained statehood. In October 1802, the town on the VT side of the Connecticut River changed its name from Hinsdale to Vernon (Child, 1884. p. 304; Holmes et al., 1991, p. 56).

Turners Falls itself was not settled until 1792, when a canal and dam were proposed by the Proprietors of the Upper Locks and Canals of the Connecticut River to aid navigation around both Turners Falls and South Hadley to the south. When completed in 1798, the locks and canals formed a vital link in the 300-mile system of waterways from Wells River, VT to Hartford, CT (Jenkins, 1980, p. 8.1). The canal, designed by Benjamin Prescott of Northampton, was approximately 2.1 miles long and 14 feet wide, with ten locks. In 1799, the Fifth Massachusetts Turnpike Company was established to either construct new roads or take over and improve existing ones in western MA.

Early Industrial Period (1830-1870). Railroads opened up the entire Connecticut River Valley area to sustained economic development beginning in the 1840s and remained the area’s transportation backbone for nearly a century. The first railroad line to reach the Turners Falls area of Montague was the Connecticut River Railroad, a north-south line between New Haven and Greenfield which began service in 1846 (Holmes *et al*., 1991, p. 24). This line was extended to Brattleboro, VT in 1851.

The present-day Village of Turners Falls in Montague dates only from 1866, when Colonel Alvah Crocker decided to create a planned industrial community on the model of Lowell or Holyoke (Jenkins, 1980, p. 8.1). Crocker and his associate Wendell T. Davis bought up the stock and water rights of the defunct Proprietors of the Upper Locks and Canals and eventually acquired 700 acres of land in the Turners Falls area (Abercrombie, 1925). Crocker and Davis founded the Turners Falls Company which embarked on building a dam and a new power canal that roughly paralleled the route of the old navigational canal, from which water was thereafter leased or sold to factories for power purposes. A wood-and-stone crib dam with a 30-foot fall at the Turners Falls rapids was completed in early 1867 (Jenkins, 1980, p. 8.2).

The new village received a huge boost in 1868, when the John Russell Manufacturing Company moved to Turners Falls. Its complex of two- and four-story buildings (no longer standing) running for nearly 2,000 feet along the power canal housed one of the largest cutlery factories in the world at the time (Jenkins, 1980, p. 8.2; Montague Bicentennial Committee, 1954, p. 12; Great Falls Discovery Center, 1996, p. 3).

Late Industrial Period (1870-1915). In 1871, the Montague Paper Company (partially owned by Alvah Crocker) built its complex on a site on either side of the power canal just below the dam bulkhead. The Keith Paper Company (later Hammermill Paper) Mill complex was completed in 1873. In 1874, the Turners Falls Cotton Mill was built at the southern end of the power canal (Holmes *et al*., 1991, p. 28).

The Riverside area of Gill remained sparsely populated until late 1867 when Amos Perry, David Wood, and Nathaniel Holmes bought water rights on the Connecticut River from the Turners Falls Company along with a small parcel of land in Riverside at the edge of the river for a grist- and saw-mill (Gill Historical Commission, 1999, p. 2). In 1872, Holmes, Wood and Perry incorporated as the Turners Falls Lumber Company to bring logs downriver to their saw-mill from VT, NH, and Canada. The company's saw-mill provided vast amounts of lumber for the development of Turners Falls across the river and lumber production soon surpassed the gristmill (Gill Historical Commission, 1999, p. 3).

By the early 1880s, Hinsdale possessed a well-developed industrial infrastructure, centered on several paper and cotton mills built along the Ashuelot River. High, Hancock, and Prospect Streets were laid out on the north side of town, reflecting the steep hillside on which the village is built. High Street, located above the heat and noise of the valley below, was soon lined with spacious architect-designed residences (NHDOT, 2007, p. 8).

On June 9, 1886, A.S. Clarke of the Clarke & Chapman Machine Company, made arrangements with the Turners Falls Company for a six-hour additional use of water for the purpose of generating electricity at night. In late 1886, an electric generating station opened at the Turners Falls gatehouse and in 1892, the gatehouse was expanded for greater water flow (Sanborn Map Company, 1895). The present Turners Falls gatehouse was built in 1903-1904 following demolition of the original 1866 gate house and was substantially enlarged in 1913-1914 (Turners Falls Power & Electric Company, 1914a, 1914b; Gregory, 2006, p. 12).

The Turners Falls Power Canal also was improved by widening it and increasing its depth (Sanborn Map, Company, 1895). By 1917, the canal was extended to its present length of approximately 2.1 miles (Turners Falls Power & Electric Company, 1917). Final work on the canal's excavation was completed that year when it reached its present depth of between 25-40 feet and between 100-920 feet (the latter at the Cabot forebay) in width (Jenkins, 1980, p. 8.4; Gregory, 2006, p. 13; Holmes *et al*., 1991, p. 28).

In 1892, the Boston & Maine Railroad acquired the entire Connecticut River Railroad, made up of the former 21-mile Ashuelot Railroad and the Cheshire Railroad, among others (Wallace *et al*., 2001, p. 36). In 1911, the railroad extended its line from Dole Junction, NH to Brattleboro, VT on the other side of the river. Known as the Fort Hill Branch of the Boston & Maine Railroad, the rail line at one time included eight bridges, a 2,800-foot causeway and numerous stone culverts and drains (Hostutler and Muzzey, 1994). In 1904, the Central Railroad of VT, rebuffed in its offer to construct a combination rail/vehicular bridge, proceeded with plans to construct its own bridge across the Connecticut River in Northfield. The six-span, pin-connected, metal Pratt truss bridge was completed later that year. The bridge's current appearance with five spans now consisting of a series of Warren deck trusses is the result of a major reconstruction carried out by the American Bridge Company for the railroad after the bridge was severely damaged in the 1936 flood (Arts Council of Franklin County, 1978d).

By the beginning of the twentieth century, the Turners Falls Company had moved into the emerging hydro-electric market (Jenkins, 1980, p. 8.3). In 1904, Charles Hazelton, treasurer of the Turners Falls Company, proposed to his board of directors that that they make better use of the water power currently being wasted by widening and extending the power canal, and establishing a hydroelectric generating plant of 5,000 kilowatt capacity. (Bennett, 1990a, p. 5).

In 1905, the Turners Falls Company completed construction of Station No. 1, a 1,000-kilowatt unit built approximately 3,000 feet downstream of the Turners Falls gatehouse at the upstream end of the power canal (Turners Falls Company, 1904, 1907). As designed, the construction of Station No. 1 involved the installation of six small horizontal Francis-type units (WMECO, 1987, p. 2). The first generation of electricity from water power by the Turners Falls Company took place in 1906. By 1913, the station had grown to five units with a total capacity of 5,000 kW.

In 1908, Boston financier Phillip Cabot assumed the post of president of the Turners Falls Company, which was reorganized and renamed the Turners Falls Power & Electric Company, reflecting the company's new focus on hydroelectric power and its transmission. Cabot's ambitious plans called for the construction of a second powerhouse, named Cabot Station in his honor, replacing and raising the original Crocker-built dam with the present Gill and Montague (Turners Falls) Dams, and extending and widening the power canal and Gate House. Work began on dam construction in 1912 and was completed in 1915 along with the Cabot Station in 1917 and the newly improved power canal by the 1920s.

The Sixth Street Bridge was constructed across the power canal in 1912. It is a riveted, double-intersection Warren thru-truss, designed by the Eastern Bridge & Structural Company of Worcester MA, and erected by a crew of workers from the Turners Falls Company (Bennett, 1990a, p. 4). The Eastern Bridge & Structural Company also built footbridges at Fifth Street and to the Keith's Mill (Arts Council of Franklin County, 1978a, 1978b, and 1978c).

Modern Period (1915-Present). In 1915, the Eleventh Street Bridge was completed over the power canal. The bridge is a unique triple-barreled configuration of a double-intersection Warren thru-truss, with a pair of trusses on either side of the roadway, and lateral bracing between each pair, but none over the roadway. The Eleventh Street Bridge was also engineered by the Eastern Bridge & Structural Co. and is the only known example of this bridge type in MA (Arts Council of Franklin County, 1978e; Bennett, 1990a, p. 1). In 1915, the Turners Falls Company completed construction of a new Turners Falls Dam to replace the original Crocker-built dam. That same year, construction began on the Cabot Station powerhouse located at the south end of the power canal. Cabot Station was named for Philip Cabot who was largely responsible for its construction, first as President of the Turners Falls Company after 1908, and then as founder and president of the Turners Falls Power & Electric Company (Arts Council of Franklin County, 1978c). Historically, Cabot Station represents the last major industrial development of the water resources at Turners Falls. When it was completed, Cabot Station was the largest hydroelectric facility in MA, and the principal source of power for the Turners Falls Power & Electric Company.

With the advent of the automobile in the early 1900s, the Ma Highway Commission made plans to improve all the state's roads, including the section of highway from Greenfield to North Adams. Work was begun in September of 1912 and completed in November of 1914, at a cost of $350,000. At the opening ceremonies, October 24, 1914, the highway was officially dedicated as "The Mohawk Trail" after the Mohawk Indians of that region (Bennett, 1990b, p. 1).

The French King Bridge was conceived as part of a state-financed project to relocate a particularly hazardous seven-mile stretch of the old Mohawk Trail Highway (State Route 2) between Erving and Greenfield. After looking at several plans, the engineers decided to cross the Connecticut River with a bridge at the height of the hills on either side, about 135 feet above the water. Construction of the French King Bridge began in September of 1931, was completed at a cost of $385,000, and opened to travel on September 10, 1932. The bridge is one of four known steel deck-arch vehicular bridges in MA and has the sixth-longest span of any vehicular bridge in the state (Bennett, 1990b, p. 6).

After extensive studies in the 1920s and 1930s, the Turners Falls Power & Electric Company and the Connecticut River Power Company of NH combined to form the Connecticut River Conservation Company. Its purpose was to "develop a system of reservoirs on the headwaters and tributaries of the Connecticut whereby the tremendous spring run-off might be stored for use during the period of low flow in the River." It was projected that five-billion cubic feet of storage water could be made available for power purposes, saving ten thousand tons of coal annually (Samartino, 1991, p. 26).

In 1942, the biggest merger was made when three pre-existing companies were merged into Western Massachusetts Electric Company (WMECO): Turners Falls Power & Electric Company, Pittsfield Electric Company, and United Electric Light Company. The several power companies continued to expand and to cooperate in transmission exchanges. Combined, nearly two dozen major hydroelectric stations along the Connecticut River were capable of producing collectively 700 thousand kilowatts of power. Studies to increase the generating capacity at the Turners Falls plants were well underway in 1961. In 1965, three Connecticut Valley power companies—WMECO, Connecticut Light & Power Company, and the Hartford Light Company—joined forces to form Northeast Utilities Service Company (NU) (WMECO, 1987, p. 4). Construction of the Northfield Mountain Project began in 1968, with the major job being the drilling and dynamiting of a 2,500-foot tunnel, 565-foot ventilation shaft, 1130-foot pressure shaft, and the mile-long tailrace between the powerhouse and the river, as well as the 10-story-high underground powerhouse. Over 4.9 billion tons of rock were blasted to create the tunnels, shafts, and powerhouse (Samartino, 1991, p. 26). Four 250,000-kilowatt capacity turbine generators were placed in the powerhouse cavern 700 feet below the surface. Also built were a 286-acre reservoir, a rock-fill dam 144 feet high and 5600 feet long, and other dikes totaling 5600 feet. At the same time, the Turners Falls Dam downriver was raised, which created a 2,110 acre reservoir on the Connecticut River. The Northfield Mountain Project began operation in early 1972. As part of the Northfield Mountain Project, WMECO created the Northfield Recreation and Environmental Center (also known as the Northfield Mountain Tour and Trail Center or the Visitors Center), with exhibits on the area's geology, history, and ecology, along with facilities and trails for hiking, skiing, and snowshoeing (Samartino, 1991).

