UNITED STATES OF AMERICA

BEFORE THE

FEDERAL ENERGY REGULATORY COMMISSION

TRANSCANADA HYDRO NORTHEAST INC.

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)

Updated Study Report

Volume III – Containing Sub Volumes III.A – III.B

September 14, 2015

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Volume III.A

Study 13 – Tributary and Backwater Fish Access and Habitats Study Report

Updated Study Report

September 14, 2015

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TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 13
Tributary and Backwater Fish Access and Habitats Study

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

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September 14, 2015

EXECUTIVE SUMMARY

The goals of this study were to assess whether water-level fluctuations from project operations impede fish movement into and out of tributaries and backwater areas within the project-affected areas; and affect available fish habitat and water quality in the tributaries and backwater areas within the study area. The objectives of this study were to conduct a field study of a subset of tributaries and backwaters to identify and assess the potential effects of project related water-level fluctuations on fish access, available habitat, and water quality. The study area included 37 tributary and backwater sites within the area from the uppermost extent of the Wilder impoundment to the area downstream of Vernon Dam, including the Wilder, Bellows Falls, and Vernon impoundments and the riverine sections downstream of Wilder and Bellows Falls dams, and extending approximately 1.5 miles below Vernon dam.

The study was conducted from the period between late July and mid-November 2014 during which time each site was visited multiple times. Water level loggers were installed within the tributaries and backwaters along with a comparison water level logger installed in the Connecticut River mainstem near the confluence with the tributary/backwater. Bed profiles were measured and the length of the project-affected reach was estimated for each study site. Water quality data was collected and photographs were during each site visit.

Twenty-three of the 37 study sites showed no project effect on fish access or habitat (e.g., water depth and water level fluctuation under the full range of TransCanada operating conditions. Water quality at all sites was generally within state water quality standards, and not discernably affected by project operations.

The 10 remaining sites underwent additional analysis. Four of these sites were also shown to have no project effect. Two sites were shown to have minimal project effects and two more have some potential for stranding under low tributary and mainstem conditions. The two sites located in the Vernon riverine section just below Vernon Dam are apparently more influenced by the downstream Turners Falls project impoundment elevation and operations than by Vernon operations.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Abbreviations

AOQL	Average Outgoing Quality Limit
CRWC	Connecticut River Watershed Council
DO	Dissolved oxygen
FERC	Federal Energy Regulatory Commission
FWS	U.S. Department of the Interior – Fish and Wildlife Service
µS/cm	Micro-siemens per centimeter
NHDES	New Hampshire Department of Environmental Services
NHFGD	New Hampshire Fish and Game Department
NTU	Nephelometric Turbidity Units
RTK	Real Time Kinematic Unit
SN	Serial number
su	Standard units
TransCanada	TransCanada Hydro Northeast Inc.
VANR	Vermont Agency of Natural Resources
VTDEC	Vermont Department of Environmental Conservation
WSE	Water surface elevation

1.0 INTRODUCTION

This study report presents the initial findings of the 2014 Tributary and Backwater Area Fish Access and Habitats Study (Study 13) 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).

Operations at TransCanada's Wilder, Bellows Falls and Vernon hydroelectric projects (projects) may impede fish movement into and out of tributary and backwater areas in the impoundments and riverine reaches. In their study requests, U.S. Department of the Interior-Fish and Wildlife Service (FWS), New Hampshire Department of Environmental Services (NHDES), New Hampshire Fish and Game Department (NHFGD), Vermont Agency of Natural Resources (VANR), and Connecticut River Watershed Council (CRWC) expressed concern that water-level fluctuations due to project operations have the potential to create conditions that could impede the movement of fish between the Connecticut River and its tributaries and backwaters. These conditions, if present, could limit access to spawning habitat and growth opportunities. Additionally, project-related, water-level changes have the potential to alter water quality in these areas, which could decrease productivity. Study Plan 13, as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination, specified that a subset of project-affected tributaries and backwaters would be evaluated for potential effects of water-level fluctuations on fish access, habitat and water quality.

An initial site selection report was posted on TransCanada's relicensing website on May 8, 2014 and comments were received during an aquatics working group meeting held on May 23, 2014; during a follow up conference call on July 1, 2014; and in email communications from FWS and NHFGD (July 2, July 8, and July 9, 2014). The final sampling locations were randomly selected in the Updated Revised Site Selection Report (Normandeau 2014a) which included modifications that addressed all working group discussion and comments. The Final Site Selection Report was filed with FERC on September 15, 2014 in Volume III.C of TransCanada's Initial Study Report.

This report provides results from Study 13 from data collected at the selected tributaries and backwater locations during the period July-November, 2014 and water quality data collected at two sites downstream of Vermont Yankee (VY) in 2015. Collection of this additional water quality data after the closure of VY was requested by stakeholders in a technical meeting held November 26, 2013; discussed as part of a December 18, 2013 aquatics working group conference call; and included in TransCanada's December 31, 2013 study plan modification letter to FERC.

2.0 STUDY GOALS AND OBJECTIVES

As stated in the Revised Study Plan (RSP), the goals of this study were to assess whether water-level fluctuations from project operations:

- impede fish movement into and out of tributaries and backwater areas within the project-affected areas; and;
- Affect available fish habitat and water quality in the tributaries and backwater areas within the project-affected areas.

Specific objectives for this study were to conduct a field study:

- of a subset of tributaries and backwaters in the project-affected areas to assess potential effects of water-level fluctuations on fish access to these areas in the impoundments and riverine reaches below the projects; and
- to examine potential effects of water level fluctuations on available habitat and water quality in a subset of project-affected tributaries and backwaters.

3.0 STUDY AREA

Locations for the assessment of tributary and backwater access were randomly selected within nine sub-reaches defined by project structures, naturally occurring river breaks, and the magnitude of daily water surface elevation (WSE) fluctuations occurring within the project area from the upper extent of Wilder impoundment (RM 262.4) to the downstream extent of Stebbins Island below Vernon Dam (RM 141.9). These sub-reaches were defined during the selection process detailed in the Updated Revised Site Selection Report (Normandeau 2014a). A total of 36 randomly selected sampling locations were identified and one additional site (Cold River, ID CT-BR-4.02) was added to the study at the request of NHFGD. The numbers of sample sites by sub-reach visited during 2014 were:

Upper Wilder Impoundment – 4 locations
Middle Wilder Impoundment – 5 locations
Lower Wilder Impoundment – 5 locations
Upper Wilder Riverine – 2 locations
Lower Wilder Riverine – 3 locations
Bellows Falls Impoundment – 6 locations
Bellows Falls Riverine – 3 locations
Vernon Impoundment – 7 locations
Vernon Riverine – 2 locations

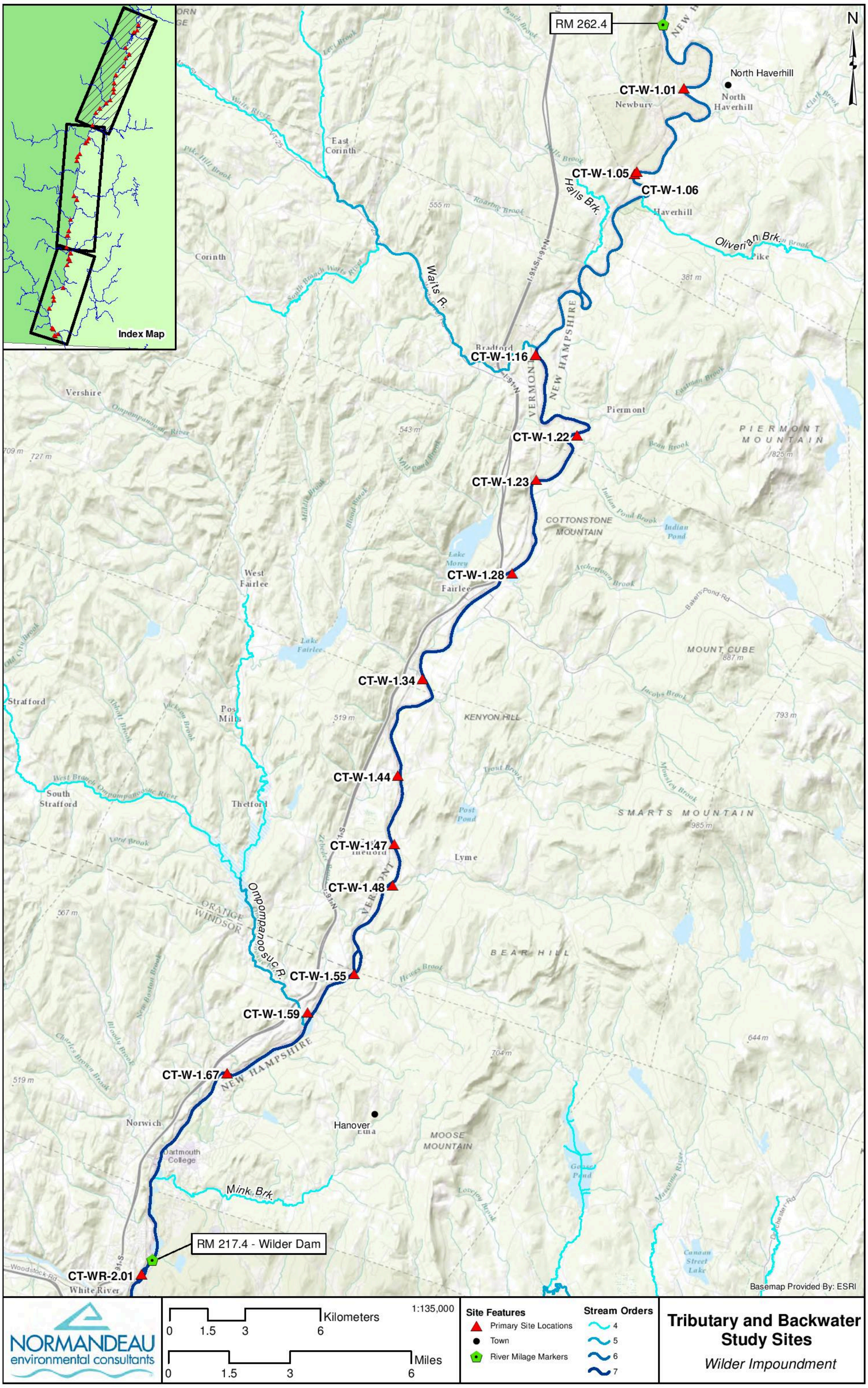
A full listing of the 37 study sites is presented in tabular format in Table 3-1 and graphically in Figure 3-1.

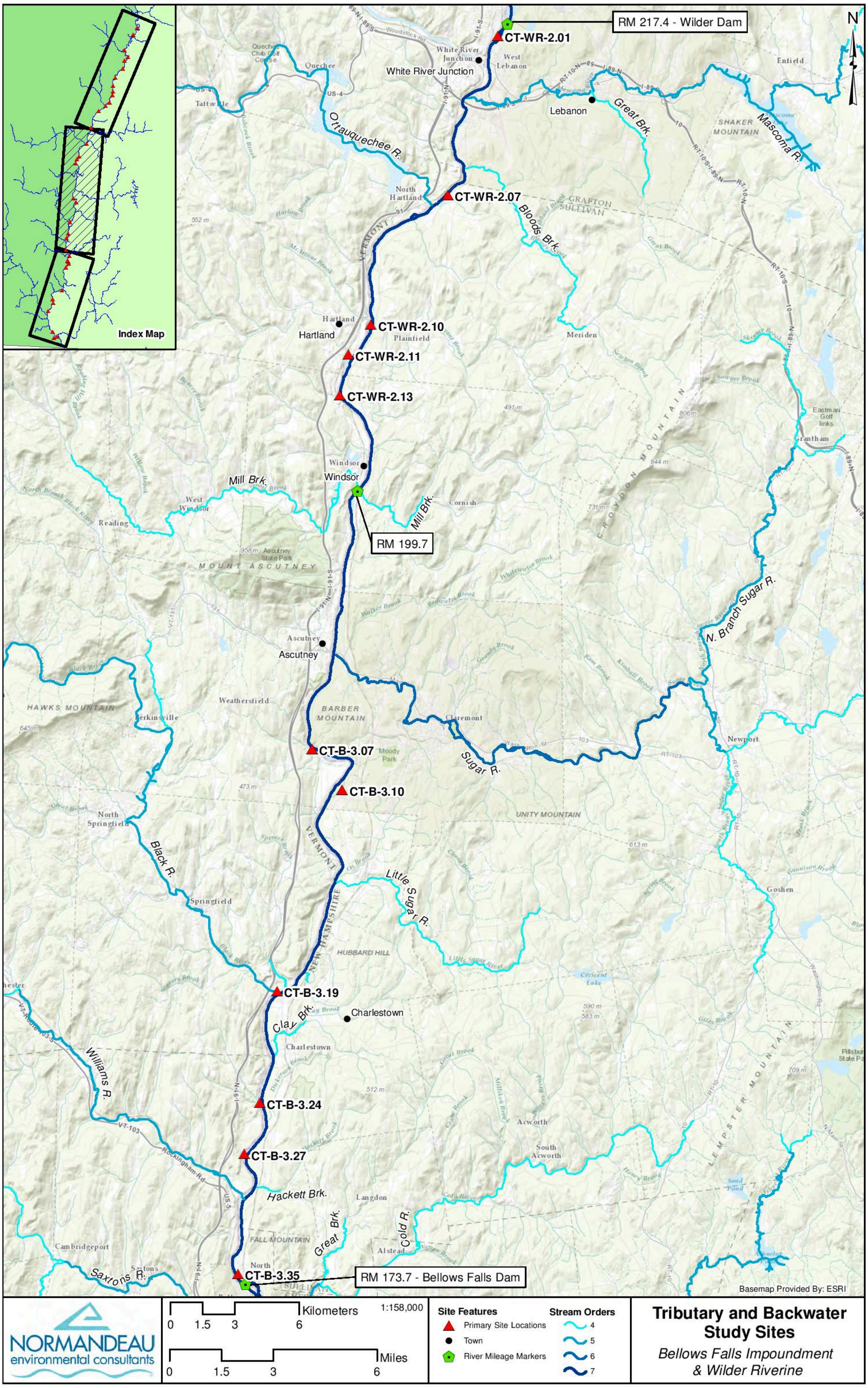
Table 3-1. Tributary and backwater study locations.

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Coordinates	
CT-W-1.01	Upper Wilder	Minor Trib	Harriman Brook	2	-72.043789	44.087891
CT-W-1.05	Upper Wilder	Backwater		0	-72.067176	44.058021
CT-W-1.06	Upper Wilder	Minor Trib		2	-72.068263	44.057211
CT-W-1.16	Upper Wilder	Backwater		0	-72.116927	43.992195
CT-W-1.22	Middle Wilder	Major Trib	Indian Pond Brook	3	-72.096067	43.963445
CT-W-1.23	Middle Wilder	Minor Trib		1	-72.116113	43.947391
CT-W-1.28	Middle Wilder	Backwater		0	-72.128038	43.913834
CT-W-1.34	Middle Wilder	Minor Trib		2	-72.171864	43.875890
CT-W-1.44	Middle Wilder	Backwater		0	-72.183827	43.841237
CT-W-1.47	Lower Wilder	Minor Trib		1	-72.185333	43.816672
CT-W-1.48	Lower Wilder	Major Trib	Grant Brook	3	-72.186158	43.801778
CT-W-1.55	Lower Wilder	Minor Trib		1	-72.204879	43.770009
CT-W-1.59	Lower Wilder	Backwater		0	-72.227711	43.756159
CT-W-1.67	Lower Wilder	Minor Trib		2	-72.267375	43.734246
CT-WR-2.01	Upper Wilder Riverine	Minor Trib		2	-72.308929	43.661900
CT-WR-2.07	Upper Wilder Riverine	Minor Trib	Hanchetts Brook	1	-72.337180	43.595029
CT-WR-2.10	Lower Wilder Riverine	Minor Trib	McArthur Brook	2	-72.380636	43.540433
CT-WR-2.11	Lower Wilder Riverine	Major Trib	Lulls Brook	3	-72.393608	43.527828
CT-WR-2.13	Lower Wilder Riverine	Minor Trib	Bashan Brook	1	-72.398248	43.510763
CT-B-3.07	Bellows	Major Trib	Barkmill Brook	3	-72.412279	43.362394
CT-B-3.10	Bellows	Minor Trib		1	-72.394886	43.345417
CT-B-3.19	Bellows	Backwater		0	-72.431303	43.260732
CT-B-3.24	Bellows	Major Trib	Commissary Brook	3	-72.440597	43.213887
CT-B-3.27	Bellows	Minor Trib		2	-72.449136	43.192375
CT-B-3.35	Bellows	Minor Trib		2	-72.452103	43.142063
CT-BR-4.02	Bellows Riverine	Major Trib	Cold River	5	-72.431083	43.118314
CT-BR-4.03	Bellows Riverine	Minor Trib		2	-72.440915	43.097277
CT-BR-4.04	Bellows Riverine	Major Trib	Cobb Brook	3	-72.438781	43.094376
CT-V-5.02	Vernon	Minor Trib	Mad Brook	2	-72.432666	43.085102
CT-V-5.04	Vernon	Major Trib		3	-72.450288	43.068487
CT-V-5.19	Vernon	Minor Trib		1	-72.471748	42.971787

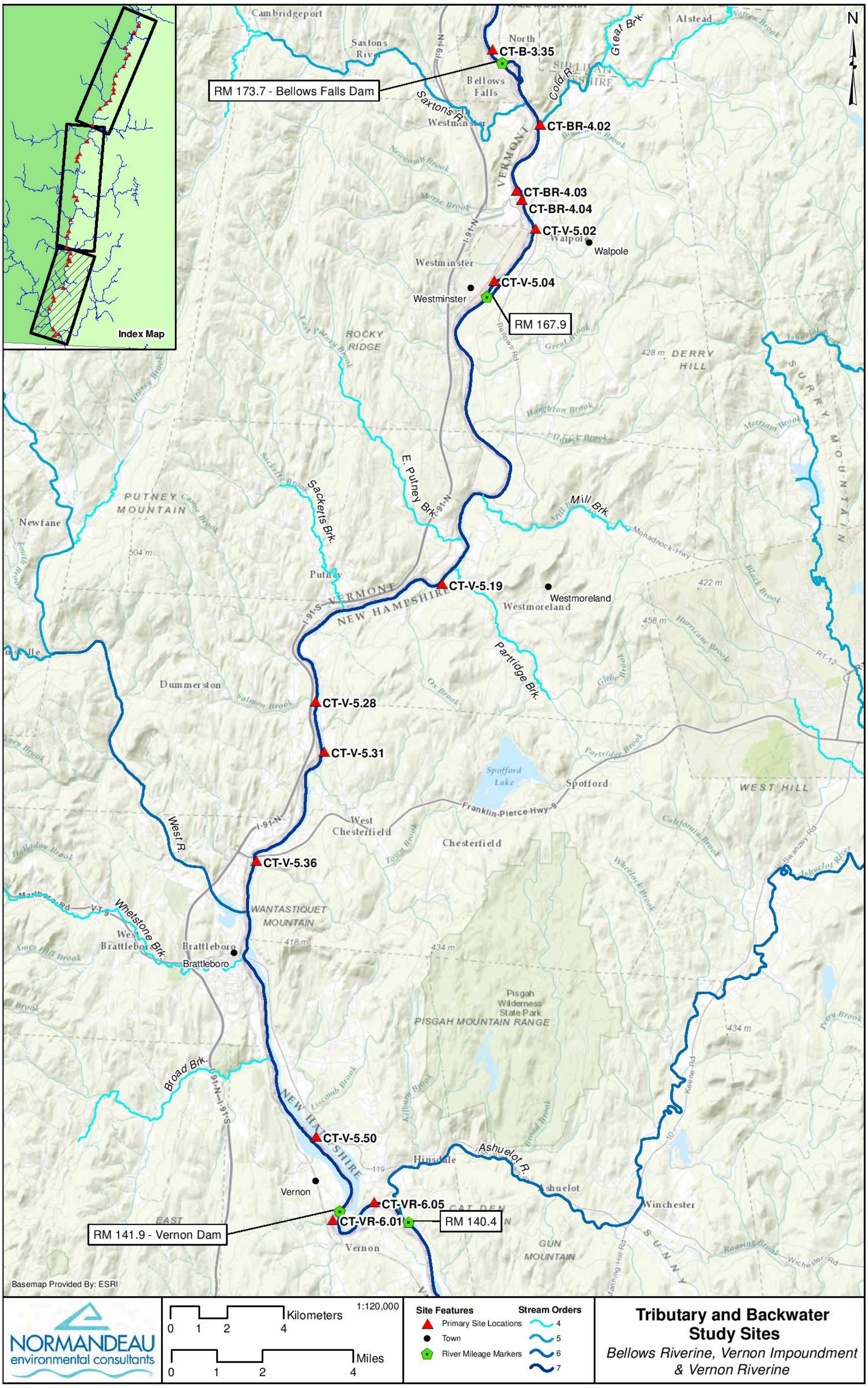
Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Coordinates	
CT-V-5.28	Vernon	Major Trib	Salmon Brook	3	-72.526038	42.933915
CT-V-5.31	Vernon	Minor Trib		2	-72.521983	42.918029
CT-V-5.36	Vernon	Minor Trib		2	-72.550993	42.882986
CT-V-5.50	Vernon	Backwater		0	-72.523771	42.795522
CT-VR-6.01	Vernon Riverine	Minor Trib		2	-72.516318	42.768916
CT-VR-6.05	Vernon Riverine	Minor Trib		1	-72.498398	42.774687

Figure 3-1. Tributary and backwater study locations.





RM 217.4 - Wilder Dam
CT-WR-2.01
White River Junction
Lebanon
Great Brk.
Mascoma R.
Ottauquechee R.
CT-WR-2.07
Bloods Brk.
Index Map
Hartland
CT-WR-2.10
CT-WR-2.11
CT-WR-2.13
Windsor
Mill Brk.
Mill Brk.
RM 199.7
N. Branch Sugar R.
Ascutney
CT-B-3.07
Sugar R.
CT-B-3.10
Black R.
Little Sugar R.
CT-B-3.19
Clay Brk.
Charlestown
Williams R.
CT-B-3.24
CT-B-3.27
Hackett Brk.
Great Brk.
Cold R.
Saxtons R.
CT-B-3.35
RM 173.7 - Bellows Falls Dam
Basemap Provided By: ESRI
N
NORMANDEAU
environmental consultants
Kilometers
0 1.5 3 6
1:158,000
Miles
0 1.5 3 6
Site Features
Primary Site Locations
Town
River Mileage Markers
Stream Orders
4
5
6
7
Tributary and Backwater Study Sites
Bellows Falls Impoundment & Wilder Riverine


Index Map
N
CT-B-3.35
RM 173.7 - Bellows Falls Dam
CT-BR-4.02
CT-BR-4.03
CT-BR-4.04
CT-V-5.02
Walpole
Westminster
CT-V-5.04
RM 167.9
Saxtons R.
Cold R.
Great Brk.
E. Putney Brk.
Sackets Brk.
Mill Brk.
CT-V-5.19
Westmoreland
Partridge Brk.
CT-V-5.28
CT-V-5.31
West R.
CT-V-5.36
Whetstone Brk.
Brattleboro
Broad Brk.
CT-V-5.50
Ashuelot R.
Vernon
CT-VR-6.05
CT-VR-6.01
RM 140.4
RM 141.9 - Vernon Dam
Basemap Provided By: ESRI
NORMANDEAU
environmental consultants
1:120,000
Kilometers
0 1 2 4
Miles
0 1 2 4
Site Features
Primary Site Locations
Town
River Mileage Markers
Stream Orders
4
5
6
7
Tributary and Backwater Study Sites
Bellows Riverine, Vernon Impoundment & Vernon Riverine

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4.0 METHODOLOGY

4.1 Field Sampling

Each site was first visited during July or August 2014. During the initial site visit, two HOBO level loggers (vertical accuracy of ±0.1 inch) were installed at each selected location and programmed to collect temperature and pressure information at 15-minute intervals. One level logger was installed within the tributary or backwater of interest and the second was located in the mainstem river, adjacent to the study site of interest. During installation, the exact position of each unit (latitude, longitude and elevation relative to the project structures) was recorded using a Leica GS-14 Real Time Kinematic (RTK) unit. Level loggers were maintained at their set elevations by being placed inside a perforated well pipe structure affixed to a piece of ¾-inch rebar and set vertically into the bottom substrate (Figure 4.1-1). Barometric reference loggers were installed over the study reach for use in processing water level logger data collected at the mainstem, tributary, and backwater locations.

Bed elevation information was collected at each site during the initial site visit at (1) a single cross section placed at the apparent confluence of the tributary or backwater and the mainstem river, and (2) along the thalweg of the tributary/backwater within the apparent project-affected area. The approximate extent of the project-affected area was determined visually by the survey crew during the initial visit. The visual examinations looked for areas that were obviously subjected to wetting due to fluctuations as well as water lines on tributary or backwater bankings or abutments, culvert pipes, large boulders, bank vegetation, and the like that indicated the predominant water surface elevation.

Bed elevation points were collected using the Leica RTK unit where coverage was available and by the use of a Topcon level and stadia rod referenced to a bench mark with a known elevation in areas where RTK coverage was unavailable (i.e., beneath heavy tree canopy). Water quality data was collected at locations generally near the midpoint of the project-affected reach and included temperature, dissolved oxygen, pH, conductivity and turbidity, using handheld meters which calibrated at the beginning of each day. At locations with a water depth of greater than three feet, water quality data w were collected in the form of vertical profiles (surface, mid, bottom). At locations with less than three feet of water depth, a single water quality measurement was made at approximate mid-depth. A series of geo-referenced photographs was taken at each location during the initial visit.

Each site was then visited once monthly during August and September, with a final visit during October or November 2014. Following each download, the level logger was returned to the well pipe. The “pull” and “set” times bracketing the period of time the level logger was out of water were recorded. The same suite of parameters recorded during the initial site visit was also collected (i.e., date-time of visit, cross section water depths at the confluence with mainstem, water quality parameters, and condition photographs). During the final visits, level loggers were removed from the well pipe holding structure and data were downloaded to a laptop computer loaded with HOBOware Pro Software.

4.2 Data Processing

Level logger data files were downloaded and imported into HOBOware Pro Software for air pressure compensation. Sensor depths at each 15-minute interval were determined based on the relationship between recorded pressure values at the in-water level logger and in-air barometric reference location. Following determination of water depth values, each individual record was assigned a use code that defines its collection status and subsequent use in analytical tasks (Table 4.2-1). Water level logger data in Excel format and updated geodata files (in ArcGIS and kmz format) are included as part of this study report.

Data sheets containing all field recorded parameters (e.g., water quality, level logger pull and set information, bed elevations, etc.) were collected and data was keypunched and then subjected to a QC inspection to assure a 1% AOQL (Average Outgoing Quality Limit) according to a lot sampling plan (ASQL 1993). This procedure ensures that ≥99% of the observations in a data file agree with the original data sheets. The number of observations to be checked, and the number of those that must be within tolerance are presented in Table 4.2-2. If more than the acceptable number of failures is found then the data set must be inspected 100%.

Figure 4.1-1. Installation set-up used for HOBO water level loggers.

Table 4.2-1. Use code definitions for HOBO water level logger data.

Use Code	Description
1	Valid for all analytical tasks
2	Logger out of water (act of downloading)
3	Logger out of water (not yet deployed)
4	Sensor potentially out of water (based on depth readings)
5	Sensor depth exceeds reported instrument range
6	Manually flagged during data review: bad pressure data due to malfunction
7	Manually flagged during data review: ice formation in sensor
8	Manually flagged during data review: ice formation in barometer
9	Manually flagged after time series review

Table 4.2-2. Lot sampling plan for QC inspection at less than 1% AOQL.

Lot Size	Sample Size	Number of Failures	
		Accept if ≤	Reject if ≥
1-32	ALL	0	1
33-500	32	0	1
501-3,200	125	1	2
3,201-10,000	200	2	3
10,001-35,000	315	3	4
35,001-150,000	500	5	6
150,001-500,000	800	7	8
500,001 and over	1,250	10	11

5.0 RESULTS AND DISCUSSION

All 37 study sites were visited 3 or 4 times from late July to late October or mid-November, 2014. During each site visit, water quality data was collected, water depth was measured, and representative photographs were taken. Water level loggers were downloaded and replaced if found to be missing or apparently malfunctioning.

This study was conducted from late July to mid-November 2014, encompassing the late summer-early fall time period when natural tributary flows are typically lower than levels encountered during the spring. The majority of movement for fish present in the mainstem Connecticut River into tributary and backwater habitats is likely to occur during the spring spawning period (April-June). This includes backwater spawning species such as Northern Pike, Chain Pickerel, Largemouth Bass, and Pumpkinseed, tributary confluence spawners such as White Sucker, Walleye, and Smallmouth Bass, and anadromous migrants such as Sea Lamprey which may move upstream into larger tributaries. Only Rainbow Trout, a non-native salmonid stocked for recreational purposes, would potentially spawn during the fall. Juvenile American Shad are likely to use backwater habitat as nursery areas prior to fall outmigration. American Eels may move into (mostly larger) tributaries for their freshwater life stage, but can access tributaries in very low water levels.

Portions of the 2014 study season were also somewhat drier than normal. Monthly precipitation data is collected by TransCanada at Comerford Station (at the Fifteen Mile Falls project located about 58 river miles upstream of Wilder Station) and at Bellows Falls Station. July was wetter than the 10-year average at both locations. August and September had much lower precipitation than the 10-year average as recorded at Comerford (43.6% and 84.3%, respectively), while October and November were well above average there. At Bellows Falls, August had slightly above average precipitation (102.5%), while September, October, and November were all below the 10-year average for precipitation (40.4%, 88.3%, and 66.8%, respectively).

5.1 Water Level Logger Data

Table 5.1-1 provides a summary of the installation, site visitation, and removal dates for level loggers at all 37 study sites, as well as notes on water level logger data associated with the sites. During the course of the study, there were fourteen instances of missing data from mainstem or tributary/backwater level loggers. The majority of those instances were due to either vandalism or missing equipment. Two level loggers stopped recording for unknown reasons following their initialization and deployment in the field. All units that malfunctioned, were found missing, or were vandalized were replaced immediately upon discovery. However, there remain some data gaps at some sites. For instance, at this time there is no mainstem level logger data associated with the Cold River (site CT-BR 4.02). Mainstem data for that site was to be collected from a water level logger that had been overwintered in 2013 to 2014. Divers were unable to search for and retrieve that logger in early summer but presumed it to be in place and operational. When the level logger was searched by divers in October it was found to be missing and a replacement unit was installed. However, data from October 10 through the last site visit on November 10 may become available after 2015 spring high flows when divers will attempt to retrieve the level logger which is being overwintered again from 2014 to 2015.

Three level loggers had bad data discovered during post-season data processing. In these cases, following correction of recorded air pressure values, data was plotted and the results were visually examined for potential outliers. In some instances, air pressure values recorded by these level loggers resulted in plotted sensor water depths far exceeding the expected normal range for a particular location, and as a result the data was assigned a Use Code of 9 (in Table 4.2-1).

Because missing or invalid WSE data from mainstem and/or tributary/backwater site limited the period of analysis at some sites, the WSE-based data presented herein for those sites may not be truly representative of site conditions over the entire study season. WSE data from mainstem level loggers located in the vicinity of the site of interest (e.g., related to other nearby study sites) was reviewed for use as surrogate data. In all cases, the distances and the change in longitudinal gradient of the mainstem between sites precluded the reasonable use of surrogate data.

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Table 5.1-1. Summary of site visits and level logger data notes.

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Initial Visit	2nd Visit	3rd Visit	Last Visit	Level Logger Notes
CT-W-1.01	Upper Wilder	Minor Trib	Harriman Brook	2	08/04	08/26	09/25	11/04	
CT-W-1.05	Upper Wilder	Backwater		0	08/04	08/26	09/25	11/04	
CT-W-1.06	Upper Wilder	Minor Trib		2	08/04	08/26	09/25	11/04	Site logger post-processing found bad data. Data available from 08/04 – 08/26. Mainstem logger found missing on 11/04. Data available from 08/04 – 09/25.
CT-W-1.16	Upper Wilder	Backwater		0	08/06	08/26	09/25	11/04	
CT-W-1.22	Middle Wilder	Major Trib	Indian Pond Brook	3	08/06	08/26	09/25	11/04	Site logger malfunction, data available from 08/26 – 11/04. Mainstem logger found missing on 11/04. Data available from 08/04 – 09/25.
CT-W-1.23	Middle Wilder	Minor Trib		1	08/05	08/26	09/25	11/05	Site logger malfunction, data available from 08/10 – 11/05.
CT-W-1.28	Middle Wilder	Backwater		0	08/05	08/25	09/25	11/05	
CT-W-1.34	Middle Wilder	Minor Trib		2	08/05	08/25	09/25	11/05	Site logger post-processing found bad data. Data available from 08/05 – 08/26.
CT-W-1.44	Middle Wilder	Backwater		0	08/05	08/26	09/25	10/10	
CT-W-1.47	Lower Wilder	Minor Trib		1	07/24	08/25	09/25	11/03	
CT-W-1.48	Lower Wilder	Major Trib	Grant Brook	3	07/25	08/26	09/25	11/06	
CT-W-1.55	Lower Wilder	Minor Trib		1	07/24	08/25	09/24	11/06	Mainstem logger removed 10/20
CT-W-1.59	Lower Wilder	Backwater		0	07/23	08/26	09/24	10/20	Mainstem logger installed 07/24
CT-W-1.67	Lower Wilder	Minor Trib		2	07/22	08/25	09/24	10/20	

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Initial Visit	2nd Visit	3rd Visit	Last Visit	Level Logger Notes
CT-WR-2.01	Upper Wilder Riverine	Minor Trib		2	07/23	08/28	09/23	11/06	Site logger missing, replaced 08/28, data available from 08/28 – 11/06.
CT-WR-2.07	Upper Wilder Riverine	Minor Trib	Hanchetts Brook	1	07/22	08/28	09/23	11/06	Site logger missing, replaced 08/28, data available 08/28 – 11/06. Mainstem logger found missing on 11/06, data available from 07/22 – 09/23.
CT-WR-2.10	Lower Wilder Riverine	Minor Trib	McArthur Brook	2	09/02	09/24	n/a	11/07	
CT-WR-2.11	Lower Wilder Riverine	Major Trib	Lulls Brook	3	08/28	09/24	n/a	11/07	
CT-WR-2.13	Lower Wilder Riverine	Minor Trib	Bashan Brook	1	07/22	08/28	09/24	11/07	Site logger found out of stream flow due to site tampering on 08/28, data available 08/28 – 11/07
CT-B-3.07	Bellows	Major Trib	Barkmill Brook	3	07/28	08/27	09/22	11/07	
CT-B-3.10	Bellows	Minor Trib		1	08/03	08/27	09/22	11/07	Mainstem logger missing on 08/27, replaced. Data available 08/27- 11/07
CT-B-3.19	Bellows	Backwater		0	07/27	08/27	09/23	11/08	
CT-B-3.24	Bellows	Major Trib	Commissary Brook	3	07/27	08/27	09/23	11/08	
CT-B-3.27	Bellows	Minor Trib		2	07/26	08/27	09/23	11/08	
CT-B-3.35	Bellows	Minor Trib		2	07/26	08/27	09/23	11/08	

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	Initial Visit	2nd Visit	3rd Visit	Last Visit	Level Logger Notes
CT-BR-4.02	Bellows Riverine	Major Trib	Cold River	5	07/21	08/27	09/22	11/10	The existing mainstem logger which had been overwintered in 2013/2014 was not searched for by divers in early July, due to increased flows which cut short overwintered logger retrieval. However, it was presumed to be still in place. The logger was searched for by divers on 10/09/2014 and found to be missing at that time. It was replaced and is being overwintered again in 2014/2015. Data after 10/09 will not be available until unit can be successfully retrieved and downloaded in spring 2015.
CT-BR-4.03	Bellows Riverine	Minor Trib		2	08/11	09/10	n/a	11/09	
CT-BR-4.04	Bellows Riverine	Major Trib	Cobb Brook	3	08/11	09/10	n/a	11/09	
CT-V-5.02	Bellows Riverine/ Vernon	Minor Trib	Mad Brook	2	08/08	09/08	n/a	11/08	Site logger post-processing found some bad data. No mainstem data available.
CT-V-5.04	Vernon	Major Trib		3	08/07	09/09	n/a	11/11	Mainstem logger removed by vandalism and retrieved by police dept. Replaced on 09/22. Data available 08/07 – 09/09 and 09/22 – 11/11.
CT-V-5.19	Vernon	Minor Trib		1	08/06	09/09	n/a	11/11	
CT-V-5.28	Vernon	Major Trib	Salmon Brook	3	08/07	09/09	n/a	11/10	
CT-V-5.31	Vernon	Minor Trib		2	08/07	09/09	n/a	11/11	
CT-V-5.36	Vernon	Minor Trib		2	08/07	09/09	n/a	11/10	
CT-V-5.50	Vernon	Backwater		0	08/07	09/09	n/a	10/21	
CT-VR-6.01	Vernon Riverine	Minor Trib		2	08/12	09/09	n/a	11/11	
CT-VR-6.05	Vernon Riverine	Minor Trib		1	08/12	09/09	n/a	11/11	

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5.2 Summary of Site Conditions

Site conditions and key observations are summarized in Table 5.2-1. This information is further described in Section 5.3 and detailed for each site in Appendix A. The range of water depths measured during site visits at the deepest point in the confluence cross-section, and notes and observations related to tributary/backwater access limitations are presented.

Project-affected reach was estimated by extending the maximum mainstem WSE recorded during normal operating conditions (e.g., non-spill periods) up into the tributary or backwater to the thalweg point where that value was first reached. There were occasional periods of non-operational high water during the study period that resulted in spillage at one or more of the projects, including over short periods in late July, mid-August, and late October. WSE data recorded during those time periods is outside the range of TransCanada's project operations. The maximum mainstem WSE recorded (as described in Appendix A) includes such high flow periods (where applicable for the period of data record at each site) and these data were excluded from the determination of project-affected reach length. Further analysis to determine the primary driver for water surface elevations in the Upper Wilder impoundment is necessary and will require the hydraulic model (Study 4) and/or comparison of upstream USGS gage data and Wilder dam elevation data with site specific water level logger WSE data. Preliminary results from the hydraulic model suggest upstream inflow has a significant influence on WSE in the Upper Wilder reach.

At some small tributaries, the project-affected reach is very short, less than 200 feet. At numerous sites, regardless of length, the project-affected reach and/or water access may be restricted by culverts, debris, blockages, or naturally shallow areas that may limit mainstem water inundation within the tributaries or backwaters. Some of the smaller order tributaries had low naturally occurring outflows based on visual observations and/or tributary level logger data, and one of those sites (CT-WR-2.10, McArthur Brook) had no natural outflow on 2 of the 3 site visits.

Water surface elevation at the confluence cross section in conjunction with thalweg bed elevation data determine if, how often, and how far up into the tributary or backwater the mainstem river influence is present. The project-affected reach was first determined in the field based on visual evidence. The extent of project effects was later estimated by extending the maximum WSE value recorded under normal (non-spill) operations by the mainstem level logger upstream to the point along the tributary thalweg profile where that elevation was first achieved. In some cases, WSE data later showed that the project-affected reach length was different (either longer or shorter) than visually estimated and upon which the tributary or backwater thalweg bed elevation was determined.

Summaries, WSE and bed elevation plots, and photographs of the available data recorded at each study site are presented in Appendix A. Summary figures (two pages including photographs) for each site consist of the following:

- **Plot map**: Presents the geo-referenced location of the mainstem and tributary/backwater level loggers, each identified by serial number, installed at each sampling location.
- **Water Surface Elevation Time Series**: Presents a time series plot for calculated WSE as recorded by mainstem and study site level loggers (i.e., "tributary"). WSE values were calculated as the sum of the measured level logger bed elevation at the pressure sensor and the sensor depth values compensated for atmospheric pressure near ground level.
- **Cross-section Elevation Plot**: Presents bed elevation data for a cross-section located across the tributary/backwater of interest in the vicinity of the confluence with the mainstem. The minimum and maximum WSE values calculated from level logger depths recorded during the period of record by the mainstem level logger are overlaid (dashed blue line). Likewise, the median (solid blue line) WSE value is also displayed. The plot is drawn at scale for readability.
- **Mainstem Logger WSE Summary**: tabular presentation of the average, minimum, maximum, 25th, 50th, and 75th percentile of WSE values calculated based on sensor depth information collected by the mainstem level logger (may include non-project related high flow periods).
- **Thalweg Elevation Plot**: Presents bed elevation data along the thalweg from the vicinity of the visually-determined confluence upstream and through the project-affected reach. In some cases the thalweg plot extends further into the mainstem than the location of the cross section, based on the actual mainstem water's edge observed on the initial site visit. The location of the cross section and approximate extent of the project-affected reach are indicated. The minimum, maximum (vertical red line) and median (red open circle) WSE values calculated based on compensated sensor depth readings from the tributary/backwater level logger are displayed at the level logger location. The distance along the thalweg (i.e., distance in feet from confluence) was estimated from the cumulative sum of point-to-point distances between bed elevation readings. The plot is drawn at scale for readability.
- **Tributary Depth Frequency Distribution**: Presents the frequency distribution of calculated water depth values (ft) at the location of the tributary/backwater level logger data.
- **Tributary Logger WSE Summary**: tabular presentation of the average, minimum, maximum, 25th, 50th, and 75th percentile of WSE values calculated based on sensor depth information collected by the tributary/backwater level logger.
- **Water Depths**: Maximum measured water depths at the confluence cross section from field measurements taken during site visits, and tributary/backwater water depths calculated from sensor depth information collected at the tributary/backwater level logger are displayed next to the cross section and thalweg plots.

- **Site Photographs**: Presents a series of representative time-stamped photographs from the site confluence cross section and at culverts upstream from the confluence taken during each of the monthly site visits. With the exception of photographs presented to highlight instream features (e.g., culverts, downed trees, etc.) the majority of photographs presented were taken at or near the confluence of the tributary or backwater with the mainstem Connecticut River.

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Table 5.2-1. Project-affected reach length, confluence cross-section water depth, notes and observations from site visits.

Site #	Waterbody Name	Stream Order	Project-affected Reach (ft)	Observed Max. Depth Range (ft) at Confluence	Site Observations
CT-W-1.01	Harriman Brook	2	128	0.8 – 1.4	Beaver dam present.
CT-W-1.05		backwater	2119	1.2 – 2.3	Downed trees and branches, sediment limit depth at access channel.
CT-W-1.06		2	136	0.5 – 1.0	Culvert present, limited suitable habitat observed.
CT-W-1.16		backwater	416	1.0 – 1.5	Shallow areas observed in backwater access channel.
CT-W-1.22	Indian Pond Brook	3	1114	1.5 – 4.2	Downed logs, scour hole observed.
CT-W-1.23		1	263	0.1 – 1.6	Shallow, shoaled area observed.
CT-W-1.28		backwater	1285	5.6 – 7.2	Shallow areas observed.
CT-W-1.34		2	322	0.5 – 1.9	Shallow margins observed (November visit)
CT-W-1.44		backwater	1391	8.8 – 9.8	Culvert present, upper feeder stream is limited to natural outflow.
CT-W-1.47		1	683	1.9 – 2.9	Scour hole observed near confluence.
CT-W-1.48	Grant Brook	3	3338	5.7 – 6.6	Thalweg bed elevation variable.
CT-W-1.55		1	402	1.5 – 3.1	Downed trees and branches, thalweg bed elevation variable.
CT-W-1.59		2	1689	2.1 – 2.9	Culvert present with debris loading on culvert's chain link fence.
CT-W-1.67		2	804	5.3 – 6.7	Culvert present, variable thalweg bed elevation. A farm water withdrawal is present.
CT-WR-2.01		2	45	0.2 – 0.7	Perched culvert observed.
CT-WR-2.07	Hanchetts Brook	1	-1[1]	0.3 – 0.4	Downed trees and branches observed.
CT-WR-2.10	McArthur Brook	2	160	0 – 2.0	Intermittent stream, no outflow on 2 of 3 visits.
CT-WR-2.11	Lulls Brook	3	688	0.6 – 1.7	Variable thalweg profile, debris and scour/ deposition present.
CT-WR-2.13	Bashan Brook	1	-9[2]	0.1 – 0.4	Manmade blockages observed.

Site #	Waterbody Name	Stream Order	Project-affected Reach (ft)	Observed Max. Depth Range (ft) at Confluence	Site Observations
CT-B-3.07	Barkmill Brook	3	113	0.6 – 1.3	Culvert present, shoaled area observed.
CT-B-3.10		1	117	0.7 – 1.7	Debris, shallow areas observed.
CT-B-3.19		backwater	2252	2.9 – 5.3	Shallow littoral margins observed.
CT-B-3.24	Commissary Brook	3	455	1.0 – 2.1	Downed trees and branches, thalweg profile variable.
CT-B-3.27		2	2422	5.1 – 6.4	Thalweg profile variable.
CT-B-3.35		2	64	3.6 – 4.4	Culvert present, thalweg profile variable.
CT-BR-4.02	Cold River	5	900[3]	0.8 – 2.9	Cobble observed to have shifted between visits.
CT-BR-4.03		2	254	0.1 – 2.6	Downed trees and branches observed.
CT-BR-4.04	Cobb Brook	3	535	1.4 – 2.2	Culvert, downed trees and branches present.
CT-V-5.02	Mad Brook	2	80[3]	0.7 – 1.1	Perched culvert present.
CT-V-5.04		3	157	1.2 – 1.9	Downed trees and branches, shallow thalweg profile near confluence.
CT-V-5.19		1	99	0.1 – 0.8	Thalweg profile varies.
CT-V-5.28	Salmon Brook	3	169	1.2 – 1.7	Culvert present.
CT-V-5.31		2	78	0.3 – 1.0	Culvert present, thalweg profile varies.
CT-V-5.36		2	275	0.7 – 1.9	Culvert and retaining wall present.
CT-V-5.50		backwater	4989	6.3 – 10.3	Some shallow areas and shallow littoral margins observed, thalweg profile varies.
CT-VR-6.01		2	125	0.2 – 0.4	Downed trees and branches present.
CT-VR-6.05		1	165	0.1 – 0.3	Downed trees and branches present.

1. CT-WR-2.07 project-affected reach determined by WSE data to be 1 ft closer to mainstem than the visually determined confluence location.
2. CT-WR-2.13 project-affected reach determined by WSE data to be 9 ft closer to mainstem than the visually determined confluence location.
3. Sites CT-BR-4.02 and CT-V-5.02 project-affected reaches are based on visual determination only, not WSE data.

5.3 Water Quality

Water quality parameters were collected at each study site in a location approximately mid-way in the visually determined project-affected reach (rather than at the confluence cross section location) to better reflect the tributary/backwater conditions. Water quality data included temperature (^oC), pH, conductivity (µS/cm), turbidity (NTU), DO (mg/L), and DO saturation (%). All measurements were taken with handheld field meters and data represent instantaneous readings. Table 5.4-1 presents the results of water quality sampling conducted at each site on each visit date. Table notes indicate the tributaries identified by each state as being water quality impaired in the most recent Section 303(d) List of Impaired Waters state submittals to the US Environmental Protection Agency. Both states have numeric water quality standards for pH and DO, but only narrative criteria for the other parameters measured.

Table 5.4-2 presents water quality data at the two sites (VR-6.01 and VR-6.02) that had been potentially affected by VY operations. Data was collected in 2014 while VY was still operating, and in 2015 after VY's closure, as requested by stakeholders during the final study plan modification process in late 2013 (see Section 1.0).

Temperature

Temperature in all tributaries and backwaters ranged from 3.6 to 27.5^oC over the course of the study (late July to mid-November). In keeping with naturally occurring seasonal temperature differences, of the 36 temperature readings below 10^oC (50^oF), all but 3 occurred in the November sampling round. Similarly, of the 41 temperature readings above 20^oC (68^oF), all but 3 occurred from July 21 – August 22.

pH

Approximately 39% of all pH measurements in tributaries and/or backwaters were lower than then New Hampshire and Vermont state standards of 6.5 standard units (su) for Class B waters (highlighted in pink in Table 5.4-1). Approximately 59% of all pH measurements were within state standards. In 3 sampling instances (less than 2% and highlighted in blue in Table 5.4-1), pH readings were higher than the New Hampshire standard of 8.0 su, with 2 of those instances also higher than the Vermont standard of 8.5 su. There were no apparent trends related to the few high pH values. All of the pH measurements at site CT-W-1.22 (Indian Pond Brook) were below 6.5 su. Several sites had pH measurements less than 6.5 su in the majority of sampling rounds. Chronic low pH is common throughout New Hampshire and Vermont in smaller streams whose watersheds are dominated by wetlands and organic material. Episodic low pH is also quite common in New Hampshire and Vermont and is usually associated with acidic precipitations event or period of snowmelt. High pH is usually associated with algal growth.

Conductivity

Conductivity measurements across all sites and sampling rounds ranged from 18 to 466 µS/cm. Twenty-eight percent of conductivity measurements were less than

100 µS/cm; 53% were between 100 and 200 µS/cm; and 19% were greater than 200 µS/cm. Sites CT-WR-2.01 and CT-B-3.10 had the highest conductivity readings and some other sites had consistently higher readings than other sites, but no other general trends were apparent. Conductivity is generally related to the type of bedrock and associated soils that are found in the watershed. Relatively higher conductivity is often associated with calcareous bedrock and soils while lower conductivity is commonly found in granitic bedrock and soils. In streams closely associated with highways or in urban settings, elevated conductivity is often associated with sodium chloride.

Turbidity

Turbidity measurements across all sites and sampling rounds ranged from less than 1 to 265 NTU, with 134 readings (88%) less than 10 NTU. Four turbidity readings (approximately 3% of the total) were greater than 50 NTU, with 2 of those readings greater than 250 NTU. Elevated turbidity levels are generally related to precipitation events and associated sediment movement. Instream construction or logging activities can also lead to short-term increases in turbidity.

Dissolved Oxygen

Dissolved oxygen remained within New Hampshire and Vermont Class B water quality standards at most sites and in most sampling rounds with only a few instances of measurements outside of one or both state standards. In 3 sampling instances, instantaneous DO measured in mg/l was lower than New Hampshire’s 5.0 mg/l instantaneous standard and in 3 more sampling instances, lower than Vermont’s 6.0 mg/l standard. In all 6 instances (3.5% of all samples), DO % saturation was also lower than the Vermont standard of 70% for cold water habitat. New Hampshire’s 75% DO saturation standard is a daily average numerical standard, while the data collected in this study was instantaneous, so the New Hampshire DO % saturation standard is not applicable for this study. There was one additional sampling instance where DO measured in mg/l met both state standards, but the % saturation measurement was below the Vermont standard for cold water habitat. Four of the six low DO readings occurred at a single site (CT-B-3.27, a stream order 2 tributary), with 3 instances on the same day (surface, mid and bottom samples). These data are highlighted in yellow in Table 5.4-1.

Table 5.4-1. Summary of water quality data collected in 2014 at tributary and backwater sites.

