Relicensing Study 3.3.1

Conduct Instream Flow Habitat Assessments in the Bypass Reach and below Cabot Station

Study Report

Addendum 5 Assessment of Sea Lamprey (new spawning HSI curves) and Yellow Lampmussels in Reach 3

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

Prepared for:

FirstLight Power Resources

Prepared by:

Kleinschmidt

Gomez and Sullivan Engineers

MARCH 2019

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

cfs	cubic feet per second
cm	centimeters
FERC	Federal Energy Regulatory Commission
FL	FirstLight Hydro Generating Company
ft	feet
ft/s	feet per second
in	inches
MADFW	Massachusetts Division of Fisheries & Wildlife
NHESP	Natural Heritage and Endangered Species Program
NMFS	National Marine Fisheries Service
ROR	Run-of-river
SI	Suitability Index
USFWS	United States Fish and Wildlife Service
WUA	weighted usable area

1 INTRODUCTION

On October 14, 2016, FirstLight Hydro Generating Company (FL) filed with the Federal Energy Regulatory Commission (FERC) Study Report No. 3.3.1 Instream Flow Habitat Assessment in the Bypass Reach and below Cabot Station.

Between April 3, 2017 and May 1, 2018, FL filed the following additional addendums to Study No. 3.3.1:

- Addendum 1- Addressed Miscellaneous Comments Provided on the Original Study 3.3.1 filing
- Addendum 2- Instream Flow Study Results for Mussels in Reach 5
- Addendum 3- Yellow Lampmussel Assessment in Reach 3
- Addendum 4- Sea Lamprey Assessment with new Habitat Suitability Index Curves

On October 9, 2018, FL held its Study Report Meeting in which Addendums 1-4 were discussed and filed its meeting summary on October 24, 2018 per FERC regulations. Stakeholder comments on the meeting summary and addendums were due by November 23, 2018. Comments on Study No. 3.3.1 were filed by the United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS) and the Massachusetts Division of Fisheries & Wildlife (MADFW). Some of the comments filed on Study No. 3.3.1 requested additional information. On December 21, 2018, FL filed its response to comments with FERC. In its responsiveness summary, FL agreed to provide the following additional information by March 1, 2019.

- Persistent habitat maps for Reach 3 and dual flow results for Reach 4[1] for the new Sea Lamprey Habitat Suitability Index Curves.
- Persistent habitat mapping of juvenile Yellow Lampmussels in Reach 3 over a range of Project Operations.

[1] As noted in the cover letter transmitting this Addendum, FirstLight proposes to file the dual flow analysis in Reach 4 for the new Sea Lamprey spawning habitat suitability index curves on April 22, 2019 (the same day FERC required FirstLight to file its assessment of Yellow Lampmussels in Reach 4).

2 METHODS

2.1 Hydrologic and Hydraulic Modeling

Study No. 3.8.1 *Evaluate the Impact of Current and Potential Future Modes of Operation on Flow, Water Elevation, and Hydropower Generation* used the HEC-ResSim modeling software to develop an operations model of the Connecticut River from the Wilder Project to the Holyoke Project. The model was operated on an hourly basis and was used to determine flow and power production for the period of record: January 1962 to the end of December 2003. Specifically, FirstLight used the operations model to simulate two scenarios- baseline (existing) conditions and run-of-river (ROR) operations. Under the ROR operation, the Wilder, Bellows Falls, Vernon and Turners Falls Projects were operated as ROR, while Northfield Mountain operated as it currently does. Although the ROR scenario simulated Northfield Mountain under its current operation, the flow regime below Cabot was maintained smooth as the Turners Falls Impoundment was used to buffer times of pumping and generating. Also, under both the baseline and ROR scenarios, the bypass flows reflected current minimum flow requirements.

The HEC-ResSim model provided hourly bypass flows and Cabot Station generation flows for the period of record. As part of Study No. 3.3.1 *Instream Flow Habitat Assessments in the Bypass Reach and below Cabot Station*, the entire area of Reach 3 was surveyed for bed elevation, substrate, and water velocity. Hydraulic modeling of the area was then performed using River2D software. River2D is a depth-averaged two-dimensional (lateral-longitudinal), finite-element hydraulic and habitat model. Over 250 modeling runs were completed as part of Study No. 3.3.1 and subsequent modeling requests to cover a wide range of bypass flows, incremental Cabot Station operations, and high (1,445 cfs) and low (200 cfs) flows from the lowermost hydropower facility[2] on the Deerfield River which enters the lower part of Reach 3. However, for the habitat time series analyses, only the low inflow scenarios (200 cfs) from the Deerfield River were used to focus the effects on habitat caused by FirstLight operations. This method is conservative to the resource, particularly in the lower portions of the reach that may be affected by flows from the Deerfield River.

2.2 Flow Time Series Data Processing

Conversion

The flow values were converted to the nearest flow values that were modeled in the habitat/flow tables. Conversion was chosen over interpolation between modeled values because, unlike standard weighted usable area (WUA) versus habitat relationships, persistent or dual flow habitat may not be adequately represented by interpolation between modeled values due to spatial shifts in habitat. Flow values above or below the modeled habitat range were considered to be equal to the highest or lowest modeled habitat flow, respectively.

Flows Encountered by Cohorts

Analysis of persistent habitat was performed on a cohort-specific basis for juvenile Yellow Lampmussel and Sea Lamprey spawning in Reach 3, as follows:

- Juvenile Yellow Lampmussel cohorts were analyzed over a 2-year-long juvenile period. The first four months for each cohort (June through September) was considered to be the critical flow window for juvenile mussel settling and burrowing into the substrate, as discussed with the Natural

[2] The lowermost hydropower facility is Station No. 2. The minimum flow at Station No. 2 is 200 cfs and the maximum hydraulic capacity of the facility is 1,445 cfs.

Heritage and Endangered Species Program (NHESP) on May 25th, 2018. For this time period, a list of unique bypass and generation flow combinations was developed for each cohort from the full flow time series. An additional list of unique flow rates for the remaining 20 months of each cohort was also developed.

- Sea Lamprey spawning cohorts were analyzed over the span of the Sea Lamprey spawning season, from May 20 through July 31. For this time period, a list of unique bypass and generation flow combinations was developed for each cohort from the full flow time series.

2.3 Persistent Habitat Analysis

Given the multiple flow sources that result in complex flow changes in Reach 3, persistent habitat was analyzed spatially by overlaying a node matrix from the River2D model for all unique combinations of flows and associated suitable habitat that occurred for each cohort. Any areas that did not contain suitable habitat during any flow combination were assigned an unsuitable value for persistent habitat for that cohort. This habitat time series analysis was performed based on flows from the operations model that encompassed the years 1962 through 2003. As such, the analysis encompassed persistent habitat over the range of the combination of natural and operational flows based on available water during that time period. The results are shown spatially in terms of the areas where persistent suitable habitat was available for a proportion of cohorts in the analysis. Additionally, the total amount of persistent habitat area was calculated for each cohort based on the node matrix. The criteria used to develop the persistent habitat time series results are shown in the following subsections for Juvenile Yellow Lampmussel and Sea Lamprey spawning.

