Relicensing Study 3.3.15

Assessment of Adult Sea Lamprey Spawning within the Turners Falls Project and Northfield Mountain Project Area

Study Report

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

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EXECUTIVE SUMMARY

FirstLight Hydro Generating Company (FirstLight) is the current licensee of the Northfield Mountain Pumped Storage Project (Northfield Mountain Project, FERC No. 2485) and the Turners Falls Hydroelectric Project (Turners Falls Project, FERC No. 1889). FirstLight has initiated with the Federal Energy Regulatory Commission (FERC, the Commission) the process of relicensing the Northfield Mountain and Turners Falls Projects using the FERC's Integrated Licensing Process (ILP). The current licenses for the Northfield Mountain and Turners Falls Projects were issued on May 14, 1968 and May 5, 1980, respectively, with both set to expire on April 30, 2018. This report documents the results of Study No. 3.3.15 *Assessment of Adult Sea lamprey Spawning within the Turners Falls Project and Northfield Mountain Project Area.*

The purpose of this study was to evaluate spawning of Sea Lamprey, *Petromyzon marinus*, in the Northfield Mountain and Turners Falls Project (Project) areas to determine whether Project operations adversely affect spawning activity. Forty lamprey were radio tagged and released in two locations (20 at the Route 116 Bridge and 20 upstream of the Turners Falls Dam (TFD)) during the early and mid-portions of their runs to identify spawning locations via radio telemetry. Twenty-nine lamprey redds were selected in five regions within the Project area to be monitored throughout the spawning season. Spawning/nesting behavior was confirmed in all selected spawning sites. Several parameters (water velocity, water depth, substrate characterization, presence/absence, and water quality) were measured weekly at each lamprey redd throughout the study period (June 12 to July 31, 2015).

Spawning sites were located in areas dominated by cobble or gravel substrate with shallow, flowing water where water velocities increased due to riverine physical characteristics (*e.g.,* shifts in depth contours, channel meanders, or islands). Three sites were located in tributaries along the Connecticut River (Ashuelot River, Millers River and the Fall River). Two sites were located along the mainstem of the Connecticut River around Stebbins Island and at the Hatfield S Curve along a cobble/gravel bar. The overall mean velocity at all spawning sites over the monitoring period was 1.83 feet per second (fps; range 0.06 – 6.08 fps). The mean depth at all spawning sites was 3.2 feet (ft; range 0.6 – 8.8 ft). The Stebbins Island site recorded the maximum mean depth (4.59 ft) and highest mean velocity (2.99 fps). The Fall River site recorded the lowest mean depth (1.53 ft) and lowest mean velocity (0.82 fps). Water depth, velocity and any structural changes to the monitored redds were analyzed in relation to operation of the Northfield Mountain and Turners Falls Projects, as well as any other hydroelectric facilities in close proximity to selected redds.

Five redds were capped after visual confirmation of spawning/nesting activity to characterize spawning success by collecting any emerging larval sea lamprey, or ammocoetes. Redds were not disturbed during field measurements. Emerging ammocoetes were captured at two of the five capped redds. The Fall River ammocoete measured 7-8 millimeters (mm; total length) and the Hatfield S Curve ammocoete measured approximately 47 mm.

Using the Turners Falls Impoundment (TFI) hydraulic model developed as part of Study No. 3.2.2 *Hydraulic Study of TFI, Bypass Reach and below Cabot*, suitable lamprey spawning and incubation habitat

was mapped in the TFI under a single operating condition[1] (9,630[2] cfs release from the Vernon Hydroelectric Project, Northfield Mountain Project idle and the water surface elevation at the TFD of 181.5 ft). The hydraulic model predicted depth and velocity values at cells across each transect. Using the depth, velocity and substrate data, composite suitability index maps were produced using habitat suitability index (HSI) curves for spawning sea lamprey that were developed as part of Study No. 3.3.1 *Instream Flow Studies in Bypass Channel and below Cabot Station*. Based on this one operating condition, the region where the model produced any sizable portions of suitable lamprey spawning habitat was located around Stebbins Island. These model findings corroborated the field study in that several redds were located around Stebbins Island, where the suitable spawning habitat was predicted. It should also be noted that TransCanada Study No. 9 included conducting an instream flow study in the reach between Vernon Dam and the downstream end of Stebbins Island. As part of that study, the relationship between flow and sea lamprey spawning habitat was evaluated.

Relative to mapping suitable lamprey spawning and incubation habitat below the TFD, FirstLight proposes to rely on the findings of Study No. 3.3.1. As part of that study, instream flow studies are being conducted in the bypass reach and below Cabot Station downstream to the Route 116 Bridge in Sunderland. Like the instream flow study being conducted by TransCanada, the FirstLight instream flow study is also evaluating the relationship between flow and sea lamprey spawning habitat.

Projects operations at Northfield Mountain and Turners Falls were deemed to have no adverse effects on lamprey spawning activity based on the data collected throughout this study. Monitoring data from all the redds were analyzed in conjunction with operational data, and at no point were any redds dewatered, scoured or damaged due to Project operations during the study. No changes in lamprey spawning or nesting activity that could be attributed to Project operations were observed throughout the study period.

[1] There are numerous combinations that could impact sea lamprey spawning habitat in the TFI including Vernon discharges, Northfield Mountain Project operations (pumping, generating, or idle), contribution of tributary flow, and the TFI elevation at the TFD. Given this, for purposes of this report, a single scenario was considered. As noted above, in the location where sea lamprey redds were located near Stebbins Island, TransCanada has conducted an instream flow study to evaluate the relationship between flow and sea lamprey spawning habitat.

[2] A flow of 9,630 cfs is equivalent to the median June discharge at Vernon, the time period when sea lamprey spawning is likely to occur.

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cfs	cubic feet per second
cm	centimeters
COE	U.S. Army Corps of Engineers
CSI	Combined Suitability Index
°C	Degrees Celsius
DO	dissolved oxygen
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight Hydro Generating Company
ft	foot or feet
fps	foot or feet per second
GPS	Global Positioning System
HSC	Habitat Suitability Criteria
HSI	Habitat Suitability Index
ILP	Integrated Licensing Process
µS/cm	Micro-Siemens per centimeter
mg/L	milligram per liter
MHz	Megahertz
Mm	Millimeters
NTU	Nephelometric Turbidity Units
NAI	Normandeau Associates, Inc.
PAD	Pre-Application Document
PHABSIM	Physical Habitat Simulation
PSP	Proposed Study Plan
RSP	Revised Study Plan
SD1	Scoping Document 1
SD2	Scoping Document 2
SPDL	Study Plan Determination Letter
TFD	Turners Falls Dam
TFI	Turners Falls Impoundment
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VY	Vermont Yankee Nuclear Power Plant
WSEL	Water Surface Elevation

1 INTRODUCTION

FirstLight Hydro Generating Company (FirstLight) is the current licensee of the Northfield Mountain Pumped Storage Project (FERC No. 2485) and the Turners Falls Hydroelectric Project (FERC No. 1889). FirstLight has initiated with the Federal Energy Regulatory Commission (FERC, the Commission) the process of relicensing the two Projects using the FERC's Integrated Licensing Process (ILP). The current licenses for Northfield Mountain and Turners Falls Projects were issued on May 14, 1968 and May 5, 1980, respectively, with both set to expire on April 30, 2018.

As part of the ILP, FERC conducted a public scoping process during which various resource issues were identified. On October 31, 2012, FirstLight filed its Pre-Application Document (PAD) and Notice of Intent with the FERC. The PAD included FirstLight's preliminary list of proposed studies. On December 21, 2012, FERC issued Scoping Document 1 (SD1) and preliminarily identified resource issues and concerns. On January 30 and 31, 2013, FERC held scoping meetings for the two Projects. FERC issued Scoping Document 2 (SD2) on April 15, 2013.

FirstLight filed its Proposed Study Plan (PSP) on April 15, 2013 and, per the Commission regulations, held a PSP meeting at the Northfield Visitors Center on May 14, 2013. Thereafter, FirstLight held ten resource-specific study plan meetings to allow for more detailed discussions on each PSP and on studies not being proposed. On June 28, 2013, FirstLight filed with the Commission an Updated PSP to reflect further changes to the PSP based on comments received at the meetings. On or before July 15, 2013, stakeholders filed written comments on the Updated PSP. FirstLight filed a Revised Study Plan (RSP) on August 14, 2013 with FERC addressing stakeholder comments.

On August 27, 2013 Entergy Corp. announced that the Vermont Yankee Nuclear Power Plant (VY), located on the downstream end of the Vernon Impoundment on the Connecticut River and upstream of the two Projects, will be closing no later than December 29, 2014. With the closure of VY, certain environmental baseline conditions will change during the relicensing study period. On September 13, 2013, FERC issued its first Study Plan Determination Letter (SPDL) in which many of the studies were approved or approved with FERC modification. However, due to the impending closure of VY, FERC did not act on 19 proposed or requested studies pertaining to aquatic resources. The SPDL for these 19 studies was deferred until after FERC held a technical meeting with stakeholders on November 25, 2013 regarding any necessary adjustments to the proposed and requested study designs and/or schedules due to the impending VY closure. FERC issued its second SPDL on the remaining 19 studies on February 21, 2014, approving the RSP for Study No. 3.3.15 *Assessment of Adult Sea Lamprey Spawning within the Turners Falls Project and Northfield Mountain Project Area* with the following modifications:

- Include habitat-based surveys to locate all areas of suitable spawning habitat with a focus on the areas described in the study plan.
- Any sedimentation that occurs due to redd caps will be noted during routine monitoring.
- FirstLight should utilize the hydraulic model to assist with the evaluation of project effects on spawning sites/redds.

1.1 Background

Sea Lamprey, *Petromyzon marinus*, is an anadromous species native to the Connecticut River and known to spawn within the Turners Falls and Northfield Mountain Project areas. In the western Atlantic Ocean, Sea Lamprey distribution ranges from Canada to the Gulf of Mexico in Florida, with landlocked populations occupying the Great Lakes, Finger Lakes, Oneida Lake and Lake Champlain (Renaud, 1997). Sea Lamprey populations migrating up the Connecticut River are some of the most numerous found on the east coast (Beamish, 1980). Sea Lamprey are a federal trust resource and one of New Hampshire and Vermont's

Species of Greatest Conservation Need within the Connecticut River (3.3.15 Revised Study Plan). Lamprey have benefited from the construction of multiple fish passage facilities designed for other species. The fish passage facility at Holyoke Dam was completed in 1955 to support and monitor the passage of American Shad through the first mainstem dam on the Connecticut River (CTDEEP, 2012). Its construction has allowed the annual monitoring of upstream passage for several important Connecticut River species, including Sea Lamprey, and provides valuable data to help support the overall health of the river ecosystem.

According to the United States Fish and Wildlife Service (USFWS) historic fish count data, the number of Sea Lamprey passing upstream of the Holyoke Dam and TFD has remained stable in recent years. Adult Sea Lamprey passing Holyoke Dam were not counted prior to 1975, but subsequent counts have ranged from about 15,000 to over 100,000 annually, with a maximum of 101,758 recorded in 1998 (Gephard and McMenemy, 2004) (Figure 1.1-1). From 2000 to 2015, Sea Lamprey Counts at Turners Falls Gatehouse have ranged from 1,350 to 32,029 annually, with a mean count of 9,656 (USFWS, 2016). Currently, there are no restoration programs in place to increase lamprey populations (USFWS, 2010).

1.1.1 Life History and Spawning Habitat

The life cycle and habitat preferences of the adult oceanic stage is not well understood. Adult lamprey spend an estimated 18 to 24 months at sea before returning to freshwater environments to spawn. During the adult phase, they feed exclusively off the blood, tissues and bodily fluids of larger fish, using their well-designed suction like mouths and sharp keratonized teeth to physically attach themselves to their hosts (Kircheis, 2004; Kottelat & Freyof, 2007). Upon entry into freshwater environments, lamprey stop feeding and males and females focus their remaining energy on spawning (Jang & Lucas, 2005). Sea Lamprey undergo several physiological and morphological changes (e.g., digestive breakdown, loss of teeth, blindness) during their freshwater spawning migrations until they spawn and die, providing a food source and important micronutrients to animals and the surrounding environment (Kircheis, 2004; Beamish, 1980).

At the onset of the spawning period, when water temperatures reach 15 to 19°C, lamprey utilize mainstem and tributary habitats to construct spawning nests (known as redds) on sand, gravel and small rock/cobble riffle areas of stable water flow (Leim & Scott, 1966; Scott and Scott, 1988). Lamprey physically excavate the substrate during redd construction, moving stones with their mouths and using body movements to remove silt and finer material while clearing a nesting area. The size of redds can vary, some have been documented to be 0.25 meters wide, others up to one meter wide, with varying lengths (Auer, 1982; Kircheis, 2004). Several spawning lamprey may occupy a single redd, which explains the variations in size; as more lamprey utilize an area to spawn they will continue to expand the redd size and adjacent redds may merge (Hussakof, 1912, Rooney *et al*., 2013).

Lamprey deposit varying numbers of eggs (150,000 to 300,000 per female) in small interstitial spaces between the gravel and sand. It is estimated that approximately 14% of eggs remain in the redds, the remainder are washed downstream. A large proportion of the eggs that remain in the nest (85-90%) survive to hatch (Manion & Hanson, 1980; Smith *et al*., 2009). Flowing water provides oxygen to the eggs before hatching 10 to 14 days post fertilization (Applegate, 1950; Beamish, 1980). Once hatched, Sea Lamprey larvae, known as ammocoetes, will spend an additional 4 to 5 days in the redds before emerging and drifting downstream to burrow into muddy, sandy/silty bottoms of streams and 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). Lamprey ammocoetes range in length from 3 mm to approximately 194 mm, undergoing several stages of metamorphosis within that size range before emerging from silt beds to begin feeding parasitically and transitioning to their adult life stage (Auer, 1982; Manion & Smith, 1978).

1.1.2 Previously Identified Spawning Locations

Within the Project area, lamprey spawning has been reported from the Route 116 Bridge in Sunderland, Massachusetts upstream to Cabot Station in areas of preferred habitat (3.3.15 Revised Study Plan). The

USFWS Connecticut River Coordinator has also observed Sea Lamprey spawning upstream of TFD in close proximity to Vernon Dam around Stebbins Island. While previous research has revealed that Sea Lamprey spawning activity occurs within the Project area, no studies to date have identified locations of suitable spawning habitat and/or assessed the effects of Turners Falls and Northfield Mountain Project operations on spawning.

1.2 Study Goals and Objectives

The purpose of this study was to determine the impacts that operations of the Turners Falls and Northfield Mountain Projects may have on Sea Lamprey spawning activity. Specific study objectives were to:

- Identify areas within the Project area where suitable spawning habitat may exist for adult Sea Lamprey.
- Conduct spawning surveys to confirm use of areas identified as containing suitable spawning habitat.
- Describe spawning mound characteristics, including location, size, substrate, water depth, and velocity.
- Collect the information to assess whether operations of the Turners Falls Project and Northfield Mountain Project are adversely affecting spawning areas (*e.g.*, if flow alterations are causing dewatering and scouring of lamprey spawning area).

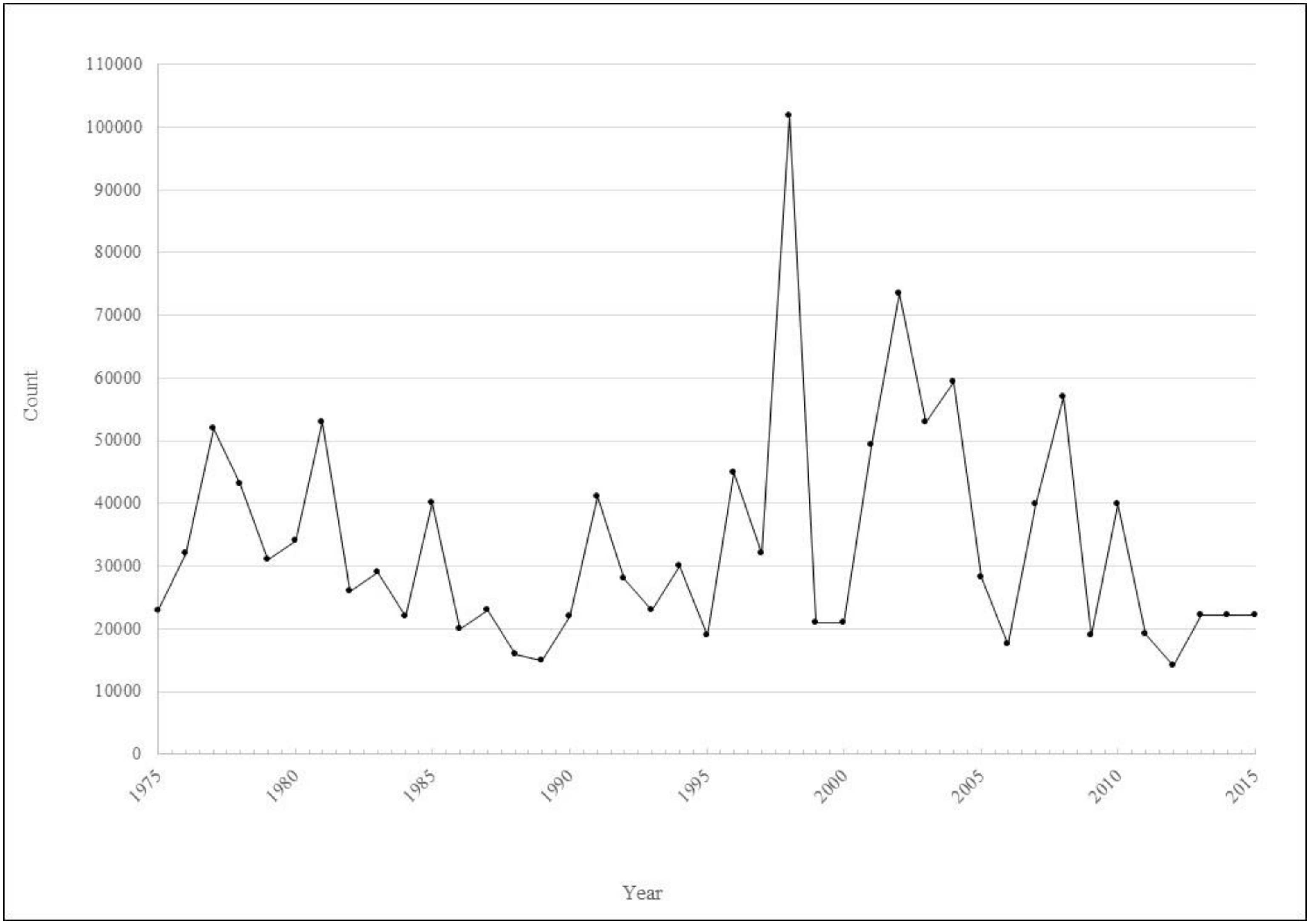


Figure 1.1-1: Summary of Connecticut River Historic Sea Lamprey Counts at Holyoke Dam from 1975 to 2015

2 STUDY AREA AND SURVEY SITE SELECTION

In accordance with the RSP, the study area included the following (see Figure 2.0-1):

- Suitable gravel or cobble riffle habitat within the Connecticut River mainstem from Cabot Station downstream to Sunderland Bridge.
- Suitable gravel or cobble riffle habitat in the Turners Falls bypassed reach (Connecticut River mainstem) and specifically the spawning habitat in the vicinity of Rawson Island.
- Suitable gravel or cobble riffle habitat within the riverine portion of the upper TFI that is subjected to flow or elevational regulation resulting from project operations. Specifically, surveyors will focus in on the following areas:
    a. The Connecticut River mainstem within close proximity of the Vernon Dam (habitat adjacent to Stebbins Island, both sides of island).
    b. Mainstem gravel bar and shallow water habitats within the TFI (*e.g.*, at or near the Massachusetts State Line and the railroad bridge gravel bar).
- Suitable gravel or cobble riffle habitat within tributary confluence areas that are or may be affected by the current operational protocols, including:
    a. The Deerfield River confluence with the Connecticut River.
    b. The Millers River confluence with the Connecticut River.
    c. The Ashuelot River confluence with the Connecticut River.
    d. The Fall River confluence with the Connecticut River.
    e. The Green River confluence with the Connecticut River.
    f. The Sawmill River confluence with the Connecticut River.

