GREAT RIVER HYDRO, LLC

ILP Study 18
American Eel Upstream Passage Assessment

Supplement #3 to Study Report

In support of Federal Energy Regulatory Commission Relicensing of:

Wilder Hydroelectric Project (FERC Project No. 1892-026)
Bellows Falls Hydroelectric Project (FERC Project No. 1855-045)
Vernon Hydroelectric Project (FERC Project No. 1904-073)

Prepared for

Great River Hydro, LLC
One Harbour Place, Suite 330
Portsmouth, NH 03801

Prepared by

Normandeau Associates, Inc.
25 Nashua Road
Bedford, NH 03110

March 26, 2019

[This page intentionally left blank.]

TABLE OF CONTENTS

List of Figures

List of Tables

List of Abbreviations

°C	Degrees Celsius
CFS	cubic feet per second
FERC	Federal Energy Regulatory Commission
FWS	U.S. Department of the Interior – Fish and Wildlife Service
GPM	Gallons per minute
GRH	Great River Hydro, LLC
ILP	Integrated Licensing Process
In	Inches
NHFGD	New Hampshire Fish and Game Department
PVC	Polyvinyl chloride
RSP	Revised Study Plan
TransCanada	TransCanada Hydro Northeast Inc.
USGS	United States Geological Survey
VANR	Vermont Agency of Natural Resources
VFWD	Vermont Fish & Wildlife Department
VY	Vermont Yankee Nuclear Power Plant

[This page intentionally left blank.]

1.0 INTRODUCTION

This document provides supplemental results from observations made during 2018 as part of the American Eel Upstream Passage Assessment (ILP Study 18) conducted originally in 2015 (Normandeau, 2016a) and supplemented during 2016 and 2017 (Normandeau, 2016b; Normandeau, 2018) in support of Federal Energy Regulatory Commission (FERC) relicensing for the Wilder Hydroelectric Project (FERC Project No. 1892), Bellows Falls Hydroelectric Project (FERC No. 1855), and Vernon Hydroelectric Project (FERC No. 1904). Weekly visual surveys along with fish ladder passage monitoring performed during 2015 suggested that few eels were present at Vernon relative to downstream dams. The most evident aggregation point identified in 2015 was the Vernon fish ladder. During 2016 a temporary eel ramp trap was constructed and installed adjacent to the fish ladder entrance and weekly visual surveys were conducted. However, the 2016 surveys did not begin until late July and the ramp trap operation did not begin until early September. Likely due to the timing of 2016 sampling, no substantial aggregations were documented and only one eel was collected in the ramp trap. In 2017 weekly visual surveys were conducted and the eel ramp trap was installed and operated from June 1 through early November. Observations during the weekly visual surveys were similar to previous years and the ramp trap collected a total of 123 juvenile eels.

Great River Hydro, LLC (GRH) completed several modifications to the upstream fish ladder at Vernon both prior to and during the 2018 American Eel upstream passage season with the goals of improving the accuracy of counting eels via the fish passage video monitoring system and improving the potential for eels to ascend the upper fish ladder to exit upstream. The initial set of proposed modifications were presented and discussed at the March 8, 2018 ILP Study Report Meeting. Prior to the opening of the upstream fishway on May 14, GRH made the following modifications:

Downstream entrance to Regulation Pool: (Figure 1.0-1)

- Plywood barrier fully covering vertical screen.

Floor grates of counting window: (Figure 1.0-2)

- Covered with plastic mesh (4mm opening) to keep eels from swimming under grating where not observed by motion activated camera.
- Installed outdoor carpet-like material on wall directly upstream and downstream of window to prevent lampreys from attaching to wall and affecting video counting software.
- Approximately ¼ of distance from the downstream end of the counting window floor, installed an approximately 12” wide x 8” high speed bump, perpendicular to window surface and extending across entire floor to act as a physical directional guidance feature to encourage eels traveling along the floor to more reliably enter the video camera/counting software field of view. Speed bump covered with outdoor carpet-like material.

Upstream entrance to Regulation Pool:

- Plywood barrier to partially cover vertical screen – leaving approximately 3 feet open above to pass up to 35 cfs into regulating pool.
- Attached 2-foot horizontal plywood shelf to top of partial wall for full width of the wall, and along sidewalls to discourage eels from tracking along the sidewalls above the horizontal shelf and entering the regulation pool.
- Painted upper shelf white.
- Attached LED light bars to illuminate the overflow area above the horizontal shelf and set to light from dusk to dawn. Lighting the area, together with white painted surface of horizontal lip may aid in discouraging eels from entering regulation pool via overflow. Lighting adjusted to be limited to the horizontal surface and not the general fish ladder area upstream of partial barrier wall.