2.3.1 Juvenile Yellow Lampmussel

For the first four months (June through September) of a cohort, flow was converted to habitat based on 4-variable habitat suitability criteria, which included depth, velocity, substrate criteria developed initially for Study No. 3.3.1 by a panel of experts using the Delphi technique (Table 2.3.1-1), along with shear stress at 10 dynes/cm^2, as requested by NHESP. Figure 2.3.1-1 is a graphical depiction of the amount of suitable habitat in the reach for juvenile Yellow Lampmussel given various combinations of bypass reach and Cabot Station flows; these values reflect the amounts of steady-state habitat in the reach given specific flow rates. For the remaining 20 months in the cohort, the same depth, velocity, and substrate criteria were used, along with a shear stress value of 150 dynes/cm^2, as requested by NHESP. Because of the higher shear stress value during this period, more habitat is typically available to juvenile Yellow Lampmussels (Figure 2.3.1-2). The lower shear stress criteria during the first four months of each cohort was requested by NHESP for successful settling and burrowing; the higher shear stress during the remainder of each cohort period was requested by NHESP because during this time, the mussels would be larger and burrowed into the substrate, and would therefore be less susceptible to the effects of shear stress.

Multiple regression was performed to examine the effects of median, minimum, and maximum bypass reach, Cabot Station, and Montague (Bypass + Montague) flows on the amount of persistent habitat found in Reach 3 for all cohorts. This was performed using parameters from both the critical summer period, and the 2-year span of each cohort.

Table 2.3.1-1: Binary habitat suitability criteria developed for juvenile yellow lampmussel.

Parameter		Yellow Lampmussel Juvenile
Class	**Benthic Velocity Range (ft/s)**	
1	<0.16	1
2	0.16-0.34	1
3	0.35-0.67	1
4	0.68-0.99	1
5	1.00-1.32	1
6	1.33-1.65	1
7	1.66-2.47	0
8	2.48-3.29	0
9	3.30-4.93	0
10	4.94-6.56	0
11	>6.56	0
Class	**Water Depth Range (ft)**	
1	0	0
2	0.03-0.34	0
3	0.35-0.83	1
4	0.84-1.65	1
5	1.66-2.47	1
6	2.48-3.29	1
7	3.30-4.93	1
8	4.94-6.56	1
9	6.57-9.85	1
10	9.86-13.12	1
11	>13.12	1
Class	**Particle Size**	
1	Organic Material	0
2	Clay	0
3	<0.002 in [mud/silt]	1
4	0.002 – 0.08 in. [sand]	1
5	0.08- 1.26 in. [fine gravel]	1
6	1.26 – 2.52 in. [coarse gravel]	1
7	2.52 – 5.90 in. [small cobble]	1
8	5.90 – 9.84 in. [large cobble]	0
9	9.84 – 157.5 in. [boulder]	0
10	Bedrock	0

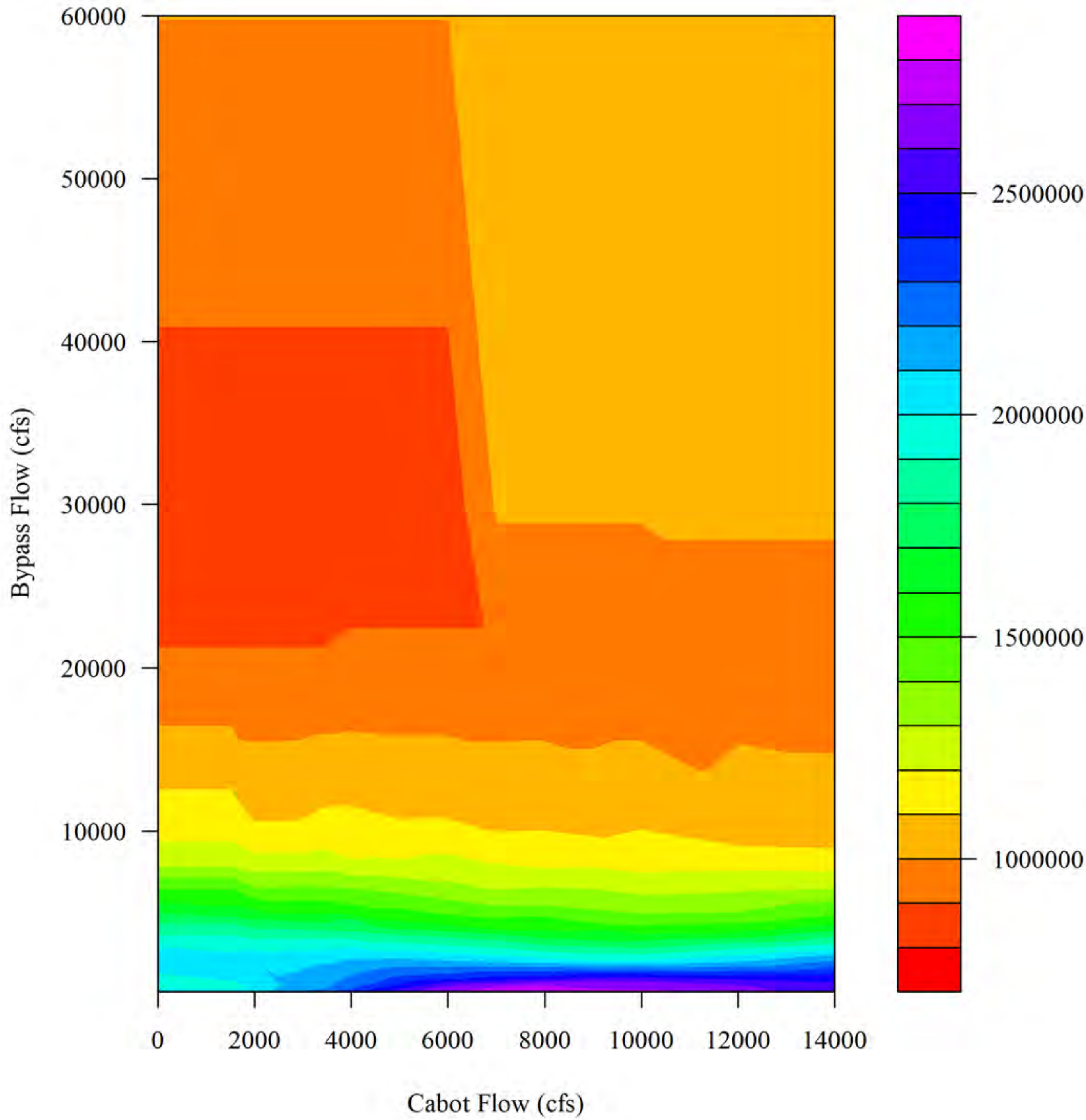

Figure 2.3.1-1: Graphical representation of the amount of WUA in Reach 3 for juvenile Yellow Lampmussel during the June through September period, based on Bypass Reach and Cabot Station Flows.