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH[1]	Conductivity (µS/cm)	Turbidity (NTU)	DO[2] (mg/L) instan.	DO[2] (%) instan.
CT-W-1.01	Wilder	Harriman Brook	2	4-Aug-14	Mid	1.2	18.9	6.2	149	7.3	8.8	95.3
				26-Aug-14	Mid	1.0	21.9	7.0	177	4.2	8.6	98.1
				25-Sep-14	Mid	0.6	11.4	6.0	262	6.5	10.2	93.3
				4-Nov-14	Mid	1.0	3.6	5.8	139	265.0	13.6	103.1
CT-W-1.05	Wilder	backwater	0	4-Aug-14	Mid	1.0	23.4	5.7	83	2.7	7.9	94.3
				26-Aug-14	Mid	1.0	22.4	6.8	85	2.1	7.1	82.2
				25-Sep-14	Mid	2.4	17.3	5.4	85	2.4	8.9	92.4
				4-Nov-14	Mid	1.6	7.3	5.6	81	2.5	10.6	87.8
CT-W-1.06	Wilder		2	4-Aug-14	Mid	0.7	19.2	6.1	146	6.4	9.0	97.2
				26-Aug-14	Mid	1.0	17.9	6.9	192	1.8	10.0	105.0
				25-Sep-14	Mid	0.7	10.0	7.5	225	3.2	10.9	96.5
				4-Nov-14	Mid	0.5	6.1	5.8	177	1.8	13.0	108.1
CT-W-1.16	Wilder	backwater	0	6-Aug-14	Mid	1.0	22.0	8.8	112	3.2	7.5	85.2
				26-Aug-14	Mid	1.0	22.5	7.2	90	2.0	6.5	74.4
				25-Sep-14	Mid	2.8	17.0	6.4	86	3.0	9.2	95.7
				4-Nov-14	Mid	0.9	6.7	5.8	95	2.1	12.1	98.7
CT-W-1.22[3]	Wilder	Indian Pond Brook	3	6-Aug-14	Mid	1.5	18.8	5.9	51	3.4	9.0	97.5
				26-Aug-14	Mid	1.0	18.1	6.3	70	1.2	8.7	92.1
				25-Sep-14	Surface	1.0	16.5	6.4	92	6.9	9.2	94.4
				25-Sep-14	Mid	3.0	12.2	6.3	82	-	10.2	94.6
				25-Sep-14	Bottom	5.0	11.6	6.3	80	-	10.2	93.9
				5-Nov-14	Mid	0.8	7.0	5.7	54	1.9	12.4	101.9
CT-W-1.23	Wilder		1	5-Aug-14	Mid	0.6	18.3	5.9	135	21.1	9.4	98.5
				26-Aug-14	Mid	1.0	23.5	6.8	98	6.7	8.0	91.2
				25-Sep-14	Mid	0.8	16.8	6.6	96	5.4	9.4	96.6
				5-Nov-14	Mid	0.1	7.3	5.8	146	2.5	11.5	95.9

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH[1]	Conductivity (µS/cm)	Turbidity (NTU)	DO[2] (mg/L) instan.	DO[2] (%) instan.
CT-W-1.28	Wilder	backwater	0	5-Aug-14	Mid	1.9	24.3	5.6	97	54.9	7.3	86.9
				25-Aug-14	Mid	1.5	26.8	7.0	85	2.6	7.8	98.1
				25-Sep-14	Surface	1.0	16.5	6.7	95	3.6	9.2	93.9
				25-Sep-14	Mid	2.0	16.8	6.6	96	3.6	9.1	93.7
				25-Sep-14	Bottom	4.0	16.2	6.6	103	3.6	8.1	82.8
				5-Nov-14	Mid	1.2	5.7	5.8	81	3.1	10.9	87.0
CT-W-1.34	Wilder		2	5-Aug-14	Mid	1.1	16.1	6.3	255	5.8	8.9	90.1
				25-Aug-14	Mid	1.0	18.1	6.5	351	2.6	7.9	83.6
				25-Sep-14	Mid	1.0	16.4	6.4	192	2.4	9.0	91.8
				5-Nov-14	Mid	0.2	9.1	6.1	370	4.5	10.0	87.0
CT-W-1.44	Wilder	backwater	0	5-Aug-14	Surface	1.0	21.3	9.1	146	1.8	6.8	78.5
				5-Aug-14	Mid	2.0	21.2	-	146	-	6.8	77.3
				5-Aug-14	Bottom	3.0	21.0	-	62	-	6.1	70.2
				26-Aug-14	Surface	1.0	20.6	7.4	128	2.2	7.6	84.9
				26-Aug-14	Mid	2.0	20.5	7.5	126	2.2	7.5	82.3
				26-Aug-14	Bottom	3.0	20.4	7.6	132	2.2	6.7	74.4
				25-Sep-14	Surface	1.0	16.6	6.6	120	14.4	9.2	94.1
				25-Sep-14	Mid	5.0	16.7	6.7	126	14.4	8.7	89.4
				25-Sep-14	Bottom	10.0	16.4	6.6	143	14.4	8.5	86.7
				20-Oct-14	Surface	1.0	13.4	6.5	98	4.7	9.1	87.6
				20-Oct-14	Mid	4.0	13.5	6.5	98	4.7	9.2	88.7
				20-Oct-14	Bottom	8.0	13.8	6.4	79	4.7	9.3	89.7
CT-W-1.47	Wilder		1	24-Jul-14	Mid	2.0	21.8	5.9	96	4.5	7.7	87.2
				25-Aug-14	Mid	1.0	20.3	6.3	135	1.5	8.6	95.0
				25-Sep-14	Mid	1.5	16.6	6.9	106	3.4	9.2	94.1
				3-Nov-14	Mid	2.0	6.1	5.8	99	4.1	10.1	81.8

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH[1]	Conductivity (µS/cm)	Turbidity (NTU)	DO[2] (mg/L) instan.	DO[2] (%) instan.
CT-W-1.48[4]	Wilder	Grant Brook	3	25-Jul-14	Mid	1.1	17.4	6.1	132	1.8	10.2	106.1
				26-Aug-14	Surface	1.0	18.8	7.1	120	-	7.1	76.1
				26-Aug-14	Mid	1.5	18.2	7.0	127	-	7.4	78.5
				26-Aug-14	Bottom	3.5	16.9	7.0	139	-	7.6	79.0
				25-Sep-14	Surface	1.0	16.7	6.5	119	3.0	8.9	91.7
				25-Sep-14	Mid	3.0	15.9	6.5	123	3.0	9.1	92.3
				25-Sep-14	Bottom	5.0	13.9	6.6	158	3.0	11.1	97.3
				6-Nov-14	Mid	1.3	5.6	6.1	127	2.4	12.5	99.0
CT-W-1.55	Wilder		1	24-Jul-14	Mid	2.3	19.1	6.5	172	2.6	8.3	89.5
				25-Aug-14	Mid	1.0	18.9	6.6	149	2.0	8.3	89.3
				24-Sep-14	Mid	1.2	16.6	7.3	103	1.8	9.1	92.9
				6-Nov-14	Mid	1.0	6.2	6.3	228	9.6	10.8	87.7
CT-W-1.59	Wilder	backwater	0	23-Jul-14	Mid	2.0	27.5	6.7	198	1.9	8.5	106.7
				26-Aug-14	Mid	1.0	21.3	7.7	192	1.4	8.0	89.5
				24-Sep-14	Mid	2.6	15.7	6.8	18	2.3	7.9	79.6
				20-Oct-14	Mid	1.7	12.5	6.3	267	2.5	8.1	76.1
CT-W-1.67	Wilder		2	22-Jul-14	Surface	1.0	23.8	6.1	142	2.7	9.1	107.4
				22-Jul-14	Mid	2.0	21.9	6.0	179	-	9.8	111.4
				22-Jul-14	Bottom	3.0	21.4	6.2	188	-	9.7	109.8
				25-Aug-14	Surface	1.0	22.3	6.2	172	2.1	7.8	89.4
				25-Aug-14	Mid	2.0	21.0	6.2	164	-	8.3	91.5
				25-Aug-14	Bottom	3.0	20.5	6.0	165	-	7.0	77.9
				24-Sep-14	Surface	1.0	15.7	7.0	124	-	8.7	87.1
				24-Sep-14	Mid	2.0	15.7	6.9	123	-	8.7	87.1
				24-Sep-14	Bottom	3.0	15.7	6.9	122	-	8.4	83.6
				20-Oct-14	Mid	2.0	12.4	6.3	123	7.7	6.9	65.1
CT-WR-2.01	Wilder Riverine		2	23-Jul-14	Mid	0.1	11.6	6.3	461	1.0	10.6	98.0
				28-Aug-14	Mid	0.8	11.0	6.7	462	1.1	11.0	99.6
				23-Sep-14	Mid	0.5	9.3	7.2	466	0.4	11.5	100.2
				6-Nov-14	Mid	0.6	8.7	6.6	462	29.0	11.6	100.2

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH[1]	Conductivity (µS/cm)	Turbidity (NTU)	DO[2] (mg/L) instan.	DO[2] (%) instan.
CT-WR-2.07	Wilder Riverine	Hanchetts Brook	1	22-Jul-14	Mid	0.5	16.1	7.1	127	1.9	9.3	94.6
				28-Aug-14	Mid	0.4	18.3	6.6	136	1.1	9.0	96.2
				23-Sep-14	Mid	0.3	10.3	7.0	149	0.5	10.8	96.2
				6-Nov-14	Mid	0.5	6.5	6.0	125	0.5	12.2	99.1
CT-WR-2.10[5]	Wilder Riverine	McArthur Brook	2	2-Sep-14	Mid	0.2	14.8	6.6	356	-	6.9	68.5
				7-Nov-14	Mid	1.1	6.9	6.2	309	0.3	12.4	102.5
CT-WR-2.11	Wilder Riverine	Lulls Brook	3	28-Aug-14	Mid	1.0	19.3	6.5	204	6.3	9.0	98.8
				24-Sep-14	Mid	1.2	12.4	7.6	288	0.9	11.8	110.8
				7-Nov-14	Mid	0.9	6.2	6.2	226	0.8	13.0	105.2
CT-WR-2.13	Wilder Riverine	Bashan Brook	1	22-Jul-14	Mid	0.5	18.0	7.1	297	4.3	9.5	100.4
				28-Aug-14	Mid	0.3	17.3	6.7	245	4.7	9.7	99.8
				24-Sep-14	Mid	0.2	13.3	7.2	388	1.2	11.1	106.3
				7-Nov-14	Mid	0.4	6.5	6.3	237	0.3	12.6	102.4
CT-B-3.07	Bellows Falls	Barkmill Brook	3	28-Jul-14	Mid	1.4	18.4	6.7	90	21.8	9.4	99.9
				27-Aug-14	Mid	1.0	16.8	7.5	158	0.7	7.9	81.1
				22-Sep-14	Mid	1.2	13.0	6.9	185	0.3	9.8	91.9
				7-Nov-14	Mid	0.3	5.9	6.1	127	0.6	12.9	103.4
CT-B-3.10	Bellows Falls		1	28-Jul-14	Mid	0.9	17.2	6.6	441	1.6	9.5	98.7
				27-Aug-14	Mid	1.0	14.5	7.1	241	0.5	8.5	82.4
				22-Sep-14	Mid	0.2	14.3	7.2	399	0.9	10.4	101.2
				7-Nov-14	Mid	1.3	6.9	6.3	404	0.3	11.7	96.0
CT-B-3.19	Bellows Falls	backwater	0	27-Jul-14	Mid	2.0	24.5	6.4	153	19.1	8.3	97.9
				27-Aug-14	Surface	1.0	22.4	7.5	131	3.1	7.5	85.5
				27-Aug-14	Mid	3.0	21.1	7.4	125	3.1	6.9	76.5
				27-Aug-14	Bottom	6.0	20.4	7.2	123	3.1	7.3	79.8
				23-Sep-14	Surface	1.0	17.4	7.3	158	4.0	8.9	92.5
				23-Sep-14	Mid	3.0	17.1	7.4	158	4.0	8.7	89.3
				23-Sep-14	Bottom	6.0	16.5	7.4	158	4.0	7.8	79.6
				8-Nov-14	Mid	1.4	5.1	6.4	132	4.6	12.6	98.4

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH[1]	Conductivity (µS/cm)	Turbidity (NTU)	DO[2] (mg/L) instan.	DO[2] (%) instan.
CT-B-3.24[6]	Bellows Falls	Commissary Brook	3	27-Jul-14	Mid	1.0	17.5	6.7	126	257.0	9.3	96.8
				27-Aug-14	Mid	1.0	18.4	7.5	172	2.0	8.9	95.2
				23-Sep-14	Mid	2.1	11.7	7.4	200	3.6	11.2	103.8
				8-Nov-14	Mid	0.8	5.2	6.5	147	1.1	13.7	109.0
CT-B-3.27	Bellows Falls		2	26-Jul-14	Mid	1.8	25.2	5.4	132	7.3	5.7	66.6
				27-Aug-14	Surface	1.0	24.1	6.7	129	16.3	5.7	67.7
				27-Aug-14	Mid	2.0	22.2	6.7	147	16.3	4.3	50.1
				27-Aug-14	Bottom	3.5	21.3	6.5	161	16.3	1.9	22.1
				23-Sep-14	Surface	1.0	18.8	7.4	140	4.7	8.3	89.1
				23-Sep-14	Mid	3.0	17.2	7.4	140	4.7	7.7	80.2
				23-Sep-14	Bottom	5.0	16.6	7.4	133	4.7	6.9	76.4
				8-Nov-14	Mid	1.2	6.7	6.5	108	12.7	10.1	82.0
CT-B-3.35	Bellows Falls		2	26-Jul-14	Mid	1.5	18.9	6.5	62	16.4	7.5	80.6
				27-Aug-14	Mid	1.0	22.8	7.0	84	3.9	8.0	93.5
				23-Sep-14	Mid	2.2	19.7	7.6	136	2.4	8.8	95.5
				8-Nov-14	Mid	1.6	7.3	6.0	55	4.8	11.6	96.6
CT-BR-4.02	Bellows Riverine	Cold River	5	21-Jul-14	Mid	1.0	21.9	5.7	70	1.1	11.2	127.4
				27-Aug-14	Mid	1.0	21.9	6.9	77	1.7	8.9	101.2
				22-Sep-14	Mid	1.1	15.7	6.3	91	1.7	10.1	101.6
				10-Nov-14	Mid	1.5	4.5	6.9	61	0.5	14.0	107.7
CT-BR-4.03	Bellows Riverine		2	11-Aug-14	Mid	0.7	14.9	5.0	320	31.3	2.1	20.8
				10-Sep-14	Mid	0.5	13.7	6.5	248	0.8	7.3	74.6
				9-Nov-14	Mid	0.8	7.0	6.4	206	9.7	9.2	76.3
CT-BR-4.04	Bellows Riverine	Cobb Brook	3	11-Aug-14	Mid	1.7	18.0	6.1	78	2.8	9.0	94.7
				10-Sep-14	Mid	1.9	14.7	7.2	91	3.1	9.8	96.9
				9-Nov-14	Mid	1.9	7.9	6.5	66	0.7	11.5	97.0
CT-V-5.02	Bellows Riverine/ Vernon	Mad Brook	2	8-Aug-14	Mid	1.6	18.4	-	188	3.9	8.2	87.0
				8-Sep-14	Mid	1.0	16.8	6.1	451	0.5	9.2	94.9
				8-Nov-14	Mid	1.5	6.8	6.5	279	1.3	12.3	101.1
CT-V-5.04	Vernon		3	7-Aug-14	Mid	1.5	18.8	6.0	278	9.0	8.1	87.6
				9-Sep-14	Mid	1.7	16.9	6.9	323	9.3	9.8	101.3
				11-Nov-14	Mid	1.4	6.3	7.6	279	4.2	11.8	96.0

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH[1]	Conductivity (µS/cm)	Turbidity (NTU)	DO[2] (mg/L) instan.	DO[2] (%) instan.
CT-V-5.19	Vernon		1	6-Aug-14	Mid	0.7	18.8	5.0	108	71.0	8.0	86.5
				9-Sep-14	Mid	0.6	16.5	6.2	145	2.1	6.5	64.5
				11-Nov-14	Mid	0.5	9.6	7.7	133	10.0	8.9	78.4
CT-V-5.28	Vernon	Salmon Brook	3	7-Aug-14	Mid	1.4	15.3	6.7	141	6.2	9.4	93.6
				9-Sep-14	Mid	1.2	15.3	6.7	146	0.6	10.7	107.1
				10-Nov-14	Mid	0.8	6.4	6.9	125	0.8	13.0	105.4
CT-V-5.31	Vernon		2	7-Aug-14	Mid	1.0	15.5	5.2	87	1.3	6.2	62.0
				9-Sep-14	Mid	0.9	16.7	5.8	82	0.7	6.9	70.8
				11-Nov-14	Mid	0.3	7.8	7.3	81	2.0	10.9	91.8
CT-V-5.36	Vernon		2	7-Aug-14	Mid	0.5	16.5	5.4	49	1.9	8.8	90.6
				9-Sep-14	Mid	0.4	15.6	6.3	60	0.7	10.3	103.5
				10-Nov-14	Mid	0.9	6.3	6.8	41	0.3	12.7	103.1
CT-V-5.50	Vernon	backwater	0	7-Aug-14	Surface	1.0	23.0	8.5	113	2.3	6.9	82.0
				7-Aug-14	Mid	2.5	22.5	-	115	-	6.8	81.5
				7-Aug-14	Bottom	5.0	22.0	-	119	-	6.4	75.0
				9-Sep-14	Surface	1.0	22.9	7.0	114	3.7	7.1	82.5
				9-Sep-14	Mid	4.0	22.4	6.7	117	3.7	7.1	81.4
				9-Sep-14	Bottom	8.0	22.1	6.7	125	3.7	5.9	67.1
				21-Oct-14	Surface	1.0	13.2	7.0	122	3.3	9.4	90.1
				21-Oct-14	Mid	3.0	13.2	6.9	120	3.3	9.1	87.2
				21-Oct-14	Bottom	6.0	13.2	6.9	121	3.3	8.7	82.9

1. Values of pH less than 6.5 are highlighted in pink; values greater than 8.0 are highlighted in blue.
2. Values for DO (mg/l) lower than 5.0 and values for DO (% saturation) lower than 70% are highlighted in yellow.
3. Site CT-W-1.22, Indian Pond Brook is the outlet of Indian Pond which is designated as impaired for pH (NHDES, 2012).
4. Site CT-W-1.48, Grant Brook has been identified as impaired based on fisheries bioassessments (NHDES, 2012).
5. Site CT-WR-2.10, McArthur Brook had no outflow on the 2 Sep site visit. Data was taken in a small standing pool in the stream channel.
6. Site CT-B-3.24, Commissary Brook has been identified as impaired for sediment due to bank failure and erosion from past clay mining (VTDEC, 2014).

Table 5.4-2. Summary of water quality data collected in 2014 and 2015 at tributary and backwater sites potentially affected by the closure of Vermont Yankee.

Site ID	Sub Reach	Waterbody Name	Stream Order	Date	Depth layer	Sample Depth (ft)	Temp. (°C)	pH[1]	Conductivity (µS/cm)	Turbidity (NTU)	DO (mg/L) instan.	DO (%) instan.
CT-VR-6.01	Vernon Riverine		2	12-Aug-14	Mid	0.7	9.6	5.9	73	1.7	12.1	106.2
				9-Sep-14	Mid	0.8	9.1	6.4	74	0.4	12.9	111.9
				11-Nov-14	Mid	1.1	7.1	7.1	73	0.5	12.5	103.4
				17-Jun-15	Mid	1.5	16.8	7.2	96	n/a[2]	108.6	10.6
				29-Jul-15	Mid	0.4	13.7	7.0	108	n/a[2]	113.8	11.8
				26-Aug-15	Mid	1.5	17.7	7.3	105	2.1	111.3	10.6
CT-VR-6.05	Vernon Riverine		1	12-Aug-14	Mid	0.4	15.6	5.8	180	n/a[2]	10.2	102.3
				9-Sep-14	Mid	0.4	13.6	6.9	192	6.1	11.1	107.2
				11-Nov-14	Mid	0.9	8.4	7.3	194	7.8	11.8	100.9
				17-Jun-15	Mid	1.5	18.3	7.3	98	n/a[2]	113.6	10.7
				29-Jul-15	Mid	0.5	22.9	7.0	142	n/a[2]	105.9	9.1
				26-Aug-15	Mid	0.5	16.5	7.7	182	53	124.0	12.1

1. Values of pH less than 6.5 are highlighted in pink; values greater than 8.0 are highlighted in blue.
2. Turbidity meter did not calibrate in the field, recorded values were suspect.

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6.0 ASSESSMENT OF PROJECT EFFECTS

Water-level fluctuations have the potential to create conditions that could impede the movement of fish between the Connecticut River and its tributaries and backwaters. These conditions, if present, could limit access to spawning and rearing habitat. Additionally, project-related, water-level changes could potentially alter water quality in these areas, which could decrease productivity. Water level changes in the project affected areas occur as a result of changes in natural flows, changes in flow and water levels due to upstream flow management at TransCanada projects, US Army Corps of Engineer Flood Control dams and other public and private dams, as well as by the operation of the Wilder, Bellows Falls and Vernon Projects. Assessment of project effects will rely upon associating observed changes in water levels at the study sites and specific project operations that are not otherwise caused by the influences stated above. Hydraulic model derived water level elevations at these locations based upon project operations will provide critical information in the assessment.

6.1 Water Depth and Fluctuation

Adequate access for fish to enter into tributaries and backwaters from the mainstem river was defined as water depths 0.5 ft or greater at the confluence cross section at least 75% of the time during the period of WSE data record (or conversely <0.5 ft less than 25% of the time). For sites that met these criteria, fish access was not considered to be adversely affected by project operations. As noted in Section 5.0, the observation period was limited for some sites due to missing or invalid level logger data; did not encompass the earlier spring season when most fish species would be likely to seek access to tributaries and backwaters for spawning and residency; and included the typically drier late summer/early fall months which in 2014 were drier than normal. Therefore, conditions at all study sites can reasonably be considered worst case.

6.1.1 Initial Assessment

The approximate percentage of time (occurrence of valid water level readings) < 0.5 ft of water depth at the confluence cross sections in the ranges of <25%, 25-49.9%, 50-74.9%, 75-99.9%, and 100% is summarized in Tables 6.1-1 (by study reach) and 6.1-2 (by stream order) and detailed for each site in Table 6.1-3. The majority of locations (27) had water depths less than 0.5 ft in the confluence cross section thalweg 25% or less of the time during the period of record (or greater than 0.5 ft. 75% of the time or more), including all backwater sites. Those sites met the initial assessment criteria, and it can be concluded that there is no likely adverse effect from water level fluctuations caused by project operations on fish access at those sites.

Occurrence of water depths < 0.5 feet or more at the confluence cross section more than 25% of the time (n = 8) were more predominant in smaller tributaries (i.e., stream order = 1 or 2) located within the riverine reaches. The 2 undetermined sites are CT-BR-4.02, Cold River and CT-V-5.02, Mad Brook and since there is no mainstem data available for these sites, the initial assessment could not determine whether the sites are or are not affected by water fluctuations caused by project operations. Further analysis will require application of the hydraulic model and its specific cross-sections in the vicinity of these study sites.

Table 6.1-1. Percentage of occurrence of < 0.5 ft water depth at the confluence, by study reach.

Reach	Total # Sites	Percentage of occurrence of confluence cross section water depth less than 0.5 ft.					
		0%	0-<25%	25-<50%	50-<75%	>75%	Undeter-mined
Wilder Impoundment	14	8	6				
Wilder Riverine	5	1			2	2	
Bellows Falls Impoundment	6	3	2		1		
Bellows Falls Riverine	3		1	1			1
Vernon Impoundment	7	1	5				1
Vernon Riverine	2			1	1		
All	**37**	**13**	**14**	**2**	**4**	**2**	**2**

Table 6.1-2. Percentage of occurrence of < 0.5 ft water depth at the confluence, by stream order.

Stream Order	Total # Sites	Percentage of occurrence of confluence cross section water depth less than 0.5 ft.					
		0%	0-<25%	25-<50%	50-<75%	>75%	Undeter-mined
1	8	2	2	1	1	2	
2	14	4	6		3		1
3	8	3	4	1			
5	1						1
Backwater	6	4	2				
All	**37**	**13**	**14**	**2**	**4**	**2**	**2**

Table 6.1-3. Percentage of occurrence of < 0.5 ft water depth at the confluence of each study site.

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	% Occurrence of WSE < 0.5 ft Depth at Confluence
CT-W-1.01	Upper Wilder	Minor Trib	Harriman Brook	2	0.02%
CT-W-1.05	Upper Wilder	Backwater		0	0.05%
CT-W-1.06	Upper Wilder	Minor Trib		2	13.6%
CT-W-1.16	Upper Wilder	Backwater		0	0.5%
CT-W-1.22	Middle Wilder	Major Trib	Indian Pond Brook	3	0%
CT-W-1.23	Middle Wilder	Minor Trib		1	11.0%
CT-W-1.28	Middle Wilder	Backwater		0	0%
CT-W-1.34	Middle Wilder	Minor Trib		2	0.4%
CT-W-1.44	Middle Wilder	Backwater		0	0%
CT-W-1.47	Lower Wilder	Minor Trib		1	0%
CT-W-1.48	Lower Wilder	Major Trib	Grant Brook	3	0%
CT-W-1.55	Lower Wilder	Minor Trib		1	0%
CT-W-1.59	Lower Wilder	Backwater		0	0%
CT-W-1.67	Lower Wilder	Minor Trib		2	0%
CT-WR-2.01	Upper Wilder Riverine	Minor Trib		2	70.2%
CT-WR-2.07	Upper Wilder Riverine	Minor Trib	Hanchetts Brook	1	95.8%
CT-WR-2.10	Lower Wilder Riverine	Minor Trib	McArthur Brook	2	58.2%
CT-WR-2.11	Lower Wilder Riverine	Major Trib	Lulls Brook	3	0%
CT-WR-2.13	Lower Wilder Riverine	Minor Trib	Bashan Brook	1	100%
CT-B-3.07	Bellows	Major Trib	Barkmill Brook	3	13.9%
CT-B-3.10	Bellows	Minor Trib		1	68.3%
CT-B-3.19	Bellows	Backwater		0	0%
CT-B-3.24	Bellows	Major Trib	Commissary Brook	3	0.9%
CT-B-3.27	Bellows	Minor Trib		2	0%
CT-B-3.35	Bellows	Minor Trib		2	0%
CT-BR-4.02	Bellows Riverine	Major Trib	Cold River	5	Undetermined
CT-BR-4.03	Bellows Riverine	Minor Trib		2	11.7%
CT-BR-4.04	Bellows Riverine	Major Trib	Cobb Brook	3	40.5%
CT-V-5.02	Bellows Riverine/Vernon	Minor Trib	Mad Brook	2	Undetermined

Site ID	Sub Reach	Type	Waterbody Name	Stream Order	% Occurrence of WSE < 0.5 ft Depth at Confluence
CT-V-5.04	Vernon	Major Trib		3	2.2%
CT-V-5.19	Vernon	Minor Trib		1	1.1%
CT-V-5.28	Vernon	Major Trib	Salmon Brook	3	21.1%
CT-V-5.31	Vernon	Minor Trib		2	24.0%
CT-V-5.36	Vernon	Minor Trib		2	0.3%
CT-V-5.50	Vernon	Backwater		0	0%
CT-VR-6.01	Vernon Riverine	Minor Trib		2	58.6%
CT-VR-6.05	Vernon Riverine	Minor Trib		1	42.5%

6.1.2 Potentially Affected Sites

The sites with confluence water depth <0.5 ft of water depth at least 25% of occurrences and the 2 sites with no mainstem WSE data warranted additional evaluation of site-specific factors to better understand and assess potential project effects. Conditions at those "potentially affected" sites are summarized in Table 6.1-4 including the % of occurrences with water depth <0.5 ft at the confluence cross section, the range of water depths measured at the confluence cross section during site visits, the overall range of water depths at the tributary water level logger location (during the period of logger record), and other site factors that could limit access for fish.

Sites with limited water level logger data in the tributary and/or mainstem are identified and data from those sites may not be fully representative of overall site conditions during the entire study period. Sections 6.1.2.1 – 6.1.2.10 describe each site in more detail, and Tables 6.1-4 and 6.1-5 summarize relevant data.

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Table 6.1-4. Summary of conditions at potentially affected sites.

Site #	Sub Reach	Water Body Name	Stream Order	% of Time <0.5 ft Water Depth at Confluence	Project-Affected Reach Length (from confluence, ft)	Range of Water Depths at Confluence Measured on Site Visits (ft)	Range of Water Depths at Tributary Logger (ft)	Limited Data	Other Potential Factors
CT-WR-2.01	Upper Wilder Riverine		2	70.2%	45	0.2 – 0.7	0.0 – 3.8	Some tributary WSE data missing	Perched culvert.
CT-WR-2.07	Upper Wilder Riverine	Hanchetts Brook	1	95.8%	-1	0.3 – 0.4	0.5 – 2.2	Some tributary WSE and mainstem WSE data missing	Downed trees and branches present. Project-affect reach limited.
CT-WR-2.10	Lower Wilder Riverine	McArthur Brook	2	58.2%	16	0.0 – 2.0	0.4 – 4.7		Intermittent stream, no outflow on 2 of 3 visits.
CT-WR-2.13	Lower Wilder Riverine	Bashan Brook	1	100%	-9	0.1 – 0.4	0.0 – 0.9	Some tributary WSE data missing	Man-made blockages. Project-affected reach limited.
CT-B-3.10	Bellows Falls		1	68.3	117	0.7 – 1.7	0.9 – 2.2	Some mainstem WSE data missing	Debris, shallow areas observed.
CT-BR-4.02	Bellows Riverine	Cold River	5	Undetermined	~900	0.8 – 2.9	1.0 – 5.7	No mainstem WSE data available	Cobble observed to have shifted between site visits.
CT-BR-4.04	Bellows Riverine	Cobb Brook	3	40.5%	535	1.4 – 2.2	1.8 – 6.4		Culvert, downed trees and branches present.
CT-V-5.02	Vernon	Mad Brook	2	Undetermined	~ 80	0.7 – 1.1	0.8 – 4.8	No mainstem WSE data available	Perched culvert.
CT-VR-6.01	Vernon Riverine		2	58.6%	125	0.2 – 0.4	0.6 – 4.4		Downed trees and branches present.
CT-VR-6.05	Vernon Riverine		1	42.5%	165	0.1 – 0.3	0.1 – 3.6		Downed trees and branches present.

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Project operations data were reviewed for the period of available mainstem WSE data at each site. Table 6.1-5 summarizes minimum mainstem WSE needed to achieve 0.5 ft of water depth at the confluence cross section, along with maximum mainstem WSE values recorded during normal project operations, and maximum mainstem WSE values recorded over the entire period of record. There were occasional, mostly brief, periods of non-operational high water resulting in spillage at one or more of the projects that occurred during late July, in mid-August, and in late October and WSE data recorded during those time periods is outside of the range of project operations, and outside of TransCanada's control.

WSE data was available for all sites in the Wilder riverine section during the week of September 9 – September 15. Wilder operations during that 7-day period ranged from minimum flow up to full or nearly full generation flow, providing a representative range of operations. WSE data was available for all sites in the Bellows Falls and Vernon projects (except at sites BR-4.02 and V-5.02) during the 7-day period from October 15 to October 21. Both projects operated between minimum flows and full or nearly full generation, providing a representative range of operations for sites in the Bellows Falls and Vernon project areas. For sites BR-4.02 (Cold River) and V-5.02 (Mad Brook), tributary WSE data were used as a proxy for mainstem WSE data which was unavailable for the entire study period.

Project operations during these time periods were plotted along with recorded site mainstem WSE data as well as the calculated site mainstem WSE needed to achieve 0.5 ft of water depth at the tributary confluence cross section. Figures 6.1-1 through Figure 6.1-12 in Sections 6.1.2.1 – 6.1.2.10 present these graphs for the 10 potentially affected sites. It should be noted that the two vertical scales on each graph (project discharge on the left and WSE on the right) are not correlated numerically, so that elevation data does not equate to specific project discharge levels, and vice versa at any point on the graphs.

Table 6.1-5. Mainstem WSE values recorded at potentially affected sites.

Site #	Minimum Mainstem WSE for 0.5 ft Confluence Water Depth (ft)	Maximum Project-Affected Mainstem WSE (ft)	Maximum Recorded Mainstem WSE (ft)
CT-WR-2.01	328.8	332.7	334.6
CT-WR-2.07	319.3	320.8	321.9
CT-WR-2.10	302.7	307.2	307.3
CT-WR-2.13	304.0	302.9	303.0
CT-B-3.10	289.8	290.4	290.9
CT-BR-4.02	223.7	No data	No data
CT-BR-4.04	220.2	224.5	225.7
CT-V-5.02	221.2	No data	No data
CT-VR-6.01	183.1	187.2	189.0
CT-VR-6.05	181.6	185.9	187.6

6.1.2.1 Site CT-WR-2.01

Site CT-WR-2.01 is a stream order 2 tributary located approximately 0.4 mi downstream from the Wilder Project. A perched culvert is present (see photographs in Appendix A) and the project-affected reach extends approximately 45 ft into the tributary from the cross section to an elevation of 332.7 ft, slightly above the culvert bottom sill elevation (at elevation 332.4). The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 328.8 ft. Water depth at the confluence cross section was < 0.5 ft about 70% of the time during the period of record, and ranged from 0.2 to 0.7 ft as measured at site visits. Water depth at the tributary logger location ranged from 0.0 to 3.8 ft based on limited tributary data. Figure 6.1-1 illustrates that mainstem water levels at the site closely track Wilder discharge flows. The thalweg profile within the project-affected reach is gradual without apparent stranding spots. It is likely that channel depths within the tributary are limited as part of its natural flow regime. As a result, potential access for fish into this small tributary is likely limited more by its own specific characteristics (i.e., limited outflow) than by TransCanada operations.

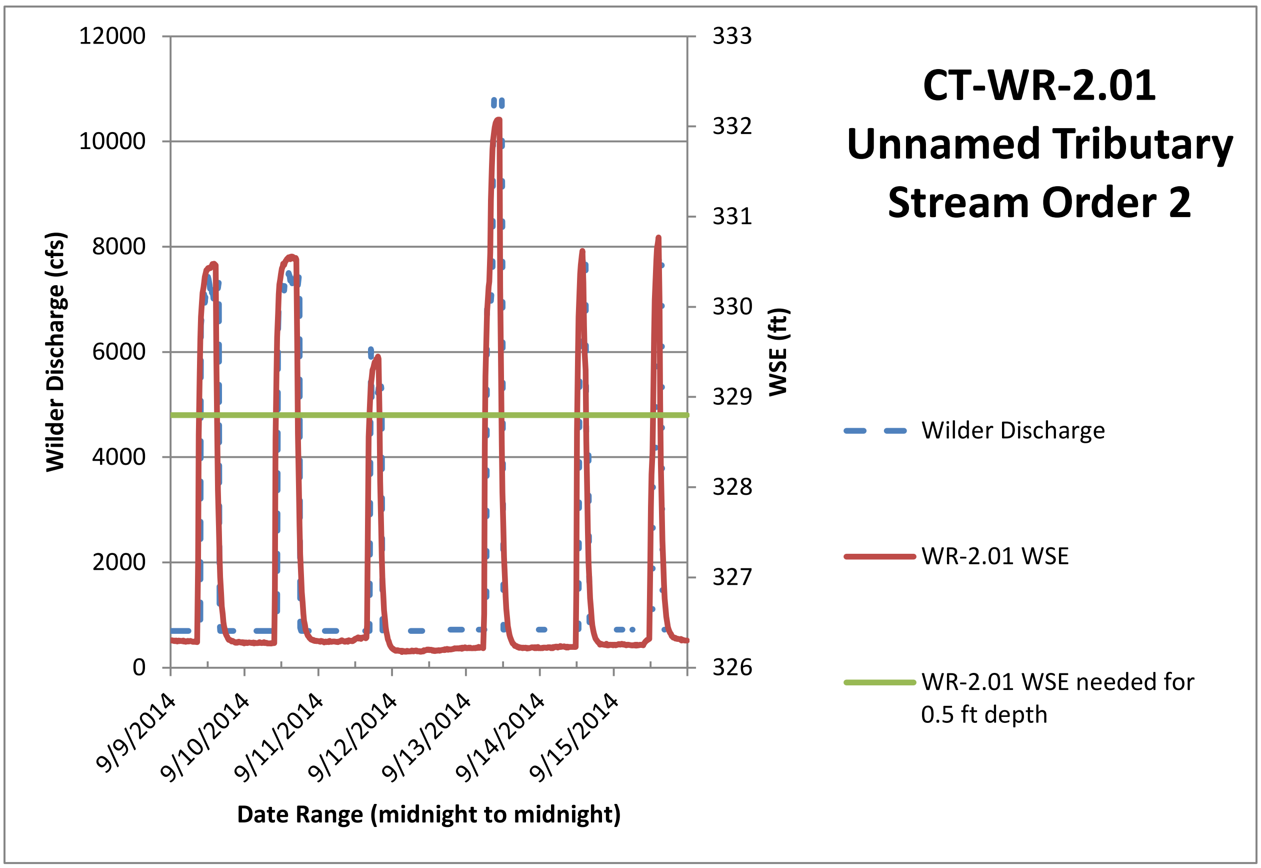

Figure 6.1-1. Representative operating conditions at Site CT-WR-2.01.

6.1.2.2 Site CT-WR-2.07

Site CT-WR-2.07, Hanchetts Brook, is a stream order 1 tributary located approximately 6 mi downstream from the Wilder Project. Downed trees and branches were observed that likely restrict mainstem flow into the tributary (see photographs in Appendix A). Water depth at the observed confluence cross section was less than 0.5 ft nearly 96% of the time based on limited mainstem data, and ranged from 0.3 to 0.4 ft as measured at site visits. The project-affected reach determined by WSE data, was calculated to be 1 ft closer to the mainstem than visually observed (e.g., at the tributary logger location). The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 319.3 ft and the maximum recorded project-affected WSE is 320.8 ft. Water depth at the tributary logger location ranged from 0.5 to 2.2 ft based on limited tributary data. Figure 6.1-2 illustrates that mainstem water levels at the site track Wilder discharge flows (with a slight time delay due to distance). The tributary thalweg profile changes in the vicinity of the project-affected reach which could create stranding under low mainstem and tributary conditions. It is likely that channel depths within the tributary are limited as part of its natural flow regime under virtually all operational project discharge levels. As a result, potential access for fish into this small tributary is limited by its own specific characteristics (i.e., limited outflow).

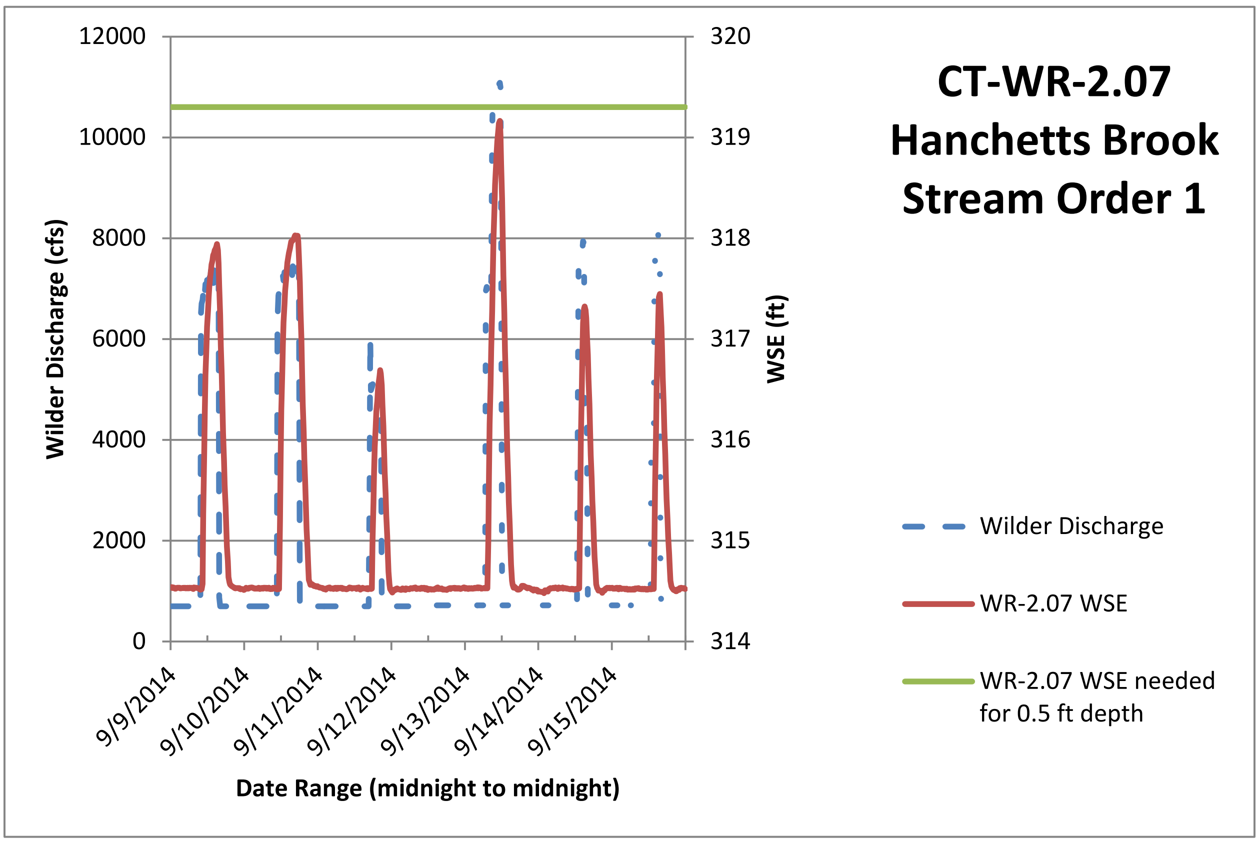

Figure 6.1-2. Representative operating conditions at Site CT-WR-2.07.

6.1.2.3 Site CT-WR-2.10

Site CT-WR-2.10, McArthur Brook, is an intermittent stream located approximately 10.9 miles downstream from the Wilder Project. The stream had no outflow on 2 of 3 site visits. Even so, water depth at the confluence cross section was 0.5 ft or greater approximately 42% of the time during the study period. The project-affected reach extends approximately 160 ft into the tributary from the cross section to an elevation of 307.2 ft. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 302.7 ft. Water depth at the confluence cross section ranged from 0.3 to 0.4 ft as measured at site visits. Water depth at the tributary logger location ranged from 0.4 to 4.7 ft. Figure 6.1-3 illustrates that mainstem water levels at the site track Wilder discharge flows (with a time delay due to distance). The thalweg profile within the project-affected reach is gradual without apparent stranding spots. Based on its intermittent nature, channel depths within the tributary are limited as part of its natural flow regime. Access to additional aquatic habitat within this tributary will be limited by the seasonal presence of outflow which is unrelated to TransCanada operations.

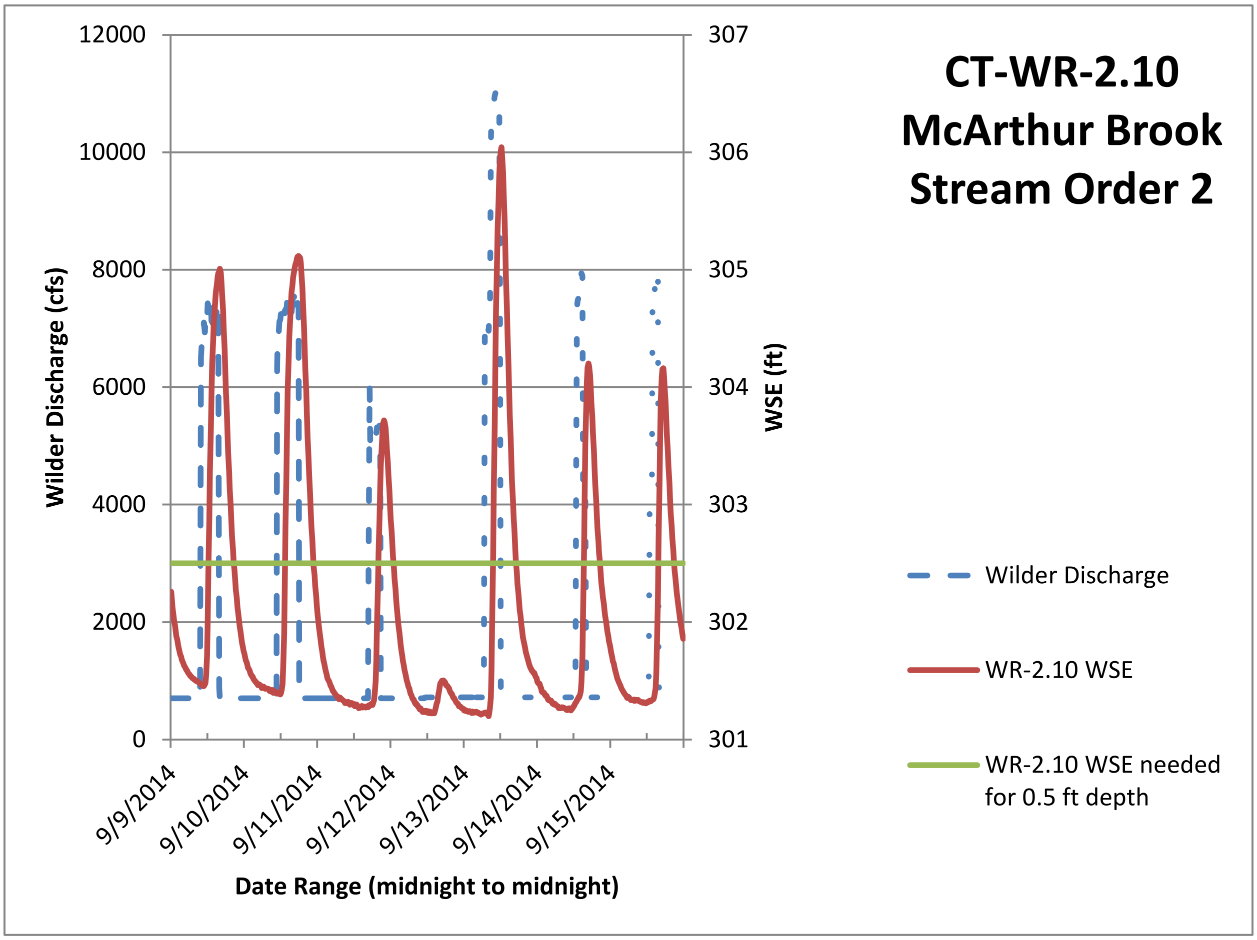

Figure 6.1-3. Representative operating conditions at Site CT-WR-2.10.

6.1.2.4 Site CT-WR-2.13

Site CT-WR-2.13, Bashan Brook is a stream order 1 tributary located approximately 13.1 miles downstream from the Wilder Project. The tributary is located in a high-traffic put-in/take-out for recreational boaters and subject to repeated construction of rock blockages, apparently to create pools in the stream (see photographs in Appendix A). These blockages contributed to mainstem inflow and confluence depth less than 0.5 ft under all recorded conditions (100% of occurrences). The project-affected reach determined by WSE data, was calculated to be 9 ft closer (elevation 302.9) to the mainstem than visually observed (e.g., at the tributary logger location), and upstream into the tributary from the tributary logger location. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 304.0 ft. Water depth measured at the cross section during sites visits ranged from 0.1 to 0.4 ft. Water depth at the tributary logger location ranged from 0.0 to 0.9 ft based on limited tributary data. Figure 6.1-4 illustrates that mainstem water levels at the site follow Wilder discharge flows (with a time delay due to distance). The thalweg profile within the project-affected reach is gradual without apparent stranding spots. Channel depths within the tributary are limited to natural outflow under low mainstem and tributary conditions, and mainstem water inflow is restricted due to manmade blockages under all operational project discharge levels during the period of record. As a result, potential access for fish into this small tributary is likely limited more by its own specific characteristics (i.e., limited outflow) and anthropogenic factors than by TransCanada operations.

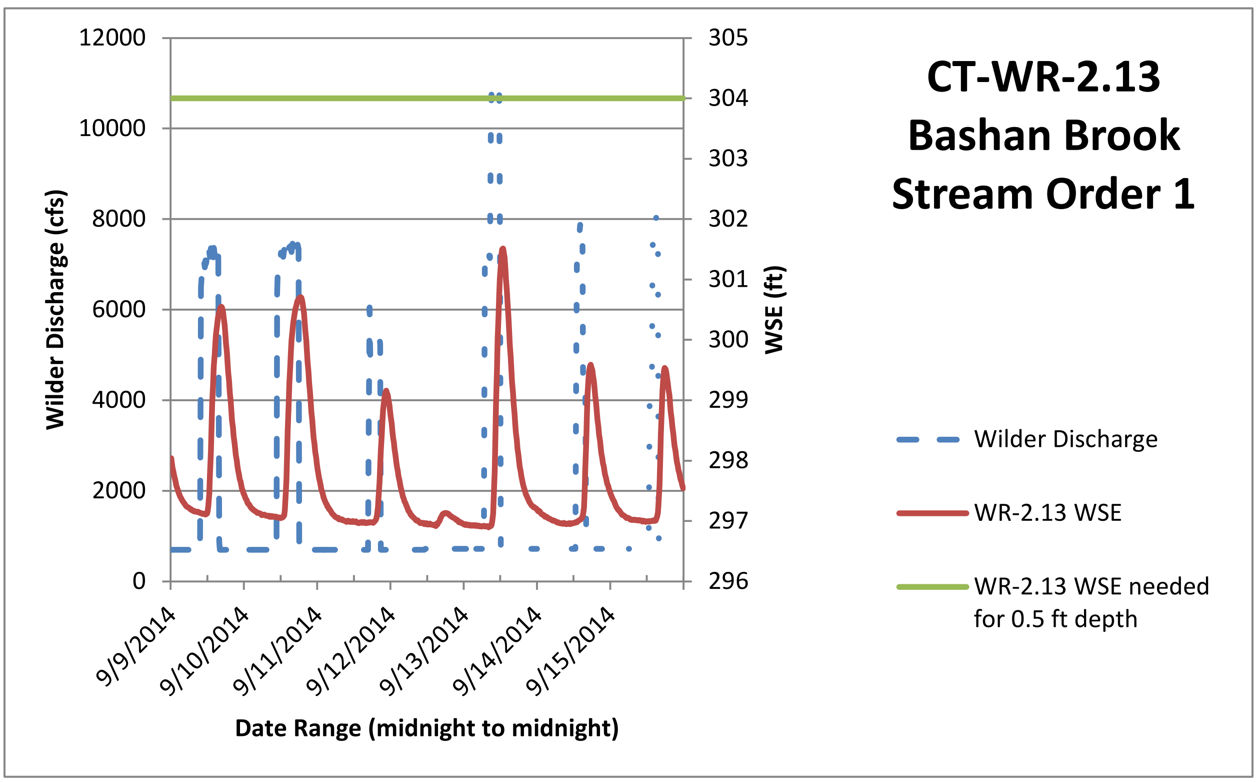

Figure 6.1-4. Representative operating conditions at Site CT-WR-2.13.

6.1.2.5 Site CT-B-3.10

Site CT-B-3.10 is a stream order 1 tributary located approximately 16 miles upstream of the Bellows Falls Project. Based on its location, this impoundment tributary is potentially affected by both Wilder and Bellows Falls project operations. The project-affected reach extends approximately 117 ft into the tributary from the confluence cross section to an elevation of 290.4 ft. The WSE needed to achieve 0.5 ft depth at the confluence cross section is 289.8 ft. Water depth at the confluence cross section was less than 0.5 ft approximately 68.3% of the time based on limited mainstem water level logger data; however, water depths ranged from 0.7 to 1.7 ft as measured during the site visits. Water depth at the tributary logger location ranged from 0.9 to 2.2 ft based on water level logger data. Figure 6.1-5 illustrates that mainstem water levels at the site fluctuate with changes in the upstream Wilder discharge flows (allowing for time differences due to distance from the project). The thalweg profile varies somewhat within the project-affected reach, and potential stranding spots are present. Therefore, access into this tributary may be limited by available water depths through shallower portions of the channel under low mainstem and tributary low flow conditions such as those observed during the November 7th site visit (see photographs in Appendix A).

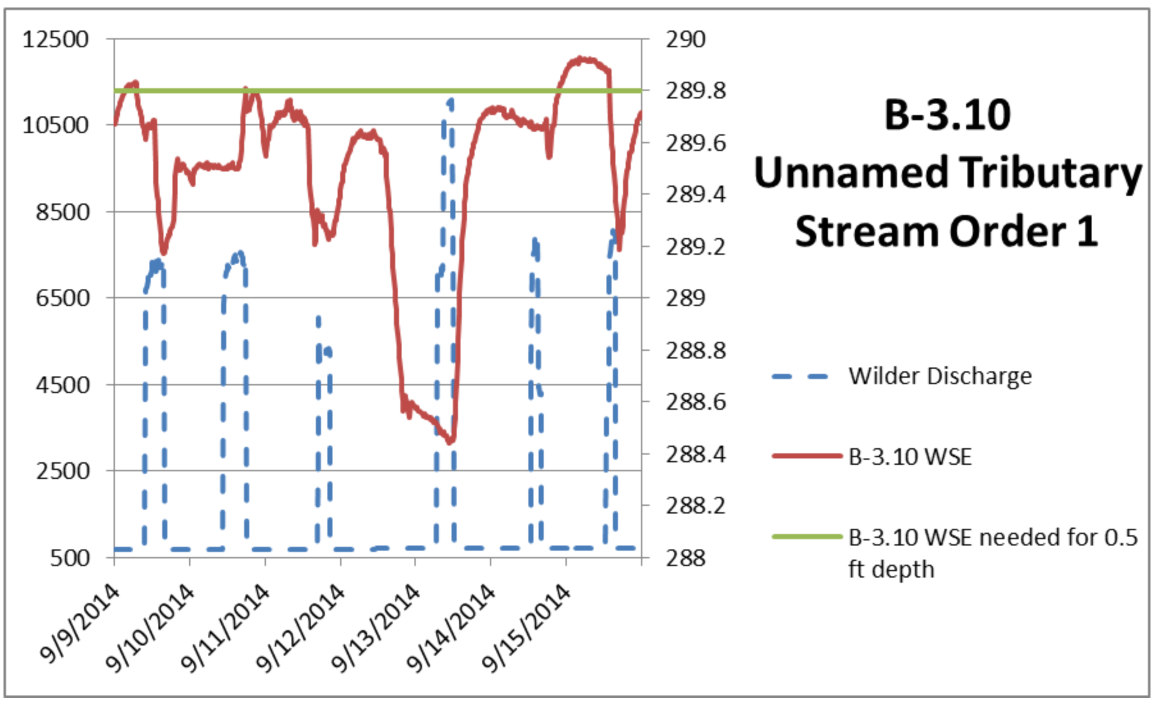

Figure 6.1-5. Representative operating conditions at Site CT-B-3.10.

6.1.2.6 Site CT-BR-4.02

Site CT-BR-4.02, the Cold River, is a stream order 5 tributary located approximately 1.2 miles downstream from the Bellows Falls Project. Based on visual evidence, the project-affected reach was estimated based on visual observation (not verified due to missing mainstem WSE data) to extend approximately 900 ft into the tributary from the confluence cross section to a point just upstream of the Route 12 Bridge. Water depths in the confluence cross section ranged from 0.8 – 2.9 feet as measured at site visits. Water depth at the tributary logger location ranged from 1.0 – 5.7 feet. The cobble substrate over which the Cold River flows at its confluence with the mainstem is dynamic and changes in location and quantity of cobble were evident from one site visit to the next (see photographs in Appendix A). Since no mainstem data was available for the study period (see Section 5.1), the effects of fluctuations in mainstem WSE on the tributary are unknown at this time and in Figure 6.1-6, Cold River tributary WSE data was used as a proxy for the mainstem data. The figure illustrates that the minimum tributary water elevation recorded (224.6 ft) during the representative week and throughout the study period (224.4 ft) remained above the minimum mainstem WSE needed to achieve 0.5 ft of depth at the confluence cross section (223.7 ft). The thalweg profile within the project-affected reach is slightly variable near the confluence, but not likely to create standing spots given the level of outflow from the Cold River which provides sufficient water depths for fish access under normal project operations.

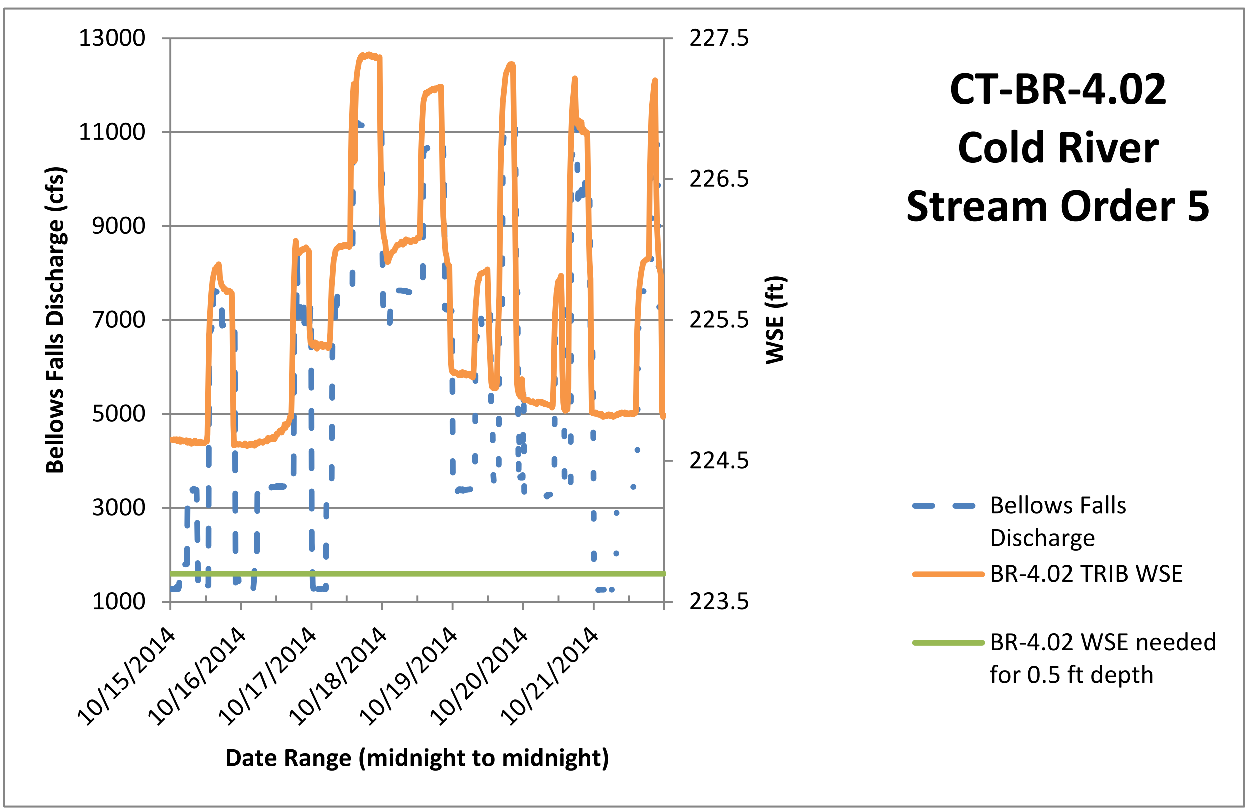

Figure 6.1-6. Representative operating conditions at Site CT-BR-4.02.

