

**TRANSCANADA HYDRO NORTHEAST INC.**

**ILP Study 18**  
**American Eel Upstream Passage Assessment**  
***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)

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**March 1, 2016**

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## EXECUTIVE SUMMARY

The goal of this study was to provide baseline data on the presence of American Eel (*Anguilla rostrata*) attempting to move upstream of the Wilder, Bellows Falls, and Vernon Projects and the locations where they congregate while attempting upstream passage. The study involved conducting nighttime visual surveys of eel presence/abundance at tailrace and spillway locations at the projects. Also, baited eel pots were placed in specific locations in order to capture eels for additional observation and analysis. If eel concentrations warranted, temporary eel trap passes would be installed at specific locations below project dams and tailraces. The temporary eel trap passes would provide useful information for identifying potential upstream passage routes for American Eel.

Field work was initiated May 6, 2015 and continued through October 20, 2015, although the use of baited eel pots was terminated on August 27, 2015 with concurrence of the aquatics working group, due to a lack of eel captures. No temporary eel trap passes were deployed due to low concentrations of eels in the project areas.

During systematic surveys and eel pot sets no eels were observed at Wilder, three eels were observed at Bellows Falls (including the only two captured in eel pots in the study), and 80 were observed at Vernon. In addition to the observations gathered during Study 18 field work, eel observations from the counting windows in the upstream fish ladders at each dam collected for Study 17 - Upstream Passage of Resident Fish, as well as results from Study 10 - Fish Assemblage Study and Study 11 - American Eel Survey, provided supplemental data on eel presence at or near the dams. Of the eels observed, the greatest concentrations were observed in the fish ladders (Study 17) which operated continually throughout the study season as prescribed in the methods for that study.

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### List of Abbreviations

CRWC	Connecticut River Watershed Council
°C	Degrees Celsius
FERC	Federal Energy Regulatory Commission
FWS	U.S. Department of the Interior – Fish and Wildlife Service
ILP	Integrated Licensing Process
NHDES	New Hampshire Department of Environmental Services
NHFGD	New Hampshire Fish and Game Department
RSP	Revised Study Plan
TransCanada	TransCanada Hydro Northeast Inc.
TU	Trout Unlimited
USR	Updated Study Report
VANR	Vermont Agency of Natural Resources
VDEC	Vermont Department of Environmental Conservation
VY	Vermont Yankee Nuclear Power Plant



## 1.0 INTRODUCTION

This study report presents the findings of the 2015 American Eel Upstream Passage Assessment (ILP Study 18) conducted in support of Federal Energy Regulatory Commission (FERC) relicensing efforts by TransCanada Hydro Northeast Inc. (TransCanada) for the Wilder Hydroelectric Project (FERC Project No. 1892), Bellows Falls Hydroelectric Project (FERC No. 1855), and the Vernon Hydroelectric Project (FERC No. 1904).

Due to their physical structures, the three project dams may impede upstream migration of American Eels. Prior to this study there was no information about locations where upstream migrating eels could be concentrating below the three dams as they seek upstream passage, nor about the annual numbers of eels attempting to ascend the dams. While eels have been documented ascending the Wilder, Bellows Falls, and Vernon fish ladders (most recently as part of Study 17), fish ladder efficiency for passing eels is not known. The existing fish ladders were designed to pass Atlantic Salmon and American Shad, the primary species of concern when fish passage was initiated at the projects in the 1980s. Although some eels ascend the fish ladders, smaller eels may encounter velocity barriers within the fish ladders that increase their residency time below the dams or within the ladders.

In their study requests, US Fish & Wildlife Service (FWS), New Hampshire Department of Environmental Services (NHDES), New Hampshire Fish & Game Department (NHFGD), Vermont Agency of Natural Resources (VANR), Connecticut River Watershed Council (CRWC), and Trout Unlimited (TU) identified potential issues related to upstream American Eel passage at the Wilder, Bellows Falls, and Vernon Projects. TU only requested upstream eel studies for the Bellows Falls and Vernon Projects; the other five requestors also included the Wilder Project.

Revised Study Plan (RSP) 18, as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination, specified that this study would provide baseline data on the presence of American Eels attempting to move upstream of the projects and the locations where they congregate while attempting upstream passage. The RSP for this study was modified by TransCanada in its December 31, 2013 filing, based on stakeholder agreement from FERC's technical meeting held on November 26, 2013 to discuss impacts of the Vermont Yankee (VY) decommissioning, with the following specific changes.

- Consolidate the systematic surveys and temporary eel trap passes into a single study year (2015);
- Install temporary eel trap passes within 24 hours to the extent possible if adequate concentrations of eels are identified in the systematic surveys; and
- Develop a communication and consultation protocol with agencies and the aquatics working group that enables periodic, updated information on the surveys, observations, and data from eel trap passes to be shared.

An additional change to the RSP was approved by the aquatics working group during a February 10, 2015 consultation conference call. The change involved replacing elastomer tags with fin clips for marking captured eels (see Section 3.2).

This report provides results from data collected at the selected study locations during 2015, and reports on eel observations from other studies including Study 10 – Fish Assemblage Study, Study 11 – American Eel Survey, and Study 17 – Upstream Passage of Riverine Fish Species. During Study 17, eels were observed in the fish ladders of all three dams. This activity in the fish ladders proved to be the only distinguishable congregation of eels at each of the dams, with the activity seen in the Vernon fish ladder being the greatest volume.

## **2.0 STUDY GOALS AND OBJECTIVES**

As stated in the RSP, the goal of this study was to provide baseline data on the presence of American Eels attempting to move upstream of the projects and the locations where they congregate while attempting upstream passage. The specific objectives of this study were to:

- conduct systematic surveys of eel presence/abundance at tailrace and spillway locations at the Wilder, Bellows Falls, and Vernon Projects to identify areas of concentration of eels staging in pools or attempting to ascend wetted structures; and
- collect eels with temporary eel trap passes from areas identified from the surveys at locations of eel concentrations to assess whether eels can be collected and passed in substantial numbers.

### **2.1 Study Area**

The study area included the tailrace and spillway locations at the Wilder, Bellows Falls, and Vernon dams and the Bellows Falls bypassed reach. Systematic surveys were conducted in the spillway areas, especially where significant spill or leakage flow exists where eels may attempt to climb. Visual searches and eel pot trapping were conducted around the fish ladders and in the Bellows Falls bypassed reach. If needed based on concentrations of eels observed during systematic surveys, temporary eel trap passes were to be installed in areas downstream of project spillways, fish ladders, and/or in the Bellows Falls bypassed reach.

## **3.0 METHODOLOGY**

### **3.1 Systematic Surveys**

Visual surveys were conducted at night, once per week, downstream of each dam on foot or from a boat from May 6, 2015 through October 20, 2015. Visual surveys were done in areas where eels were likely to congregate below each dam, such as spillways, places where there is significant leakage or overflow points along the dams, the Bellows Falls bypassed reach, and in areas near the fish ladders (Figures 3.1-1 – 3.1-4. Data collected included location, observation of eels (presence, absence, numbers, and estimated sizes), time and date of observation, notes on weather conditions, and moon phase. Other data that were recorded included notes

on project operations during sampling such as spill gates that were open and/or spill conditions during high flows. Figure 3.1-5 illustrates night survey work.