Diffuser:

- Covered with plastic mesh (4mm opening) to create a flow-through eel barrier to the make-up water chamber below the fish ladder floor.

Exit Weir: (Figures 1.0-3 and 1.0-4)

- Modified exit weir to include a full-width 9” high orifice at the base of the fish ladder floor.
- Added a Berry and Escott eel tile through the orifice extending approximately 1/3 on the upstream side of orifice and 2/3 on downstream side to improve the ability for various eel sizes to navigate through the orifice velocity.
- Installed an upright baffle, perpendicular to the floor approximately the same height as the height of orifice and about 9-12” upstream of the orifice to modulate velocity over the eel tile.

Attach eel tiles for trial: (Figure 1.0-5)

- First weir downstream of the counting window, installed an eel tile in the orifice approximately 1/3 on the upstream side and 2/3 on downstream side to serve as a trial to see how the material handles river debris and to determine maintenance or cleaning requirement.
- First opening in serpentine section upstream of the counting window, installed an eel tile in the floor approximately 1/3 on the upstream side and 2/3 on downstream side to serve as a trial to see how the material handles river debris and to determine maintenance or cleaning requirement.

Pressure transducer replacement:

- Metritape depth sensing equipment for monitoring regulating pool depth was replaced with a pressure transducer tied into SCADA.
- Elevation monitoring devices in tailrace and fish ladder entrance replaced with upgraded pressure transducers. Tailrace transducer moved to just outside fish ladder entrance. Both tied to SCADA.

Observations made during the shad passage season indicated that juvenile eels had gained access under the grates of the counting window which had been initially covered with the 4mm plastic mesh intended to exclude them. Entrance of individuals into the closed off area reduced the ability to collect accurate passage count data. Following consultation with the resource agencies, mesh over the floor grates of the counting window was initially cut (June 1) and then fully removed by a diver (June 11). The similar plastic mesh covering the diffuser was evaluated with an underwater camera on June 21. Large openings in the mesh were found where it had been affixed to the floor.

At the completion of the shad passage season, the fishway was dewatered for four days (July 24-27) and the following modifications were made:

- Counting room floor grates covered with plywood,
- All visible cracks sealed with underwater sealant (e.g., floor of counting room, regulating pool walls, etc.),
- Diffuser mesh covering replaced with aluminum dewatering screen (Figure 1.0-6).