6.1.2.7 Site CT-BR-4.04

Site CT-BR-4.04, Cobb Brook is a stream order 3 tributary located approximately 3 miles downstream from the Bellows Falls Project. Downed trees and branches were observed that likely limit mainstem inflow at the upper extent of the reach. The project-affected reach extends approximately 535 ft from the confluence cross section to a railroad culvert (see photographs in Appendix A) with a bottom sill elevation of 225.85 ft. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 220.2 ft. Water depth at the confluence cross section was < 0.5 ft about 41% of the time during the period of record, and ranged from 1.4 to 2.2 ft as measured at site visits. Water depth at the tributary logger location ranged from 1.8 to 6.4 ft as measured during site visits. Figure 6.1-7 illustrates that mainstem water levels at the site closely follow Bellows Falls generation and discharge flows (with a slight time delay due to distance). The thalweg profile is variable within the project-affected reach and as a result, stranding is possible. Tributary outflow is generally sufficient to provide access, but could be limited for larger fish under low mainstem and tributary low flow conditions.

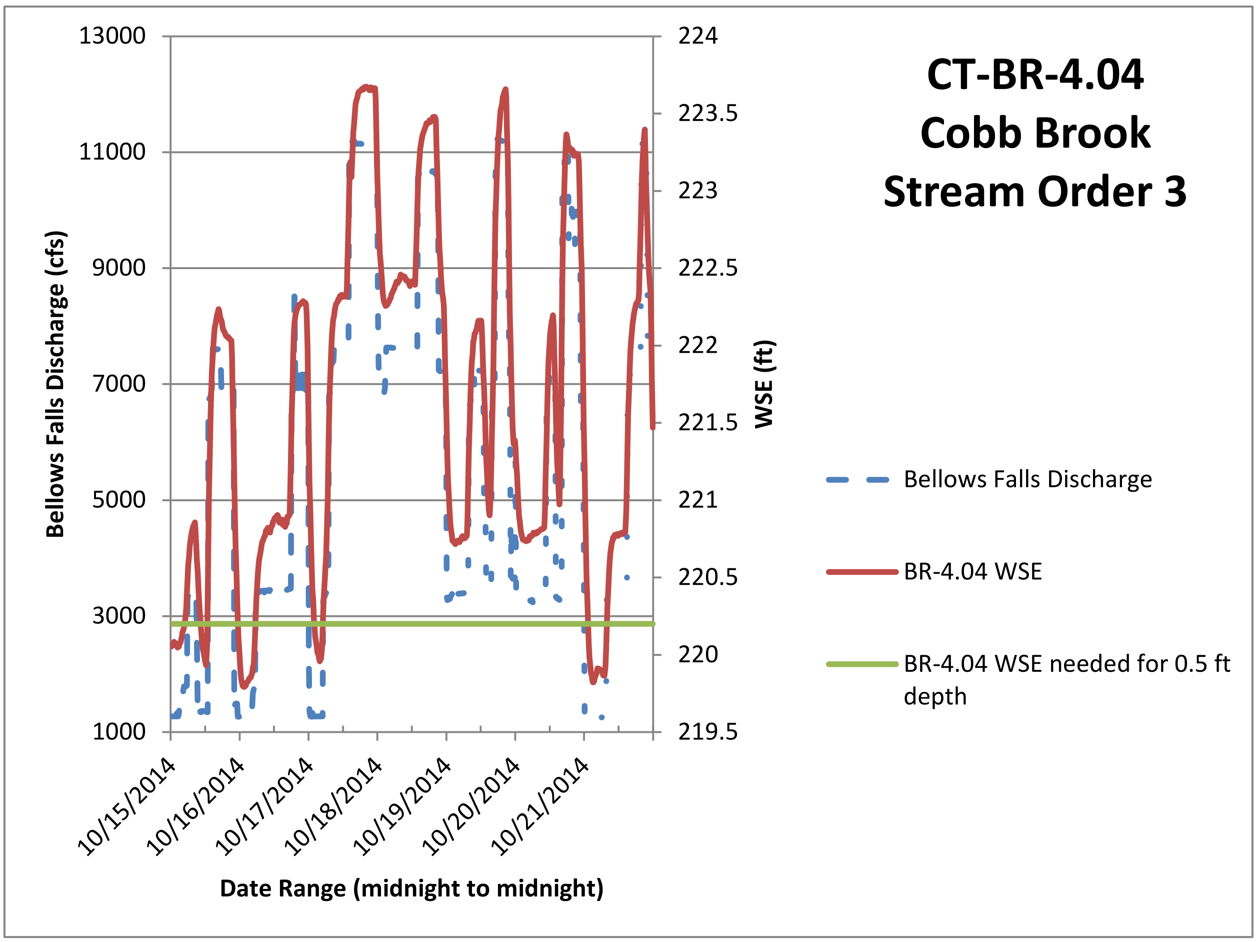

Figure 6.1-7. Representative operating conditions at Site CT-BR-4.04.

6.1.2.8 Site CT-V-5.02

Site CT-V-5.02, Mad Brook, is a stream order 2 tributary located just upstream of Walpole Bridge, so can be considered part of the Bellows Falls riverine reach, rather than the Vernon impoundment as the site was first identified. Based on visual evidence, the project-affected reach was estimated based on visual observation (not verified due to missing mainstem WSE data) to extend approximately 80 ft into the tributary to a culvert with a bottom sill elevation of 223.8 ft. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 221.2 ft and water depths in the confluence cross section ranged from 0.7 – 1.1 feet as measured at site visits. Water depth at the tributary logger location ranged from 0.8 – 4.8 feet. Since no mainstem data was available for the study period, the effects of fluctuations in mainstem WSE on the tributary are unknown. In Figure 6.1-8, Mad Brook tributary WSE data was used as a proxy for the mainstem data. The figure illustrates that the minimum tributary water elevation recorded during the representative week (221.0 ft) and throughout the study period (220.9 ft, see Appendix A) were less than the minimum mainstem WSE needed to achieve 0.5 ft of depth at the confluence cross section (221.2 ft). The thalweg profile varies slightly within the estimated project-affected reach, and some areas of stranding are possible under low mainstem and tributary conditions. Access into the tributary may be limited to the tributary's natural outflow under low mainstem and tributary low flow conditions.

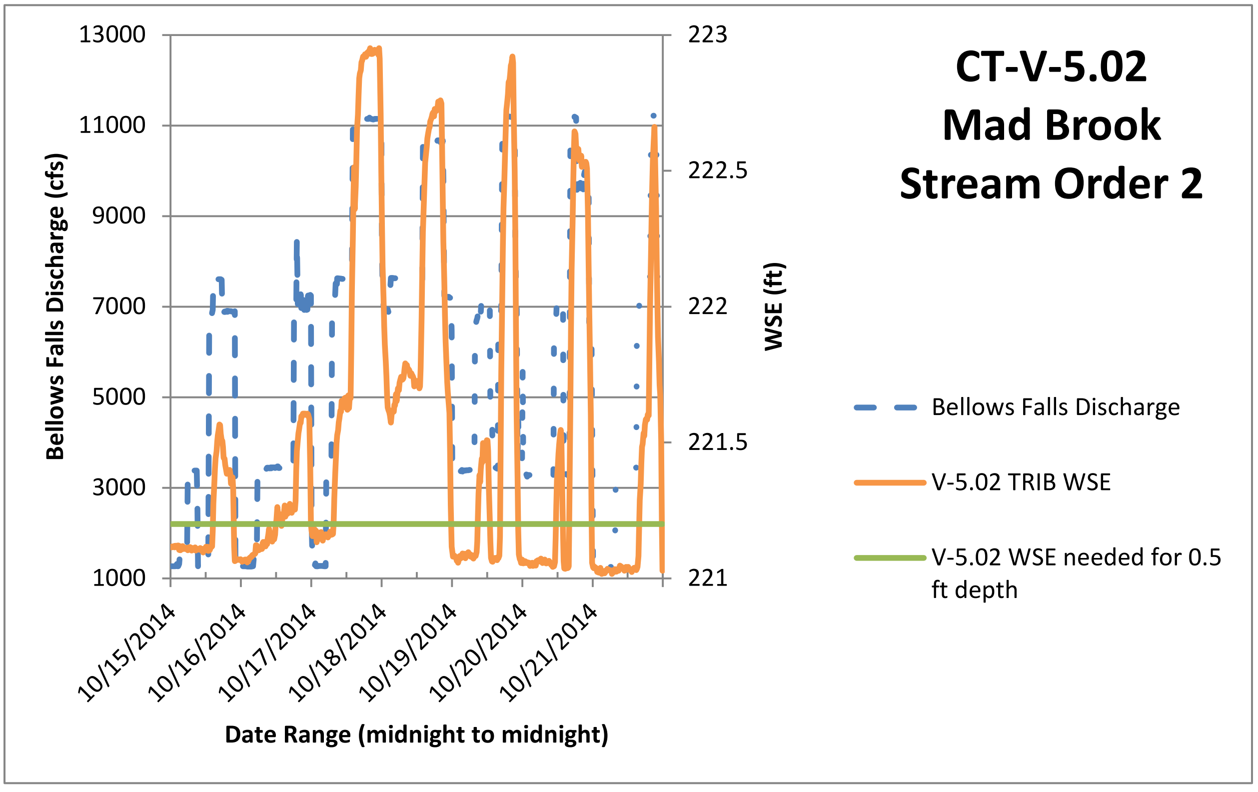

Figure 6.1-8. Representative operating conditions at Site CT-V-5.02.

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6.1.2.9 Site CT-VR-6.01

Site CT-VR-6.01 is a stream order 2 tributary located 0.2 miles downstream from the Vernon Project. Downed trees and branches were observed that likely limit mainstem inflow at the upper extent of the reach (see photographs in Appendix A). The project-affected reach extends approximately 125 ft from the confluence cross section to an elevation of 187.2. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 183.1 ft. Water depth at the confluence cross section was < 0.5 ft about 59% of the time during the period of record, and ranged from 0.2 - 0.4 ft as measured at site visits. Water depth at the tributary logger location ranged from 0.6 – 4.4 ft. Figure 6.1-9 illustrates that mainstem water levels at the site closely track Vernon discharge flows.

This site is at the upper end of FirstLight's Turners Falls impoundment and therefore also influenced by FirstLight operations and impoundment elevation fluctuations. As a proxy for FirstLight operations, the figure includes Vernon tailwater elevations during the representative Vernon operating conditions (Figure 6.1-9), which may not be conditions representative of FirstLight's impoundment operations. Under Vernon minimum flow periods, the tailwater elevation can range between approximately 181.0 ("low low tailwater elevation") and 184.0 ft ("low high tailwater elevation") largely due to operation of the FirstLight projects (see Figure 6.1-13 below).

Figure 6.1-10 presents data for October 31, 2014. This was a day in which TransCanada restricted Vernon discharge to minimum flows and FirstLight lowered the Turners Falls impoundment during a portion of the day to facilitate low mainstem conditions needed for Study 8 – Channel Morphology and Benthic Habitat Study. Data for this date therefore represents extremely low mainstem conditions.

The thalweg profile varies slightly within the project-affected reach which could create stranding spots under low mainstem and tributary conditions. Therefore, access into this tributary by larger fish may be limited to the tributary's natural outflow under low mainstem and tributary low flow conditions.

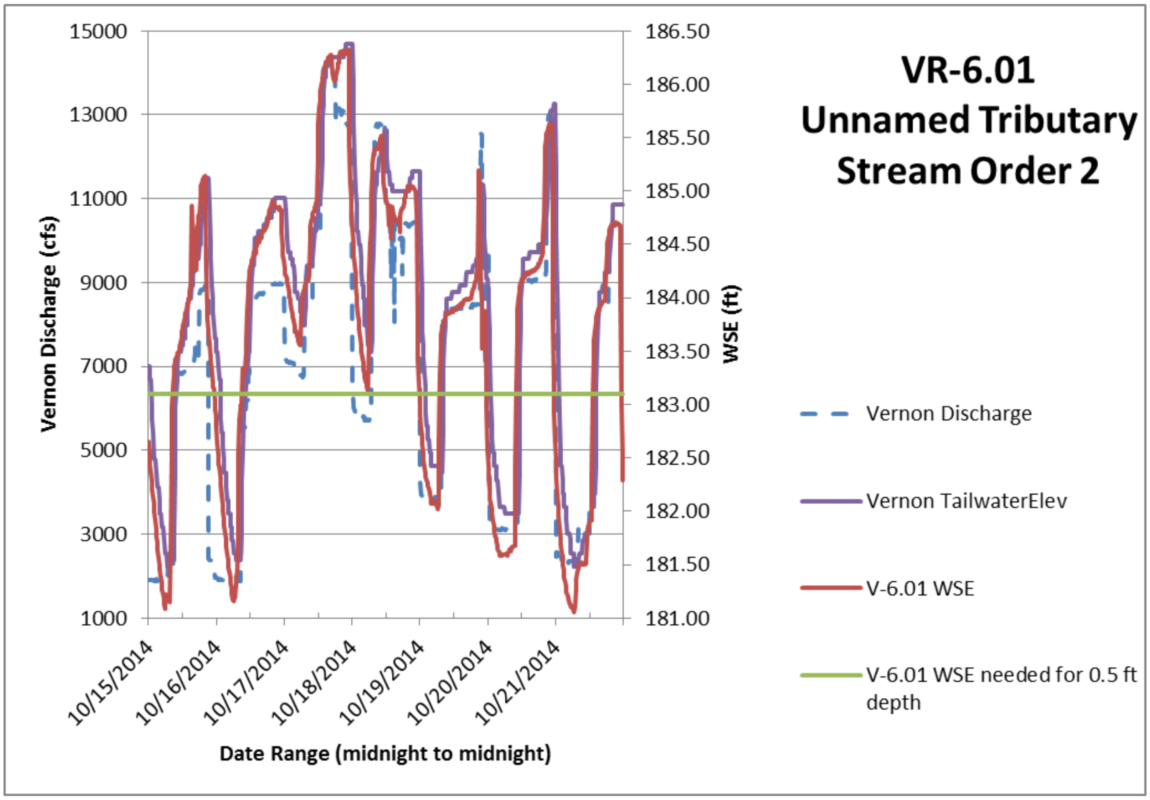

Figure 6.1-9. Representative operating conditions at Site CT-VR-6.01.

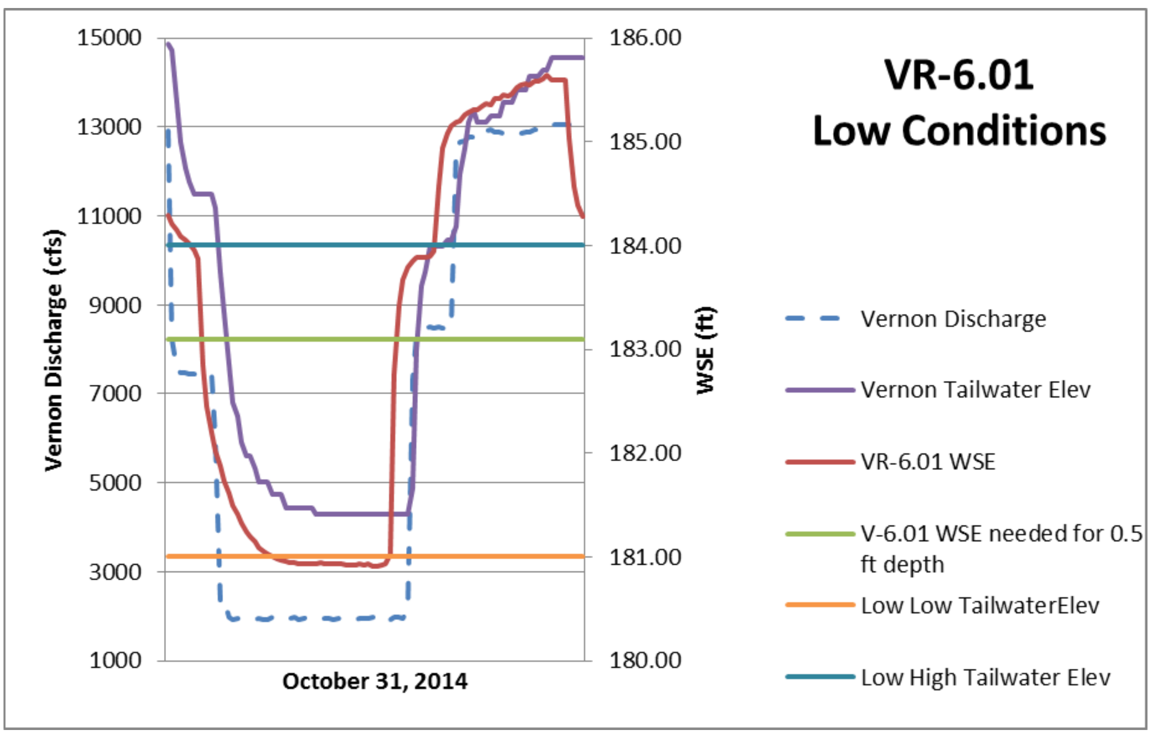

Figure 6.1-10. Low Vernon operating and low Turners Falls impoundment conditions at Site CT-VR-6.01.

6.1.2.10 Site CT-VR-6.05

Site CT-VR-6.05 is a stream order 1 tributary located approximately 1.5 miles downstream from the Vernon Project in a portion that is influenced by Vernon discharge and First Light's downstream projects. Downed trees and branches were observed that likely limit mainstem inflow at the upper extent of the reach. The project-affected reach extends approximately 165 ft from the confluence cross section to an elevation of 185.9 ft. The minimum mainstem WSE needed to achieve 0.5 ft of water depth at the cross section is 181.6 ft. Water depth at the confluence cross section was < 0.5 ft about 43% of the time during the period of record, and ranged from 0.1 – 0.3 ft as measured at site visits. Water depth at the tributary logger location ranged from 0.1 – 3.6 ft. Figure 6.1-11 illustrates that mainstem water levels at the site closely follow Vernon discharge flows.

This site is at the upper end of FirstLight's Turners Falls impoundment and therefore also influenced by FirstLight operations and impoundment elevation fluctuations. As a proxy for FirstLight operations, the figure includes Vernon tailwater elevations during the representative Vernon operating conditions (Figure 6.1-11), which may not be conditions representative of FirstLight's impoundment operations. Under Vernon minimum flow periods, the tailwater elevation can range between approximately 181.0 ("low low tailwater elevation") and 184.0 ft ("low high tailwater elevation") largely due to operation of the FirstLight projects (Figure 6.1-13).

Figure 6.1-12 presents data for October 31, 2014. This was a day in which TransCanada restricted Vernon discharge to minimum flows and FirstLight lowered the Turners Falls impoundment during a portion of the day to facilitate low mainstem conditions needed for Study 8 – Channel Morphology and Benthic Habitat Study. Data for this date therefore represents extremely low mainstem conditions.

The thalweg profile varies slightly within the project-affected reach which could create stranding spots under low mainstem and tributary conditions. Access into this tributary is generally adequate, but may be limited to the tributary's natural under low mainstem and tributary low flow conditions.

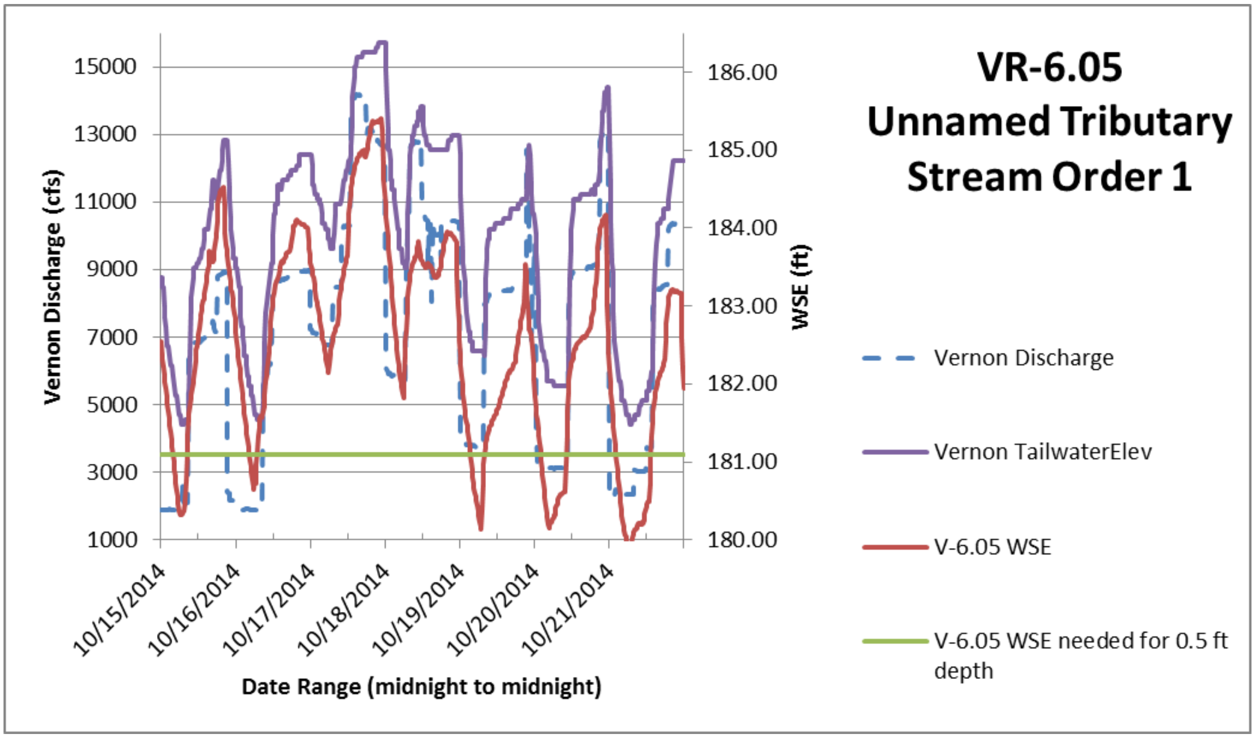

Figure 6.1-11. Representative operating conditions at Site CT-VR-6.05.

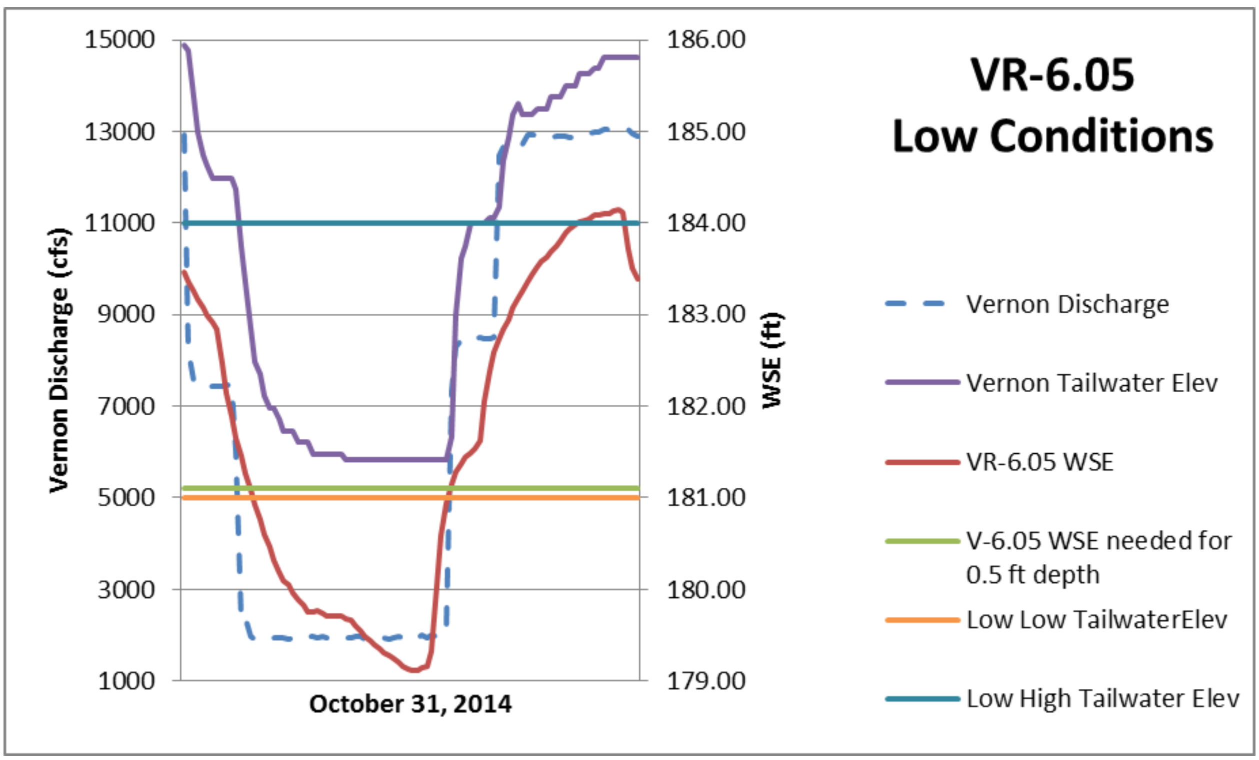

Figure 6.1-12. Low Vernon operating and low Turners Falls impoundment conditions at Site CT-VR-6.05

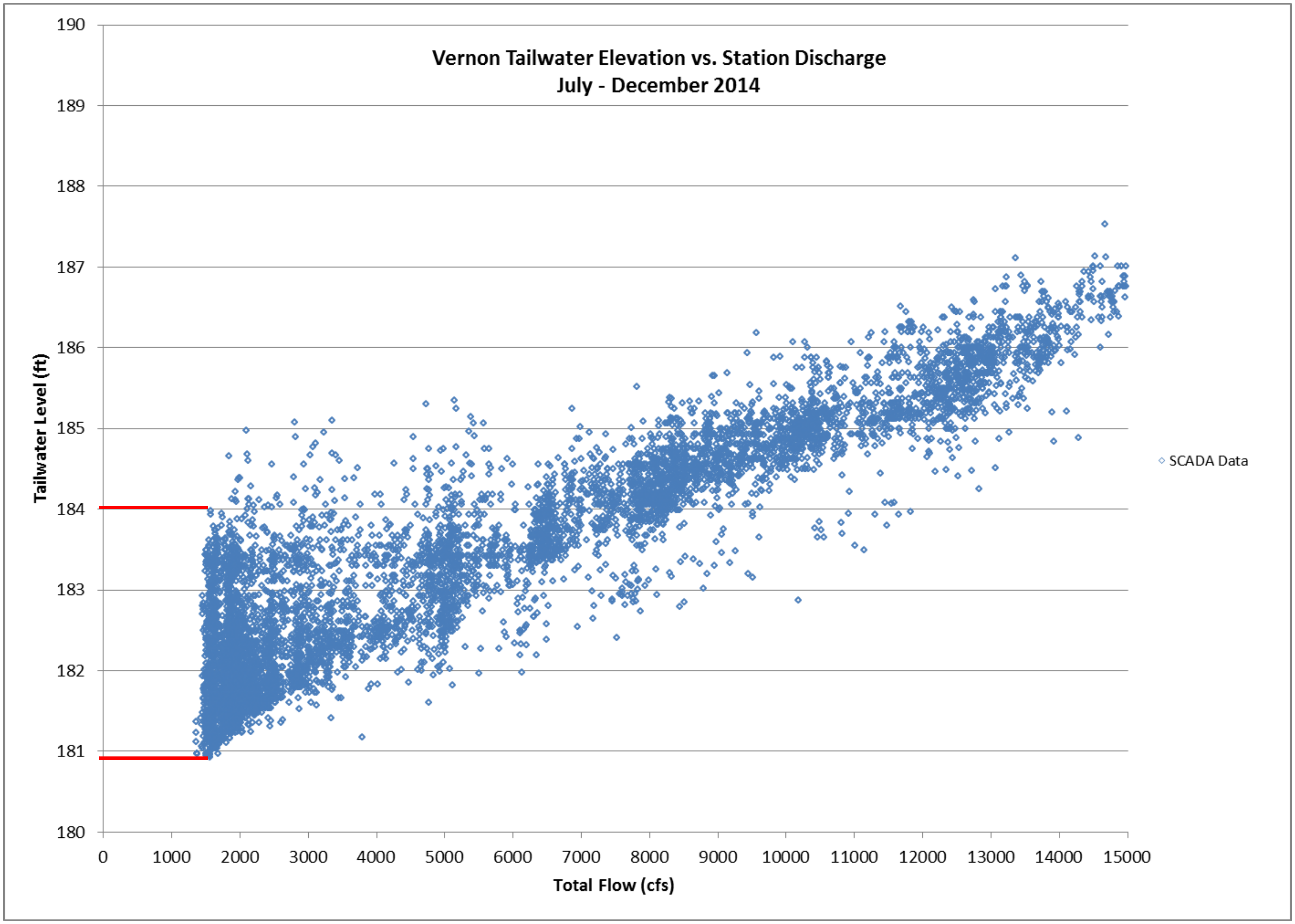

Figure 6.1-13. Vernon tailwater elevation at different station discharge levels.

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6.2 Water Quality

Water quality measurements taken within the tributaries and backwaters at the study sites generally met state water quality standards, except for pH at some sites (Section 5.2). Low pH is most likely due to naturally occurring causes. Similarly, temperature, conductivity, and turbidity are most likely to be functions of the tributaries and backwaters themselves rather than a function of project operations. Dissolved oxygen standards were met on most occasions at virtually all sites throughout the study period. Thus, the study data indicate that project operations do not have a discernable adverse effect on water quality in tributaries and backwaters.

The baseline water quality study conducted in 2012 (Normandeau, 2013) corroborates this conclusion. That study took place from June through September 2012 and was conducted under a wide range of flow and operating conditions including an extensive period of low flow/high temperature conditions. That study concluded that under ordinary hydroelectric operating conditions during summer high temperature/low flow periods, basic water quality parameters generally met applicable state standards; and irrespective of the effects of project operations, water quality in project waters supported all designated uses and met applicable criteria for the overwhelming majority of the study period throughout the entire study area.

6.3 Study Conclusions

The project effects assessment included herein should be considered preliminary for those sites identified as potentially affected by project operations. Results from other studies will be needed to better evaluate project effects for those sites. Relevant studies include the Hydraulic Modeling Study (Study 4), Operations Modeling Study (Study 5), and the Instream Flow Study (Study 9). None of these studies are complete at this time. Further assessment of the potential effects of project operations on specific tributary and backwater site access and habitats identified as potentially affected in this report will be included in a study report addendum and/or the Draft License Applications once results from the other studies are available.

Results of this study indicate that 27 of the 37 study sites including all backwater sites are not adversely affected by TransCanada project operations based on the conservative study criteria of sites having a confluence water depth < 0.5 ft for at least 25% of the time (based on each site's available 15-minute WSE data occurrences over the period of record).

Additional evaluation was conducted for the remaining 10 sites (Section 6.1). The relative level of overall potential project effects for those sites is summarized in Table 6.3-1. Factors including stream order, project-affected reach length, site conditions, thalweg profile, and natural outflow of the tributaries contribute to the relative importance of project operational changes (water depth and fluctuation) on fish access and habitat.

Only sites CT-B-3.10 (impoundment site) and CT-BR-4.04 (Cobb Brook) appear to have potential project effects of any significance that could limit fish access.

All other sites appear to have either no project effect or very minor effects under low mainstem and/or tributary conditions. The two sites downstream of Vernon (CT-VR-6.01 and CT-VR-6.05) are apparently more affected by Turners Falls impoundment elevations and operation of the Turners Falls/Northfield Mountain projects than by Vernon project operations.

Table 6.3-1. Summary of potential project effects.

Site #	Waterbody Name	Stream Order	Project-affected Reach Length (from confluence ft)	Contributing Site Factors	Potential Project Effect
CT-WR-2.01		2	45	Perched culvert.	None – low tributary outflow
CT-WR-2.07	Hanchetts Brook	1	-1	Downed trees and branches.	Minor - potential stranding under low tributary and mainstem conditions
CT-WR-2.10	McArthur Brook	2	160	Intermittent stream.	None – low tributary outflow
CT-WR-2.13	Bashan Brook	1	-9	Man-made blockages.	None – low tributary outflow
CT-B-3.10		1	117	Debris and shallow areas observed.	Potential stranding under low tributary and mainstem conditions
CT-BR-4.02	Cold River	5	~900	Shifting cobble. No mainstem WSE data.	None - sufficient natural outflow
CT-BR-4.04	Cobb Brook	3	535	Culvert. Downed trees and branches.	Potential stranding under low tributary and mainstem conditions, but generally sufficient natural outflow.
CT-V-5.02	Mad Brook	2	~80	Perched culvert. No mainstem WSE data.	Minor - potential stranding under low tributary and mainstem conditions
CT-VR-6.01		2	125	Downed trees and branches. Turners Falls impoundment levels.	Potential stranding under low tributary and mainstem conditions, attributable to Turners Falls operational effect.
CT-VR-6.05		1	165	Turners Falls impoundment levels.	Potential stranding under low tributary and mainstem conditions, attributable to Turners Falls operational effect.

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7.0 LITERATURE CITED

ASQL (American Society for Quality Control). 1993. Sampling procedures and tables for inspection by attributes. ANSI/ASQC Z1.4-1993.

NHDES (New Hampshire Department of Environmental Services). 2012. Final 2012 Section 303(d) Surface Water Quality List Submitted to EPA for Approval. February 12, 2014.

Normandeau (Normandeau Associates, Inc.) 2013. 2012 Baseline Water Quality Study Final Report. Prepared for TransCanada Hydro Northeast Inc. August 23, 2013.

Normandeau 2014a. ILP Study 13 -Tributary and Backwater Fish Access and Habitats Study - Updated Revised Site Selection Report. Prepared for TransCanada Hydro Northeast Inc. July 17, 2014.

Normandeau 2014b. ILP Study 7 - Aquatic Habitat Mapping Study Final Report. Prepared for TransCanada Hydro Northeast Inc. March 2, 2015.

VTDEC (Vermont Department of Environmental Conservation). 2014. State of Vermont 2014 303(d) List of Impaired Waters. September 2014.

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Appendix A

Tributary and Backwater Study Site Detail

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APPENDIX A – TABLE OF CONTENTS

APPENDIX A – TABLE OF CONTENTS - CONTINUED

1.0 WILDER IMPOUNDMENT

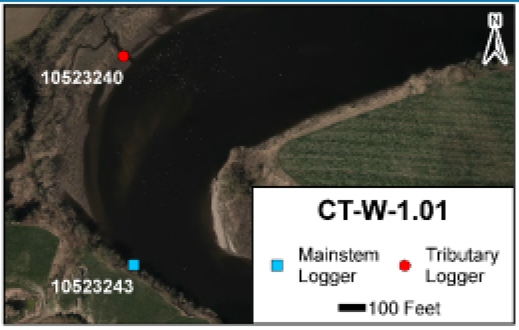
1.1 Site CT-W-1.01 Harriman Brook

Site CT-W-1.01 Harriman Brook, is a stream order 2 tributary located on the Vermont side in the upper Wilder impoundment. This location was initially visited on August 4, 2014 and tributary (SN 10523240) and mainstem (SN 10523243) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 4, 2014 at which time the level loggers were removed.

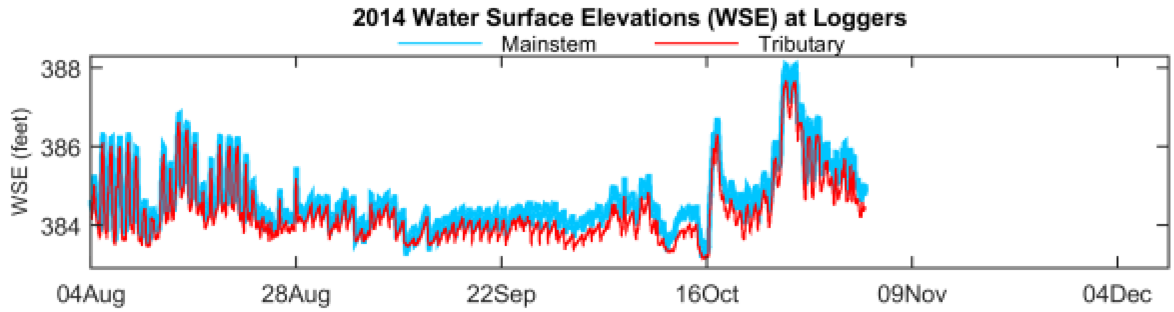
The tributary level logger was installed approximately 40 feet upstream from the visually determined confluence with the mainstem. During the initial site visit, the field crew visually determined that the project-affected reach extends approximately 128 ft up into Harriman Brook to a beaver dam with a crest elevation of 387.3 ft. Review of the WSE values recorded by the mainstem level logger indicates that a minimum of 75% of the time, water levels remain below the beaver dam crest elevation (75% occurrence = 384.9 ft / beaver dam crest = 387.3 ft). However, the maximum operational WSE (388.1 ft) recorded by the mainstem level logger indicates that the project-affected reach extends farther up the tributary on occasion. Flow was present in Harriman Brook during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.8 to 1.4 ft. Water depths were measured along the channel thalweg during the initial site visit on August 4th and ranged between 1.2 and 2.3 ft (mean = 1.5 ft). Water depths at the tributary logger location ranged from 0.2 to 4.7 ft (mean = 1.4 ft).

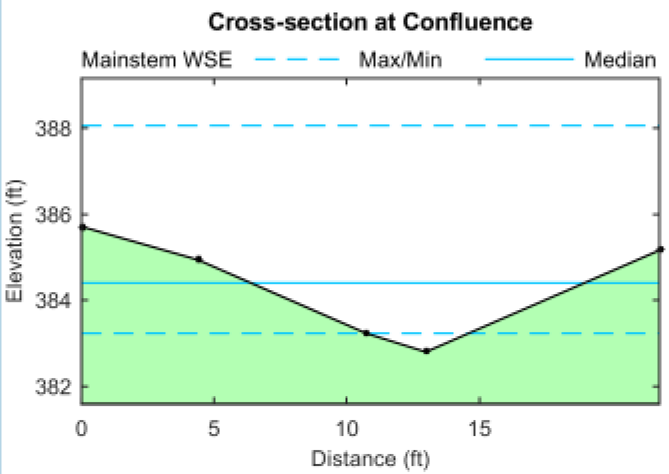
Review of the frequency distribution of tributary water depth recorded by the tributary level logger (Figure 5.1-1), indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at that location ranged between 0.9 and 1.6 ft. As indicated by the minimum water depth recorded by the tributary level logger (0.2 ft), access may be reduced under low flow mainstem and tributary conditions (0.02% of data occurrences < 0.5 ft of depth at the confluence).

Beaver dam at Harriman Brook, site CT-W-1.01.

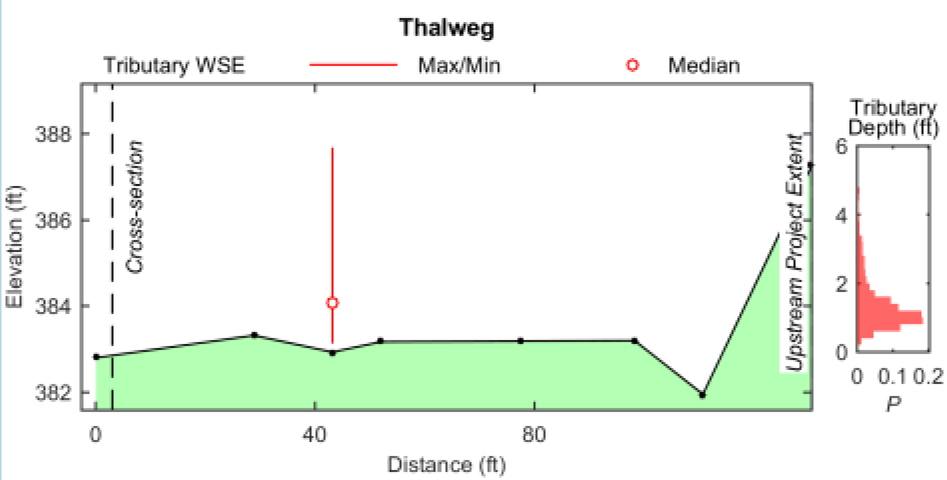


Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.01
Harriman Brook, Minor tributary, Stream Order 2





Mainstem Logger 10523243 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 388.1	04Aug2014	1.4
75%: 384.9	26Aug2014	0.8
Mean: 384.6	25Sep2014	1.1
50%: 384.4	04Nov2014	0.8
25%: 384.1		
Min: 383.2		



Tributary Logger 10523240 Feet:	WSE	Water Depth
Max:	387.7	4.7
75%:	384.5	1.6
Mean:	384.3	1.4
50%:	384.1	1.2
25%:	383.8	0.9
Min:	383.2	0.2

Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.01
Harriman Brook, Minor tributary, Stream Order 2

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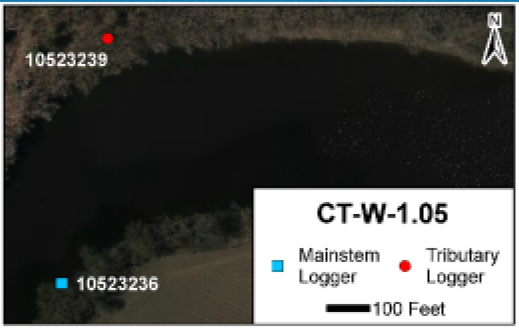
1.2 Site CT-W-1.05 Backwater

Site CT-W-1.05 is a backwater located on the Vermont side in the upper Wilder impoundment. This location was initially visited on August 4, 2014 and tributary (SN 10523239) and mainstem (SN 10523236) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 4, 2014 at which time the level loggers were removed.

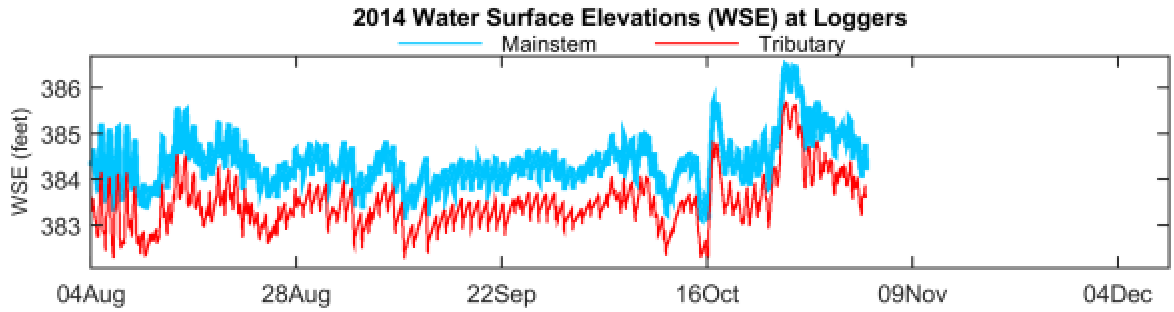
The site is connected to the mainstem via an approximately 700-foot-long stream-like access channel (see access channel confluence with mainstem in photograph dated 25Sep14 below). The backwater level logger was installed within the access channel at a location approximately 60 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of the mainstem influenced area as the entire length of the access channel, and across the ponded backwater area (a linear distance of approximately 2,180 ft). The project-affected reach was later determined from WSE data to extend to approximately 2,119 ft. Sedimentation in the vicinity of large downed tree trunks/branches was apparent (see photo below). Water was present within the access channel and backwater section of Site CT-W-1.05 during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged between 1.2 and 2.3 ft.

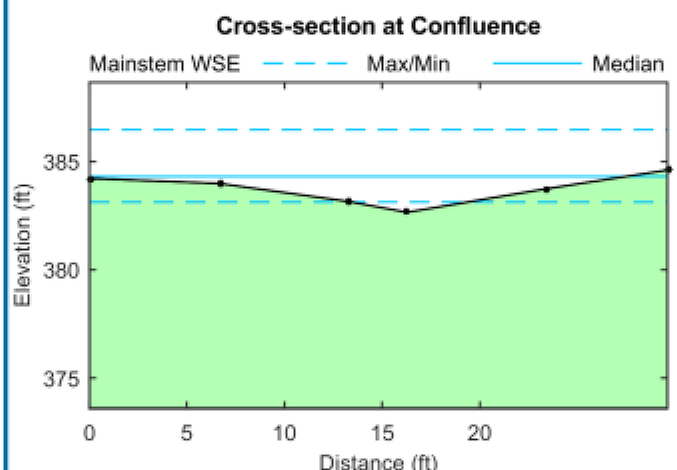
Water depths along the access channel thalweg ranged between 1.3 and 2.4 ft (mean = 1.9 ft). Review of the frequency distribution of water depth recorded by the tributary level logger in the access channel indicates that under most conditions (i.e., 25^{th} through 75^{th} percentiles) water depth at that location ranged between 1.4 and 2.0 ft and is adequate for access. Water depths measured within the ponded backwater area primarily ranged from 1-4 ft with deeper areas up to 8-9 ft. However, as indicated by the minimum water depth recorded at the backwater level logger location (0.6 ft), access may be reduced at higher elevation thalweg locations upstream of the level logger location under low mainstem conditions (0.05% of data occurrences < 0.5 ft of depth at the confluence).

View within the access channel connecting mainstem to backwater at Site CT-W-1.05 showing numerous downed logs creating potential blockage during low flow conditions.

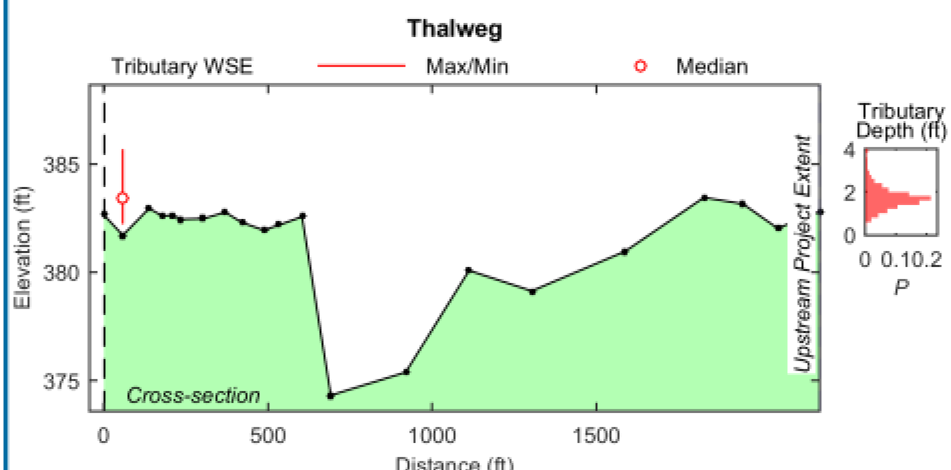


Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.05
Unnamed backwater, Stream Order 0





Mainstem Logger 10523236 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 386.5	04Aug2014	2.3
75%: 384.6	26Aug2014	1.6
Mean: 384.4	25Sep2014	1.2
50%: 384.3	04Nov2014	1.8
25%: 384.0		
Min: 383.1		



Tributary Logger 10523239 Feet:	WSE	Water Depth
Max:	385.7	3.9
75%:	383.7	2.0
Mean:	383.5	1.7
50%:	383.4	1.7
25%:	383.1	1.4
Min:	382.3	0.6

Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.05
Unnamed backwater, Stream Order 0

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1.3 Site CT-W-1.06

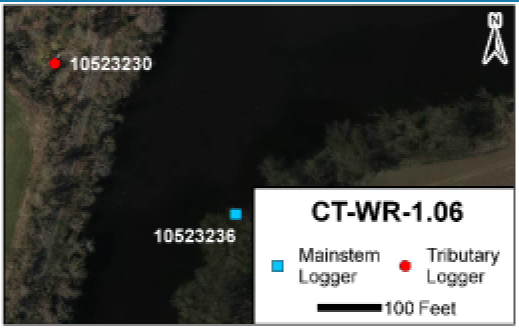
Site CT-W-1.06 is an unnamed stream order 2 tributary located on the Vermont side in upper Wilder impoundment. This location was initially visited on August 4, 2014 and tributary (SN 10523230) and mainstem (SN 10523236) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 4, 2014 at which time the level loggers were removed. During the manual data review portion of post-processing, it was discovered that pressure readings recorded by the tributary level logger were impacted by a logger malfunction. This malfunction resulted in plotted sensor depths far exceeding the range expected for this particular location and data from this location was assigned a Use Code = 9 (Table 4.2-1). As a result sensor depth information for the tributary logger is limited to the period August 4 to August 26, 2014. The mainstem logger was found to be missing from its installation location during the final site visit and as a result sensor depth information for the mainstem logger is limited to the period August 4 to September 25, 2014.

Tributary CT-W-1.06 converges with the mainstem Connecticut River just downstream of an approximately 90-ft-long tunnel underneath the railroad (see photo section below). The tributary level logger was installed on the upstream side of the tunnel, approximately 100 ft above the confluence. During the initial site visit, the field crew visually determined that the mainstem influence extends approximately 137 ft up into tributary to a large blockage with a crest elevation of 385.3 ft. A minimum of 75% of the time, project-affected water levels remain below the project-affected elevation (75% occurrence = 384.6 ft /project extent = 385.3 ft). However, the maximum operational WSE (386.5 ft) recorded by the mainstem level logger indicates that the project-affected extends farther up into the tributary on occasion. Flow was present in the tributary during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.5-1.0 ft. Water depths were measured along the channel thalweg and ranged between 1.0 and 0.3 ft (mean = 0.6 ft) with shallow depths present towards the upstream end of the suspected project-affected reach.

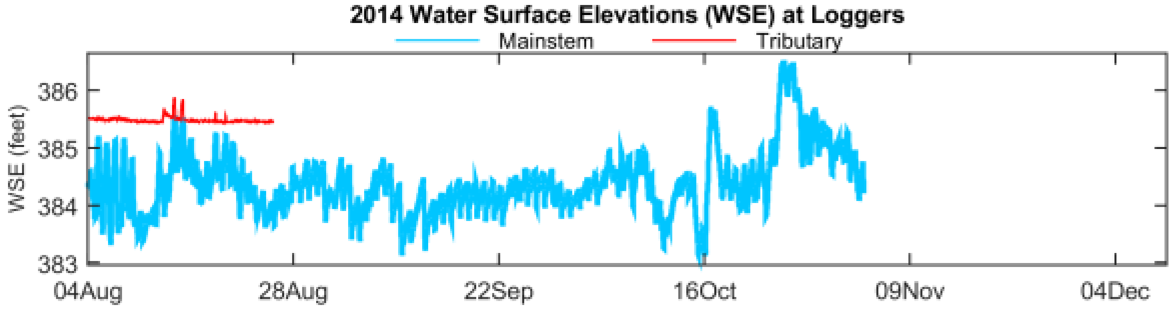
The project-affected portion of tributary CT-W-1.06 is relatively short (136 ft) with the majority of the reach lying within a culvert tunnel and offering limited aquatic habitat (see photo below). The downstream edge of the culvert is located at an elevation of 383.6 ft, and based on the recorded range of mainstem WSE values is submerged 0.4 ft at least 75% of the time. As indicated by the minimum WSE recorded at the mainstem level logger location (383.1 ft), water depth at the downstream edge of the culvert may be limited to only natural stream outflow under low mainstem and tributary conditions (13.6% of data occurrences < 0.5 ft of depth at the confluence).

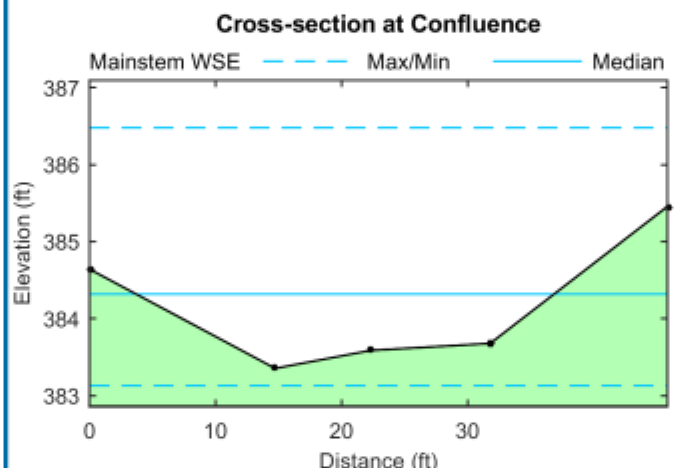
View of the end of project-affected reach within site CT-W-1.06.

View looking upstream through tunnel at site CT-W-1.06.

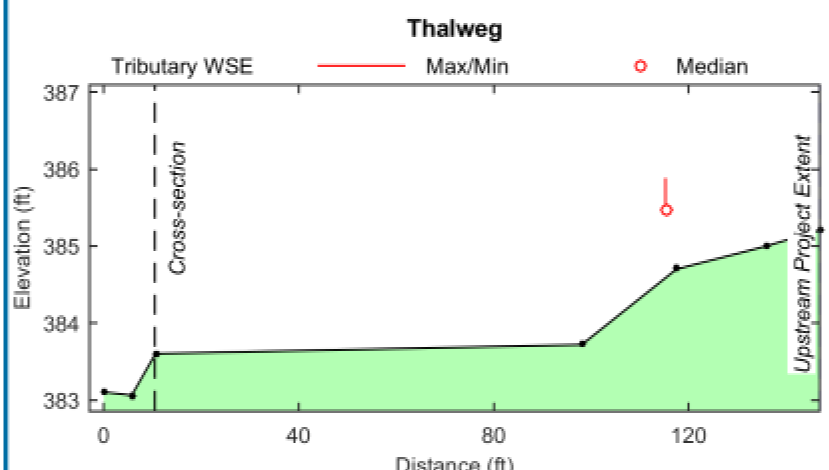


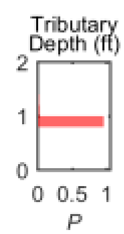
Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.06
Unnamed minor tributary, Stream Order 2





Mainstem Logger 10523236 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 386.5	04Aug2014	0.6
75%: 384.6	26Aug2014	0.5
Mean: 384.4	25Sep2014	1.0
50%: 384.3	04Nov2014	1.0
25%: 384.0		
Min: 383.1		





Tributary Logger 10523230 Feet:	WSE	Water Depth
Max:	385.9	1.3
75%:	385.5	0.9
Mean:	385.5	0.9
50%:	385.5	0.9
25%:	385.5	0.9
Min:	385.4	0.8

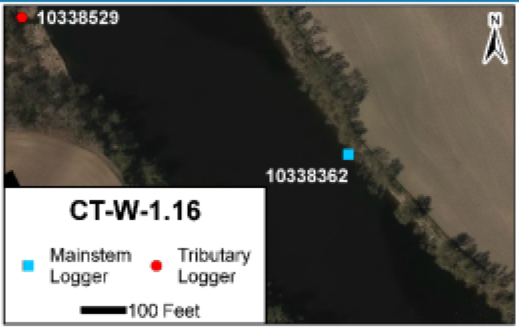
Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.06
Unnamed minor tributary, Stream Order 2

1.4 Site CT-W-1.16 Backwater

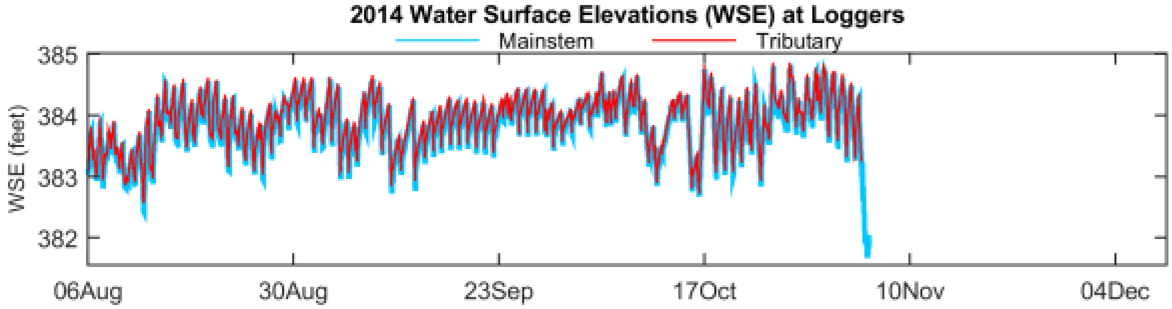
Site CT-W-1.16 is a backwater located on the Vermont side in the upper Wilder impoundment. This location was initially visited on August 6, 2014 and tributary (SN 10338529) and mainstem (SN 10338362) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 4, 2014 at which time the level loggers were removed.