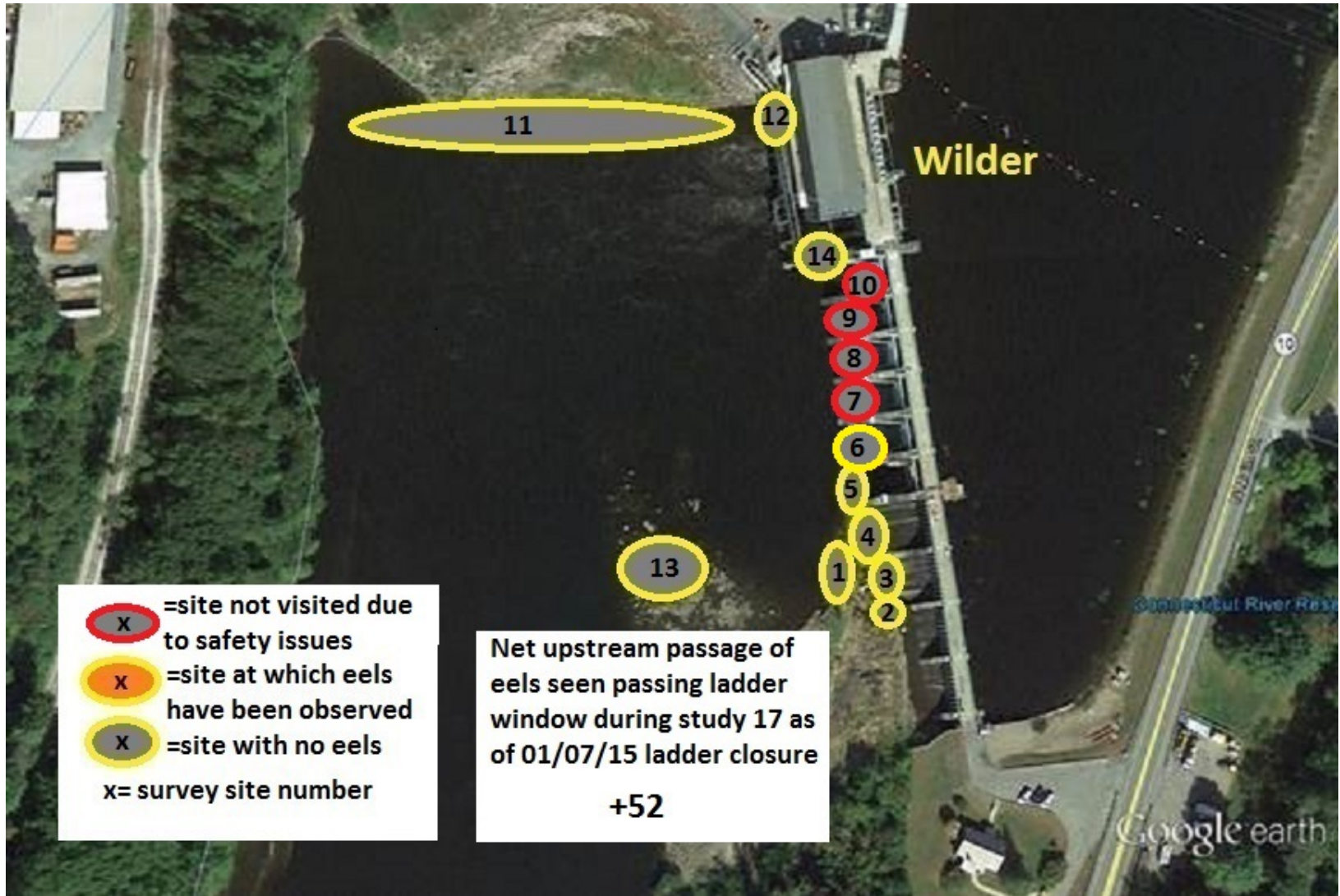


Figure 3.1-1. Wilder dam systematic survey locations.



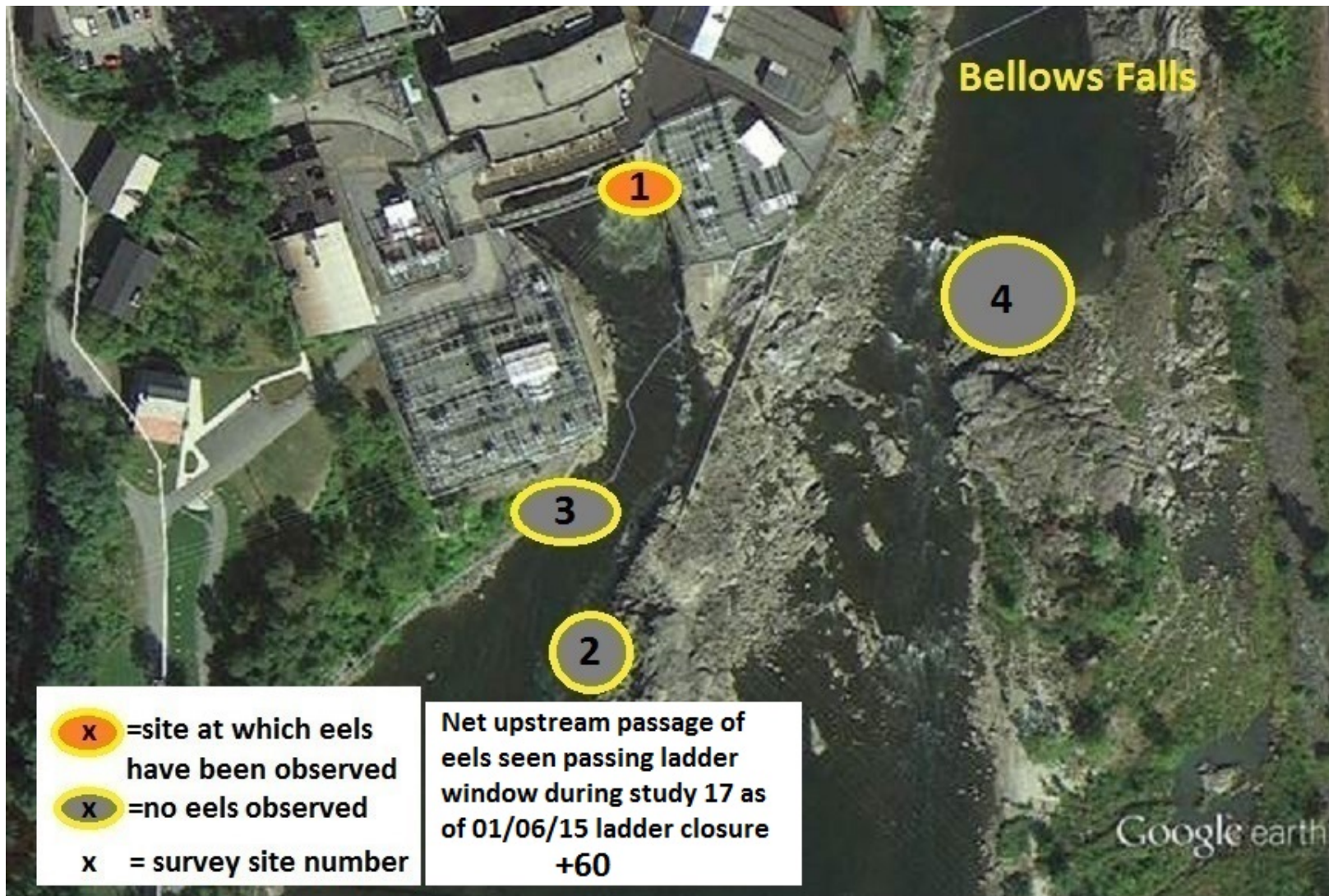


Figure 3.1-2. Bellows Falls tailrace (left) and lower bypassed reach (right) systematic survey locations.



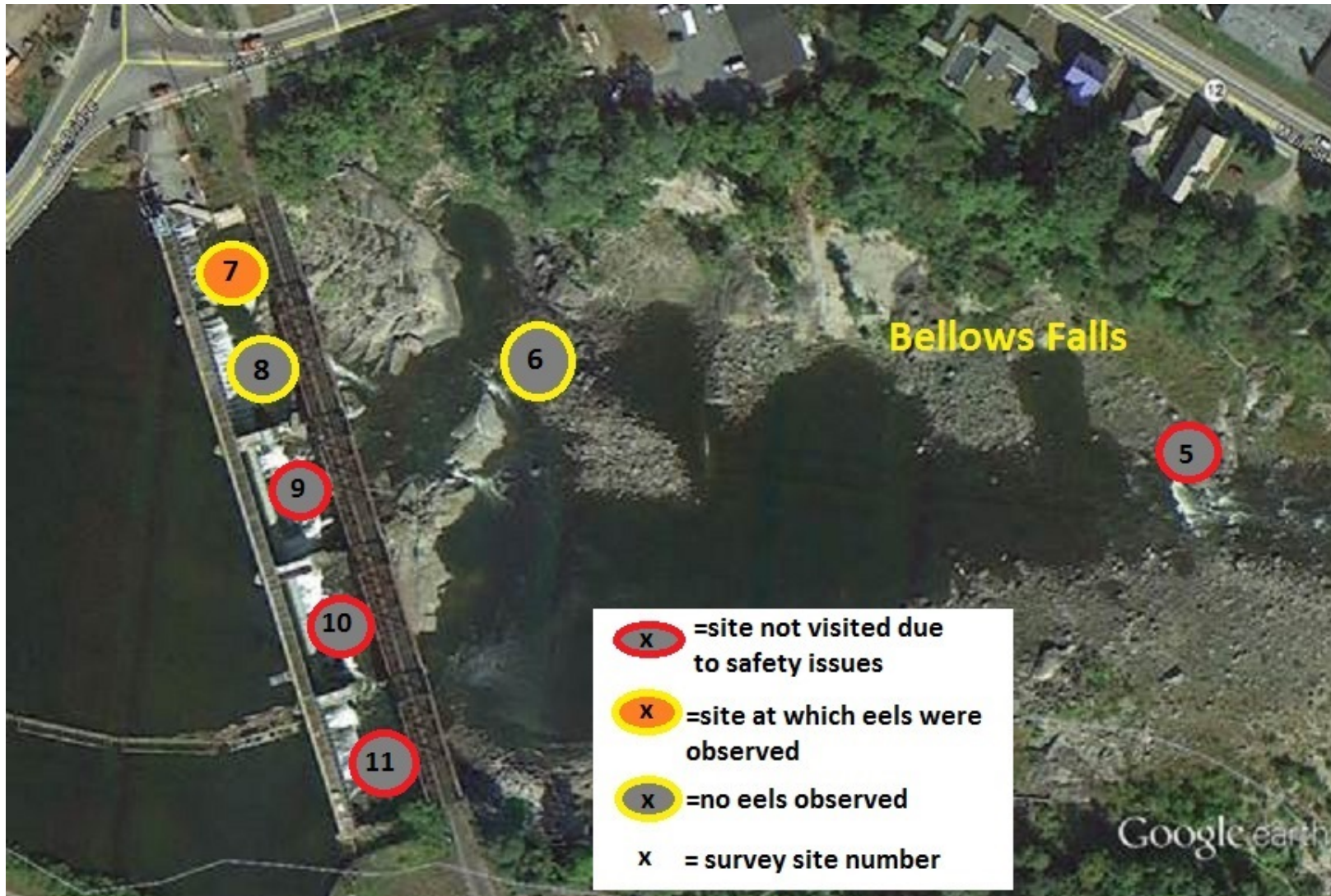


Figure 3.1-3. Bellows Falls dam and upper portion of bypassed reach systematic survey locations.