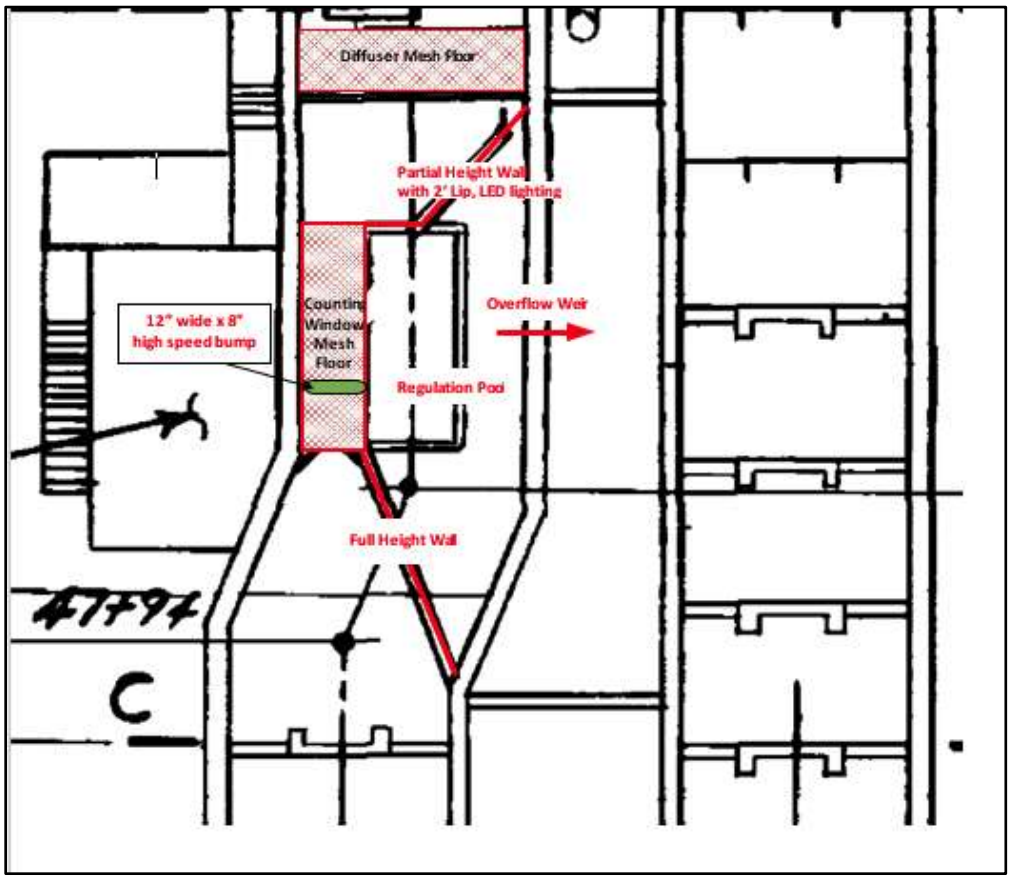

Figure 1.0-1. Overview of modifications made to fish ladder in the area of the counting window.

Figure 1.0-2. Counting window floor covered in plastic mesh and speed bump installed.

Figure 1.0-3. Exit Weir looking downstream with eel tile and upstream baffle.

Figure 1.0-4. Exit Weir from above with eel tile and before upstream baffle installed.

Figure 1.0-5. Eel tile placement in serpentine section upstream of the counting window.

Figure 1.0-6. Aluminum dewatering screen on diffuser room floor.

2.0 STUDY GOALS AND OBJECTIVES

As stated in the Revised Study Plan (RSP), the goal of Study 18 was to provide baseline data on the presence of American Eels attempting to move upstream of the Wilder, Bellows Falls, and Vernon projects and the locations where they congregate while attempting upstream passage. The goal of the 2018 supplemental effort was to collect information on upstream migrating eels at Vernon throughout the migration season and during a period when the Vernon fish ladder was operating. Specifically, the 2018 supplemental effort was intended to:

- conduct systematic surveys of eel presence/abundance at Vernon tailrace and spillway locations (including within the fish ladder following eel-specific modifications) in order to identify areas of concentration of eels staging in pools or attempting to ascend wetted structures.

Visual survey methodology employed during the 2018 study was based on the approach and techniques developed and utilized during the 2015, 2016 and 2017 studies.

3.0 METHODS

3.1 Visual Surveys

Nighttime visual surveys were conducted weekly by Normandeau personnel on foot or from a boat downstream of Vernon dam. Weekly surveys were initiated on June 7, 2018 and continued through November 1, 2018. Visual surveys began at least one-half hour after sunset, and complete surveys took approximately 1 to 2 hours. Survey site locations were similar to those observed during 2015-2017. The study design included survey sites in areas where eels were likely to congregate (e.g., fishway, relatively quiescent areas with leakage flows) below the dam. However, the overall survey was designed to systematically observe virtually all of the downstream face of the dam as well as specific leakage flow areas, the fish ladder when in operation, fish ladder entrance, and a riprapped area downstream of the fishway entrance (Table 3.1-1). Certain locations could not be accessed under specific conditions for safety reasons (e.g., below spill gates during spilling conditions) and were omitted from surveys when necessary. During 2018 the trash/ice sluice was examined as conditions permitted. Survey effort was expended at the upstream end of the trash/ice sluice (site 17; see Figure 4.1.1 for site locations) on dates when an eel aggregation was observed at the base of the sluice (site 12). The tailrace (site 16) was surveyed as operational conditions allowed.

Data collected included date and time of survey, general notes on weather conditions, moon phase, and any pertinent operational conditions that limited observations (e.g., open spill gates), survey site, time of observation, presence / absence of eels, and when present, estimated number, and length class distribution. Visually estimated lengths of eels observed were assigned to one of four classifications: <6 inches, 6-12 inches, 12-18 inches, and >18 inches.

Table 3.1-1. American Eel upstream passage visual survey site locations evaluated during 2018 at Vernon Dam.