Note: 4-variable depth, velocity, substrate with shear stress less than 10 dynes/cm^2

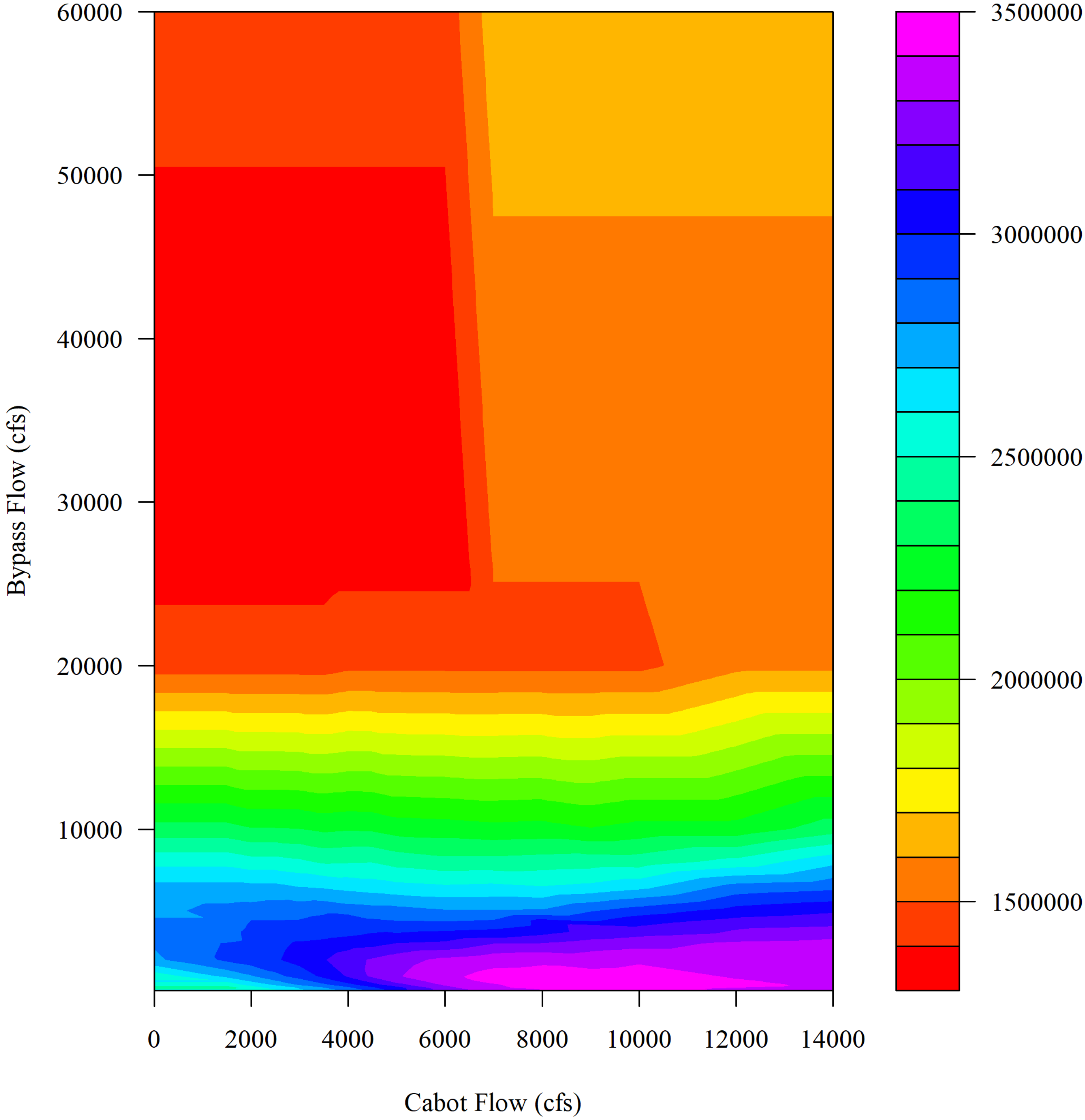

Figure 2.3.1-2: Graphical representation of the amount of WUA in Reach 3 for juvenile Yellow Lampmussel during the 20 months of the cohort-period after the critical settling stage, based on Bypass Reach and Cabot Station Flows.

Note: 4-variable depth, velocity, substrate with shear stress less than 150 dynes/cm^2; WUA scale differs from Figure 2.3.1-1.

2.3.2 Sea Lamprey Spawning

Habitat time series analysis was performed based on flows from the operations model that encompassed the years 1962 through 2003. Flows were converted to habitat using the habitat suitability criteria for Sea Lamprey spawning are shown in Figures 2.3.2-1 (depth), Figure 2.3.2-2 (velocity) and Figure 2.3.2-3 (substrate). The total amount of habitat available at each flow combination is shown in Figure 2.3.2-4. Persistent habitat was analyzed based on a Combined Suitability (SI) ≥ 0.5, which was considered "Quality Habitat" in previous reports.

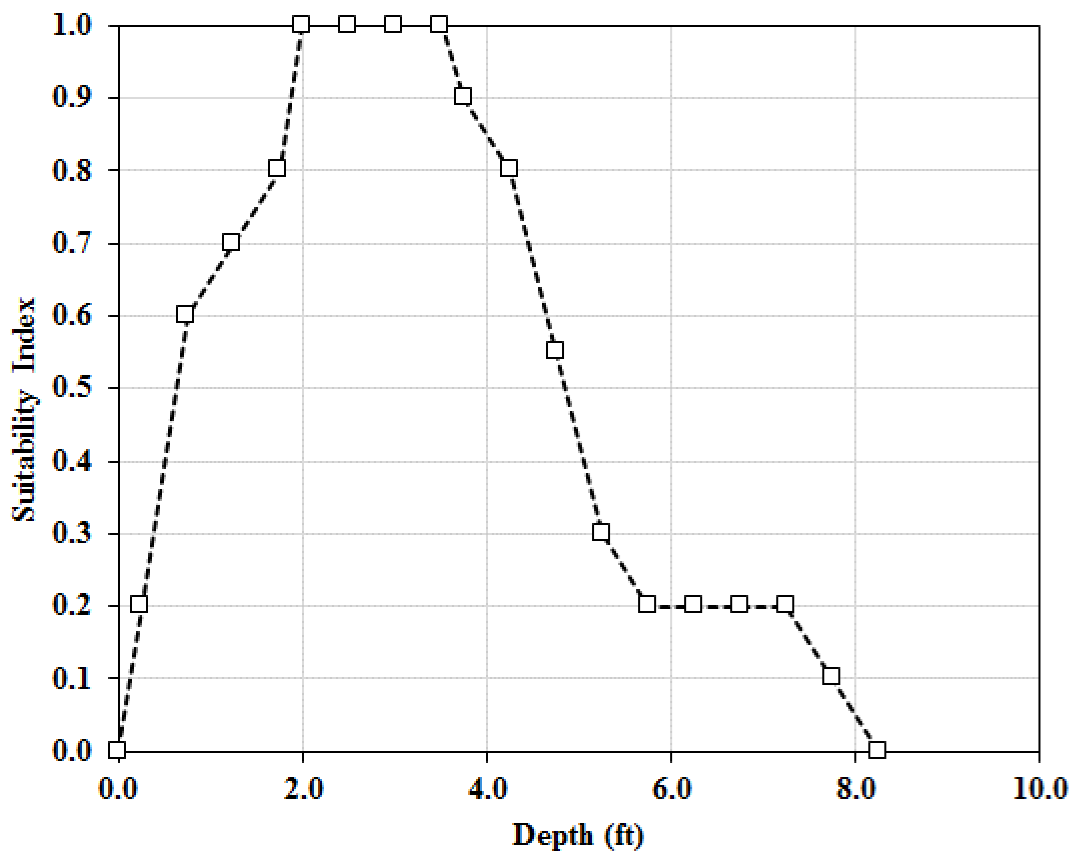

Figure 2.3.2-1: Depth suitability criteria for Sea Lamprey Spawning.