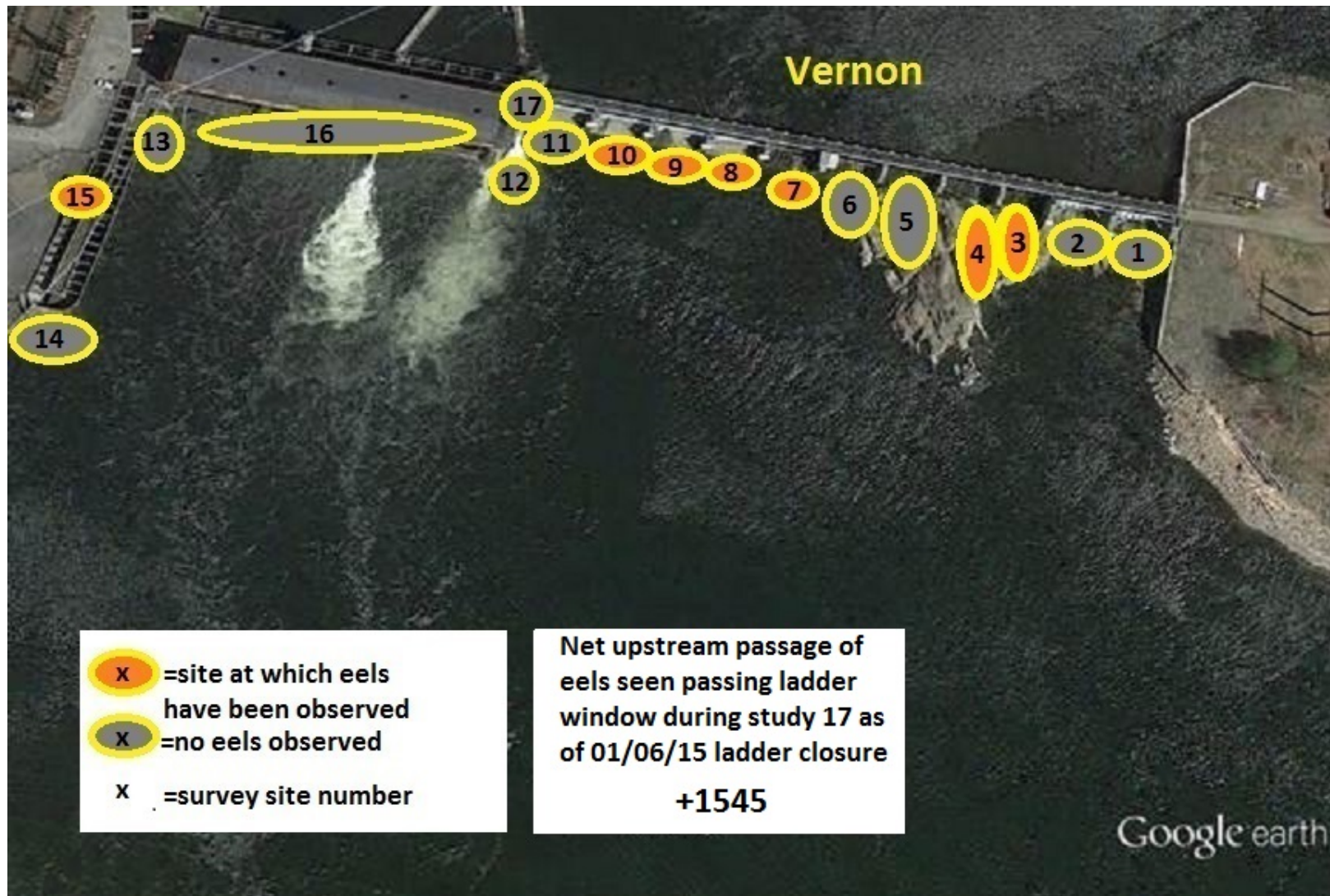


Figure 3.1-4. Vernon dam systematic survey locations.





Figure 3.1-5. Systematic night survey on rocks below Bellows Falls dam in the bypassed reach.

### 3.2 Baited Eel Pots and Temporary/Portable Eel Trap Passes

Downstream of the Wilder, Bellows Falls, and Vernon projects, 10 baited eel pots per project were fished once per week (overnight sets) from May 11 through August 27, 2015. Fishing began the week following the initial systematic survey date due to coordination with TransCanada Operations Department on the official worker safety zones to be entered for the field surveys, and one week of exploratory field work necessary to familiarize personnel with field conditions. The sampled areas included below the spillways, Bellows Falls bypassed reach, near the three fish ladders, and in locations that upstream migrating eels might be expected to congregate such as submerged flood gates at Vernon dam, and exposed rocks below leakages in various spill gates at each dam.

Eel pots (Figure 3.2-1) consisted of standard double-entry, 1/8-inch galvanized wire mesh cylinders approximately 3.5-ft long and weighted to remain on station for the duration of their soak time before retrieval via a float line. Eel pots were loaded with a variety of bait types, each tested in an attempt to increase catch counts. A variety of baits was used in an attempt to increase the number of eels collected. Canned smoked herring (kipper snacks) were used in the pots from May 11 to August 18, with a few exceptions. A variety of fish-based canned cat foods were used in 3 out of the 10 available pots fished from June 29 to July 13 and August 17 to 18. Fresh ocean clams were tested as bait, based on eel potting success in other river systems in 9 of the 10 available pots fished on August 8 at Vernon only



(kipper snacks were the other bait type used). Canned sardines were used in 2 of the 10 pots fished at each dam on August 17 and 18 (along with kipper snacks and cat food). Finally, canned smoked clams were used in all 10 pots at each dam on August 24 and 25 (Table 3.2-1).



Figure 3.2-1. Standard double entry eel pot with extended middle section.

Table 3.2-1. Summary of eel pot set times and bait used.

Project	Date Set	Time Set	Date Pull	Time Pull	Number of Pots Deployed and Bait Used						Comments
					Total	Kippers	Cat Food	Sardines	Smoked Clams	Fresh Clams	
W	05/11/15	2340	05/12/15	1215	9	9	0	0	0	0	
W	05/18/15	1620	05/19/15	2030	10	10	0	0	0	0	
W	05/25/15	2000	05/26/15	1125	10	10	0	0	0	0	
W	06/01/15	2000	06/02/15	1115	10	10	0	0	0	0	
W	06/09/15	1915	06/10/15	1200	10	10	0	0	0	0	
W	06/15/15	1675	06/16/15	1125	7	7	0	0	0	0	
W	06/22/15	1545	06/23/15	1155	6	6	0	0	0	0	
W	06/29/15	1650	06/30/15	1150	6	4	2	0	0	0	
W	07/07/15	1655	07/08/15	1100	10	8	2	0	0	0	
W	07/13/15	1715	07/14/15	1140	10	9	1	0	0	0	
W	07/20/15	1800	07/21/15	1230	5	5	0	0	0	0	
W	07/27/15	1830	07/28/15	1135	10	10	0	0	0	0	
W	08/03/15	1945	08/04/15	1120	10	10	0	0	0	0	
W	08/10/15	2115	08/11/15	1105	10	10	0	0	0	0	
W	08/17/15	1905	08/18/15	1125	10	8	1	1	0	0	
W	08/24/15	1700	08/25/15	1150	10	0	0	0	10	0	
B	05/12/15	2240	05/13/15	1545	10	10	0	0	0	0	
B	05/18/15	2045	05/19/15	1350	10	10	0	0	0	0	
B	05/25/15	1600	05/26/15	1855	10	10	0	0	0	0	
B	06/01/15	1420	06/02/15	2025	10	10	0	0	0	0	
B	06/09/15	1504	06/10/15	1933	10	10	0	0	0	0	
B	06/15/15	1410	06/16/15	1940	10	10	0	0	0	0	
B	06/22/15	1315	06/23/15	1935	7	7	0	0	0	0	
B	06/29/15	1445	06/30/15	1930	7	5	2	0	0	0	