It should be noted that from the Vernon Dam downstream approximately 1.5 miles, or the downstream tip of Stebbins Island, TransCanada conducted an instream flow study. Sea lamprey spawning habitat was a target of that study. Thus, a relationship between flow and habitat for this species and life stage is available as part of TransCanada Report No. 9.

2.1 Lamprey Spawning Monitoring Sites

The habitat where Sea Lamprey are likely to spawn was searched in the study area and included the mainstem Connecticut River from Vernon Dam to the Route 116 Bridge in Sunderland [3], as well as locations within the tributaries listed above. Summarized below are locations where redds were detected and evaluated, from upstream to downstream.

2.1.1 Connecticut River Mainstem around Stebbins Island- TFI

Stebbins Island is located approximately 0.8 miles (1.28 kilometers) downstream of Vernon Dam. Surrounding Stebbins Island is a large area consisting primarily of coarse substrate such as cobble and gravel with moderate to high water velocities. This is a known Sea Lamprey spawning area; several redds have been observed in the area during this study and in the past. During this study there were seven lamprey redds monitored in this location, two were on the eastern side of the island and five on the western side (Figure 2.1.1-1). Fine sediments that are deposited below the island may serve as settling areas for emerging ammocoetes from upstream redds.

[3] As noted further below, although the RSP called for terminating the study at the Route 116 Bridge, the study team did not locate any redds between Cabot Station and the Sunderland Bridge hence they boated further downstream and located redds near the Hatfield S Curve. In addition, the study team was able to mobile track a lamprey to the Hatfield S Curve location.

2.1.2 Ashuelot River Confluence- TFI

The Ashuelot River is the longest tributary of the Connecticut River within New Hampshire measuring approximately 64 miles (103 kilometers) from its headwaters to the mainstem Connecticut. It begins in Washington, New Hampshire and flows south and west where it enters the Connecticut River in Hinsdale, New Hampshire. Ashuelot River flows have been regulated by the Army Corps of Engineers (COE) Surry Mountain Lake 33 miles upstream since 1942, the COE's Otter Brook Lake, 29 miles upstream on Otter Brook since 1958 and by small hydroelectric projects. Approximately 2,500 ft upstream of the confluence, there is a riffle where the substrate is dominated by cobble and gravel. During this study there were 11 lamprey redds monitored at this site. All redds were located within the riffle upstream from the confluence with the Connecticut River (Figure 2.1.2-1).

2.1.3 Millers River Confluence- TFI

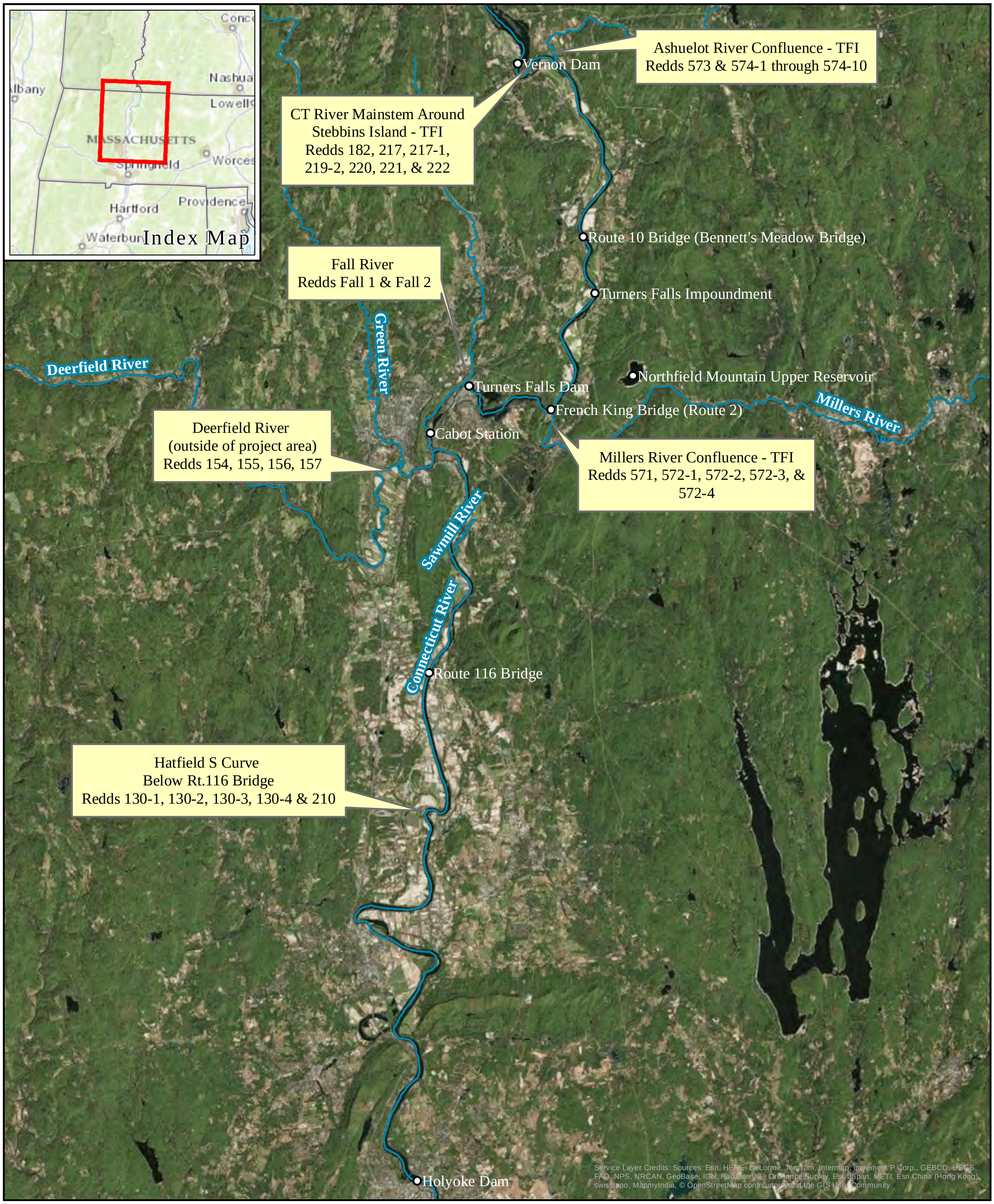
The Millers River is 52.1 miles (83.8 kilometers) long originating in Ashburnham, Massachusetts and empties into the Connecticut River just downstream of Millers Falls, Massachusetts. Water surface elevations (WSELs) at the Millers River confluence fluctuate due to a combination of Project operations and flow from the tributary itself. Flows on the Millers River are regulated by power plants and by Lake Mononomac and other reservoirs; high flows have been regulated by the COE's Birch Hill Reservoir, 22 miles upstream since 1941 and by Tully Lake since 1948. The section of the Miller's River influenced by the TFI extends upstream to the first riffle, where the substrate consists of sand/gravel with cobble and some small boulder, ideal for lamprey spawning. During this study there were five redds monitored at this location. The cluster of redds monitored for this study were located approximately 1,000 ft upstream from the confluence with the Connecticut River (Figure 2.1.3-1).

2.1.4 Fall River Confluence- Turners Falls Bypass Reach

The Fall River empties into the upstream end of the bypass reach, approximately 0.16 miles (0.25 kilometers) below the TFD; its drainage area is 34.2 mi^2 (88.5 $kilometers^2$). The lower extent of the Fall River is comprised of sand, gravel and cobble riffle habitat with shallow depths and low to moderate water velocities, appropriate for Sea Lamprey spawning. Due to its close proximity to TFD, the lower extent of the Fall River confluence is susceptible to backwater that can cause varying depths and decreased velocities. During this study there were two lamprey redds monitored at this location, one of which was capped. The capped redd was located approximately 195 ft upstream from the Connecticut River confluence (Figure 2.1.4-1).

2.1.5 Hatfield S Curve below Route 116 Bridge- below Cabot Station

The Hatfield S Curve is located on the mainstem Connecticut River approximately 18 miles (29 kilometers) downstream of the TFD and approximately 15 miles (24 kilometers) downstream of Cabot Station. Riffle habitat is uncommon in most of the reach below Cabot Station with the exception of some small gravel/cobble bars located directly downstream of Cabot Station that emerge at lower river flows. There were no lamprey redds located at these locations during the initial spawning survey. This study site is located on a gravel bar on the eastern bank of the river immediately downstream of the sharp Hatfield S Curve (Figure 2.1.5-1). The cobble/gravel bar provides an area of shallower depth than the surrounding pool as well as moderate velocities and suitable habitat conditions for lamprey spawning. During this study there were four lamprey redds monitored at this location. Redds were monitored below the Route 116 Bridge because they were the only redds located in the mainstem of the river below TFD during the spawning survey.



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Northfield Mountain Pumped Storage Project (No. 2485)
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ASSESSMENT OF ADULT SEA LAMPREY SPAWNING
WITHIN THE TURNERS FALLS PROJECT AND
NORTHFIELD MOUNTAIN PROJECT AREA
RELICENSING STUDY 3.3.15

N

0 2.5 5 10
Miles

Figure 2.0-1: Overview Map of Lamprey Redds Identified in the Project Area During 2015 Surveys

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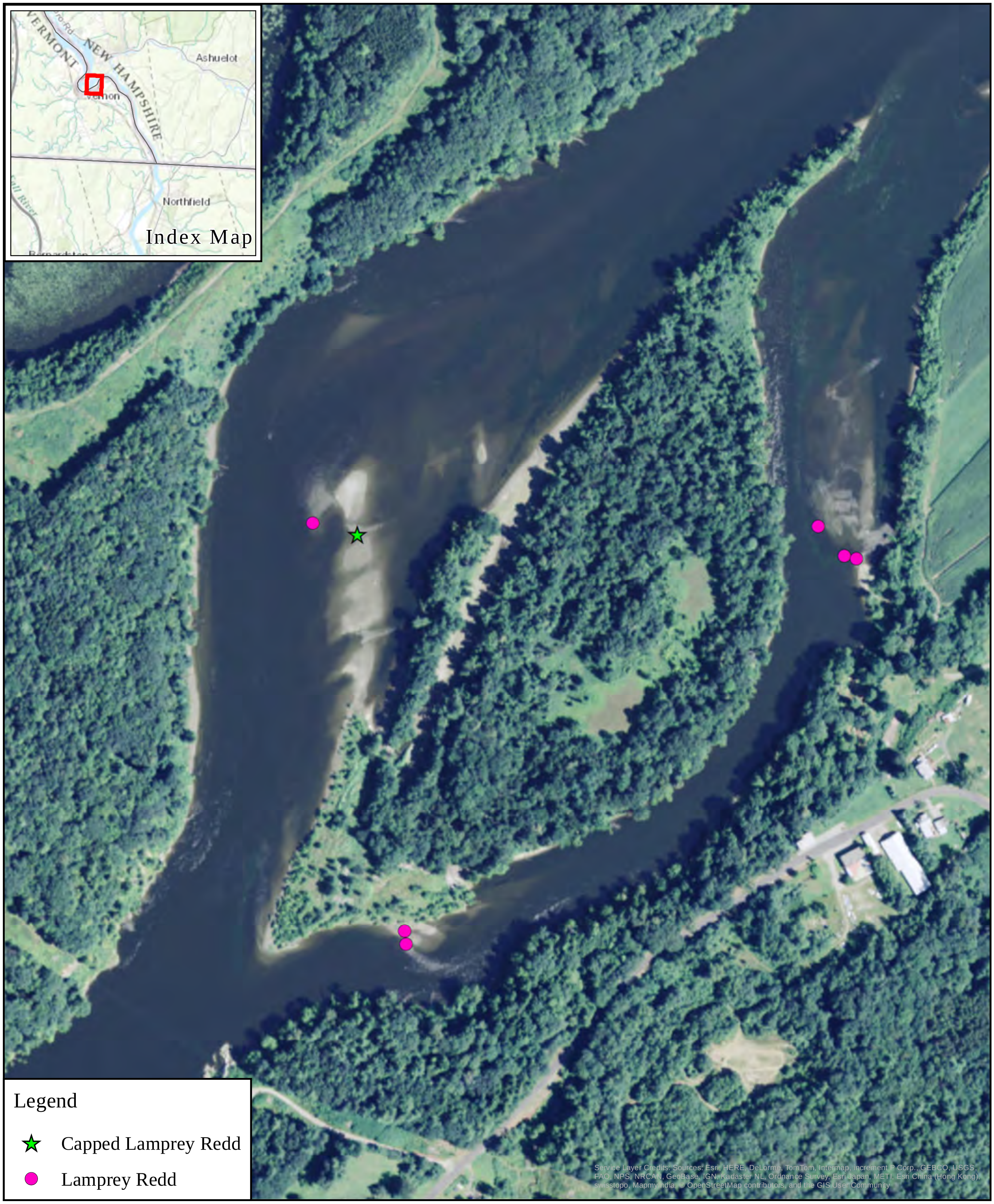

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N

0 100 200 400 Feet

Figure 2.1.1-1: Lamprey Redds Identified Near Stebbins Island on the Connecticut River During 2015 Surveys

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0 25 50 100 Feet

Figure 2.1.2-1: Lamprey Redds Identified in the Ashuelot River During 2015 Surveys

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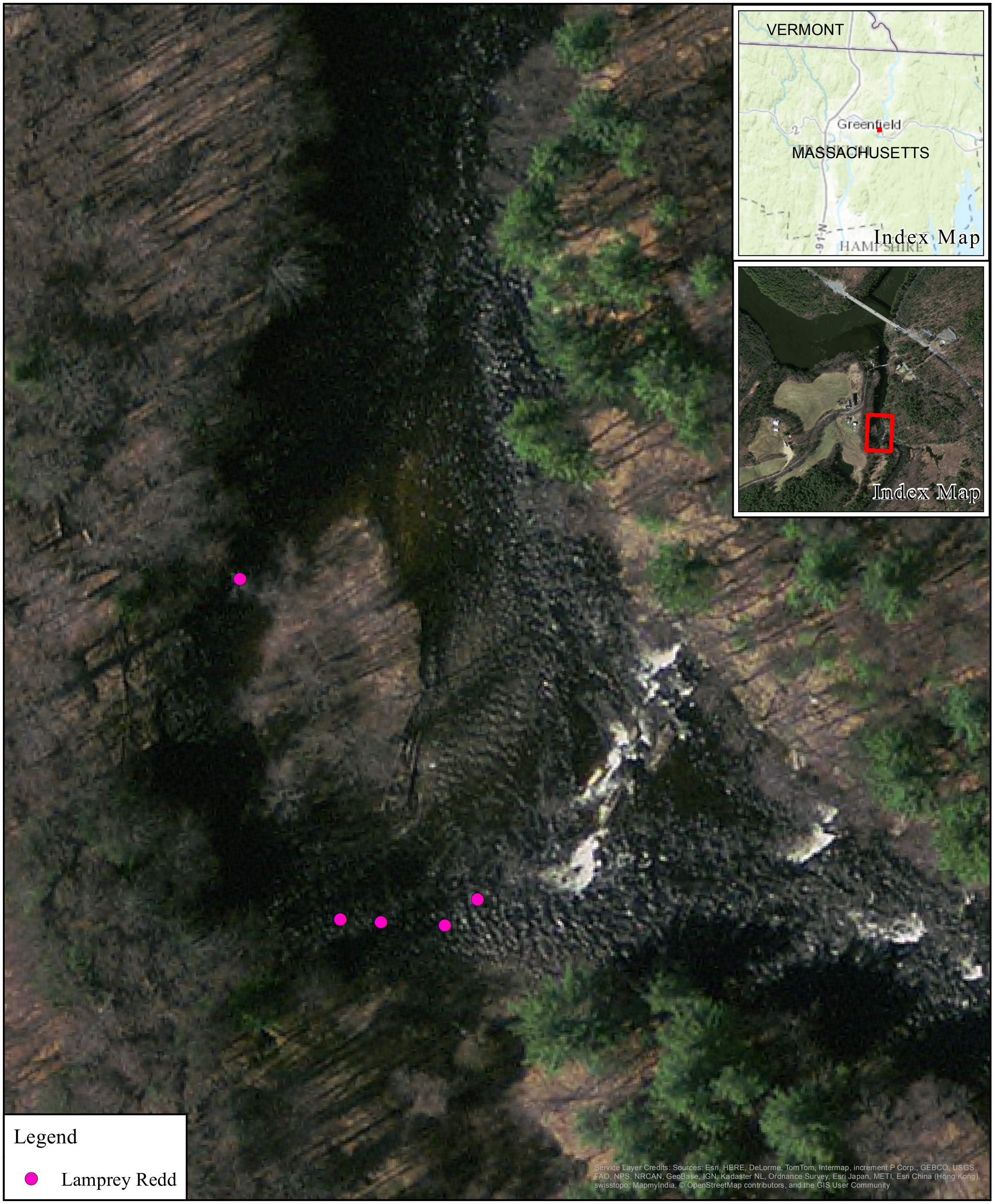

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N

0 25 50 100 Feet

Figure 2.1.3-1: Lamprey Redds Identified in the Millers River During 2015 Surveys