3.3.8.1.3 **Precontact and Historic Archaeological Resources**

In July and August 2014, FirstLight conducted an archaeological reconnaissance survey (Phase IA Study) within the Project APEs (Sara *et al*., 2014a, 2014b, 2015). The purpose of the Phase IA archaeological reconnaissance was to identify archaeologically sensitive areas within the Project APEs and provide recommendations where Phase IB archaeological surveys should occur based on identified sensitivity and Project-related effects. The study integrated background research with field investigations. The background research involved a review of state files at the MHC, NHDHR, and VDHP to identify known archaeological resources within a one-mile buffer of the Project APEs and to review previous archaeological studies conducted in the region. In addition, numerous local repositories were consulted in order to provide a cultural context for the Project. The purpose of this research was to provide a framework for understanding the historic contexts of the region and to develop a sensitivity model for predicting the locations of potential archaeological resources. The field investigations consisted of walkover inspection and boat survey of the shoreline within the Project boundaries to assess current environmental conditions.

The field investigations segregated the Project APEs into 65 segments (48 segments in MA, 10 in NH, and 7 in VT) based on geomorphic and topographic differences. These segments consist of floodplains, older river terraces, islands, and glacial and/or early postglacial landforms. Portions of all 65 segments are considered sensitive for archaeological resources. In addition to the 65 segments evaluated during the study, a separate archaeological sensitivity analysis was conducted for the Fuller Farm property in the Town of Northfield, MA.

In MA, background research identified 65 previously recorded precontact period and six historic period archaeological sites within the Project APEs. Additionally, 70 precontact period and 25 historic period archaeological sites were identified within a one-mile distance of the Project boundaries. Precontact period sites in the vicinity of the Project span the known human occupation of the region from the Paleoindian period to the Late Woodland and Contact period. In addition, historic period sites are located within or adjacent to the Project APEs. These include domestic, transportation related (ferry and bridge crossings), and industrial related sites dating from the first European contact in the region in the seventeenth century to the present day.

As a result of the fieldwork in MA, the locations of two previously recorded precontact period sites were confirmed in the field based on the observation of surface artifacts, and four previously unrecorded historic period archaeological sites and one previously unrecorded precontact site were located within the Project APEs. These newly identified archaeological sites include a precontact artifact scatter near the Ashuela Brook confluence with the Connecticut River, the remnants of historic Munns Ferry north of Kidds Island, the remnants of a small summer cottage on an upland ridge overlooking the Connecticut River, a historic surface scatter and related ground depression west of Cabot Camp, and a partial stacked-stone foundation and spring-related feature on a hillside west of the Route 2 Bridge (French King Bridge).

In addition, the sensitivity analysis for the Fuller Farm property in MA found it to be sensitive for the presence of archaeological resources.

In NH, background research did not identify any previously recorded sites within the Project APEs, although there were three previously reported archaeological resources in Cheshire County, NH located within one mile but outside of the Project APEs.

In VT, four sites (WD-1, WD-10, WD-124, and WD-125) are located within or directly adjacent to the Project APEs. Site WD-1 is also located within the Project boundary for the Vernon Hydroelectric Project (Project No. 1904), which is currently undergoing relicensing. During field investigation, no newly identified archaeological sites were recorded in VT or NH during the Phase IA study.

Following background research and fieldwork, a total of 80 recorded archaeological sites have been recorded within the Project APEs (70 precontact and 10 historic archaeological sites).

A sensitivity model was developed to categorize the sensitivity of landforms within the Project areas for precontact period archaeological resources. This model is based on analysis of environmental attributes associated with previously recorded archaeological site locations within a one-mile distance of the Project boundaries and is intended to predict where precontact period archaeological resources may be located in the Project APEs. The model found that modern floodplains and early Holocene river terraces in the northern half of the Project APEs are considered to have the greatest sensitivity for precontact period archaeological resources with no preference for secondary tributaries of the Connecticut River. In its Phase IA study review letter of February 5, 2015 to FirstLight, the NHDHR commented that not many surveys have been conducted along the margins of the Connecticut River and cautioned that this should be taken into account when using the model's data set on informing archaeological sensitivity.

In addition to a sensitivity assessment, areas of shoreline in the Project APEs were also evaluated for evidence of active erosion that may threaten culturally sensitive landforms although the causes of erosion were not examined in the Phase IA study. The causes of erosion within the TFI were examined as part of Study No. 3.1.2 *Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability* (FirstLight, 2017a). The erosion classification was based on the criteria set forth in the 2013 Full River Reconnaissance (FRR) of the Project APEs and included identification of the type, stage, indicators, and extent of erosion (FirstLight, 2014d). Indicators of active erosion such as exposed roots, creep, overhanging banks, and notching were noted along the shoreline during the course of the archaeological reconnaissance. In general, the FRR determined that 84.8% of the total length of the TFI riverbanks were found to have none/little erosion, 14.1% some erosion, 0.5% some to extensive erosion, and 0.6% extensive erosion. Furthermore, 5.5% of the total length of Impoundment riverbanks were found to have potential future erosion, 0.6% active erosion, 9.1% eroded, 83.5% stable, and 1.3% in the process of stabilization. Based on the findings of the 2013 FRR, it was observed that from 2008 to 2013 there has been an increase in riverbank stability and a corresponding decrease in eroding banks of approximately 1.5%. The FRR study report stated that the increase in stability was a combined result of natural processes of vegetation recruitment and growth and the ongoing stabilization work as required by the Erosion Control Plan

As part of the relicensing studies, FirstLight commissioned a detailed, state of the science erosion causation study (Study 3.1.2) for the TFI, as approved by FERC. The study utilized the Bank Stability and Toe Erosion Model (BSTEM) to calculate bank erosion rates and determine the causes of erosion throughout the TFI under existing conditions. The model utilized site specific information at detailed study sites along the TFI. This study was conducted in close consultation with the licensing stakeholders including the MA Department of Environmental Protection (MADEP). This study found that current hydropower operations have a very limited impact on bank erosion in the TFI. Dominant causes of erosion in the TFI were naturally occurring high flows (86%) and waves from boat wakes (14%). The influence of boat waves on erosion is greatest in the lower TFI, in the vicinity of Barton Cove, below the French King Gorge. Turners Falls Project existing operations were not found to impact bank erosion in the TFI. Existing Northfield Mountain Project operations were not found to affect erosion in the vast majority (98%) of the TFI and were found to be a partial (or contributing) cause of erosion at one out of 25 detailed study sites. When extrapolated, this site accounts for approximately 2% of all riverbank segments (i.e., approximately 4,700 linear feet). Although Northfield Mountain existing operations were found to be a contributing cause of erosion at this one site, the site has already been restored and the amount of erosion which occurs annually from any cause there is very minor (i.e., 0.73 ft^3/ft/yr. under existing conditions).

3.3.8.1.4 **Historic Buildings and Structures**

Between November 2013 and July 2015, FirstLight conducted a historic architectural survey and NRHP evaluation of all buildings, structures, objects, sites, and districts 50 years or older within the Project APEs (FirstLight, 2014c; FirstLight 2015j). The 2013-2015 historic architectural survey consisted of background research on previously identified architectural resources in the APE; preparation of a historic context of the APE from the colonial period to the modern period; a survey of all architectural resources 50 years or older within the APE; and evaluation of their NRHP eligibility, either as an individual resource or as a contributing resource in an NRHP-listed or -eligible historic district. The Northfield Mountain Project, built between 1968 and 1972, also was surveyed as it is now over 50 years old.

There are 31 previously identified resources within the Project APEs. The Turners Falls Historic District, consisting of historic industrial, residential, and commercial buildings in Turners Falls, was listed in the NRHP in 1983 and contains 13 contributing resources located within the Project APE. Six historic resources in the APE—Cabot Power Station and Dam; Eleventh Street Bridge; East Mineral Road Bridge; Gill-Montague Bridge; French King Bridge; and Schell Memorial Bridge (all located in MA)—were previously determined eligible for the NRHP. (The Cabot Station Gantry Crane was determined NRHP-eligible in 1987 but has since been demolished after being recorded via the Historic American Engineering Record). Three previously surveyed resources—Central Vermont Railroad Bridge over the Connecticut River (MA); Boston & Maine Railroad-Fort Hill Branch Bridge over Ashuelot River (NH); and Boston & Maine Railroad-Fort Hill Branch Bridge Piers over the Connecticut River (NH)—were previously determined not eligible for NRHP listing. Eight previously surveyed resources in the Project APEs—"The Patch" Historic District, Frederick Morgan House, Red Suspension Bridge, the Capt. Turner Monument, the Riverside Historic District and three individual resources, the Frank Smith House, Albert Smith House, and the Hunt-Sanderson House located within the Riverside Historic District—had not been previously evaluated for NRHP eligibility at the time of the 2013 – 2015 survey. There are no previously surveyed resources located within the VT section of the APE.

As a part of its field survey, FirstLight identified an additional 38 resources 50 years or older not previously surveyed within the APEs. FirstLight evaluated these 38 resources and the eight previously surveyed resources not yet evaluated, for NRHP-eligibility according to the NRHP Criteria and standards for integrity. Of the eight previously surveyed resources, "The Patch" Historic District in Turners Falls and the Riverside Historic District in Gill (with the three previously surveyed contributing resources located within the Project APE) and the Hinsdale Historic District are eligible for the NRHP. Three previously surveyed resources—Red Suspension Bridge, Capt. Turner Monument, and Morgan House—are not eligible for NRHP listing.

Of the 38 newly surveyed resources, 13 resources are eligible for NRHP listing (all located within MA) and 24 (22 in MA and 2 in VT) are not eligible for the NRHP due to lack of architectural/historical significance and/or loss of integrity. One resource, the Mohawk Trail, is undetermined. In NH three newly surveyed resources (a highway bridge, a culvert, and a USGS gaging station) are contributing resources within the NRHP-eligible Hinsdale Historic District in Hinsdale. The Northfield Mountain Project is considered NRHP-eligible under Criteria A and C and attained 50 years of age in 2018.

The VT SHPO has concurred with FirstLight's recommendation that there are no NRHP-eligible architectural resources within the Project APEs. The NH SHPO concurred that no additional survey or evaluation is required. By letter dated December 11, 2015 the MA SHPO commented that the 3.7.2 *Historic Architectural Resources Survey & National Register Evaluation Study Report Addendum* incorporates additional mapping and information requested by the MA Historical Commission and that it looks forward to reviewing FERC's determinations of eligibility and effect for historic properties within the APEs.

3.3.8.1.5 **Traditional Cultural Properties**

To document TCPs in the Project APEs, FirstLight contacted the Narragansett Indian Nation (NIT) and the Nolumbeka Project on several occasions in 2014 to initiate tribal consultation and documentation of TCPs within the Project APE. Despite several attempts to initiate interviews and field investigations with Tribal members to document TCPs within the Project APEs, interviews and field investigations have not occurred as neither entity has yet agreed to meet with FirstLight's ethnographer. In response to an April 29, 2015 request of the Nolumbeka Project, by letter dated June 9, 2015, FirstLight agreed to walk the Wissatinnewag Property (located outside of the APEs) with the Nolumbeka Project. To date, the Nolumbeka Project, however, has not contacted FirstLight's ethnographer to set up a site visit. Background research conducted in accordance with the Revised Study Plan identified one NRHP-listed TCP in the Project vicinity. The TCP is located at the Turners Falls Municipal Airport, Franklin County, MA. Known as the Turners Falls

Sacred Ceremonial Hill Site, it consists of four visible stone piles and an extended row of stacked stones. No NRHP-listed TCPs in the Project APEs have otherwise been identified (FirstLight, 2015k).

Following filing of the TCP study, the Elnu Abenaki Tribe corresponded on three occasions with the Commission in letters dated May 13, 2016, July 16, 2018, and November 28, 2019 expressing continued interest in the relicensing process and looked "…*forward to a developing, continuing, and positive collaboration with FirstLight, its consultants, the SHPOs, other THPOs should they be involved, and with FERC itself*" (letter of July 16, 2018). The Elnu Abenaki also participated in tribal monitoring of Phase IB and Phase II archaeological fieldwork and offered to continue collaborating in creating a comprehensive TCP *as a living document* that identifies significant landscape features within the Project important to the Abenaki people (letter of November 28, 2019).