Project	Date Set	Time Set	Date Pull	Time Pull	Number of Pots Deployed and Bait Used						Comments
					Total	Kippers	Cat Food	Sardines	Smoked Clams	Fresh Clams	
B	07/07/15	1445	07/08/15	2005	10	8	2	0	0	0	1 EEL CAUGHT (KIPPERS)
B	07/13/15	1530	07/14/15	1945	10	9	1	0	0	0	
B	07/20/15	1530	07/21/15	1920	5	5	0	0	0	0	
B	07/27/15	1730	07/28/15	1950	10	10	0	0	0	0	
B	08/03/15	1630	08/04/15	2030	10	10	0	0	0	0	
B	08/10/15	1905	08/11/15	2200	10	10	0	0	0	0	
B	08/17/15	1620	08/18/15	1620	10	7	1	2	0	0	
B	08/24/15	1740	08/25/15	2142	10	0	0	0	10	0	1 EEL CAUGHT (SMOKED CLAMS)
V	05/12/15	1800	05/13/15	2030	10	10	0	0	0	0	
V	05/19/15	1630	05/20/15	1900	10	10	0	0	0	0	
V	05/26/15	1415	05/27/15	1817	10	10	0	0	0	0	
V	06/02/15	1515	06/03/15	1938	10	10	0	0	0	0	
V	06/10/15	1455	06/11/15	1525	10	10	0	0	0	0	
V	06/16/15	1444	06/17/15	2010	10	10	0	0	0	0	
V	06/23/15	1435	06/24/15	1925	5	5	0	0	0	0	
V	06/30/15	1510	07/01/15	1925	7	5	2	0	0	0	
V	07/08/15	1505	07/09/15	-	10	8	2	0	0	0	
V	07/14/15	1455	07/15/15	1900	10	10	0	0	0	0	
V	07/21/15	1510	07/22/15	1955	7	7	0	0	0	0	
V	07/28/15	1455	07/29/15	2010	10	10	0	0	0	0	
V	08/04/15	1745	08/05/15	1955	10	1	0	0	0	9	
V	08/12/15	1945	08/13/15	1149	10	10	0	0	0	0	
V	08/18/15	1720	08/19/15	1945	10	5	3	2	0	0	
V	08/25/15	1805	08/26/15	1927	10	0	0	0	10	0	

Data collected included location, number of eels captured (or recorded as none captured), relative sizes, and time and date of observation. Each eel collected was assigned a length class (0 to 6 inches, 6 to 12 inches, 12 to 18 inches, and >18 inches). The first 10 individuals within each length class were individually measured for total length (nearest mm) and wet weight (nearest gram). Had any eels been captured in the >18 inches length class, the first 10 individual eels in the >18-inch length class would also have eye diameter measurements recorded. To facilitate collection of length and weight data as well as reduce the risk of injuries, eels were anesthetized with MS-222 before handling.

All eels collected from baited eel pots were marked with fin clips so that individuals that had already been captured could be identified to avoid overestimating eel abundance. The RSP had specified the use of elastomer tags, but in an aquatics working group conference call on February 10, 2015, the working group agreed to the use of fin clips as a better alternative. All captured eels were examined for existing fin clips, and all un-marked (> 1 gram wet weight) eels were marked with a project-specific fin clip using a 'V' punch and a standard hole punch. Eels captured at Vernon would get a 'V' punch in the dorsal fin, those at Bellows Falls would get a circle punch in the dorsal fin, and those at Wilder would get a circle punch in the anal fin (Figure 3.2-1). The two eels caught in eel pots were captured at Bellows Falls and were marked with a circle punch in the dorsal fin..

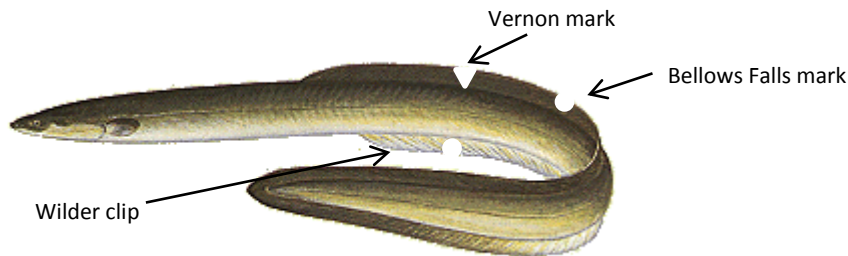


Figure 3.2-1. Fin marking of captured eels.

Eel pots were moved to different locations if no eels were captured in a particular location after three overnight samples. After limited catch, some locations were repeated if the site showed the characteristics (i.e., leakage) that could be most attractive to eels attempting to migrate upstream.

Collection of eels using baited eel pots ended on August 27, 2015, with concurrence of the aquatics working group, due to the limited success of eel pots despite the use of a variety of baits.

The RSP included a provision to consult with the working group on locations in which to install temporary eel trap passes and collect additional data, if adequate concentrations of eels were identified during the systematic surveys. It was decided on August 27 that no temporary eel trap passes would be deployed because the only aggregation point identified was the Vernon fish ladder and it would have been infeasible to deploy the ramp traps during the continued upstream fish passage

operational flows required by Study 17 – Upstream Passage of Resident Fish Species Assessment.

## **4.0 RESULTS AND DISCUSSION**

### **4.1 Systematic Surveys**

Field work was initiated May 6, 2015 and was terminated on October 20, 2015 after three consecutive weeks of no observations at any of the projects and after water temperatures had reached 10°C in all project areas. During most of this period, a crew of two biologists sampled each project site once per week. Surveys were started one hour after sunset. A full survey at any single dam took approximately 1 to 2 hours when water conditions permitted safe access to all available sites. Surveys could be as short as 45 minutes when water conditions made accessing select survey sites unsafe. Generally, the systematic survey schedule followed the river from upstream to downstream. Typically the surveys occurred on Mondays at Wilder, Tuesdays at Bellows Falls, and Wednesdays at Vernon. Occasionally the schedule was changed based on weather. Generally, one dam was surveyed on any single night. Some weeks at the very beginning and end of the sampling season allowed for surveys at two dams in a single night due to earlier sunsets.

Potential survey sites at each of the dams were first chosen using satellite photos, and then the safety of accessing sites was determined during the first week of field work. Some survey sites are excluded from Tables 4.1-1 (Wilder site #s 7-10) and 4.1-2 (Bellows Falls dam site #5, and site #s 9-11) since they were deemed too unsafe for the study after inspection in the field. Unsafe conditions varied greatly and included unacceptable fall risks, unsafe boat launching conditions, unsafe boat operating conditions, and water conditions producing water levels too high or too low for safe boating. For example, after the first two weeks of systematic surveys at Wilder, it was decided that launching a boat every week in the dark without a ramp carried too great a risk of injury, so all subsequent surveys were conducted on foot at Wilder. This made survey sites 7-10 at Wilder completely inaccessible. Another example occurred at Bellows Falls site #5 in the lower half of the Bellows Falls bypassed reach. Site #5 is upstream of an underwater line of rocks that made it unsafe to access by boat, and the site is downstream of multiple rock outcroppings that made it unsafe to access at night by foot.

No eels were observed at Wilder during weekly systematic surveys over 24 weeks (Table 4.1-1). At Bellows Falls, only one eel, estimated to be within the 12 to 18 inch size class, was observed during the 24 weekly systematic surveys at site #1 located near the fish ladder entrance (Table 4.1-2). Eighty eels were observed at Vernon dam during weekly visits over 25 weeks of surveys (Table 4.1-3, Figure 4.1-1).

Table 4.1-1. Numerical data for Wilder eel observations<sup>a</sup>.

Date	Site Number <sup>b</sup>										Total by Date	
	1	2	3	4	5	6	11	12	13	14		
5/6/2015	0	0	0	0	0	0	0					0
5/11/2015	0	0	0	0	0	0						0
5/19/2015	0	0	0	0			0	0				0
5/25/2015	0	0	0	0	0	0	0	0				0
6/1/2015							0	0				0
6/9/2015	0	0	0	0	0		0	0				0
6/15/2015	0	0	0	0			0	0				0
6/22/2015		0	0	0			0	0				0
6/29/2015	0	0	0	0			0	0				0
7/7/2015	0	0	0	0	0	0	0	0				0
7/13/2015	0	0	0	0	0		0	0	0			0
7/20/2015	0	0	0	0			0	0				0
7/27/2015	0	0	0	0	0		0	0				0
8/3/2015	0	0	0	0	0		0	0				0
8/10/2015	0	0	0	0	0		0	0				0
8/17/2015	0	0	0	0	0		0	0				0
8/24/2015	0	0	0	0	0		0	0				0
9/1/2015	0	0	0	0	0	0	0	0	0			0
9/7/2015	0	0	0	0	0	0	0	0	0	0		0
9/14/2015	0	0	0	0	0		0	0		0		0
9/22/2015	0	0	0	0	0	0	0	0	0	0		0
9/29/2015	0	0	0	0	0		0	0	0	0		0
10/5/2015	0	0	0	0			0	0			0	0
10/12/2015	0	0	0	0	0		0	0			0	0
<b>Total by Site</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>

a. Survey site numbers can be referenced to site numbers in Figure 3.1-1.

b. Sites not visited during a given date due to safety concerns are marked by shaded cells. Sites 7-10 were not visited at all due to safety concerns.

Table 4.1-2. Numerical data for Bellows Falls eel observations<sup>a</sup>.