FirstLight Power Resources

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N

0 50 100 200 Feet

Figure 2.1.4-1: Lamprey Redds Identified in the Fall River During 2015 Surveys

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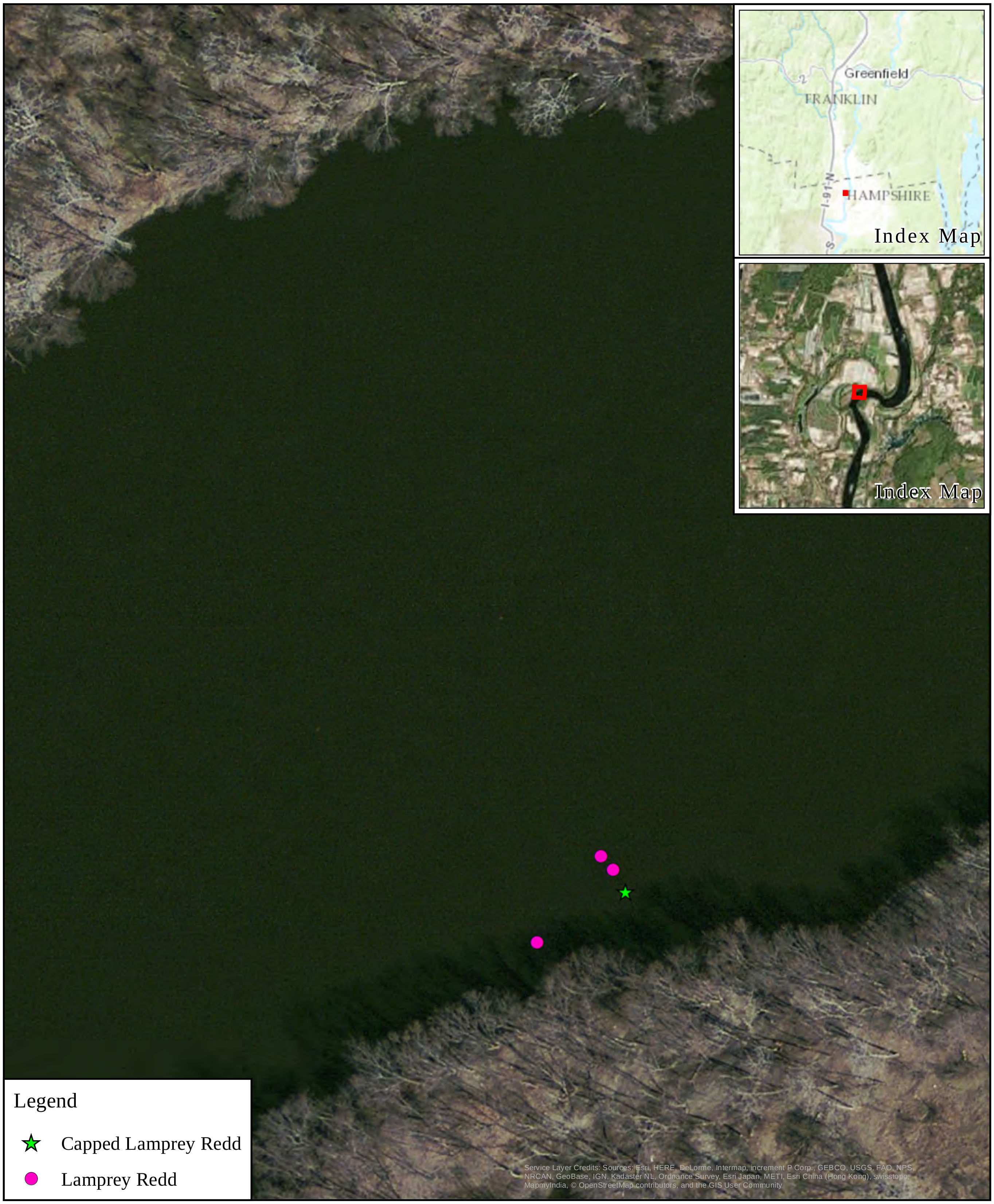

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N

0 50 100 200 Feet

Figure 2.1.5-1: Lamprey Redds Identified in the Hatfield Area of the Connecticut River During 2015 Surveys

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3 METHODS

3.1 Tagging

Forty adult sea lamprey were collected at Holyoke Dam and transported to one of two locations (Route 116 Bridge and TFI) where they were radio-tagged and released. Per the study plan, during the early portion of the run (May 21, 2015) 20 lamprey were tagged with 10 released at the Route 116 Bridge and 10 released above the Gatehouse at the TFD. The same process was repeated during the mid-portion of the run (May 28, 2015).

All sea lamprey were anesthetized, measured for weight, total length, and girth (directly anterior of the exposed gill slits), sexed and surgically implanted with a radio tag. Radio tags were inserted into the peritoneal cavity through a small incision on the ventral side, approximately 3 inches anterior to the cloacal aperture. The incisions were closed using a catgut suture and Bactrim was applied to the wound to prevent infection. Tagged lamprey were allowed to recover for 4 to 5 hours in a flow-through water bath before being released. All 40 lamprey recovered successfully and swam away vigorously at the time of release.

3.2 Mobile Tracking and Telemetry

Sea Lamprey were mobile-tracked twice weekly using a Lotek model SRX 400 receiver and a 3-element yagi antenna aboard a boat. Each week, the first tracking event was conducted from Holyoke Dam to the Mount Herman School and the second spanned the reach from the Hatfield S curve to Cabot Station. Tracking continued in the TFI from Barton Cove to Vernon Dam. A total of 17 days of mobile tracking occurred between June 3, 2015 and July 7, 2015 below the TFD and in the TFI. All radio frequencies were shared with TransCanada in the event that fish moving from the Turners Falls Project into the Vernon Project vicinity could be monitored.

3.3 Spawning Grounds and Habitat Assessment

Sea Lamprey spawning habitat within the study area was inspected in detail to confirm the suitability of spawning grounds and to assess the potential effects of Project operations on spawning areas. Study sites were selected based on previously noted redd locations (NOAA, 2013; and Yergeau, 1983), the presence of appropriate habitat conditions (gravel/cobble substrate with stable flowing water), and mobile tracking of tagged lamprey.

Once redds were located during the initial spawning survey, GPS coordinates were confirmed at each redd for relocation and subsequent mapping purposes. The GPS-located redds were surveyed for several parameters including substrate, depth, water velocity and water quality (temperature, dissolved oxygen (DO), turbidity, pH, and conductivity). Redds were not disturbed when data were collected to ensure ambient conditions remained during the nesting, spawning and monitoring periods. Measurements were always taken along the outer edge of the redds. Velocity measurements were taken using a Marsh McBirney flow meter and locating it adjacent to the redd so as not to disturb it. The mean column water velocity was measured. Depth was recorded with a pre-marked staff gage and temperature was recorded near mid-depth adjacent to the redd. Presence/absence of Lamprey and any variations in structural habitat/redd characteristics were recorded.

Five redds were capped using a 4x4-ft, weighted, PVC-framed net (1 mm mesh) funneling into a collection jar on the downstream end to capture emerging larvae (Figure 3.3-1). Caps were deployed only after Sea Lamprey spawning/nesting behavior was initially observed and revisited on multiple days to ensure lamprey were no longer actively spawning on the site. Caps remained in place for 14 to 21 days, at which point samples were collected in jars, fixed with formaldehyde and transported to the laboratory for further analysis. Spawning grounds within the study area were monitored from the time of lamprey arrival until water temperatures exceeded 22°C. All identified redds were monitored over a range of operational conditions and observed changes to the habitat or redd quality were recorded.

In the laboratory, samples from the capped redds were processed using a dissecting microscope. Sea Lamprey larvae were removed from the samples, measured for total length and enumerated. The samples collected at the Hatfield S Curve below the Rt. 116 Bridge were processed in the field due to lack of formaldehyde needed to preserve the sample.

3.4 Mapping

3.4.1 Suitable Habitat

Habitat Suitability Criteria (HSC) for the spawning and incubation life stage of Sea Lamprey were initially based on Kynard and Horgan (2013). Revisions to depth and substrate were provided by USFWS in a July 3, 2014 letter. These changes were extrapolated from Yergeau (1983), to be incorporated into Study No. 3.3.1 *Instream Flow Studies in Bypass Channel and below Cabot Station* (Figure 3.4.1-1). HSC relate to the behavior of adults selecting nesting sites, and fertilizing and burying eggs. Because the incubation life stage is non-mobile and utilizes the same habitat, it follows that flows suitable for spawning should also be suitable for incubation, and thus, the same criteria apply. In the HSC revised by USFWS, habitat suitability index (HSI) values ranging from 0 to 1 were defined for depth, velocity, and substrate (Figure 3.4.1-1, Table 3.4.1-1). Each HSI value indicates how close the habitat is to the species' optimal conditions, with higher values representing the most suitable areas (Hirzel *et al*., 2006).

3.4.1.1 Turners Falls Impoundment

An ArcGIS model was developed to identify areas of suitable habitat for lamprey spawning in the TFI. As part of Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and Below Cabot* velocity and depth[4] data for each transect in the TFI hydraulic model was imported into ArcGIS using the HEC-GeoRAS extension and transformed into continuous raster surfaces. Hydraulic conditions vary in the TFI; therefore, velocity and depth data were obtained from the TFI hydraulic model under the following conditions:

- A WSEL at the TFD of 181.5 ft, which represents the median elevation for the months of May-July based on hourly elevation data for the period 2000-2015.
- Vernon Hydroelectric Project discharge of 9,630 cfs (June median flow)
- Northfield Mountain Project operating condition of 0 cfs (idle)

Substrate data obtained from Study No. 3.3.14 *Aquatic Habitat Mapping of Turners Falls Impoundment* was transformed into a continuous raster surface for the TFI. A computer program using a Python script was developed to assign HSI values to the velocity (*v*), depth (*d*), and substrate (*s*) suitability index (*si*) rasters and to produce a new raster of composite suitability index (*csi*) scores computed using the following equation:

$$csi = (si_v)(si_d)(si_s) \qquad \textit{Equation 1}$$

The raster for combined suitability index scores were used to identify and map suitable lamprey spawning habitat in the TFI under the Vernon discharge and Northfield Mountain Project operating scenario listed above.

[4] For each transect in the hydraulic model it was divided into 20 equally sized cells. The depth and velocity from each cell, along with the substrate, was subsequently used to compute the composite suitability.

3.4.1.2 Below Turners Falls Dam

As part of Study No. 3.3.1 *Instream Flow Study of Bypass Reach and below Cabot,* a separate instream flow study was conducted in the bypass reach and below Cabot Station to the Route 116 Bridge to develop relationships between flow and habitat for various target species and life stages of fish. One of the species being assessed is the spawning life stage of Sea Lamprey. A total of four study reaches (Reach 1, 2, 3 and 4) cover the bypass reach and down to the Route 116 Bridge. The hydraulics in each reach are influenced by the following:

- Reach 1: TFD spill at the bascule and taintor gates, Spillway fish ladder flows, Spillway ladder attraction flows and Fall River flows.
- Reach 2: Reach 1 plus Station No. 1 discharges.
- Reach 3: Reach 2 plus Cabot Station operations and Deerfield River flow.
- Reach 4: Reach 3 plus other smaller tributaries down to the Route 116 Bridge.

The report for Study No. 3.3.1 will be filed with FERC on October 14, 2016. As part of the report, FirstLight will assess the relationship between flow and Sea Lamprey spawning habitat under a range of flows and operating conditions.

3.5 Effects of Project Operations

3.5.1 Criteria for Project Effects

The date and time of observed activities, water measurements and visual variations of structural spawning habitat and redd characteristics were related to operational data. Effects were classified per spawning site, using visual observations of the surveys sites during each site visit, as:

1) **No effect** (no observable difference to habitat/redd structure or lamprey activity).
2) **Moderate effect** (observable difference to habitat/redd structure and/or behavior noticed, but normal spawning occurs).
3) **Large effect** (observable structural differences to habitat/redds and observable decreased spawning activity)
4) **Severe effect** (noticeable habitat/redd degradation, dewatering, scour, and no successful spawning)

3.5.2 Elevation Duration Curves

In addition to the visual observations, the hourly time step hydraulic model of the TFI was used to determine if the redd locations observed near Stebbins Island were ever dewatered during the monitoring period from June 19 to July 10, 2015. This model was developed as part of Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and below Cabot*. The model was calibrated to measured water surface elevations (WSEL) collected throughout the TFI using water level loggers—the calibration was excellent as modeled WSELs closely matched observed WSELs.

The calibrated hydraulic model was used to simulate WSELs during the monitoring period based on the flow inputs. The flow inputs to the hydraulic model included observed Vernon hourly discharges; observed tributary inflow based on United States Geological Survey (USGS) gaged flows on the Ashuelot and Millers River; observed Northfield Mountain Project pumped flows/generation flows; and the observed WSEL at the TFD. The hydraulic model was operated on an hourly basis using the above inputs in unsteady mode for the monitoring period. From this, the WSELs at identified spawning locations near Stebbins Island under the conditions that occurred during the 2015 study period were compared to the redd elevation to determine if any of the spawning areas were likely to have been exposed.

The lamprey spawning sites identified in tributaries and the site on the Hatfield S Curve were located in areas without detailed bathymetric data; therefore, only the Stebbins Island redds were used in this analysis.

Elevation duration curves (see Appendix A- note that the evaluation of elevation duration curves is discussed in Section 5.0) were developed to explore the percentage of time that the WSEL equaled or exceeded the elevation of each Stebbins Island redd during the study period. Monitoring of redds at the Stebbins Island site ceased once the water temperature exceeded 22°C.

Table 3.4.1-1: Sea Lamprey- Spawning and Incubation Habitat Suitability Index Values for Velocity, Depth and Substrate

Velocity		Depth		Substrate	
Velocity (fps)	**SI Value**	**Depth (ft)**	**SI Value**	**Substrate Class**	**SI Value**
0.00	0.00	0.00	0.00	Detritus – 1	0.00
0.30	0.00	0.13	0.00	Mud/soft clay – 2	0.00
1.28	0.34	0.46	0.50	Silt – 3	0.00
2.26	1.00	0.79	1.00	Sand – 4	0.04
3.25	0.86	1.12	1.00	Gravel – 5	1.00
4.23	0.30	1.44	0.60	Cobble/Rubble – 6	0.50
5.22	0.12	1.77	0.40	Boulder – 7	0.02
6.20	0.08	2.20	0.20	Bedrock – 8	0.00
6.23	0.00	2.30	0.00		

Figure 3.3-1: Lamprey Redd Cap: 4x4 ft, Weighted PVC Framed Collection Net (1 mm Mesh) Funneling into a Collection Jar.

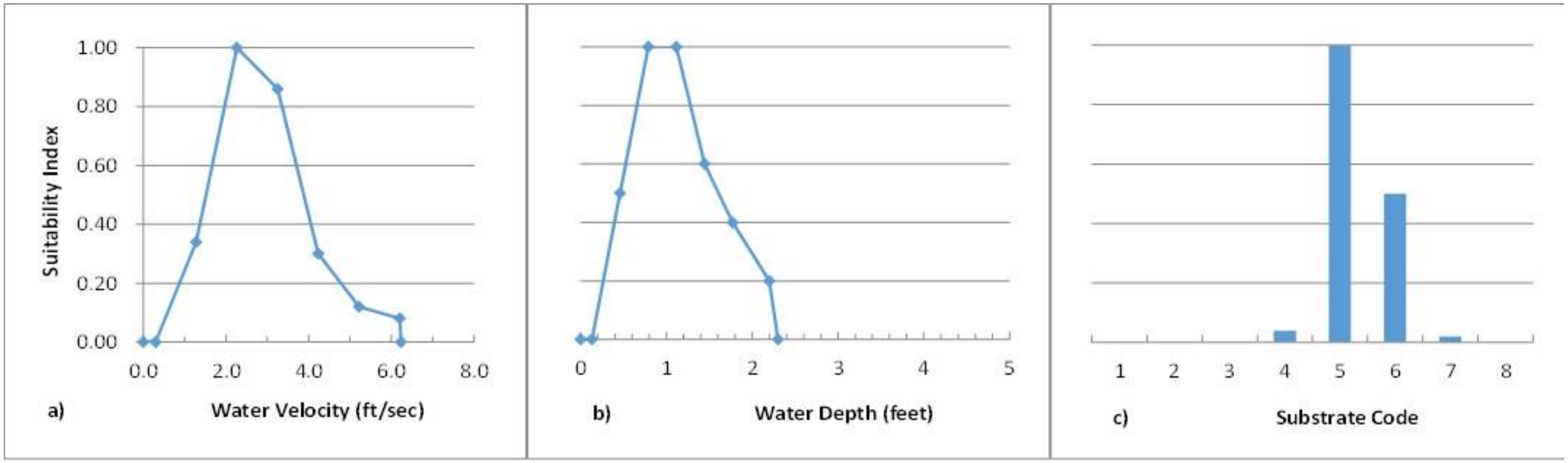


Figure 3.4.1-1: Habitat Suitability Curves for a) Velocity, b) Depth, and c) Substrate for Sea Lamprey Redds

4 RESULTS

4.1 Tagging

During the early portion of the run (5/21/15), 20 lamprey were tagged, 10 were released at the Route 116 Bridge and 10 upstream of Turners Falls Gatehouse. During the late-portion of their run (5/28/15), an additional 20 lamprey were radio tagged and 10 were released at each of the two identified release locations. All lamprey were tagged on the frequency 149.78 MHz, using codes 44-63 (early release) and codes 99-118 (late release). Tagging and release information is summarized below in Table 4.1-1.

Sixteen of the 40 radio tagged Lamprey were determined to be females based on presence of visible eggs during the tagging process (Table 4.1-2). No additional invasive measures were taken to sex lamprey if eggs were not present; therefore, the remainder were categorized as unknown sex. Total length for females (N=16) ranged from 64-84 cm (mean = 72.2 cm), weight ranged from 450-970 g (mean = 652.5 g), and girth ranged from 13-16 cm (mean = 14.5 cm). Total length for unknown sexes (N=24) ranged from 62-78 cm (mean = 72.2 cm), weight ranged from 430-850 g (mean = 671 g), and girth ranged from 12-17 cm (mean = 14.3 cm). Figure 4.1-1 shows the length frequencies of the 40 lamprey tagged in this study. Total length ranged from 62-84 cm (mean = 72.2 cm), weight ranged from 430-970 g (mean = 663.6 g), and girth ranged from 12-17 cm (mean = 14.4 cm).

4.2 Tracking

Seventeen days of mobile tracking occurred between June 3 and July 17, 2015. Of the 40 tagged lamprey, 17 (42.5%) were relocated via mobile tracking. Six of the 17 lamprey were tracked in the reach below the TFD (see Figure 4.2-1 for the tag number and dates detected) and 11 were tracked between the TFD and Vernon Dam (see Figure 4.2-2). Of the six (6) lamprey tracked in the reach below TFD, 3 (three) passed through the Turners Falls fishways.

Table 4.2-1 summarizes each lamprey that was tracked, the release information, the number of relocations, last tracked live date, and the maximum distance traveled from the release site, along with any related notes. Release information was designated “early” if lamprey were tagged and released on May 21, 2015 and “late” if tagged and released on May 28, 2015.

An additional 10 lamprey (Codes 52, 55, 56, 57, 59, 60, 63, 110, 111, and 114) were never detected during mobile tracking in the study area, but were relocated by Normandeau Associates (NAI) in support of the FERC relicensing for TransCanada Hydroelectric Projects, which includes Vernon (FERC No. 1904), Bellows Falls (FERC No. 1855) and Wilder Projects (FERC No. 1892) (Table 4.2-2). One lamprey (code 60) was reportedly located by NAI in the White River on June 10, 2015 as far north as West Hartford, Vermont (approximately 100.6 river miles from the release site).