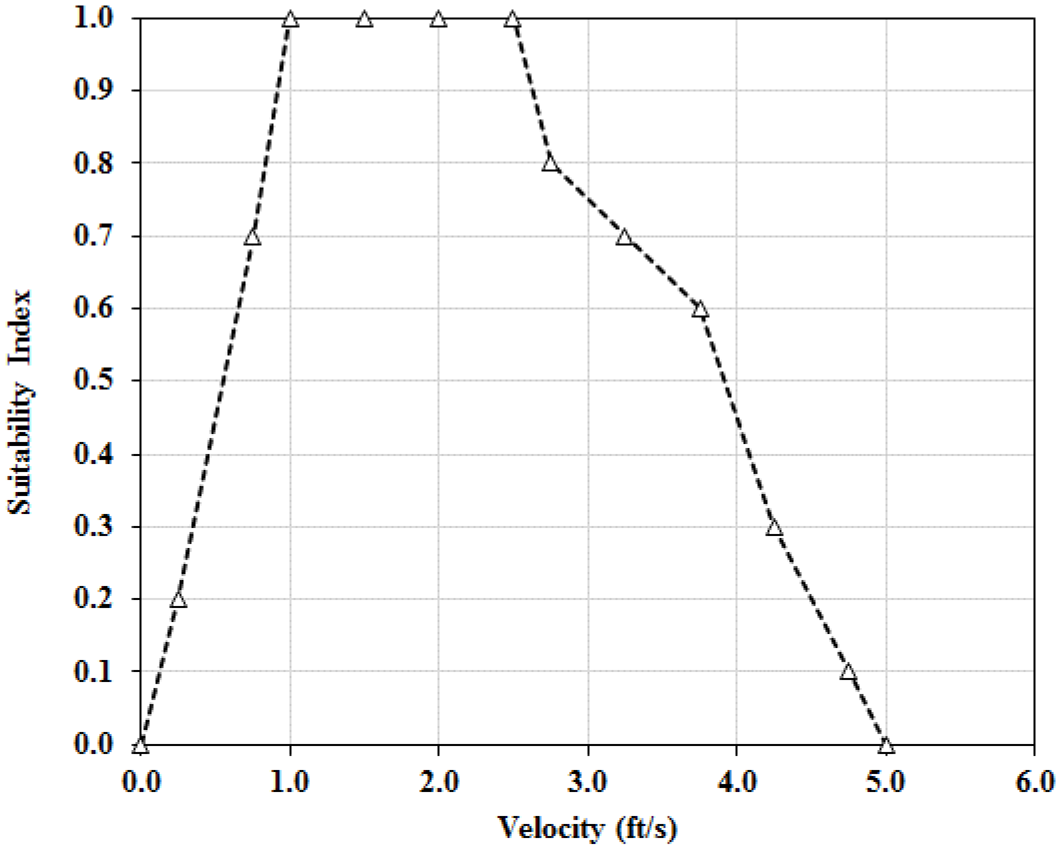

Figure 2.3.2-2: Velocity suitability criteria for Sea Lamprey Spawning.

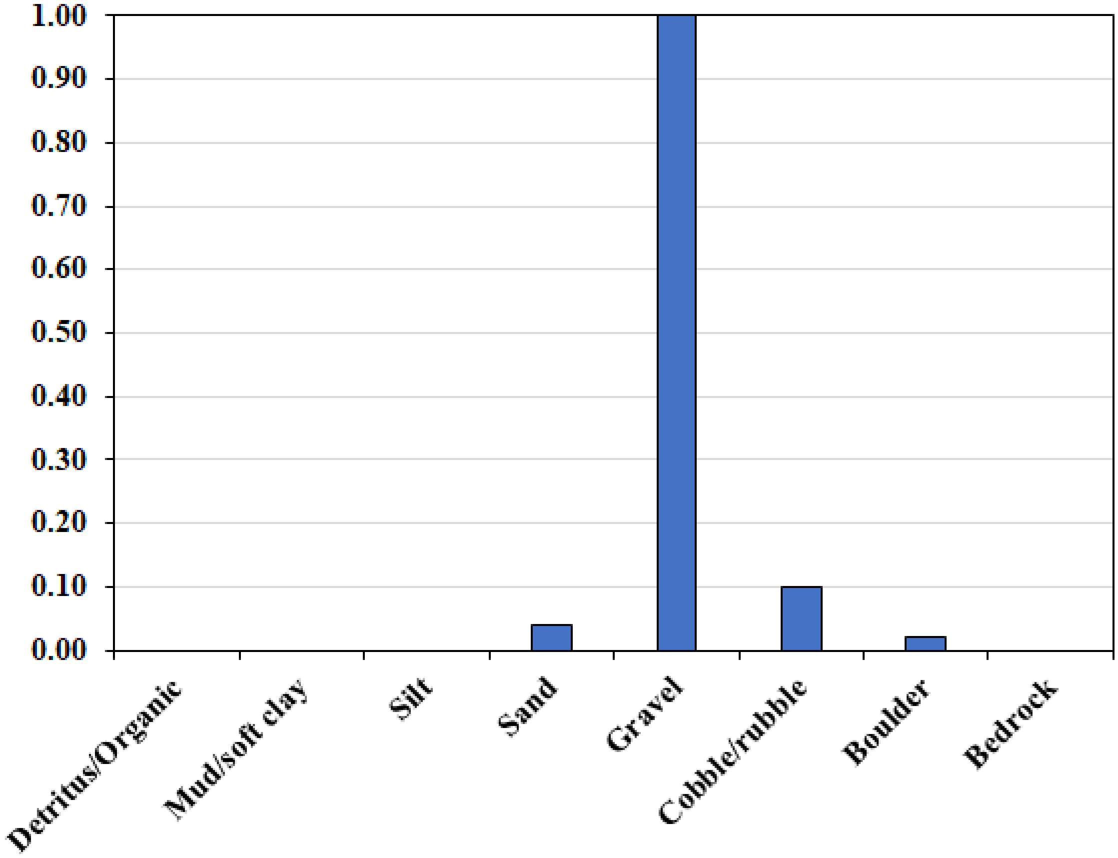

Figure 2.3.2-3: Substrate suitability criteria for Sea Lamprey Spawning.