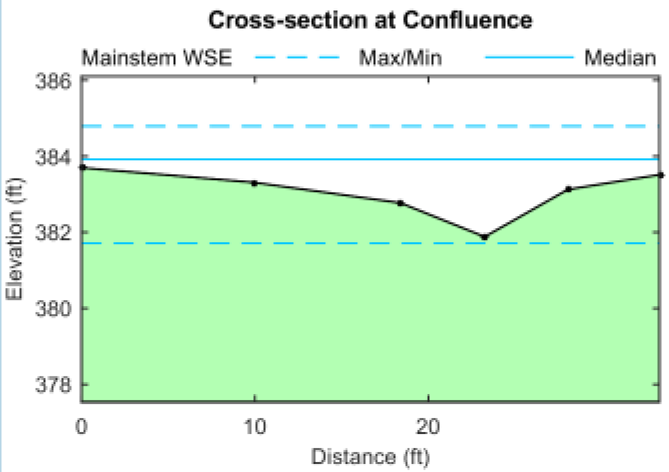
Site CT-W-1.16 is connected to the mainstem via an approximately 125-ft-long stream-like access channel (see access channel confluence with mainstem in photograph dated 06Aug14). The backwater level logger was installed within the access channel at a location near the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of the project influence as the entire length of the access channel, and across the ponded backwater area (a linear distance of 415 ft), later determined by evaluation of WSE data to be 416 ft. Water was present within the access channel and backwater section during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 1.0 to 1.5 ft. Water depths were measured along the access channel thalweg and within the ponded backwater area during the initial site visit and ranged between 1.2 and 1.5 ft (mean = 1.3 ft) in the thalweg. Water depths measured within the ponded backwater area primarily ranged from 1-2 ft with deeper areas up to 4-5 ft.

Based on the measured water depths, it is most likely that any access restrictions at the site (if present) would be located in the access channel based on its shallower bathymetry than was observed in the ponded backwater area. However, review of the frequency distribution of water depth recorded by the tributary level logger in the access channel, indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at that location ranged between 2.1 and 2.6 ft with a minimum recorded water depth of 1.0 ft which will provide adequate access under virtually all conditions (0.5% of data occurrences < 0.5 ft of depth at the confluence).

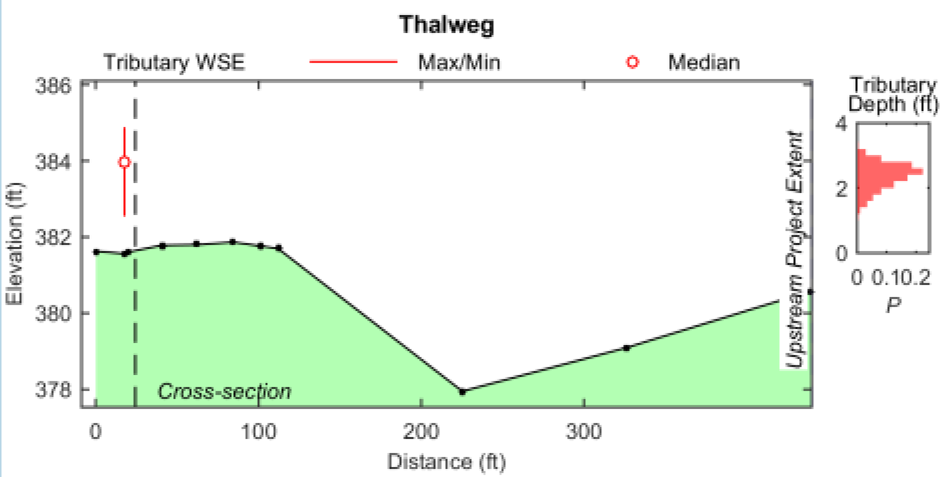


Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.16
Unnamed backwater, Stream Order 0





Mainstem Logger 10338362	Date	Maximum Measured Water Depth (ft)
Feet: WSE		
Max: 384.8	06Aug2014	1.0
75%: 384.1	26Aug2014	1.5
Mean: 383.8	25Sep2014	1.5
50%: 383.9	04Nov2014	1.2
25%: 383.6		
Min: 381.7		



Tributary Logger 10338529		Water
Feet:	WSE	Depth
Max:	384.9	3.3
75%:	384.2	2.6
Mean:	383.9	2.4
50%:	384.0	2.4
25%:	383.7	2.1
Min:	382.6	1.0

Upper Wilder Impoundment, Connecticut River
Site ID: CT-W-1.16
Unnamed backwater, Stream Order 0

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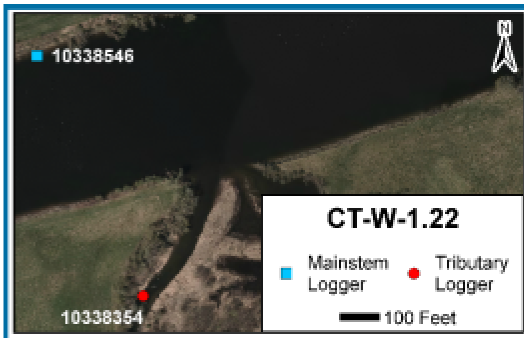
1.5 Site CT-W-1.22 Indian Pond Brook

Site CT-W-1.22 Indian Pond Brook, is a stream order 3 tributary located on the New Hampshire side in the middle Wilder impoundment. This location was initially visited on August 6, 2014 and tributary (SN 10338354) and mainstem (SN 10338546) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 4, 2014 at which time the level loggers were removed. The level logger initially installed in the mainstem suffered a launch failure after installation and did not record from the time it was initially installed until the first check on August 26th. The unit was reprogrammed on that date. The mainstem level logger was also found to be missing during the final site visit. As a result mainstem sensor depth information is limited to the period August 26 to September 25, 2014.

The tributary level logger was installed approximately 180 feet upstream from the confluence with the mainstem. The extent of project influence was estimated by extending the maximum operational WSE value recorded by the mainstem level logger (384.4 feet) upstream to the point along the tributary thalweg profile where that elevation was first achieved. Mainstem data collected at this site was limited to a one month period and based on that limitation, the project-influenced reach was estimated at 1,114 ft up into the tributary. The maximum mainstem WSE elevation (384.6) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach. Flow was present in Indian Pond Brook during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.5 to 4.2 ft. Water depths were measured along the channel thalweg during the initial site visit on August 6th and ranged between 0.2 ft on the downstream side of an instream obstruction (see photo below) and 3.4 ft (mean = 1.9 ft).

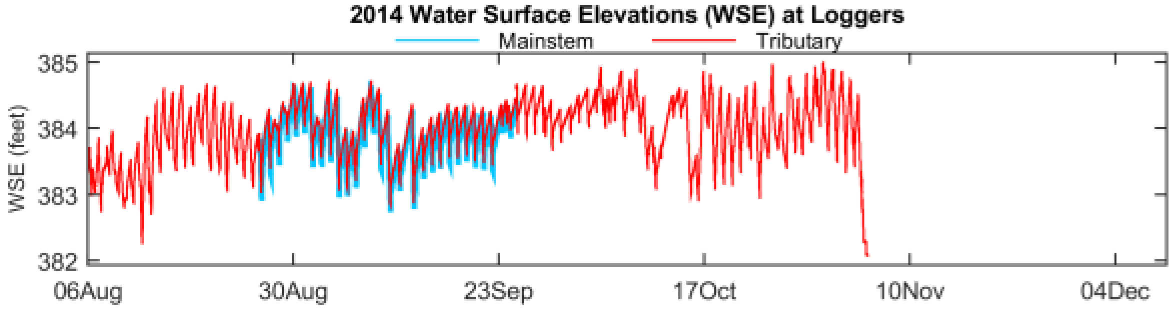
There is a single shallow water area located approximately 1,000 ft upstream of the confluence with the mainstem. The presence of this shallow water area can be attributed to downed logs with a deeper scour hole on the upstream side and area of deposition on the downstream side (see thalweg plot and photographs). However, under all recorded conditions access appears adequate (0% of data occurrences < 0.5 ft of depth at the confluence).

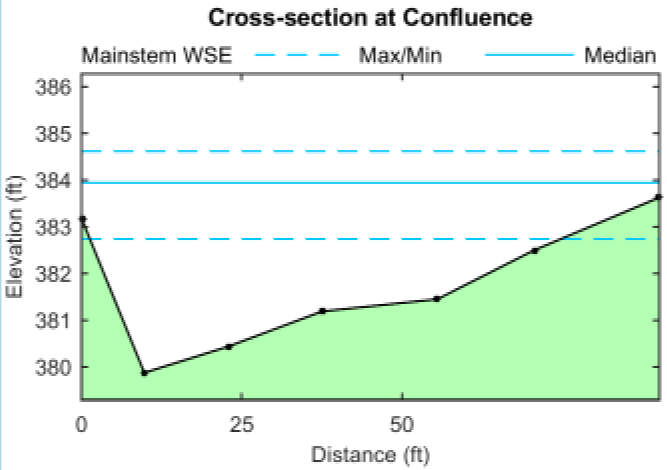
View looking from upstream to downstream of in-stream obstruction creating shallow-water shoal area within the project-affected portion of Indian Pond Brook approximately 1,000 ft upstream from the confluence with mainstem river during 2014.



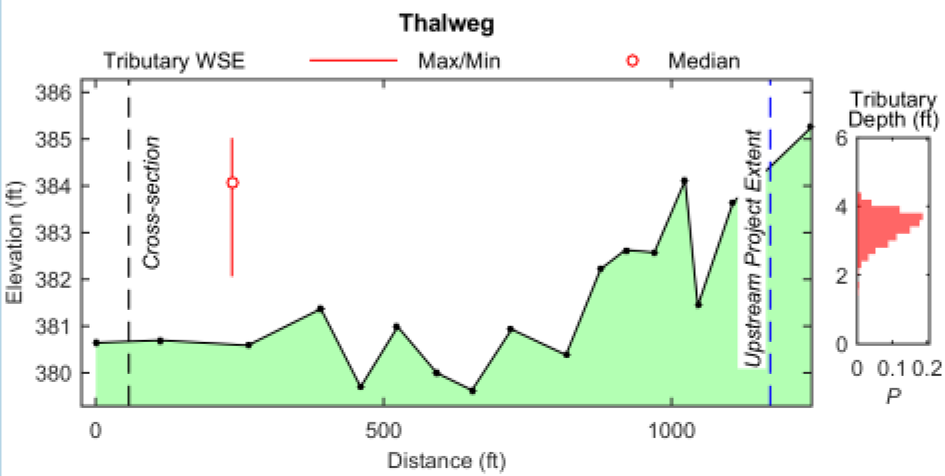
Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.22

Indian Pond Brook, Major tributary, Stream Order 3





Mainstem Logger 10338546 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 384.6	06Aug2014	2.8
75%: 384.1	26Aug2014	3.9
Mean: 383.9	25Sep2014	4.2
50%: 383.9	05Nov2014	1.5
25%: 383.7		
Min: 382.7		



Tributary Logger 10338354

Feet:	WSE	Water Depth
Max:	385.0	4.4
75%:	384.3	3.7
Mean:	384.0	3.4
50%:	384.1	3.4
25%:	383.7	3.1
Min:	382.1	1.5

Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.22
Indian Pond Brook, Major tributary, Stream Order 3

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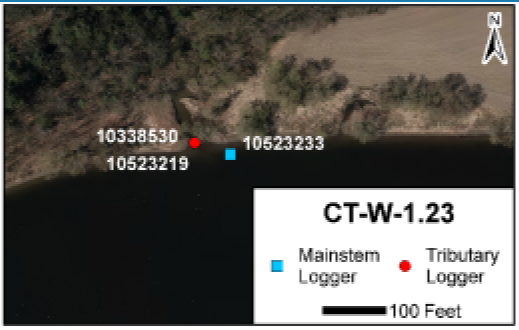
1.6 Site CT-W-1.23

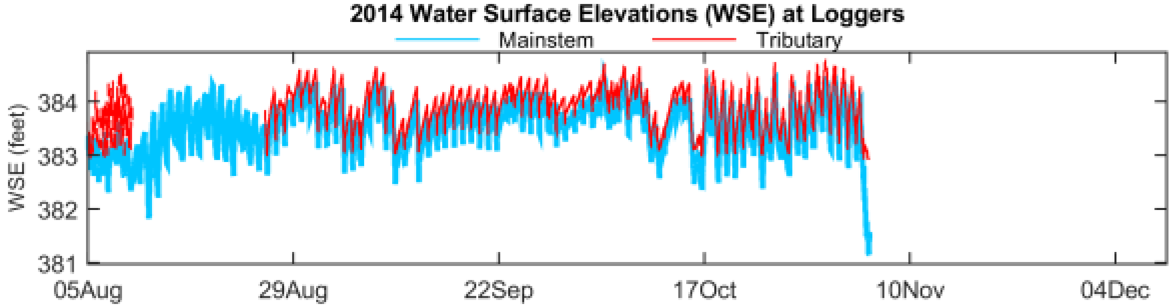
Site CT-W-1.23 is an unnamed stream order 1 tributary located on the Vermont side in the middle Wilder impoundment. This location was initially visited on August 5, 2014 and tributary (SN 10523219) and mainstem (SN 10523233) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 5, 2014 at which time the level loggers were removed. The level logger initially installed in the tributary was determined to have stopped working five days after installation in the field. The field crew replaced that unit with a new logger (SN 10338530). As a result data sensor depth information for the tributary is limited to the period August 10 to November 5, 2014.

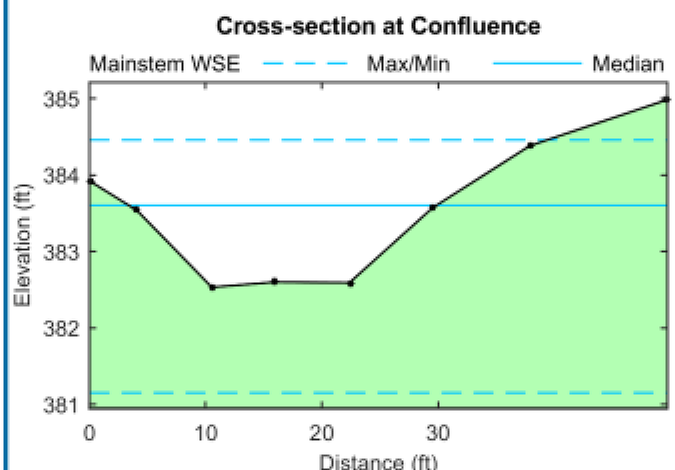
The tributary level logger was installed approximately 9 feet upstream from the confluence with the mainstem. The extent of project effects was estimated by extending the maximum operational WSE value recorded by the mainstem level logger (384.2 feet) upstream to the point along the tributary thalweg profile where that elevation was first achieved and the project-affected reach was determined to be 263 ft. The maximum mainstem WSE (384.5) indicates that the mainstem influence extends farther up in to the tributary than the project-affected reach. Flow was present in tributary CT-W-1.23 during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.1 to 1.6 ft. Water depths were measured along the channel thalweg during the November 5th site visit and ranged between 0.1 and 0.7 ft (mean = 0.2 ft).

Site CT-W-1.23 is a small, stream order 1 tributary. Review of the frequency distribution of water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the immediate confluence area ranged between 1.2 and 1.7 ft and should provide adequate upstream access. However, access will likely be hindered at a shallow, shoaled area (elevation = 383.9 ft) located approximately 100 ft upstream from the confluence (see photo taken at 0939 on 05Nov14 below). Only WSE values in the upper 25th percentile of those recorded by the mainstem level logger indicated that mainstem inflow would be available to provide access over the shoaled area. Access into this tributary is limited under low flow mainstem and tributary conditions such as those observed during the November 5th site visit (11.0% of data occurrences < 0.5 ft of depth at the confluence).

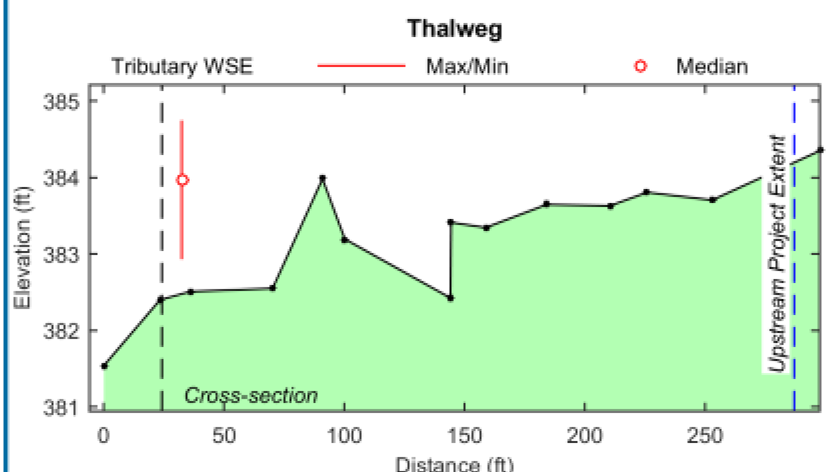


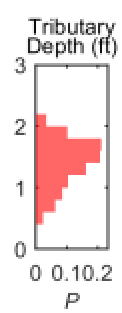
Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.23
Unnamed minor tributary, Stream Order 1





Mainstem Logger 10523233 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 384.5	05Aug2014	0.8
75%: 383.9	26Aug2014	1.6
Mean: 383.5	25Sep2014	0.7
50%: 383.6	05Nov2014	0.1
25%: 383.2		
Min: 381.2		





Tributary Logger 10338530 Feet:	WSE	Water Depth
Max:	384.7	2.3
75%:	384.2	1.7
Mean:	383.9	1.4
50%:	384.0	1.5
25%:	383.7	1.2
Min:	382.9	0.5

Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.23
Unnamed minor tributary, Stream Order 1

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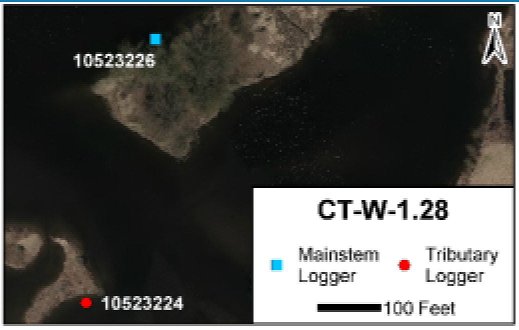
1.7 Site CT-W-1.28 Backwater

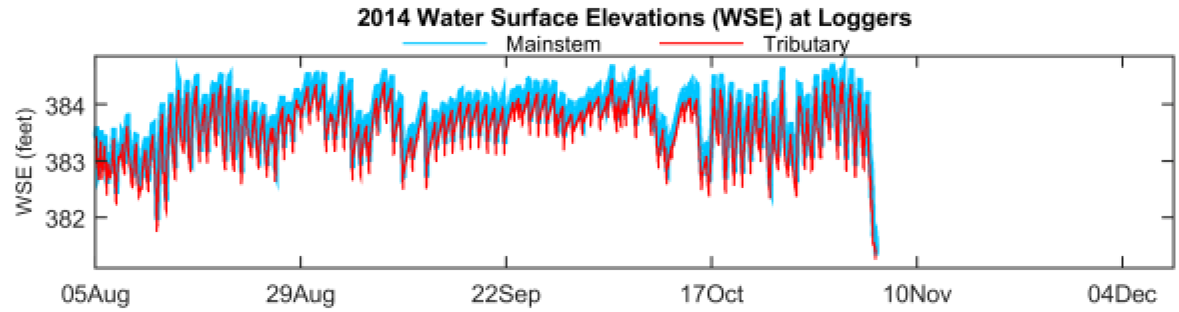
Site CT-W-1.28 is a backwater located on the New Hampshire side in the middle Wilder impoundment. This location was initially visited on August 5, 2014 and tributary (SN 10523224) and mainstem (SN 10523226) level loggers were installed on that date. Subsequent site visits were conducted on August 25 and September 25, 2014. The final site visit occurred on November 5, 2014 at which time the level loggers were removed.

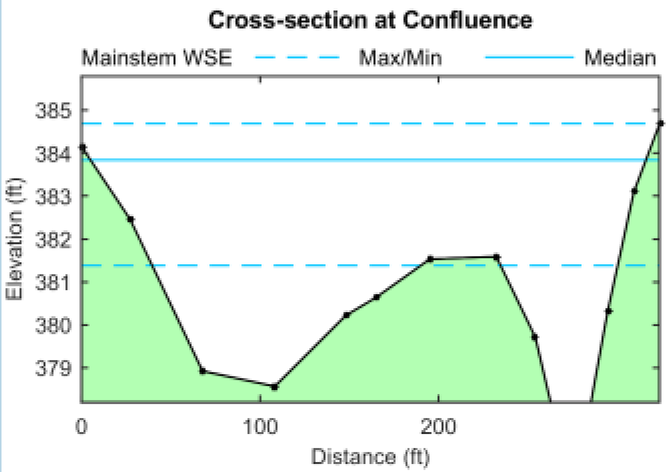
Backwater Site CT-W-1.28 is connected to the mainstem via a wide opening (see confluence with mainstem in photograph section below). The backwater level logger was installed approximately 120 ft from the confluence. During the initial site visit, the field crew visually determined the extent of the project-affected area (elevation 384.5 ft) as running across the ponded backwater area (a linear distance of 1,285 ft), verified later by evaluation of WSE data. The maximum mainstem WSE (384.7) indicates that the mainstem influence extends farther than the project-affected reach. Water was present within the backwater during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 5.6 to 7.2 ft. Water depths were measured across the ponded backwater area during the initial site visit and ranged between 1.0 and 3.0 ft (mean = 1.9 ft).

Review of range of WSE values recorded by the mainstem level logger, indicates that under all observed conditions (i.e., min through max values) water depth at thalweg within the immediate confluence area ranged between 5.4 and 8.7 ft, and will provide adequate upstream access. As evidenced by the thalweg profile, bottom elevations vary from the confluence across the backwater. When the range of WSE values recorded by the backwater level logger is considered, under most conditions (i.e., 25th through 75th percentiles) WSE ranged between 383.2 ft and 383.9 ft. This range of WSE values would provide greater than 1 foot of water over all of the higher elevation locations in the thalweg (with 0% of data occurrences < 0.5 ft of depth at the confluence). However, as indicated by the minimum WSE values recorded at the mainstem and backwater level logger locations (381.4 and 381.3 ft, respectively), available habitat area within the backwater may be reduced somewhat under low mainstem conditions.

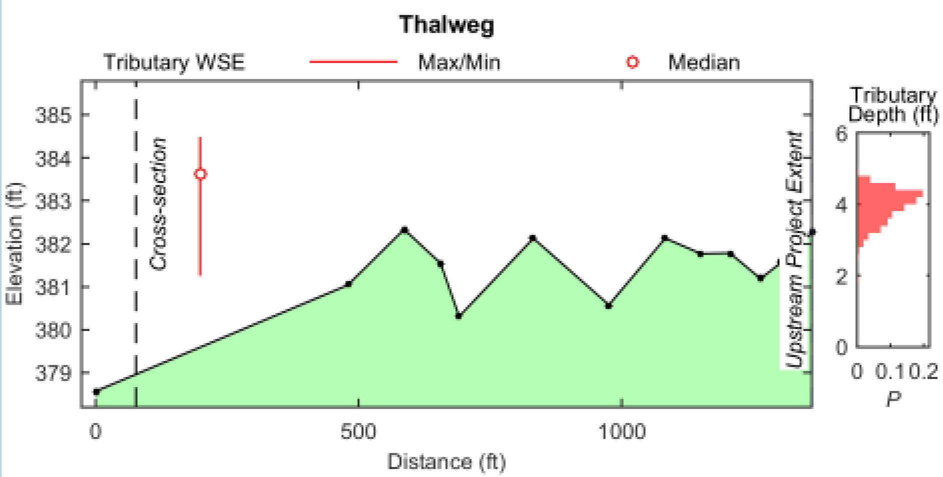


Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.28
Unnamed backwater, Stream Order 0





Mainstem Logger 10523226	Date	Maximum Measured Water Depth (ft)
Feet: WSE	Date	Depth (ft)
Max: 384.7	05Aug2014	7.2
75%: 384.1	25Aug2014	6.4
Mean: 383.8	25Sep2014	6.9
50%: 383.8	05Nov2014	5.6
25%: 383.5		
Min: 381.4		



Tributary Logger 10523224		
Feet:	WSE	Water Depth
Max:	384.5	4.9
75%:	383.9	4.3
Mean:	383.5	4.0
50%:	383.6	4.0
25%:	383.2	3.7
Min:	381.3	1.7

Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.28
Unnamed backwater, Stream Order 0

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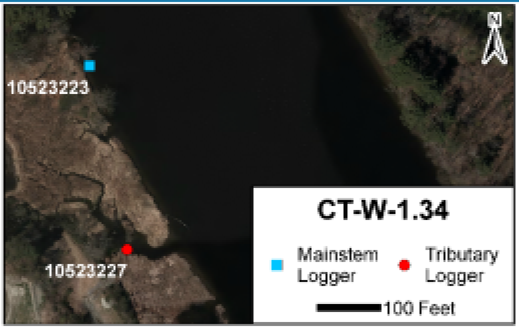
1.8 Site CT-W-1.34

Site CT-W-1.34 is an unnamed stream order 2 tributary located on the Vermont side in middle Wilder impoundment. This location was initially visited on August 5, 2014 and tributary (SN 10523227) and mainstem (SN 10523223) level loggers were installed on that date. Subsequent site visits were conducted on August 25 and September 25, 2014. The final site visit occurred on November 5, 2014 at which time the tributary level logger was removed. The mainstem level logger at site CT-W-1.34 was removed six days later (November 11, 2014). During the manual data review portion of post-processing, it was discovered that pressure readings recorded by the tributary level logger were impacted by a logger malfunction. This malfunction resulted in plotted sensor depths far exceeding the range expected for this particular location and data from this location was assigned a Use Code = 9 (Table 4.2-1). As a result sensor depth information for the tributary is limited to the period August 5 to August 26, 2014.

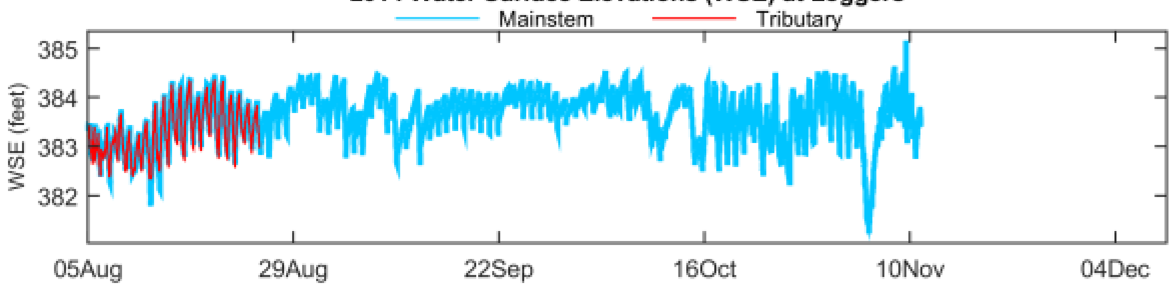
The tributary level logger was installed in the immediate vicinity of the confluence with the mainstem. The extent of project effects was estimated by extending the maximum operational WSE value recorded by the mainstem level logger upstream to the point along the tributary thalweg profile where that elevation was first achieved, approximately 322 ft up into the tributary. The maximum mainstem WSE (385.2 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (384.3 ft elevation). Flow was present in tributary CT-W-1.34 during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.5 to 1.9 ft. Water depths were measured along the channel thalweg during the August 5th site visit and ranged between 0.2 and 1.2 ft (mean = 0.6 ft).

Site CT-W-1.34 is a small, stream order 2 tributary. Review of the frequency distribution of water depth recorded by the tributary level logger over the limited period of logger data indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the immediate confluence area ranged between 0.9 and 1.6 ft and should provide adequate access. Under median conditions (WSE = 383.6 ft; mainstem level logger), the tributary will be inundated by mainstem water approximately 250 ft upstream from the confluence. Under low mainstem WSE conditions (minimum value recorded = 381.2 ft), the tributary is no longer inundated by mainstem water and is limited to its own natural outflow. Under those conditions, access would be limited as evidenced by the minimum water depth recorded by the tributary logger (water depth = 0.3 ft, see Nov 5 photos) and may be limited (0.4% of data occurrences < 0.5 ft of depth at the confluence).

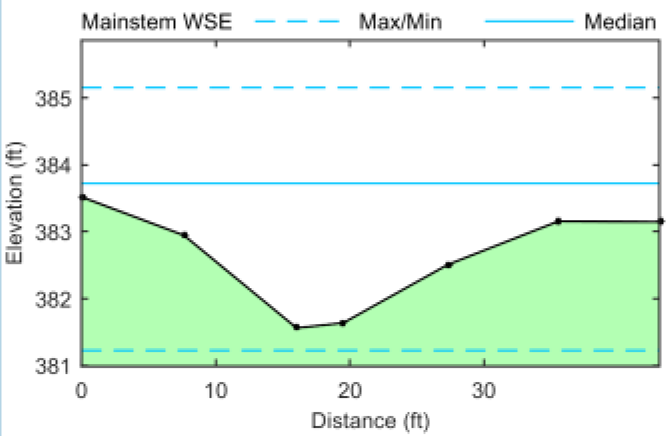


Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.34
Unnamed minor tributary, Stream Order 2

2014 Water Surface Elevations (WSE) at Loggers

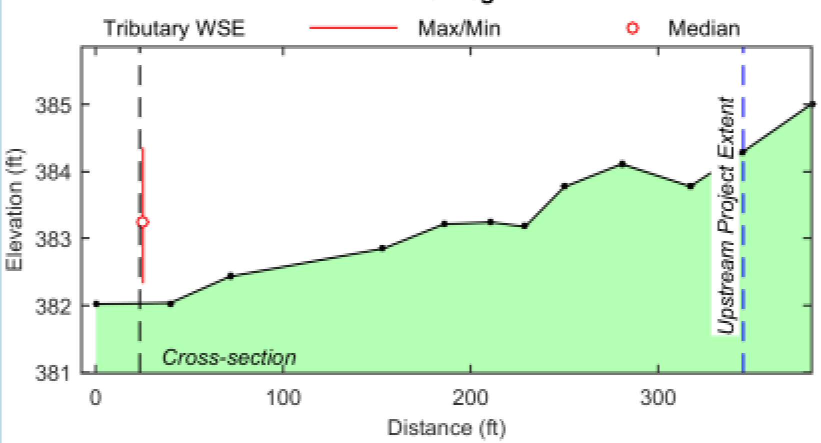


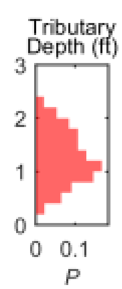
Cross-section at Confluence



Mainstem Logger 10523223 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 385.2	05Aug2014	1.9
75%: 384.0	25Aug2014	1.1
Mean: 383.6	25Sep2014	1.9
50%: 383.7	05Nov2014	0.5
25%: 383.3		
Min: 381.2		

Thalweg





Tributary Logger 10523227 Feet:	WSE	Water Depth
Max:	384.3	2.3
75%:	383.7	1.6
Mean:	383.3	1.3
50%:	383.2	1.2
25%:	382.9	0.9
Min:	382.3	0.3

Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.34
Unnamed minor tributary, Stream Order 2

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1.9 Site CT-W-1.44 Backwater

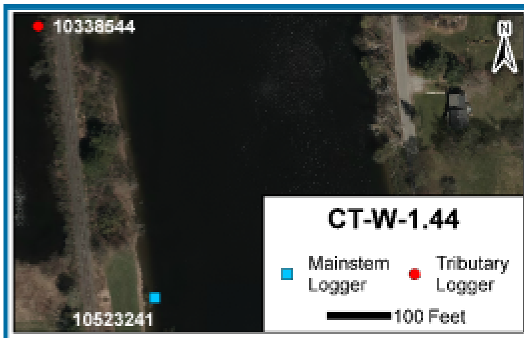
Site CT-W-1.44 is a backwater located on the Vermont side in the middle Wilder impoundment. This location was initially visited on August 5, 2014 and tributary and mainstem level loggers were installed on that date. Subsequent site visits were conducted on August 25/26 and September 25, 2014. The final site visit occurred on October 20, 2014 at which time the level loggers were removed.

The site is connected to the mainstem via a large culvert approximately 5 ft wide and 13 ft deep which runs for approximately 50 ft underneath the railroad. The backwater level logger was installed adjacent to the culvert entrance on the backwater side. During the initial site visit, the field crew visually determined the extent of the project-affected area as running across the ponded backwater area and up a small feeder stream to a point where visible bank scour was absent (see photo below). The project-affected area was estimated to cover a linear distance of 1,391 ft, later confirmed by evaluation of WSE data. The maximum mainstem WSE (384.8 ft) indicates that the mainstem influence extends farther into the backwater than the project-affected reach (384.5 ft elevation).

The small feeder stream covered the upper 400 ft of the project-affected reach. Water was present within backwater Site CT-W-1.44 during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 8.8 to 9.8 ft. Water depths were measured during the initial site visit across the ponded backwater area and up the small feeder stream located along the western bank of the backwater. Water depths within the feeder stream ranged between 0.3 and 3.2 ft (mean = 1.9 ft) with shallower readings at the upper extent of the project-affected area. Water depths measured within the ponded backwater area primarily ranged from 1-3 ft with deeper areas up to 4-5 ft.

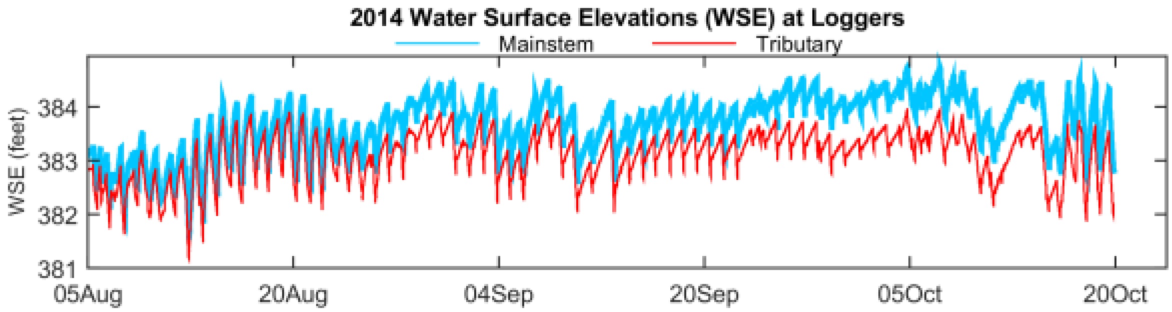
Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth within the culvert located at the confluence ranged between 8.3 and 11.1 ft and will provide adequate upstream access. As evidenced by the thalweg profile bottom elevations vary from the confluence across the backwater and up the feeder stream. When the range of WSE values recorded by the backwater level logger is considered, under all observed conditions (i.e., min through max values) WSEs were sufficient to cover the thalweg point within the ponded backwater area with the greatest elevation (380.7 ft) with 0.5 ft of water depth. When the bed elevation at the upstream extent of the feeder stream was compared to the range of WSE values recorded by the backwater level logger, that location was inundated with at least 0.4 ft of water under most conditions (i.e., 25th through 75th percentiles; WSE values of 382.8 ft and 383.4 ft (with 0% of data occurrences < 0.5 ft of depth at the confluence). As indicated by the minimum WSE recorded at the backwater level logger location (381.2 ft), water depth at the upstream end of the feeder stream may be limited to natural stream outflow under low mainstem conditions.

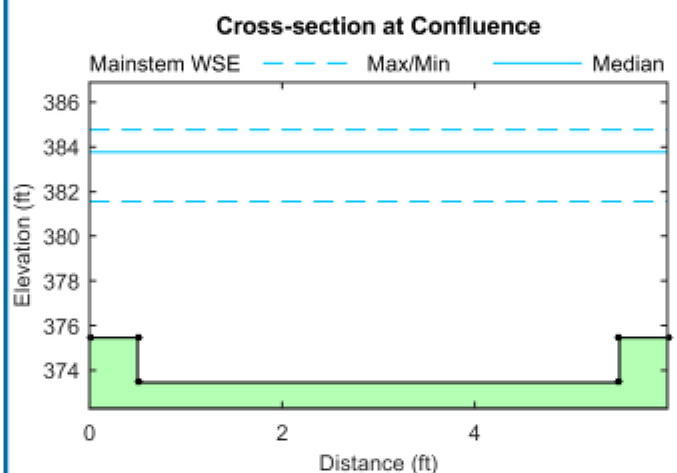
Upstream extent of project-affected area associated with backwater Site CT-W-1.44 as determined by visual observations, August 2014.



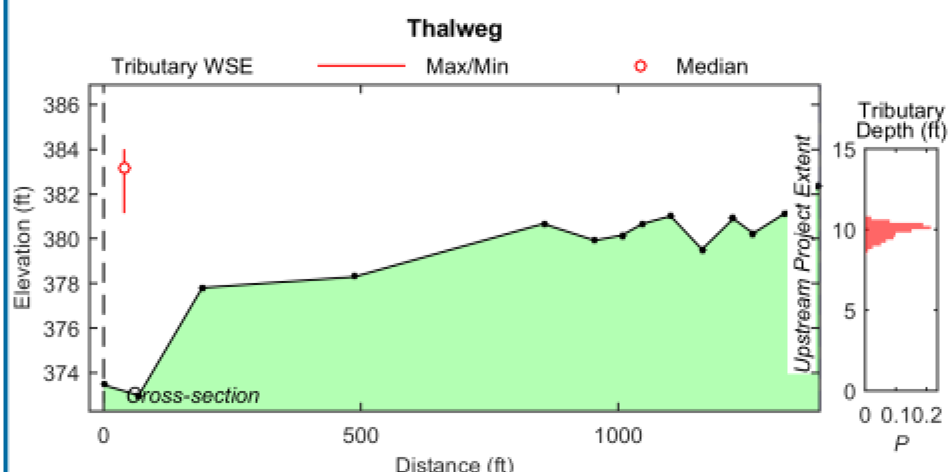
Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.44

Unnamed backwater, Stream Order 0





Mainstem Logger 10523241 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 384.8	05Aug2014	9.4
75%: 384.1	26Aug2014	8.8
Mean: 383.7	25Sep2014	9.8
50%: 383.8	20Oct2014	8.8
25%: 383.3		
Min: 381.6		



Tributary Logger 10338544 Feet:	WSE	Water Depth
Max:	384.0	10.8
75%:	383.4	10.2
Mean:	383.1	9.9
50%:	383.2	10.0
25%:	382.8	9.6
Min:	381.2	8.0

Middle Wilder Impoundment, Connecticut River
Site ID: CT-W-1.44
Unnamed backwater, Stream Order 0

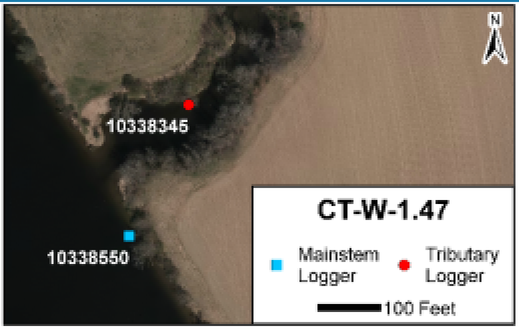
1.10 Site CT-W-1.47

Site CT-W-1.47 is an unnamed stream order 1 tributary located on the New Hampshire side in the lower Wilder impoundment. This location was initially visited on July 24, 2014 and tributary (SN 10338345) and mainstem (SN 10338550) level loggers were installed on that date. Subsequent site visits were conducted on August 25 and September 25, 2014. The final site visit occurred on November 3, 2014 at which time the level loggers were removed.

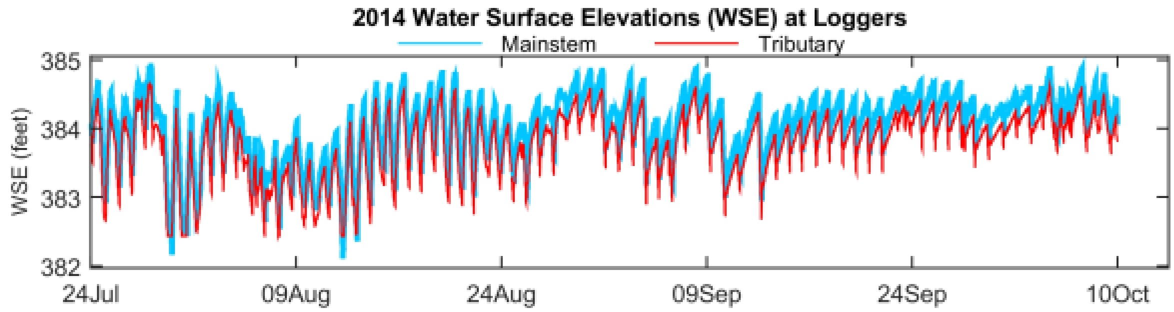
The tributary level logger was installed approximately 123 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 683 ft, later confirmed by evaluation of WSE data, up into the tributary to a section where bank vegetation did not indicate significant fluctuating water levels (see photo below). The maximum mainstem WSE (384.9 ft)indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (384.7 ft elevation). Flow was present in the tributary during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.8 to 2.9 ft. Water depths were measured along the channel thalweg during the July 24th site visit and ranged between 0.3 and 3.9 ft (mean = 1.8 ft). Thalweg water depths of ≤ 0.5 ft were limited to the upper 40-50 ft of the project-affected reach.

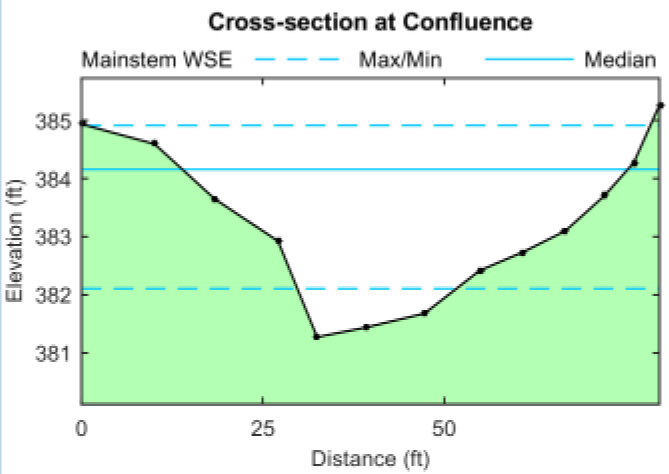
Site CT-W-1.47 is a small, stream order 1 tributary. Review of the frequency distribution of water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at that location ranged between 1.1 and 1.7 ft with deeper conditions present in the 123 ft stretch between the tributary level logger and the mainstem confluence. Under median mainstem conditions (WSE = 384.2 ft; mainstem level logger), the tributary is inundated by mainstem water to the upstream end of the project-affected reach. Under low mainstem WSE conditions (minimum value recorded = 382.1 ft), the tributary is inundated by project-affected water approximately 100 ft upstream and above that, at and beyond a deep thalweg hole, is limited to only its own natural outflow but access should still be adequate (0% of data occurrences < 0.5 ft of depth at the confluence).

Upstream extent of project-affected area associated with
Site CT-W-1.47 as determined by visual observations, July 2014.

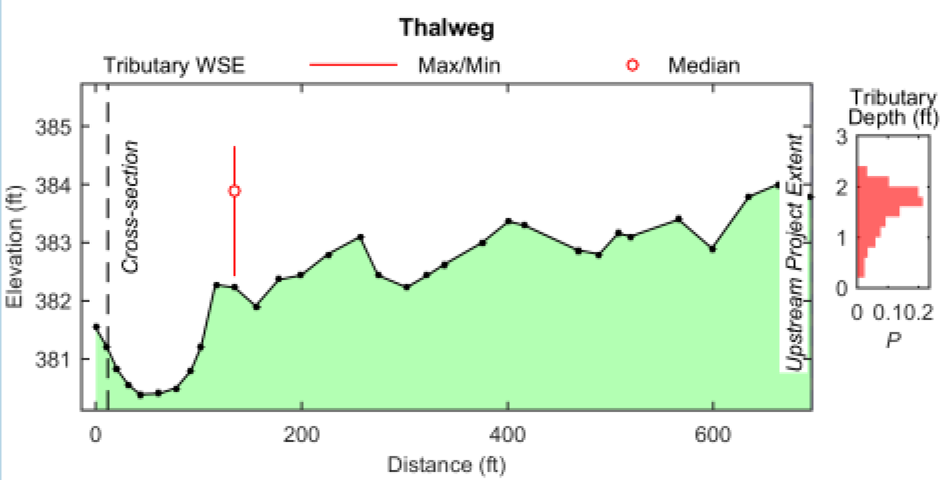


Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.47
Unnamed minor tributary, Stream Order 1





Mainstem Logger 10338550 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 384.9	24Jul2014	2.6
75%: 384.4	25Aug2014	1.8
Mean: 384.0	25Sep2014	2.9
50%: 384.2	03Nov2014	2.6
25%: 383.8		
Min: 382.1		



Tributary Logger 10338345 Feet:	WSE	Water Depth
Max:	384.6	2.4
75%:	384.1	1.9
Mean:	383.8	1.5
50%:	383.9	1.7
25%:	383.5	1.3
Min:	382.4	0.2

Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.47
Unnamed minor tributary, Stream Order 1

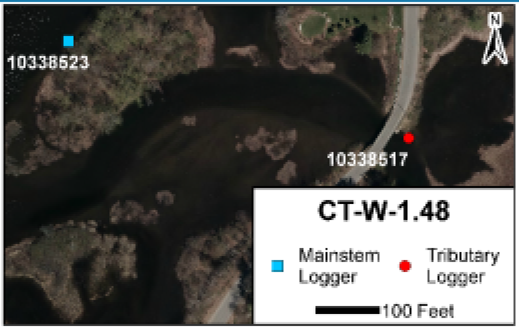
1.11 Site CT-W-1.48 Grant Brook

Site CT-W-1.48 Grant Brook, is a stream order 3 tributary located on the New Hampshire side in the lower Wilder impoundment. This location was initially visited on July 25, 2014 and tributary (SN 10338517) and mainstem (SN 10338523) level loggers were installed on that date. Subsequent site visits were conducted on August 26 and September 25, 2014. The final site visit occurred on November 6, 2014 at which time the level loggers were removed.

The tributary level logger was installed approximately 810 feet upstream from the confluence with the mainstem and just on the upstream side of the River Road bridge. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 2,284 ft up into Grant Brook to a section of the tributary where bank vegetation did not indicate significant fluctuating water levels (see photo below). Review of the WSE values recorded by the mainstem level logger indicates that the project-affected reach extends to approximately 3,338 ft, and the maximum mainstem WSE (384.7 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (384.5 ft). Project-affected water levels remain below the end of project elevation (383.6 ft) between 25-50 percent of the time (25% occurrence = 383.5 ft / 50% occurrence = 383.9 ft).

Flow was present in Grant Brook during each of the four visits. Water depth at the confluence cross section was measured during three of the four visits and the maximum water depth ranged from 5.7 to 6.6 ft. Water depths were measured along the channel thalweg during the initial site visit on July 25th and ranged between 0.6 ft and 8.3 ft (mean = 3.9 ft). The shallowest water depth on the date of measurement was located at the upstream extent of the project-affected reach and access should be adequate (0% of data occurrences < 0.5 ft of depth at the confluence).

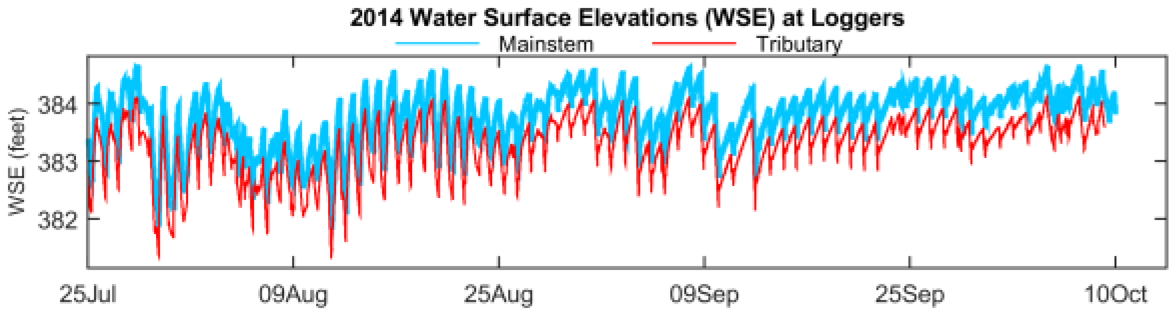
Upstream extent of project-affected area associated with Site CT-W-1.48 as determined by visual observations, July 2014.

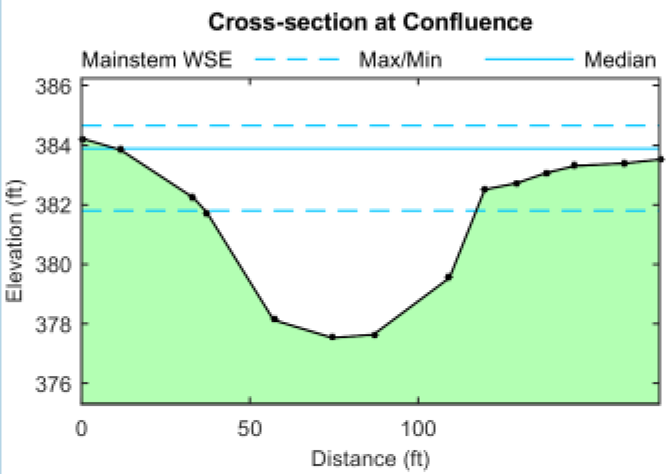


Lower Wilder Impoundment, Connecticut River

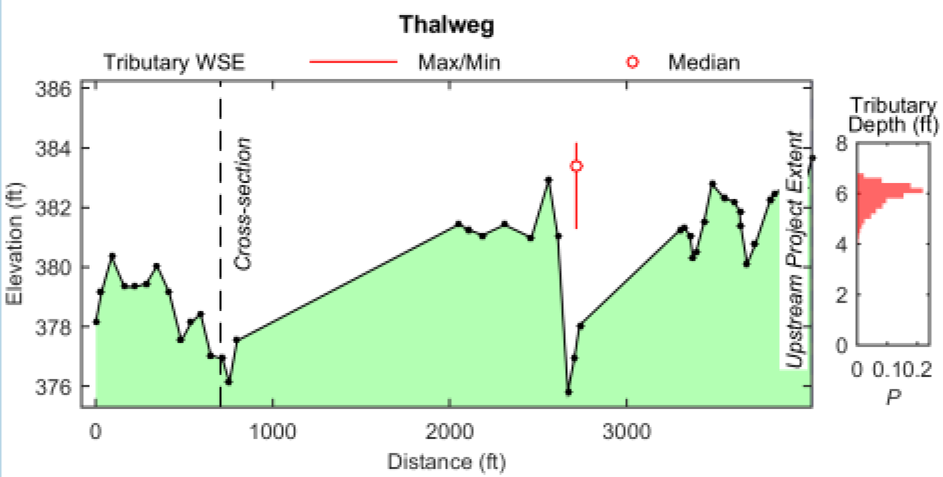
Site ID: CT-W-1.48

Grant Brook, Major tributary, Stream Order 3





Mainstem Logger 10338523 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 384.7	25Jul2014	6.6
75%: 384.1	26Aug2014	NaN
Mean: 383.8	25Sep2014	5.7
50%: 383.9	06Nov2014	6.0
25%: 383.5		
Min: 381.8		



Tributary Logger 10338517 Feet:	WSE	Water Depth
Max:	384.1	6.8
75%:	383.6	6.2
Mean:	383.3	5.9
50%:	383.4	6.0
25%:	383.0	5.6
Min:	381.3	3.9

Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.48
Grant Brook, Major tributary, Stream Order 3

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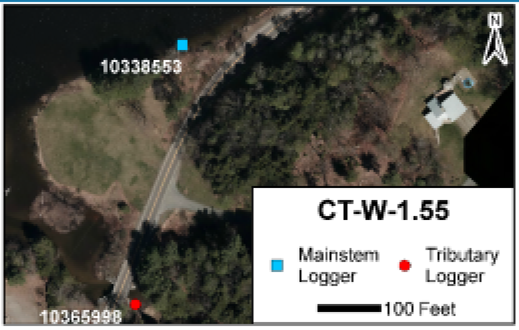
1.12 Site CT-W-1.55

Site CT-W-1.55 is an unnamed stream order 1 tributary located on the New Hampshire side in the lower Wilder impoundment. This location was initially visited on July 24, 2014 and tributary (SN 10365998) and mainstem (SN 10338553) level loggers were installed on that date. Subsequent site visits were conducted on August 25 and September 24, 2014. The final site visit was initiated late in the day on October 20, 2014 and the mainstem level logger was removed on that date. Due to high flows associated with a rain event, the remainder of the final site visit was conducted on November 6, 2014 at which time the tributary logger was removed.

The tributary level logger was installed approximately 321 feet upstream from the confluence with the mainstem and just on the upstream side of the River Road bridge. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 402 ft up into the tributary (later confirmed by evaluation of WSE data) to a section where bank vegetation did not indicate significant fluctuating water levels (see photo below). The maximum mainstem WSE (384.8 ft) indicates that the mainstem influence extends slightly farther upstream than the project-affected reach (384.5 ft). Flow was present in tributary CT-W-1.55 during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.5 to 3.1 ft. Water depths were measured along the channel thalweg during the initial site visit on July 24th and ranged between 1.2 ft and 4.6 ft (mean = 2.6 ft).

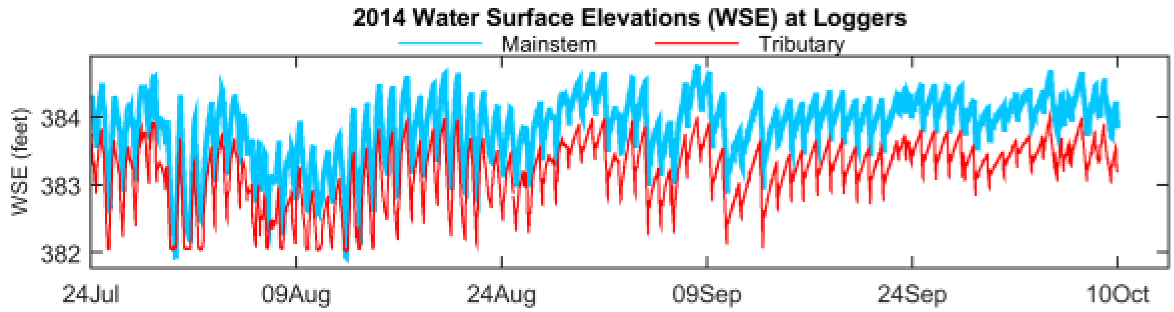
Review of the frequency distribution of tributary water depth recorded by the level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at that location ranged between 0.9 and 1.5 ft. As indicated by the minimum water depth recorded at the tributary level logger location (0.1 ft), access may be reduced within some sections of the channel downstream of the level logger location under low mainstem conditions and access could be limited, but 0% of data occurrences were < 0.5 ft of depth at the confluence.