4.3 Spawning Grounds and Habitat Assessment

During Sea Lamprey mobile tracking, potential spawning habitats and/or redds were inspected along the Connecticut River mainstem and its confluences within the study area. Note that the redds located were not tied specifically to tracked lamprey, but included other non-tagged lamprey as well. During this time several lamprey were observed actively nesting or moving along redds (Figure 4.3-1). Twenty-nine of these redds were GPS-located to ensure relocation for weekly monitoring. A breakdown of the number of redds located at each spawning site along with associated caps at each site and larval collection information is summarized in Table 4.3-1. In many areas, several redds (up to 10 or 11) were observed in a relatively confined area, such as the sites found in the Ashuelot River (Figure 2.1.2-1). Only one GPS location was used in areas where multiple redds were in close proximity to one another. The naming of redds used in Table 4.3-2 is based on the region in which the redd was located, followed by the GPS waypoint, and the number of redds associated with that waypoint. Sea Lamprey were observed in all five study regions. All areas within the study area were surveyed before choosing the 29 redds for continuous monitoring. Subsequent to the initial survey in early June, additional redds were observed in the Deerfield River (4 redds) and on the western side of Rawson Island (2 redds).

The 29 redds were monitored weekly for temperature, water velocity, depth, and substrate. (Table 4.3-2). Data collection started on June 12, 2015 and continued through July 31, 2015, or until water temperature exceeded 22°C, whichever occurred first. Substrate characteristics among the 29 redds remained consistent and contained a circular or oval area (dashed line) of exposed sand and/or gravel with cobble and gravel around the perimeter (Figure 4.3-1, Table 4.3-2). The lamprey depicted in Figure 4.3-1 appeared to be using its suction like mouth to hold onto a rock during redd construction and may have been exhibiting resting behavior. All redds monitored during this study were located in areas of flowing water that remained accessible to field staff throughout the study period.

The mean depth for all 29 redds was 3.2 ft based on instantaneous measurements at all sites over the monitoring period. A minimum depth of 0.6 ft was recorded once at a redd in the Fall River on July 27, 2015 and once at a redd in the Ashuelot River on June 19, 2015 (Table 4.3-2). A maximum depth of 8.8 ft was recorded at a redd at Stebbins Island on June 24, 2015 during high Vernon discharge (above the 17,130 cfs hydraulic capacity of the Vernon Hydroelectric Project). Mean velocity, again based on instantaneous measurements at all sites over the monitoring period was 1.83 fps. A minimum velocity of 0.02 fps was measured at a redd in the Fall River on June 24, 2015 (note that water spilling over TFD at the time likely backwatered the redd located in the Fall River). A maximum velocity of 6.08 fps was measured at a redd around Stebbins Island on June 24, 2015 (Table 4.3-2). Throughout the 6-week monitoring period, the Stebbins Island site (7 redds) recorded the highest mean velocity (2.99 fps) and highest mean depth (4.59 ft). The Fall River site (2 redds) recorded the lowest mean velocity (0.82 fps) and the lowest mean depth (1.53 ft) (Table 4.3-2). Site-specific spawning parameters are summarized by region in Table 4.3-3.

Stebbins Island and the Hatfield S Curve were the deepest spawning sites monitored during this study and as a result there were days in which field staff had to rely solely on GPS locations to obtain water parameters. As depths subsided, field staff were able to successfully relocate the redds originally found at these sites. All redds remained intact for the entirety of the study, exhibiting no signs of damage or scouring despite relatively high velocity measurements in some areas.

Water Quality Parameters

Water quality parameters recorded at each spawning site during the monitoring season are summarized in Table 4.3-4. Temperature across all spawning sites ranged from 17.39 to 25°C from June 12, 2015 to July 31, 2015. The lowest site-specific mean temperature throughout the study period (19.1°C) was measured in the Fall River and the highest mean temperature (21.8°C) was measured in the Millers River. Conductivity across all sites ranged from 70 to 254 micro-Siemens per centimeter (µS/cm) with the highest mean conductivity (190.5 µS/cm) measured in the Fall River. Measurements of pH ranged from 6.72 to 8.16 with an overall mean of 7.48. Turbidity across all spawning sites ranged from 0.53 to 9.08 Nephelometric Turbidity Units (NTU), the Fall River measurements represented the entire range. The lowest mean value (3.8 NTU) was measured in the Millers River and the highest mean value (8.07 NTU) was measured at the Stebbins Island site. DO (mg/l) across all spawning sites ranged from 1.72 to 11.57 mg/l, once again the Fall River represented the entire extent of the range. The Fall River also measured the lowest mean DO (7.31 mg/l) and the Stebbins Island site measured the highest mean DO (9.8 mg/l).

4.4 Spawning Success

Upon retrieval of sample jars from the capped redds, two caps were successful in capturing lamprey ammocoetes in the recovered samples. The Hatfield S Curve cap (retrieved July 7, 2015) produced a larvae measuring approximately 47 mm (Figure 4.4-1). The Fall River cap (retrieved July 2, 2015) produced a much smaller ammocoete measuring approximately 7 to 8 mm in total length (Figure 4.4-2).

The Stebbins Island cap was not recovered, as the apparatus apparently did not remain on the redd and was never relocated. There were no larvae collected from the samples at the two caps on the Ashuelot River redds (retrieved July 2, 2015).

4.5 Site-Specific Habitat Measurements

Figures 4.5-1 through 4.5-4 represent mean daily velocity and depth measurements recorded at redd sites along with the hourly flow data. Three of the regions monitored for this study were located in tributaries (Fall River, Ashuelot River and Millers River). The Ashuelot and Millers River are equipped with USGS Gages, whereas there is no streamflow monitoring equipment on the Fall River.

Stebbins Island Redds

Lamprey redds around Stebbins Island are in very close proximity (0.8 miles downstream) to the Vernon Hydroelectric Project. Based on Study No. 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and below Cabot,* the hydraulics in the area of these redds can be impacted by FirstLight Project operations and TransCanada's Vernon Project operations depending on several variables. In Figure 4.5-1, a time series (June 19, 2015 to July 10, 2015) of Vernon Dam discharge[5] is plotted along with mean daily depth and velocity as measured at the seven redds monitored in that region. Note that the Vernon Hydroelectric Project has a maximum hydraulic capacity of 17,130 cfs; discharges shown in Figure 4.5-1 above this flow are spilled and beyond its control. Six spot measurements occurred between June 19, 2015 and July 10, 2015. During this time, the maximum discharge at Vernon was 35,287 cfs on June 24, 2015. Coincidently, field staff recorded water velocity and depth measurements at the seven redds around Stebbins Island on the same date (June 24, 2015) of peak discharge. The maximum mean depth (7.96 ft) and maximum mean velocity (4.64 fps), based on the seven redd locations, were recorded on this date, which was the highest of any observed lamprey spawning site throughout the entire study period. The next two days of sampling were June 30, 2015 and July 2, 2015. On these dates, discharge at Vernon was still high, ranging from 16,742 to 27,042 cfs. Spot measurements of mean depth and velocity on these dates continued to be higher than any other measurements recorded at other spawning sites throughout the study period. Despite high depth and velocity measurements at the Stebbins Island site, no redds were ever observed to be degraded at any time.

Ashuelot River Redds

Figure 4.5-2 represents a time series (June 10, 2015 to July 6, 2015) of the hourly Ashuelot River discharge as measured at the USGS gage at Hinsdale, NH (Gage No. 01161000). The drainage area at the USGS Gage is approximately 420 square miles. Six spot measurements occurred at this site between June 12 and July 16, 2015 and mean depths and velocities were calculated as shown in Figure 4.5-2. On June 24, 2015, field staff measured a maximum mean depth (5.28 ft) and a minimum mean velocity (0.22 fps) for the 11 redds. Discharge on the Ashuelot River remained low, not exceeding 400 cfs until June 30, 2015. Peak discharge at Vernon Dam during the Lamprey spawning study was on June 24, 2015 (35,287 cfs). In the FirstLight relicensing 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*, it was determined during high flows on the Connecticut River, it backwaters approximately 2,500 ft upstream of the Ashuelot River to a riffle where the tributary changes slightly in elevation. Using the GPS locations, the cluster of monitored redds in the Ashuelot River was located approximately 2,150 ft upstream from the confluence, within the extent of potential backwatering. High Vernon discharges on June 24, 2015 may explain the high

[5] At the Vernon Hydroelectric Project, the hourly discharges, which includes generation flow and spill are estimated by TransCanada; spill is computed via rating curves

depth and the very low velocity measured at the redds on that date. At no point were any of the monitored redds disturbed in any way during the study period.

Millers River Redds

Figure 4.5-3 shows a time series (June 6, 2015 to July 10, 2015) of the hourly Millers River discharge as measured at the USGS gage at Erving, MA (Gage No. 01166500). The drainage area at the USGS Gage is approximately 372 square miles. Average depth and velocity based on seven spot measurements recorded at the five Lamprey redds monitored in the Millers River throughout the study period are also depicted. Mean depth (1.46 to 2.32 ft) in the Millers River varied by only 0.8 ft throughout this study. Mean velocity had a slightly larger range (0.92 to 2.84 fps), with the maximum velocity (2.84 fps) measured on July 2, 2015. The maximum mean velocity for the five redds was recorded on July 2, 2015; corresponding with the day of maximum discharge at the Birch Hill Dam (1,500 cfs) during the study period. Spot measurements were recorded at the Millers River redds on seven dates between June 12, 2015 and July 6, 2015.

The WSEL in the lower reaches of the Millers River is influenced by inflows to its watershed, by the level of the TFI, Northfield Mountain operations (pump and generation scenarios), and Connecticut River flows. The redds that were located in the Millers River and any variations in depth and velocity were only due to discharge at the Birch Hill Dam rather than Project operations. Since there were no large fluctuations in depth or velocity, nor any observed differences to redd structure or lamprey activity throughout the study, the influences listed above are considered negligible on the Millers River lamprey spawning habitat. Between June 12, 2015 and July 10, 2015, the elevation of the TFI ranged from 179.69 to 183.65 ft as measured at the TFD and Northfield Mountain operated under all scenarios (1, 2, 3 and 4 units pumping and generating). At no point were any of the monitored redds disturbed in any way during the study period.

Fall River Redds

Figure 4.5-4 shows a time series (June 17, 2015 to July 31, 2015) of the discharge at the TFD and the mean daily velocity and depth based on spot measurements of the two redds monitored in the Fall River. The Fall River redds were monitored for the longest period of time because the water temperature did not reach 22°C until August 3, 2015. In Figure 4.5-4, the two greatest mean depths (2.9 and 3.05 ft) and the two lowest mean velocities (0.44, 0.14 fps) were measured on June 24, 2015 and June 30, 2015, respectively. Peak discharge at the TFD occurred between June 23, 2015 and July 2, 2015 with a maximum value of 20,818 cfs on June 24, 2015. The extent of the Fall River confluence and the amount of backwater experienced is influenced by spillage at the TFD. The FirstLight relicensing Study No. 3.3.17 determined that Connecticut River backwatering effects can extend approximately 250-300 ft upstream into the Fall River. In the 2015 monitoring period, the capped redd in the Fall River was located approximately 195 ft upstream of the confluence, which is within the range susceptible to backwatering depending on mainstem conditions. Figure 4.5-4 clearly shows that as discharge at the dam increases, the depth increases at the Fall River redds and the water velocity decreases due to backwatering.

Hatfield S Curve Redds

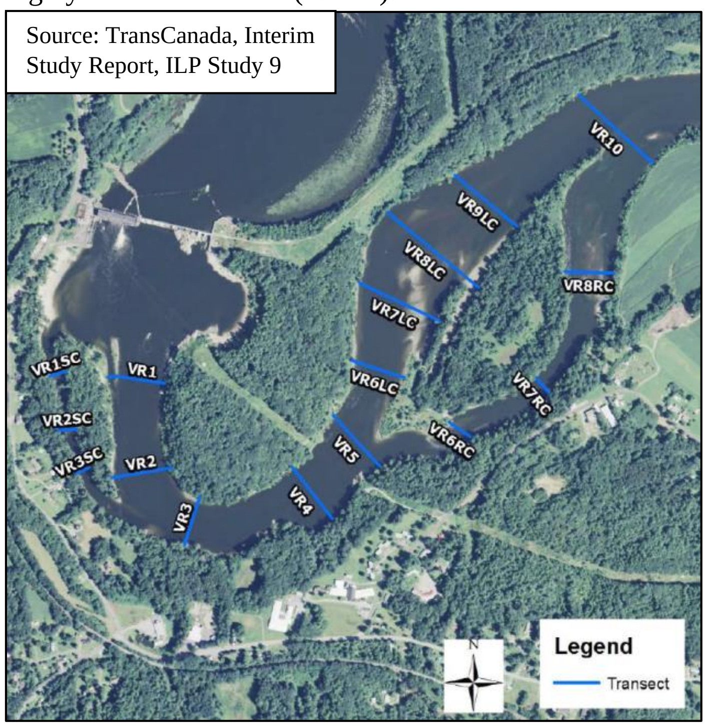
Figure 4.5-5 shows a time series (June 6, 2015 to July 7, 2015) of the Montague gage discharge and associated mean daily velocity and depth based on spot measurements at the four redds monitored at the Hatfield S Curve. Field staff measured an overall mean velocity (1.77 fps) and a mean depth (3.96 ft) during sampling events at the four redds from June 6, 2015 to July 7, 2015. The range of velocity (1.41 to 2.84 fps) remained consistent throughout the study period. The depth range (2.8 to 7.9 ft) during the study period was more variable and at times (June 23, 2015 to June 29, 2015) caused field staff to rely solely on GPS waypoints to locate the redds. Lack of visibility to the bottom made it difficult to determine the exact positions of the certain redds. As mentioned above in regards to the Stebbins Island sites, lamprey spawn and nest in a variety of depths and there was never any observed degradation to redds around the Hatfield S curve.

4.6 Habitat Suitability Mapping

4.6.1 Turners Falls Impoundment

A map of suitable lamprey spawning habitat within the TFI was created based upon the HSI criteria developed for FirstLight's IFIM study, Study No. 3.3.1 (Figure 3.4.1.1-1). As described earlier, each transect in the TFI hydraulic model was divided into 20 equally sized cells. Within each cell, the hydraulic model produces the mean velocity and depth. These hydraulic variables, coupled with the substrate data obtained for Study No. 3.3.14 *Aquatic Habitat Mapping of the TFI*, were used to compute the combined suitability index (CSI) value based on the HSI criteria for the sea lamprey spawning life stage. CSI values range from 0 to 1 with values closest to 1 representing the species' optimal spawning and incubation conditions. Also, as noted above, only a single operational scenario was examined as part of this assessment consisting of a Vernon Hydroelectric Project discharge of 9,630 cfs, Northfield Mountain Project idle (no pumping or generating) and the WSEL at the TFD of 181.5 feet.

Figure 4.6.1-1 is a visual representation of suitable lamprey spawning habitat in the TFI under the flow/water level conditions described above. Throughout most of the TFI, small areas of suitable lamprey spawning habitat exist. There are two very small areas of low to marginally suitable habitat (0-0.25 CSI), just upstream of the Northfield Mountain Project intake/discharge and at the head of Kidds Island. The only other area of suitable lamprey spawning habitat is located around Stebbins Island and just downstream of Vernon Dam as visualized in the top inset of Figure 4.6.1-1. CSI values around Stebbins Island range from marginally suitable habitat (0-0.25 CSI) to highly suitable habitat (0.75-1). There were seven redds monitored around Stebbins Island throughout the study period. All of the redds monitored around Stebbins Island were located in areas where suitable habitat was mapped in Figure 4.6.1-1. Upstream of Stebbins Island and immediately downstream (0.2 miles) of Vernon Dam is another small island where an area of marginally suitable habitat (0.01-0.25 CSI) was mapped. NAI mobile tracked 7 tagged lamprey for this study in the area of this island. This may be an important spawning location for Sea Lamprey in the TFI.



Although FirstLight conducted the above assessment based on one operating regime, as noted earlier, TransCanada conducted an instream flow study (IFIM) from Vernon Dam downstream approximately 1.5 miles to the bottom of Stebbins Island. Shown in the inset are the 16 transect locations used in the IFIM Study. The TransCanada IFIM study area covers the locations where redds were detected as part of FirstLight's study. As part of TransCanada IFIM study one of the target species and life stages was sea lamprey spawning. Thus, a relationship between flow and habitat for this species and life stage is available as part of TransCanada Report No. 9.

4.6.2 Below Turners Falls Dam

For the reach between the Turners Falls Dam and the Sunderland Bridge[6], separate IFIM studies are being conducted to determine the relationship between Sea Lamprey spawning habitat and flow. Thus, FirstLight proposes to address habitat suitability as part of the IFIM Study (Study No. 3.3.1), slated for filing with FERC on 10/14/2016.

4.6.3 Habitat Classification

Sea Lamprey spawning habitat within the project affected area was classified as 1) non-suitable habitat 2) suitable habitat-no observed spawning 3) active spawning area 4) active spawning area with larval sampling. A map of this classification was produced for the TFI (Figure 4.6.3-1), as well as for below TFD (Figure 4.6.3-2).

[6] The IFIM study includes three separate reaches (Reach 1, 2, and 3) between the TFD and Montague USGS Gage and one reach (Reach 4) between the Montague USGS gage and Sunderland Bridge.