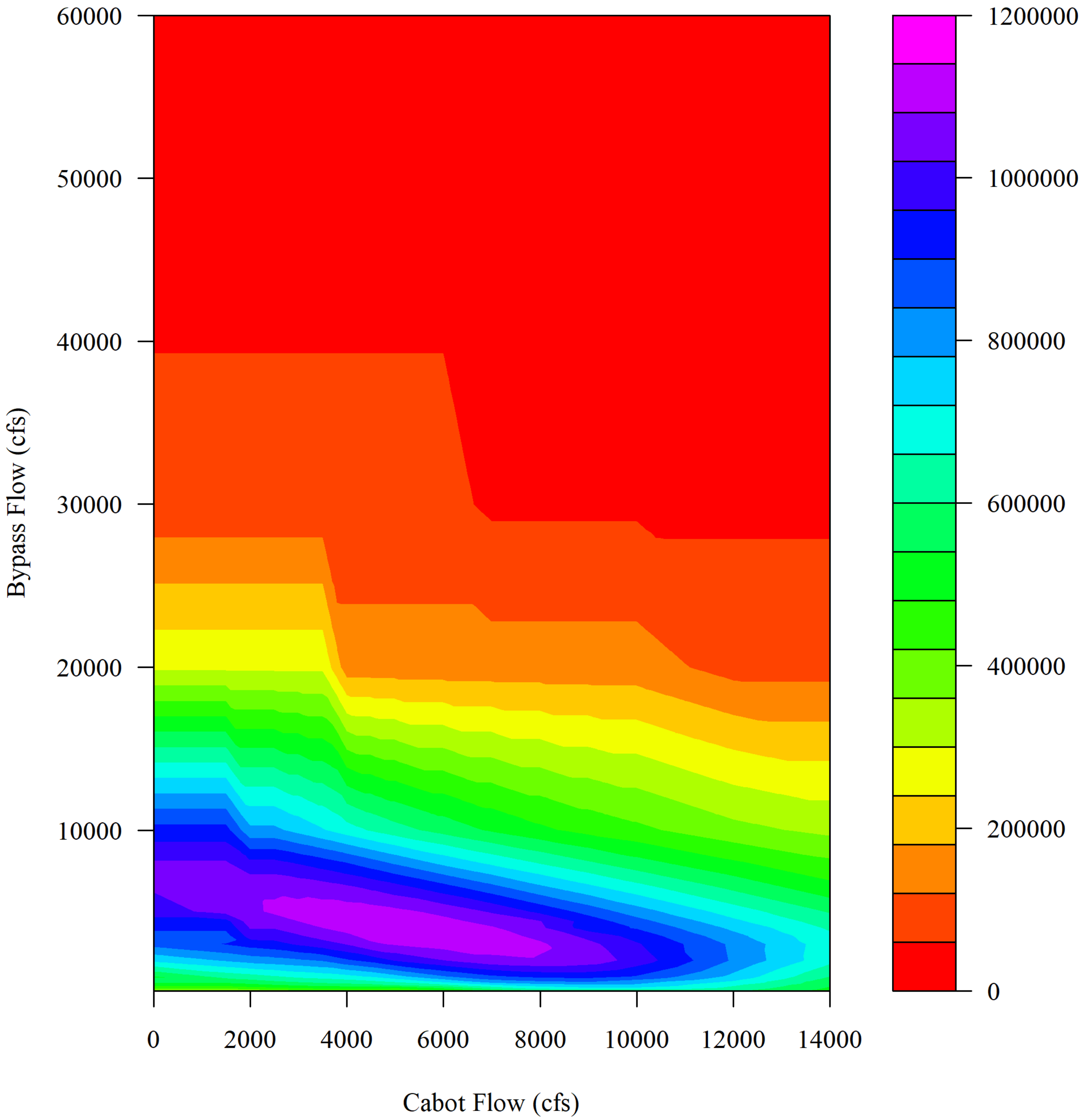

Figure 2.3.2-4: Graphical representation of the amount of WUA in Reach 3 for Sea Lamprey spawning based on Cabot Station and Bypass Reach Flows

3 RESULTS

3.1 Juvenile Yellow Lampmussel

Habitat time series data were developed for 40 2-year juvenile Yellow Lampmussel cohorts using flow time series data from 1962 through 2003 (from the operations model). Spatially, there is a relatively small amount of juvenile Yellow Lampmussel habitat in Reach 3 that persists over the span of a 2-year juvenile mussel cohort (Figure 3.1-1). The mean and median amount of persistent habitat available to any given cohort under baseline conditions was 74,304 and 67,261 ft^2, respectively, with a standard deviation of 24,019 ft^2. For ROR conditions, the mean and median amount of persistent habitat available to any given cohort was 81,706 and 79,994 ft^2, respectively, with a standard deviation of 23,754 ft^2. The total amount of persistent habitat available to each cohort under baseline and ROR conditions is shown in Table 3.1-1 and Table 3.1-2, respectively. For perspective, there is over 9.45 million square feet of modeled area in Reach 3; the mean and median amount of persistent habitat over the span of a cohort during ROR conditions represents only 0.86% and 0.85% of that area, respectively. Overall, though ROR conditions appeared to offer slightly more habitat to juvenile mussels, baseline and ROR conditions provided a similar amount of habitat to cohorts over the span of the time series (Figure 3.1-2)

Two primary locations where habitat was persistent for most or all cohorts included a small area just upstream of Cabot Station, and near the Deerfield River and Connecticut River confluence. Additionally, some small areas near Rock Dam and on river left downstream of the Deerfield River confluence were occasionally suitable for juvenile mussel cohorts.

Multiple regression results indicated that flows at Montague were the primary drivers of the amount of persistent habitat available to juvenile Yellow Lampmussel cohorts in Reach 3; specifically, the maximum flow at Montague observed during the critical summer period, and the median flow at Montague over the span of a cohort. Based on the multiple regression, these variables exhibited a negative logarithmic relationship with persistent habitat area, which was significant ($p < 0.001$) and explained over 88% of the variance (Table 3.1-3). Maximum June through September flows observed during the first year of each cohort were above the Project capacity at Cabot Station (13,728 cfs), and showed a very strong negative effect on mussel habitat (Figure 3.1-3). These flows were highly correlated with the maximum bypass flows during the same period (Figure 3.1-4), which is not surprising since bypass flows would be the primary driver of flows that are above the Project capacity. Additionally, higher median flows over the span of a cohort resulted in less persistent habitat for mussels (Figure 3.1-5); one extreme case was the 1964 cohort, which contained considerably higher amounts of habitat than any other cohort. This cohort spanned the timeframe of June 1964 through May 1966, which was when New England was in the midst of a multi-year drought that reached its driest year in 1965. The 1964 cohort experienced a combination of very low summer flows during its critical settling period, along with low flows over the remaining 20 months after settling.

Table 3.1-1: The amount of persistent habitat modeled for juvenile mussel cohorts in Reach 3 under baseline modeled conditions.

Cohort	Persistent Habitat Area (Square Feet)		Cohort	Persistent Habitat Area (Square Feet)
1962	96,789		1982	69,112
1963	103,124		1983	64,494
1964	180,036		1984	37,850
1965	92,226		1985	83,068
1966	96,530		1986	60,663
1967	64,837		1987	69,975
1968	71,717		1988	93,992
1969	60,838		1989	60,623
1970	98,122		1990	60,395
1971	98,523		1991	64,173
1972	76,584		1992	74,372
1973	37,848		1993	87,924
1974	70,075		1994	90,319
1975	61,325		1995	60,324
1976	38,498		1996	62,475
1977	75,324		1997	60,809
1978	93,188		1998	60,838
1979	60,950		1999	60,367
1980	83,752		2000	60,623
1981	64,087		2001	65,409

Table 3.1-2: The amount of persistent habitat modeled for juvenile mussel cohorts in Reach 3 under ROR modeled conditions.