Date	Site Number <sup>b</sup>							Total by Date
	1	2	3	4	6	7	8	
5/6/2015	0	0	0					0
5/12/2015	0	0	0					0
5/18/2015	0	0	0	0	0	0	0	0
5/26/2015	0			0	0	0	0	0
6/2/2015	0		0					0
6/10/2015	0		0					0
6/16/2015	0		0					0
6/23/2015	0	0	0					0
6/30/2015	0	0	0					0
7/8/2015	0	0	0		1 eel pot	0	0	1 eel pot
7/14/2015	0	0	0		0	0	0	0
7/21/2015	1 survey		0					1 survey
7/28/2015	0	0	0	0	0	0	0	0
8/4/2015	0	0	0		0	0	0	0
8/11/2015	0	0	0		0	0	0	0
8/18/2015	0	0	0		0	0	0	0
8/25/2015	1 eel pot	0	0		0	0	0	1 eel pot
9/3/2015	0	0	0		0	0	0	0
9/8/2015	0	0	0		0	0	0	0
9/15/2015	0	0	0	0	0	0	0	0
9/24/2015	0	0	0		0	0	0	0
9/29/2015	0	0	0		0	0	0	0
10/5/2015	0		0		0	0	0	0
10/12/2015	0		0		0	0	0	0
<b>Total by Site</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>3</b>

a. Survey site numbers can be referenced to site numbers in Figures 3.1-2 and 3.1-3.

b. Sites not visited during a given date due to safety concerns are marked by shaded cells. Sites 5, 9, 10 and 11 were not visited at all due to safety concerns.

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Table 4.1-3. Numerical data for Vernon eel observations<sup>a</sup>.

Date	Site Number <sup>b</sup>																	Total by Date
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
5/7/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0
5/13/2015	0		0	0	0	0	0	0	0	0	0	0	0	0				0
5/20/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0
5/27/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0
6/3/2015				0	0	0	0	0	0	0	0	0	0	0				0
6/11/2015					0	0	0	0	0	0		0	0					0
6/17/2015				0	0	0	0	0	0	0	0	0	0	0	1			1
6/24/2015													0	0	4			4
7/1/2015				0	0	0	0	0	0	0	0	0	0	0	5			5
7/9/2015	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0			2
7/15/2015	0	0	0	0	0	0	3	3	4	4	0	0	0	0	7			21
7/22/2015				0	0	0	0	0	0	0	0	0	0	0	2			2
7/29/2015	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1			3
8/5/2015	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0		1
8/12/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		1
8/19/2015	0	0	0	0	0	0	1	2	1	0	0	0	0	0	2	0		6
8/26/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0		2
9/2/2015	0	0	0	0	0	0	0	4	0	0	0	0	0	0	6	0	0	10
9/9/2015	0	0	0	2	0	0	1	4	0	0	0	0	0	0	3	0	0	10
9/16/2015	0	0	1	0	0	0	0	1	0	0	0	0	0	0	3	0	0	5
9/23/2015	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2	0	0	4
9/28/2015	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	3
10/6/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/13/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Site Number <sup>b</sup>																	Total by Date
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
10/20/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total by Site</b>	0	0	1	4	0	0	5	21	5	5	0	0	0	0	39	0	0	80 <sup>c</sup>

- a. Survey site numbers can be referenced to site numbers in Figure 3.1-4.
- b. Sites not visited during a given date due to safety concerns are marked by shaded cells.
- c. All eels were observed during systematic surveys, no eels were captured in eel pots.



Figure 4.1-1. Systematic night survey crew member locates an eel on the rocks below Vernon dam.

At Vernon, eels were observed at four discernible site types: the fish ladder window and surrounding area viewed from the catwalk surrounding the ladder (site #15), an area in the vicinity of the submerged flood gates below four tainter gates (site #10) just east of the powerhouse, a submerged flood gate below one of the hydraulic panels (site #7), and an area of emergent rocks below stanchion bays (sites #3 and #4) (Figure 4.1-2). The Vernon fish ladder was the site where eels were most frequently observed with 39 individuals (49% of the total), while the submerged flood gate sites collectively yielded 36 eel observations (45% of the total; Table 4.1-4). All of the eels observed at the fish ladder were seen swimming by the window and thus using the fishway to move upstream. When surveying the fish ladder, one crew member stood in the counting room monitoring the window in person, while the other crew member walked all of the accessible area of the ladder to view any eels active on the surface within the ladder. The survey of this site generally lasted about 5-10 minutes. The same procedure of surveying the ladder window and surrounding area was used at Wilder and Bellows Falls (Site #1 at Bellows Falls, and #12 at Wilder).

Behavioral notes of the eels observed at the Vernon flood gate sites indicated that many individuals did not seem to be attempting to migrate upstream at the time of observation and appeared to be taking cover under the overhead lip of these submerged structures.

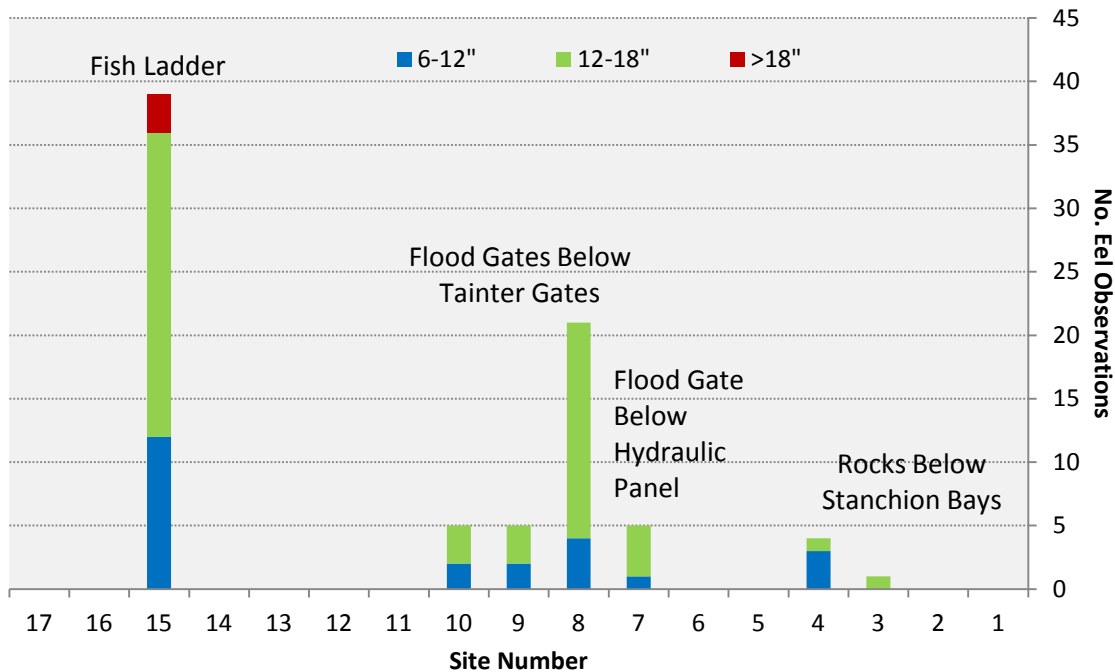


Figure 4.1-2. Vernon eel observations by site numbers and size class.

Table 4.1-4. Distribution of eel size classes observed by site and major location type at Vernon dam.

		Site Type						
		Fish Ladder	Flood Gates Below Tainter Gates			Flood Gate Below Hydraulic Panel	Rocks Below Stanchion Bays	
Site number:		15	10	9	8	7	4	3
Size Class	6-12"	12	2	2	4	1	3	0
	12-18"	24	3	3	17	4	1	1
	>18"	3	0	0	0	0	0	0

#### 4.2 Baited Eel Pots

Sampling by eel pots (also called eel potting) was initiated on May 11, 2015 and continued through August 27, 2015. Only two eels were caught in the baited eel pots. As a result of the poor catch results, the use of baited eel pots was terminated with concurrence of the working group while systematic night surveys continued. At Bellows Falls and Vernon, up to 10 eel pots (depending on safe access to potting sites) were set overnight one night per week for 17 weeks for an average of 8.8 pots set per week and a total of 149 potting days of effort at each project (Table 4.1-4). At Wilder, up to 10 eel pots (depending on safe access to potting sites) were set overnight for 17 weeks for an average of 8.6 pot sets per week and a total of 146 potting days of effort.

Both eels caught in baited eel pots were at Bellows Falls (Table 4.2-1) and measured within the 12 - 18 inch size class (Table 4.1-5). One was caught in the fish ladder (site #1) in a pot baited with kippers, and the other was caught in a collection of rocks below the dam in the bypassed reach (site #6) in a pot baited with smoked clams.

Table 4.2-1. Eel potting effort and result statistics.

	Wilder	Bellows	Vernon
No. of Sets	17	17	17
Avg. No. Pots/Set	8.6	8.8	8.8
Total Pot Nights	146	149	149
No. of Eels Caught	0	2	0

#### 4.3 Temporary Eel Trap Passes

No temporary eel trap passes were deployed due to low concentrations of eels other than at the Vernon fish ladder, where deployment of temporary eel trap passes was

deemed infeasible due to the continuous flows through the fish ladder. Since the RSP specified that water quality data would only be collected after the deployment of temporary eel ramps, no water quality data were collected; however, field crews did collect water temperature and weather information during systematic night surveys and eel potting. Comprehensive water quality data in the tailraces and the Bellows Falls bypassed reach, collected over the study season, are provided via Study 6 - Water Quality Monitoring Study.