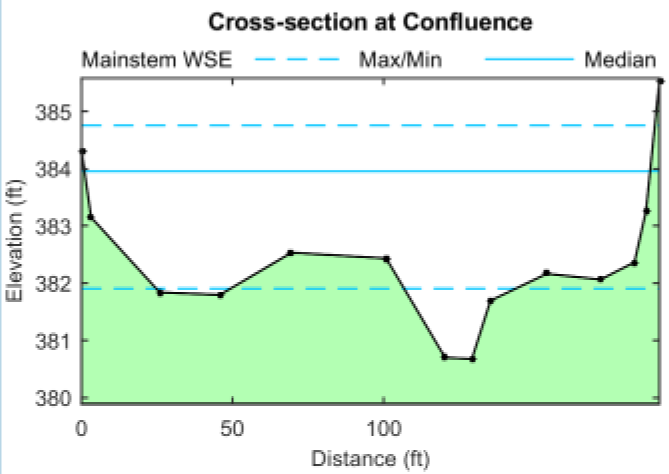
Upstream extent of project-affected area associated with Site CT-W-1.55 as determined by visual observations, 2014.



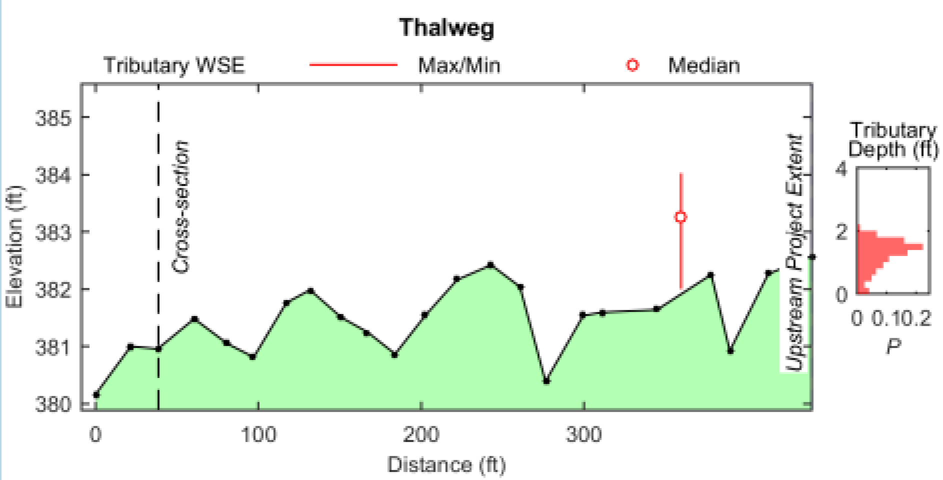
Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.55

Unnamed minor tributary, Stream Order 1





Mainstem Logger 10338553 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 384.8	24Jul2014	2.6
75%: 384.2	25Aug2014	1.5
Mean: 383.8	24Sep2014	3.1
50%: 384.0	06Nov2014	2.7
25%: 383.6		
Min: 381.9		



Tributary Logger 10365998 Feet:	WSE	Water Depth
Max:	384.0	2.1
75%:	383.5	1.6
Mean:	383.2	1.2
50%:	383.3	1.4
25%:	382.9	1.0
Min:	382.0	0.1

Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.55
Unnamed minor tributary, Stream Order 1

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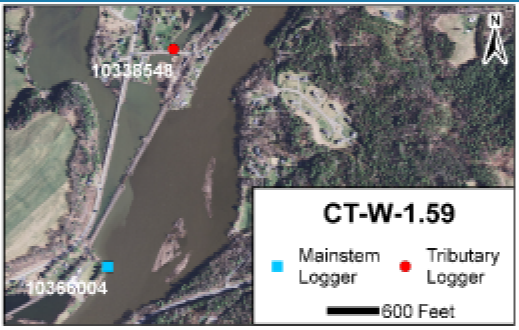
1.13 Site CT-W-1.59

Site CT-W-1.59 is a backwater located on the Vermont side in the lower Wilder impoundment. This location was initially visited on July 23, 2014. The tributary level logger (SN 10338548) was installed on that date and the mainstem level logger (SN 10366004) was installed the following day (July 24, 2014). Subsequent site visits were conducted on August 26 and September 24, 2014. The final site visit occurred on October 20, 2014 at which time the level loggers were removed.

Backwater Site CT-W-1.59 is connected to the mainstem via a culvert approximately 3 ft wide and 2.9 ft deep which runs for approximately 70 ft underneath Kendall Station Road. The backwater level logger was installed adjacent to the culvert entrance on the backwater side. During the initial site visit, the field crew visually determined the extent of the project-affected area as running across the ponded backwater area (see photograph time stamped 15:16 20Oct14). The project-affected area was estimated to cover a linear distance of 1,689 ft, later confirmed by evaluation of WSE data. The maximum mainstem WSE (384.6 ft) indicates that the mainstem influence extends slightly farther into the backwater than the project affected reach (384.5). Water was present within the backwater during each of the four visits. Water depth at the access culvert was measured during each visit and ranged from 2.1 to 2.9 ft. Water depths were measured across the ponded backwater area during the initial site visit and ranged between 1.4 and 4.4 ft (mean = 3.1 ft) with shallower readings at the upper extent of the project-affected area. Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth within the culvert located at the confluence ranged between 1.0 and 3.6 ft and will provide adequate upstream access. The culvert entrance into the backwater is covered with a section of chain link fencing which was regularly clogged with woody debris (see photographs below).

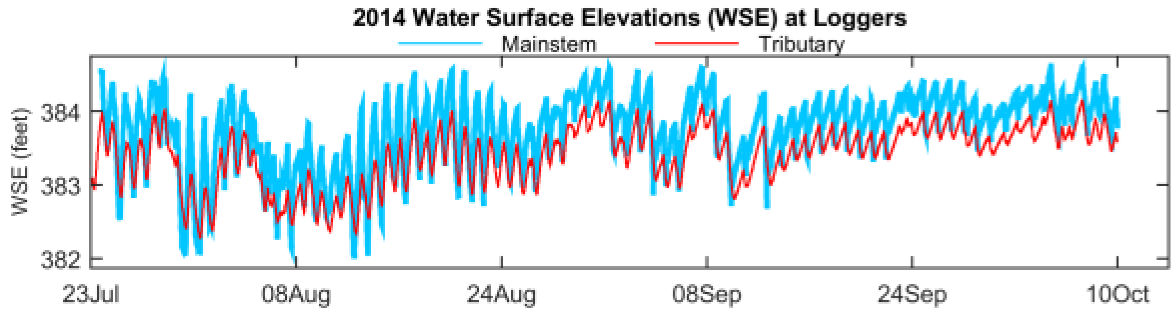
As evidenced by the thalweg profile , bottom elevations vary from the confluence across the backwater. When the range of WSE values recorded by the backwater level logger is considered, under the majority of observed conditions (i.e., 25% occurrence and greater) WSEs were sufficient to cover the thalweg point with the greatest elevation (382.1 ft) with 1.0 ft of water depth. Although unrelated to TransCanada operations, fish access may be periodically hindered by the occurrence of debris loading on the section of chain link fencing installed over the backwater side of the access culvert. Access into the backwater is adequate (0% of data occurrences < 0.5 ft of depth at the confluence).

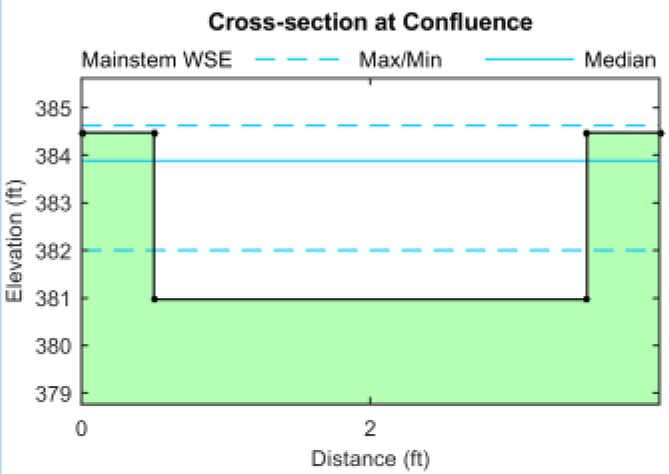


Lower Wilder Impoundment, Connecticut River

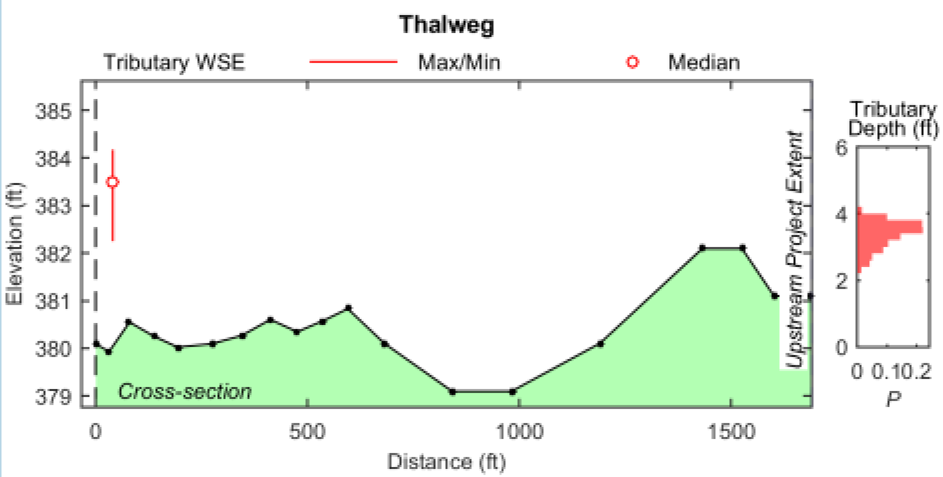
Site ID: CT-W-1.59

Unnamed backwater, Stream Order 0





Mainstem Logger 10366004 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 384.6	23Jul2014	2.1
75%: 384.1	26Aug2014	2.3
Mean: 383.8	24Sep2014	2.9
50%: 383.9	20Oct2014	2.6
25%: 383.5		
Min: 382.0		



Tributary Logger 10338548 Feet:	WSE	Water Depth
Max:	384.2	4.1
75%:	383.7	3.7
Mean:	383.4	3.4
50%:	383.5	3.5
25%:	383.1	3.1
Min:	382.3	2.2

Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.59
Unnamed backwater, Stream Order 0

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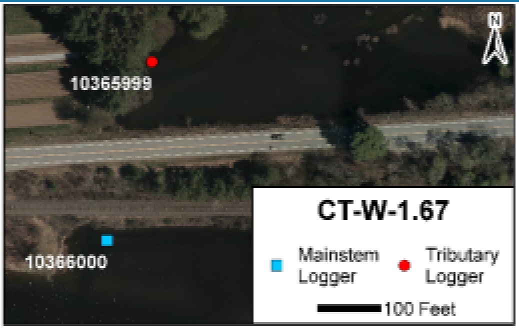
1.14 Site CT-W-1.67

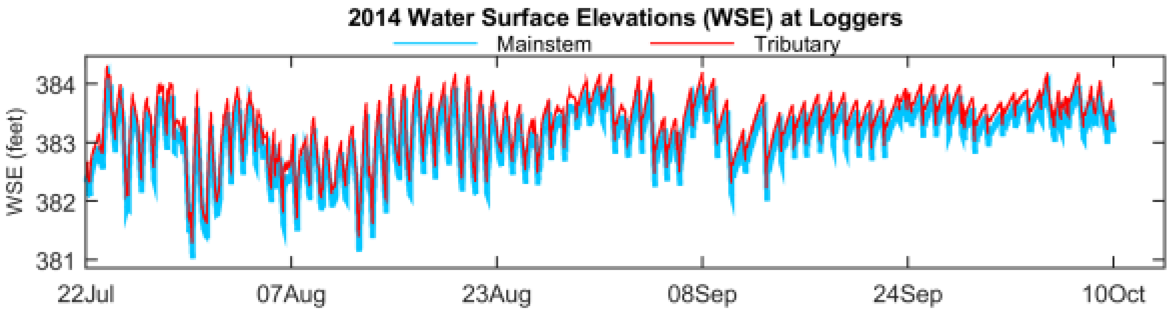
Site CT-W-1.67 is an unnamed stream order 2 tributary located on the Vermont side in the lower Wilder impoundment. This location was initially visited on July 22, 2014 and tributary and mainstem level loggers were installed on that date. Subsequent site visits were conducted on August 25 and September 24, 2014. The final site visit occurred on October 20, 2014 at which time the level loggers were removed.

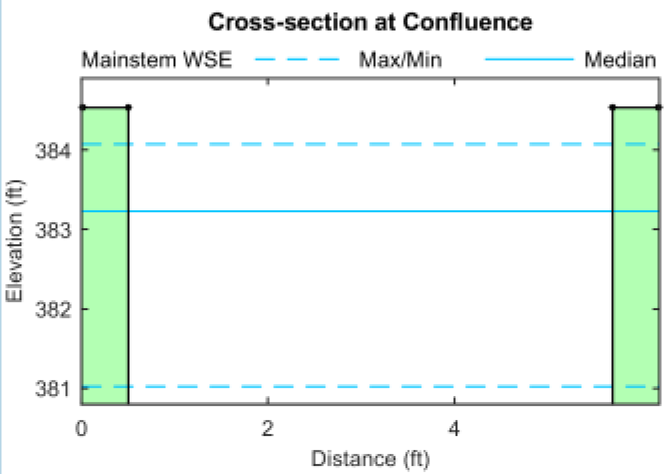
The tributary is connected to the mainstem via a culvert approximately 5 ft wide and 8 ft deep which runs for approximately 150 ft underneath the railroad and Route 5. There is a pump withdrawal for an adjacent farm operation located along the western bank just upstream from the culvert entrance. The tributary functions more as a backwater than as a tributary due to the presence of the culvert and can be characterized by a large ponded area (see photos and site map below). The tributary level logger was installed approximately 25 feet upstream of the culvert entrance on the backwater side. During the initial site visit, the field crew visually determined the extent of the project-affected area as running across the ponded backwater area (see photo time stamped 0959 20Oct14 below). The project-affected area was estimated to cover a linear distance of 804 ft, later confirmed by evaluation of WSE data. The maximum mainstem WSE (384.1 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (383.8 ft). Water was present within the backwater during each of the four visits. Water depth at the access culvert was measured during each visit and ranged from 5.3 to 6.7 ft. Water depths across the ponded backwater area were calculated as the difference between the measured WSE during the initial site visit and measured bed elevation information collected during Study 7 (Normandeau 2014b) and ranged between 0 and 1.9 ft (mean = 1.1 ft) with non-wetted areas towards the upper extent of the project-affected reach.

Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth within the culvert located at the confluence ranged between 3.9 and 7.0 ft and will provide adequate upstream access. As evidenced by the thalweg profile , bottom elevations vary from the confluence across the backwater. When the range of WSE values recorded by the tributary/backwater level logger is considered, under the majority of observed conditions (i.e., 25% occurrence and greater) WSEs were sufficient to wet each surveyed thalweg point. Thalweg points with the greatest elevation (383.0 ft; located a linear distance of 550-600 ft from culvert exit into backwater) would be minimally wetted (0.1 ft to dry) under low water conditions (i.e., WSE values occurring 25% of the time or less). Due to shallow bed elevations present within the ponded, backwater area, wetted area available to fish will likely be reduced during periods of low mainstem flow. However, access at the confluence is adequate (0% of data occurrences < 0.5 ft of depth at the confluence).

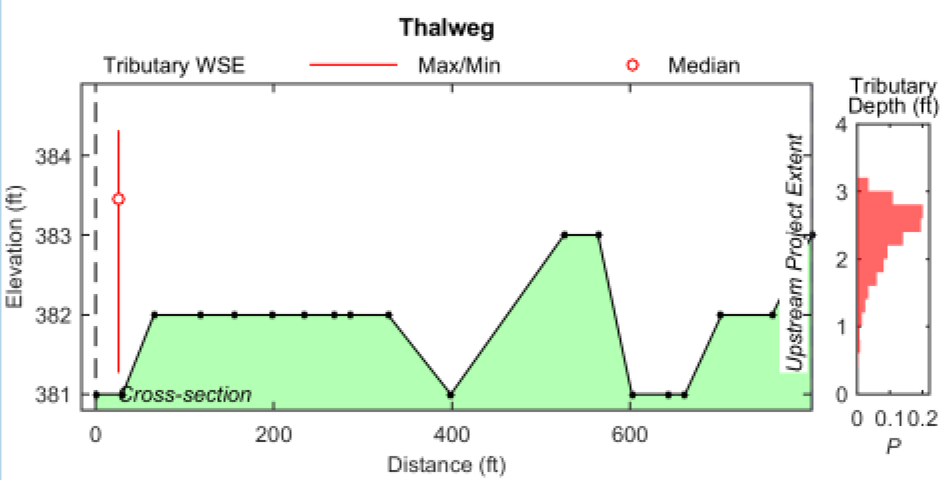


Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.67
Unnamed minor tributary, Stream Order 2





Mainstem Logger 10366000 Feet:	WSE	Date	Maximum Measured Water Depth (ft)
Max:	384.1	22Jul2014	5.3
75%:	383.5	25Aug2014	5.9
Mean:	383.1	24Sep2014	6.4
50%:	383.2	20Oct2014	6.7
25%:	382.8		
Min:	381.0		



Tributary Logger 10365999 Feet:	WSE	Water Depth
Max:	384.3	3.3
75%:	383.7	2.7
Mean:	383.3	2.3
50%:	383.4	2.4
25%:	383.1	2.1
Min:	381.3	0.3

Lower Wilder Impoundment, Connecticut River
Site ID: CT-W-1.67
Unnamed minor tributary, Stream Order 2

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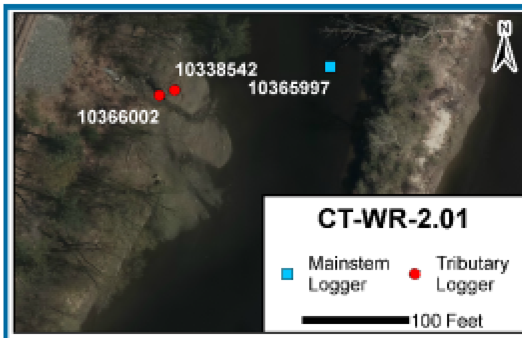
2.0 WILDER RIVERINE SECTION

2.1 Site CT-WR-2.01

Site CT-WR-2.01 is an unnamed stream order 2 tributary located on the Vermont side in the upper Wilder riverine reach. This location was initially visited on July 23, 2014 and tributary (SN 10366002) and mainstem (SN 10365997) level loggers were installed on that date. Subsequent site visits were conducted on August 28 and September 23, 2014. The final site visit occurred on November 6, 2014 at which time the level loggers were removed. The level logger initially installed in the tributary was found to be missing during the subsequent download visit and it was replaced with a new logger (SN 10338542). As a result, data sensor depth information for the tributary is limited to the period August 28 to November 6, 2014.

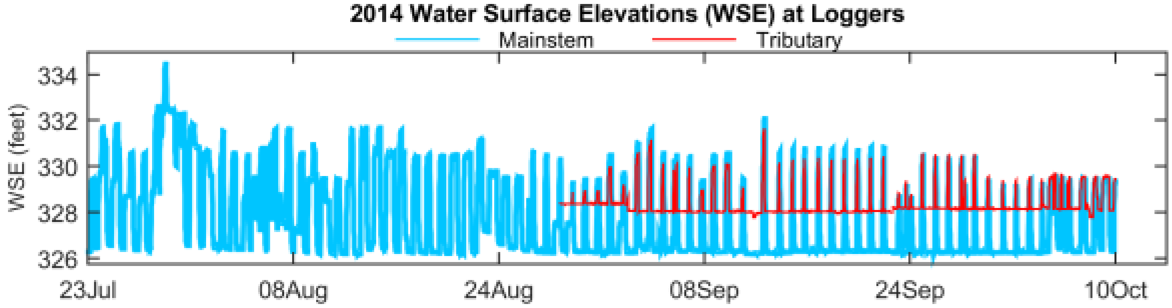
The tributary level logger was installed in the immediate vicinity of the apparent confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 45 ft upstream from the cross section location to the base of a perched culvert passing underneath the railroad (see photo time stamped 0829 06Nov14 below). Review of the WSE values recorded by the mainstem level logger indicates that a minimum of 75% of the time, mainstem water levels remain below the lower sill of the perched pipe culvert (75% occurrence = 329.4 ft / culvert sill = 332.4 ft). However, the maximum operational mainstem WSE (332.7 ft) slightly inundates the culvert entrance and project effects may extend further upstream. The maximum mainstem WSE (334.6 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach.

Water was present at the site during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 0.2 to 0.7 ft with 70.2% of data occurrences < 0.5 ft of depth. Water depths were measured along the channel thalweg during the initial site visit on July 23rd and ranged between 0.1 ft and 0.3 ft (mean = 0.2 ft). Site CT-WR-2.01 is a small, stream order 2 tributary with a relatively short reach. Based on visual evaluation of the site on four dates during 2014, it does not appear that the tributary provides a significant flow contribution to the mainstem reach. Channel depths within the site are limited as part of the stream's natural flow regime and as a result, access may be limited during low mainstem and tributary conditions (70.2% of data occurrences < 0.5 ft of depth at the confluence).

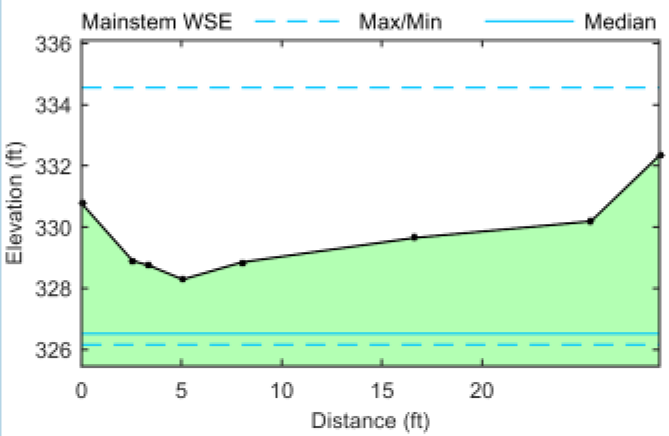


Upper Wilder Riverine, Connecticut River
Site ID: CT-WR-2.01
Unnamed minor tributary, Stream Order 2

2014 Water Surface Elevations (WSE) at Loggers

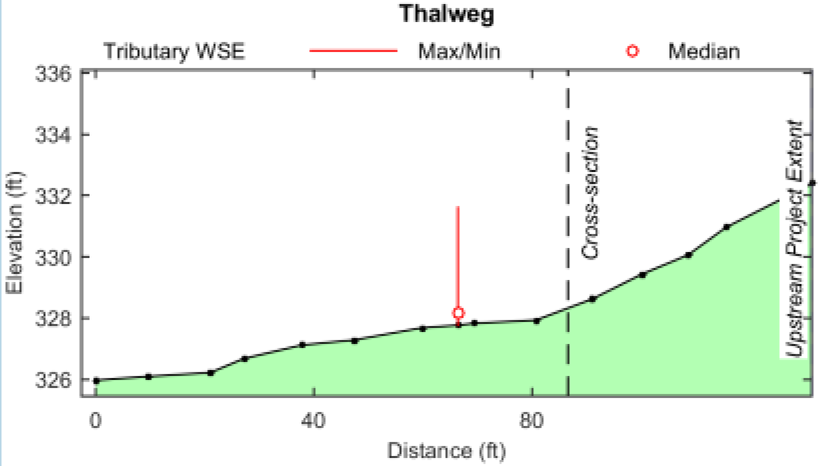


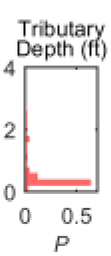
Cross-section at Confluence



Mainstem Logger 10365997 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 334.6	23Jul2014	0.2
75%: 329.4	28Aug2014	0.7
Mean: 327.7	23Sep2014	0.4
50%: 326.5	06Nov2014	0.4
25%: 326.3		
Min: 326.2		

Thalweg





Tributary Logger 10338542 Feet:	WSE	Water Depth
Max:	331.6	3.8
75%:	328.4	0.6
Mean:	328.4	0.6
50%:	328.1	0.4
25%:	328.0	0.3
Min:	327.8	0.0

Upper Wilder Riverine, Connecticut River
Site ID: CT-WR-2.01
Unnamed minor tributary, Stream Order 2

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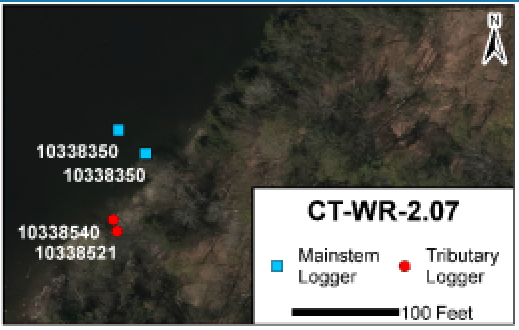
2.2 Site CT-WR-2.07 Hanchetts Brook

Site CT-WR-2.07 Hanchetts Brook, is a stream order 1 tributary located on the New Hampshire side in the upper Wilder riverine reach. This location was initially visited on July 22, 2014 and tributary (SN 10338521) and mainstem (SN 10338350) level loggers were installed on that date. Subsequent site visits were conducted on August 28 and September 23, 2014. The final site visit occurred on November 6, 2014 at which time the tributary level logger was removed and the mainstem logger was found to be missing. The level logger initially installed in the tributary was found to be missing during the August 28 download visit and a new logger (SN 10338540) was installed in its place. As a result, tributary data sensor depth information is limited to the period August 28 to November 6 and mainstem information is limited to the period July 22 to September 23, 2014.

The tributary level logger was installed in the vicinity of the confluence with the mainstem. The project-affected reach was estimated at approximately 35 ft; however, the maximum operational WSE value recorded by the mainstem level logger (320.8 feet) indicates that the project-affected reach ends approximately 1 ft downstream of the visually determined confluence cross section. The maximum mainstem WSE (321.9 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach. Flow was present in Site CT-WR-2.07 during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.3 to 0.4 ft (see photo below). Water depths were measured along the channel thalweg during the final site visit on November 6th and ranged between 0.1 and 0.3 ft. Channel depths within the tributary are limited as part of the stream's natural flow regime and access can be limited under virtually all mainstem and tributary conditions (95.8% of data occurrences < 0.5 ft at the originally presumed confluence).

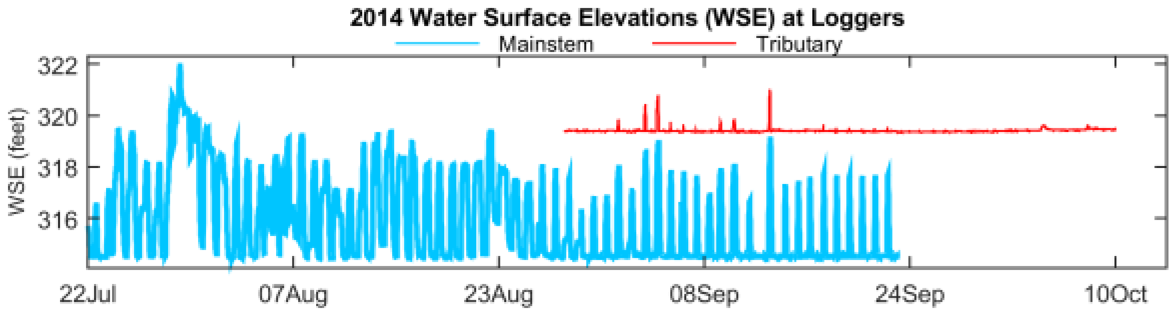
Site CT-WR-2.07 flow through lower end of tributary.

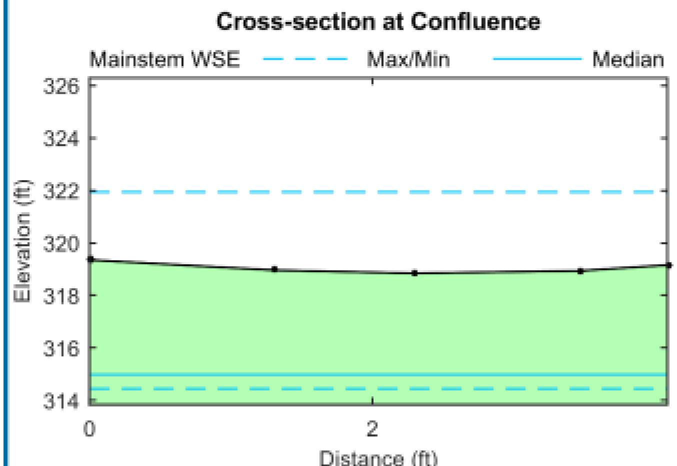


Upper Wilder Riverine, Connecticut River

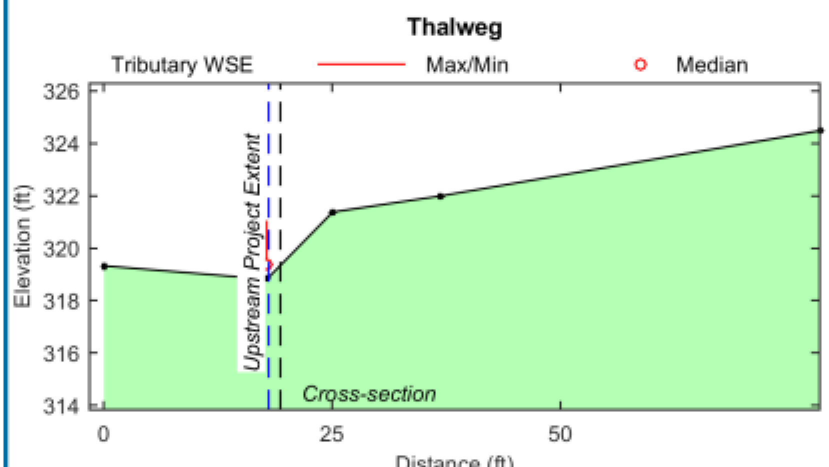
Site ID: CT-WR-2.07

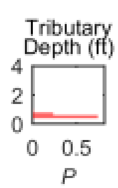
Hanchetts Brook, Minor tributary, Stream Order 1





Mainstem Logger 10338350 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 321.9	22Jul2014	0.3
75%: 317.1	28Aug2014	0.4
Mean: 315.9	23Sep2014	0.3
50%: 315.0	06Nov2014	0.3
25%: 314.5		
Min: 314.4		





Tributary Logger 10338540

Feet:	WSE	Water Depth
Max:	321.0	2.2
75%:	319.4	0.6
Mean:	319.4	0.6
50%:	319.4	0.6
25%:	319.4	0.6
Min:	319.3	0.5

Upper Wilder Riverine, Connecticut River
Site ID: CT-WR-2.07
Hanchetts Brook, Minor tributary, Stream Order 1

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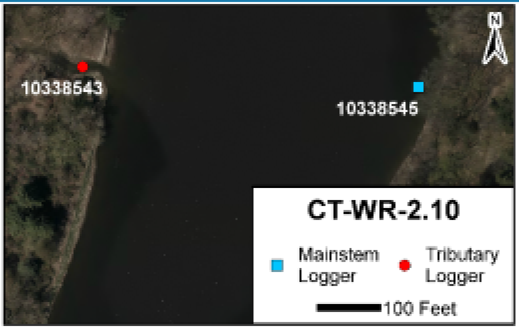
2.3 Site CT-WR-2.10 McArthur Brook

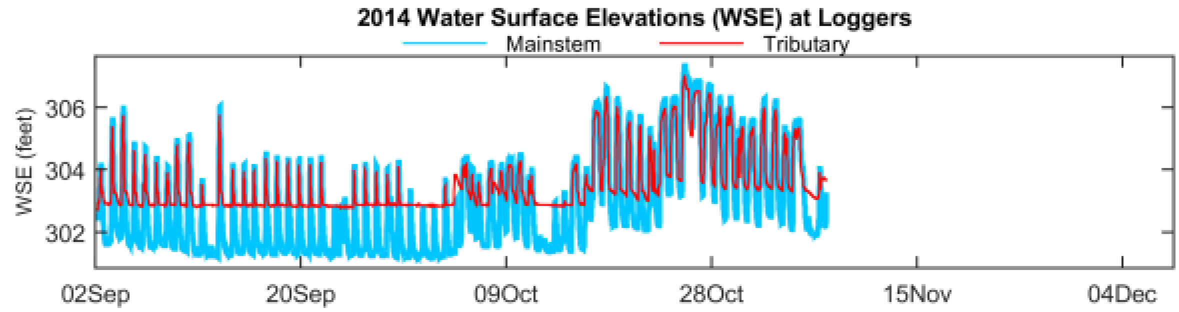
Site CT-WR-2.10 McArthur Brook, is a stream order 2 tributary located on the Vermont side in the lower Wilder riverine reach, downstream of Sumner Falls. This location was initially visited on September 2, 2014 and tributary (SN 10338543) and mainstem (SN 10338545) level loggers were installed on that date. On the date of level logger installation, McArthur Brook was mostly dry and the tributary logger was installed in the apparent 'thalweg' of the stream bed. An additional site visit was conducted on September 24, 2014 during which the brook was completely dry. The final site visit occurred on November 7, 2014 at which time flow was present and the level loggers were removed.

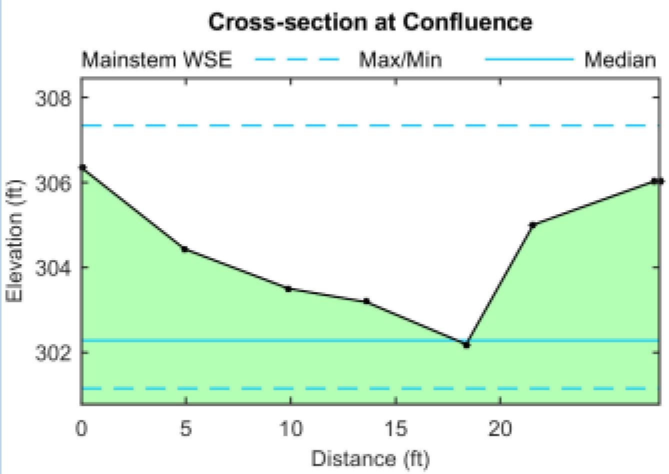
The tributary level logger was installed in the vicinity of the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 160 ft up into McArthur Brook to a section of the tributary where bank vegetation did not indicate significant fluctuating water levels, later confirmed by evaluation of WSE data (see photo below). Review of the WSE values recorded by the mainstem level logger indicates that a minimum of 75% of the time, project-affected water levels remain below the suspected extent of project effects (75% occurrence = 303.9 ft / suspected upper extent = 305.5 ft). The maximum mainstem WSE (307.3 ft) indicates that the mainstem influence extends slightly farther up into the tributary than the project-affected reach elevation (307.2 ft). Flow was present in McArthur Brook during one of the three visits. Water depth at the confluence cross section was measured during the November 7th visit and was 2.0 ft at its deepest point. Bed elevations were recorded from the dry channel bed during the September 24th site visit. It appears that McArthur Brook only seasonally provides a flow contribution to the mainstem river. Based on its intermittent nature, channel depths within McArthur Brook are limited as part of the natural flow regime in that tributary. However, access is adequate under some conditions (58.2% of data occurrences < 0.5 ft at the confluence).

Upstream extent of project-affected area associated with McArthur Brook as determined by visual observations, 2014.

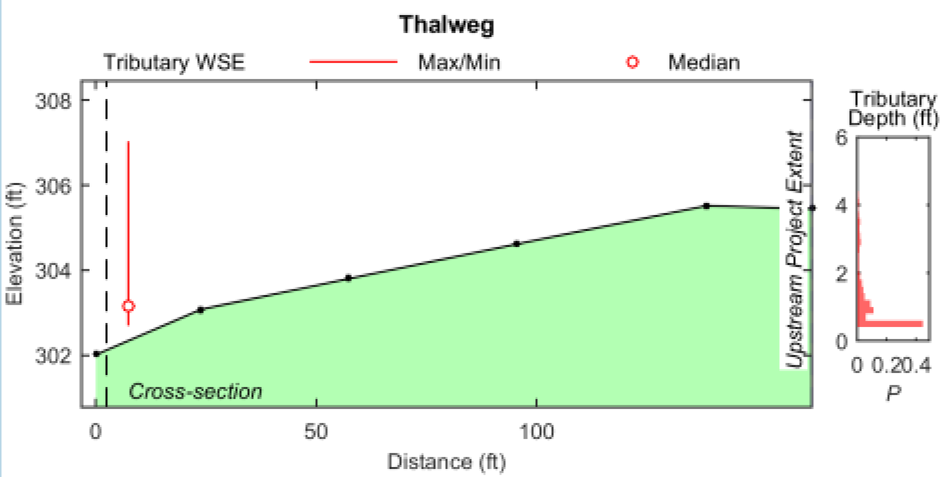


Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.10
McArthur Brook, Minor tributary, Stream Order 2





Mainstem Logger 10338545 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 307.3	02Sep2014	0.0
75%: 303.9	24Sep2014	0.0
Mean: 302.8	07Nov2014	2.0
50%: 302.3		
25%: 301.5		
Min: 301.2		



Tributary Logger 10338543

Feet:	WSE	Water Depth
Max:	307.0	4.7
75%:	303.7	1.4
Mean:	303.5	1.2
50%:	303.1	0.8
25%:	302.9	0.5
Min:	302.7	0.4

Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.10
McArthur Brook, Minor tributary, Stream Order 2

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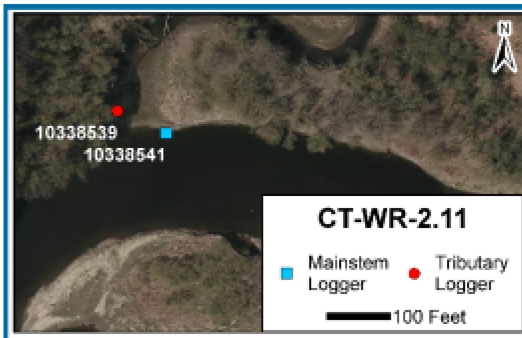
2.4 Site CT-WR-2.11 Lulls Brook

Site CT-WR-2.11 Lulls Brook, is a stream order 3 tributary located on the Vermont side in the lower Wilder riverine reach. This location was initially visited on August 28, 2014 and tributary (SN 10338539) and mainstem (SN 10338541) level loggers were installed on that date. An additional site visit was conducted on September 24, 2014. The final site visit occurred on November 7, 2014 at which time the level loggers were removed. Lulls Brook has a significant amount of woody debris present in it creating areas of scour and deposition (see photos below).

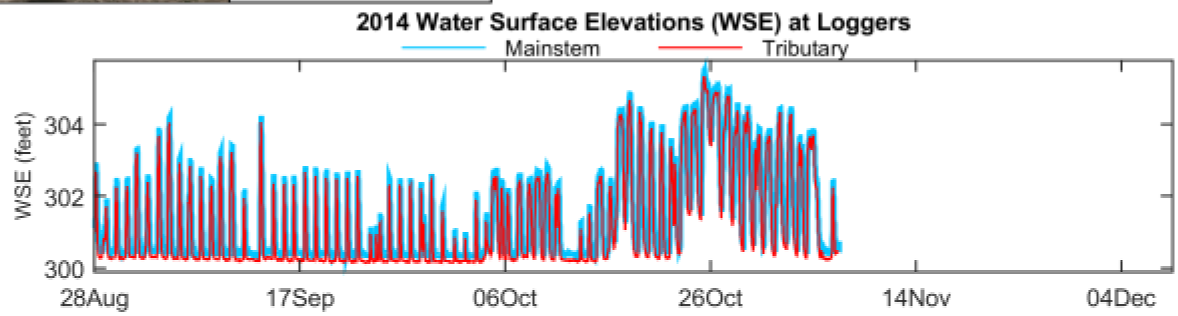
The tributary level logger was installed approximately 40 ft upstream of the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 690 ft upstream (elevation 301.6 ft), later confirmed at 688 ft from evaluation of WSE data. Review of the WSE values recorded by the mainstem level logger indicates that between 50 and 75% of the time, project-affected water levels remain below the suspected upper end of the project-affected portion of Lulls Brook (50% occurrence = 300.6 ft / 75% occurrence = 302.2 ft). The maximum mainstem WSE (305.5 ft) indicates the mainstem influence extends slightly farther upstream than the project-affected reach (305.3 ft elevation). Water was present within Lulls Brook during each of the three visits. Water depth at the confluence cross section was measured during each visit and ranged from 0.6 to 1.7 ft. Water depths were measured along the channel thalweg during the September 24th site visit and ranged between 0.5 ft and 2.4 ft (mean = 1.3 ft).

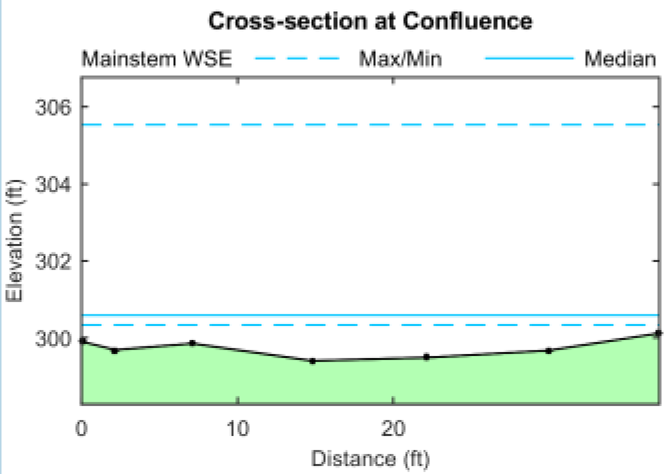
Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth at the thalweg within the immediate confluence area ranged between 0.9 and 6.1 ft and will provide adequate upstream access. As evidenced by the thalweg profile , bottom elevations show an increase-decrease pattern with distance moved upstream. It is possible that under low mainstem and tributary flow conditions, areas of significant woody debris may hinder upstream movement; however there were no data occurrences of < 0.5 ft depth at the confluence.

Examples of scour and depositional areas associated with the abundant woody debris present in Lulls Brook.

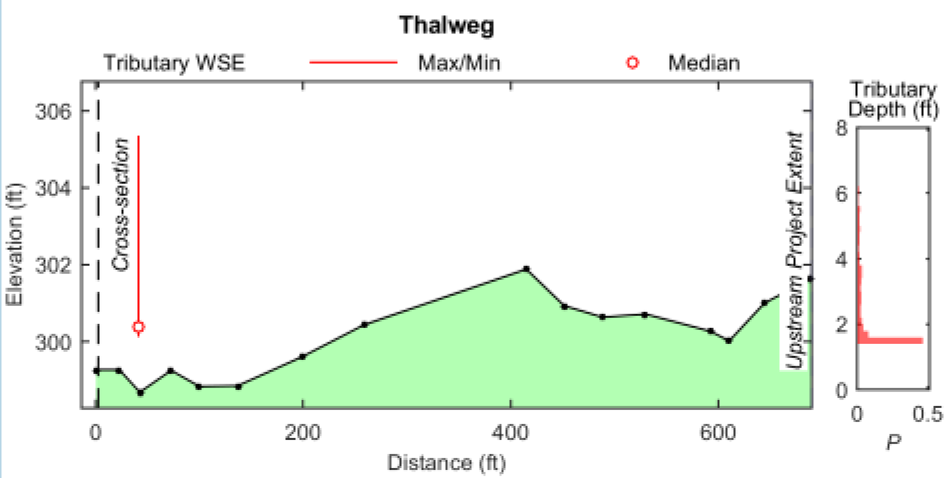


Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.11
Lulls Brook, Major tributary, Stream Order 3





Mainstem Logger 10338541 Feet:	WSE	Date	Maximum Measured Water Depth (ft)
Max:	305.5	28Aug2014	1.7
75%:	302.2	24Sep2014	0.6
Mean:	301.4	07Nov2014	0.9
50%:	300.6		
25%:	300.4		
Min:	300.3		



Tributary Logger 10338539 Feet:	WSE	Water Depth
Max:	305.3	6.6
75%:	302.0	3.3
Mean:	301.2	2.5
50%:	300.4	1.7
25%:	300.2	1.5
Min:	300.2	1.4

Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.11
Lulls Brook, Major tributary, Stream Order 3

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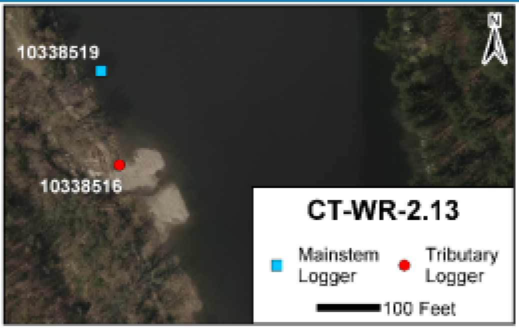
2.5 Site CT-WR-2.13 Bashan Brook

Site CT-WR-2.13 Bashan Brook, is a stream order 1 tributary located on the Vermont side in the lower Wilder riverine reach. This location was initially visited on July 22, 2014 and tributary (SN 10338516) and mainstem (SN 10338519) level loggers were installed on that date. Subsequent site visits were conducted on August 28 and September 24, 2014. The final site visit occurred on November 7, 2014 at which time the level loggers were removed.

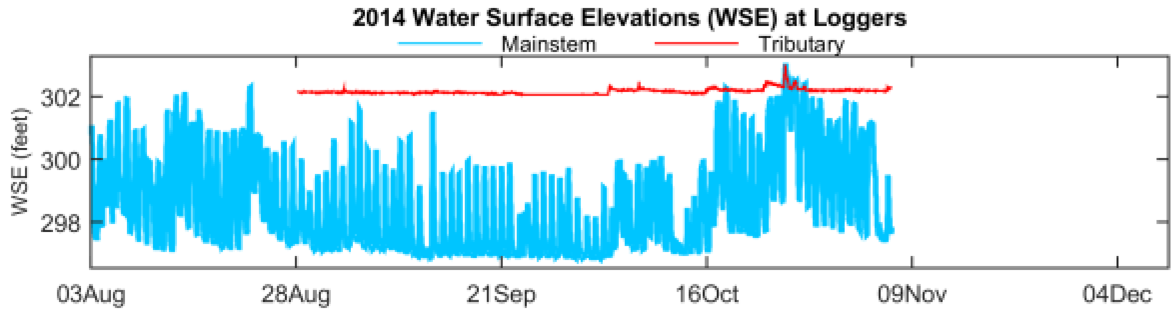
Bashan Brook enters the lower Wilder riverine reach in the vicinity of a high-traffic put-in/take-out for recreational boaters. As seen in site photographs below, man-made rock blockages were frequently built in the stream creating small pool areas in this tributary as it flowed through cobble/gravel substrate between the water's edge and vegetated shoreline. One of these blockages rerouted the stream away from the tributary logger during the initial period of deployment (July 22- August 28) and as a result, tributary information is limited to the period August 28 to November 7, 2014.

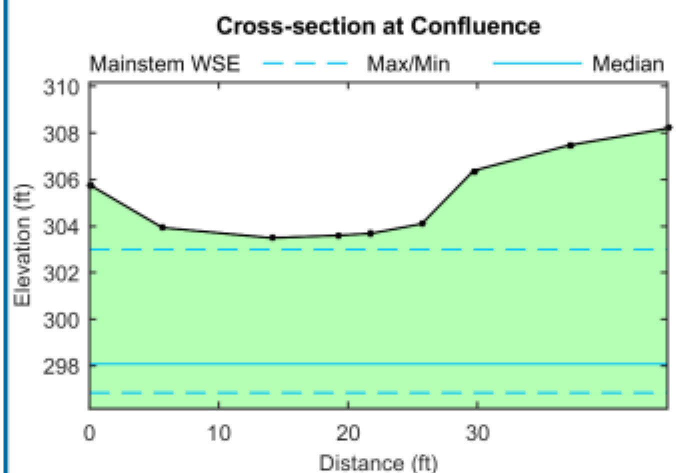
During the initial site visit, the field crew established a cross section at a point in Bashan Brook near the vegetated shoreline (photograph time stamped 09:47 22Jul14). The field crew visually estimated that project effects extend approximately 250 ft upstream from the cross section to an elevation of 308.1 ft. However, later evaluation of WSE data showed that the project-affected reach does not enter the tributary (located 9 feet downstream of the visually determined confluence cross section at 302.9 ft elevation). Similarly, the extent of the mainstem influence lies approximately 7 ft below the confluence cross section (303.0 ft elevation). Water was present within Bashan Brook during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 0.1 to 0.4 ft. Water depths were measured along the channel thalweg during the initial July 22nd site visit and ranged between 0.1 ft and 0.6 ft (mean = 0.3 ft). There were no data occurrences with confluence water depths of 0.5 ft or greater.

Bashan Brook is a small, stream order 1 tributary. Based on visual evaluation of the project-affected reach on four dates during 2014, it does not appear that Bashan Brook provides a significant flow contribution to the mainstem reach downstream of Wilder dam. Channel depths within Bashan Brook are limited as part of the stream's natural flow regime and access is modified and/or limited by manmade obstructions.

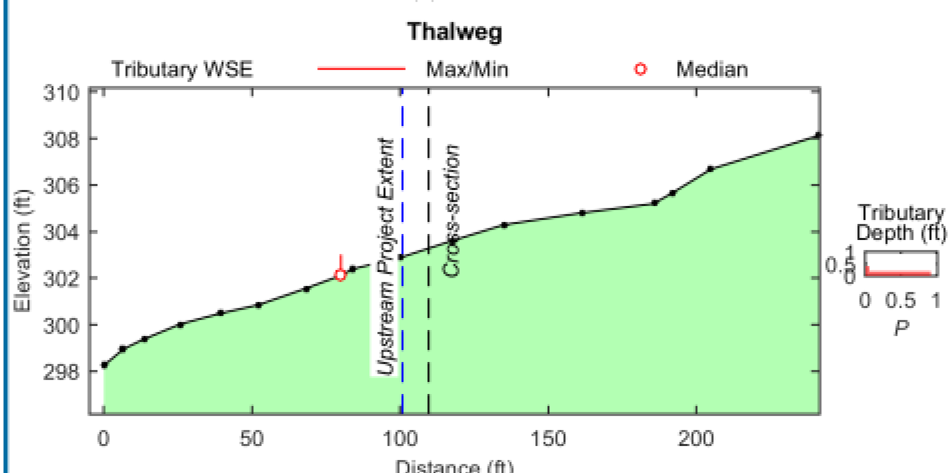


Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.13
Bashan Brook, Minor tributary, Stream Order 1





Mainstem Logger 10338519 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 303.0	22Jul2014	0.2
75%: 299.6	28Aug2014	0.1
Mean: 298.6	24Sep2014	0.4
50%: 298.1	07Nov2014	0.4
25%: 297.3		
Min: 296.8		



Tributary Logger 10338516

Feet:	WSE	Water Depth
Max:	303.0	0.9
75%:	302.2	0.1
Mean:	302.2	0.1
50%:	302.1	0.1
25%:	302.1	0.1
Min:	302.1	0.0

Lower Wilder Riverine, Connecticut River
Site ID: CT-WR-2.13
Bashan Brook, Minor tributary, Stream Order 1

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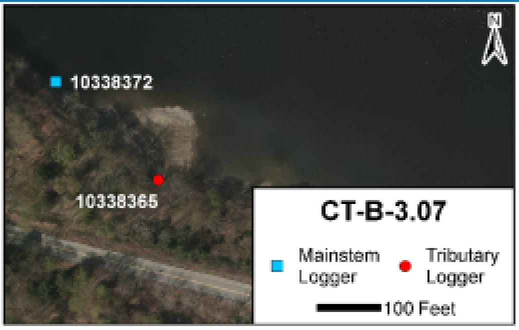
3.0 BELLOWS FALLS IMPOUNDMENT

3.1 Site CT-B-3.07 Barkmill Brook

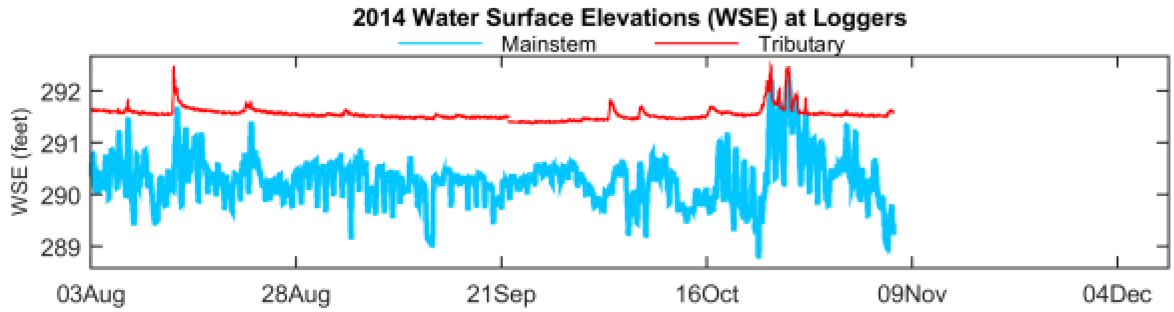
Site CT-B-3.07 Barkmill Brook, is a stream order 3 tributary located on the Vermont side in the Bellows Falls impoundment. This location was initially visited on July 28, 2014 and tributary (SN 10338365) and mainstem (SN 10338372) level loggers were installed at that time. Subsequent site visits were conducted on August 27 and September 22, 2014. The final site visit occurred on November 7, 2014 at which time the level loggers were removed.

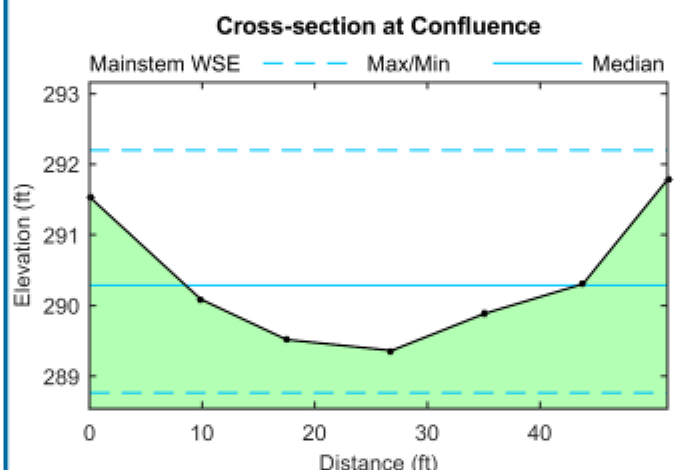
The tributary level logger was installed approximately 104 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 115 ft up into Barkmill Brook to the base of a large culvert extending under Route 5 later confirmed by WSE data to be 113 ft (see photo time stamped 11:24 28Jul14). The maximum mainstem WSE (292.2 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (291.6 ft elevation). Water was present within Barkmill Brook during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 0.6 to 1.3 ft. Water depths were measured along the channel thalweg during the initial July 28th site visit and ranged between 0.2 ft and 2.0 ft (mean = 0.9 ft). The shallowest depth was located at the upstream extent of the project-affected reach (i.e., culvert lip).