3.3.8.2 Environmental Effects

FirstLight is proposing the removal of a 0.2 acre parcel of land at 39 Riverview Drive in Gill, MA from the Turners Falls and Northfield Mountain Project boundary. FirstLight has no ownership rights on this residential parcel and land rights are not needed for Project operations or any other Project purpose. None of the lands FirstLight proposes to exclude from the Project boundary contains historic properties eligible or potentially eligible for the NRHP.

FirstLight is proposing the removal of an 8.1 acre parcel of land referred to as Fuller Farm located near 169 Millers Falls Road in Northfield, MA from the Northfield Mountain Project Boundary. The 8.1-acre farm property includes residential and agricultural structures, and the underlying lands are not necessary for power generation, recreation, or any other Project purpose. FirstLight's historical structures survey found that the buildings (house, barn, and outbuildings) located on the 8.1 acre parcel are not eligible for listing on the NRHP due to lack of historic/architectural significance and lack of integrity.[30] While FirstLight's Phase IA reconnaissance level archaeological survey included the Fuller Farm parcel in its recommendations for Phase IB survey, the parcel is not in a location that is susceptible to erosion or in an area that suggests there are Project-related effects on the property .

FirstLight is proposing the removal of a 20.1 acre parcel from the Turners Falls Project Boundary. The parcel is occupied by the United States Geological Survey's (USGS) Silvio Conte Anadromous Fish Laboratory located at One Migratory Way, P.O Box 796, in Turners Falls, MA 01376. The Conte Lab does not serve any Project purpose and is not necessary to fulfill any license requirements. The Phase IA Study identified several previously recorded archaeological resources on this parcel, which have not been investigated for NRHP eligibility. Nonetheless, because the parcel will remain under the ownership of USGS (a federal governmental entity), which is subject to Section 106 requirements, there will be no adverse effect as a result of removing the Conte Lab parcel from the Project. FirstLight's historical structures survey did not identify any eligible historic structures on this parcel.

FirstLight is proposing several small recreational improvement projects that have the potential to affect cultural resources. These projects will be reviewed in accordance with the Historic Properties Management Plan (HPMP) filed concurrently with the AFLA (see Volume IV-Non Public for the HPMP, separate volumes for each Project).

A single Draft HPMP, combining the Turners Falls and Northfield Mountain Projects, were provided to the SHPOs, representatives of Native American Tribes, and local historical commissions by letter dated April 29, 2016, the same date FirstLight filed its Final License Application. When the Final License Application

[30] Historic Architectural Resources Survey & National Register Evaluation at V-35, Project Nos. 2485 and 1889 (filed Jan. 21, 2015).

was filed the Turners Falls and Northfield Mountain Projects were combined. However, FirstLight is now filing separate Amended Final License Applications for each Project. Since the AFLA proposes to keep the Turners Falls Project and Northfield Mountain Project as separately licensed FERC projects, a Final HPMP was prepared for each Project that provides the same protection measures as the Draft HPMP. The Final HPMPs contain essentially the same information as the Draft HPMP but have been updated to include the results of the Phase IB and II archaeological surveys and to also address comments received from agency reviewers on the Draft HPMP.

To protect eligible cultural resources over the term of a new license, FirstLight developed separate HPMPs for the Turners Falls Project and Northfield Mountain Project which are included in the AFLA. The two HPMPs are being filed with FERC as non-public and will be sent to the MA, NH and VT SHPOs and Tribes. The purpose of the HPMPs are to set forth specific actions and processes to manage historic properties within the Project APEs. It is intended to serve as a guide for FirstLight's operating personnel when performing necessary activities and to prescribe site treatments designed to address ongoing and future effects to historic properties. The HPMPs also describes a process of consultation with state and federal agencies. Measures included in the HPMPs are identification surveys and site NRHP evaluations, site management measures; training of staff; routine monitoring of known cultural resources; and periodic review and revision of the HPMPs.

As reported in the Phase IA archaeological reconnaissance survey reports, based on the results of the sensitivity modeling and the observed erosion, 15.2 miles (24,425 meters) of shoreline in the Project APEs were recommended for Phase IB survey. This includes 7.6 miles (12,200 m) of shoreline in MA, 4.3 miles (6,875 m) of shoreline in NH, and 3.3 miles (5,350 m) of shoreline in VT. The purpose of such field survey was to ascertain the presence or absence of archaeological site(s) and if such resources have the potential to be adversely impacted by erosion.

As noted above, an erosion causation analysis was conducted as part of the licensing process using the state of the science Bank Stability and Toe Erosion Model (BSTEM)- see Section 3.3.1 of this AFLA for further details. This analysis found that the major cause of erosion in the TFI was attributed to either naturally high flows or boat waves. Project operations are not a major cause of erosion anywhere in the TFI but were found to be a contributing factor to erosion at only two sites. The first of these sites was affected by existing operations and has already been remediated under the existing license. The second detailed study site where the cumulative effects (e.g. minimum flows, ramping, etc.) of the proposed operating regime were found to be a contributing cause of erosion has a moderate rate of erosion. However, it was determined that the Projects are responsible for less than 1% of the total erosion in the entire TFI. Given this negligible effect FirstLight is not proposing any additional erosion remediation measures.

The MHC concurred that an intensive (locational) archaeological survey (Phase IB) should be conducted within the survey segments identified in the MA Phase IA report (Sara *et al*., 2015a). The NHDHR and VDHP also concurred with the recommendation for Phase IB archaeological survey within the segments identified for survey in NH and VT (Sara *et al*., 2015b).

The Phase IB study within the VT portion of the Project APE was conducted in May 2018 in the Town of Vernon, Windham County (Sara *et al*., 2018a). The survey was conducted on approximately 4,950 m of shoreline within four survey segments (one portion of segment VT-1 was not surveyed due to land access denial from landowners, accounting for approximately 400 of the 800 m segment length). In accordance with the *VDHP Guidelines*, the Phase IB survey consisted of the hand-excavation of 50-x-50 cm shovel test pits (STPs) placed at 10-m intervals along one linear transect within the shoreline survey segments. Each STP was hand-excavated to a minimum depth of 100 centimeters below ground surface (cmbgs); every fourth STP was extended by 4-inch auger excavation to depths of 150-250 cmbgs in order to examine the potential for deeply buried cultural deposits.

In total, 445 50-x-50-cm square STPs were excavated. Twenty-one (21) artifacts were recovered from three (3) discrete areas (Historic isolated finds VT-7.1 and VT-7.2, and Historic scatter VT-7.3), all historic. None of the three resources represented focused areas of human activity or long-term occupation and were assessed as having poor research value. As such, they were recommended as ineligible for listing in the NRHP and for no further study. These recommendations of ineligibility and no further work were considered final by the VDHP.

The Phase IB study within the NH of the Project APEs was conducted in May 2018 and October 2018 in the Town of Hinsdale, Cheshire County (Sara *et al*., 2018b). Although 7,075 m of shoreline were originally proposed for Phase IB survey, the survey was first conducted on 5,700 m of shoreline within five survey segments. The three remaining survey segments were surveyed in October 2018 on property owned by GRH near Vernon Dam within the FERC project boundary of the Vernon Hydroelectric Project. In accordance with the NHDHR Guidelines, the Phase IB survey consisted of the hand-excavation of 50-x-50 cm STPs placed at 8-m intervals along one linear transect.

The Phase IB survey included excavation of 589 50-x-50 cm square STPs (434 in May 2018 and 155 in October 2018) and one 1-m^2 test unit (TU). Seventy-six artifacts were recovered from seven (7) discrete areas, two (2) of which (NH-5.2 and NH-10.2) were defined as newly recorded archaeological sites (27CH244 and 27CH245 respectively) while the remaining five (5) were identified as field scatters or isolated finds. The two newly recorded archaeological sites, both precontact-period sites, were recommended as potentially eligible for the NRHP and for Phase II evaluation. The remaining five resources did not represent focused areas of human activity or long-term occupation and were recommended for no further study. The NHDHR concurred with these findings and requested Phase II studies on sites 27CH244 and 27CH245 to evaluate their NRHP eligibility.

Phase II fieldwork was conducted in June 2018 and included hand-excavation of additional short-interval STPs and a series of 1-m^2 TUs leading to the recovery of an additional 71 artifacts from site 27CH244 and 46 artifacts from site 27CH245. The recovered artifacts indicated a short-term, Late Woodland occupation. However, a low frequency of recovered artifacts and absence of features did not provide sufficient data to address research questions and both sites were recommended as ineligible for inclusion in the NRHP. No further work was recommended on these sites and the NHDHR concurred that neither site was eligible for inclusion in the NRHP.

The Phase IB study within the MA portion of the Project APEs was conducted from August through October 2018 (Phase IB is also known as *intensive survey* in MA) in the Towns of Greenfield, Gill, and Northfield, Franklin County (Sara *et al*., 2019a). The survey was conducted along approximately 13,700 m of shoreline within 13 survey segments. Survey segments MA-1, 3, 5, 6, 9, 10, 12, 18, 19, 22 were located in Northfield; survey segments MA-14 and 34 in Gill; and survey segment MA-41 is located in Greenfield.

In total, 1,888 50-x-50-cm shovel tests were excavated using a standard interval of 7.5 m in accordance with the MHC Guidelines, yielding a total of 1,768 artifacts (1,070 historic, 655 precontact, 35 faunal, and eight modern items). These included 175 historic artifacts identified as historic field scatter. As a result of the survey, 27 newly recorded and five previously recorded archaeological sites were identified, in addition to nine findspots and nine features.

The sites were identified as either precontact, multi-component, or historic, and consisted of, in Northfield, the Pauchaug Historic Refuse Site, Moose Plain 1, 2, and 3 Sites, Bottom Brook Confluence Site, Moose Plain Historic Refuse Site, Great Meadow 1, 2, 3, 4, 5, 6, 7, and 8 Sites, Bennett Meadow Site, Kidds Island Site, Pine Meadow 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 Sites, and the L'Etoile Site; in Gill, the Munns Ferry, Munns Ferry 1, and Barton Island Sites; and in Greenfield, the Rawson Island Water Diversion Site.

As a result of the Phase IB surveys, at present a total of 109 archaeological sites have been recorded in the Project APEs.

Based on the MHC review of the findings in MA, 17 sites were selected for Phase II study (*site examination* in MA) to ascertain research potential and NRHP eligibility. In accordance with a Curation Agreement among FirstLight, MHC, and Springfield Museums, all collected artifacts and study records from the archaeological studies will be curated at the Springfield Science Museum.

The seventeen Phase II site examinations were conducted in July and August 2019 based on a research design approved by the MHC and summarized as follows.

In July and August 2019, archaeological site examinations (Phase II) were conducted for seventeen (17) archaeological sites identified during intensive survey (Phase IB) of the MA of the Turners Falls Project APE (FERC No. 1889) in 2018 (Sara *et al.*, 2019b). The sites included the Bottom Brook Confluence Site (19-FR-342) Loci 2 and 3, the Great Meadow 1, 3, 4, 5, 6, and 7 Sites, and the Pine Meadow 1, 3, 4, 5, 6, 9, and 11 Sites in the town of Northfield; the Munns Ferry Site (GIL.HA.9) and the Barton Island Site (19-FR-349) in the Town of Gill; and the Rawson Island Water Diversion Site in the Town of Greenfield.

The goal of the site examinations was to further investigate the horizontal and vertical extent of cultural deposits, determine the presence or absence of *in situ* cultural features, determine site function and formation, and assess eligibility to the NRHP. Fieldwork included excavation of 198 50-x-50 cm additional STPs and 95 TUs. Approximately 6,000 artifacts were collected, and 16 additional subsurface cultural features were identified. As a result of the investigations, six sites (Bottom Brook Confluence – Loci 2 and 3 (19-FR-342), Great Meadow 1 and 6, Munns Ferry, Barton Island, and the Rawson Island Water Retention Site) have been recommended as eligible for National Register listing based on their research value that, through further study, could provide valuable insight into the precontact and historic periods in the Connecticut River valley. In study report review letter submitted to FERC dated November 21, 2019, the MHC concurred that these sites meet Criteria A and D for listing in the NRHP (35 CFR 60).

Provisions are included in the Project HPMPs to provide for continuing archaeological surveys in the event that future projects have the potential to affect archaeological resources, including the possible transfer of the Fuller Farm property out of FirstLight ownership.