Cohort	Persistent Habitat Area (Square Feet)		Cohort	Persistent Habitat Area (Square Feet)
1962	101,780		1982	87,187
1963	103,542		1983	69,837
1964	197,194		1984	39,729
1965	96,435		1985	80,711
1966	95,766		1986	81,793
1967	75,955		1987	71,317
1968	79,654		1988	80,334
1969	74,867		1989	80,962
1970	97,264		1990	75,100
1971	93,683		1991	68,387
1972	84,953		1992	78,575
1973	43,312		1993	96,316
1974	87,722		1994	99,680
1975	74,624		1995	65,172
1976	67,004		1996	88,988
1977	81,083		1997	66,351
1978	73,016		1998	65,358
1979	66,766		1999	64,136
1980	97,225		2000	67,105
1981	87,256		2001	62,115

Table 3.1-3: Multiple regression results relating persistent habitat area (log of persistent habitat area in square feet) to the maximum critical stage Montague flow and the median Montague flow for juvenile mussel cohorts in Reach 3 under baseline modeled conditions.

Coefficient	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	17.79893	0.40066	44.424	< 2.00e-16
log(Maximum Cohort Critical Stage Montague Flow)	-0.50507	0.04008	-12.602	5.90e-15
log(Median Cohort Montague Flow)	-0.15346	0.04462	-3.439	0.00146
Residual standard error: 0.09946 on 37 degrees of freedom				
Multiple R-squared: 0.8889, Adjusted R-squared: 0.8829				
F-statistic: 148 on 2 and 37 DF, p-value: < 2.2e-16				

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Figure 3.1-1:
Juvenile Yellow Lampmussel
Persistent Habitat for Cohorts

Legend

Proportion of Years

- 0
- 0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0
- 1.0

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 500 1,000 2,000 Feet

1 inch = 1,000 feet

FirstLight Power Resources

Path: W:\gis\studies\3_3_1\maps\figure_3_1-1_juv_ylm_baseline_vs_ror.mxd

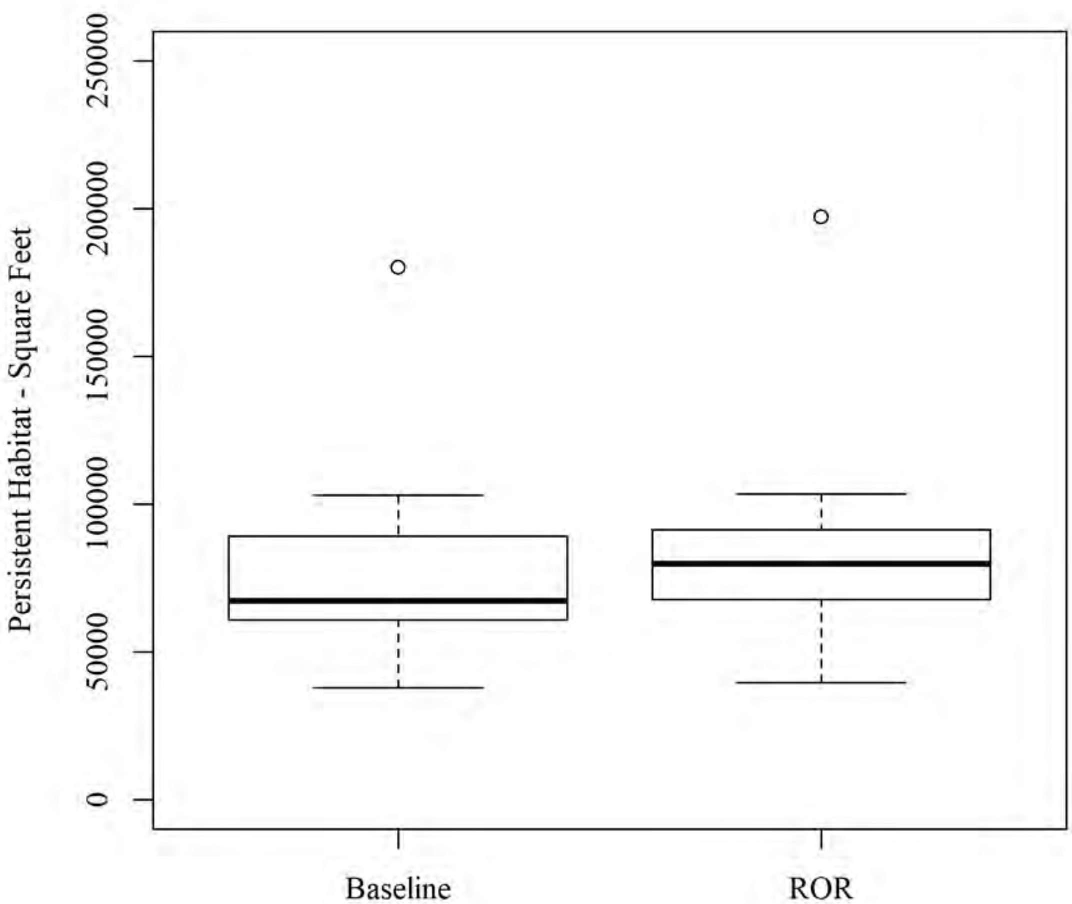

Figure 3.1-2: Distribution of persistent habitat provided to juvenile Yellow Lampmussel cohorts, under baseline and ROR modeled conditions, 1962-2003.