**4.4 Size Classes of Observed Eels**

All three eels observed at Bellows Falls were estimated to be within the 12 – 18 inch size class. Of the 80 eels observed at Vernon 24 (30%) were estimated to be within the 6 to 12 inch size class, 53 (66%) within the 12 and 18 inch size class, and three (4%) within the 18+ inch size class (Table 4.4-1). Given these size ranges, all of the observed eels were larger than the elver or “black eel” phase (2-4 inches) and would fall into the “yellow eel” phase (Bigelow & Schroeder, 1953; Langdon et al., 2006). The Vernon fish ladder (Vernon site #15) was the only site where eels estimated at greater than 18 inches were observed; it also held a significant portion of the 6-12 and 12-18 inch size classes (50% and 45%, respectively).

Most of the remaining Vernon survey sites where eels were observed held only nominal representative individuals in the 6-12 and 12-18 inch size classes. Site #8 in the flood gate area was the only other survey site to hold a notable number of eels (32% of 12-18 inch size class). Collectively, the flood gates (Vernon sites #7-10) accounted for 37% and 52% of the observed eels estimated to be within the 6-12 or 12-18 inch size classes, respectively. The rocks below the hydraulic panels and stanchion bays (Vernon sites #3-6) accounted for 13% of the eels estimated to be in the 6-12inch size class, and 4% of the eels estimated to be within the 12-18 inch size class.

Table 4.4-1. Estimated lengths of American Eel by size class for those observed and collected by pots.

Project	Size Class			
	0-6"	6-12"	12-18"	>18"
Wilder	0	0	0	0
Bellows Falls	0	0	3	0
Vernon	0	24	53	3

**4.5 Environmental Conditions**

**4.5.1 Precipitation and Dam Discharge**

For many diadromous fish species, including American Eel, periods of significant precipitation that lead to higher levels of river discharge can correlate with increased migration volume (Welsh and Liller, 2013). Precipitation and river flow in April and May were less than average, however June was an unusually wet month

(Table 4.5-1). Numerous rain events resulted in periods of spill through June at all three projects. A single rain event resulted in spill at all three projects from September 30 continuing into the first few days of October. Bellows Falls also spilled briefly on September 15. Most of the sampling events when eels were observed were during months when monthly precipitation levels were greater than two inches (Figure 4.5-1).

Project discharges were consistently higher during June with frequent, sustained periods of spill while more short-lived spill events occurred at each dam in late July, and near the end of September and into early October. Wilder and Bellows Falls dams often ran near or at spill conditions during May and July, while Vernon mostly operated well below maximum operational flows during both months (Figure 4.5-2).

Spill occurred at Wilder and Bellows Falls just before and into July 21, one of the three dates that eels were observed at Bellows Falls. On the other two dates (July 8 and August 25) when eels were observed, Bellows Falls did not spill. Given the small number of eels attempting to migrate past Bellows Falls and the few dates of observed eels, conclusions cannot be drawn about where they might attempt to pass under different precipitation and project discharge levels.

Vernon was the only project to have eel observations during the month of June. However, despite spill conditions occurring during 60% of the days in June at Vernon, eel observations were minimal (Table 4.5-2, Figure 4.5-2). On the other end of the spectrum, Vernon had spill conditions on only 16% of the days in July but the greatest monthly total of eels observed. Higher flows in June may have attracted eels to migrate upstream where they were observed at Vernon in July.

September precipitation totals were above the 10-year average at all three projects and the month during which the second major pulse of eel observations occurred at Vernon (33 eels observed in June vs. 32 observed in September). Even September, which had only one day (September 30) with spill conditions at Vernon, yielded the second largest monthly eel observation total in the study.

Night survey effectiveness is inherently subject to weather, project discharge flows, and turbidity. These factors can change rapidly due to project operations, precipitation, and light availability. High water and increased turbidity levels limited visibility at some site locations, such as at Vernon's flood gates (sites #7-#11, Figure 3.1-4) where even a foot of water could make the difference between conditions that were safe and conducive for observation and conditions that were unsuitable. Thus, observations made at these sites during periods of high discharge and increased precipitation potentially missed eels that may have been present but not seen given the conditions. Baited eel potting was also periodically impaired by high water levels that limited areas that could be safely navigated to set pots, and discharge flows swift enough to drag buoys underwater preventing retrieval of the pots.

Table 4.5-1. Monthly precipitation at Wilder, Bellows Falls, and Vernon: 2015 and 10-year averages (TransCanada data).

<b>WILDER</b>	<b>May</b>	<b>Jun.</b>	<b>Jul.</b>	<b>Aug.</b>	<b>Sep.</b>	<b>Oct.</b>
2015	2.69	8.05	2.53	3.48	6.71	2.22
2015 YTD	9.05	17.10	19.63	23.11	29.82	32.04
10 Yr Avg.	3.27	3.98	4.98	3.63	3.68	4.86
10 Yr Avg. YTD	13.07	17.05	22.04	25.67	29.34	34.20
% 10YR AVE MOS	0.82	2.02	0.51	0.96	1.82	0.46
% 10YR AVE YTD	0.69	1.00	0.89	0.90	1.02	0.94
<b>BELLOWS FALLS</b>	<b>May</b>	<b>Jun.</b>	<b>Jul.</b>	<b>Aug.</b>	<b>Sep.</b>	<b>Oct.</b>
2015	1.87	5.96	2.23	3.69	6.67	1.83
2015 YTD	8.58	14.54	16.77	20.46	27.13	28.96
10 Yr Avg.	3.16	4.35	4.48	3.36	3.3	4.78
10 Yr Avg. YTD	13.11	17.46	21.93	25.30	28.6	33.38
% 10YR AVE MOS	0.59	1.37	0.50	1.10	2.02	0.38
% 10YR AVE YTD	0.65	0.83	0.76	0.81	0.95	0.87
<b>VERNON</b>	<b>May</b>	<b>Jun.</b>	<b>Jul.</b>	<b>Aug.</b>	<b>Sep.</b>	<b>Oct.</b>
2015	1.04	3.88	1.93	3.90	6.62	2.22
2015 YTD	8.97	12.85	14.78	18.68	25.3	27.52
10 Yr Avg.	3.68	5.50	4.22	4.16	3.60	6.01
10 Yr Avg. YTD	15.86	21.36	25.58	29.73	33.33	39.34
% 10YR AVE MOS	0.28	0.71	0.46	0.94	1.84	0.37
% 10YR AVE YTD	0.57	0.60	0.58	0.63	0.76	0.70

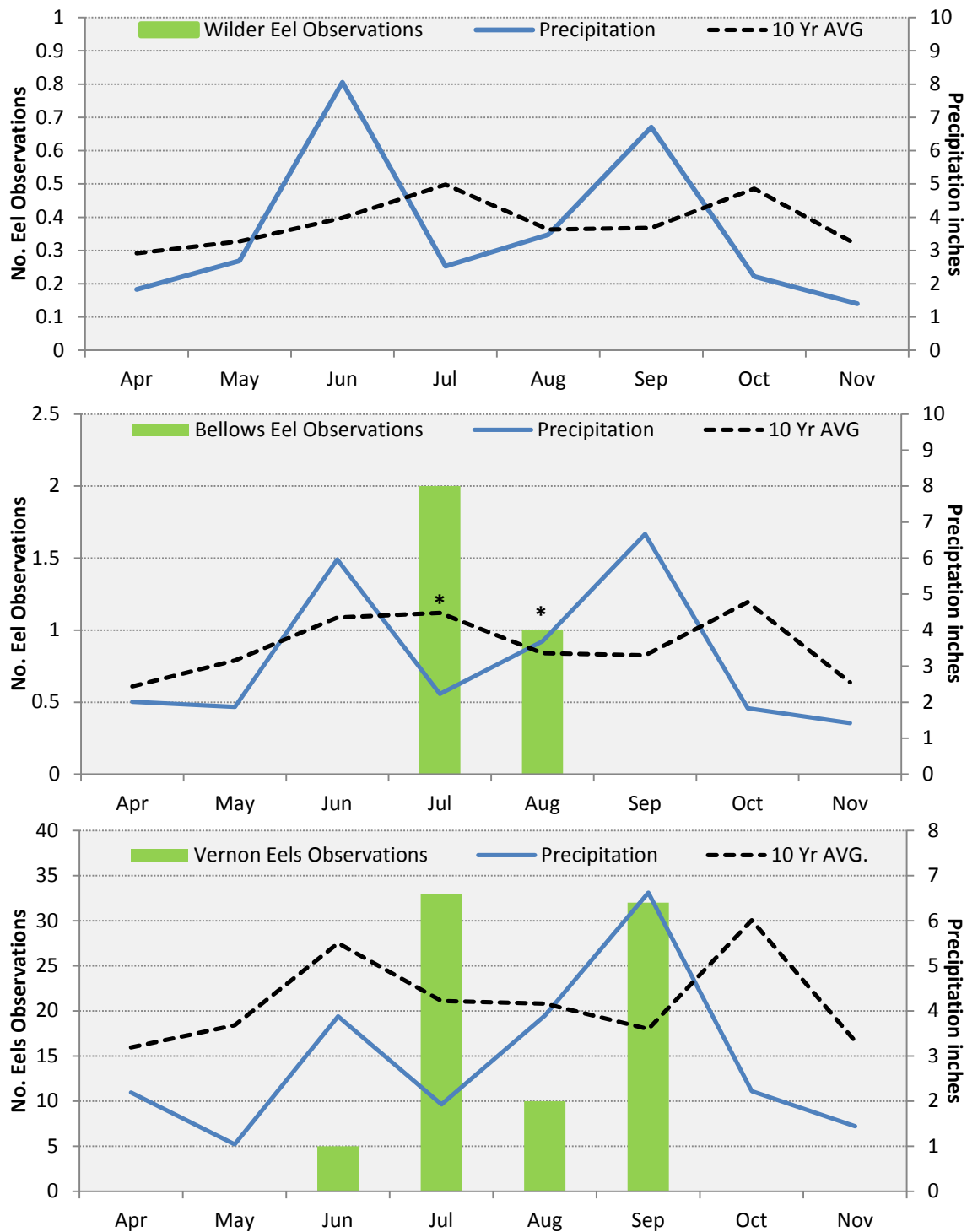


Figure 4.5-1. Monthly eel observations (bars) and potting results (bars with asterisks) with precipitation totals (solid line) and 10 year average precipitation (dashed line) at each dam site.