As noted in Section 3.3.8.1.4, there are 23 previously evaluated architectural resources and 16 newly evaluated architectural resources located in the Project APEs (all located within MA), which are either listed (the Turner Falls Historic District) or eligible for NRHP listing. One of these resources is the Northfield Mountain Project, which became 50 years old in 2018. Provisions are included in the HPMPs to provide for management measures to avoid adverse effects to these resources from any future Project modifications or activities.

3.3.8.3 Proposed Environmental Measures

FirstLight's proposed operations is detailed in Section 2.2 of Exhibit E. To summarize, for various times of the year it includes a) increased bypass flows, b) establishing baseflows below Cabot Station, c) up- and down-ramping restrictions at Cabot Station, d) peaking restrictions at Cabot Station, and f) TFI rate of rise restrictions. FirstLight also proposes to expand the availability of Upper Reservoir storage at Northfield Mountain. Items c) and d) are subject to certain exceptions discussed in Section 2.2

As described above, FirstLight's proposed Project includes one measure specifically related to the protection of cultural resources, which is the development and implementation of an HPMP for each Project. The HPMP (see Volume IV-Non Public for the HPMP, separate volumes for each Project) will ensure that appropriate consultation occurs prior to any future activity that may affect the historic properties associated with the Project. The final HPMPs are being provided to the SHPOs for MA, VT, and NH, Tribes, and filed with FERC under separate cover as "non-public," because they contain confidential archaeological site location information. The HPMPs address known NRHP-eligible historic properties as well as includes provisions to address any subsequently historic properties identified during the term of the new licenses.

3.3.8.4 Unavoidable Adverse Impacts

Continued operation of the Project will result in no unavoidable adverse impacts on historic properties caused by Project operations. Implementation of the HPMPs would assure that the effects of the Project on cultural resources will be taken into account. Therefore, pursuant to the National Historic Preservation Act, Section 106 (16 U.S.C. § 470f (2006) and 36 CFR § 800.5(b) (2008), the Project as proposed would not have any adverse effects on historic properties located at the Project.

References:

Abercrombie, F. (1925). The Turners Falls Power & Electric Company: A Public Utility since 1792. Turners Falls, MA: Turners Falls Power & Electric Co.

Arts Council of Franklin County. (1978a). "Avenue A" MHC Survey Form A. Boston MA.

Arts Council of Franklin County. (1978b). "Cabot Gantry Crane" MHC Survey Form F. Boston MA.

Arts Council of Franklin County. (1978c). "Cabot Hydro Plant" MHC Survey Form F. Boston MA.

Arts Council of Franklin County. (1978d). "Central Railroad of Vermont Bridge" MHC Survey Form F. Boston MA.

Arts Council of Franklin County. (1978e). "Eleventh Street Bridge" MHC Survey Form F. Boston MA.

Bennett, L. (Historic American Buildings Survey [HAER] Historian). (1990a). Eleventh Street Bridge Spanning the Turners Falls Power Canal (HAER No. MA-107). Massachusetts Historic Bridge Recording Project, HAER, Washington, D.C.

Bennett, L. (Historic American Buildings Survey [HAER] Historian). (1990b). French King Bridge Spanning the Connecticut River Between Gill and Erving (HAER No. MA-100). Massachusetts Historic Bridge Recording Project, HAER, Washington, DC.

Boisvert, R. (1999). Paleoindian Occupation of the White Mountains, New Hampshire. Geographic Physique et Quarternaire 53(1):1-16.

Child, H. (1884). Gazetteer and Business Directory of Windham County, Vermont. Syracuse, NY. July 1884.

Curran, M. L. & Dincauze, D. (1977). Paleoindians and Paleo-Lakes: New Data from the Connecticut Drainage. Annals of the New York Academy of Sciences 288:333-348.

Dincauze, D., Moore, J., Root, D. Roberts, M. and Casjens, L. (1977). An Archaeological Properties Study of the Pauchaug Meadow Boat Landing; Northfield, MA. On file at MHC.

Dincauze, D., Thomas, P., Wilson, J. and Mulholland, M. (1976). Cultural Resource Survey and Impact Evaluation: Route 2 Extension: Corridor in Gill, Greenfield, Erving, Wendell and Orange, MA. On file at MHC.

FirstLight. (2014d). Full River Reconnaissance Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889). Prepared for FirstLight Power Resources/Gulf Suez. Northfield, MA: Author.

FirstLight. (2014c). Relicensing Study 3.7.2 Historic Architectural Resources Survey & National Register Evaluation. Prepared by Gomez and Sullivan Engineers and TRC Solutions. Northfield, MA: Author.

FirstLight. (2015j). Relicensing Study 3.7.2 Historic Architectural Resources Survey & National Register Evaluation Report Addendum. Prepared by Gomez and Sullivan Engineers and TRC Solutions. Northfield, MA: Author.

FirstLight. (2015k). Relicensing Study 3.7.3 Traditional Cultural Properties Study, Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889). Prepared by Gomez and Sullivan Engineers and TRC Solutions. Northfield, MA: Author.

FirstLight. (2017a). Relicensing Study 3.1.2 Northfield Mountain / Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability Study Report. Prepared for FirstLight Power Resources. Northfield, MA: Author.

Gill Historical Commission. (1999). Riverside Historic District (GIL-D), MHC Form A. MHC, Boston MA.

Great Falls Discovery Center. (1996). “Walking Tour of Downtown Turners Falls, Massachusetts.” Turners Falls, MA: Author.

Gregory, E. (2006). “Power Canal,” Vertical file at Turners Falls (Carnegie) Library, Turners Falls, MA: Author.

Hasenstab, R.J. (1987). Archaeological Locational Survey at the Turners Falls Airport, Franklin County, Massachusetts. On file at MHC.

Holmes, R., D. Mitchell, T. Mulholland & Hertz, C.D. (1991). Archaeological Reconnaissance Survey for the Proposed Riverbank Erosion Control Study, Massachusetts, Vermont, and New Hampshire. Amherst, MA: UMASS Archaeological Services, University of Massachusetts at Amherst.

Hostutler, E. & Muzzey, W. (1994). “Fort Hill Division of Boston & Maine Railroad,” New Hampshire Division of Historical Resources Area Form. Concord NH.

Jenkins, C. (1980). “Turners Falls Historic District,” National Register of Historic Places Nomination Form, Massachusetts Historical Commission, Boston, MA.

Johnson, E. (2007). Prehistoric Overview. In Historic and Archaeological Resources of the Connecticut River Valley: A Framework for Preservation Decisions, PDF version, p. 19-45. On file at MHC.

Johnson, E. & Krim, A. (2007). Topographic Overview. In Historic and Archaeological Resources of the Connecticut River Valley: A Framework for Preservation Decisions, PDF version, p. 12-15. On file at MHC.

Martin, P. S. (1973). The Discovery of America. Science 179:969-974.

Montague Bicentennial Committee. (1954). Montague: 1754-1954. Montague, MA: Private publisher.

Nassaney, M. (1999). The Significance of the Turners Falls Locality in Connecticut River Valley Archaeology. In The Archaeological Northeast, edited M.A. Levine, K. Sassaman, and M. Nassanney.

New Hampshire Department of Transportation (NHDOT). (2007). "Hinsdale Historic District," Project Area Form prepared for intersection Improvements in Hinsdale, Cheshire County, NH.

Robinson, B.S. (1992). Early and Middle Archaic Occupation in the Gulf of Maine Region: Mortuary and Technological Patterning. In Early Holocene Occupation in Northern New England, edited By B. S. Robins, J.B. Petersen, and A. K. Robinson. Occasional Publications in Maine Archaeology, no. 9. Augusta, ME: The Maine Historic Preservation Commission.

Samartino, Claudia F. (1991). The Northfield Mountain Interpreter: Facts about the Mountain, the River, and its People. Berlin, CT: Northeast Utilities.

Sanborn Map Company. (March 1895). Sanborn Fire Insurance Map from Turners Falls, Franklin County, Massachusetts. Brooklyn NY: Sanborn Map & Publishing Company.

Sara T. R., Moore, E. Mundt, J. Walters, P. & Will, R. (2014a). Relicensing Study 3.7.1 Phase IA (Reconnaissance) Archaeological Survey. Prepared by TRC Environmental Corporation. Prepared for FirstLight Hydro Generating Company. Northfield, MA: FirstLight.

Sara T. R., Moore, E. Mundt, J. Walters, P. & Will, R. (2014b). Relicensing Study 3.7.1 Phase IA Archaeological Survey. Prepared by TRC Environmental Corporation. Prepared for FirstLight Hydro Generating Company. Northfield, MA: FirstLight.

Sara, T., Moore, R.E., Mundt, J., Walters, P., & Will, R. (2015). Relicensing Study 3.7.1 Final Report: Phase IA (Reconnaissance) Archaeological Survey. Prepared by TRC Environmental Corporation. Prepared for FirstLight Hydro Generating Company.

Sara, T.R., K. Mack, B. Kenline-Nyman, P. Walters, and J. Gollup (2018a). Relicensing Study 3.7.1 Phase IB Archaeological Survey - End of Fieldwork Report. Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889), Windham County, VT. Submitted to FirstLight Hydro Generating Company, Federal Energy Regulatory Commission, Vermont Division for Historic Preservation, and New Hampshire Division of Historic Resources.

Sara, T.R., K. Mack, B. Kenline-Nyman, P. Walters, and J. Gollup (2018b). Relicensing Study 3.7.1 Phase IB Archaeological Survey and Phase II Archaeological Evaluations of Sites 27CH244 and 27CH245 Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889), Cheshire County, NH. Submitted to FirstLight Hydro Generating Company, Federal Energy Regulatory Commission, Vermont Division for Historic Preservation, and New Hampshire Division of Historic Resources.

Sara, T. R., K. Mack, B. Kenline-Nyman, P.Walters, and J.Gollup (2019a). Relicensing Study 3.7.1, Intensive (Locational) Survey (Phase IB Archaeological Survey), Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889), Towns of Northfield, Gill, and Greenfield, Franklin County, Massachusetts. TRC Environmental Corp., Lanham, Maryland. Submitted to FirstLight Hydro Generating Company, Federal Energy Regulatory Commission, and Massachusetts Historical Commission.

Sara, T. R., E. Moore, J. Gollup, E. Masters, J. Warrenfeltz, and K. Mack (2019b). Relicensing Study 3.7.1, Site Examinations (Phase II Archaeological Evaluations) of Seventeen Archaeological Sites, Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889), Towns of Northfield, Gill, and Greenfield, Franklin County, Massachusetts (Volumes I and II). TRC: Lanham, Maryland. Submitted to FirstLight Power Inc, Federal Energy Regulatory Commission, and Massachusetts Historical Commission.

Spiess A., Wilson, D. & Bradley, J. (1998). Paleoindian Occupation in the New England-Maritimes Region: Beyond Cultural Ecology. Archaeology of Eastern North America 26:201-264.

Thomas, P. (1980). The Riverside District, the WMECO Site, and Suggestions for Archaeological Modeling. In Early and Middle Archaic Cultures in the Northeast, edited by D.R. Starbuck and C. Bolian. Occasional Publications in Northeastern Anthropology 7:73-95.

Turners Falls Company. (1904). Floor Plan of Powerhouse. Turners Falls Company, Edwin C. Ball Engineer. Turners Falls, Mass. September 1904.

Turners Falls Company. (1907). Plan of 44” Wheels for Power House. Turners Falls Company, Edwin C. Ball Engineer. Turners Falls, Mass. March 1907.

Turners Falls Power & Electric Company. (1914a). General Plan of Dam and Dam Construction. Turners Falls Power & Electric Company, Engineering Division, Turners Falls Office. October 24, 1914.

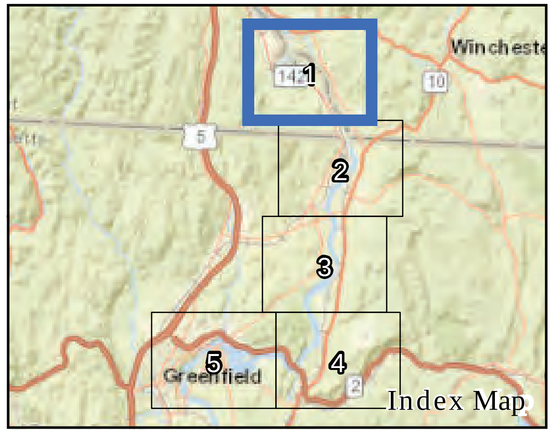
Turners Falls Power & Electric Company. (1914b). Dam and Headgates Cross Section. Turners Falls Power & Electric Company, Engineering Division, Turners Falls Office. October 24, 1914.