Review of the frequency distribution of water depth recorded by the mainstem level logger, indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the immediate confluence area ranged between 0.6 and 1.1 ft and should provide adequate upstream access. However, access may be limited under low mainstem and tributary conditions through a shallow, spread-out section of stream located between 40 and 100 ft upstream of the cross section having thalweg elevations between 290.5 and 291.3 ft. Only WSE values in the upper 25th percentile of those recorded by the mainstem level logger indicated that mainstem water would be available to provide access over the shoaled area. Access into this tributary may be limited by available water depths over the shoaled portion of the channel under low mainstem and tributary conditions such as those observed during the November 7th site visit (see photograph time stamped 14:20 07Nov14 below). However, access is generally adequate with only 13.9% of data occurrences < 0.5 ft depth at the confluence.

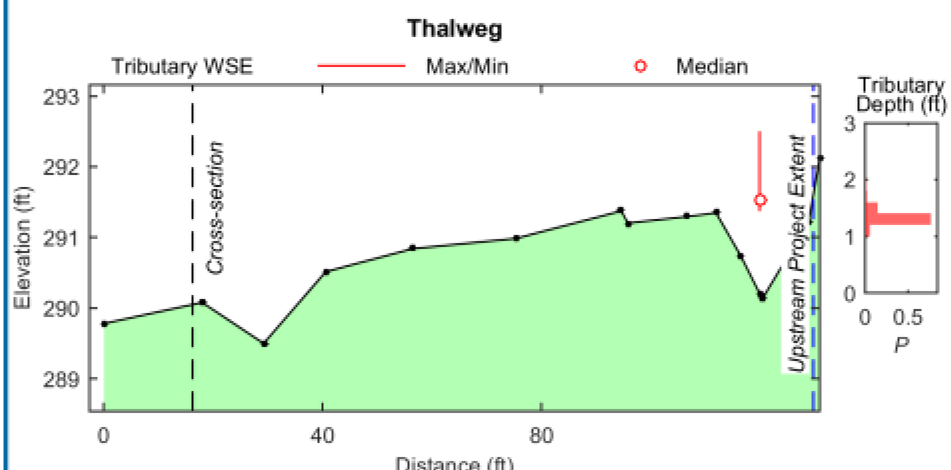


Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.07
Barkmill Brook, Major tributary, Stream Order 3





Mainstem Logger 10338372 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 292.2	28Jul2014	1.3
75%: 290.5	27Aug2014	1.0
Mean: 290.3	22Sep2014	0.9
50%: 290.3	07Nov2014	0.6
25%: 290.0		
Min: 288.8		



Tributary Logger 10338365

Feet:	WSE	Water Depth
Max:	292.5	2.3
75%:	291.6	1.4
Mean:	291.6	1.3
50%:	291.5	1.3
25%:	291.5	1.3
Min:	291.4	1.2

Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.07
Barkmill Brook, Major tributary, Stream Order 3

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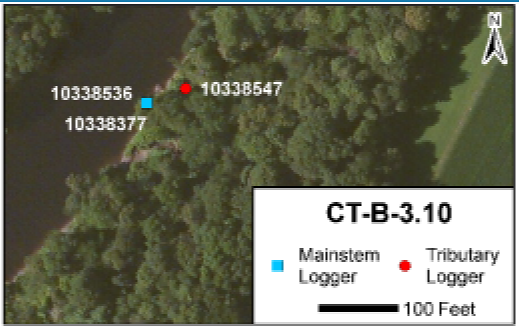
3.2 Site CT-B-3.10

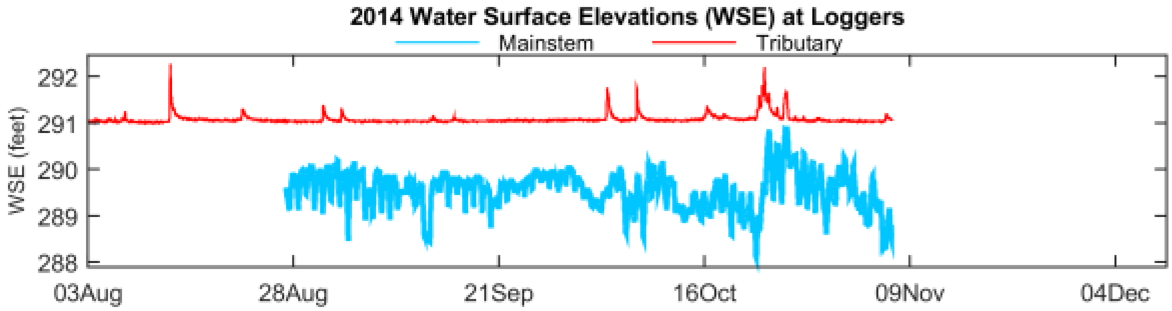
Site CT-B-3.10 is an unnamed stream order 1 tributary located on the New Hampshire side in the Bellows Falls impoundment. This location was initially visited on July 28, 2014. Cross sectional and channel thalweg bed elevation information and water quality readings were collected on that date. Tributary (SN 10338547) and mainstem (SN 10338377) level loggers were installed at this location on August 3, 2014. Subsequent site visits were conducted on August 27 and September 22, 2014. The final site visit occurred on November 7, 2014 at which time the level loggers were removed. The level logger initially installed in the mainstem was found to be missing during the subsequent download visit and a new logger was installed at that site (SN10338536). As a result, mainstem sensor depth information is limited to the period August 27 to November 7, 2014.

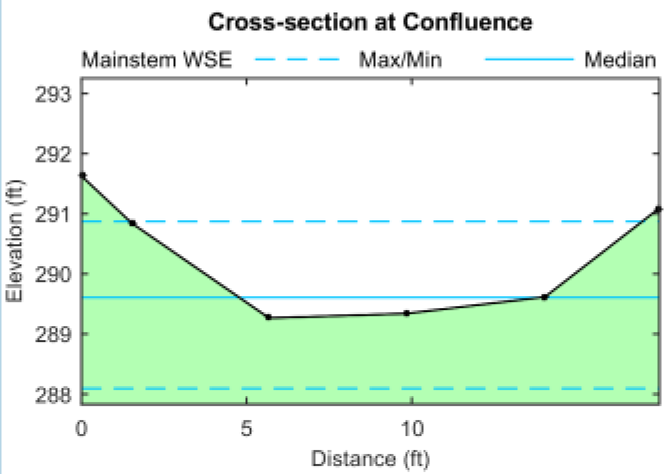
The tributary level logger was installed approximately 120 feet upstream from the confluence with the mainstem, later confirmed by WSE data to be 117 ft. The maximum WSE value recorded by the mainstem level logger (290.9 ft) indicates that the mainstem influence can extend farther up into the tributary than the project-affected reach (290.4 ft elevation). Flow was present in the tributary during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.7 to 1.7 ft. Water depths were measured along the channel thalweg during the November 7th site visit and ranged between 0.4 and 1.0 ft (mean = 0.6 ft).

Site CT-B-3.10 is a small, stream order 1 tributary. Review of the percentiles for WSE values recorded by the mainstem level logger indicate that under conditions at or below the 25th percentile, mainstem water provides no additional inundation at the confluence and depth there is determined by natural stream outflow under those conditions. Access into this tributary may be limited by available water depths through shallower portions of the channel under low tributary flow conditions such as those observed during the November 7th site visit (see photograph time stamped 15:30 07Nov14 below). Access is limited a majority of the time (68.3% of data occurrences < 0.5 ft depth at the confluence).

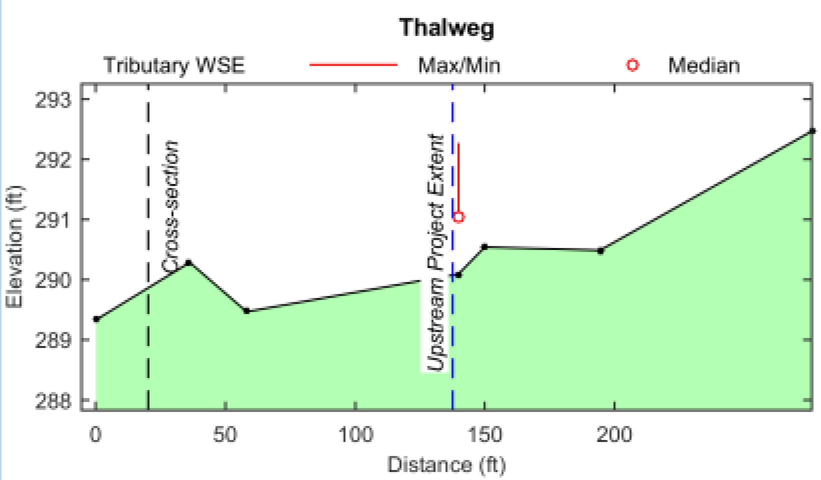


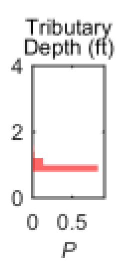
Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.10
Unnamed minor tributary, Stream Order 1





Mainstem Logger 10338536 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 290.9	28Jul2014	1.1
75%: 289.8	27Aug2014	1.7
Mean: 289.5	22Sep2014	1.3
50%: 289.6	07Nov2014	0.7
25%: 289.3		
Min: 288.1		





Tributary Logger 10338547

Feet:	WSE	Water Depth
Max:	292.3	2.2
75%:	291.1	1.0
Mean:	291.1	1.0
50%:	291.1	1.0
25%:	291.0	0.9
Min:	291.0	0.9

Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.10
Unnamed minor tributary, Stream Order 1

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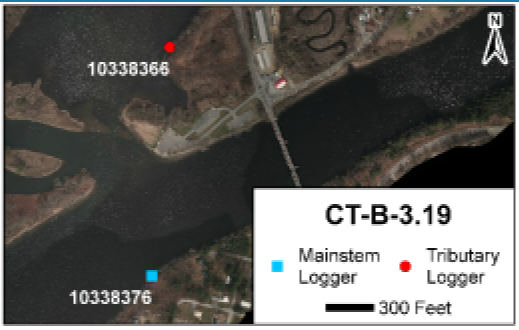
3.3 Site CT-B-3.19 Backwater

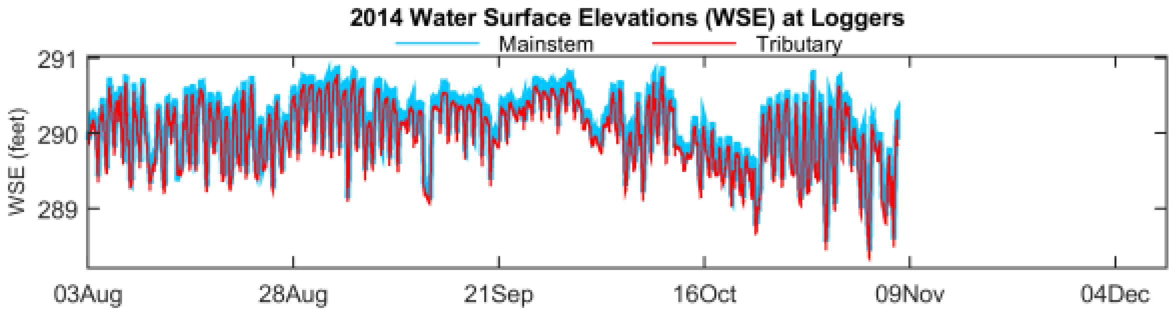
Site CT-B-3.19 is a backwater located on the Vermont side in the Bellows Falls impoundment. This location was initially visited on July 27, 2014 and tributary (SN 10338366) and mainstem (SN 10338376) level loggers were installed on that date. Subsequent site visits were conducted on August 27 and September 23, 2014. The final site visit occurred on November 8, 2014 at which time the level loggers were removed.

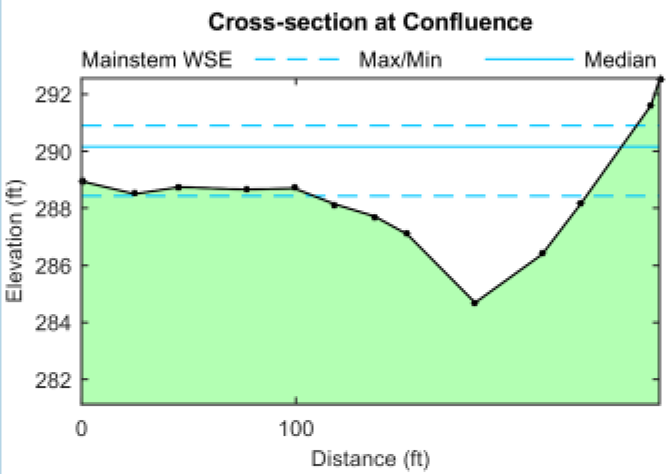
The backwater is connected to the mainstem via the Black River near the Hoyts Landing in Springfield, Vermont. The backwater level logger was installed approximately 1,000 feet away from the confluence. During the initial site visit, the field crew visually determined the extent of the project-affected area as running across the ponded backwater area (see photo time stamped 13:07 27Jul14 below). The project-affected area was estimated to cover a linear distance of 2,252 ft, later confirmed by evaluation of WSE data. Water was present within the backwater during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 2.9 to 5.3 ft. Water depths across the ponded backwater area were measured during the initial site visit and ranged between 3.8 and 7.9 ft (mean = 6.4 ft).

Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth at the confluence ranged between 3.7 and 6.2 ft and will provide adequate upstream access. As evidenced by the thalweg profile , bottom elevations vary from the confluence across the backwater. When the range of WSE values recorded by the backwater level logger is considered (290.8-288.3 ft), WSEs under all observed conditions were sufficient to wet each surveyed thalweg point by a minimum of 2.5 ft. Due to shallow bed elevations present along the littoral margins of the ponded, backwater area, wetted area available to fish will likely be reduced in those margins during periods of low mainstem flow; however there were no data occurrences < 0.5 ft of depth at the confluence.

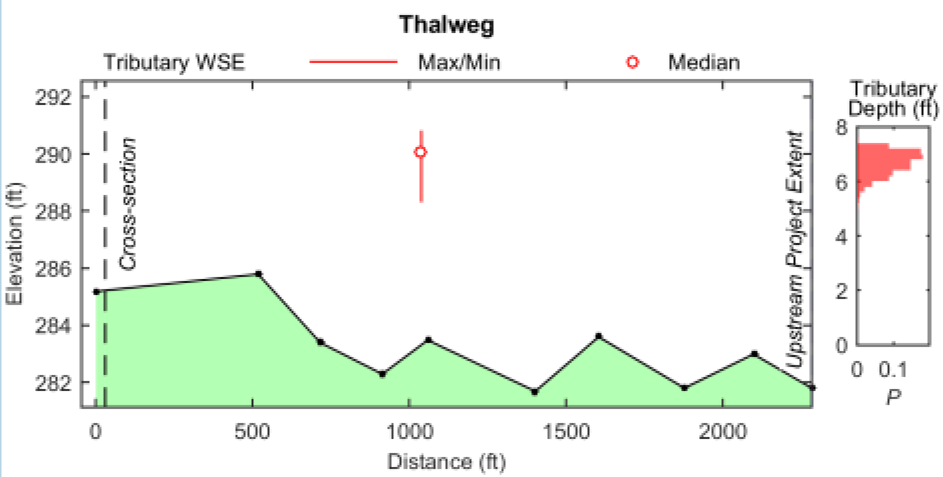


Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.19
Unnamed backwater, Stream Order 0





Mainstem Logger 10338376 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 290.9	27Jul2014	4.9
75%: 290.4	27Aug2014	5.3
Mean: 290.1	23Sep2014	2.9
50%: 290.2	08Nov2014	2.9
25%: 289.8		
Min: 288.4		



Tributary Logger 10338366

Feet:	WSE	Water Depth
Max:	290.8	7.5
75%:	290.3	7.0
Mean:	290.0	6.7
50%:	290.0	6.7
25%:	289.7	6.4
Min:	288.3	5.0

Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.19
Unnamed backwater, Stream Order 0

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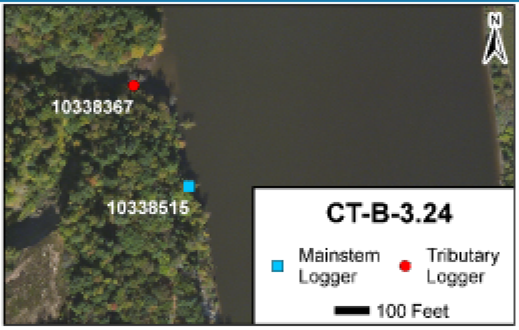
3.4 Site CT-B-3.24 Commissary Brook

Site CT-B-3.24 Commissary Brook, is a stream order 3 tributary located on the Vermont side in the Bellows Falls impoundment. This location was initially visited on July 27, 2014 and tributary (SN 10338367) and mainstem (SN 10338515) level loggers were installed on that date. Subsequent site visits were conducted on August 27 and September 23, 2014. The final site visit occurred on November 8, 2014 at which time the level loggers were removed.

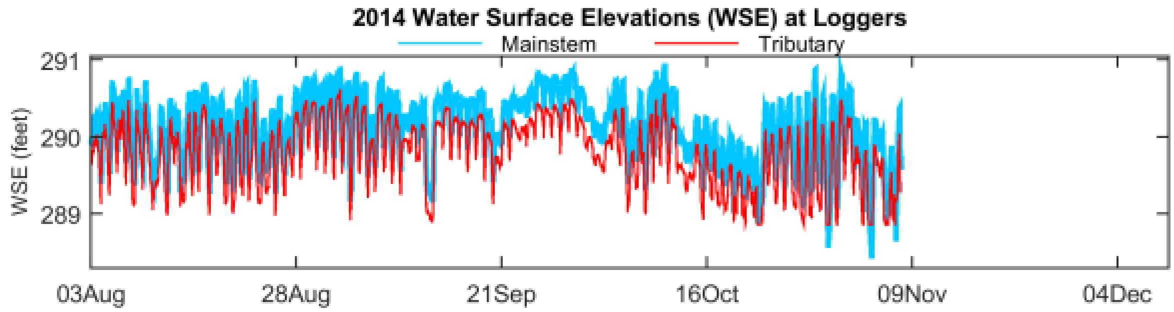
The tributary level logger was installed in the immediate vicinity of the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 200 ft upstream to a point where the tributary narrowed greatly and had dense canopy cover see photo below). Additional bed elevation data for this location was collected in association with Study 7 during 2013 and upon review of that data for this report and WSE data the thalweg profile was extended to a point approximately 455 ft upstream of the confluence (290.9 ft elevation). Flow was present in Commissary Brook during each of the four visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.0 to 2.1 ft. Water depths were measured along the lowermost 200 ft of the channel thalweg during the initial site visit on July 27th and ranged between 1.4 ft and 2.3 ft (mean = 1.9 ft).

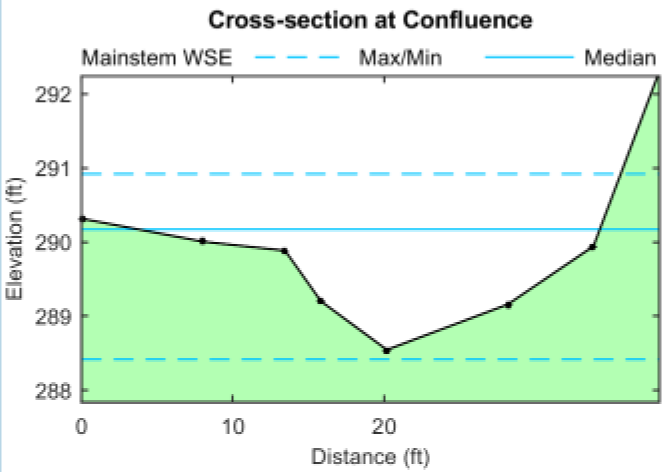
Review of the frequency distribution of water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the immediate confluence area ranged between 1.0 and 1.6 ft and should provide adequate upstream access. Under median conditions (WSE = 290.2 ft; mainstem level logger), Commissary Brook is inundated by mainstem water to the point approximately 200 ft upstream from the confluence that was visually determined to be the extend of project effects during the initial July 27th site visit. Under low mainstem WSE conditions (minimum value recorded = 288.4 ft, Commissary Brook is no longer inundated by mainstem water and is limited to only its own natural outflow. Under those conditions, access may be limited for larger fish as evidenced by the minimum water depth recorded by the tributary logger during the study period (water depth = 0.4 ft); however under most conditions access is adequate (0.9% of data occurrences < 0.5 ft of depth at the confluence).

Upstream extent of mainstem influenced area associated with Commissary Brook as determined by visual observations, 2014.

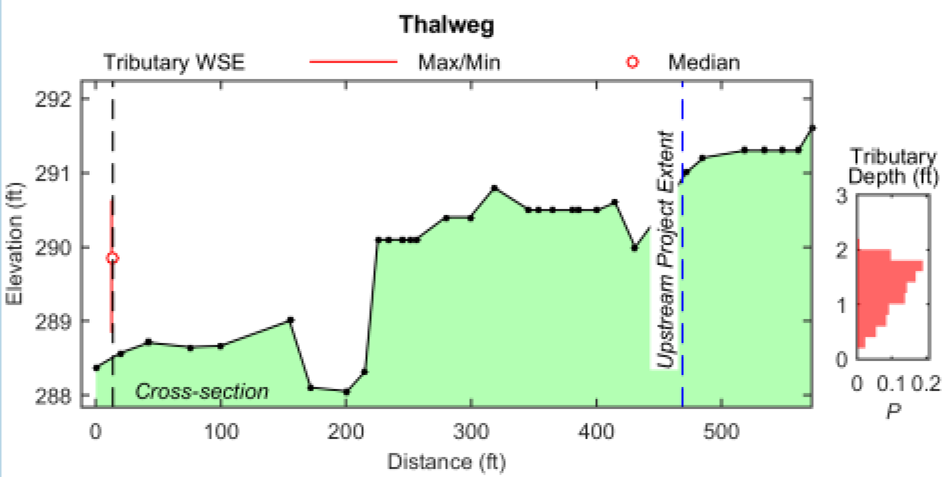


Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.24
Commissary Brook, Major tributary, Stream Order 3





Mainstem Logger 10338515 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 290.9	27Jul2014	1.9
75%: 290.5	27Aug2014	1.8
Mean: 290.1	23Sep2014	2.1
50%: 290.2	08Nov2014	1.0
25%: 289.8		
Min: 288.4		



Tributary Logger 10338367 Feet:	WSE	Water Depth
Max:	290.6	2.1
75%:	290.1	1.6
Mean:	289.8	1.3
50%:	289.8	1.3
25%:	289.5	1.0
Min:	288.9	0.4

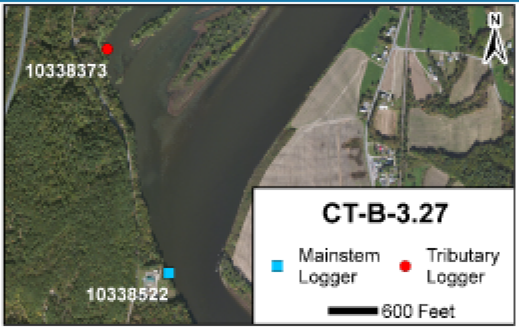
Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.24
Commissary Brook, Major tributary, Stream Order 3

3.5 Site CT-B-3.27

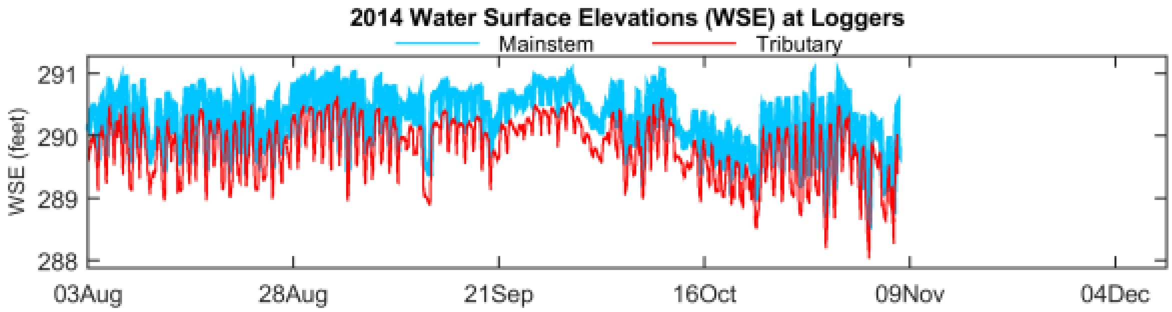
Site CT-B-3.27 is an unnamed stream order 2 tributary located on the Vermont side in the Bellows Falls impoundment. This location was initially visited on July 26, 2014 and tributary (SN 10338373) and mainstem (10338522) level loggers were installed on that date. Subsequent site visits were conducted on August 27 and September 23, 2014. The final site visit occurred on November 8, 2014 at which time the level loggers were removed.

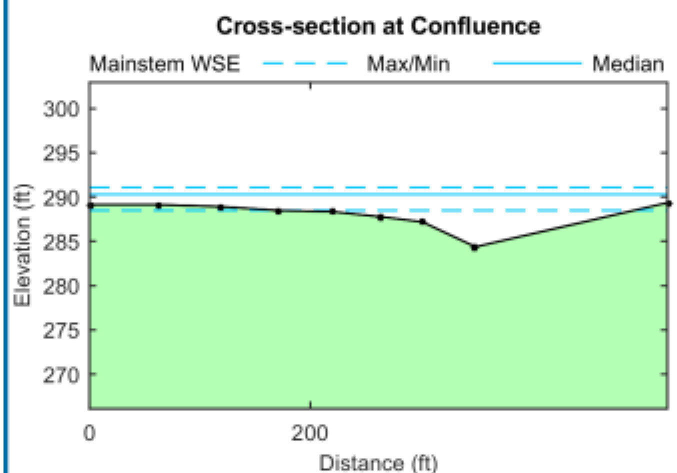
The tributary level logger was installed approximately 860 feet upstream from the confluence with the mainstem. The extent of project effects was estimated at 2,422 ft up into the tributary, later confirmed by evaluation of WSE data (291.1 ft elevation). Flow was present at Site CT-B-3.27 during each of the four visits. Water depth at the confluence cross section was measured during each of the four visits and the maximum water depth ranged from 5.1 to 6.4 ft. Water depths were measured along the channel thalweg during the initial site visit on July 26th and ranged between 1.2 ft and 19.2 ft (mean = 6.8 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger, indicates that under all observed conditions (i.e., min through max WSE values) water depth at the immediate confluence area maintained a minimum value of 4.1 ft. Review of the frequency distribution of tributary water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at that location ranged between 5.3 and 6.0 ft and adequate access is available and access is adequate (0% of data occurrences <0.5 ft depth at the confluence).

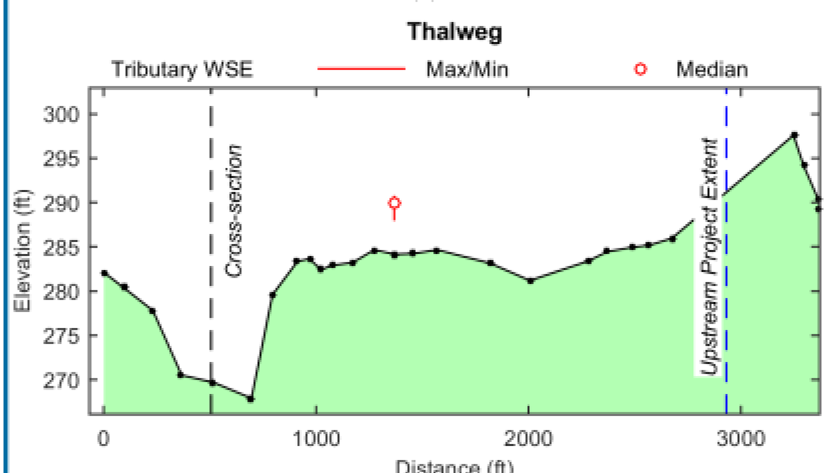


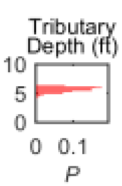
Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.27
Unnamed minor tributary, Stream Order 2





Mainstem Logger 10338522 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 291.1	26Jul2014	6.2
75%: 290.6	27Aug2014	6.4
Mean: 290.3	23Sep2014	5.6
50%: 290.3	08Nov2014	5.1
25%: 290.0		
Min: 288.5		





Tributary Logger 10338373

Feet:	WSE	Water Depth
Max:	290.6	6.5
75%:	290.2	6.0
Mean:	289.8	5.6
50%:	289.9	5.7
25%:	289.5	5.3
Min:	288.0	3.9

Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.27
Unnamed minor tributary, Stream Order 2

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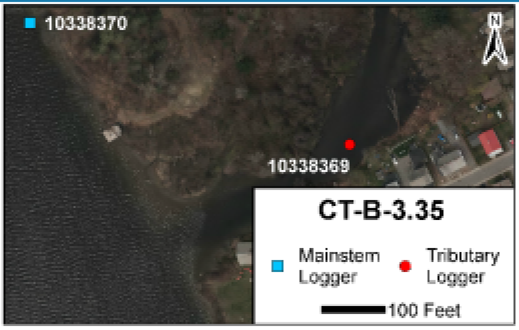
3.6 Site CT-B-3.35

Site CT-B-3.35 is an unnamed stream order 2 tributary located on the New Hampshire side in the Bellows Falls impoundment. This location was initially visited on July 26, 2014 and tributary (SN 10338369) and mainstem (SN 10338370) level loggers were installed on that date. Subsequent site visits were conducted on August 27 and September 23, 2014. The final site visit occurred on November 8, 2014 at which time the level loggers were removed.

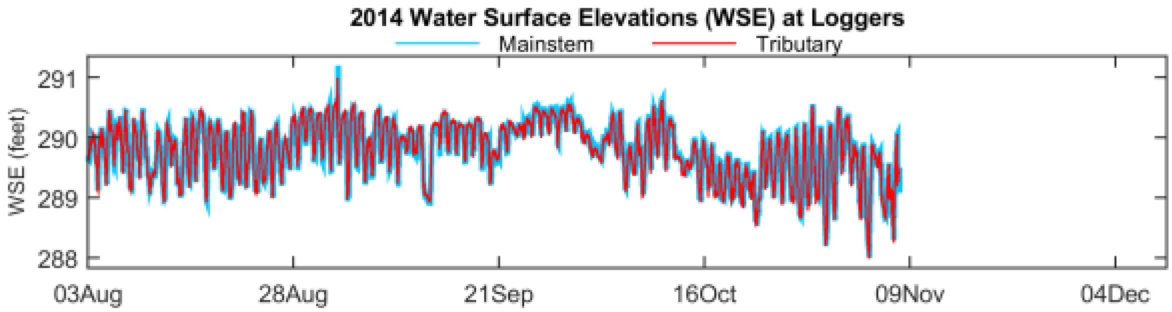
The tributary level logger was installed approximately 173 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 643 ft up into the tributary to the base of a 5-ft diameter culvert extending approximately 125 ft under Route 12 (see photo below). The sill elevation of the culvert was at 289.6 ft and was visually determined to be the upper end of the project-affected reach. Later evaluation of WSE data indicates that the project-affected reach extends beyond the culvert (291.2 ft elevation) and the culvert sill is inundated by mainstem water nearly 75% of the time. Water was present within the tributary during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 3.6 to 4.4 ft. Water depths were measured along the channel thalweg during the initial July 28th site visit and ranged between 0.9 ft and 4.8 ft (mean = 2.4 ft).

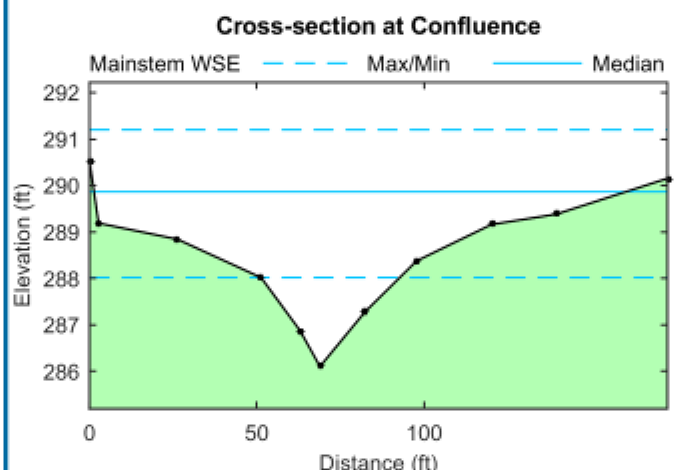
Review of the frequency distribution of water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the immediate confluence area ranged between 1.9 and 2.6 ft and should provide adequate upstream access (0% of data occurrence < 0.5 ft depth at the confluence).

Culvert near upstream extent of project-affected area associated with Site CT-B-3.35 as determined by visual observations, 2014.

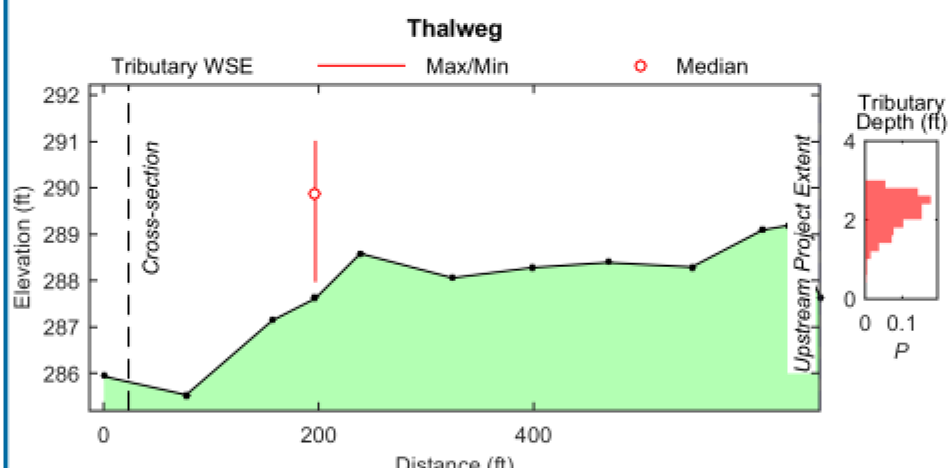


Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.35
Unnamed minor tributary, Stream Order 2





Mainstem Logger 10338370			Maximum Measured Water Depth (ft)
Feet:	WSE	Date	
Max:	291.2	26Jul2014	4.4
75%:	290.2	27Aug2014	4.2
Mean:	289.8	23Sep2014	3.8
50%:	289.9	08Nov2014	3.6
25%:	289.5		
Min:	288.0		



Tributary Logger 10338369		
Feet:	WSE	Water Depth
Max:	291.0	3.4
75%:	290.2	2.6
Mean:	289.8	2.2
50%:	289.9	2.2
25%:	289.5	1.9
Min:	288.0	0.4

Bellows Falls Impoundment, Connecticut River
Site ID: CT-B-3.35
Unnamed minor tributary, Stream Order 2

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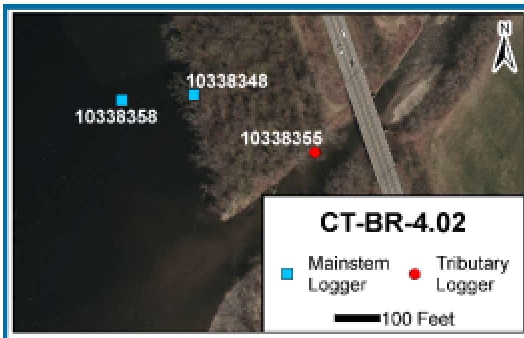
4.0 BELLOWS FALLS RIVERINE SECTION

4.1 Site CT-BR-4.02 Cold River

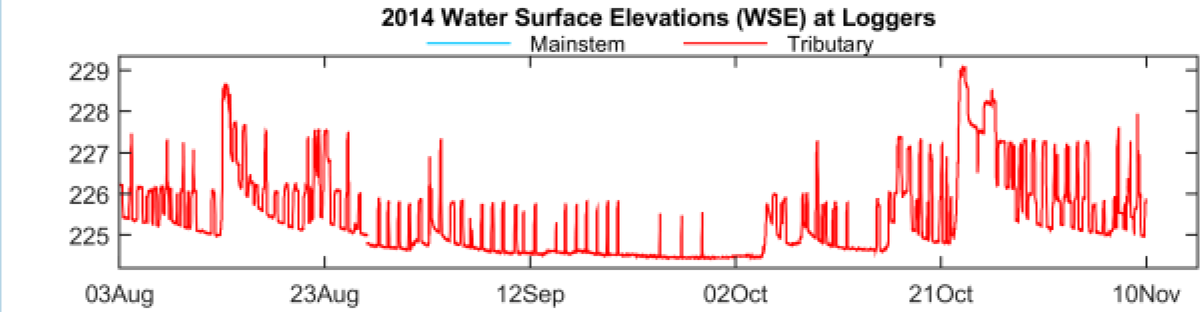
Site CT-BR-4.02 Cold River, is a stream order 5 tributary located on the New Hampshire side in the Bellows Falls riverine reach. This location was initially visited on July 21, 2014 and a tributary level logger (SN 10338355) was installed on that date. A mainstem logger was not installed during the initial site visit as one was presumed to be already present at a location adjacent to the confluence (SN 10338348; over-winter logger site associated with Study 7). Subsequent site visits were conducted on August 27 and September 22, 2014. The final site visit occurred on November 10, 2014 at which time the tributary level logger was removed. The Study 7 overwinter mainstem logger at site CT-BR-4.02 was determined to be missing on October 9, 2014 during dive sampling. A new logger (SN 10338358) was installed at that time. Mainstem logger 10338358 is still deployed and is scheduled for download once divers can safely access that area following spring 2015 high flows.

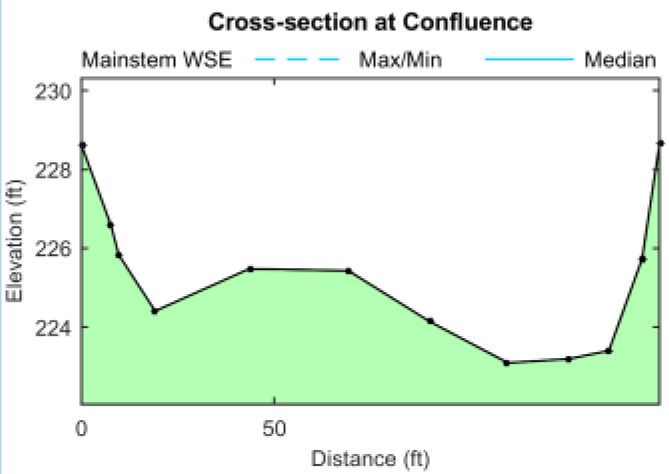
The tributary level logger was installed approximately 200 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined the extent of project effects to extend approximately 900 ft up into the Cold River to a point just upstream of the Route 12 Bridge. Water was present within the Cold River during each of the four visits. Water depth at the confluence cross section was measured during each visit and ranged from 0.8 to 2.9 ft. Water depths were measured along the channel thalweg during the July 21st (min = 1.2 ft; max = 2.2 ft; mean = 1.5 ft), August 27th (min = 0.7 ft; max = 1.7 ft; mean = 1.2 ft), and November 10th (min = 1.0 ft; max = 3.0 ft; mean = 2.1 ft) site visits.

The Cold River is a large, stream order 5 tributary. Based on visual observations of the project-affected reach on four dates during 2014, it appears that natural outflow from the Cold River provides sufficient water depths for access. An adequate thalweg was present on the date of each site visit. The cobble substrate over which the Cold River flows at its confluence with the mainstem is very dynamic and changes in location and quantity were evident from one site visit to the next (see photograph time stamped 14:30 21Jul14 below).

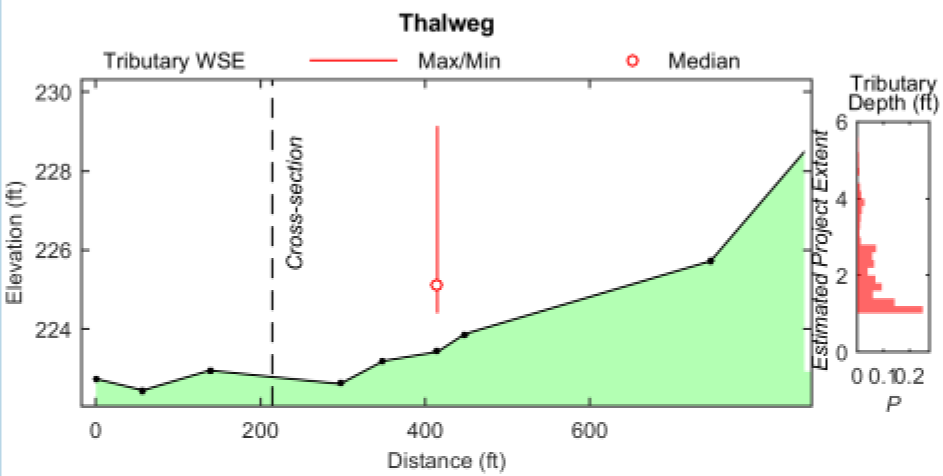


Bellows Riverine, Connecticut River
Site ID: CT-BR-4.02
Cold River, Major tributary, Stream Order 5





Date	Maximum Measured Water Depth (ft)
21Jul2014	1.9
27Aug2014	0.8
22Sep2014	1.2
10Nov2014	2.9



Tributary Logger 10338355

Feet:	WSE	Water Depth
Max:	229.1	5.7
75%:	225.9	2.5
Mean:	225.4	2.0
50%:	225.1	1.7
25%:	224.6	1.2
Min:	224.4	1.0

Bellows Riverine, Connecticut River
Site ID: CT-BR-4.02
Cold River, Major tributary, Stream Order 5

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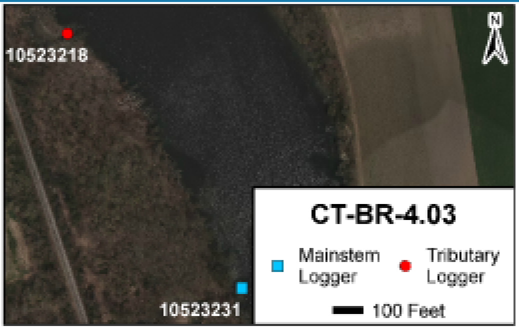
4.2 Site CT-BR-4.03

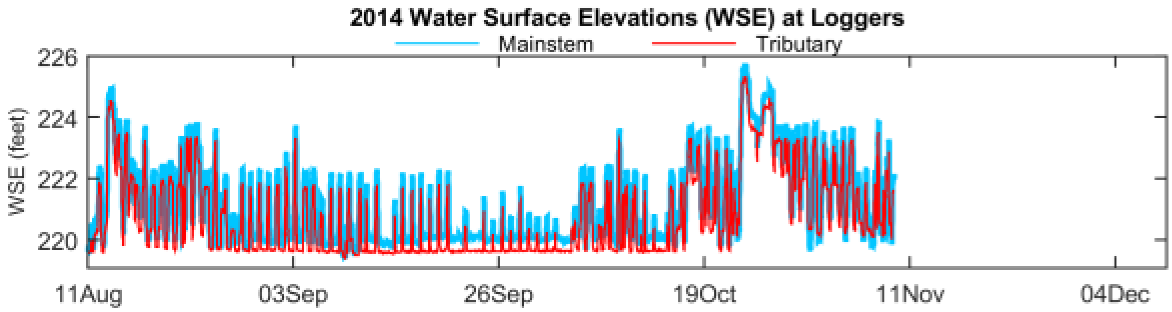
Site CT-BR-4.03 is an unnamed stream order 2 tributary located on the Vermont side in the Bellows Falls riverine reach. This location was initially visited on August 11, 2014 and tributary (SN 10523218) and mainstem (SN 10523218) level loggers were installed on that date. A subsequent site visit was conducted on September 10, 2014. The final site visit occurred on November 9, 2014 at which time the level loggers were removed.

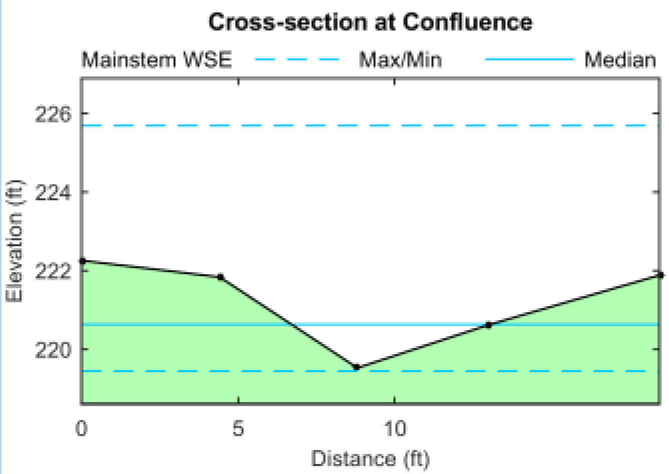
The tributary level logger was installed in the immediate vicinity of the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 254 ft (later confirmed by evaluation of WSE data) up into the tributary to a section where bank vegetation did not appear to indicate significant fluctuating water levels (bed elevation = 222.3 ft). Review of the WSE values recorded by the mainstem level logger indicates that under nearly all conditions observed, mainstem water levels remained below the suspected end of the project-affected reach (75% occurrence = 222.2 ft). However, the maximum mainstem WSE (225.7 ft) indicated that the mainstem influence extends farther upstream than the project-affected reach (224.5 ft elevation). Flow was present in tributary CT-BR-4.03 during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.1 to 2.6 ft. Water depths were measured along the channel thalweg during the August 8th site visit and ranged between 0.1 and 0.6 ft (mean = 0.2 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (elevation = 217.9 ft) ranged between 0.5 and 2.7 ft. Under low mainstem WSE conditions (minimum value recorded = 219.4 ft), Site CT-BR-4.03 is not inundated by mainstem water (see photograph time stamped 07:37 10Sep14 below) and is limited to only its own natural outflow. Under those conditions, access may be limited for larger fish as evidenced by the minimum water depth recorded by the tributary logger (water depth = 0.3 ft); however, only 11.7% of all data occurrences were < 0.5 ft depth at the confluence).

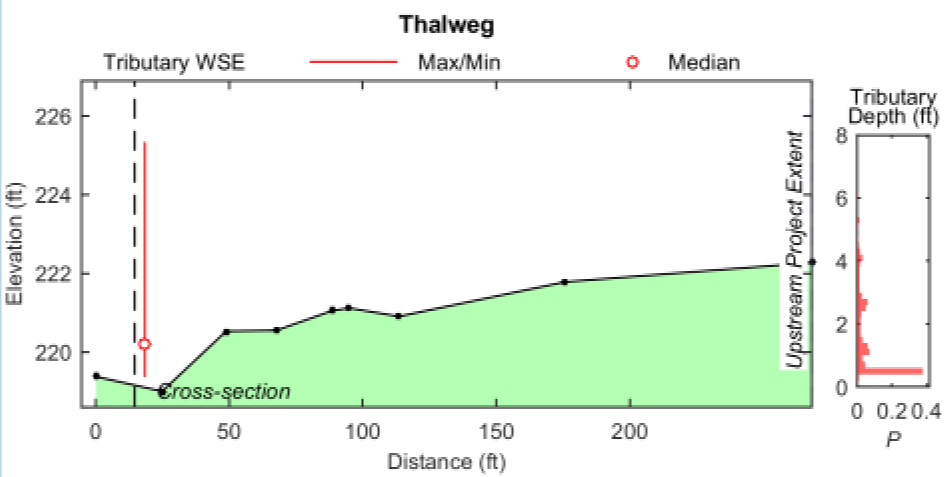


Bellows Riverine, Connecticut River
Site ID: CT-BR-4.03
Unnamed minor tributary, Stream Order 2





Mainstem Logger 10523231	Date	Maximum Measured Water Depth (ft)
Feet: WSE		
Max: 225.7	11Aug2014	0.1
75%: 222.2	10Sep2014	0.3
Mean: 221.1	09Nov2014	2.6
50%: 220.6		
25%: 220.0		
Min: 219.4		



Tributary Logger 10523218		
Feet:	WSE	Water Depth
Max:	225.3	6.2
75%:	221.7	2.6
Mean:	220.7	1.6
50%:	220.2	1.1
25%:	219.6	0.5
Min:	219.4	0.3

Bellows Riverine, Connecticut River
Site ID: CT-BR-4.03
Unnamed minor tributary, Stream Order 2

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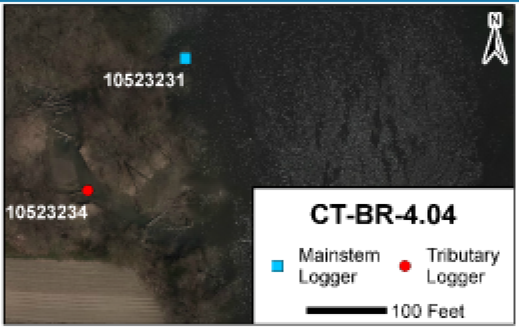
4.3 Site CT-BR-4.04 Cobb Brook

Site CT-BR-4.03 Cobb Brook, is a stream order 3 tributary located on the Vermont side in the Bellows Falls riverine reach. This location was initially visited on August 11, 2014 and tributary (SN 10523234) and mainstem (SN 10523231) level loggers were installed on that date. A subsequent site visit was conducted on September 10, 2014. The final site visit occurred on November 9, 2014 at which time the level loggers were removed.

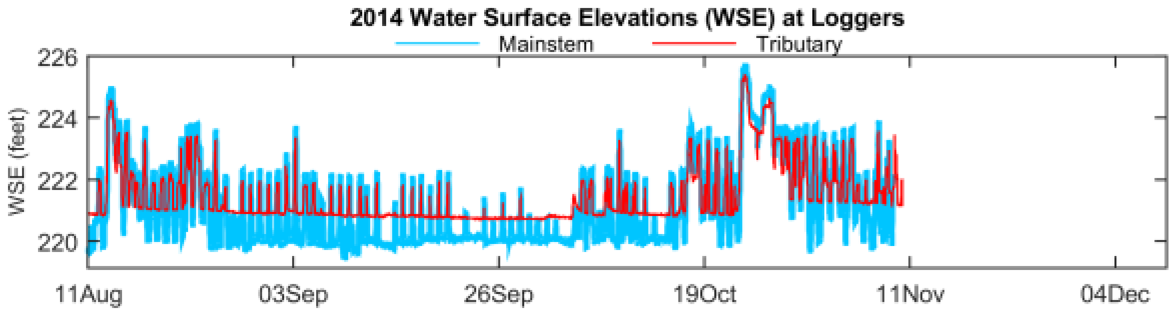
The tributary level logger was installed approximately 113 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 540 ft up into Cobb Brook to the base of a railroad culvert (later confirmed by evaluation of WSE data to be 535 ft, see photograph time stamped 10:58 11Aug14). Review of the WSE values recorded by the mainstem level logger indicates that under all conditions, both the project-affected elevation (224.5 ft) and the maximum mainstem influence (225.7 ft) remained just below the culvert bottom sill elevation of 225.85 ft). Flow was present in Cobb Brook during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.4 to 2.2 ft. Water depths were measured along a 189 ft section of the channel thalweg during the initial site visit on August 11th and ranged between 0.4 and 1.9 ft (mean = 1.0 ft).

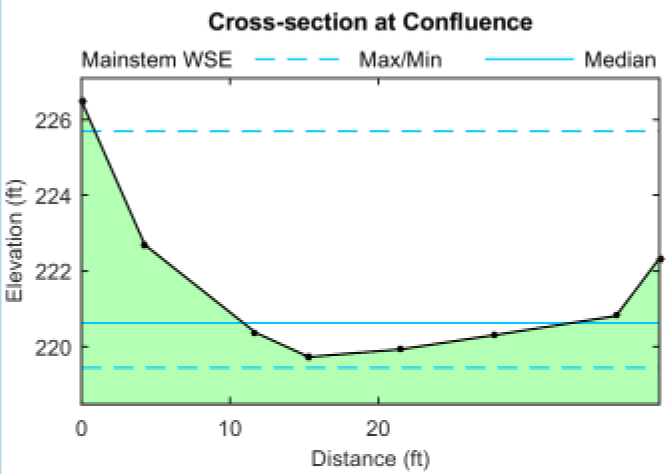
Review of the frequency distribution of water depth recorded by the tributary level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the tributary logger ranged between 1.9 and 2.9 ft and should provide adequate access. Under low mainstem conditions (minimum value recorded = 219.4 ft), Cobb Brook is no longer inundated by mainstem water and is limited to only its own natural outflow which is generally adequate for access; however, 40.5% of data occurrences were < 0.5 ft depth at the confluence indicating that under both mainstem and tributary low conditions, access could be limited for larger fish.



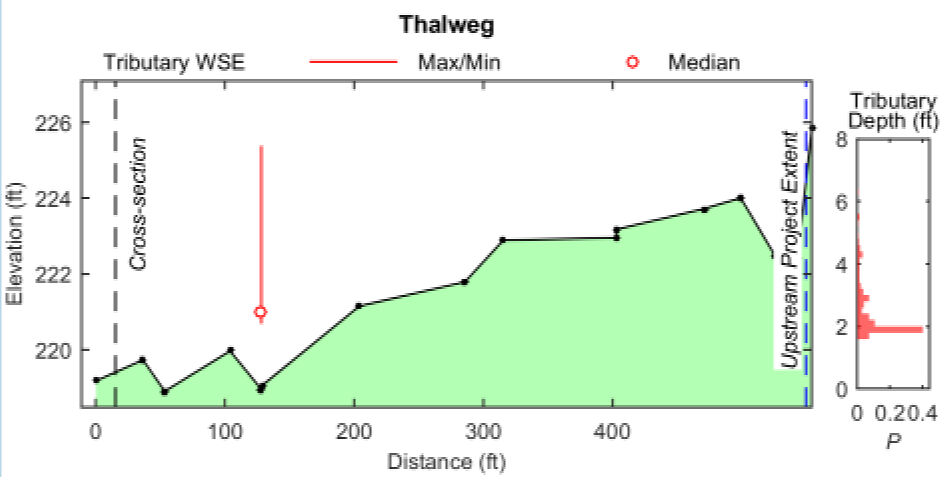
Bellows Riverine, Connecticut River
Site ID: CT-BR-4.04

Cobb Brook, Major tributary, Stream Order 3





Mainstem Logger 10523231 Feet:	WSE	Date	Maximum Measured Water Depth (ft)
Max:	225.7	11Aug2014	1.4
75%:	222.2	10Sep2014	1.8
Mean:	221.1	09Nov2014	2.2
50%:	220.6		
25%:	220.0		
Min:	219.4		



Tributary Logger 10523234 Feet:	WSE	Water Depth
Max:	225.4	6.4
75%:	221.8	2.9
Mean:	221.5	2.5
50%:	221.0	2.0
25%:	220.8	1.9
Min:	220.7	1.8

Bellows Riverine, Connecticut River
Site ID: CT-BR-4.04
Cobb Brook, Major tributary, Stream Order 3

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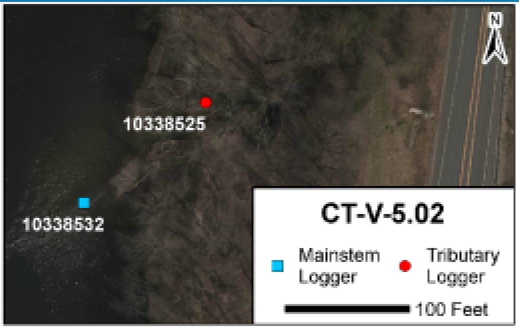
4.4 Site CT-V-5.02 Mad Brook

Site CT-V-5.02 Mad Brook, is a stream order 2 tributary located on the New Hampshire side at the lower end of the Bellows Falls riverine section/at the just upstream of the upper end of the Vernon impoundment. This location was initially visited on August 8, 2014 and tributary (SN 10338525) and mainstem (SN 10338532) level loggers were installed on that date. A subsequent site visit was conducted on September 8, 2014. The final site visit occurred on November 8, 2014 at which time the level loggers were removed. During the manual data review portion of post-processing, it was discovered that pressure readings recorded by the mainstem level logger were impacted by a logger malfunction. This malfunction resulted in plotted sensor depths exceeding the range expected for this particular location and data from this location was assigned a Use Code = 9 (Table 4.2-1). As a result, no mainstem level logger data is available.