Site No.	Description
18-V-01-s	Taintor Gate 1 (large), apron, and bedrock
18-V-02-s	Taintor Gate 2 (large), apron, and bedrock
18-V-03-s	Stanchion Bay 1, apron, and bedrock
18-V-04-s	Stanchion Bay 2, apron, and bedrock
18-V-05-s	Stanchion Bay 3, apron, and bedrock
18-V-06-s	Hydraulic Floodgate Bay, apron, and bedrock
18-V-07-s	Hydraulic Panel Bay and apron
18-V-08-s	Taintor Gate 3 (small) and apron
18-V-09-s	Taintor Gate 4 (small) and apron
18-V-10-s	Taintor Gate 5 (small) and apron
18-V-11-s	Taintor Gate 6 (small) and apron
18-V-12-s	Trash Sluice outfall area
18-V-13-s	Fishway entrance

Site No.	Description
18-V-14-s	Riprap bank at downstream bend of fishway
18-V-15-s	Fishway
18-V-16-s	Tailrace / unit discharge interface
18-V-17-s	Top of sluice (if justified by aggregation at bottom)

3.2 Environmental and Operations Data

Vernon dam operational discharge data were provided by GRH. Water temperature and dissolved oxygen point samples were recorded weekly from June 7 – November 1, 2018 during the weekly nighttime visual surveys. Daily percent lunar illumination data were obtained from the U.S. Naval Observatory[1].

4.0 RESULTS

4.1 Visual Surveys

Over the 22 weeks of visual surveys conducted from June 7, 2018 through November 1, 2018, 221 eels were observed at Vernon dam (Table 4.1-1, Figure 4.1-1). The greatest number of eels observed in a single survey was 42 on June 13. Eels were observed at 11 of the 17 survey sites. The greatest number of eel observations (summed for all surveys) were recorded in the fishway (site 15, N = 135, 61.1% of total), the apron of Taintor gate 2 and the bedrock below it (site 02, N = 16, 7.2%); the apron of Stanchion Bay 1 and the bedrock below it (site 03, N = 16, 7.2%); and the apron of Taintor Gate 3 and the submerged flood gate below it (where most of the count was observed, site 08, N = 15, 6.8%, Table 4.1-1). Observations of eels within the fishway were limited to two locations; (1) the visitor's viewing window, located at a large turn-pool in the fish ladder, or (2) the counting room window. At the visitor's window, eels were observed to be actively swimming, but frequently appeared to be circling in the large turn pool. In the counting room window, eels usually appeared traveling upstream at the bottom of the water column and "falling back" or traveling downstream mid water column. Although both windows were visited during each survey, observations were more readily made at the counting room window where eels are guided towards the glass. Recorded numbers of eel observed in the fishway represent a "snap shot" and count numbers presented in this report should be considered as an approximate number of individuals visible at the viewing windows at the time of survey.

Generally, eels were observed at three distinct areas: the fishway (site 15), an area in the vicinity of the submerged flood gates below four Taintor gates and one of the hydraulic panels (sites 07–11), and in the bedrock outcrop below the taintor gates and stanchion bays (sites 01–04). After the fishway, eels were most frequently observed in the submerged flood gates, where 46 eels were observed collectively (21% of the total). As noted during the 2015-2017 surveys, field staff felt that eels

[1] http://aa.usno.navy.mil/data/docs/MoonFraction.php

observed in that location did not appear to be seeking flow or otherwise actively migrating at the time of observation, but instead appeared to be seeking refuge in the submerged structures. Overall, 40 eels (18% of the total) were observed in the bedrock outcrop (i.e., sites 01-04) and because the area was characterized by rivulets of running water and an increase in elevation, those eels appeared to be actively migrating (Figure 4.1-2).

4.1.1 Fishway Dewatering Observation

During the 2018 upstream passage season which was initiated on May 14 and concluded on October 15 when the fishway was dewatered, a negative net count of 6,251 eels was estimated using the Vernon fishway as part of VANR's Vernon fish passage monitoring[2]. Observations made during the October 15, 2018 dewatering (by J. Griffin, Great River Hydro) demonstrated a relatively low number of eels using or residing in the facility. American Eels as well as other resident fish species were removed from the fishway during the dewatering process and were later relocated (Figure 4.1-3).

[2] Source: Personal communication – Lael Will (Vermont Agency of Natural Resources). Email dated December 17, 2018.

Table 4.1-1. Number of eels observed during nighttime visual surveys by site location and date, 2018[a].