Turners Falls Power & Electric Company. (1917). Plan and Profiles I.P. Mill, Raising Upper Canal Walls. Turners Falls Power & Electric Company, Engineering Division, Turners Falls Office. February 23, 1917.

Ulrich, T. (1978). Preliminary Report of a Cultural Resource Survey of the Deer-field Industrial Park, Phase I/IIa, Deerfield, MA. On file at MHC.

Wallace, R.S. & Mausolf, L. (2001). New Hampshire Railroads: Historic Context Statement. Concord, NH: New Hampshire Department of Transportation

Western Massachusetts Electric Company (WMECO). (1987). Before the Federal Energy Regulatory Commission: Turners Falls Project FERC Project No. 1889, Application for Amendment of License, Proposed Cabot Unit 7. Springfield, MA: Author.



Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E
Figure 3.3.8.1.1-1: Area of Potential Effects
Map 1

Legend

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Area of Potential Effects

- Turners Falls (TF) Area of Potential Effect
- Northfield Mountain (NFM) Area of Potential Effect
- TF/NFM Area of Potential Effect Overlap

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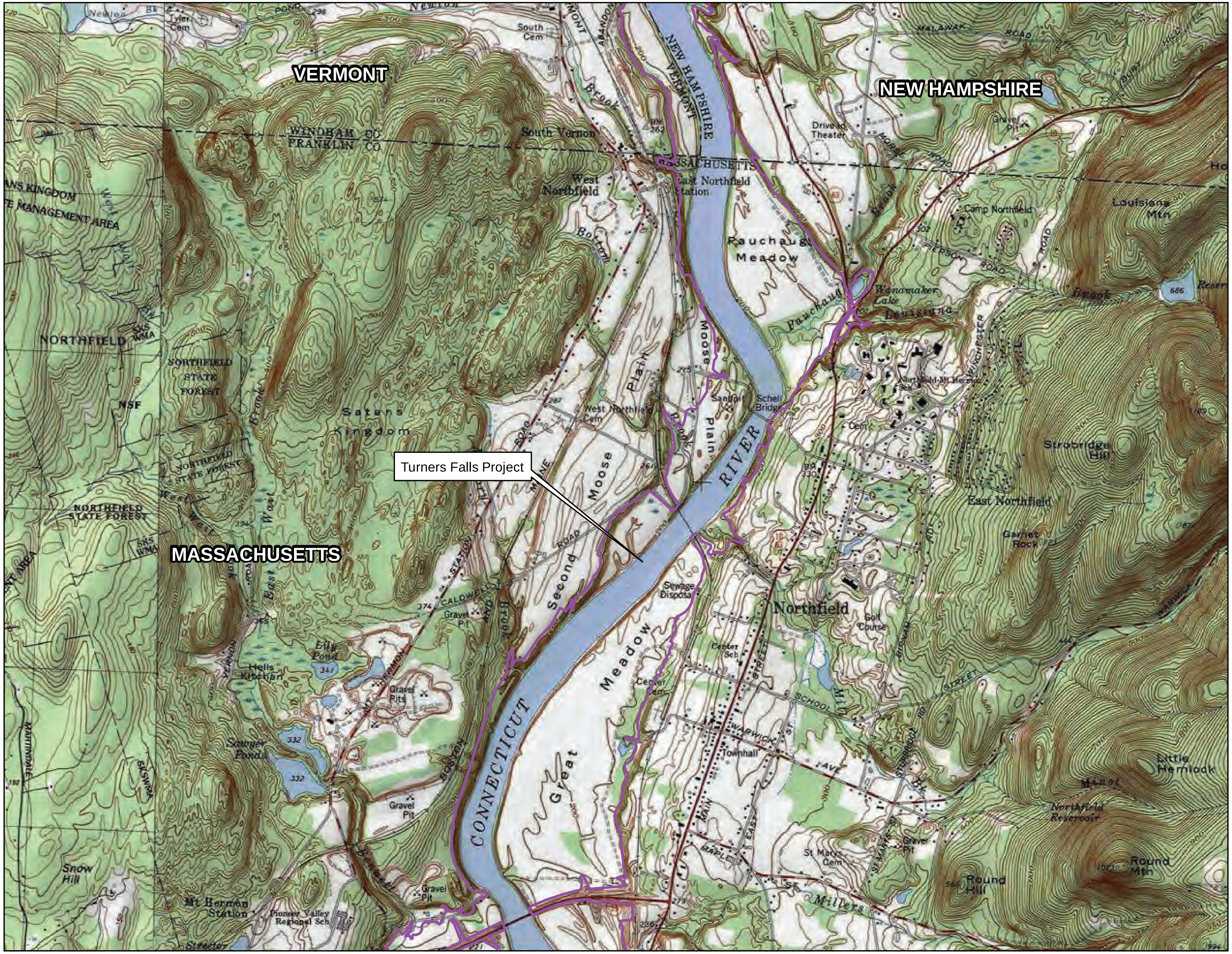

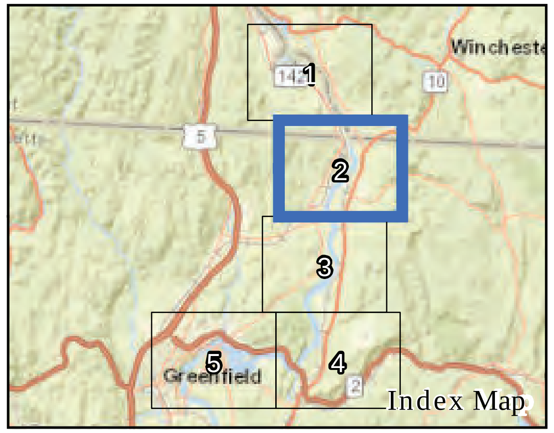

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E
Figure 3.3.8.1.1-1: Area of Potential Effects
Map 2

Legend

Area of Potential Effects

- Turners Falls (TF) Area of Potential Effect
- Northfield Mountain (NFM) Area of Potential Effect
- TF/NFM Area of Potential Effect Overlap

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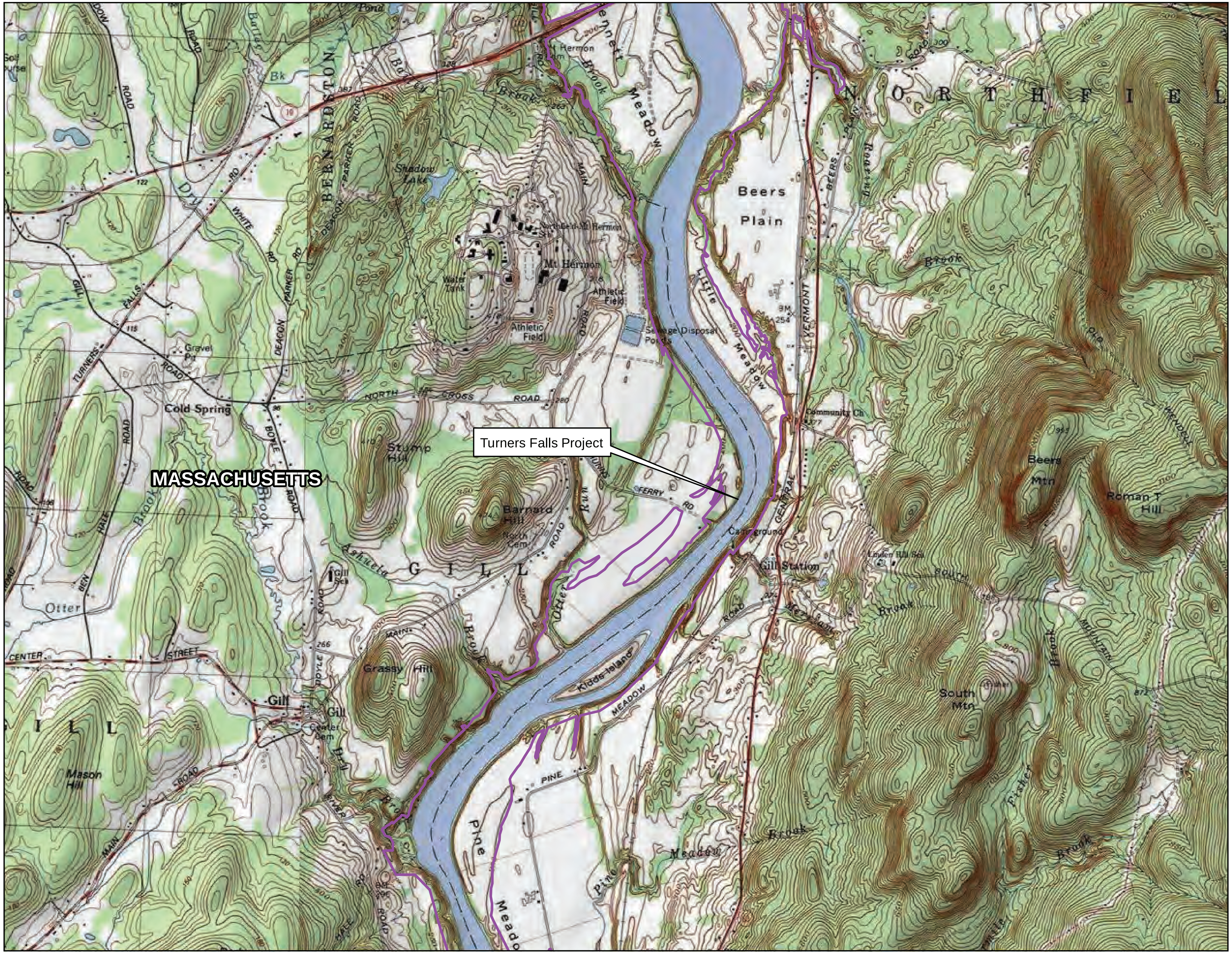

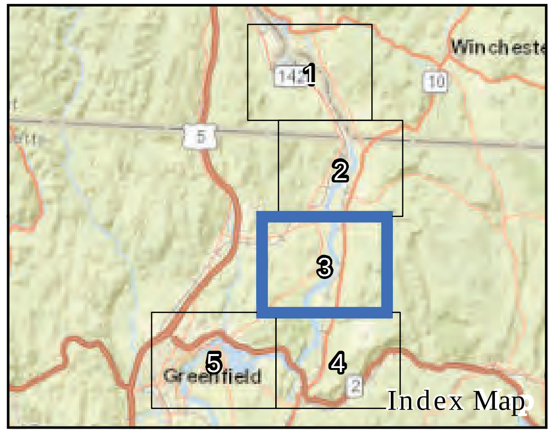

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E
Figure 3.3.8.1.1-1: Area of Potential Effects
Map 3

Legend

Area of Potential Effects

- Turners Falls (TF) Area of Potential Effect
- Northfield Mountain (NFM) Area of Potential Effect
- TF/NFM Area of Potential Effect Overlap