Table 4.1-1: Sea Lamprey Collection, Tagging and Release Summary

Date of Collection/Release	Collection Location	Number tagged and release location	Number tagged and release location	Total Tagged and Released
5/21/2015 (Early)	Holyoke Dam	10 – Rt. 116 Bridge	10 – Turners Falls Gatehouse	20
5/28/2015 (Late)	Holyoke Dam	10 – Rt. 116 Bridge	10 – Turners Falls Gatehouse	20

Table 4.1-2: Summary Characteristics of 40 Radio Tagged Sea Lamprey: Sex, Number (N), Range and Mean of Length (cm), Weight (g) and Girth (cm)

Sex	N	Length (cm)		Weight (g)		Girth (cm)	
		Range	Mean	Range	Mean	Range	Mean
Female	16	64-84	72.2	450-970	652.5	13-16	14.5
Unknown	24	62-78	72.2	430-850	671.0	12-17	14.3
Total	**40**	**62-84**	**72.2**	**430-970**	**663.6**	**12-17**	**14.4**

Table 4.2-1: Summary of Mobile Tracked Sea Lamprey that were Relocated in the Study Area

Code	Release Information	Number of Relocations	Last tracked date alive	Maximum Distance and direction traveled from release site (river miles)	Comments
45	Sunderland - Early	3	6/10/2015	5.5 - downstream	Located near Hatfield redds
46	Sunderland - Early	1	7/72015	52.3 - upstream	NAI reported above Vernon Dam
47	Sunderland - Early	1	6/3/2015	20.7 - upstream	Passed TFD
50	Sunderland - Early	2	6/29/2015	5.9 – downstream	Located near Hatfield redds
51	Sunderland - Early	2	7/6/2015	32.2 - upstream	NAI reported near island 0.2 mi below Vernon Dam
53	Sunderland - Early	3	6/29/2015	22.1 - downstream	Never tracked upstream of release
62	Impoundment - Early	2	6/17/2015	19.7 - upstream	NAI reported near island 0.2 mi below Vernon Dam
99	Sunderland - Late	2	6/30/2015	26.5 – upstream	Passed TFD
100	Sunderland - Late	2	6/16/2015	7.8 – downstream	Never tracked upstream of release
102	Sunderland - Late	2	6/17/2015	32.2 – upstream	NAI reported near island 0.2 mi below Vernon Dam
105	Sunderland - Late	1	6/17/2015	19.3 – upstream	Passed TFD
108	Sunderland - Late	2	6/29/2015	9.4 – downstream	Located near Hatfield redds
112	Impoundment - Late	1	6/17/2015	19.7 – upstream	NAI reported near island 0.2 mi below Vernon Dam
113	Impoundment - Late	1	6/30/2015	15.3 - upstream	Stayed in TFI
115	Impoundment - Late	2	6/30/2015	19.7 - upstream	NAI reported near island 0.2 mi below Vernon Dam
116	Impoundment - Late	1	6/9/2015	19.7 - upstream	NAI reported near island 0.2 mi below Vernon Dam
117	Impoundment - Late	2	6/30/2015	19.7 - upstream	NAI reported near island 0.2 mi below Vernon Dam

NAI = Normandeau Associates, TFD = Turners Falls Dam

Table 4.2-2: Summary of Mobile Tracked Sea Lamprey that were Relocated by NAI

Code	Release Information	Number of Relocations	Maximum Distance traveled from release site (river miles)	Notes (from NAI)
52	Impoundment - Early	4	94.5	Wilder Riverine
55	Impoundment - Early	5	48.1	Bellows Falls Riverine
56	Impoundment - Early	2	18	Vernon Riverine
57	Impoundment - Early	1	51.8	Bellows Falls Riverine
59	Impoundment - Early	4	79	Wilder Riverine
60	Impoundment - Early	2	100.6	Tributary
63	Impoundment - Early	2	51.8	Bellows Falls Riverine
110	Impoundment - Late	4	46.5	Vernon Impoundment
111	Impoundment - Late	2	51.8	Bellows Falls Riverine
114	Impoundment - Late	1	39.8	Vernon Impoundment

Table 4.3-1: GPS Located Redds within the Study Area with Associated Caps and Larval Collection Success

Study Area	Number of GPS located redds	Number of Capped redds	Number of collected larvae
Connecticut River mainstem within close proximity of Vernon Dam (both sides of Stebbins Island)	7	1	0
Ashuelot River confluence with the Connecticut River	11	2	0
Millers River confluence with the Connecticut River	5	0	0
Fall River confluence with the Connecticut River	2	1	1
Hatfield S curve below Rt. 116 Bridge	4	1	1
Total	**29**	**5**	**2**

Table 4.3-2: Summary of Lamprey Redd Data Measured from 6/12/15 to 7/31/15 (X = present, XX = present and dominant), Based on a Minimum of Six Visits to Each Location

Site	Water Depth (ft)			Water Velocity (fps)			Substrate						Presence of Lamprey
	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	Yes
Millers572-1	1.5	2.8	2.04	1.57	4.25	2.6		X	X	XX	X		Yes
Millers572-2	1.2	2.0	1.65	0.77	3.44	2.35		X	X	XX	X		Yes
Millers572-3	1.35	2.4	1.69	0.48	3.3	1.86		X	X	XX	X		Yes
Millers572-4	1.1	2.9	2.11	0.21	1.91	1.02		X	X	XX	X		Yes
Ashuelot573	1.9	6.4	3.43	0.06	1.99	0.87	X	X	XX	XX			Yes
Ashuelot574-1	1.6	5.2	3.0	0.12	3.02	1.17	X	X	XX	XX			Yes
Ashuelot574-2	1.75	5.4	3.39	0.07	2.41	1.33	X	X	XX	XX			Yes
Ashuelot574-3	1.0	4.7	2.86	0.22	2.22	1.24	X	X	XX	XX			Yes
Ashuelot574-4	1.4	5.1	3.1	0.3	2.68	1.48	X	X	XX	XX			Yes
Ashuelot574-5	1.7	5.3	3.1	0.14	2.52	1.35	X	X	XX	XX			Yes
Ashuelot574-6	1.8	5.8	3.29	0.2	2.56	1.26	X	X	XX	XX			Yes
Ashuelot574-7	1.6	5.2	3.12	0.14	2.05	1.16	X	X	XX	XX			Yes
Ashuelot574-8	1.2	5.2	3.16	0.19	1.74	0.96	X	X	XX	XX			Yes
Ashuelot574-9	0.6	4.5	2.46	0.34	2.43	1.49	X	X	XX	XX			Yes
Ashuelot574-10	1.4	1.5	1.45	1.2	1.72	1.37	X	X	XX	XX			Yes
Hatfield130-1	2.8	7.9	4.24	1.41	2.84	2.08		X	X	XX			Yes
Hatfield130-2	3.9	3.9	3.9	1.54	1.61	1.57		X	X	XX			Yes
Hatfield130-3	3.5	3.5	3.5	1.7	1.75	1.72		X	X	XX			Yes
Hatfield130-4	4.2	4.2	4.2	1.66	1.8	1.74		X	X	XX			Yes
Stebbins182	1.3	7.3	3.7	1.08	3.65	2.68		X	X	XX			Yes
Stebbins217	2.6	8.8	5.24	1.77	4.43	3.11		X	X	XX			Yes
Stebbins219	1.7	8.6	5.03	0.11	5.6	3.2		X	X	XX			Yes
Stebbins219-1	1.8	8.2	4.26	0.22	4.26	2.56		X	X	XX			Yes
Stebbins220	2.3	8.3	5.27	0.85	6.08	3.3		X	X	XX			Yes
Stebbins221	2.4	7.3	4.3	2.05	4.3	3.21		X	X	XX			Yes
Stebbins222	2.9	7.5	4.33	1.43	4.27	2.9		X	X	XX			Yes
Fall1	0.7	3.4	1.15	0.11	2.38	0.83	X	X	XX	XX			Yes
Fall2	0.6	4.8	1.91	0.02	1.69	0.82	X	X	XX	XX			Yes

Table 4.3-3: Summary of Site Specific Lamprey Spawning Habitat Parameters

Site	Dates Surveyed	Depth (ft)		Velocity (fps)		Dominant Substrate
		Range	Mean	Range	Mean	
Millers River	6/12/15-7/6/15	1.1-2.9	1.91	0.21-4.25	1.98	Cobble
Ashuelot River	6/12/15-7/6/15	0.6-5.8	2.94	0.06-3.02	1.24	Gravel/Cobble
Hatfield S Curve	6/16/15-7/7/15	2.8-7.9	3.96	1.41-2.84	1.77	Cobble
Stebbins Island	6/19/15-7/10/15	1.3-8.8	4.59	0.11-6.08	2.99	Cobble
Fall River	6/17/15-7/31/15	0.6-4.8	1.53	0.02-2.38	0.82	Gravel/Cobble

Table 4.3-4: Summary of Water Quality Parameters Recorded at Each Lamprey Spawning Site during the 2015 Monitoring Season

Site	Mean Temperature (°C)	Mean Conductivity (µS/cm)	Mean pH	Mean Turbidity (NTU)	Mean DO (mg/l)
Millers River	21.8	130.8	7.35	3.8	9.2
Ashuelot River	20.8	110.4	7.38	4.59	9.25
Hatfield S Curve	20.67	93.3	7.45	4.9	8.87
Stebbins Island	19.42	91.9	7.44	8.07	9.8
Fall River	19.1	190.5	7.82	5.17	7.31

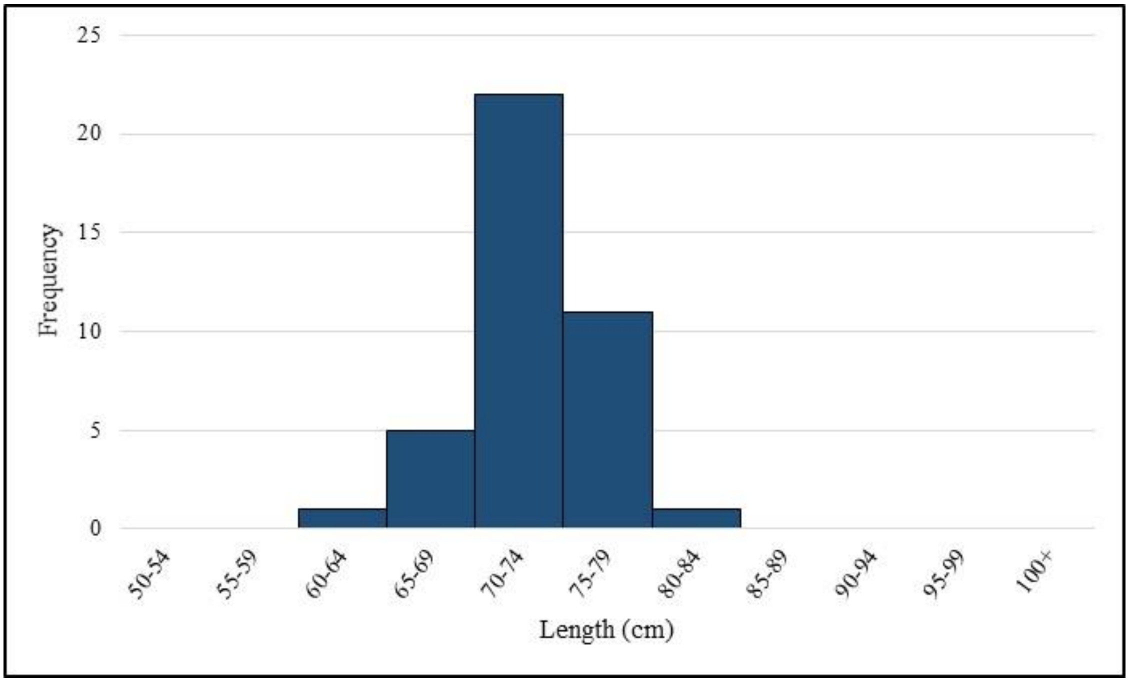
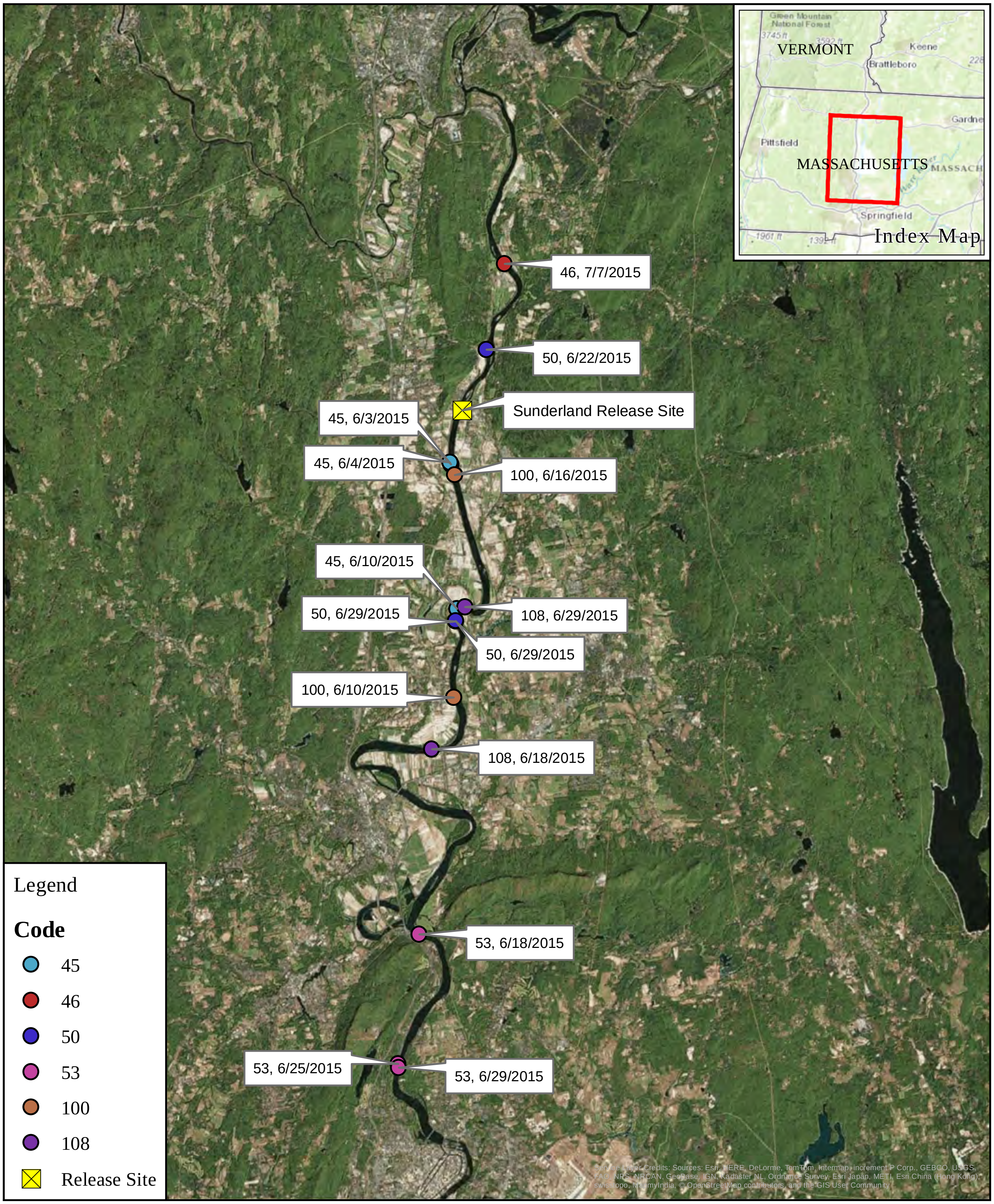


Figure 4.1-1: Length Frequencies of Sea Lamprey Tagged



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

ASSESSMENT OF ADULT SEA LAMPREY SPAWNING WITHIN THE TURNERS FALLS PROJECT AND NORTHFIELD MOUNTAIN PROJECT AREA
RELICENSING STUDY 3.3.15

N

0 1.5 3 6 Miles

Figure 4.2-1: Lamprey Mobile Tracking Locations Below Turners Falls Dam

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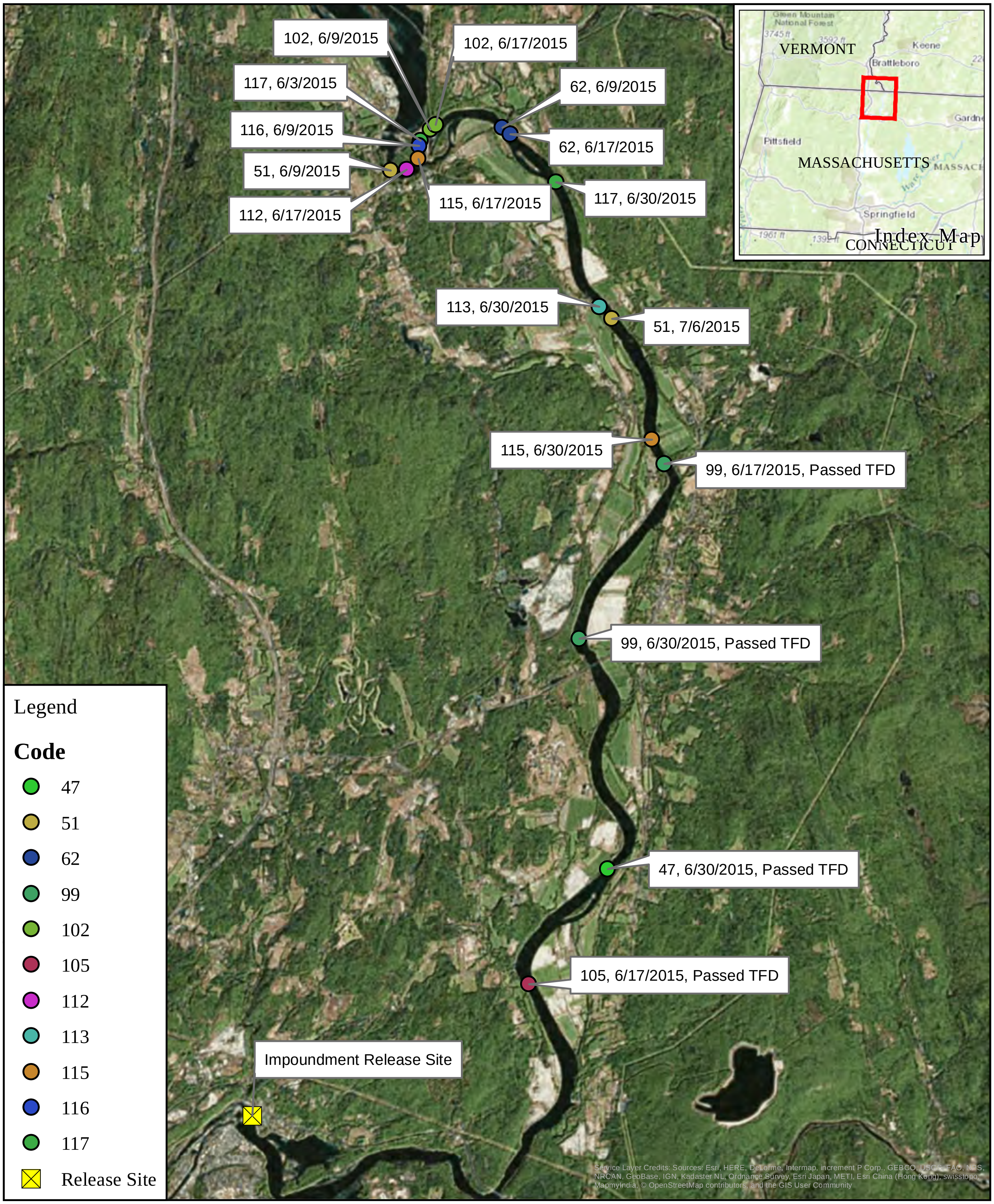

Northfield Mountain Pumped Storage Project (No. 2485)
and Turners Falls Hydroelectric Project (No. 1889)

N

ASSESSMENT OF ADULT SEA LAMPREY SPAWNING
WITHIN THE TURNERS FALLS PROJECT AND
NORTHFIELD MOUNTAIN PROJECT AREA
RELICENSING STUDY 3.3.15