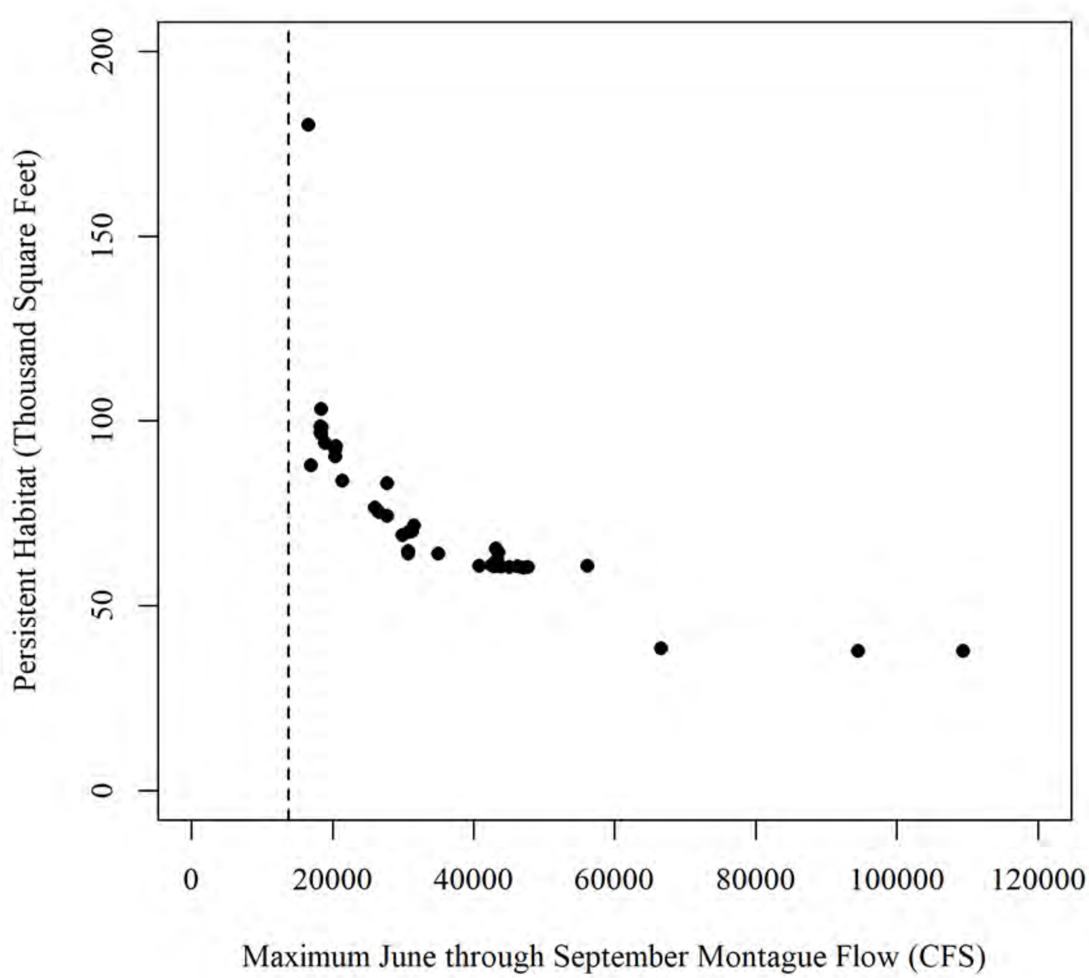

Figure 3.1-3: The amount of persistent habitat modeled for each cohort in relation to the maximum June through September flow at Montague during the first summer of a juvenile Yellow Lampmussel cohort under baseline modeled conditions.

Note: The vertical dashed line is the Cabot Station generation capacity- 13,728 cfs

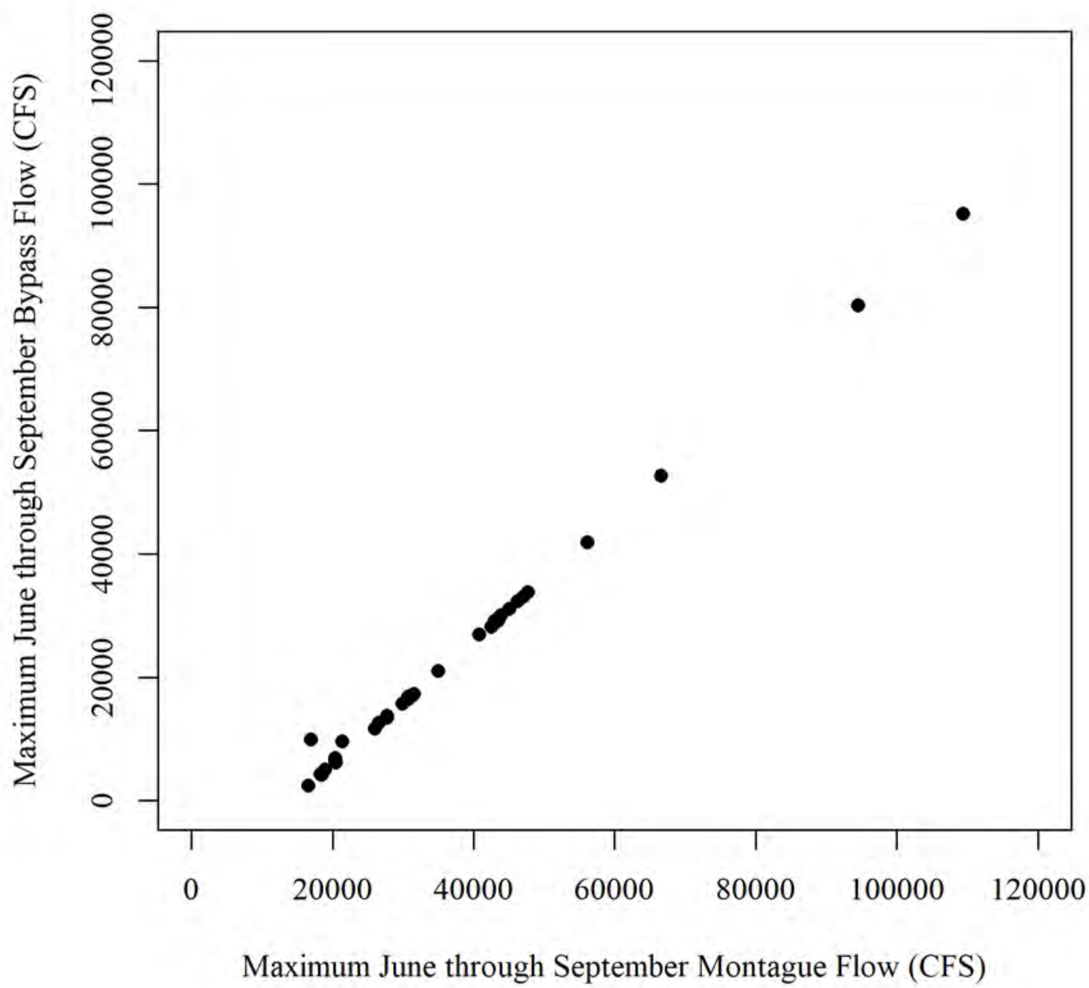

Figure 3.1-4: The maximum June through September bypass reach flow for each cohort in relation to the maximum June through September flow at Montague during the first summer of a juvenile Yellow Lampmussel cohort under baseline modeled conditions.