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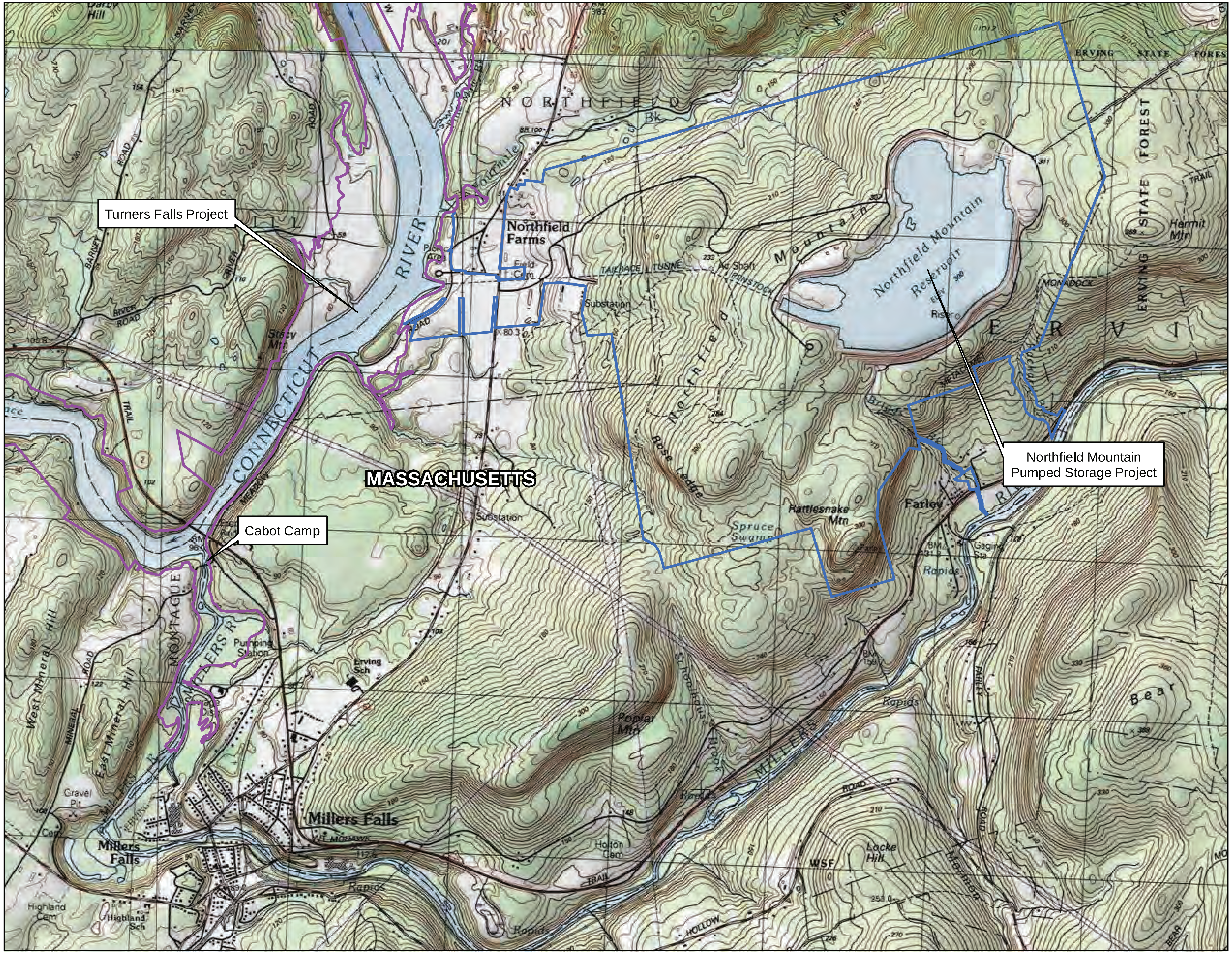

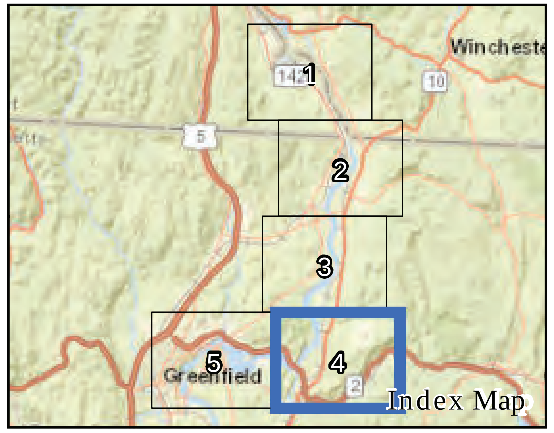

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

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Exhibit E
Figure 3.3.8.1.1-1: Area of Potential Effects
Map 4

Legend

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Area of Potential Effects

- Turners Falls (TF) Area of Potential Effect
- Northfield Mountain (NFM) Area of Potential Effect
- TF/NFM Area of Potential Effect Overlap

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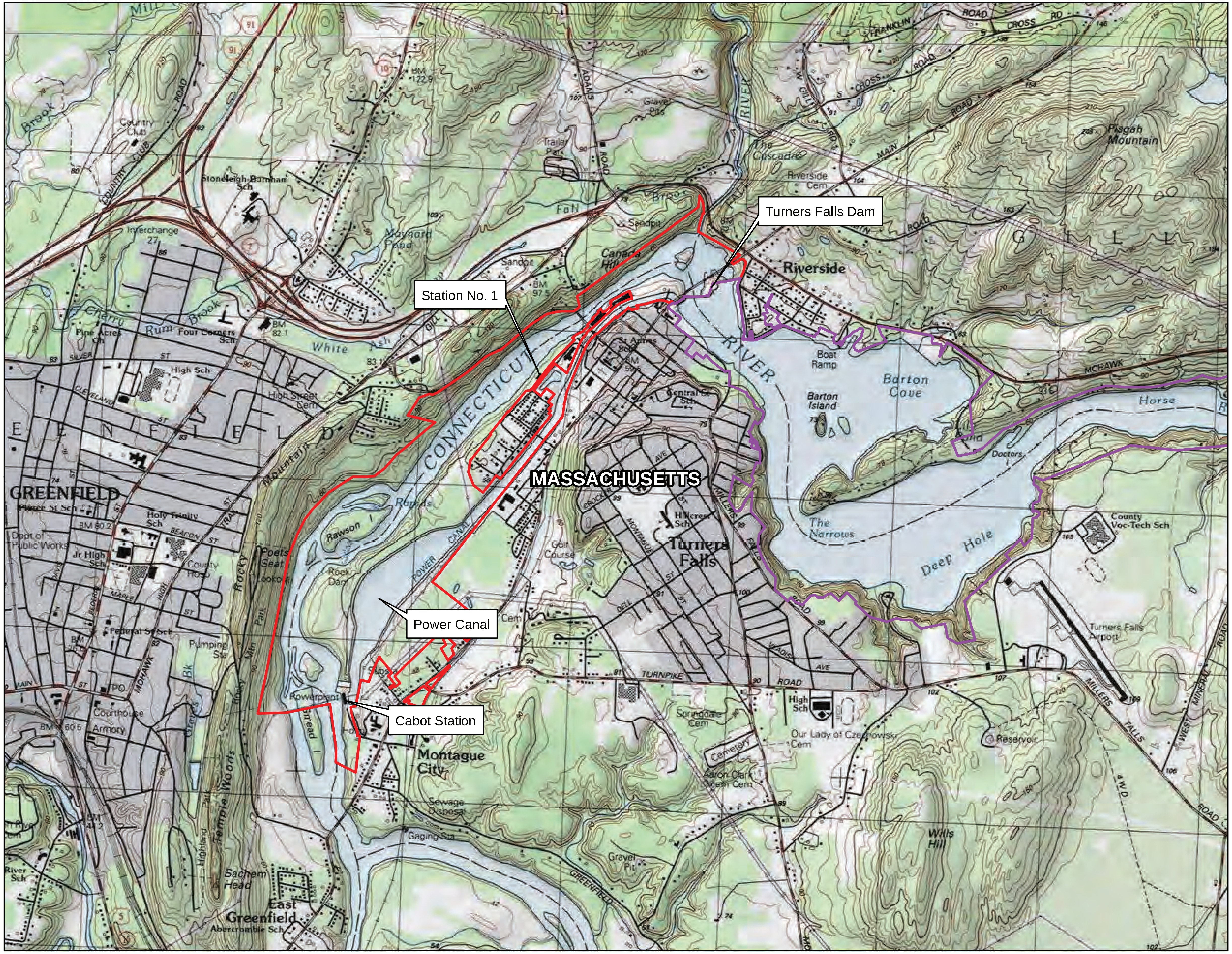

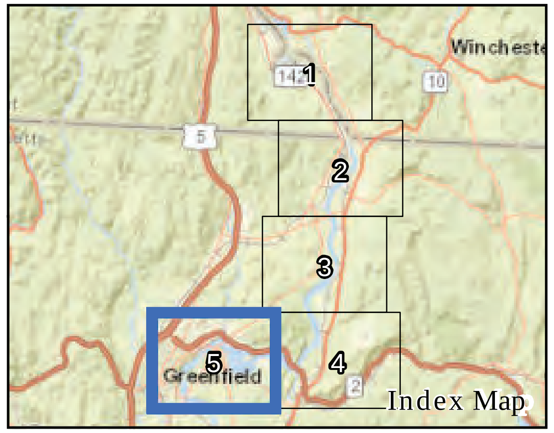

Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Amended Final License Application
Exhibit E
Figure 3.3.8.1.1-1: Area of Potential Effects
Map 5

Legend

Area of Potential Effects

- Turners Falls (TF) Area of Potential Effect
- Northfield Mountain (NFM) Area of Potential Effect
- TF/NFM Area of Potential Effect Overlap

N

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3.3.9 Aesthetic Resources

3.3.9.1 Affected Environment

3.3.9.1.1 Landscape Description

The Connecticut River valley's landscape has distinct natural beauty and classic New England farm village patterns. In the Project vicinity, historic villages and working landscapes combine with natural riverine beauty to create a scenic corridor. The region is comprised of riverside farmlands, woodlands, historic village centers founded in the late 1600s, working landscapes laid out during Colonial times, and vistas of the Connecticut River and mountain ranges. Step-like terraces and floodplains slope up to the bordering hills. The valley is framed by the Berkshire Mountains on the west and by the central uplands on the east. In autumn, the trees blaze with color (PVPC, 2012).

The corridor along the TFI was designated as a scenic landscape in 1981 by the MA Department of Conservation and Recreation (then Department of Environmental Management). Below Cabot Station, most of the river corridor down to South Hadley is also considered a scenic landscape. Figure 3.3.9.1.1-1 depicts these scenic landscape designations as well as other aesthetic elements and scenic byways in the Turners Falls Project and Northfield Mountain Project vicinity.

3.3.9.1.2 Scenic Byways and Viewscapes

Connecticut River National Scenic Byway

The roadways along the Connecticut River in NH, VT, and MA were designated as state scenic byways in 1994, 1999, and 2000, respectively. In 2005, the VT and NH sections were designated as a National Scenic Byway. The MA section, which extends from the state border in Northfield down to South Hadley, was added to the Connecticut River National Scenic Byway in 2009. Scenic byway routes in the Project vicinity include Route 142 through Vernon, VT, Route 63 through Hinsdale, NH and Northfield, Erving, and Montague, MA, and Route 47 through Sunderland, Hadley, and South Hadley, MA. Designated waypoints along the byway include Northfield Mountain Tour and Trail Center and the Great Falls Discovery Center in Turners Falls. Figure 3.3.9.1.1-1 shows the route of the Connecticut River Scenic Byway in the Turners Falls Project and Northfield Mountain Project vicinity (USDOT, 2012).

Mohawk Trail Scenic Byway

The Mohawk Trail Scenic Byway was one of the earliest scenic byways in New England, receiving its designation in 1953. It follows an east-west corridor along Route 2 from Athol to Williamstown, MA. In Erving, the Byway passes through forested areas along the Millers River with views of the Erving Cliffs (Farley Ledges) as well as of mountains in Wendell and Gill. At the Erving-Gill town line, the Byway crosses the Connecticut River on the French King Bridge with spectacular views up and down the river (see below). In Gill, the Byway has a more rural feel with views of Barton Cove, some views of the river through trees to Montague and farmsteads, and a gently rolling landscape. Near the eastern town line, a panoramic view of the Village of Turners Falls and its historic industrial landscape is visible across the Connecticut River and the power canal. The Byway then turns onto Route 2A and passes through historic downtown Greenfield (FRCOG, 2009).

Connecticut River Water Trail

The Connecticut River Water Trail is a 12-mile-long paddling trail that runs from the Turners Falls Dam to a boat access point one mile north of Hatfield Center (see Figure 3.3.9.1.1-1). It features a nearly unbroken vegetated shoreline, wetlands, high bluffs, long views, and floodplain forests. The water trail is part of the longer Connecticut River Greenway State Park, which encompasses the length of the river in MA (MADCR, 2012).