0 0.75 1.5 3 Miles

Figure 4.2-2: Lamprey Mobile Tracking Locations Above Turners Falls Dam

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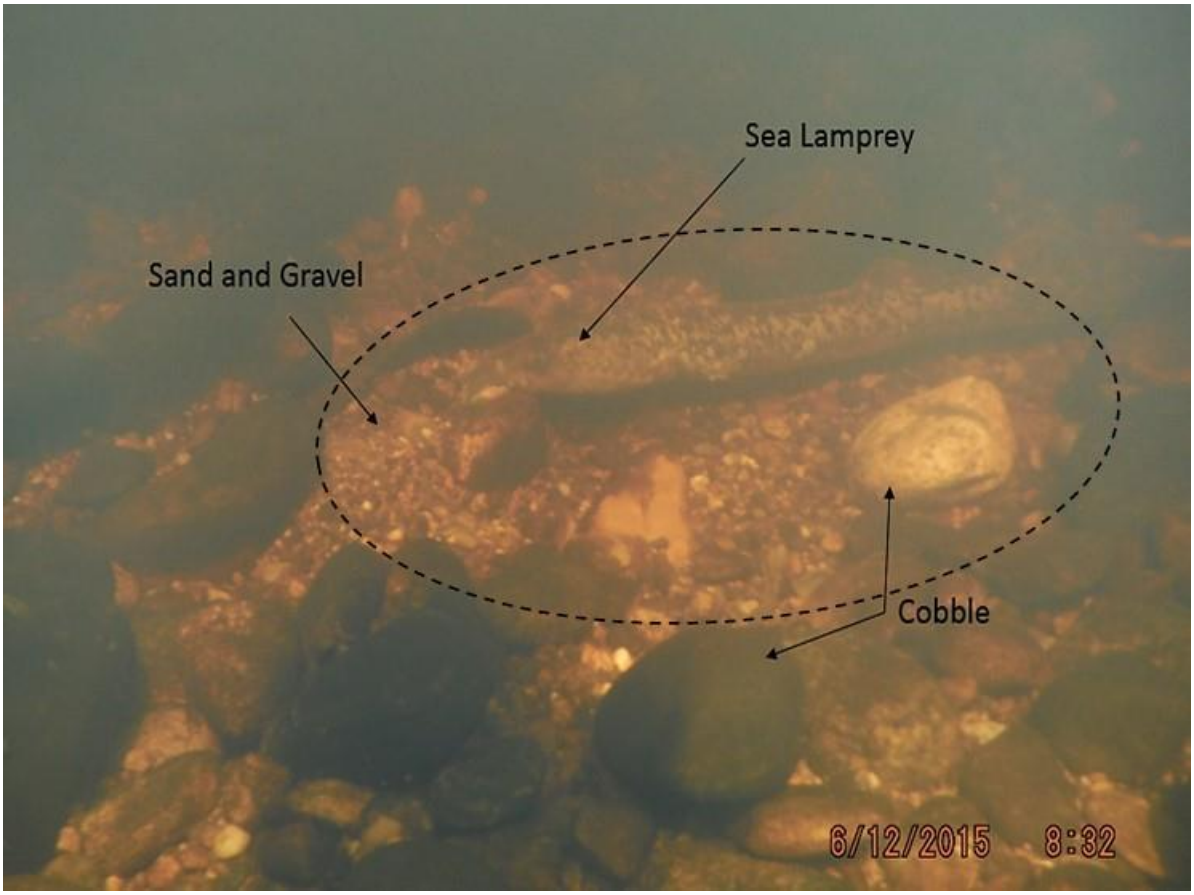


Figure 4.3-1: Sea Lamprey on a Redd in the Millers River showing Substrate/Typical Redd Characteristics

Figure 4.4-1: Photograph of the Sea Lamprey Larva Ammocoete at the Hatfield S Curve Capped Redd

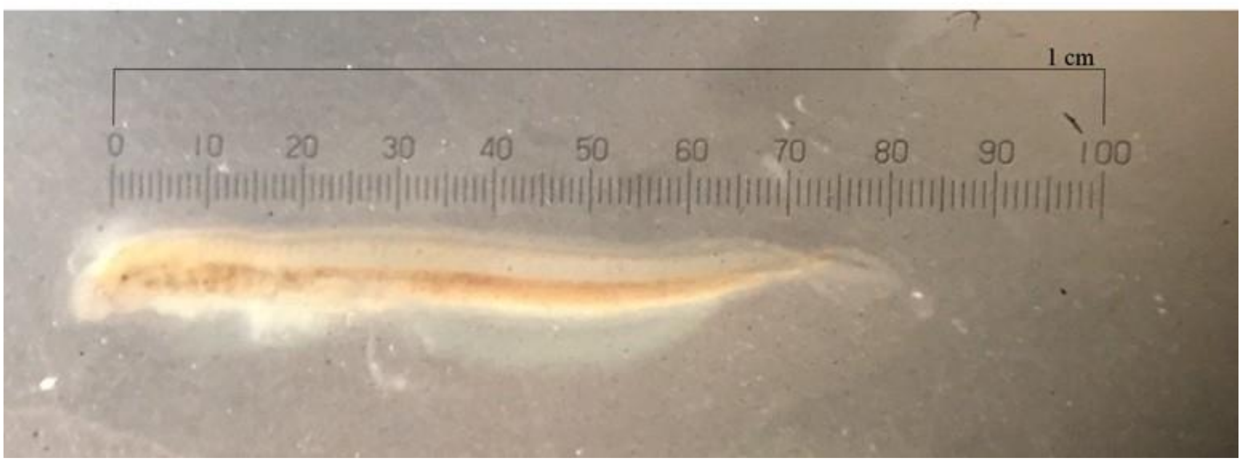


Figure 4.4-2: Photograph of the Sea Lamprey Ammocoete Collected at the Fall River Capped Redd

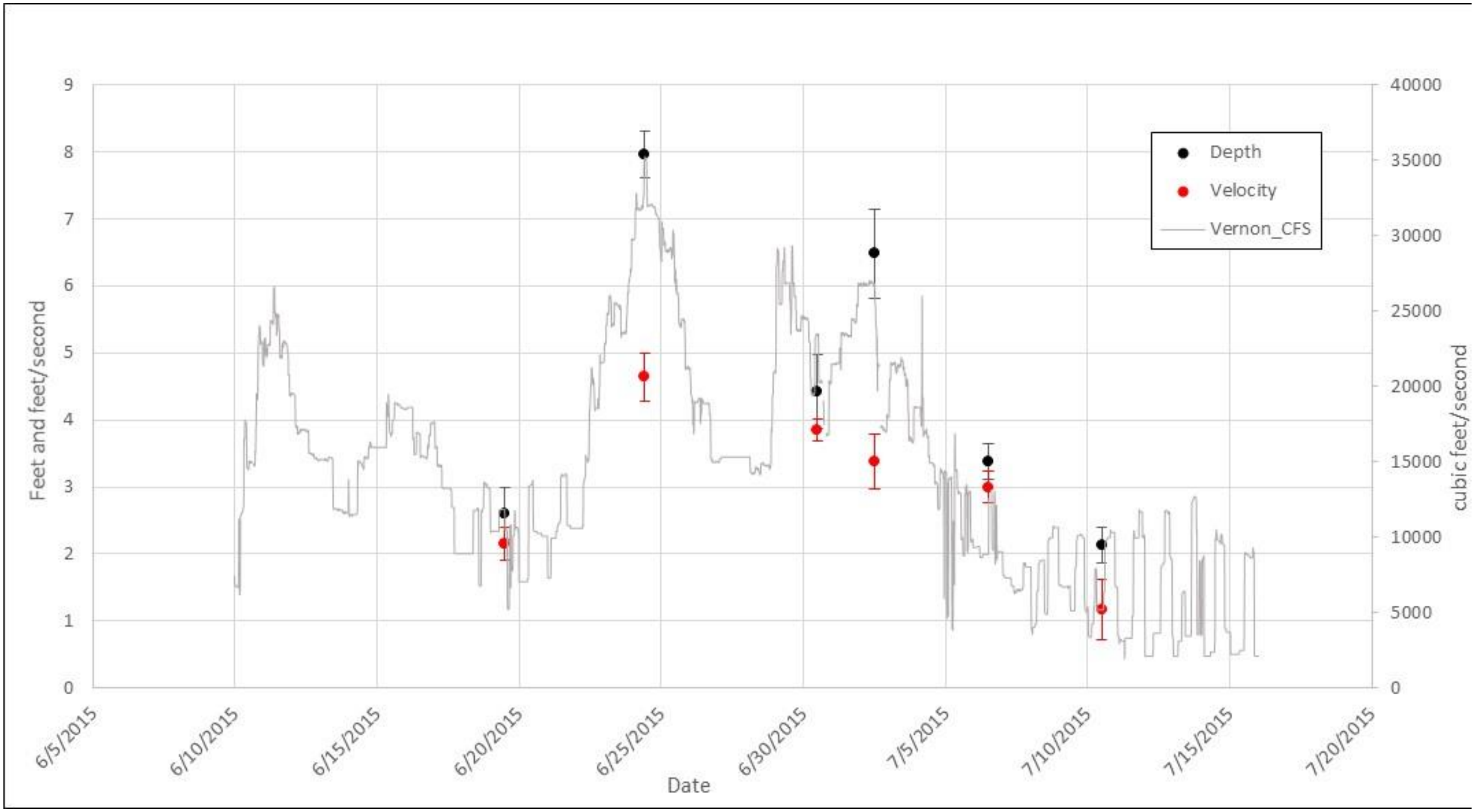


Figure 4.5-1: Vernon Dam Discharge (cfs) During Lamprey Sampling Period (6/19/15 to 7/10/15) with mean daily velocity (fps) (+/- SD) and mean daily depth (ft) (+/- SD) Measurements of the Seven Redds Monitored around Stebbins Island

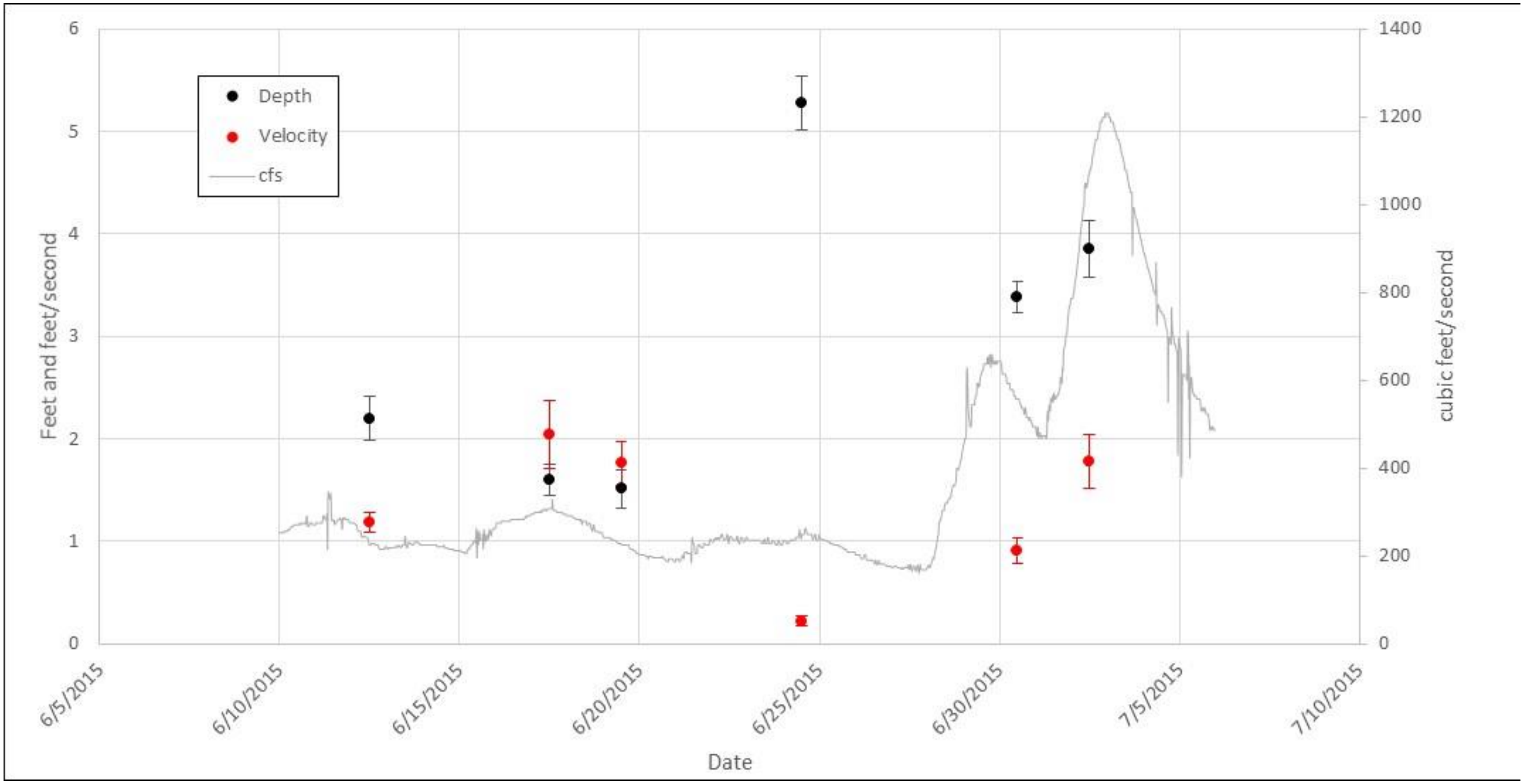


Figure 4.5-2: Ashuelot River Discharge (cfs) During Lamprey Sampling Period (6/12/15 to 7/6/15) with mean daily velocity (fps) (+/- SD) and mean daily depth (ft) (+/- SD) Measurements of the 11 redds monitored

6/24/2015 – Field staff noted significant backwatering from the Connecticut River

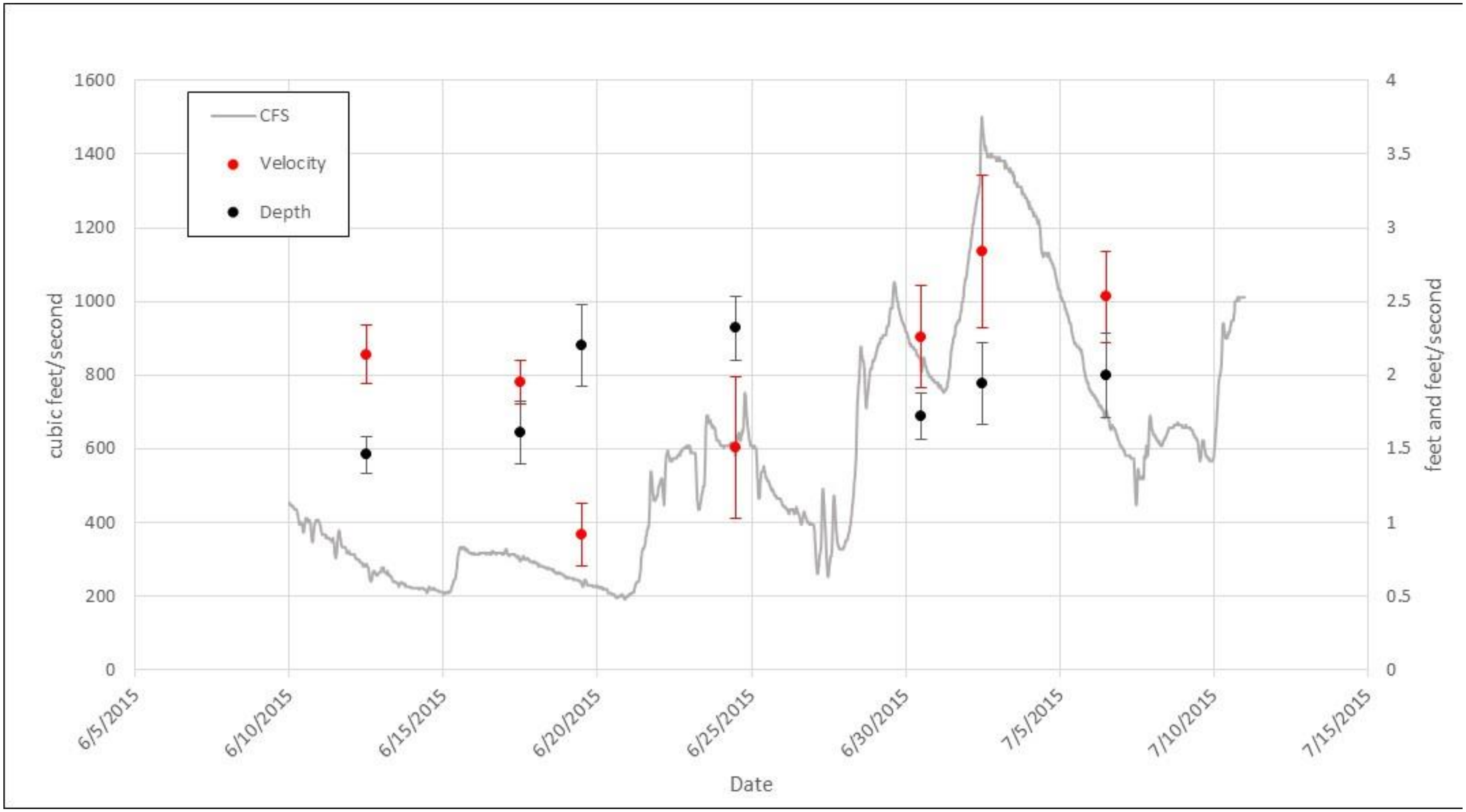


Figure 4.5-3: Millers River Discharge (cfs) During Lamprey Sampling Period (6/12/15 to 7/6/15) with mean daily velocity (fps) (+/- SD) and mean daily depth (ft) (+/- SD) measurements of the five Redds monitored

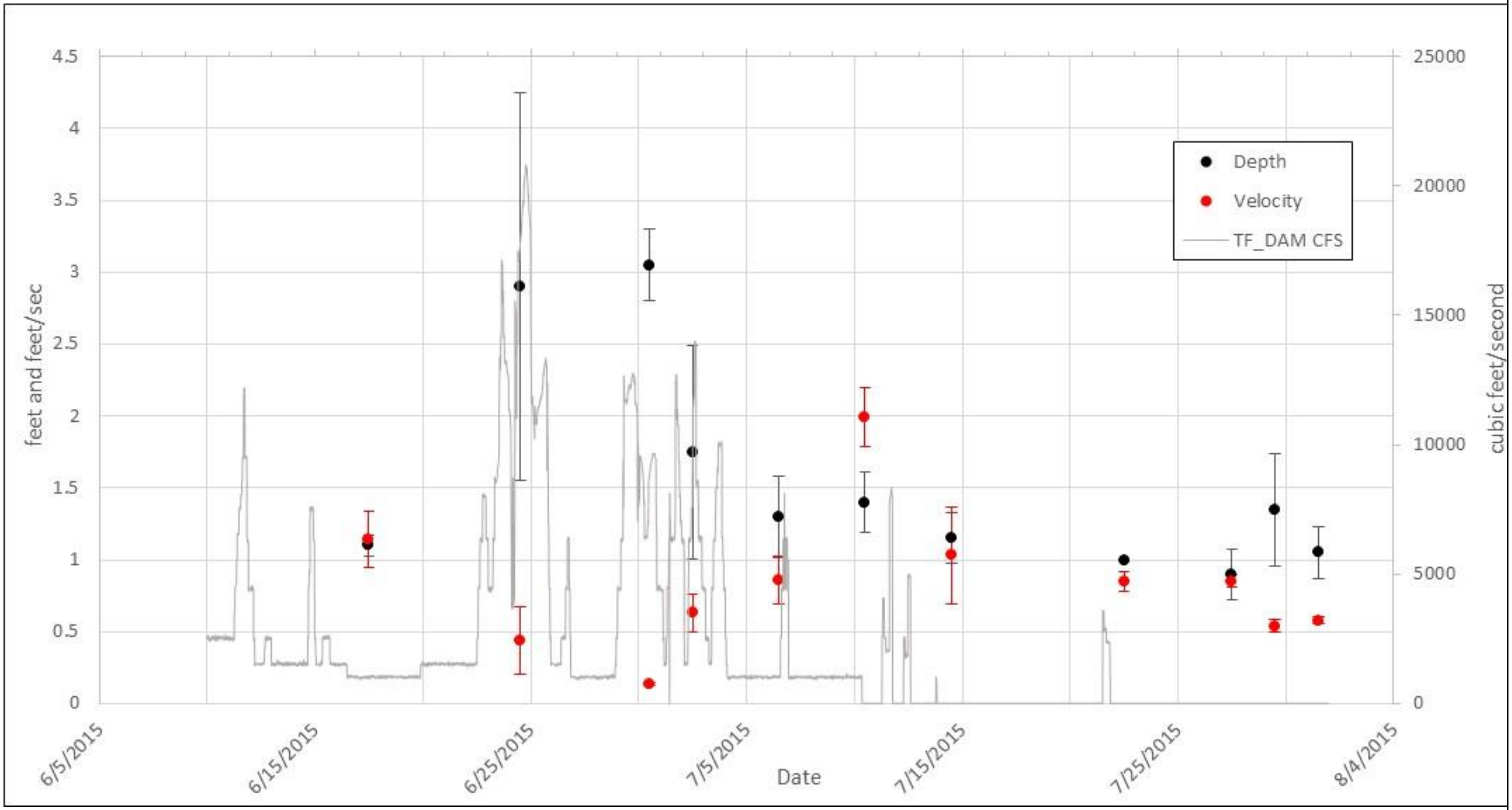


Figure 4.5-4: Turners Falls Dam Discharge (cfs) During Lamprey Sampling Period (6/17/15 to 7/31/15) with mean daily velocity (fps) (+/- SD) and mean daily depth (ft) (+/- SD) measurements for Two Redds monitored in the Fall River

6/24/2015 &6/30/2015 – Field Staff noted significant backwater from Bypass Reach

During periods recorded as zero discharge at TFD, the minimum bypass flow of at least 120 cfs was provided to the bypass reach.