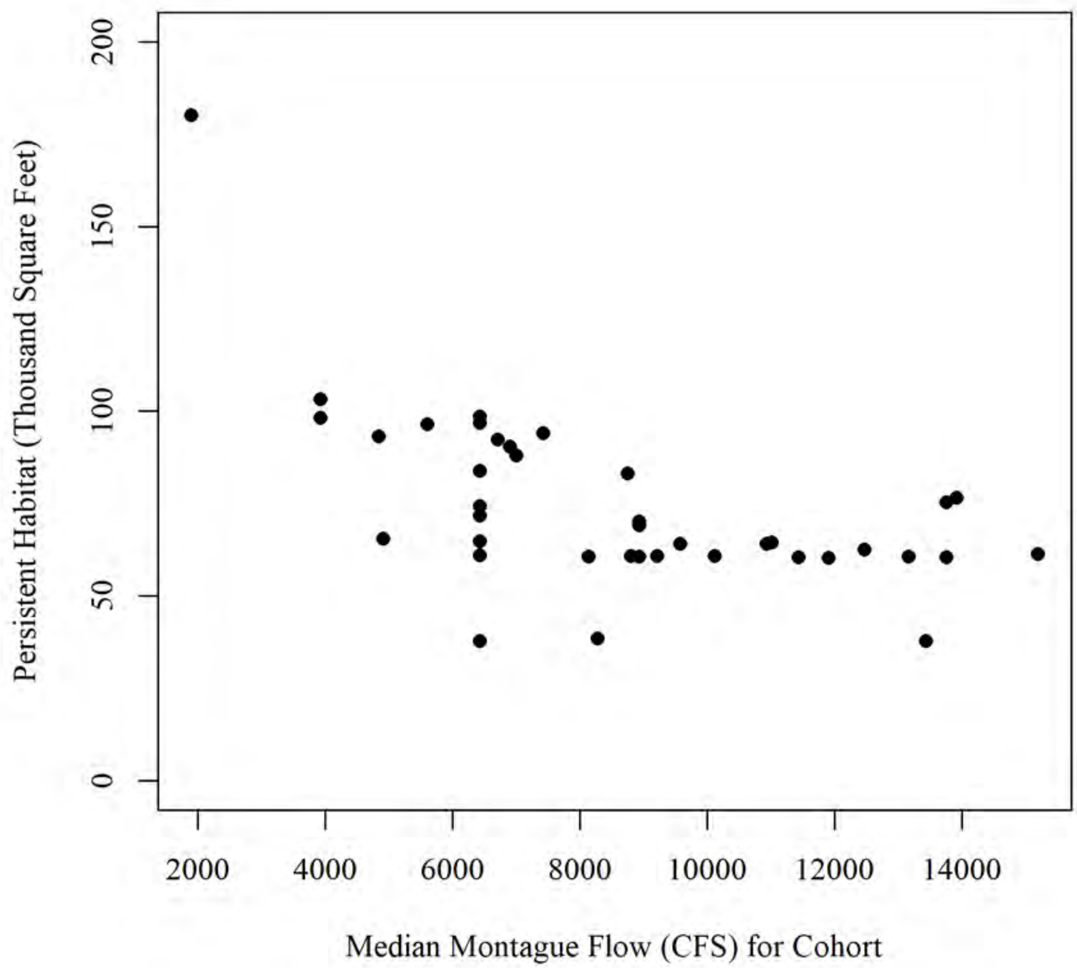

Figure 3.1-5: The amount of persistent habitat modeled for each cohort in relation to the median flow at Montague during the two-year span of a juvenile Yellow Lampmussel cohort under baseline modeled conditions.

3.2 Sea Lamprey Spawning

Very small amounts of persistent habitat for spawning Sea Lamprey were modeled for all spawning seasons between 1962 and 2003 for both the baseline and ROR modeled conditions. During most years, there was no persistent habitat available in Reach 3. There was only one year that provided a small amount of persistent suitable quality habitat under baseline conditions (Table 3.2-1), and six years when it was provided under ROR conditions (Table 3.2-2). However, the overall amount of persistent suitable habitat was very low for both scenarios. When persistent habitat was present, it was only found in small areas within the right channel near Rawson Island (Figure 3.2-1). Because most years contained no persistent suitable spawning habitat for Sea Lamprey, a regression analysis was not performed.

Table 3.2-1: The amount of persistent habitat modeled for juvenile mussel cohorts in Reach 3 at Combined Suitability (SI) ≥ 0.5 (Quality Habitat) under baseline modeled conditions.

Cohort	Persistent Habitat Area (Square Feet)		Cohort	Persistent Habitat Area (Square Feet)
1962	0		1983	0
1963	0		1984	0
1964	0		1985	0
1965	0		1986	0
1966	0		1987	0
1967	0		1988	0
1968	0		1989	0
1969	0		1990	0
1970	0		1991	972
1971	0		1992	0
1972	0		1993	0
1973	0		1994	0
1974	0		1995	0
1975	0		1996	0
1976	0		1997	0
1977	0		1998	0
1978	0		1999	0
1979	0		2000	0
1980	0		2001	0
1981	0		2002	0
1982	0		2003	0

Table 3.2-2: The amount of persistent habitat modeled for juvenile mussel cohorts in Reach 3 at Combined Suitability (SI) ≥ 0.5 (Quality Habitat) under ROR modeled conditions.

Cohort	Persistent Habitat Area (Square Feet)		Cohort	Persistent Habitat Area (Square Feet)
1962	972		1983	0
1963	0		1984	0
1964	0		1985	0
1965	0		1986	0
1966	0		1987	0
1967	0		1988	0
1968	0		1989	0
1969	0		1990	0
1970	0		1991	2,913
1971	0		1992	0
1972	0		1993	2,913
1973	0		1994	0
1974	0		1995	2,913
1975	0		1996	0
1976	0		1997	0
1977	2,913		1998	0
1978	0		1999	0
1979	0		2000	0
1980	2,913		2001	0
1981	0		2002	0
1982	0		2003	0

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

RELICENSING STUDY 3.3.1

Figure 3.2-1:
Sea Lamprey Spawning
Persistent Habitat for Cohorts

Legend

Proportion of Years

- 0
- 0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0
- 1.0

N

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 500 1,000 2,000 Feet

1 inch = 1,000 feet

FirstLight Power Resources

Path: W:\gis\studies\3_3_1\maps\figure_3_2-1_sea_lamprey_baseline_vs_ror.mxd

4 DISCUSSION

4.1 Juvenile Yellow Lampmussel

The primary driver of juvenile Yellow Lampmussel habitat within the reach are flows that are beyond the control of the Turners Falls Project. High bypass flows that result in high flows at Montague have a substantial effect on habitat within the reach, especially if these flows occur during the critical months of the first June through September period within each cohort. In general, high-flow years that also include high flow events during the critical settling stage of a cohort would be predicted to yield the lowest amounts of persistent suitable habitat. Habitat within the reach is constrained initially by the availability of suitable substrate in many areas, and at high flows, many areas would contain benthic velocities that are too high for juvenile Yellow Lampmussels. Additionally, many areas that exhibit suitable velocities and substrates at high flow rates would not remain at lower flows. Alternatively, drought years, combined with the lack of high flow events during the juvenile Yellow Lampmussel's settling season, would provide the greatest amounts of habitat for this species and life stage.

Though relatively large amounts of habitat would typically be available during any given flow combination, habitat shifts occur among the many various flow combinations in the reach. This pattern was evident for both the baseline and ROR modeled conditions; as such, providing ROR conditions is not expected to noticeably increase the amount of persistent habitat available to juvenile Yellow Lampmussel cohorts. In general, even for cohorts with the highest amount of persistent habitat, only small patches of persistent habitat exist within the reach under either flow scenario. This corroborates the findings of the mussel surveys completed in the reach, which have not found live Yellow Lampmussels. The occasional Yellow Lampmussel may be able to colonize habitat within the reach, but it would be a very rare occurrence for a suitable host fish to transport glochidia from locations where adult Yellow Lampmussels have been recently documented, many miles downstream in Reach 5, and for the glochidia to then release themselves to settle into areas with suitable persistent habitat in Reach 3.

4.2 Sea Lamprey Spawning

Though some habitat appears to be suitable during various flow conditions within Reach 3, habitat shifts with flow result in small amounts of persistent habitat over the span of a spawning season. Habitat time series analysis and mapping suggests that Reach 3 lacks persistent spawning habitat for Sea Lamprey during most years. This is consistent with the results of radio telemetry studies that tracked Sea Lamprey further upstream and into tributaries, but none were observed stopping to build redds in Reach 3 (see Relicensing Study Report for Study 3.3.15 - *Assessment of Adult Sea Lamprey Spawning within the Turners Falls Project and Northfield Mountain Project Area* – June 2016). Providing ROR conditions is not anticipated to noticeably improve the amount of persistent habitat available for Sea Lamprey spawning cohorts.