Metacomet-Monadnock Trail/New England National Scenic Trail
The Metacomet-Monadnock Trail (M-M Trail) is a long distance hiking footpath extending from the Connecticut state line to Mt. Monadnock in NH (see Figure 3.3.9.1.1-1). In 2001, the National Park Service certified sections of the trail, including those near Northfield Mountain, as a National Recreational Trail. In 2009, the trail was designated as part of the New England National Scenic Trail (NET), which also includes the Mattabesett Trail in CT (collectively known as the M-M-M Trails). In Northfield, the M-M Trail traverses the open ledges of Crag Mountain, from which views of the Northfield Mountain Upper Reservoir can be seen to the southwest (see Figure 3.3.9.1.2-1) (AMC, 2010).

Connecticut River National Blueway
The Connecticut River was designated the first National Blueway on May 24, 2012 by the US Department of Interior. The federal designation comprises the entire river, as well as its watershed. The Blueway designation was intended to provide for better coordination of local, state and federal groups to promote best management practices, information sharing and stewardship. Though the National Blueway System has been dissolved, the Connecticut River maintains the designation of the nation's first and only National Blueway.

Scenic Viewpoints
Located between the Northfield Mountain Project intake/tailrace and the Turners Falls Dam, the French King Gorge, with its 250-foot-high rocky banks, is of ecological and scenic significance. The gorge was formed thousands of years ago by glacial melt waters. The Route 2 Bridge connecting Gill to Erving, also known as the French King Bridge, provides scenic views to the north and south, where the Millers River empties into the Connecticut (see Figure 3.3.9.1.2-2). This is a popular tourist destination, and some parking is provided on both sides of the road at the bridge (MADCR, 2012).

The Gill-Montague Bridge just below Turners Falls Dam provides scenic views of the dam and bypass reach for pedestrian and automobile traffic. Figure 3.3.9.1.2-3 is an aerial image showing the bridge, the Village of Turners Falls, and the landscape surrounding the lower TFI.

At more than 1,200 feet in height, Mt. Toby in Sunderland, just south of the Turners Falls Project and Northfield Mountain Project, looms over the middle Connecticut River valley offering outstanding panoramic views. A moderate hiking trail of about 6 miles leads to the top, and there are shorter hiking trails as well. Related geologically to Mt. Sugarloaf, Mt. Toby features cliffs, caves, waterfalls, wetlands, and open fields (MADCR, 2012).

Project Location
The Turners Falls Dam, gatehouse, power canal, Station No. 1 and Cabot Station are located in an industrial area with several roads, town office buildings, and residential housing. In contrast, the Northfield Mountain Project, with the exception of the intake/tailrace and Upper Reservoir, is generally out of public view. The powerhouse and tunnels are buried with the mountain.

3.3.9.2 Environmental Effects
FirstLight is proposing to increase its bypass flows by releasing water at the Turners Falls Dam and through Station No. 1 as summarized below.

Date	Total Bypass Flow[2]	Turners Falls Dam	[3]Station No. 1
01/01-03/31	1,500 cfs or the Naturally Routed Flow (NRF), whichever is less	300 cfs	1,200 cfs[4]
04/01-05-31[1]	6,500 cfs or the NRF, whichever is less	4,290 cfs	2,210 cfs[4]
06/01-06/15[1]	4,500 cfs or the NRF, whichever is less	2,990 cfs	1,510 cfs[4]
06/16-06/30[1]	3,500 cfs or the NRF, whichever is less	2,280 cfs	1,220 cfs[4]

Date	Total Bypass Flow[2]	Turners Falls Dam	[3]Station No. 1
07/01-08/31	1,800 cfs or the NRF, whichever is less	670 cfs	1,130 cfs[4]
09/01-11/30	1,500 cfs or the NRF, whichever is less	500 cfs	1,000 cfs[4]
12/01-12/31	1,500 cfs or the NRF, whichever is less	300 cfs	1,200 cfs[4]

[1]The flow split during these periods is approximately 67% from the Turners Falls Dam and 33% from Station No. 1. If FirstLight conducts further testing, in consultation with the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS) and Massachusetts Department of Fish and Wildlife (MADFW), and determines that migratory fish are not delayed by passing a greater percentage of the bypass flow via Station No. 1, it may increase the percentage through Station No. 1 upon written concurrence of those agencies.

[2]If the NRF is less than 6,500 cfs (04/01-05/31), 4,500 cfs (06/01-06/15) or 3,500 cfs (06/16-06/30) the flow split will still be set at approximately 67% of the NRF from the Turners Falls Dam and 33% of the NRF from Station No. 1. If the NRF is less than 1,800 cfs (7/1-8/31), 1,500 cfs (9/1-11/30), or 1,500 cfs (12/1-3/31), the Licensee shall maintain the Turners Falls Dam discharges at 670 cfs, 500, cfs, and 300 cfs, respectively.

[3]To maintain the flow split, Station No. 1 must be automated, which will not occur until Year 3 of the license. FirstLight proposes to maintain the flow split such that the Turners Falls Dam discharge will be as shown above, or higher flows will be spilled, in cases where the additional flow cannot be passed through Station No. 1.

[4]The Turners Falls Hydro (TFH) project (FERC No. 2622) and Milton Hilton, LLC project (unlicensed) are located on the power canal and discharge into the bypass reach upstream of Station No. 1. The hydraulic capacity of the TFH project and Milton Hilton, LLC project is 289 and 113 cfs, respectively. If the TFH project is operating, FirstLight will reduce its Station No. 1 discharge by 289 cfs. If the Milton Hilton, LLC project is operating, FirstLight will reduce its Station No. 1 discharge by 113 cfs.

In addition, FirstLight proposes to provide the whitewater flows below, or the NRF, whichever is less, from the Turners Falls Dam.

Date	Turners Falls Dam Magnitude of Discharge	Turners Falls Dam Release Duration
1 Saturday in July	2,500 cfs or the NRF, whichever is less	4 hours
1 Saturday in August	2,500 cfs or the NRF, whichever is less	4 hours
3 Saturdays in September	3,500 cfs or the NRF, whichever is less	4 hours
1 Saturday in October	3,500 cfs or the NRF, whichever is less	4 hours
2 Saturdays in October	5,000 cfs or the NRF, whichever is less	4 hours

The increase in bypass flows will improve aesthetics in the bypass reach for those crossing the Gill-Montague Bridge and 5th Street Bridge as well as for the public that access the bypass via the formal and informal recreation sites.

3.3.9.3 Proposed Environmental Measures

FirstLight is proposing to increase bypass flows and provide whitewater flows which will improve aesthetics (auditory and visual) in the bypass reach.

3.3.9.4 Unavoidable Adverse Impacts

No unavoidable adverse impacts are expected on aesthetic resources.

References:

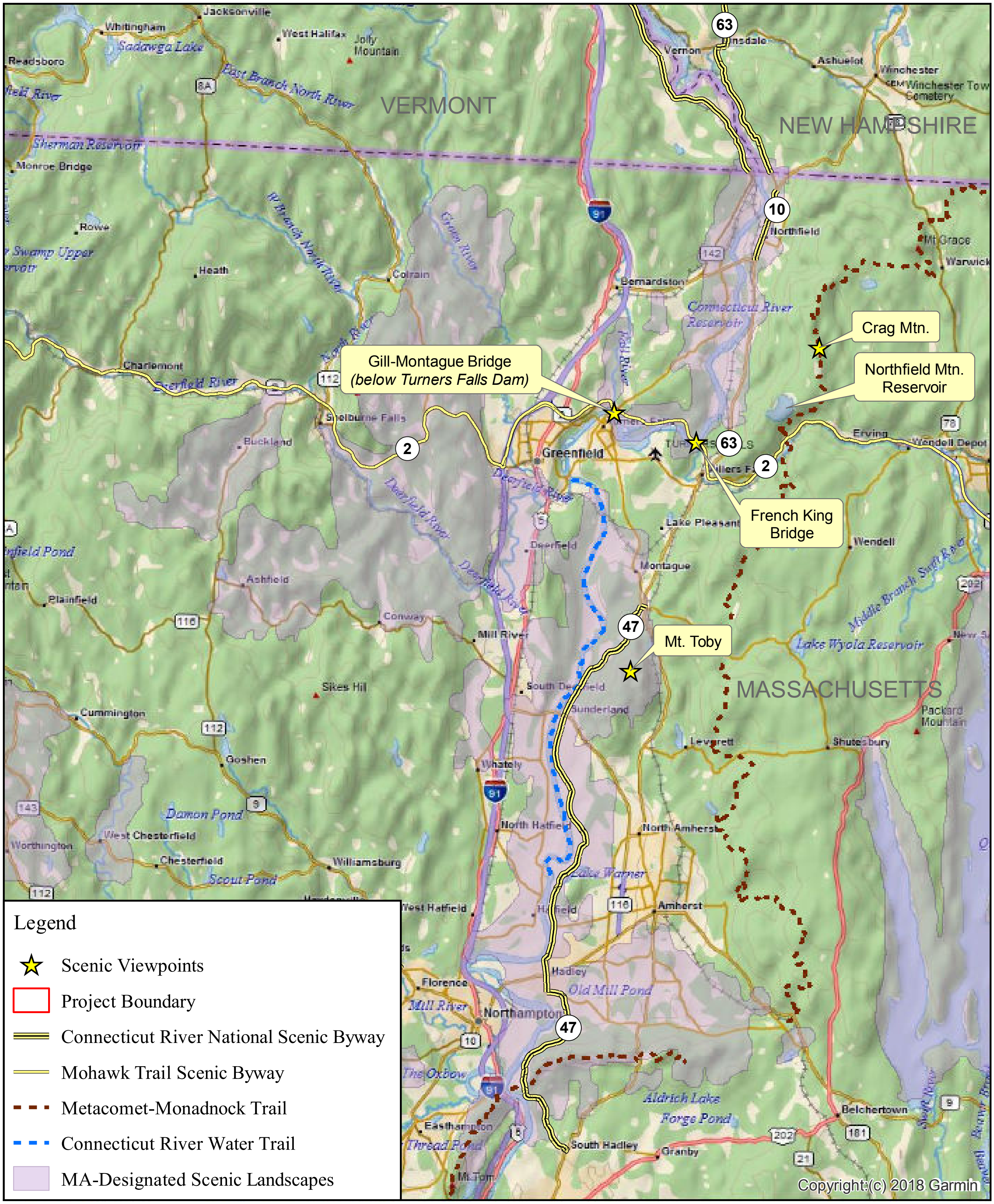
Appalachian Mountain Club (AMC). (2010). *Metacomet-Monadnock Trail*. Retrieved from the AMC Berkshire Chapter website: http://amcberkshire.org/mm-trail

Franklin Regional Council of Governments (FRCOG). (2009). *Mohawk Trail Scenic Byway Eastern Section – Athol to Greenfield: Corridor Management Plan*. Greenfield, MA: FRCOG. Retrieved from: http://www.frcog.org/services/transportation/trans_mohawk.php

Massachusetts Department of Conservation and Recreation (MADCR). (2012). *Connecticut River Greenway State Park*. Retrieved from: http://www.mass.gov/dcr/parks/central/crgw.htm

Pioneer Valley Planning Commission (PVPC). (2012). *Various articles*. Retrieved from: http://www.pvpc.org

US Department of Transportation (USDOT). (2012). *Connecticut River byway*. Retrieved from USDOT Federal Highway Administration's National Scenic Byways Program website: http://byways.org/explore/byways/2487



Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

FirstLight

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Amended Final License Application
Exhibit E

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Figure 3.3.9.1.1-1:
Aesthetic Resources
in the Project Vicinity

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Figure 3.3.9.1.2-1: View of Northfield Mountain Reservoir from Crag Mountain