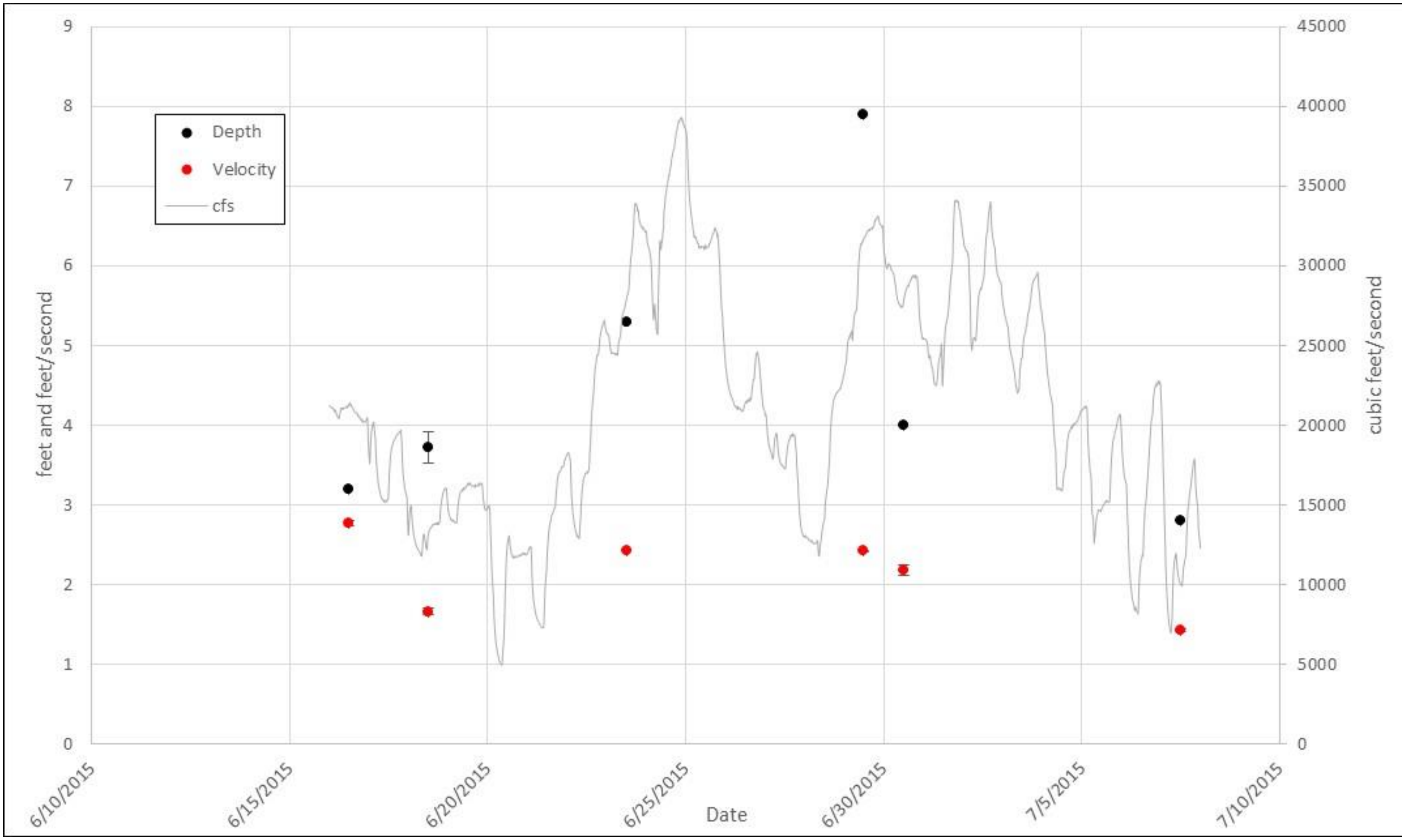
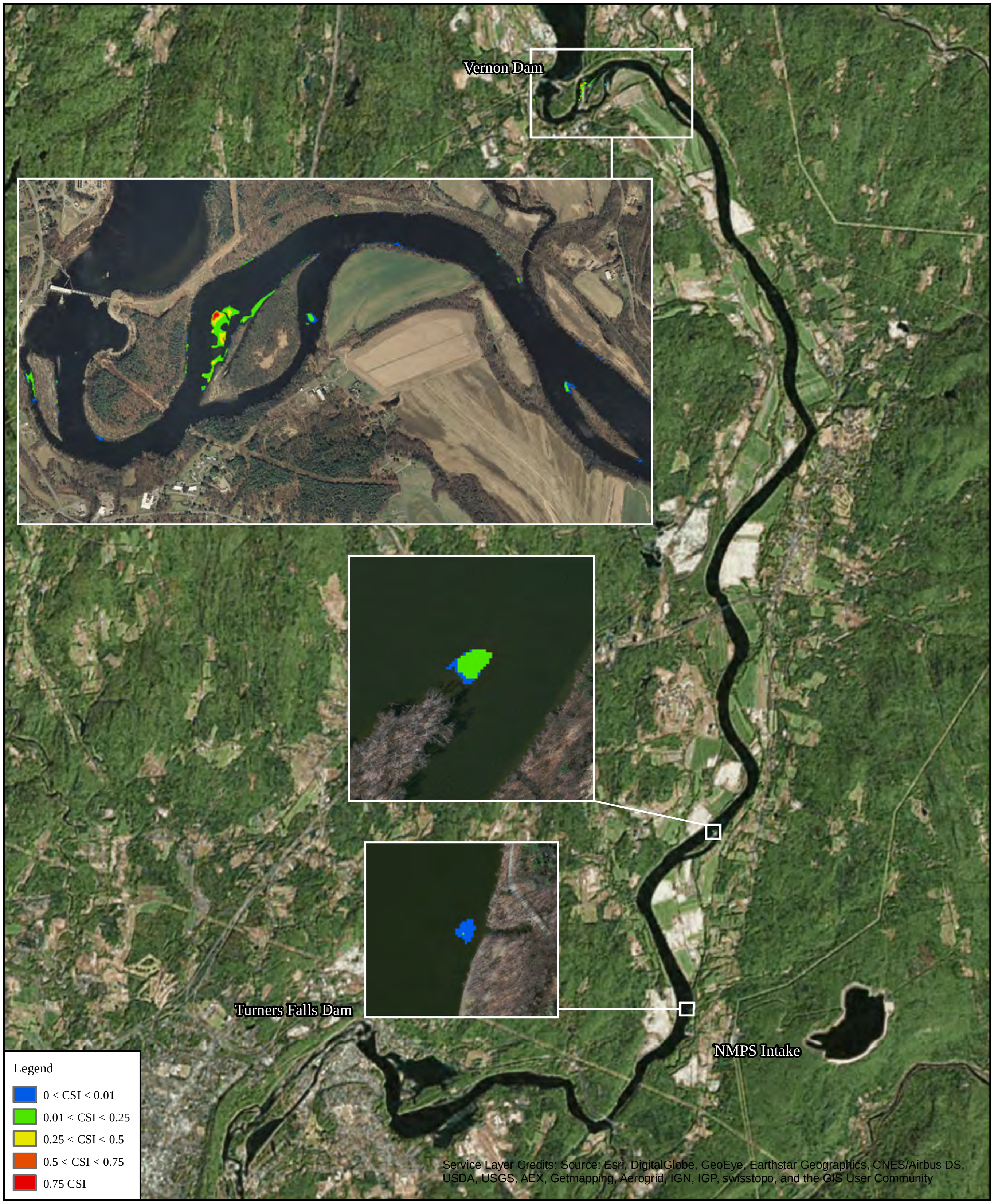


Figure 4.5-5: Montague Gage Discharge (cfs) During Lamprey Spawning Period (6/16/15 to 7/7/15) with Mean Daily Velocity (fps) (+/- SD) and mean daily depth (ft) (+/- SD) Measurements of the Four Redds Monitored at the Hatfield S Curve



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ASSESSMENT OF ADULT SEA LAMPREY SPAWNING WITHIN THE TURNERS FALLS PROJECT AND NORTHFIELD MOUNTAIN PROJECT AREA
RELICENSING STUDY 3.3.15

N

0 0.25 0.5 1
Miles

Figure 4.6.1-1: Suitable Sea Lamprey Spawning Habitat in Turners Falls Impoundment with 9,630 cfs at Vernon and NMPS Off

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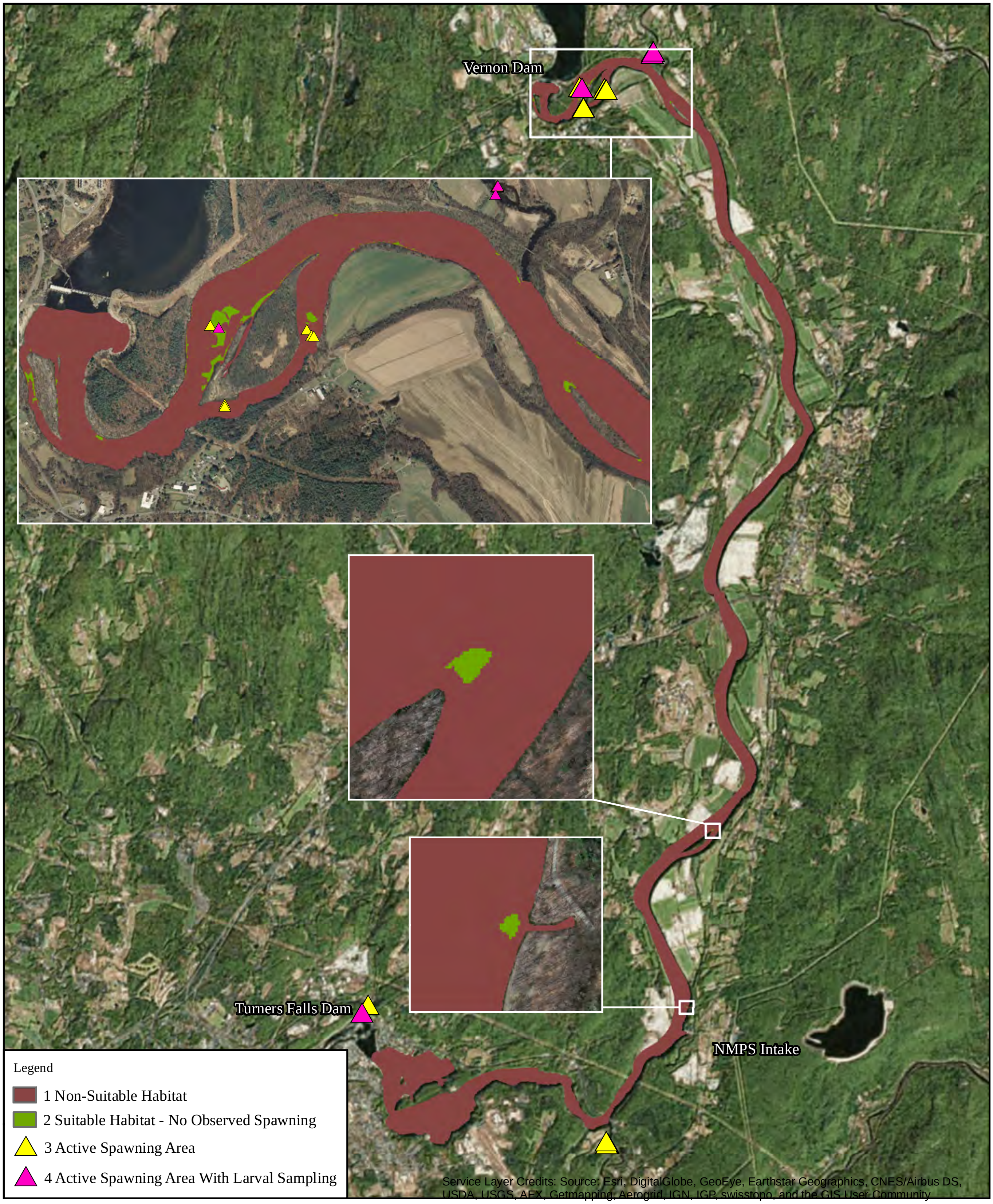

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WITHIN THE TURNERS FALLS PROJECT AND
NORTHFIELD MOUNTAIN PROJECT AREA
RELICENSING STUDY 3.3.15

Figure 4.6.3-1: Classification of Suitable Lamprey Spawning Habitat Above Turners Falls Dam

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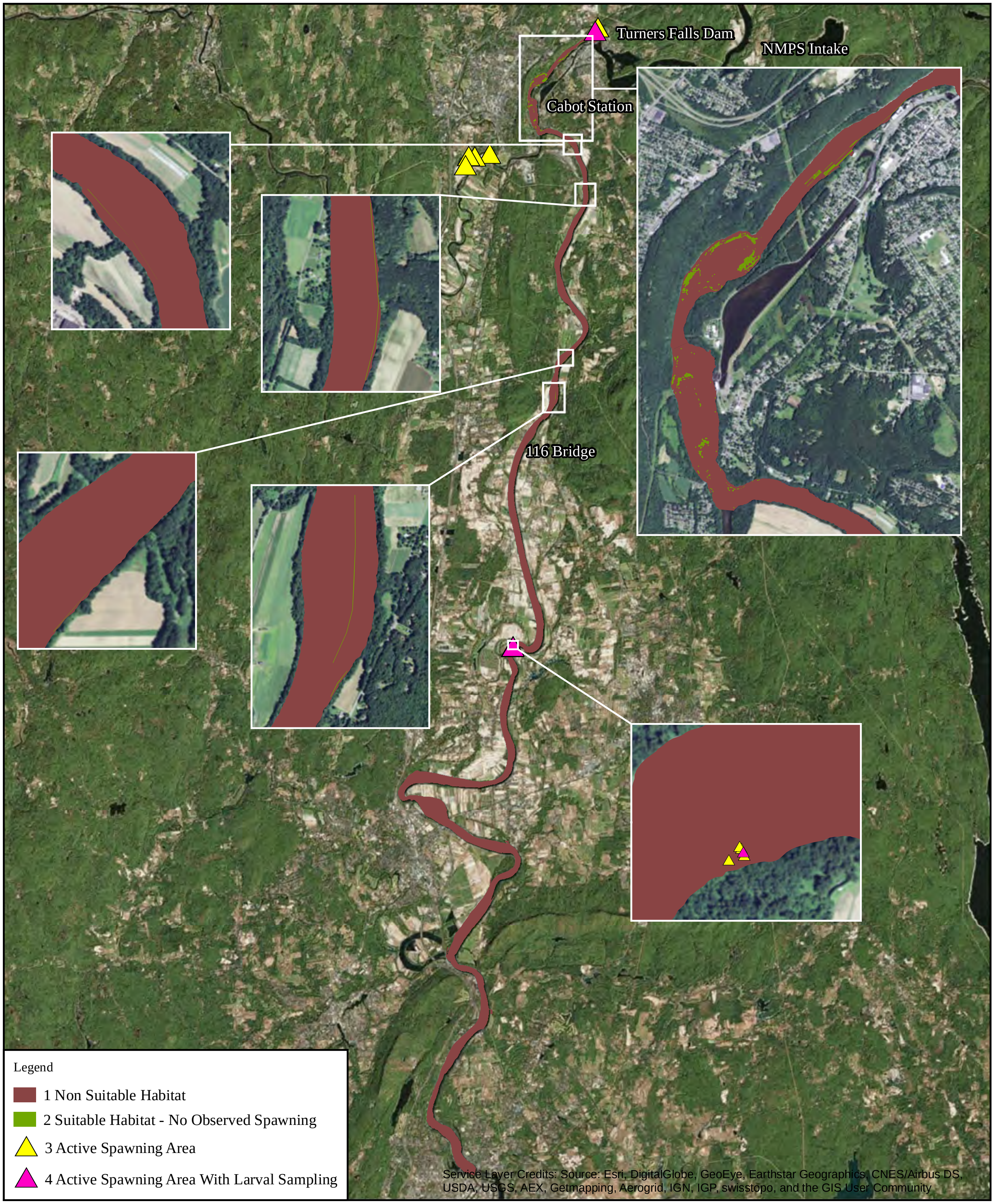

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Turners Falls Hydroelectric Project No. 1889

ASSESSMENT OF ADULT SEA LAMPREY SPAWNING WITHIN THE TURNERS FALLS PROJECT AND NORTHFIELD MOUNTAIN PROJECT AREA
RELICENSING STUDY 3.3.15

Figure 4.6.3-2: Classification of Suitable Lamprey Spawning Habitat below Turners Falls Dam

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5 DISCUSSION

Sea Lamprey spawning habitats within the Project area were identified and surveyed to confirm the existence of suitable spawning habitat for Sea Lamprey within the Turners Falls and Northfield Mountain Project areas, and to determine whether Project operations adversely impact that habitat. Twenty-nine lamprey redds were monitored from June 12, 2015 to July 31, 2015; results of the 2015 study in relation to specific objectives identified in Section 1.2 are discussed in the following sections.

5.1 Tagging and Tracking

Forty Sea Lamprey were captured at Holyoke Dam fish lift and transported to the Turners Falls and Northfield Mountain study area where they were tagged and released. Twenty lamprey were tagged during the early portion of their run (May 21, 2015) and released in two locations: Route 116 Bridge and upstream of Turners Falls Gatehouse. Another 20 lamprey were tagged during the mid-portion of their run (May 28, 2015) and released at the same locations.