\* At Bellows Falls, one eel in July was observed during night surveys and the other was caught in a baited eel pot.



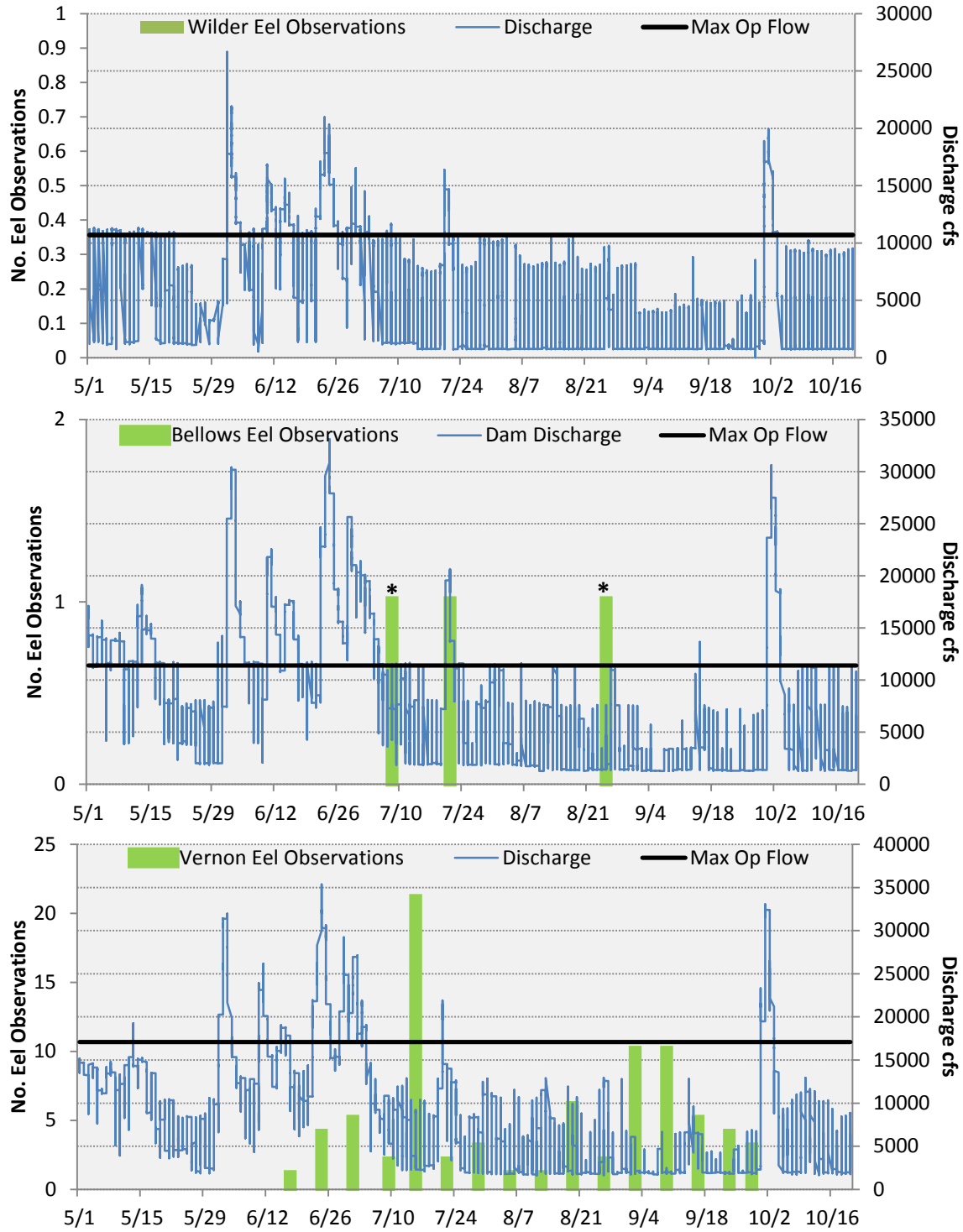


Figure 4.5-2. Discharge below project dams (blue line) with eel observations (bars) and eel potting counts (bars with asterisk). Discharge events greater than the maximum operation capacity (black line) represent spill conditions.

Table 4.5-2. Number of days in which spill occurred by month at each dam. Spill occurred when discharge exceeded max operation flows at any point in a given day.

		May	June	July	Aug.	Sep.	Oct.
<b>Wilder</b>	Spill Days	19	28	8	0	1	3
	% Frequency <sup>a</sup>	61	93	26	0	3.3	15
<b>Bellows Falls</b>	Spill Days	22	30	19	2	2	3
	% Frequency	71	100	61	6	6	15
<b>Vernon</b>	Spill Days	1	18	5	0	1	3
	% Frequency	3	60	16	0	3	15

a. % Frequency = percent of days per month in which spill conditions occurred.

#### 4.5.2 Water Temperature

At Bellows Falls, two eels were collected in pots and one eel was observed while water temperatures ranged from 20.4° to 23.8°C (Figure 4.5-3). All eel observations occurred at Vernon while water temperatures exceeded 16.9°C, the majority of which (67 of 80 or 84%) occurred when temperatures consistently exceeded 20°C (Figures 4.5-3). Overall, more than half (47 of 80 or 59%) of the eels observed at Vernon were during visits with water temperatures between 23.0-23.9°C.

At Vernon, the month of June had ample discharge and over two weeks of spill days to attract migrating eels (Figure 4.5-2; Table 4.5-2), water temperatures did not exceed 20°C at night and observations were low (Figure 4.5-3, Figure 4.5-4). The drier than normal conditions and discharge levels lower in July than in June (Figure 4.5-1, Figure 4.5-2) coincided with both a rapid rise in temperature from 16.9 to 23.7°C and a surge in observations (33 of 80 or 41%; Figures 4.5-3 and 4.5-4). A second surge of eel observations (32 of 80 or 40%) occurred in September as water temperatures dropped gradually throughout the month. Then, wetter than normal precipitation levels and a significant peak in discharge at the end of September coincided with a rapid drop in temperature from 18.7° to 13.3°C during the first week of October. No eels were observed at Vernon after this time for the remainder of the night surveys.