Date	Site Number[b]																	Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15[c]	16	17[d]	
6/7	0	4	0	0	0	0	0	0	0	0	0	0	0	0	12		N/A	16
6/13	0	0	0	0	0	0	9	6	4	5	0	0	0	0	18	0	N/A	42
6/20	0	0	0	0	0	0	0	0	1	1	0	0	0	0	27	0	N/A	29
6/27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13		N/A	13
7/5	0	2	0	1	0	0	1	5	4	2	0	0		0	9		N/A	24
7/11	0	1	0	2	0	0	1	2	1	0	0	0			3		N/A	10
7/18	0	1	4	1	0	0	0	0	1	0	0	0	0	0	12	0	N/A	19
7/24	0	8	1	0	0	0	0	0	0	0	0	0	0	0	N/A		N/A	9
8/2	3	0	2	0	0	0	0	0	0	0	0	0	0	0	8	0	N/A	13
8/8	1	0	8	0	0	0	0	1	0	0	0	0		0	14		N/A	24
8/15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10		N/A	10
8/22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		N/A	0
8/28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2		N/A	2
9/5	0	0	1	0	0	0	0	1	0	0	0	0	0	0	6		N/A	8
9/12	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		N/A	1
9/18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		N/A	0
9/25	0	0	0	0	0	0	0	0	0	0	0	0		0	0		N/A	0
10/3	0	0	0	0	0	0	0	0	0	0	0	0			1		N/A	1
10/11	0	0	0	0	0	0	0	0	0	0	0	0		0	0		N/A	0
10/18	0	0	0	0	0	0	0	0	0	0	0	0		0	N/A		N/A	0
10/25	0	0	0	0	0	0	0	0	0	0	0		0	0	N/A			0
11/1	0	0	0	0	0	0	0	0	0	0	0		0	0	N/A			0
Total by Site	**4**	**16**	**16**	**4**	**0**	**0**	**11**	**15**	**11**	**8**	**1**	**0**	**0**	**0**	**135**	**0**	**0**	**221**

a. Survey site numbers can be referenced to site numbers in Figure 4.1-1.

b. Sites not visited during a given date due to safety concerns are marked by shaded cells.

c. Site 15 (fish ladder) not surveyed July 24 or after October 15 when the fish ladder was dewatered.

d. Site 17 (upper end ice/waste sluice) not surveyed due to lack of aggregations at Site 12.

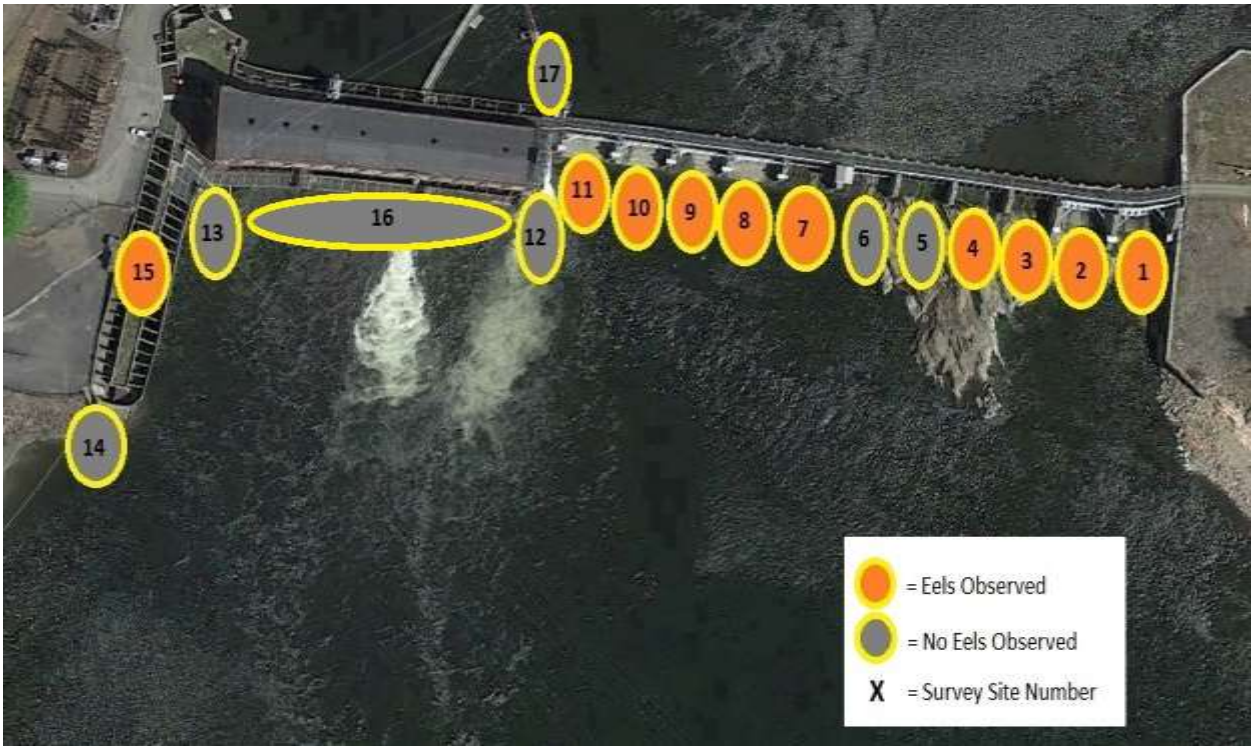

Figure 4.1-1. Vernon nighttime visual survey sites, 2018.