Mobile tracking in the project area began on June 1, 2015 and continued through July 7, 2015. Seventeen of the 40 tagged lamprey (42.5%) were relocated within the study area (Table 4.2-1). NAI reported an additional 10 lamprey relocated just downstream of Vernon Dam or in areas above Vernon Dam. Eight of the 17 lamprey tracked in the study area were also relocated above Vernon Dam by NAI. In total, 18 of the 40 tagged lamprey (45%) moved north of the project area to presumably spawn. Twenty-seven (27) of the 40 tagged lamprey (67.5%) were relocated via mobile tracking by Kleinschmidt Associates in the Turners Falls and Northfield Mountain study area or by NAI above Vernon Dam.

5.2 Spawning Habitat Surveys

Surveying for suitable Sea Lamprey habitat in the Turners Falls and Northfield Mountain Project areas began on June 1, 2015. Locations of spawning habitat identified previously by NOAA and the Connecticut River Coordinator were confirmed. Field staff observed nest formation in the Connecticut River mainstem and accessible tributary areas consisting of gravel and cobble riffle habitat with flowing water. Five sites were chosen for routine monitoring of depth, velocity, temperature, and substrate characteristics: the Connecticut River mainstem adjacent to Stebbins Island, the Ashuelot River confluence, the Millers River confluence, the Fall River confluence, and the Hatfield S Curve. Each of the five sites chosen contained multiple redds within close proximity and areas of suitable spawning habitat. In total, 29 redds were GPS-located and monitored throughout the study period (June 12, 2015 to July 31, 2015).

Five redds were capped to characterize spawning success based on the collection of any emerging larvae from redds. The caps were placed on top of redds and remained in place for 2 to 3 weeks. In this study, two capped redds successfully captured ammocoetes: Fall River and the Hatfield S Curve, both of which are located below the TFD. The ammocoetes recovered from the Fall River and from the Hatfield S Curve were different in length, 7-8 mm and 45 mm, respectively. It is difficult to determine the age of these ammocoetes based on length but the two ammocoetes (Figures 4.4-1 and 4.4-2) were clearly in different stages of development and/or metamorphosis.

5.3 Suitable Habitat in the Project Area

Turners Falls Impoundment

Suitable habitat exists in the TFI in small areas, with the largest region being around Stebbins Island. Based on the one operating condition described above, the only area in the TFI having high suitability habitat (red, 0.75-1) is near Stebbins Island, the location of the seven redds monitored during this study.

Below Turners Falls Dam

For the reach below the TFD, FirstLight proposes to evaluate suitable Sea Lamprey spawning habitat using the IFIM study, which is slated to be filed with FERC on October 14, 2016.

5.4 Effect of Project Operations on Spawning Habitat

Stebbins Island Redds

Lamprey spawning habitat around Stebbins Island experienced large fluctuations in water depth (1.3 to 8.8 ft) and water velocity (0.22 to 6.08 fps) during the monitoring period in 2015. The mean site depth (4.9 ft) and mean site velocity (2.99 fps) were the highest parameters recorded at any observed spawning site in 2015. Sea Lamprey are documented to spawn in a variety of depths, ranging from 13 cm to 2 m (5 inches to 6.5 feet), indicating a tolerance to a variety of water depths (Manion & Hanson, 1980).

FirstLight's Relicensing Study 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and Below Cabot* contained data from several hydraulic transects on the mainstem Connecticut River, including areas around Stebbins Island. Water levels and velocities at this location can be affected to varying degrees by discharges from Vernon Dam, operations of Northfield Mountain and water surface elevation changes at the TFD. The calibrated hydraulic model was used along with flow inputs (Vernon discharge, Northfield discharge/generation or idle flow, Ashuelot River flows, Millers River flows, and the recorded WSEL at the TFD) to determine the WSEL at transects where the redds were located. The hydraulic model produced hourly WSELs at the redd locations for the monitoring June 19-July 10, 2015. Using the hourly data, elevation duration curves were developed as shown in Appendix A.

Elevation curves were developed for Stebbins Island redd locations to it determine if the redds may have been dewatered, or exposed, during the monitoring period (June 19, 2015 to July 10, 2015) (Appendix A). Analysis revealed that there was no time when any of the redds at the Stebbins Island site were exposed from June 19 to July 10, 2015. Redds were revisited after July 10, 2015; confirming water temperatures exceeded 22°C and monitoring of redds around Stebbins Island ceased.

Based on the direct observations and the hydraulic modeling the impact of Turners Falls and Northfield Mountain Project operations in this region is classified as **(1) no effect (no observable difference to habitat/redd structure or lamprey activity)**.

Ashuelot River Redds

The Ashuelot River had a very high density of redds in a relatively small area. The presence of Lamprey actively nesting/spawning and constructing redds during preliminary habitat inspection provided evidence of site productivity. Based on Study 3.2.2 *Hydraulic Study of Turners Falls Impoundment, Bypass Reach and Below Cabot*, similar to areas around Stebbins Island, water levels at the mouth of the Ashuelot River can be affected to varying degrees by discharges from Vernon Dam, Northfield Mountain Project operations and WSEL at the TFD. However, the redds observed in the Ashuelot River were located approximately 2,150 ft upstream from the confluence with the Connecticut River. Under high Vernon discharges and TFI levels, this area can experience a backwater effect, and this was observed in the field on June 24, 2015 when Vernon discharge was approximately 35,000 cfs.

Based on the direct observations, the impact of Turners Falls and Northfield Mountain Project operations to the Ashuelot River lamprey spawning habitat is classified as **(1) no effect (no observable difference to habitat/redd structure or lamprey activity)**.

Millers River Redds

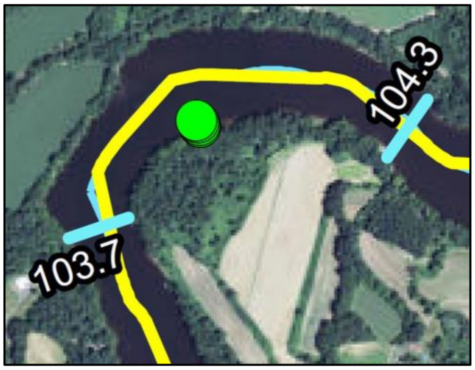
The cluster of redds monitored was located approximately 1,000 ft upstream from the confluence with the Connecticut River. No structural differences to the monitored redds in the Miller River were observed during the study period. During the monitoring period, field staff observed new redds developed directly upstream of the five monitored redds that were originally located, suggesting the Millers River was a productive lamprey spawning site in 2015. Based on direct observation, the impact of Turners Falls and Northfield Mountain Project operations to the Millers River lamprey spawning habitat is classified as **(1) no effect (no observable difference to habitat/redd structure or lamprey activity)**.

Fall River Redds

Despite low velocity values, one ammocoete was collected in the sample from the capped redd. No observable differences to habitat/redd structure and/or lamprey spawning behavior were recorded. In fact, lamprey were observed actively nesting, spawning and swimming in the Fall River multiple times during the monitoring period. Although the Fall River can be influenced by discharges from the TFD, releases are generally constant during the lamprey spawning period, except under situations when inflows are above the capacity of the Power canal (~18,000 cfs) and the remainder of water is spilled into the bypass reach. These conditions are beyond control of the Turners Falls Project. Based on the direct observations, impact of Turners Falls and Northfield Mountain Project operations to the Fall River lamprey spawning habitat is classified as **(1) no effect (no observable difference to habitat/redd structure or lamprey activity)**.

Hatfield S Curve Redds

The Hatfield S Curve cap was recovered and produced an ammocoete. Additionally, no observable differences to habitat/redd structure and/or lamprey spawning behavior were recorded. A hydraulic model of the reach between the Montague USGS Gage and Holyoke Dam was developed as part of Study No. 3.2.2. For this hydraulic model, detailed bathymetric mapping was not conducted. Instead the transects in the model were developed from various sources including: a) Flood Insurance Study transects, b) transects collected by in the Northampton area by the US Army Corps of Engineers and The Nature Conservancy and c) supplement transect data collected in the Hatfield area. The location of the Hatfield S Curve redds relative to the hydraulic model transects are shown in the inset. The hydraulic model can interpolate transects between the two shown in the inset; however, because the redds are located near the water's edge, it would not be reasonable or accurate to interpolate. Note that at this location some visual observations were made under some of the lower flows encountered during the monitoring period (see Figure 4.5-5). During those observations, the minimum depth was 2.8 feet. In addition, at this location an ammocoete was obtained.



Based on the direct observations the impact of Turners Falls and Northfield Mountain Project operations in this region is classified as **(1) no effect (no observable difference to habitat/redd structure or lamprey activity)**.

All site classifications of effects of Project operations on lamprey spawning habitat and associated comments are located in Table 5.4-1.

5.5 Conclusions

All instantaneous field measurements recorded at the redds during the study period (6/12/15 – 7/31/15) were analyzed in conjunction with Northfield Mountain and Turners Falls operations data to assess the possible effects on lamprey spawning habitat. The spawning sites located around Stebbins Island and in the Ashuelot River are within the Project boundary but are in close proximity to Vernon Dam. Following the criteria of possible project effects, all five spawning sites monitored in this study were deemed to show no adverse effects due operations.

The redds in the Fall River are susceptible to backwatering during times of high discharge at the TFD but there were never any observable differences to habitat/redd structure or lamprey activity. In fact, the Fall River was one of two sites from which an ammocoete was successfully captured. The Stebbins Island and Ashuelot River lamprey sites appeared to experience some minor effects from discharges from Vernon Dam. The redds around Stebbins Island recorded the greatest mean velocities and depths but field staff never observed any differences in habitat/redd structure or lamprey activity during the study period. The redds in the Ashuelot River experienced substantial backwatering at times that decreased water velocity running over the redds and increased the depth of the water in the tributary but no structural differences were observed.

Overall, suitable spawning habitat for Sea Lamprey is limited in the TFI and the only sizable area is located around Stebbins Island. This is an area of known lamprey spawning activity and an area where lamprey activity (spawning/nesting/swimming) was observed and monitored during the 2015 study. The remainder of the TFI lacks the appropriate conditions (relatively shallow, fast moving water in a cobble/riffle area) needed for lamprey to spawn.

Table 5.4-1: Classification of Effects of Project Operations on Lamprey Spawning Habitat

Spawning Site	Classification	Comments
Stebbins Island	**1) No effect** (no observable difference to habitat/redd structure or lamprey activity).	-Inside Project area - -High velocity and depth under high Vernon discharge conditions
Ashuelot River	**1) No effect** (no observable difference to habitat/redd structure or lamprey activity).	-Inside Project area --Backwater causing low velocity and increased depth
Millers River	**1) No effect** (no observable difference to habitat/redd structure or lamprey activity).	N/A
Fall River	**1) No effect** (no observable difference to habitat/redd structure or lamprey activity).	Backwater causing low velocity and increased depth during high TFD discharge
Hatfield S Curve	**1) No effect** (no observable difference to habitat/redd structure or lamprey activity).	N/A

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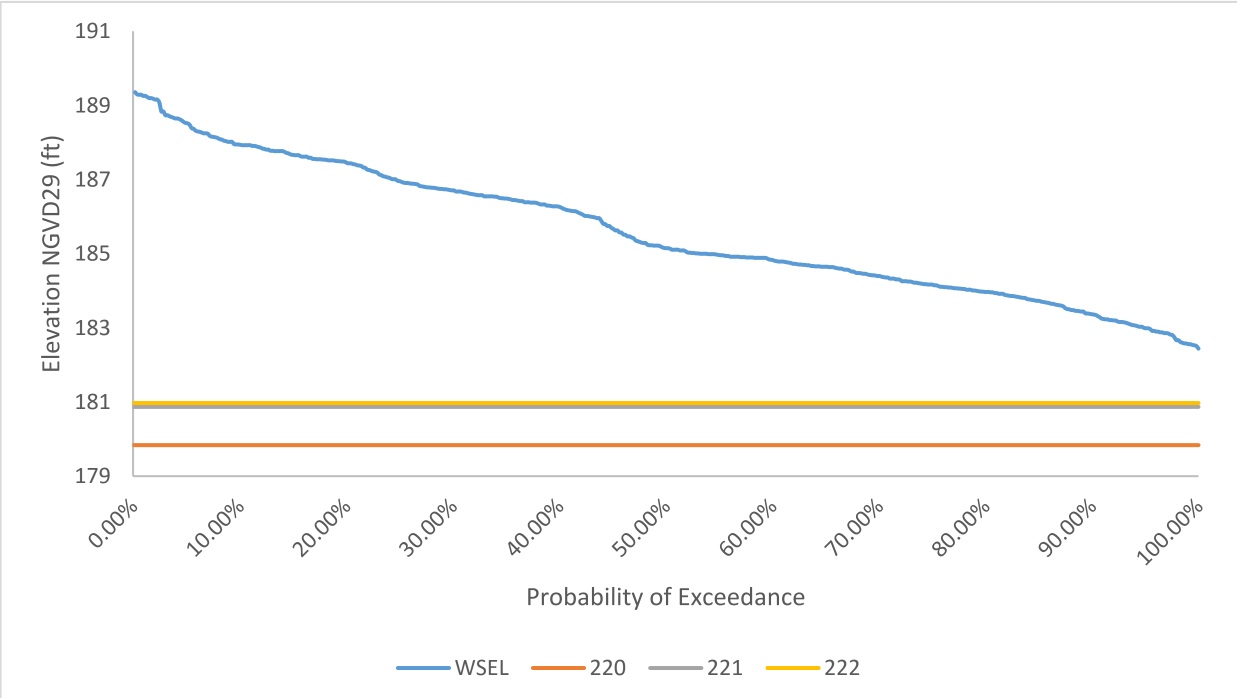
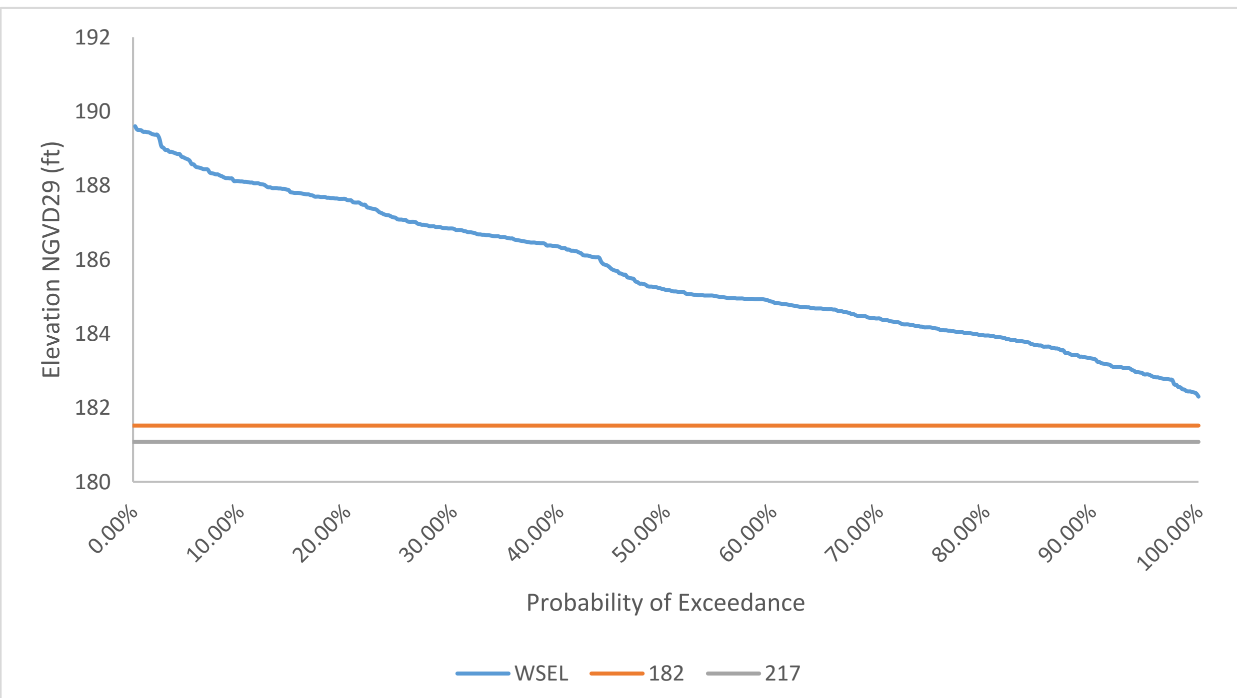
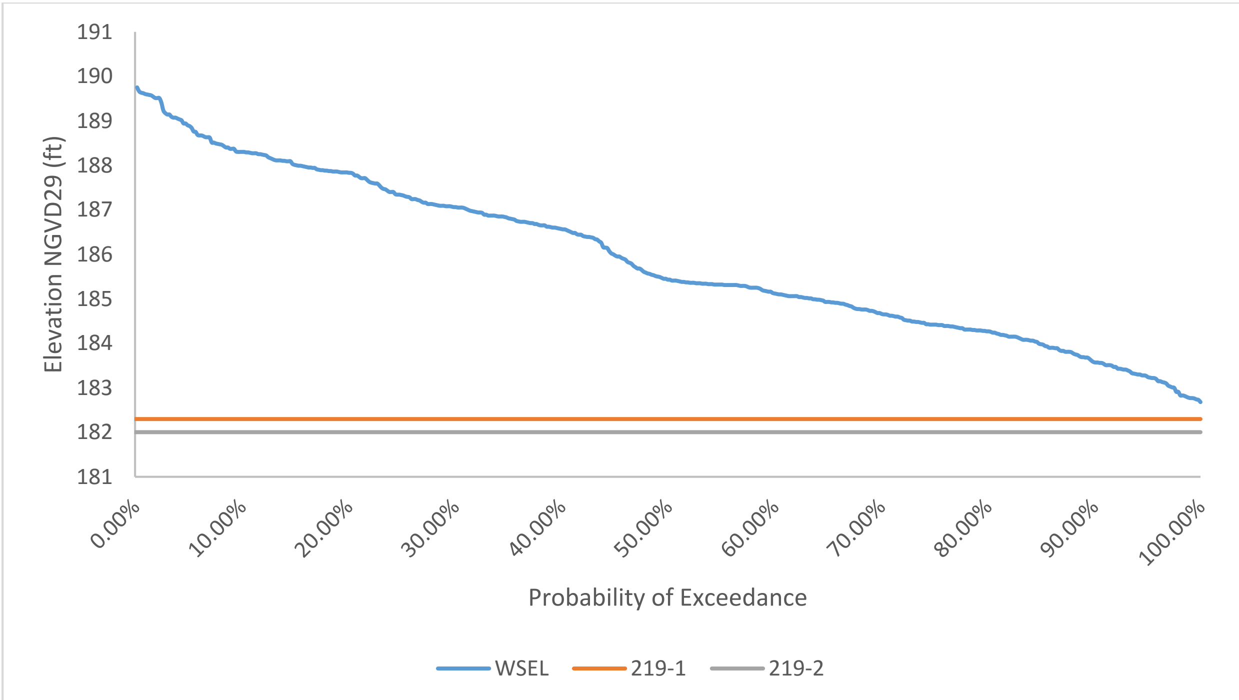
APPENDIX A – ELEVATION DURATION CURVES

WATER SURFACE ELEVATION CURVE FOR STEBBINS ISLAND REDDS RELATIVE TO THE REDD LOCATION (JUNE 19TH TO JULY 10TH, 2015):







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Elevation NGVD29 (ft)
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%
90.00%
100.00%
Probability of Exceedance
WSEL
219-1
219-2