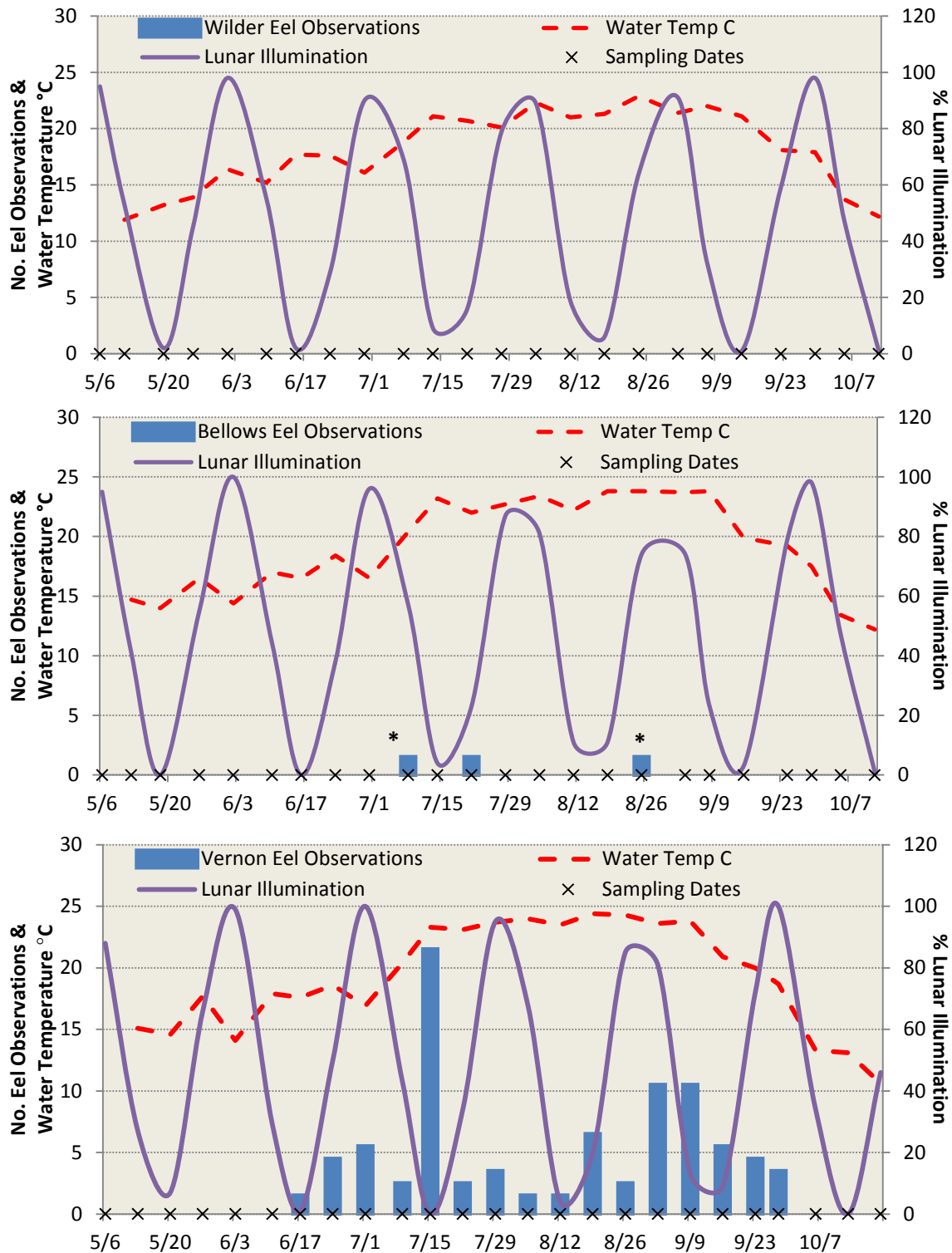


Figure 4.5-3. Periodicity of eel observations (bars) and eel potting results (bars with asterisk) with range of daily water temperatures (dashed line) and lunar illumination (solid line).

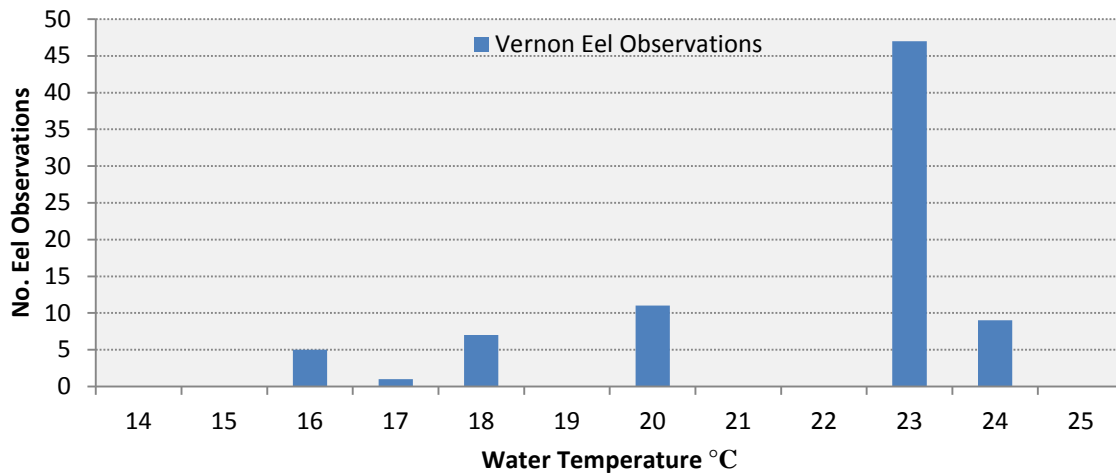


Figure 4.5-4. Vernon eel observations by water temperature. All observations occurred between 16.9 and 24.4°C, with a peak between 23.0 and 23.9°C.

### 4.5.3 Lunar Illumination

All of the pulses in observed eels in July and half of the pulses of observed eels in September at Vernon occurred during nights with less than 25% lunar illumination, as did the few observations at Bellows Falls (Figure 4.5-3). More than half of all observed eels at Vernon (55%) were seen during nights mostly devoid of moon light (Table 4.5-3). However, eels were also observed on nights with lunar illumination in excess of 75% (23 of 80 or 29%). With over 80% of the eel observations at Vernon collectively occurring on both the darkest and brightest nights during the study, and the relatively few eels observed over the study period, the relationship between lunar illumination and the timing of eel upstream migration is not clear. Rather, lunar illumination can be affected by cloud cover and precipitation. Lunar illumination could be part of a synergistic relationship with hydraulic conditions to influence eel upstream migrations once water temperatures are above an appropriate temperature threshold. Past studies have concluded that low light conditions tend to promote eel movement, but even with higher levels of lunar illumination, low light conditions in the water can persist from a variety of factors such as increased cloud cover and turbidity (Welsh and Liller, 2013).

Table 4.5-3. Vernon eel observations by lunar illumination.

Lunar Illumination	No. of visits	No. of eel observations	Percent of total observations
0-24%	8	44	55%
25-49%	6	4	5%
50-74%	4	3	11%
75-100%	7	23	29%

#### 4.6 Additional Studies & Anecdotal Observations

Three eels were caught during the fall survey of Study 10 - Fish Assemblage Study. Two of the eels were caught in the Vernon riverine reach: the smaller eel measured 11.8 inches (yellow phase eel) and was caught in sampling map-unit 10-VR003 between 0.65 and 1 river mile downstream of Vernon dam. The larger eel measured over 28 inches in length (silver phase eel) and was caught in map-unit 10-VR002 between 0.2 and 0.75 river miles downstream of Vernon dam. The third eel collected during Study 10 was caught in the Wilder impoundment near East Thetford, VT (map-unit 10-W109 between 13.2 and 13.5 river miles upstream of Wilder dam) and measured over 38 inches (silver phase eel). Given that the larger eels caught during Study 10 were reported as sexually mature silver phase eels, it is unlikely that they would be migrating upstream and are not relevant to this study. The one yellow phase eel collected in Study 10 was caught too far downstream from Vernon dam to provide evidence of a location it might have chosen to attempt upstream migration at the dam.

Three eels were also caught in Study 11- American Eel Survey above Bellows Falls dam in the impoundment near Charlestown, NH. All three were greater than 18 inches: two were identified as yellow phase eels and one was identified as a silver phase eel. Given that the two yellow eels caught during Study 11 were located above the Bellows Falls dam, it is unclear whether these individuals were migrating and none had fin clips indicating they had been previously captured.

From April 15 through the final ladder closures of the season (January 6, 2016 at Vernon and Bellows Falls; January 7, 2016 at Wilder) as part of Study 17 - Upstream Passage of Riverine Fish Species, 52 eels were observed passing upstream in Wilder fish ladder and 60 eels were observed passing in the Bellows Falls fish ladder. By far, the greatest number of eels observed in Study 17 was in the Vernon fish ladder with a net total of 1,545 eels observed to be passing upstream. Observations and photographs of small juvenile eels in the Vernon fish ladder from TransCanada staff during a shutdown of the Vernon fish ladder on December 7, 2015 provided further documentation of this structure being used by juvenile eels (Figure 4.7-1).



Figure 4.7-1. A crayfish (left), two young eels (center), and a lamprey ammocoete (right) found in the Vernon fish ladder during a shutdown on December 7, 2015.

## 5.0 STUDY CONCLUSIONS

Systematic surveys of eel presence/abundance at tailrace and spillway locations at Wilder, Bellows Falls, and Vernon identified no concentrations of eels staging in pools or attempting to ascend wetted structures of the dams; however, relatively large numbers of eels were observed in the Vernon fish ladder.

At Vernon, the attraction flows into the ladder appeared to greatly outweigh attraction flows at smaller leakages through or over the dam that would tend to produce more observations of eels attempting to cross a physical barrier by climbing across wet surfaces. With the relatively high volume of water coming from the ladder during the entire study period, the inference can be made that the vast majority of upstream migrating eels were attracted more to the ladder than the other wetted areas across the dam. Had the ladder not been operating to pass resident fish (for Study 17) for the full duration of this study, it is possible that higher numbers of eels would have been detected and/or captured at other locations across Vernon dam. Two of the three eels observed at Bellows Falls were observed at the fish ladder, but given such low numbers, it is not clear that the fish ladder was the attractive force to the extent that the Vernon ladder was. Given the prevalence of eels seen in the fish ladders during this study and Study 17 after the typical ladder closure date, juvenile eels were documented to be attempting to move upstream through the summer and into early fall.

The second objective of this study involved the temporary eel trap ramps, but this proved to be infeasible to conduct since the only observed congregation point was the Vernon fish ladder and the flow volume and velocity in the vicinity of the ladder were not conducive to use of the temporary eel trap ramps.

While the baited eel potting portion of this study did not produce results as expected, the United States eel fishing industry and past studies by Normandeau Associates using the same gear in lower river systems demonstrates the typical effectiveness of these pots. Eel pots had a 1/8- inch sized mesh (see Section 3.2) which is appropriate for the size of eels expected at the three projects. This size mesh has been used in studies at multiple east coast river systems, including the Merrimack and Penobscot rivers with few problems. However, even when eel pots were placed directly into the fish ladder at Vernon, the pots were ineffective and bait was apparently untouched between eel pot checks. It is possible that the low number of eels present below each dam on any given night was not great enough to make baited eel pots an effective sampling method in this case.

## **6.0 LITERATURE CITED**

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