Figure 4.1-2. American Eels attempting to assend wetted substrates at bedrock outcrop sites 1 (left panel) and 3 (right panel) on August 2, 2018.

Figure 4.1-2. American Eels and other resident fish species removed from the Vernon fishway during the October 15, 2018 end of season dewatering.

4.2 Length Distribution of Eels Observed in Visual Surveys

Eels classified in the 6-12 inch and 12-18 inch size group were the most abundant during the 2018 visual nighttime surveys, representing 48% and 46% of the total number observed, respectively (Table 4.2-1, Figure 4.2-1). Eight eels (3.6%) were classified in the smallest group (i.e., <6 inches) and five eels (2.3%) were classified in the largest group (i.e., >18 inches). The length classification of eels <6 inches was verified by both biologists conducting the survey. At the fishway (15) and flood gate (sites 07-11) survey sites, the majority of eels observed fell within the 12-18 inch size class. At the bedrock outcrop downstream of the tainter and stanchion bays (sites 01-04), the majority of eels were within the 6-12 inch size class. All five of the eels greater than 18 inches were observed in the fishway. Eels in the <6 inch and 6-12 inch length groups were viewed actively moving up the bedrock immediately below Tainter Gate 1 (site 01) and Stanchion Bay 1 (site 03) on the New Hampshire side of the dam.

Table 4.2-1. Length classified counts of eels observed by survey site during nighttime visual surveys, 2018.

		Fishway	Flood Gates Below Tainter Gates & Hydraulic Panels					Rocks Below Taintor & Stanchion Bays				Total
Site number:		**15**	**11**	**10**	**9**	**8**	**7**	**4**	**3**	**2**	**1**	
Size Class (in.)	< 6	2	0	0	1	0	0	0	0	2	3	8
	6 - 12	57	0	2	5	6	2	4	15	14	1	106
	12 -18	71	1	6	5	9	9	0	1	0	0	102
	> 18	5	0	0	0	0	0	0	0	0	0	5
Total		**135**	**46**					**40**				**221**