The tributary level logger was installed approximately 30 feet upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 80 ft up into Mad Brook to culvert with a lower sill elevation of 223.8 ft, later confirmed by evaluation of WSE data (see photograph time stamped 14:28 08Sep14 below). Review of the WSE values recorded by the mainstem level logger indicates that mainstem water levels remained below the lower sill elevation of the culvert for the period of record. Flow was present in Mad Brook during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.7 to 1.1 ft. Water depths were measured along the channel thalweg during the final site visit on November 8th and ranged between 0.6 and 3.1 ft (mean = 1.6 ft).

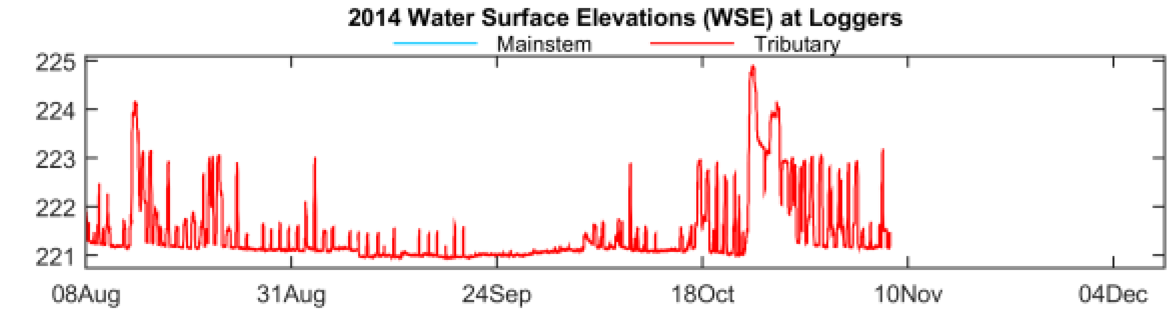
Based on visual evaluation of the project-affected reach on three dates during 2014 as well as recorded water depths along the channel thalweg and at the confluence cross section (and given the lack of mainstem data) access could be limited under low mainstem and tributary conditions.

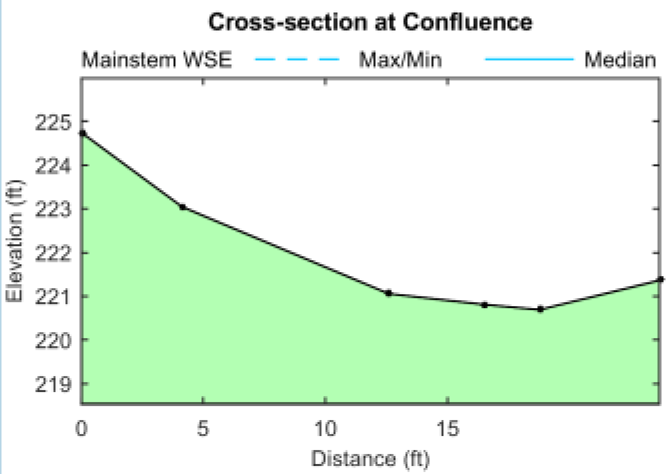


Vernon Impoundment, Connecticut River

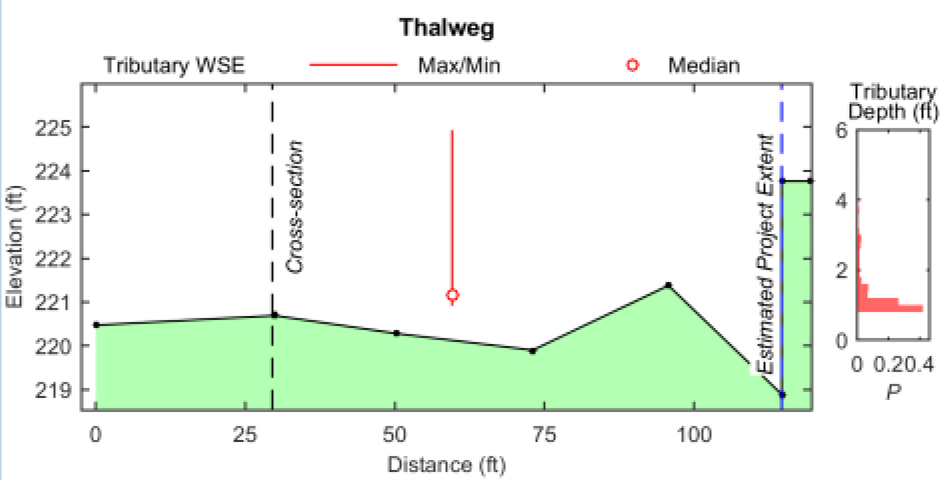
Site ID: CT-V-5.02

Mad Brook, Minor tributary, Stream Order 2





Date	Maximum Measured Water Depth (ft)
08Aug2014	1.1
08Sep2014	0.7
08Nov2014	0.8



Tributary Logger 10338525

Feet:	WSE	Water Depth
Max:	224.9	4.8
75%:	221.5	1.4
Mean:	221.5	1.3
50%:	221.2	1.0
25%:	221.1	1.0
Min:	220.9	0.8

Vernon Impoundment, Connecticut River
Site ID: CT-V-5.02
Mad Brook, Minor tributary, Stream Order 2

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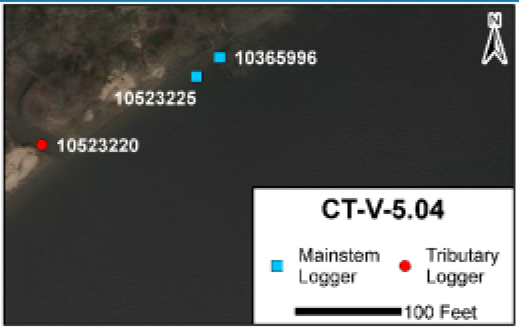
5.0 VERNON IMPOUNDMENT

5.1 Site CT-V-5.04

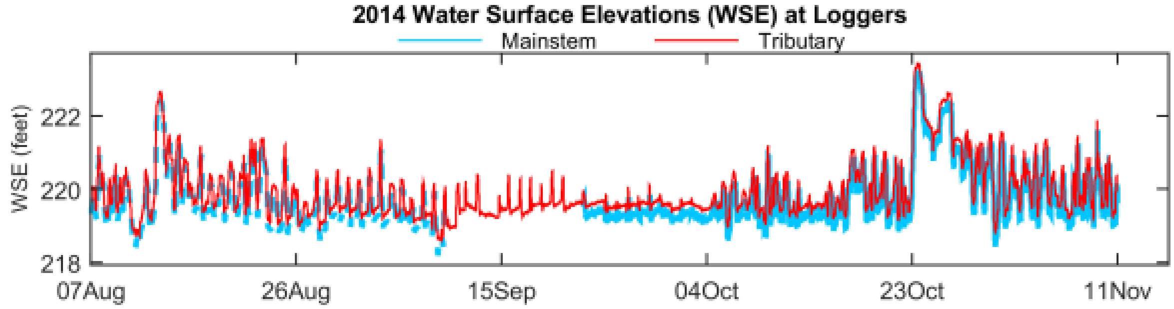
Site CT-V-5.04 is an unnamed stream order 3 tributary located on the Vermont side in the Vernon impoundment. This location was initially visited on August 7, 2014 and tributary (SN 10523220) and mainstem (SN 10523225) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 11, 2014 at which time the level loggers were removed. Following the September 9th download, Normandeau was notified by the Bellows Falls police department that level logger SN 10523225 had been turned in at their station. A new unit was installed (SN 10365996) immediately upon notification to Normandeau on September 22. As a result, sensor depth information for the mainstem site is available for the periods August 7 to September 9 and September 22 to October 11.

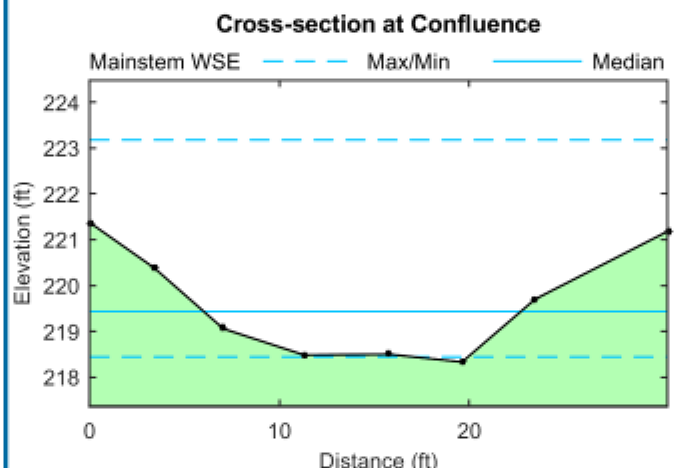
The tributary level logger was installed approximately 37 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 257 ft up into the tributary to a section where bank vegetation did not appear to indicate significant fluctuating water levels. Later evaluation of WSE data indicated that the mainstem WSE (223.2) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (222.5 ft elevation). Flow was present in the tributary during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.2 to 1.9 ft. Water depths were measured along the channel thalweg during the November 11th site visit and ranged between 1.6 and 2.1 ft (mean = 1.8 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (218.3 ft) ranged between 1.0 and 1.9 ft. Under low mainstem and tributary conditions, the site is minimally inundated by mainstem water and is primarily limited to only its own natural outflow. Under those conditions, access may be limited for larger fish as evidenced by the minimum water depth recorded by the tributary logger during the study period (water depth = 0.4 ft); however, only 2.2% of data occurrences were <0.5 ft of depth at the confluence.

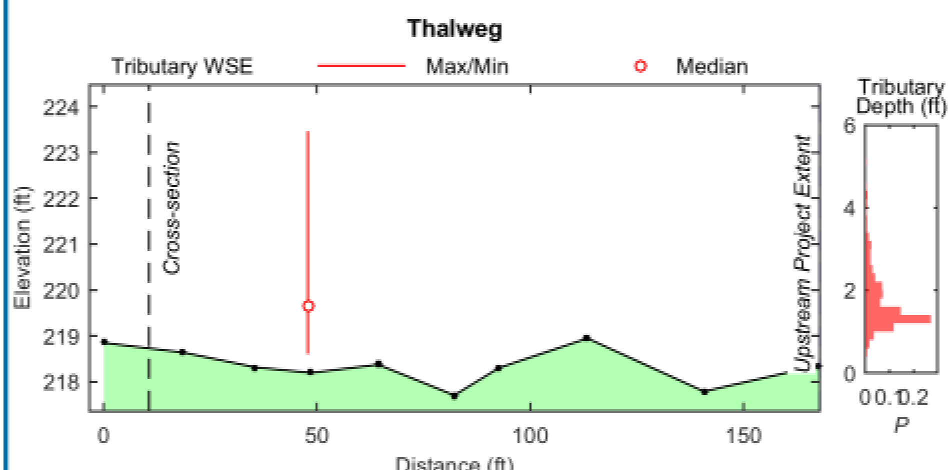


Vernon Impoundment, Connecticut River
Site ID: CT-V-5.04
Unnamed major tributary, Stream Order 3





Mainstem Logger 10365996		Date	Maximum Measured Water Depth (ft)
Feet:	WSE		
Max:	223.2	07Aug2014	1.2
75%:	220.2	09Sep2014	1.6
Mean:	219.8	11Nov2014	1.9
50%:	219.4		
25%:	219.3		
Min:	218.4		



Tributary Logger 10523220		Water
Feet:	WSE	Depth
Max:	223.4	5.2
75%:	220.2	2.0
Mean:	219.9	1.7
50%:	219.6	1.4
25%:	219.5	1.3
Min:	218.6	0.4

Vernon Impoundment, Connecticut River
Site ID: CT-V-5.04
Unnamed major tributary, Stream Order 3

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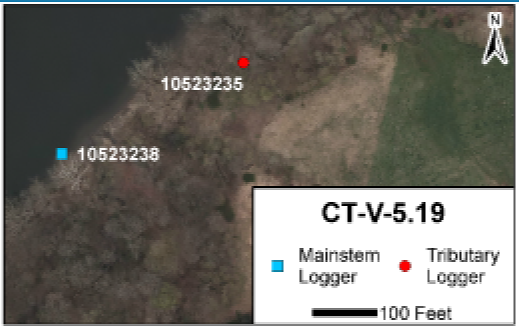
5.2 Site T-V-5.19

Site CT-V-5.19 is an unnamed stream order 1 tributary located on the New Hampshire side in the Vernon impoundment. This location was initially visited on August 6, 2014 and tributary (SN 10523235) and mainstem (SN 10523238) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 11, 2014 at which time the level loggers were removed.

The tributary level logger was installed approximately 51 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 100 ft up into the tributary to a section where bank vegetation did not appear to indicate significant fluctuating water levels, later confirmed by evaluation of WSE data to be 99 ft (see photo below). The maximum mainstem WSE (220.8 ft) indicated that the mainstem influence extends farther up into the tributary than the project-affected reach (220.4 ft elevation). Flow was present in tributary CT-V-5.19 during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.1 to 0.8 ft. Water depths were measured along the channel thalweg during the November 11th site visit and ranged between 0.2 and 1.1 ft (mean = 0.7 ft) with shallower depths located towards the upstream end of the project-affected reach.

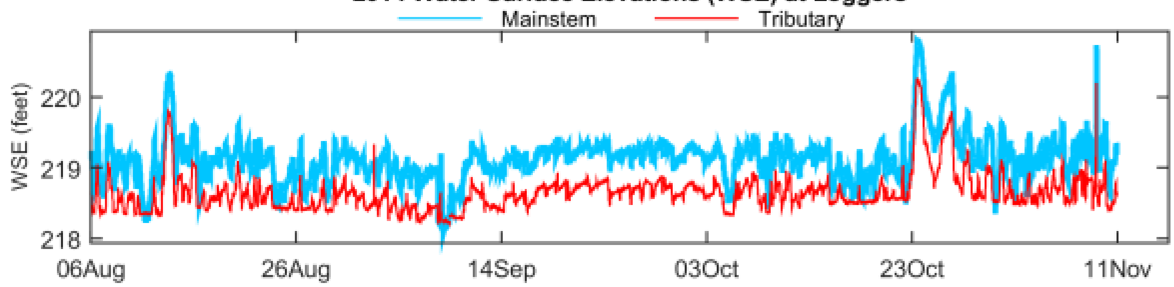
Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (217.9 ft) ranged between 1.1 and 1.4 ft. Under low mainstem WSE conditions (minimum value recorded = 218.1 ft), the tributary is minimally inundated by mainstem water (see photograph time stamped 14:35 09Sep14 below) and is primarily limited to only its own natural outflow. Under those conditions, access may be limited for larger fish as evidenced by the minimum water depth recorded by the tributary logger during the study period (water depth = 0.3 ft); however, only 1.1% of data occurrences were < 0.5 ft of depth at the confluence.

Upstream extent of project-affected area associated with
Site CT-V-5.19 as determined by visual observations, 2014.

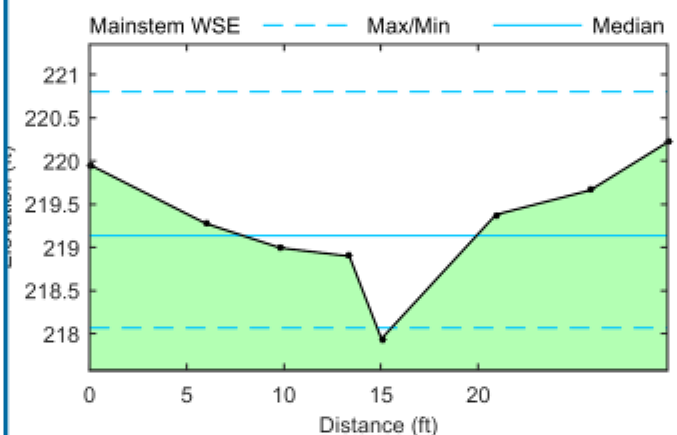


Vernon Impoundment, Connecticut River
Site ID: CT-V-5.19
Unnamed minor tributary, Stream Order 1

2014 Water Surface Elevations (WSE) at Loggers

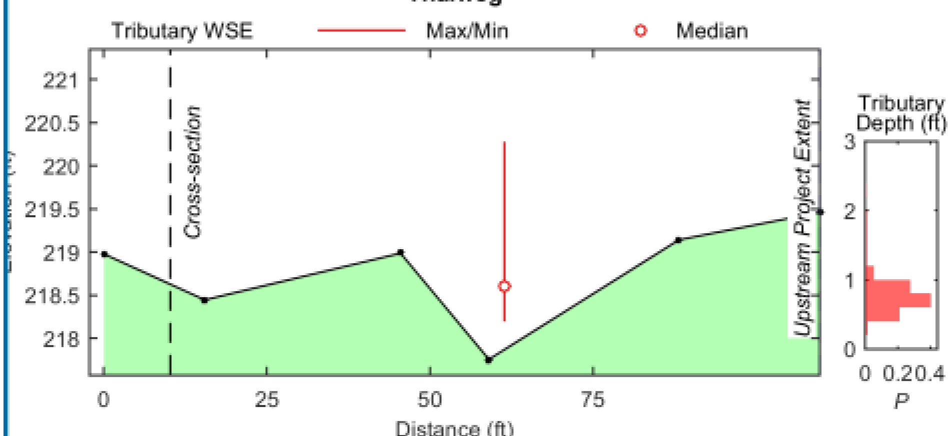


Cross-section at Confluence



Mainstem Logger 10523238 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 220.8	06Aug2014	0.8
75%: 219.3	09Sep2014	0.1
Mean: 219.1	11Nov2014	0.7
50%: 219.1		
25%: 219.0		
Min: 218.1		

Thalweg



Tributary Logger 10523235

Feet:	WSE	Water Depth
Max:	220.3	2.4
75%:	218.7	0.9
Mean:	218.6	0.8
50%:	218.6	0.7
25%:	218.5	0.6
Min:	218.2	0.3

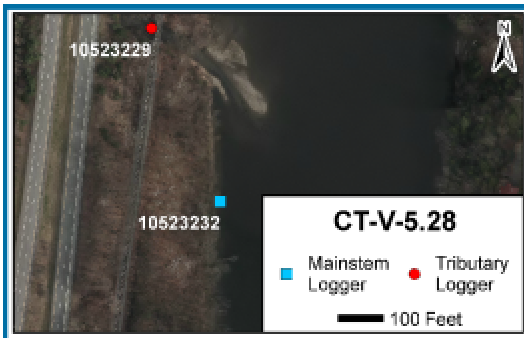
Vernon Impoundment, Connecticut River
Site ID: CT-V-5.19
Unnamed minor tributary, Stream Order 1

5.3 Site CT-V-5.28 Salmon Brook

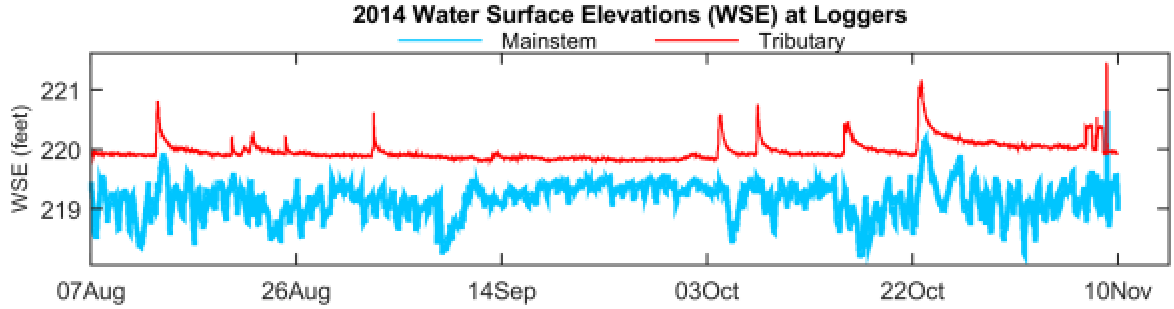
Site CT-V-5.28 Salmon Brook, is a stream order 3 tributary located on the Vermont side in the Vernon impoundment. This location was initially visited on August 7, 2014 and tributary (SN 10523229) and mainstem (10523232) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 10, 2014 at which time the level loggers were removed.

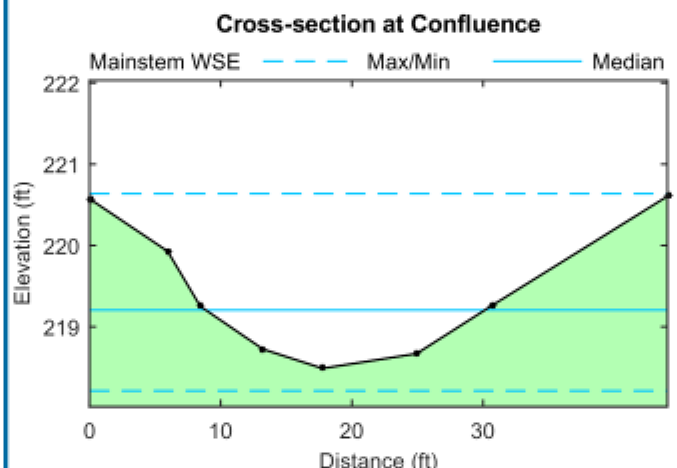
The tributary level logger was installed under a railroad bridge at a point approximately 127 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 170 ft up into Salmon Brook to the base of a large culvert running under Interstate 91, later confirmed by evaluation of WSE data to be 169 ft (see photograph time stamped 07:37 07Aug14 below). The maximum mainstem WSE (220.6 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (220.0 ft elevation). Flow was present in tributary CT-V-5.28 during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 1.2 to 1.7 ft. Water depths were measured along the channel thalweg during the August 7th site visit and ranged between 0.3 and 1.1 ft (mean = 0.7 ft) with shallower depths located towards the upstream end of the project-affected reach.

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (218.5 ft) ranged between 0.5 and 0.8 ft. Under low mainstem WSE conditions (minimum value recorded = 218.2 ft), the tributary is not inundated by mainstem water and is limited to only its own natural outflow. Under those conditions, access should still be adequate as evidenced by the minimum water depth recorded by the tributary logger during the study period (water depth = 1.1 ft), and only limited under some low mainstem (21.1% of data occurrences < 0.5 ft of depth at the confluence).

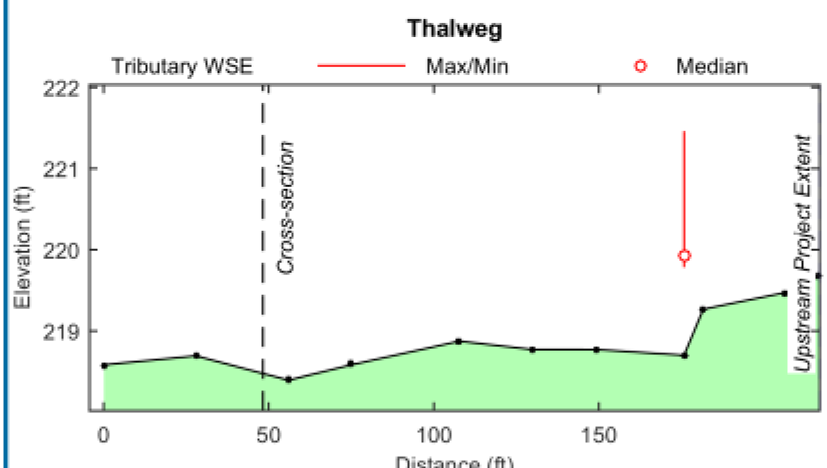


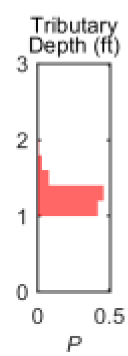
Vernon Impoundment, Connecticut River
Site ID: CT-V-5.28
Salmon Brook, Major tributary, Stream Order 3





Mainstem Logger 10523232		Date	Maximum Measured Water Depth (ft)
Feet:	WSE		
Max:	220.6	07Aug2014	1.5
75%:	219.4	09Sep2014	1.7
Mean:	219.2	10Nov2014	1.2
50%:	219.2		
25%:	219.0		
Min:	218.2		





Tributary Logger 10523229		
Feet:	WSE	Water Depth
Max:	221.5	2.7
75%:	220.0	1.3
Mean:	220.0	1.3
50%:	219.9	1.2
25%:	219.9	1.2
Min:	219.8	1.1

Vernon Impoundment, Connecticut River
Site ID: CT-V-5.28
Salmon Brook, Major tributary, Stream Order 3

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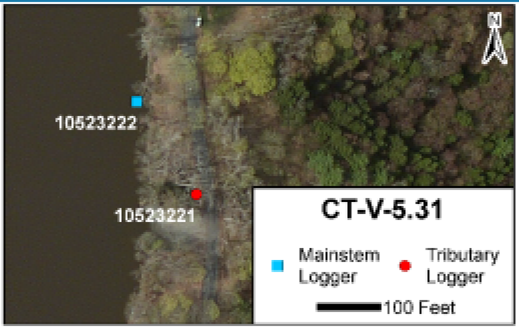
5.4 Site CT-V-5.31

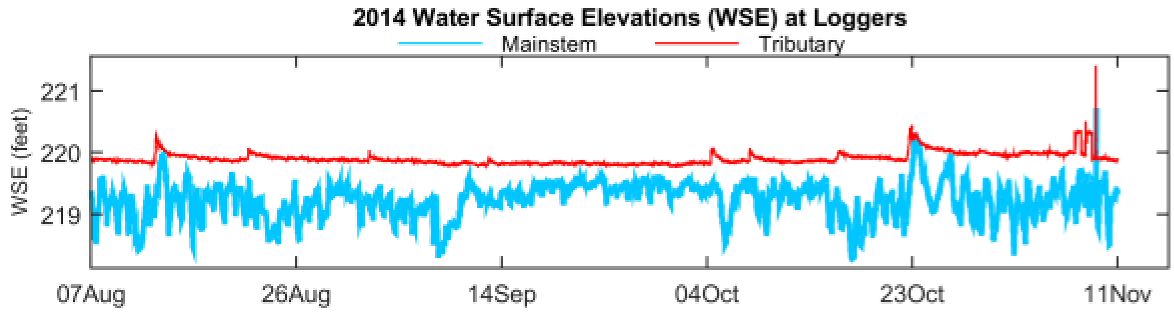
Site CT-V-5.31 is an unnamed stream order 2 tributary located on the New Hampshire side in the Vernon impoundment. This location was initially visited on August 7, 2014 and tributary (SN 10523221) and mainstem (SN 10523222) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 11, 2014 at which time the level loggers were removed.

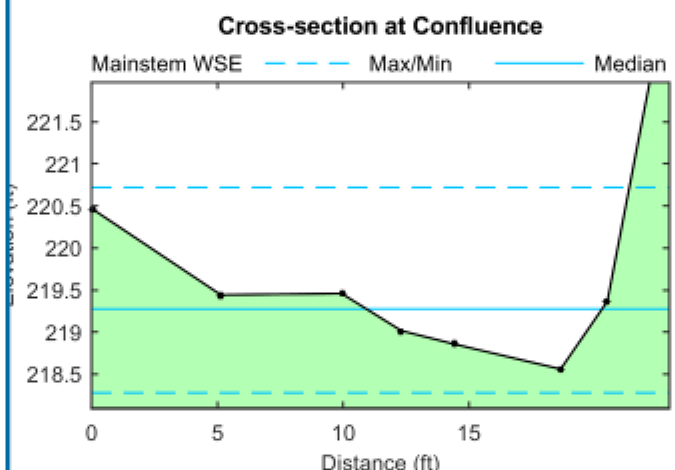
The tributary level logger was installed at a point approximately 64 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 78 ft up into the tributary to the base of a culvert running under River Road, later confirmed by evaluation of WSE data (see photograph time stamped 16:09 11Nov14 below).
The maximum mainstem WSE (220.7 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (220.0 ft elevation). Flow was present in the tributary during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.3 to 1.0 ft. Water depths were measured along the channel thalweg during the November 11th site visit and ranged between 0.2 and 1.4 ft (mean = 0.6 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (218.6 ft) ranged between 0.5 and 0.8 ft. Under low mainstem WSE conditions (minimum value recorded = 218.3 ft), the tributary is not inundated by mainstem water and is limited to only its own natural outflow. Under those conditions, access should still be adequate as evidenced by the presence of higher thalweg bed elevations located downstream of the tributary logger location with its minimum recorded water depth (1.0 ft), and only limited under some low mainstem (24% of data occurrences < 0.5 ft of depth at the confluence)..

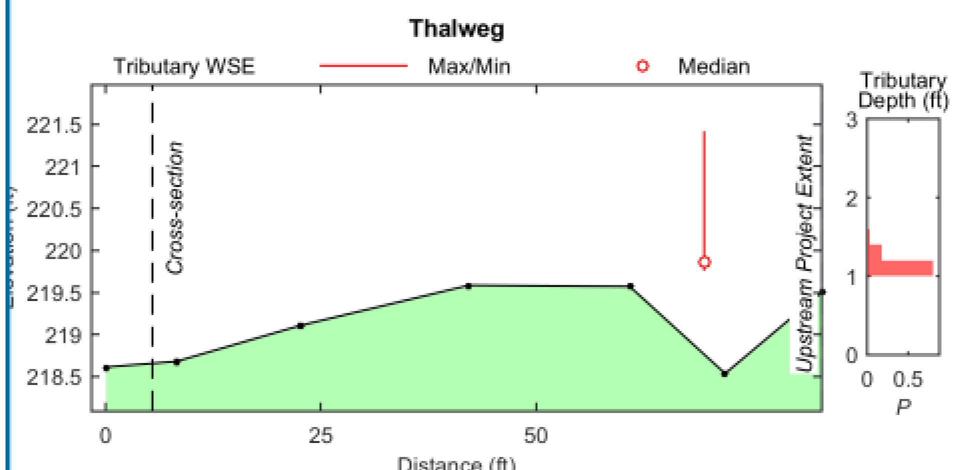


Vernon Impoundment, Connecticut River
Site ID: CT-V-5.31
Unnamed minor tributary, Stream Order 2





Mainstem Logger 10523222	Date	Maximum Measured Water Depth (ft)
Feet: WSE	Date	Depth (ft)
Max: 220.7	07Aug2014	1.0
75%: 219.4	09Sep2014	0.3
Mean: 219.2	11Nov2014	0.9
50%: 219.3		
25%: 219.1		
Min: 218.3		



Tributary Logger 10523221		
Feet:	WSE	Water Depth
Max:	221.4	2.6
75%:	219.9	1.2
Mean:	219.9	1.1
50%:	219.9	1.1
25%:	219.8	1.1
Min:	219.8	1.0

Vernon Impoundment, Connecticut River
Site ID: CT-V-5.31
Unnamed minor tributary, Stream Order 2

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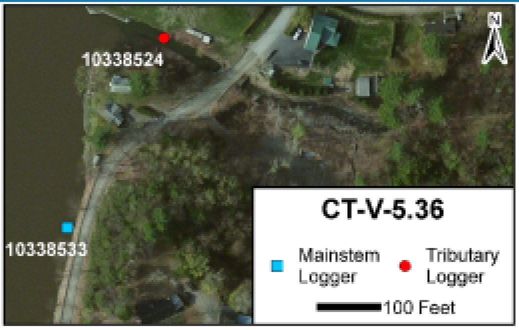
5.5 Site CT-V-5.36

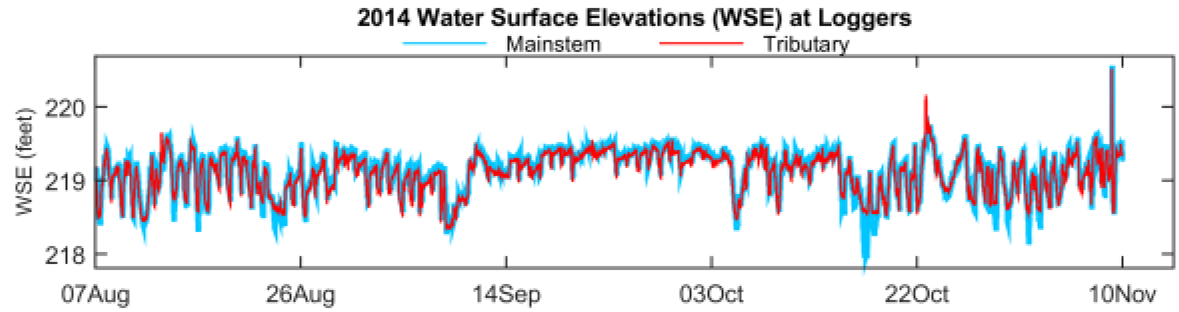
Site CT-V-5.36 is an unnamed stream order 2 tributary located on the New Hampshire side in the Vernon impoundment. This location was initially visited on August 7, 2014 and tributary (SN 10338524) and mainstem (SN 10338533) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 10, 2014 at which time the level loggers were removed.

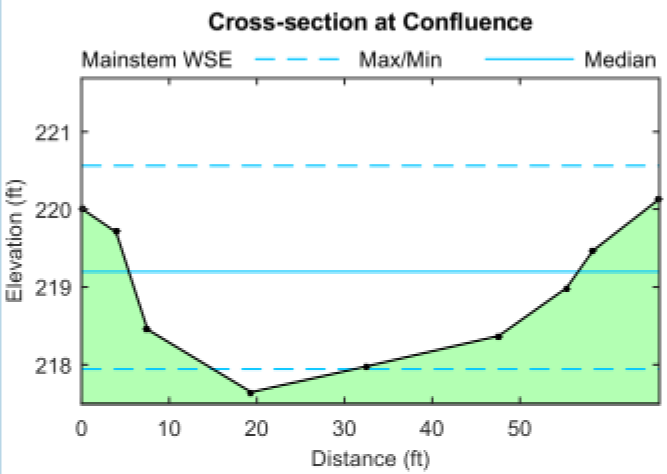
The tributary level logger was installed at a point approximately 122 ft upstream from the confluence with the mainstem and just downstream of the Mountain Road bridge. During the initial site visit, the field crew visually determined that project effects extend approximately 276 ft (bed elevation = 219.4 ft) up into the tributary to a point upstream of the bridge, later confirmed by evaluation of WSE data to be 275 ft. The maximum mainstem WSE (220.6 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (219.7 ft elevation). Flow was present in the tributary during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.7 to 1.9 ft. Water depths were measured along the channel thalweg during the August 7th site visit and ranged between 0.2 and 1.6 ft (mean = 1.0 ft) with shallower depths towards the upper end of the project-affected reach. Bed elevations (and resulting water depths) were shallower in the portion of the project-affected reach located immediately under and upstream of the Mountain Road bridge.

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under most conditions (i.e., 25th through 75th percentiles) water depth at the thalweg elevation of the cross section confluence (217.6 ft) ranged between 1.3 and 1.8 ft. Under low mainstem conditions (minimum WSE value recorded = 217.9 ft), the tributary is minimally inundated by mainstem water and is regulated by the stream's own natural outflow. Under low tributary conditions, access may be limited for larger fish as evidenced by the minimum water depth recorded by the tributary logger during the study period (water depth = 0.3 ft); however, only 0.3% of data occurrences were < 0.5 ft of depth at the confluence.

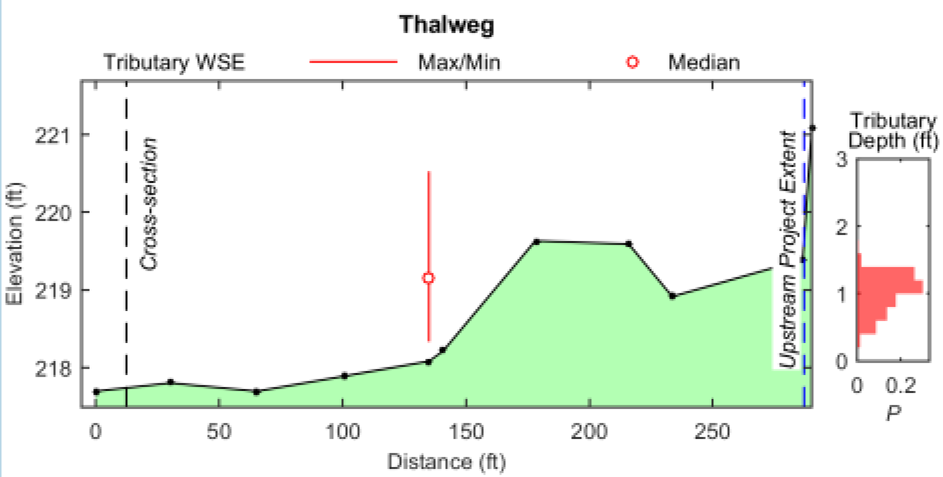


Vernon Impoundment, Connecticut River
Site ID: CT-V-5.36
Unnamed minor tributary, Stream Order 2





Mainstem Logger 10338533 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 220.6	07Aug2014	1.6
75%: 219.4	09Sep2014	0.7
Mean: 219.1	10Nov2014	1.9
50%: 219.2		
25%: 218.9		
Min: 217.9		



Tributary Logger 10338524

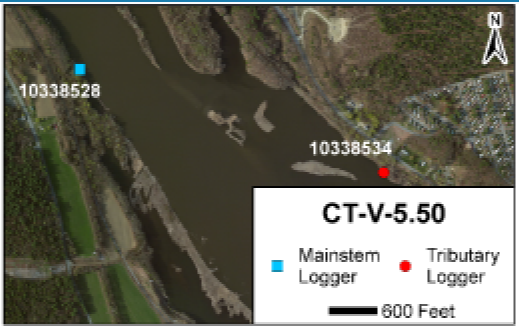
Feet:	WSE	Water Depth
Max:	220.5	2.4
75%:	219.3	1.2
Mean:	219.1	1.0
50%:	219.2	1.1
25%:	218.9	0.8
Min:	218.4	0.3

5.6 Site CT-V-5.50 Backwater

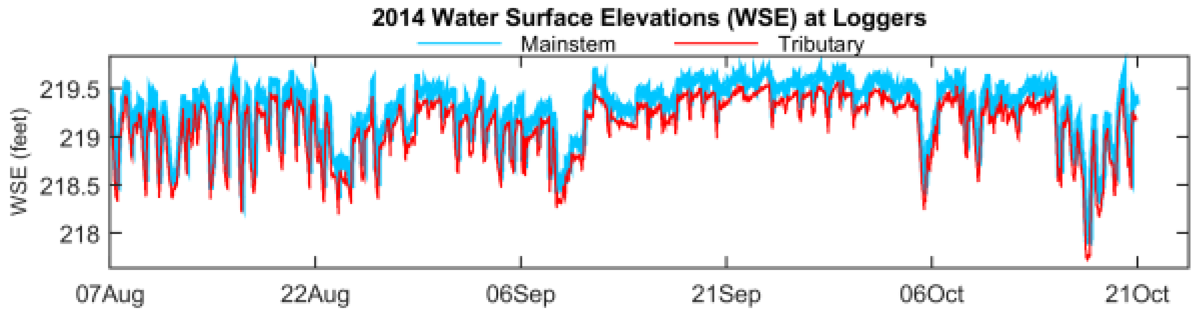
Site CT-V-5.50 is a backwater located on the New Hampshire side in the Vernon impoundment. This location was initially visited on August 7, 2014 and tributary (SN 10338534) and mainstem (SN 10338528) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on October 21, 2014 at which time the level loggers were removed.

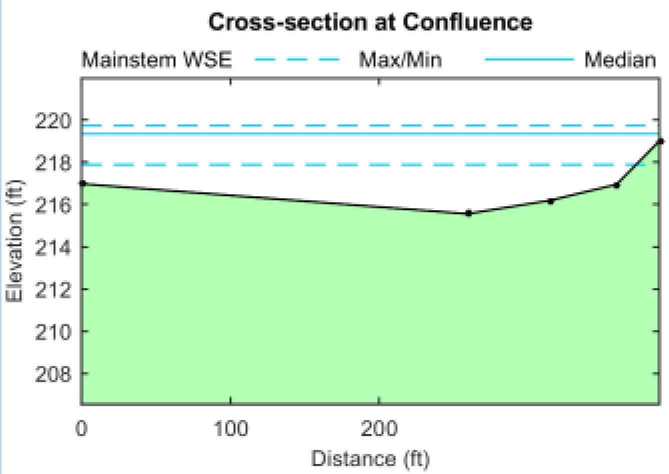
The backwater is connected directly to the mainstem via a large open access area (see photograph time stamped 09:04 07Aug14 below). The backwater level logger was installed approximately 3,800 feet away from the confluence. During the initial site visit, the field crew visually determined the extent of the project-affected area as running across the ponded backwater area, covering a linear distance of 4,988 ft, later confirmed by evaluation of WSE data to be 4,989 ft. Water was present within the backwater during each of the three visits. Water depth at the confluence cross section was measured during each visit and ranged from 6.2 to 10.3 ft. Water depths across the ponded backwater area were calculated as the difference between the measured WSE during the initial site visit and measured bed elevation information collected during Study 7 (Normandeau 2014b) and ranged between 1.3 and 12.0 ft (mean = 6.7 ft).

Review of the range of WSE values recorded by the mainstem level logger indicates that under all observed conditions (i.e., min through max values) water depth at the confluence ranged between 2.3 and 4.1 ft and will provide adequate access. As evidenced by the thalweg profile, bottom elevations vary from the confluence across the backwater. When the majority of the range of WSE values recorded by the backwater level logger is considered (i.e., 25^{th} to 75^{th} percentiles; 219.1-219.5 ft), water depth over each surveyed thalweg point was a minimum of 1.1 ft and access is adequate under most conditions. Due to shallow bed elevations present along the littoral margins and at some locations within the ponded, backwater area, wetted area available to fish will likely be reduced during periods of low mainstem flow (e.g., minimum WSE value recorded at backwater level logger; 217.7 ft); however, there were no data occurrences < 0.5 ft of depth at the confluence.

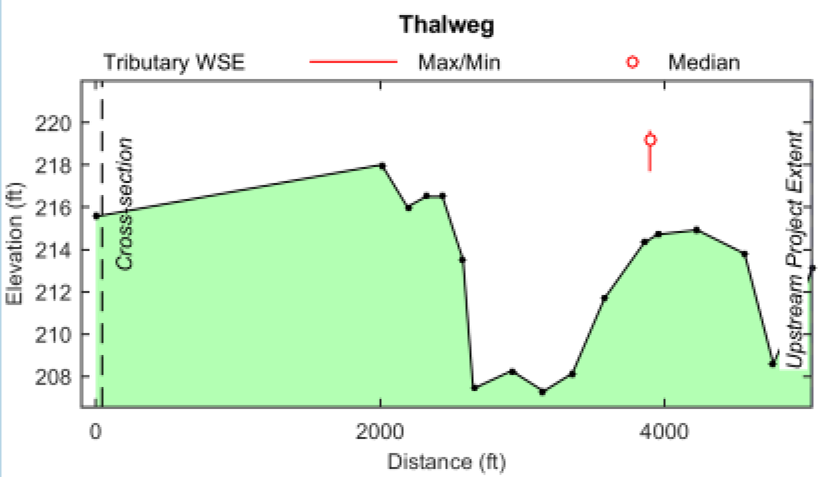


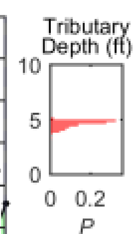
Vernon Impoundment, Connecticut River
Site ID: CT-V-5.50
Unnamed backwater, Stream Order 0





Mainstem Logger 10338528 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 219.7	07Aug2014	6.3
75%: 219.5	09Sep2014	8.2
Mean: 219.3	21Oct2014	10.3
50%: 219.4		
25%: 219.1		
Min: 217.9		





Tributary Logger 10338534

Feet:	WSE	Water Depth
Max:	219.6	5.1
75%:	219.3	4.8
Mean:	219.1	4.6
50%:	219.2	4.7
25%:	218.9	4.4
Min:	217.7	3.2

Vernon Impoundment, Connecticut River
Site ID: CT-V-5.50
Unnamed backwater, Stream Order 0

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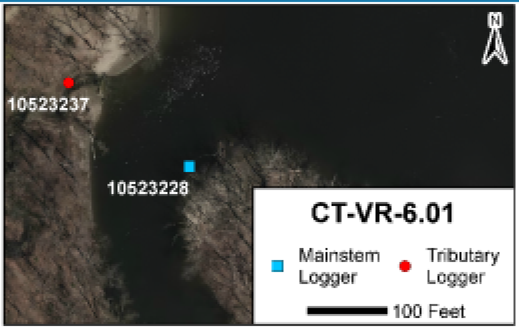
6.0 VERNON RIVERINE SECTION

6.1 Site CT-VR-6.01

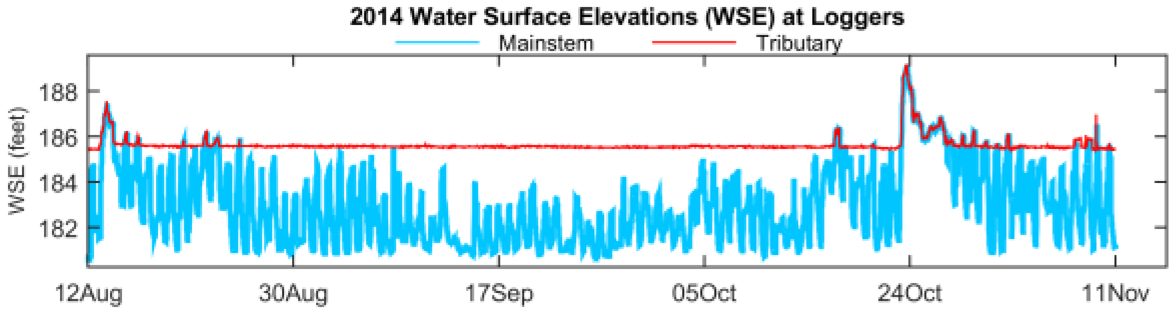
Site CT-VR-6.01 is an unnamed stream order 2 tributary located on the Vermont side in the Vernon riverine reach. This location was initially visited on August 12, 2014 and tributary (SN 10523237) and mainstem (SN 10523228) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 11, 2014 at which time the level loggers were removed.

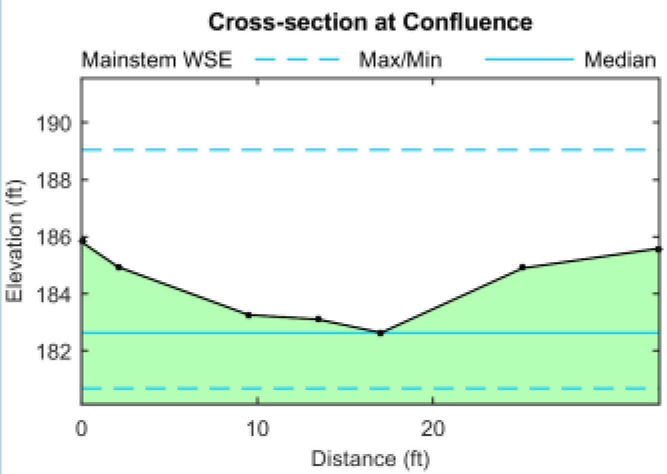
The tributary level logger was installed in the vicinity of the confluence with the mainstem. The project-affected reach was visually estimated at 138 ft up into the tributary, later confirmed by evaluation of mainstem WSE data to be 135 ft. The maximum mainstem WSE (189.0 ft) indicates that the mainstem influence extends farther up into the tributary than the project-affected reach (187.2 ft elevation). Flow was present in tributary CT-VR-6.01 during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.2 to 0.4 ft. Water depths were measured along the channel thalweg during the August 12th site visit and ranged between 0.3 and 1.2 ft (mean = 0.7 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under elevated conditions (i.e., 75th percentile) water depth at the thalweg elevation of the cross section confluence (bed elevation = 182.6 ft) was 1.6 ft. Under median mainstem WSE conditions (median = 182.6 ft), the tributary is not inundated by mainstem water and access is regulated by the stream's own natural outflow. Access may be limited for larger fish under low mainstem and tributary conditions (58.6% of data occurrences <0.5 ft of depth at the confluence). It is important to note that the site is located within the Turners Falls impoundment and subject to water level fluctuations as a result of impoundment operations, beyond the control of TransCanada operations.

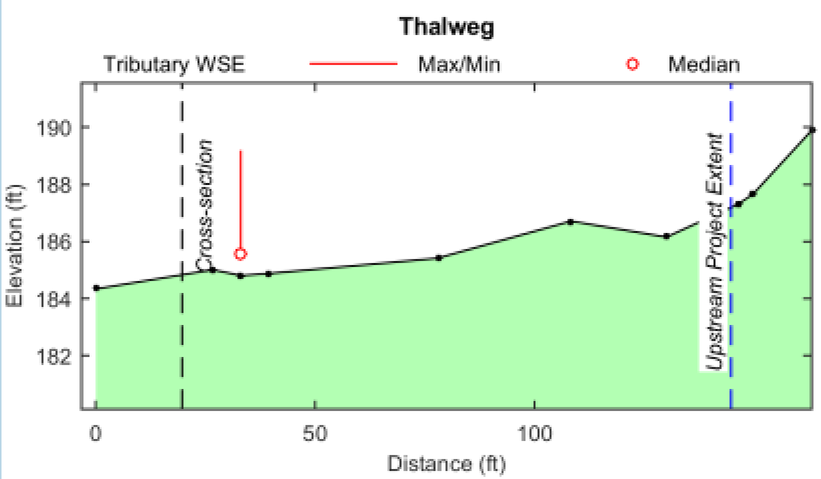


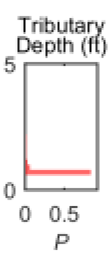
Vernon Riverine, Connecticut River
Site ID: CT-VR-6.01
Unnamed minor tributary, Stream Order 2





Mainstem Logger 10523228 Feet: WSE	Date	Maximum Measured Water Depth (ft)
Max: 189.0	12Aug2014	0.4
75%: 184.2	09Sep2014	0.2
Mean: 183.0	11Nov2014	0.3
50%: 182.6		
25%: 181.5		
Min: 180.7		





Tributary Logger 10523237

Feet:	WSE	Water Depth
Max:	189.2	4.4
75%:	185.6	0.8
Mean:	185.6	0.8
50%:	185.6	0.8
25%:	185.5	0.7
Min:	185.4	0.6

Vernon Riverine, Connecticut River
Site ID: CT-VR-6.01
Unnamed minor tributary, Stream Order 2

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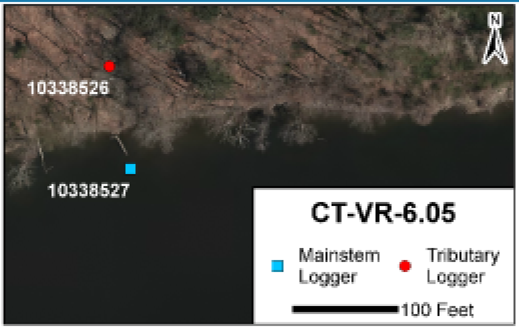
6.2 Site CT-VR-6.05

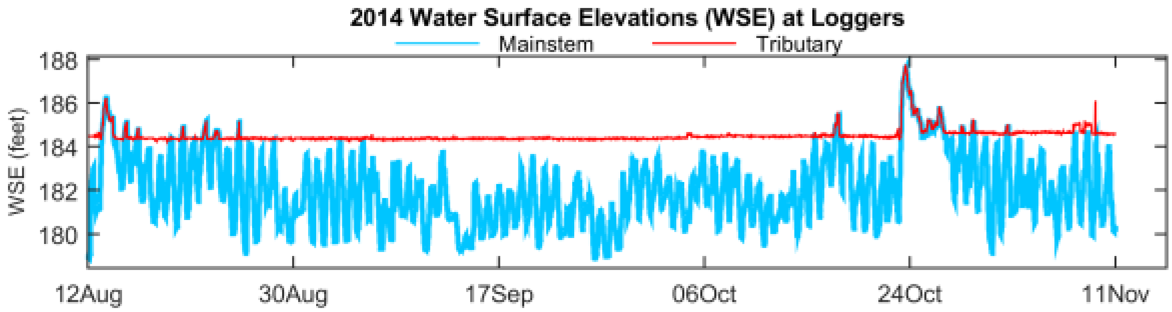
Site CT-VR-6.05 is an unnamed stream order 1 tributary located on the New Hampshire side in the Vernon riverine reach. This location was initially visited on August 12, 2014 and tributary (SN 10338526) and mainstem (SN 10338527) level loggers were installed on that date. A subsequent site visit was conducted on September 9, 2014. The final site visit occurred on November 11, 2014 at which time the level loggers were removed.

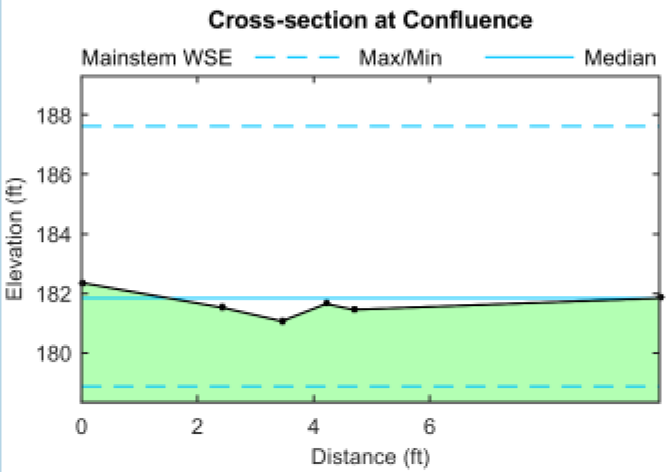
The tributary level logger was installed approximately 135 ft upstream from the confluence with the mainstem. During the initial site visit, the field crew visually determined that project effects extend approximately 170 ft up into the tributary (bed elevation = 187.4 ft). Evaluation of WSE data later indicated that the project-affected reach extends to 165 ft. The maximum mainstem WSE (187.6 ft) indicates mainstem influence extends farther up into the tributary than the project-affected reach (185.9 ft elevation). Flow was present in tributary CT-VR-6.05 during each of the three visits. Water depth at the confluence cross section was measured during each visit and the maximum water depth ranged from 0.1 to 0.3 ft. Water depths were measured along the channel thalweg during the November 11th site visit and ranged between 0.2 and 0.9 ft (mean = 0.3 ft).

Review of the frequency distribution of water depth recorded by the mainstem level logger indicates that under median conditions (i.e., 50th percentile) water depth at the thalweg elevation of the cross section confluence (bed elevation = 181.1 ft) was 0.7 ft. Under lower mainstem WSE conditions (25th percentile = 180.9 ft, the tributary is not inundated by project-affected water and access is regulated by the stream's own natural outflow. Access may be limited for larger fish under low mainstem and tributary conditions (42.5% of data occurrences < 0.5 ft of depth at the confluence). It is important to note that the site is located within the Turners Falls impoundment and subject to water level fluctuations as a result of impoundment operations, beyond the control of TransCanada operations.