Figure 3.3.9.1.2-2: French King Bridge over Turners Falls Impoundment

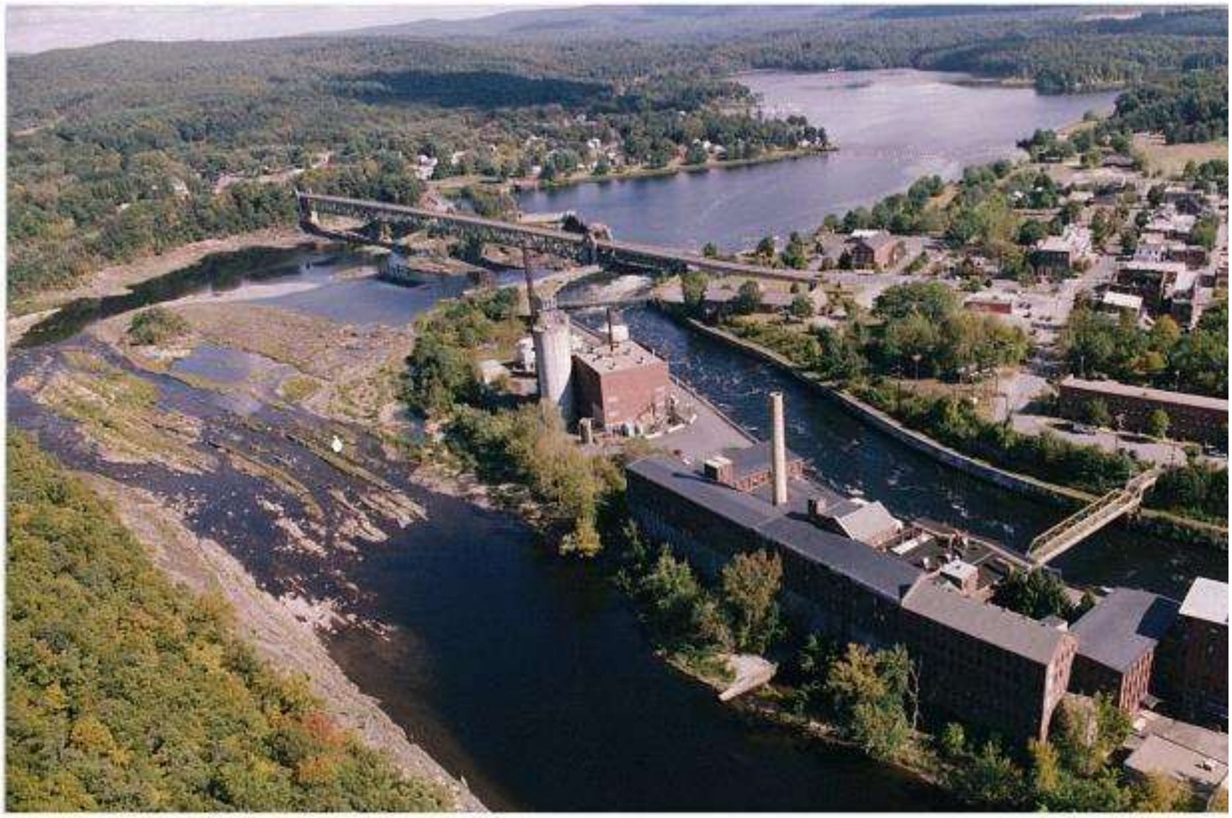

Figure 3.3.9.1.2-3: Aerial View of Turners Falls Dam Area, Looking Upstream

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3.3.10 Socioeconomic Conditions

3.3.10.1 Affected Environment

3.3.10.1.1 Population Patterns

The Pioneer Valley region encompasses 43 cities and towns in the Connecticut River Valley in western MA. An estimated 608,000 people live in the nearly 1,200-square-mile region, which includes the fourth largest metropolitan area in New England (Springfield). The Pioneer Valley's diverse economic base, its renowned academic institutions, and its wealth of natural resources make it a unique place to live and work. Residents live in downtown areas, suburban neighborhoods, quiet villages, historic areas, and rural homesteads. People work in downtown offices in Springfield, the region's cultural and economic center; in plants and factories in Holyoke and Chicopee, the first planned industrial communities in the nation; in academic halls in Amherst, Northampton, and South Hadley, home to venerable colleges and a flagship university; in tobacco fields in Hadley, where families have worked the land for generations; in distribution centers in Westfield, near the crossroads of two interstate highways; and in offices scattered throughout the region (PVPC, 2012).

The area immediately surrounding the Project is relatively rural in nature. Franklin County is the most rural in MA, and Greenfield is its largest municipality. Based on the results of the 2010 census (presented in Table 3.3.10.1.1-1), the estimated populations of the three counties within the Project boundary—Franklin County, MA, Cheshire County, NH, and Windham County, VT—are 71,444, 77,274, and 44,453, respectively. This translates to population densities of 99 people per square mile in Franklin County, 106 people per square mile in Cheshire County, and 56 people per square mile in Windham County. Housing densities are roughly 46, 48, and 37 units per square mile, respectively (US Census Bureau, 2010).
Table 3.3.10.1.1-2 shows that over the last decade, populations have remained relatively stable in the Project vicinity—ranging from a decline of 0.1% in Franklin County to an increase of 4.7% in Cheshire County (US Census Bureau, 2010).

The nearest major town is Greenfield, MA, which has a population of 17,610 (2010) and a town center located about four miles southwest of the Turners Falls Dam. Other significant population centers near the Project are shown in Table 3.3.10.1.1-3 and include Northampton (28,709 residents, 28 miles south of the Turners Falls Project and Northfield Mountain Project), Amherst (37,819 residents, 17 miles south of the facilities), Holyoke (39,885 residents, 38 miles south), Springfield (152,906 residents, 48 miles south), and Hartford, CT (124,775 residents, 70 miles south). For reference, Boston is approximately 106 miles east of the Project and has about 602,609 residents (US Census Bureau, 2010).

3.3.10.1.2 Economic Patterns

Income distributions of the counties in the Project vicinity are shown in Table 3.3.10.1.2-1. Median household income in the region was lower than that for MA overall ($62,072), ranging from $47,386 in Windham County to $52,644 in Cheshire County. In 2010, 12.7% of households throughout the state earned less than $15,000; this figure was identical for Franklin County and was bracketed by Cheshire and Windham counties at 9.7% and 13.3%, respectively. Additionally, while over 29% of MA households earned more than $100,000 in 2010, only 17.2% of households in Franklin County, 17.7% in Cheshire County, and 14.5% in Windham County surpassed that amount (US Census Bureau, 2010).

Table 3.3.10.1.2-2 displays the distribution of the civilian employed population (age 16 or over) for each county and the Commonwealth of MA. In general, counties in the Project vicinity have a higher percentage of people employed in the natural resources, construction and maintenance sector and the production, transportation, and material moving sector than in MA overall, while less people are employed in the management, business, science, and arts sector. Additionally, unemployment rates are lower in the Project vicinity—ranging from 6.5% in Windham County, 9.7% in Cheshire County, and 10.2% for MA (US Census Bureau, 2010).

Some of the larger employers in the Project vicinity include the Greenfield Community College (300 employees in 2010), Yankee Candle in Whately (1,500 employees), Cooley Dickinson Hospital and Smith College in Northampton (1,800 and 1,000 employees, respectively), and the University of MA in Amherst (7,900 employees) (Clarke, 2011). FirstLight employs approximately 53 full-time employees at the Northfield Mountain Project and 12 full-time employees at the Turners Falls Project.

FirstLight is also a major contributor to town property taxes. Shown in Table 3.3.10.1.2-3 are the approximate amount of taxes paid in 2019 for each Project. FirstLight pays over $15,065,000 in property taxes. The towns of Erving, Montague, Gill and Northfield receive significant taxes from FirstLight. Relative to the total town property taxes in 2019, FirstLight paid approximately 85%, 23%, 11% and 19% of the Erving, Montague, Gill and Northfield total tax base, respectively.

3.3.10.2 Environmental Effects

FirstLight proposes to increase bypass flows for fish and aquatic resources as well as for whitewater boating. With the increased bypass flows, it is expected that the public will use the resource more often for fishing and kayaking/canoeing/boating the bypass. In addition, FirstLight is proposing several fish passage and recreation PME measures that will require engineering, permitting and construction. Albeit temporary, these capital investment projects will bring contractors to the region and the resulting expenditure of money in the local community. The Project will also continue to supply low cost electricity and jobs, which benefits the socioeconomic health of the region. Finally, as noted above, FirstLight will continue to pay local property taxes which supports the local towns.

3.3.10.3 Proposed Measures

Because the proposed Project would continue to have a beneficial effect on socioeconomic resources, FirstLight does not propose any new measures related to socioeconomic resources.

3.3.10.4 Unavoidable Adverse Impacts

The Project has no known unavoidable adverse effects on socioeconomic resources.

References:

Clarke, P.J. (2011). Western Massachusetts 2010-2011 economic review. Springfield, MA: Western Massachusetts Electric Company.

Pioneer Valley Planning Commission (PVPC). (2012). *Various articles*. Retrieved from: http://www.pvpc.org

US Census Bureau. (2010). American community survey. Retrieved from: http://factfinder2.census.gov

Table 3.3.10.1.1-1: Population and Housing Data in the Project Vicinity

County	Population (2010)	Housing Units (2010)	Land Area (sq. mi.)	Population Density (people/sq. mi.)	Housing Density (units/sq. mi.)
Franklin Co., MA	71,444	33,695	725	99	46
Cheshire Co., NH	77,274	34,682	729	106	48
Windham Co., VT	44,453	29,601	798	56	37

Source: (US Census Bureau, 2010)

Table 3.3.10.1.1-2: Population Trends in the Project Vicinity

County	Population (2000)	Population (2010)	Percent Change
Franklin Co., MA	71,535	71,444	-0.13%
Cheshire Co., NH	73,825	77,274	4.67%
Windham Co., VT	44,216	44,453	0.54%

Source: (US Census Bureau, 2010)

Table 3.3.10.1.1-3: Major Population Centers near the Project

Town or City	Population (2010)	Approximate Distance from Turners Falls Dam (mi)
Greenfield, MA	17,610	4
Amherst, MA	37,819	17
Brattleboro, VT	7,136	22
Northampton, MA	28,709	28
Keene, NH	23,547	36
Holyoke, MA	39,885	38
Springfield, MA	152,906	48
Hartford, CT	124,775	70
Boston, MA	602,609	106

Source: (US Census Bureau, 2010)

Table 3.3.10.1.2-1: Income Distribution for Households in the Project Vicinity

County or State	Median Household Income (2010)	Percent of Households with Incomes More than $100,000	Percent of Households with Incomes Less than $15,000
Franklin Co., MA	$50,514	17.2%	12.7%
Cheshire Co., NH	$52,644	17.7%	9.7%
Windham Co., VT	$47,386	14.5%	13.3%
Massachusetts	$62,072	29.2%	12.7%

Source: (US Census Bureau, 2010)

Table 3.3.10.1.2-2: Occupation Distribution in the Project Vicinity

County or State	Occupation					Percent Unemployed
	Management, business, science, and arts	Service	Sales and office	Natural resources, construction, and maintenance	Production, transportation, and material moving	
Franklin Co., MA	37.5%	15.6%	23.3%	10.1%	13.5%	7.8%
Cheshire Co., NH	34.5%	17.3%	23.0%	9.0%	16.1%	9.7%
Windham Co., VT	39.0%	18.1%	20.2%	11.2%	11.5%	6.5%
Massachusetts	43.5%	17.4%	23.5%	6.8%	8.9%	10.2%

Source: (US Census Bureau, 2010)

Table 3.3.10.1.2-3 Taxes Paid by FirstLight to the Local Towns

Town	Turners Falls Project- FirstLight Taxes Paid in 2019 by Town	Northfield Mountain Project- FirstLight Taxes Paid in 2019 by Town
Hinsdale, NH	< $2,500	$0
Greenfield, MA	< $2,500	$0
Vernon, VT	$10,000	$0
Montague, MA	$4,207,000	$0
Northfield, MA	$13,000	$1,513,000
Gill, MA	$300,000	$7,000
Erving, MA	$0	$9,002,000
Total (note due to rounding to the nearest $1,000 the numbers do not add exactly)	**$4,527,000**	**$10,522,000**

3.4 No-Action Alternative

Under the No-action Alternative, the existing Project would continue to operate as it has historically operated as described in Section 2.1. The measures in the current licenses as described in Section 2.1 would continue - none of FirstLight's proposed measures or those that may be proposed by others would be required and any environmental or recreation benefits from such recommendations would not occur. The Project would continue to be of importance to recreation, generation of renewable energy, and minimization of atmospheric pollutants.

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