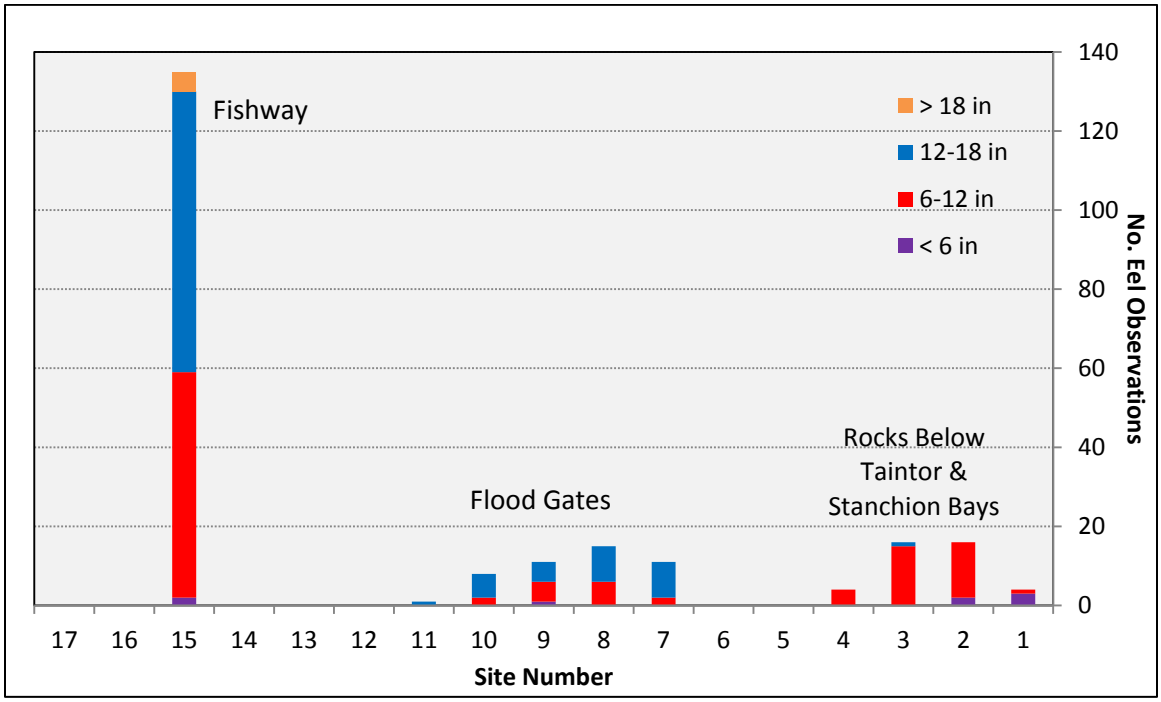

Figure 4.2-1. Length classified counts of eels observed by survey site during nighttime visual surveys, June 7 – November 1, 2018.

4.3 Environmental Conditions

The majority (95%) of eels observed during the weekly visual surveys conducted in 2018 occurred between early-June and mid-August (Table 4.1-1). Approximately 50% of all eel observations occurred over the first five weeks of the study (i.e., June 7-July 5). With the exception of a single individual, all eels were observed when water temperatures were greater than 20^{0}C, with 43% (94 of 221) occurring on survey dates where water temperature was above 25^{0}C (Figure 4.3-1). Dissolved oxygen quality (as measured on each survey date) remained good throughout the study period (Figure 4.3-1).

In 2018, local precipitation was above the 10-year monthly average for June through September and was about average during October (Table 4.3-1). In general, the 2018 season was characterized by relatively low and variable river flows. Spill events at Vernon during the 2018 eel upstream passage season were limited to two periods (1) 1300 on August 5 to 1600 on August 6 and (2) 1600 on October 12 to 0600 on October 13.

Lunar illumination has been suggested as a potential covariate with hydraulic conditions influencing upstream eel migration. Low light conditions are thought to promote eel movement, but even with higher levels of lunar illumination, low light conditions can persist from a variety of factors such as increased cloud cover and turbidity (Welsh and Liller, 2013). At Vernon, eel observations during 2018 were distributed across all moon phases.

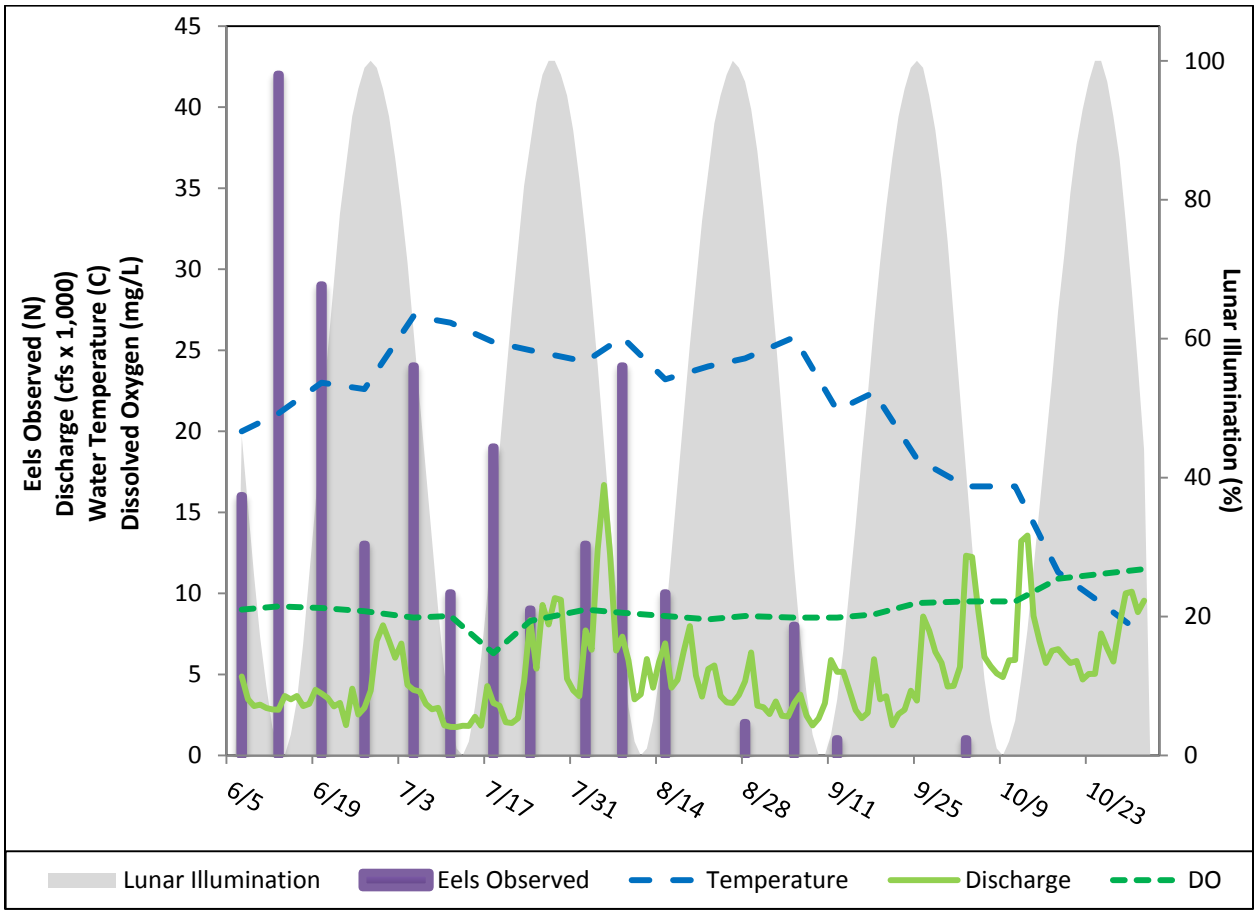

Figure 4.3-1. Number of eels observed in visual surveys (June 7 – November 1, 2018) with water temperature, dissolved oxygen, lunar illumination, and total discharge.

Table 4.3-1. Monthly cumulative precipitation (inches) at Vernon during June – October 2018 and 10-year average.

	Jun	Jul	Aug	Sep	Oct
2018	4.17	5.67	7.84	6.36	3.36
10 YR Avg. (inches)	3.16	4.90	4.22	4.00	3.43
% of 10 YR Avg.	132	116	186	159	98

5.0 STUDY CONCLUSIONS

Systematic weekly nighttime surveys of eel presence/abundance at Vernon dam were conducted over a 22 week period from June 7 through November 1, 2018. Survey locations included virtually all of the downstream face of the dam as well as specific leakage flow areas, the fish ladder, fish ladder entrance, and the rip-rapped area downstream of the fishway entrance. When all survey dates were considered, the greatest number of juvenile eel observations was recorded from three distinct areas downstream of the dam. As was observed during the 2015-2017 visual eel surveys, the fishway appeared to be the dominant aggregation point during 2018 (61% of all observations). In-ladder observations during 2018 were primarily from the visitor's viewing window, located at a large turn-pool in the lower section of the fish ladder, or the counting room window located just downstream from where the fishway transitions to a vertical slot configuration. Observations of juvenile eels from the counting room window indicated they usually appeared to be traveling upstream at the bottom of the water column and "falling back" or traveling downstream through the mid-water portion of the water column. This behavioral observation coupled with the negative net count of juvenile eels reported for the Vernon fishway by VANR for 2018 suggests that the SalmonSoft monitoring equipment is not accurately enumerating both upstream and downstream passage. It remains unclear as to what degree of success juvenile eels are utilizing the fishway.

In addition to the upstream fishway, nighttime survey observations were also recorded in the vicinity of the submerged flood gates below four tainter gates and one of the hydraulic panels (sites 07–11), and in the bedrock outcrop below the tainter gates and stanchion bays (sites 01–04). Observations of juvenile eels during each of the four survey years from the area of the submerged flood gates suggests that eels in that area do not appear to be actively seeking upstream routes of passage but rather are taking advantage of submerged habitat. In contrast, juvenile eel observations from the bedrock outcrop towards the eastern side of the dam suggest individuals there are searching for potential upstream routes of passage.

6.0 LITERATURE CITED

Normandeau (Normandeau Associates, Inc.). 2016a. ILP Study 18 – American Eel Upstream Passage Assessment Study Report. Prepared for TransCanada Hydro Northeast Inc. March 1, 2016.

Normandeau. 2016b. ILP Study 18 – American Eel Upstream Passage Assessment Supplement to Study Report. Prepared for TransCanada Hydro Northeast Inc. November 30, 2016.

Normandeau. 2018. ILP Study 18 – American Eel Upstream Passage Assessment Supplement #2 to Study Report. Prepared for Great River Hydro, LLC. January 26, 2018.

Welsh, S.A., and H.L. Liller. 2013. Environmental Correlates of Upstream Yellow-Phase American Eels in the Potomac River Drainage. Transactions of the American Fisheries Society. 142(2):483–491.