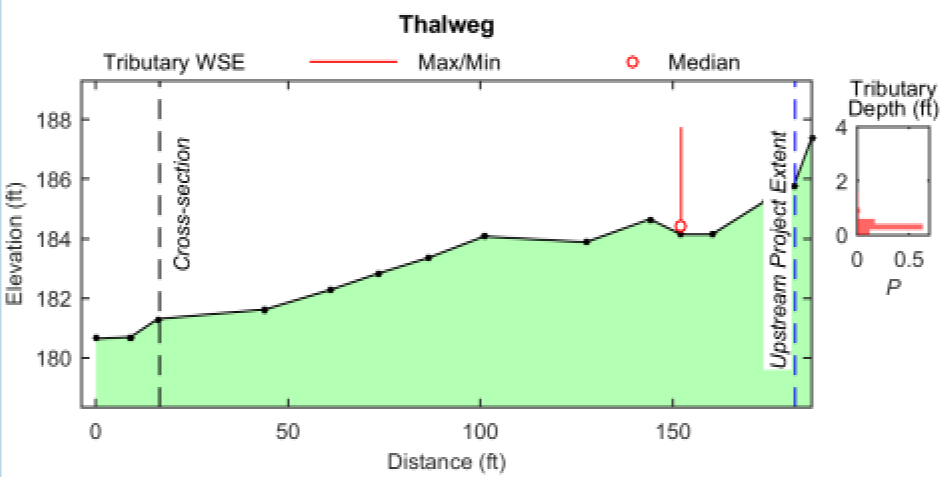


Vernon Riverine, Connecticut River
Site ID: CT-VR-6.05
Unnamed minor tributary, Stream Order 1





Feet:	Mainstem Logger 10338527 WSE	Date	Maximum Measured Water Depth (ft)
Max:	187.6	12Aug2014	0.1
75%:	183.1	09Sep2014	0.3
Mean:	182.0	11Nov2014	0.2
50%:	181.8		
25%:	180.9		
Min:	178.9		



Tributary Logger 10338526

Feet:	WSE	Water Depth
Max:	187.7	3.6
75%:	184.5	0.4
Mean:	184.5	0.4
50%:	184.4	0.2
25%:	184.4	0.2
Min:	184.2	0.1

Vernon Riverine, Connecticut River
Site ID: CT-VR-6.05
Unnamed minor tributary, Stream Order 1

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UNITED STATES OF AMERICA

BEFORE THE

FEDERAL ENERGY REGULATORY COMMISSION

TRANSCANADA HYDRO NORTHEAST INC.

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)

Volume III.B

Study 27 – Floodplain, wetland, Riparian, and Littoral Vegetation Habitats Study

Study Report

Updated Study Report

September 14, 2015

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TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 27

FLOODPLAIN, WETLAND, RIPARIAN, AND LITTORAL VEGETATION HABITATS STUDY

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

TransCanada Hydro Northeast Inc.
4 Park Street, Suite 402
Concord, NH 03301

Prepared by

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

September 14, 2015

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EXECUTIVE SUMMARY

Introduction

The goal of this study was to provide baseline mapping and characterization of riparian, floodplain, wetland, and littoral vegetation and habitats within the Wilder, Bellows Falls, and Vernon Project-affected areas and to assess the potential effects of project-related water-level fluctuations on those habitats. The objectives of this study were to describe and map riparian, floodplain, and wetland habitats; describe and map shallow-water aquatic habitat types within the zone of normal project operations water-level fluctuations; describe associated wildlife (e.g. bald eagle nesting, waterfowl nesting); and assess potential effects of project operations on riparian, floodplain, wetland, and littoral vegetation habitats, and associated wildlife.

The study area extended from the uppermost extent of the Wilder impoundment to the area downstream of Vernon Dam, including the Wilder, Bellows Falls, and Vernon impoundments and the riverine sections downstream of Wilder and Bellows Falls dams, and extending approximately 1.5 miles below Vernon dam. All of the shorelines in Vermont and New Hampshire, including the river's edge, islands, sand and gravel bars, and portions of tributaries that appeared (based on review of LiDAR and aerial photos) to be within the influence of the projects, were mapped. The terrestrial extent of the study area encompassed at least 200 feet from the river's edge. Where wetlands and floodplains extended farther inland than 200 feet, the study encompassed either the entire wetland or floodplain, or to where the topography or site features indicated the river is no longer a significant influence on the habitat.

Cover Type Map

Natural features and land uses mapped within the study area covered a total of 8,250 acres, and were comprised of upland vegetation cover (70% cover), wetlands and tributary streams (15% cover), developed lands (13% cover), and riverine features (2% cover). Upland vegetation cover was predominantly forest (64% cover) followed by agricultural land (29% cover). Large tracts of deciduous, coniferous, and mixed deciduous and coniferous forest extended across much of the study area. Agricultural uses, primarily cropland and pasture/hayfield, were the predominant cover type over much of the more level terrain adjacent to the river, and especially in the Wilder impoundment. The remaining vegetated upland cover was largely shrub communities, maintained grass such as parklands and golf courses, and old fields.

Wetlands were widely distributed across the study area with the majority consisting of emergent (40% cover), deciduous forested (34% cover) and scrub/shrub (10% cover) cover types. A variety of intermixed cover types, open water and aquatic bed habitat comprised the balance (16% cover). Infrastructure, consisting of dams and dam facilities, boat launches, roads and railroads, comprised the largest single cover type in the developed lands category.

Additional features mapped in the study area included tributary streams, steep unconsolidated slopes, visibly eroding banks and river channel structures. Most of the tributary streams, eroding banks and steep unconsolidated slopes were associated with the three impoundments. Channel features including bedrock in the Bellows Falls bypass reach and along the riverbank, boulders and cobble in shallows, gravel bars, and sand and mud, were concentrated in the free flowing sections of the river downstream of the project dams.

The most prevalent vegetation communities characterized across the study area were: hardwood forest including upland and riparian forest types, mixed hardwood-softwood forests, softwood forest, emergent wetlands, scrub/shrub wetlands, scrub/shrub & emergent wetlands, deciduous forested wetlands, deciduous forest & scrub/shrub wetlands, aquatic beds and riverbank.

Floodplains

Approximately 3,218 acres of floodplains were delineated based on a combination of elevation and evidence of flooding. Floodplains were more prevalent along the shores of the three impoundments compared to the riverine sections. Almost half of all floodplains occurred in the Bellows Falls impoundment. Wilder and Vernon impoundments had approximately 28% and 24% of the total floodplains, respectively.

The cover types of the floodplains were predominantly in natural cover or agriculture; approximately 48% were in wetland cover, 27% were in agriculture, and 20% were in natural upland cover. Typically, floodplains were confined to less than ten feet above local average high water level, were relatively flat, and often showed flooding features such as wet depressions and evidence of scour and deposition. In some instances, evidence of flooding on the aerial photos indicated floodplains occurred above the relative ten foot contour and were consequently mapped as such.

Wetland Assessment

Function and values assessments were performed for the six most common wetland types in the study area to determine the principal functions and values provided by each of these habitats using the 1999 US Army Corps of Engineers Highway Methodology (USACE, 1999). Widely occurring principal functions consisted of flood flow alteration, sediment/toxicant retention, nutrient removal, sediment/shoreline stabilization, wildlife habitat, and endangered species habitat. Occurring less commonly at a principal level were the groundwater recharge/discharge, fish/shellfish habitat and production export functions, and the visual quality/aesthetics value. The recreation, educational/scientific, and uniqueness/heritage values were not determined to occur at a principal level in any of the study area wetlands.

Emergent wetlands provided the most functions at a principal level in the study area followed by aquatic bed, scrub/shrub, and forested wetlands. Scrub/shrub-emergent and forested- scrub/shrub wetlands provided the least number of principal functions, but were also uncommon habitats in the study area, and therefore, fewer of these habitats were available for assessment. Aquatic beds were the only wetland type to provide a wetland value at a principal level.

Rare, Threatened, and Endangered Species

One-hundred-sixty-three (163) State-listed plant species and exemplary communities were to be incidentally investigated during this study, if the Element Occurrences were located on public or TransCanada-owned or leased land. Of those 163 Element Occurrences, 88 had been located since 1990 and 75 had not been observed since that date. This study's analysis focused on the 88 more recent (post-1990) observations. Of the 88 recent Element Occurrences, 46 occurred within the 2014 study area, and 42 occurred more landward of the study area. Seven Element Occurrences were confirmed during the 2014 field verification, including five silver maple-wood nettle-ostrich fern floodplain communities, and three rare species, black maple (*Acer nigrum*), obedient plant (*Physostegia virginiana*), and southern naiad (*Najas flexilis*). Another Element Occurrence of silver maple-wood nettle-ostrich fern floodplain community recorded in the study area was noted within a very marginal cover type of mixed hardwood and conifers. Located in association with a small drainage, this Element Occurrence was determined to be too small and too marginal to include as a confirmed record. Also, in addition to the recorded obedient plant Element Occurrence, this species was frequently observed on much of the riverbank and on many of the sparsely vegetated bars during vegetation field surveys conducted in 2012 (Normandeau, 2013a) and in 2014.

Invasive and Exotic Species

Twenty-seven (27) plant species designated as invasive, non-native species and one additional plant considered potentially invasive were documented in the study area as a result of this study's habitat mapping and TransCanada's 2012 rare species and exemplary community survey (Normandeau, 2013a). Over 163 acres of discrete stands of invasives were mapped. The majority of species occurred in more than one impoundment.

Japanese knotweed (*Fallopia japonica*) was the most widespread species (79 acres), with dense stands mapped along the shoreline and on islands throughout the study area and in a variety of habitats. Approximately 35 acres of Phragmites-dominated scrub/shrub and emergent cover were mapped in the study area. Approximately two-thirds of the Phragmites found in the study area occurred in the Vernon impoundment, with lesser amounts, and smaller stands in the Wilder and Bellows Falls impoundments. This species was relatively infrequent in the riverine reaches. Purple loosestrife (*Lythrum salicaria L.*) was widespread in a variety of open habitats throughout the study area, including emergent wetlands, riverbanks, and gravel bars. Where it occurred, this species was typically low in density, and seldom dominated the plant community. Reed canary grass (*Phalaris arundinacea L.*) was also widely distributed throughout the study area in dense, small patches, predominantly on riverbanks and in emergent and scrub/shrub wetlands. Forget-me-not (*Myosotis scorpioides L.*) was prevalent on many riverbanks and wetland edges throughout the study area.

Common invasive shrub species included the bush honeysuckles (*Lonicera spp*), glossy buckthorn (*Frangula alnus Mill.*), multiflora rose (*Rosa multiflora Thunb. ex Murr.*), and Japanese barberry (*Berberis thunbergii DC.*). One or more of these species were encountered in most forested and shrub stands, including both wetlands and uplands. Oriental bittersweet (*Celastrus orbiculatus Thunb.*) occurred along much of the riverbank throughout the forested cover types. It was prevalent in both wetlands and uplands, forming dense, climbing vines in the tree canopy along the open edges of stands.

The aquatic invasive, Eurasian milfoil (*Myriophyllum spicatum L.*) was prevalent in all three impoundments, particularly in quiet coves. Where it occurred, it tended to be abundant and dominated the mid-column flora. Brittle naiad (*Najas minor*) was also widespread in quiet coves.

Bald Eagle Nesting and Winter Roosting Habitat

In the 2014 breeding season, New Hampshire Audubon (NHA) documented nine bald eagle nests within the study area, eight of which were active (NHA 2012a). This was an increase from six nests (five active) in 2012 when NHA began tracking nests on the Connecticut River, and seven nests (six active) in 2013. Productivity of the nests in the study area was 0.8, 0.7, and 0.6 fledged young per nest in 2012, 2013, and 2014, respectively. While the overall productivity of these nests was lower than for nests throughout the entire watershed in all three years, the decrease in 2014 was reflected across the entire watershed, most likely due to cold weather and heavy snow in March.

All known locations of nests are within approximately 125 feet of the Connecticut River shoreline. There are no conserved lands within 250 feet of any nest, but five of the known locations are essentially on the river bank, which is partially protected from new development by statute in both Vermont and New Hampshire.

The NH Natural Heritage Bureau data identified one known winter roosting area within the study area, located in Hinsdale, NH, near Vernon Dam. Aerial photo interpretation followed by field verification identified 12 additional softwood stands that appear to offer suitable winter roosting conditions: six in Vermont; and six in New Hampshire. They are all located essentially on the riverbank, with two located on tributary inlets, and two located on islands. These potentially suitable winter roosting sites are relatively evenly distributed throughout the study area, and although the distribution is not extensive in comparison to the entire size of the study area, winter roosting habitat is unlikely to be a limiting resource.

Wildlife

A total of 87 species of wildlife were recorded during incidental observations in this study, as well as other species specific surveys (Studies 26 and 28, for Tiger Beetles and Fowler's Toad, respectively). Twelve species of wading birds and waterfowl were recorded between April and August, 2014. Common waterfowl species throughout the study area included common merganser (*Mergus merganser*), wood duck (*Aix sponsa),* mallard (*Anas platyrhynchos),* Canada goose (*Branta Canadensis)* and double crested cormorant (*Phalacrocora auritus)*.

Other common species included spotted sandpiper (*Actitis macularia)* along the water's edge, bank swallow (*Riparia riparia*) colonies on eroded banks in Bellows and Wilder projects, and belted kingfisher (*Ceryle alcyon*), great blue heron (*Ardea herodias*), and green heron (*Butorides virescens*) were common throughout the study area.

Bald eagle juveniles and adults were observed in multiple locations throughout the study area, as were numerous other species of raptors: turkey vulture (*Cathartes aura*), osprey (*Pandion haliaetus*), red-tailed hawk (*Buteo jamaicensis*), broad-winged hawk (*Buteo platypterus*), American kestrel (*Falco sparverius*), and a peregrine falcon (*Falco peregrinus*) in the Vernon impoundment.

Other wildlife observations included beaver lodges and dams in backwaters and evidence of bank dens on the mainstem, mostly in the three impoundments. Muskrat were observed in the larger emergent marshes, primarily in the lower Vernon impoundment. American toads, spring peepers, green frogs and bullfrogs were observed or heard in most of the quieter waters with emergent wetlands and aquatic beds. A white-tailed deer fawn was observed on Chase Island and tracks of raccoon, deer, mink, possum, and mice were frequently observed along the shorelines.

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TABLE OF CONTENTS

List of Figures

List of Tables

List of Abbreviations

Abbreviations:

DBH	diameter at breast height
FERC	Federal Energy Regulatory Commission
GIS	Geographic Information System
GPS	Global Positioning System
GSD	ground sample distance
ILP	Integrated Licensing Process
IPANE	Invasive Plant Atlas of New England
LiDAR	Light detection and ranging
NAIP	National Agriculture Imagery Program
NHA	New Hampshire Audubon
NHFGD	New Hampshire Fish and Game Department
NHNHB	New Hampshire Natural Heritage Bureau
QC	quality control
SAV	submerged aquatic vegetation
SPD	Study Plan Determination
USACE	U.S. Army Corps of Engineers
VTNHI	Vermont Fish and Game Department's Natural Heritage Inventory
WSE	Water surface elevation

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1.0 INTRODUCTION

In their study requests, stakeholders indicated that Wilder, Bellows Falls, and Vernon project operations may affect the distribution and composition of vegetation, the structure of riparian, floodplain, wetland, and littoral habitats, and the wildlife that utilize these areas. The Connecticut River provides habitat for vegetation communities ranging from upland to submerged aquatic systems. Groundwater and surface water close to the river are potentially influenced by daily and seasonal project operations, which in turn may affect the substrates, species composition, and structure of the vegetation communities bordering the river, particularly those in lower topographic settings such as wetlands and floodplains. Natural riparian habitat provides valuable ecological functions including water quality protection and maintenance, bank stabilization, and wildlife travel corridors.

During the Integrated Licensing Process (ILP), Study 27 was developed to investigate vegetation communities and habitats along the Connecticut River within the affected areas of the three projects. The Revised Study Plan (RSP) 27 was approved without modification in FERC's September, 13, 2013, Study Plan Determination (SPD).

2.0 STUDY GOALS AND OBJECTIVES

The goal of this study was to provide baseline mapping and characterization of riparian, floodplain, wetland, and littoral vegetation and habitats within the Wilder, Bellows Falls, and Vernon Project-affected areas and to assess the potential effects of project-related water-level fluctuations on those habitats.

The objectives of this study were to:

- quantitatively describe (e.g., substrate composition, vegetation type, and abundance with a focus on invasive species) and map riparian, floodplain, and wetland habitats within 200 feet of the river's edge and the extent of this habitat if it extends beyond 200 feet;
- quantitatively describe (e.g., substrate composition, vegetation type, and abundance) and map shallow-water aquatic habitat types within the zone of the normal project operations water-level fluctuations and where water level depths at the lowest operational range are wetted to a depth of less than 1 foot (flats, near shore area, gravel bars, with very slight bathymetric change);
- qualitatively describe associated wildlife (e.g. bald eagle nesting, waterfowl nesting); and
- assess potential effects of project operations on riparian, floodplain, wetland, and littoral vegetation habitats, and associated wildlife.

3.0 STUDY AREA

The study area (Figure 3-1) extends from the uppermost extent of the Wilder impoundment to the area downstream of Vernon Dam including the Wilder, Bellows Falls, and Vernon impoundments and the riverine sections downstream of Wilder and Bellows Falls dams, and extending approximately 1.5 miles below Vernon dam. All of the shoreline in Vermont and New Hampshire, including the river's edge, islands, sand and gravel bars, and portions of tributaries that appeared to be within the influence of the impoundments (based on review of LiDAR and aerial photos), were mapped. The terrestrial extent of the study encompassed at least 200 feet from the river's edge. Where wetlands and floodplains extended farther inland than 200 feet, the study encompassed either the entire wetland or floodplain, or to where the topography or site features indicated the river is no longer a significant influence on the habitat.

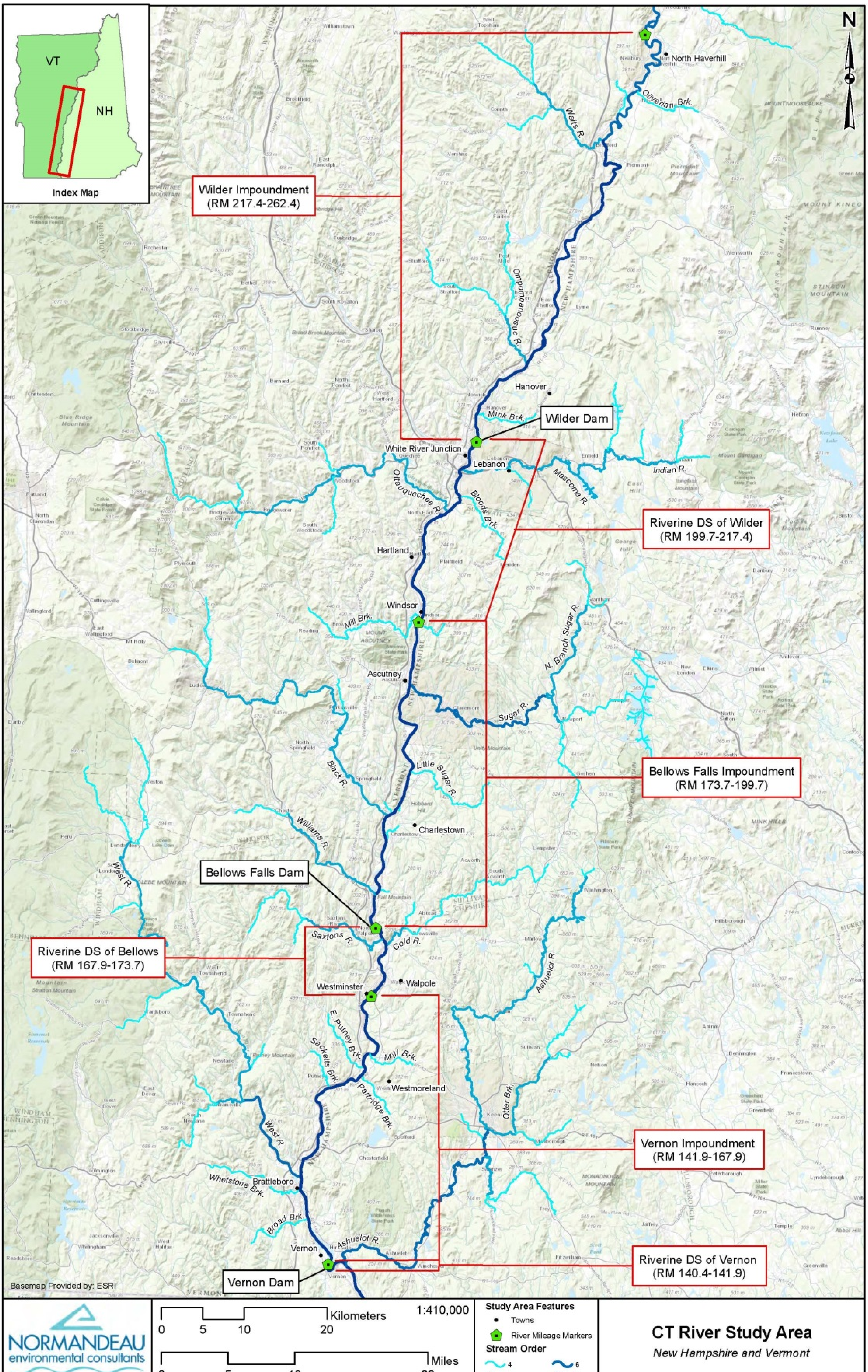

Figure 3.1. TransCanada's Wilder, Bellows Falls, and Vernon study area.

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4.0 METHODS

Information regarding terrestrial habitats was obtained for six natural resource features: vegetation mapping and characterization, wetland assessment, floodplain mapping, wildlife observations, and invasive and rare species observations. The methods for this study followed those that were described in the RSP with adjustments for local conditions.

4.1 Vegetation and Land Use

4.1.1 Cover Type Mapping

Vegetation and land use mapping and cover typing were performed using light detection and ranging (LiDAR) survey data, true color, and color infrared, stereo imagery of the study area. The LiDAR and photoimagery were flown between April 29, 2013 and May 7, 2013 at a resolution of 7.9 cm average ground sampling distance (GSD), during leaf-off, and under snow- and ice-free conditions.

Study staff digitally photo-interpreted upland and wetland cover type boundaries within the riparian, floodplain, and wetland habitats by using stereo imaging software. Cover types were delineated at least 200 feet from the Connecticut River shoreline in each impoundment and riverine section. The edge of water was determined initially using the LiDAR data, and refined in areas of discrepancy using the photoimagery. Because aquatic vegetation was not visible at the time of the imagery flight, aquatic beds were mapped from true color orthophotos (US Department of Agriculture National Agriculture Imagery Program [NAIP], 2009) and refined during field work. During photointerpretation, other resources were referenced for supporting information including hydric soil maps, National Wetland Inventory maps, hydrology maps, topographic maps, and additional publicly available aerial photographs as needed to confirm a feature.

The minimum mapping unit size for wetlands and uplands was ½ acre although distinct communities or cover types smaller than ½ acre were delineated if relevant. Cover types included both wetland and upland habitats. The following definitions were applied to the various categories. Wetland cover types were classified according to the US Fish and Wildlife Service (FWS) wetland classification (Cowardin et al., 1979).

Wetlands

Code	FWS Classification	Study Term
PFO1	Palustrine Forested Deciduous	Deciduous Forested Wetland
PFO4	Palustrine Forested Coniferous	Coniferous Forested Wetland
PSS1	Palustrine Scrub-shrub Wetland	Shrub Swamp
PEM1	Palustrine Emergent Wetland	Emergent Wetland
PEM5	Palustrine Emergent Phragmites Wetland	Emergent Wetland
PUB	Palustrine Unconsolidated Bottom	Open Water
RAB	Riverine Aquatic Bed	Aquatic Bed

Other wetland features included:

PVP Possible Vernal Pool (small seasonal open water body)

Stream- Categorized as perennial or intermittent

Other riverine and shoreline map categories included:

Ledge - exposed on bank, may extend into aquatic habitat

Rocky - boulders and cobble immersed or visible in shallows

Riprap - Large boulders set in place to protect shorelines from scour

Gravel - bars immersed or visible in shallows

S-M - Sand and mud, if not typed by aquatic habitat mapping

Eroding Bank - Areas of riverbank where material is actively eroding

Riverbank - Steep, unconsolidated slopes at the edge of the river

Upland habitats

H - Hardwood forest-intermediate or mature deciduous forest with less than 20% softwoods,

S - Softwood forest- intermediate or mature coniferous forest with less than 20% hardwoods,

HS - mix of hardwood and softwood forest- including intermediate or mature deciduous forest with more than 20% cover of both types

Shr - shrub dominated

F - old field

AGc - Agriculture, cropland

AGp - Agriculture, pasture/hayfield

G - Grassland, including large maintained lawns, golf courses, ball fields, etc.

I – Infrastructure - Roads, railroads, boat launches, Hydro dams, etc.

R - Residential, isolated or low density homes

Sub- Suburban, higher density housing

Com - Commercial/urban development

M – Mineral - Sand and gravel pits.

An additional field check notation was added to sites that were difficult to photo interpret. These sites were field checked to confirm the boundaries and cover types present.

4.1.2 Field Review

Field visits were conducted to confirm the accuracy of the mapped cover type boundaries and classification. Most of the dominant natural cover types were visited by one or more wetland scientists, and the cover type and boundary were evaluated and adjusted if necessary, based on field observations. Dominant wetland and upland cover types within each impoundment were characterized by visiting at least three examples of each cover type. At each site, data were collected on the plant community species composition and structure, soil characteristics, invasive species presence and abundance, ground features such as amount of litter, and substrate/rockiness. We also made notes on evidence of flooding or scour, or if inundated at the time of the visit, the depth of water to estimate the influence of the river on the vegetation community.

4.1.3 Quality Control

Quality control (QC) was applied throughout the photo-interpretation process. As cover type delineations in impoundment sections were completed, 30% to 100% of the section was reviewed by a different delineating scientist for consistency and completeness. As errors, inconsistencies, or differences of opinion were encountered, notations were made in the attribute tables for review, discussion, and final modifications by the original delineator. Unresolved areas were marked for ground-truthing.

Cover type maps were revised in GIS to reflect changes made during the field review. The final maps were subjected to another round of QC by an independent scientist comparing field notes to the cover type map. The approved maps were then analyzed in GIS to provide the acreages of the various cover types within the 200-foot shoreline study area, or more for wetlands and floodplains, prescribed by the study plan.

4.2 Floodplains

Floodplains were defined in the RSP based on ecological function, occurrence in the regularly flooded lowlands of the Connecticut River and its tributaries, and dominated by silver maple or sugar maple with a sparse shrub layer and a lush herbaceous layer of either ostrich fern or sensitive fern depending on the gradient of the river (NHFGD, 2005: Kart et al., 2005). Floodplains that have been converted to other uses, such as agriculture, development, or recreation, or that have been affected by riverine erosion process were mapped as well.

Reconnaissance visits were made to silver maple-wood nettle-ostrich fern floodplain communities mapped by the New Hampshire Natural Heritage Bureau (NHNHB) and Vermont Fish and Game Department’s Natural Heritage Inventory (VTNHI). These visits were used to assess the current conditions of the sites and estimate the elevation of these floodplains relative to the river. Based on LiDAR data collected in the spring of 2013, the range of elevations was approximately five and ten feet above the water surface where these known floodplains occur. This elevation range was used in conjunction with site vegetation communities and topography to map the approximate extent of other floodplain areas along the impoundments and riverine sections in the study area. Floodplains were mapped within the 200-foot buffer and extended beyond this buffer where applicable. Verification of floodplain mapping was conducted during field review.

4.3 Aquatic Vegetation

Floating and submerged aquatic vegetation (SAV) was mapped using GIS at an approximate scale of 1”=300”. NAIP orthorectified images flown between July 6 and September 20, 2009 were used to map the limits of aquatic beds. SAV habitats that were visible on the orthophotos were often defined by floating species such as fragrant water lily (*Nymphaea odorata)* and water shield (*Brasenia schreberi).* The approximate boundaries of SAV beds dominated by submerged vegetation were mapped in the field during ground truthing.

4.4 Wetland Assessment

Wetland function and value assessments were conducted for each dominant or important wetland cover type to determine the functions and values provided by these wetlands. The wetland types were selected based on frequency of occurrence and uniqueness of the type. The “representative wetlands” assessed included fringe emergent marsh, emergent marsh/scrub-shrub wetland, scrub-shrub wetland, deciduous forested wetland, and deciduous/coniferous forested wetland.

The functional assessment utilized the New England Army Corps of Engineers Highway Methodology Descriptive Approach (USACE 1999). This method provides an assessment of the functions being provided, and which of those functions are most important.

In most wetland assessment methods, including the Highway Methodology, wetland functions relate to the ecological significance of wetlands without regard to subjective human values. Functions are self-sustaining properties of a wetland ecosystem that result from both living and non-living components, and include all processes necessary for self-maintenance such as primary production and nutrient cycling. Wetland values are the societal benefits derived from the functions and physical characteristics of a specific wetland. Values are based on human judgment of the worth, merit, quality, or importance attributed to those functions. Principal functions and values are those that are an important physical component of a wetland ecosystem (function only) and/or are considered of special value to society, from a local, regional, and/or national perspective (USACE New England District, 1999).

The representative wetlands identified for this study were evaluated for thirteen functions and values as defined in the Highway Methodology as follows:

Wetland Functions

1. Groundwater recharge/discharge which considers the potential for a wetland to serve as either an area of groundwater recharge or discharge. Both of these functions pertain to the fundamental interaction between wetlands and aquifers, regardless of the size or importance.
2. Flood flow alteration (storage and desynchronization) which considers the effectiveness of the wetland in reducing flooding and erosion damage by water retention for prolonged periods following precipitation events and the gradual release of floodwaters.
3. Fish and shellfish habitat (freshwater) which considers the effectiveness of seasonal or permanent watercourses associated with the wetland in question for fish and shellfish habitat.
4. Sediment/toxicant retention which considers the effectiveness of the wetland in reducing or preventing degradation of water quality by trapping sediments, toxicants, and/or pathogens in runoff water from surrounding uplands or upstream eroding wetland areas.
5. Nutrient removal which considers the effectiveness of the wetland to retain nutrients in runoff water from surrounding uplands or contiguous wetlands and the ability of the wetland to transform these nutrients into other forms or trophic levels.
6. Production export which evaluates the effectiveness of the wetland in producing food or usable products for humans or other living organisms.
7. Shoreline stabilization which considers the effectiveness of a wetland to stabilize stream banks and shorelines against erosion.

8. Wildlife habitat which considers the effectiveness of the wetland to provide habitat for various types and populations of animals typically associated with wetlands and the wetland edge including resident and/or migrating species.

Wetland Values

1. Recreation which considers the suitability of the wetland and associated watercourses to provide recreational opportunities such as hiking, canoeing, boating, fishing, hunting, and other active or passive recreational activities.
2. Educational/science value which considers the suitability of the wetland as a site for an outdoor classroom or as a location for scientific study or research.
3. Uniqueness/heritage which considers the effectiveness of the wetland or its associated waterbodies to provide certain special values. These may include archaeological sites, critical habitat for endangered species, its overall health and appearance, its role in the ecological system of the area, its relative importance as a typical wetland class for this geographic location.
4. Visual quality/aesthetics considers the visual and aesthetic quality or usefulness of the wetland.
5. Endangered/threatened species considers the suitability of the wetland to support threatened or endangered species.

4.5 Rare, Threatened and Endangered Species

Study staff worked with the NHNHB and the VTNHI to develop a database of all known records of rare species in the vicinity of the three projects. Most of these element occurrences were visited during a rare species survey conducted in 2012 (Normandeau, 2013a). A total of 345 plant and exemplary natural community Element Occurrences (234 in New Hampshire and 117 in Vermont) are listed in the two states' rare species and community databases as being within 1,000 feet of the river's edge. Of these, 182 were actively surveyed in 2012 (Normandeau, 2013a). That study focused on Element Occurrences which were potentially affected by project operations. Also in 2012, a separate study was conducted for Jesup's milk vetch (*Astragalus robinsii* var *jesupii*), a Federal and State-Endangered species (Normandeau, 2013b).

A second Federal and State-Endangered species, Northeastern bulrush (*Scirpus ancistrochaetus*), was identified as potentially occurring in the project-affected area. The survey for this species was conducted in 2014 under a separate Study Plan (Study 29).

The remaining 163 listed plant species and exemplary communities were to be incidentally investigated during this study, if the Element Occurrences were located on public or TransCanada-owned or leased land. The objective for rare, threatened and endangered plants and communities in this study was to identify the locations of Element Occurrences within the study area which were not surveyed in 2012. A subset of recent (post-1990) Element Occurrences was to be visited to assess their current status, but not to conduct detailed inventories. To accomplish this, a desktop analysis of the remaining 163 plant and exemplary natural community Element Occurrences from the New Hampshire and Vermont lists was conducted to identify those records that occur within the 200-foot riparian zone and floodplains of this study. These data were used to assess the presence of, or the potential for, individual plant or community Element Occurrences. In several instances, new records of several species and communities were noted.

4.6 Invasive and Exotic Species

Non-native invasive plant species were observed and noted within the study area during mapping and field work. A species was considered invasive if it was listed in the The Invasive Plant Atlas of New England (IPANE, 2012; Appendix A).

Some dominant stands of “clumping” invasive species (Phragmites and Japanese knotweed (*Fallopia japonica))* were visible in the aerial photos and could be mapped remotely. Other stands of those species were mapped in the field using a GPS and sketch maps during groundtruthing. Invasive species with more diffuse growing habits were noted for approximate location and by the cover type within which they occurred.

4.7 Wildlife Observations

All wildlife observations and signs were noted during field verification, with particular emphasis on birds and aquatic mammals that could be most influenced by project operations. Species of special interest included waterfowl, wading birds, shorebirds, bank nesting birds, reptiles, and amphibians. Wildlife observations were recorded during field work and if possible, the location, species, age and gender, and activity were noted. Incidental wildlife encountered during other terrestrial field studies (Cobblestone and Puritan tiger beetle (Study 26), Fowler’s toad (Study 28), and Northeastern bulrush (Study 29)) were also noted and included in this report.

4.8 Bald Eagle Winter Habitat

The location and condition of existing bald eagle nests within the study area were summarized from data provided by New Hampshire Audubon’s ongoing Connecticut River Bald Eagle Restoration and Habitat Protection Project, which is funded by TransCanada (NHA 2012, 2013, 2014). Known and potential bald eagle wintering habitats were assessed using both desktop and field methods. Wintering bald eagles require suitable roost sites and proximity to open water areas that offer foraging opportunities. Suitable roosting habitat in the Northeast generally consists of softwood stands that offer thermal protection from prevailing winds and well-spaced branches that can be easily accessed by eagles in flight. Additionally, stands with an eastern aspect are preferred and stands near human activities are generally avoided. Nearby ice-free water where eagles can forage may also make a stand more attractive for winter roosting (Beuhler, 2000). Ice formation on rivers is governed by a wide range of variables and the location and extent of open water may vary throughout the winter (Normandeau, unpublished data).

One winter roost was identified as an Element Occurrence in the NH NHB data base. To identify additional softwood stands with the potential to offer suitable roosts, softwood stands depicted on the stereo imagery acquired by TransCanada were analyzed for size, density, aspect, and proximity to developed areas. These stands were mapped and then inspected in the field. Field observations were conducted by boat from the river during the 2014 growing season. In the field, the following variables were assessed:

- General stand composition (white pine vs. eastern hemlock, proportion of softwoods vs. hardwoods)
- Average diameter at breast height (DBH) of the trees and average height (visually estimated)
- Access to branches large enough for perching (clear or not)
- Wind protection (large stand, hill behind, or a combination of the two)
- The likely amount of disturbance, and the distance to disturbance sources. The location, type and, severity of disturbance was largely inferred from the desktop aerial photo interpretation and/or by listening to the levels of anthropogenic noise in the vicinity of the stand. The dense softwood stands generally prevented visual assessment of adjacent development.

Based on these variables observed in the field, each assessed stand was categorized as either suitable or unsuitable for winter roosting. Stands that were categorized as suitable were photographed and a GPS point of the location was recorded.

5.0 RESULTS AND DISCUSSION

5.1 Vegetation Mapping and Characterization

5.1.1 Cover Type Map

Natural features and land uses mapped within the study area covered a total of 9,153 acres, and were comprised of upland vegetation cover (62% cover), wetlands and tributary streams (23% cover), developed lands (12% cover), and riverine features (2% cover) (Table 5.1-1).

Upland vegetation cover was predominantly forest (64% cover) followed by agricultural land (29% cover) (Table 5.1-2). Large tracts of deciduous, coniferous, and mixed deciduous and coniferous forest extended across much of the study area. Agricultural uses, primarily cropland and pasture/hayfield, were the predominant cover type over much of the more level terrain adjacent to the river, and especially in the Wilder impoundment. The remaining upland cover was largely shrub communities, maintained grass such as parklands and golf courses, and old fields.

Table 5.1-1. Acreage of cover types and land use by broad categories.

Cover type	Wilder	Wilder Riverine	Bellows Falls	Bellows Falls Riverine	Vernon	Total	% of Total
Upland Vegetated	2296.8	778.1	1139.7	92.0	1449.0	5755.7	62.8
Wetland and Stream	701.5	17.4	737.2	0.7	657.3	2114.2	23.10%
Developed	338.9	180.7	242.5	42.2	305.6	1109.9	12.1
Riverine Features	32.2	58.2	31.4	26.8	25.2	173.8	1.9
Total	**3369.4**	**1034.5**	**2150.9**	**161.8**	**2437.0**	**9153.6**	**100.0**

Wetlands were widely distributed across the study area with the majority consisting of aquatic vegetation (43%), emergent (25% cover), deciduous forested (22% cover) and scrub/shrub (10% cover) cover types (Table 5.1-2). A variety of intermixed cover types and open water comprised the balance (3% cover).

Infrastructure, consisting of dams and dam facilities, boat launches, roads and railroads, comprised the largest single cover type in the developed lands category (Table 5.1-2). Other developed lands within the study area included portions of the municipalities of Bellows Falls and Brattleboro in Vermont, and Hanover and West Lebanon in New Hampshire, as well as residential areas dispersed along the Connecticut River. These areas accounted for the bulk of the commercial, urban, residential and suburban land uses. Sand and gravel mines located in the free-flowing section of the river downstream of Wilder dam comprised most of the mineral land use.

Riverine features mapped in the study area included steep unconsolidated slopes, eroding banks and river channel features (Table 5.1-2). Most of the eroding banks and steep unconsolidated slopes were associated with the three impoundments. Channel features, including bedrock in the Bellows Falls bypass reach and along the riverbank, boulders and cobble in shallows, and exposed bars of gravel, sand and mud, were concentrated in the free flowing sections of the river downstream of Wilder and Bellows Falls dams.

Table 5.1-2. Acreages of cover types within the 200-foot study area.

Cover Code	Cover type	Wilder	Wilder Riverine	Bellows Falls	Bellows Falls Riverine	Vernon	Total	% of Total
Upland								
H	Hardwood	486.3	379.2	469.8	59.1	812.1	2206.4	24.10%
H/S	Hardwood/softwood	364.3	134.9	193.9	5.7	235.3	934.2	10.21%
S	Softwood	328.2	61.7	69.1	1.2	48.1	508.2	5.55%
SHR	Shrub	126.6	12.2	84.3	6.6	40.9	270.6	2.96%
H/SHR	Hardwood/shrub	3.1	5.2	0.4	0.6	6.1	15.3	0.17%
SHR/G	Shrub/Grassland						0.0	0.00%
OLD FIELD	Old field	21.2	3.5	15.3		2.9	42.9	0.47%
GRASS	Maintained Grassland	62.0	19.9	43.5	1.2	34.2	160.8	1.76%
CROP	Crop	597.3	146.2	188.9	17.6	215.9	1166.0	12.74%
PASTURE	Pasture/hayfield	307.8	15.3	74.6		53.4	451.2	4.93%
	Total	**2296.8**	**778.1**	**1139.7**	**92.0**	**1449.0**	**5755.7**	62.88%
Wetland								
PFO1	Deciduous Forested	141.3	7.7	142.2		124.1	415.3	4.54%
PFO4	Coniferous Forested	0.7				0.0	0.7	0.01%
PFO1/4	Mixed Forested	5.3		0.4		3.6	9.3	0.10%
PFO1/PSS	Deciduous Forested/shrub	1.7		26.8		7.6	36.0	0.39%
PFO1/PEM	Deciduous Forested/Emergent			1.0		0.7	1.7	0.0%
PSS	Scrub-shrub	48.3	1.8	35.3		33.9	119.3	1.30%
PSS/PEM	Scrub-shrub/Emergent	25.6	0.6	16.1		7.9	50.3	0.55%
PEM	Emergent	133.1	4.7	241.0		108.2	486.9	5.32%
PEM5	Phragmites	7.3		4.7		22.8	34.8	0.38%
PERENN	Perennial Stream	7.1	1.9	4.6	0.7	10.9	25.2	0.27%
INTERMIT	Intermittent Stream	1.2	0.4	1.9		2.1	5.6	0.06%
PUB	Pond	11.6		3.7		7.1	22.4	0.25%
PVP	Possible vernal pool	0.5	0.3	1.3		1.5	3.6	0.04%
PAB/RAB	Submerged Aquatic Vegetation	318.0	0.0	258.3	0.0	326.9	903.2	9.87%
	Total	**383.5**	**17.4**	**478.9**	**0.7**	**330.4**	**1211.0**	23.10%

Cover Code	Cover type	Wilder	Wilder Riverine	Bellows Falls	Bellows Falls Riverine	Vernon	Total	% of Total
Developed								
Comm	Commercial	47.5	47.4	31.3	24.1	73.4	223.7	2.44%
Res	Residential	135.5	36.6	108.9	1.0	81.7	363.6	3.97%
Sub	Suburban			9.3		19.2	28.5	0.31%
Mineral/dams	Dams	1.4	25.8	3.4		2.1	32.8	0.36%
Infra	Infrastructure	154.6	70.9	89.6	17.0	129.1	461.3	5.04%
	Total	**338.9**	**180.7**	**242.5**	**42.2**	**305.6**	**1109.9**	12.13%
Riverine Features								
Ledge	Bedrock ledge	0.2	4.1	0.5	20.1	2.1	26.9	0.29%
Rocky	Rocks and Boulders	0.4	3.1	0.2		1.9	5.6	0.06%
Gravel	Gravel	0.3	19.0	1.9	6.8	3.5	31.6	0.34%
Sand-mud	Sand-mud	0.9	27.3	2.7		10.3	41.1	0.45%
Riverbank	Riverbank	9.2	4.5	18.9		5.7	38.3	0.42%
Eroding bank	Eroding bank	20.9		7.2		1.4	29.5	0.32%
Riprap	Riprap	0.3	0.2			0.3	0.9	0.01%
	Total	**32.2**	**58.2**	**31.4**	**26.8**	**25.2**	**173.8**	1.90%
Grand Total		3369.4	1034.5	2150.9	161.8	2437.0	9153.6	**100.0%**
% of Total		36.81%	11.30%	23.50%	1.77%	26.62%	100.00%	

5.1.2 Vegetation Community Characterization

Hardwood Forest

Upland Hardwood

Upland hardwood forest was the predominant cover type in the study area and was most abundant within the Vernon impoundment (Table 5.1-1). The forest canopy was composed of a relatively homogenous group of trees dominated by sugar maple (*Acer saccharum*), northern red oak (*Quercus rubra*), American beech (*Fagus grandifolia*), and basswood (*Tilia americana*). Other common overstory species included big-tooth aspen (*Populus grandidentata*), paper birch (*Betula populifolia*), red maple (*Acer rubrum*), yellow birch (*Betula allegheniensis*), American hornbeam (*Carpinus caroliniana*), bitternut hickory (*Carya cordiformis*) and black birch (*Betula lenta*).

Shrubs were generally sparse with the exception of the invasive species glossy buckthorn (*Frangula alnus*) and bush honeysuckle (*Lonicera spp.)* at a few sites. However dense growths of saplings, particularly American beech, were sometimes present. The herbaceous component was diverse and included wild-lily-of–the-valley (*Maianthemum canadense*), wild sarsaparilla (*Aralia nudicaulis*), sensitive fern (*Onoclea sensibilis*), ostrich fern (*Matteuccia struthiopteris*), white wood aster (*Eurybia divaricata*), marginal woodfern (*Dryopteris marginalis*), rough horsetail (*Equisetum hymale*), hayscented fern (*Dennsteadtia punctilobula*), New York fern (*Parathelypteris noveboracensis*) and hog peanut (*Amphicarpaea bracteata*).

The majority of the upland hardwood forest was at a mid-successional stage, with most trees at an intermediate age and height, a few large trees and a limited shrub and sapling layer. The canopy reached heights of 60 to 90 feet and canopy closures ranged from 60 to 90 percent. Structural diversity and patchiness were generally moderate to high. Few snags were present. Fine litter consisted of several inches of twigs and leaves and coarse litter, when present, was made up of many deadfalls and downed limbs. Most of this cover type was relatively high in elevation and showed little evidence of flood scour or deposition.

Riparian Hardwood

Riparian hardwood forest differed from upland hardwood forest primarily in respect to plant species and the potential for flooding. Typically, dominant canopy species in this cover type included silver maple (*Acer saccharinum*), eastern cottonwood (*Populus deltoides*), slippery elm (*Ulmus rubra*), green ash (*Fraxinus pennsylvanica*), and boxelder (*Acer negundo*). Bush honeysuckle and glossy buckthorn were common in the understory, and cinnamon fern (*Osmunda cinnamomea*), Japanese knotweed (*Fallopia japonica*), ostrich fern, and rough horsetail were abundant in the herbaceous layer. These forests appeared to be flooded on a seasonal or annual basis. As evidence of the river's influence on these communities, fine litter was absent or sparse in areas subject to periodic flooding but was replaced by alluvial sediment deposits. Coarse litter was abundant in the form of trees, limbs and other wrack washed in during high water events.

Mixed Hardwood/Softwood Forest

Upland hardwood/softwood forest was also common in the study area and was most abundant in the reach encompassing the Wilder impoundment and the free flowing section of the river downstream of Wilder Dam (Table 5.1-2). White pine (*Pinus strobus*) and eastern hemlock (*Tsuga canadensis*) made up the softwood component of the canopy, and the hardwoods were predominantly northern red oak and sugar maple. In addition, many other canopy species from the hardwood cover type were present including American beech, paper birch, red maple, yellow birch, bitternut hickory and black birch.

The understory was generally lacking in shrubs with the exception of glossy buckthorn and witch hazel (*Hamamelis virginiana*). However, saplings of striped maple (*Acer pennsylvanicum*), American beech and other canopy species were abundant in many areas. The herbaceous layer was diverse but sometime sparse or patchy. Frequently occurring species included cinnamon fern, evergreen woodfern (*Dryopteris intermedia*), Christmas fern (*Polystichum acrostichoides*), poison ivy (*Toxicodendron radicans*), and lady fern (*Athyrium felix-femina*). Many hardwood forest herbs were also present such as wild lily-of–the-valley, marginal woodfern, New York fern, ostrich fern, hayscented fern, wild sarsaparilla, and hog peanut.

Most of this cover type was at a mid-successional stage with most trees at an intermediate age and height, a few large trees and a limited shrub and sapling layer. Canopy species reached heights of 80 to 100 feet and canopy closures ranged from 60 to 90 percent. Structural diversity was generally moderate to high and patchiness was low to moderate. A few snags occurred in this cover type. Fine litter was comprised of up to several inches of leaves, and coarse litter ranged from a few to many deadfalls and downed limbs. Nearly all of this cover type was located on higher elevation terraces and slopes with little evidence of flood scour or deposition.

Softwood Forest

Softwood forest was very abundant along the periphery of the Wilder impoundment. The largest expanse of this cover type was along the eastern side of the impoundment between the dam and Hanover, New Hampshire. Softwood forest was overwhelmingly dominated by eastern hemlock and white pine, and many times included a variety of common hardwood species. Due to the dense canopy cover, the understory and herbaceous layers were usually very sparse. As a result, this vegetation was limited to a few saplings of eastern hemlock and American beech along with scattered herbs such as wild lily-of-the-valley and evergreen woodfern.

Most of this cover type was at a medium successional stage with most trees at an intermediate age and height, a few large trees and a limited shrub and sapling layer. Canopy species reached heights of 60 to 100 feet and canopy closures were 80 percent or higher. Structural diversity and patchiness were low due to the generally homogenous canopy, and lack of shrub and herbaceous cover. Snags were either absent or few in number. Fine litter was composed of several inches of leaves, and coarse litter ranged from a few to many deadfalls and downed limbs.

Most of this cover type was located on steep slopes and terraces with little evidence of flood scour or deposition.

Emergent Wetlands

Emergent marshes were the most abundant wetland cover type in the study area and were located in coves, protected shorelines, old river channels and deltas at the mouths of tributary streams (Table 5.1-2). Emergent wetlands in the Wilder impoundment were located primarily in the upstream reach from the vicinity of Fairlee, Vermont to Bradford, Vermont. At Bellows Falls, which accounted for nearly 50 percent of the study area total for this cover type, large expanses of emergent wetlands were present in the lower third of the impoundment. In the Vernon impoundment, this cover type was found primarily in the broad delta at the mouth of the West River and downstream of Brattleboro.

The larger emergent wetland stands were vegetated by dense stands of broad-leaved cattail (*Typha latifolia*) and softstem bulrush. Other dominant emergents included rice cutgrass (*Leersia orizoides*), woolgrass (*Scirpus cyperinus*), American bur-reed (*Sparganium americanum*), water-horsetail (*Equisetum fluviatile*), narrow-leaf cattail (*Typha angustifolia*), pickerel weed, duck potato, and numerous sedges including fringed sedge (*Carex crinita*), hop sedge (*Carex lupulina*), and soft fox sedge (*Carex conjuncta*). Invasive non-native wetland species such as reed canary grass, purple loosestrife (*Lythrum salicaria*), and Phragmites (*Phragmites australis*) were also abundant (see Section 5.4). In particular, large stands of Phragmites were intermixed with native emergent cover in the lower section of the Vernon impoundment.

Emergent wetlands were typically located within one foot of estimated high water levels and were typically saturated or subject to frequent flooding. Water stains on the stems indicated that the marshes were periodically inundated from 6 to 18 inches. Overall structural diversity and patchiness tended to be low due to the relatively uniform cover of many wetlands. Litter was absent or minimal and was composed of small amounts of herbaceous material and woody debris deposited as wrack. Substrates were largely silt and sand with moderate accumulations of organic matter, and were characterized by gleying, low chroma matrix colors, and redox concentrations, which were indicative of hydric conditions.

Scrub/shrub Wetlands

The distribution of scrub/shrub wetlands in the study area was similar across the impoundments and occurred in backwaters, along shorelines, on islands and peninsulas, and in the lower reaches of tributary streams (Table 5.1-2). This cover type was found throughout the Wilder impoundment but primarily in the lower half of the Bellows Falls and Vernon impoundments.

Much of the scrub/shrub cover was dominated by the invasive non-native glossy buckthorn; however, speckled alder (*Alnus incana*), black willow (*Salix nigra*), and silky dogwood (*Cornus amomum*) were also common. Canopy height ranged from six to 20 feet and canopy cover ranged widely from 20 to 100 percent. The overall herbaceous component was relatively diverse and consisted of species such as wrinkled goldenrod (*Solidago rugosa*), jewelweed (*Impatiens capensis*), false nettle

(*Bohmeria cylindrica*), cleavers (*Galium aparine*), common horsetail (*Equisetum pretense*), meadow horsetail (*Equisetum arvense*), climbing nightshade (*Solanum dulcumara*), giant goldenrod, sensitive fern, and ostrich fern. Structural diversity and patchiness were low in areas of dense shrub cover, but were moderate to high in the communities with more open cover that enabled a more robust herbaceous growth.

This cover type was frequently located slightly higher in elevation above the emergent marshes, but still showed signs of frequent inundation as exhibited by multiple wrack lines and water stains on lower trunks and leaves. In larger coves, the scrub/shrub cover type often formed a band between the emergent marshes and the upland or forested wetland. The substrate ranged from silt to sandy-silt and soil characteristics were indicative of hydric conditions. Litter was generally minimal; however, wrack made up of herbaceous plant material and small to medium sized woody debris was present in a few areas.

Scrub/shrub and Emergent Wetlands

The scrub/shrub and emergent wetlands cover type comprised a small component of the overall wetland acreage and was found in backwaters, along the river shoreline, and adjacent to tributary streams (Table 5.1-2). The majority was concentrated within the Wilder impoundment but was otherwise geographically distributed across the study area in a pattern that was very similar to that of scrub/shrub wetlands. Scrub/shrub and emergent wetlands were very similar to scrub/shrub wetlands in respect to plant cover, canopy height, and substrate. Presumably the hydrologic regime was intermediate between emergent marsh and scrub/shrub wetlands. A few new dominant plant species were noted including wild raisin (*Viburnum cassinoides*), purple loosestrife, and forget-me-not (*Myosotis scorpiodes*). However, the major difference was that the scrub/shrub and emergent cover typically had a more open canopy that enabled a more diverse and robust herbaceous component. This enhanced herbaceous cover in combination with an intermixing of shrub/shrub and emergent cover tended to result in higher structural diversity and patchiness.

Deciduous Forested Wetlands

Deciduous forested wetlands were the second-most abundant cover type in the study area (Table 5.1-2). These wetlands were evenly distributed across the three impoundments and were generally found in medium to large tracts in backwaters, along point bars, and in the lower reaches of tributary streams. These wetlands were found in the upper reaches of the Wilder impoundment, largely in the lower part of the Bellows Falls impoundment, and throughout the Vernon impoundment.

This cover type was characteristic of the floodplain forest communities that are found along large northeastern rivers. Eastern cottonwood, silver maple, boxelder, green ash, and slippery elm were prominent in the overstory, and saplings of these species were also common in the understory. Ostrich fern was particularly abundant in the herbaceous cover which also included sensitive fern, jewelweed, rough horsetail, and Canada nettle (*Laportia canadensis*). In addition, non-native invasive plants such glossy buckthorn, stilt grass, and Japanese knotweed were present in abundance at some locations.

The deciduous forested wetlands were at an early to mid-successional stage. Canopy species reached heights of 60 to 80 feet and canopy closures ranged widely from 30 to 80 percent. Structural diversity was generally moderate and patchiness was generally low. Snags were few. Fine litter consisted of leaves and herbaceous plant debris. Coarse litter was common and included deadfalls and downed limbs as well as woody debris and herbaceous material deposited as wrack. Substrates were mostly silt and indicative of hydric soil conditions. Most of this cover type appeared to be periodically flooded as indicated by alluvial soil that had been deposited at one site by a recent high water event. However, some of these wetlands were located at higher elevations and were more likely to be flooded on a less frequent basis.

Deciduous Forested and Scrub/shrub Wetlands

The deciduous forest and scrub/shrub wetland cover type formed a small part of the total study area wetlands, and was associated with backwater areas and tributary streams (Table 5.1-2). Three-quarters of the total acreage was located in the lower part of the Bellows Falls impoundment and most of the remainder was spread out across the lower half of the Vernon impoundment. The Wilder impoundment contained just a fraction of this cover type.

Vegetation cover was a mixture of common species with silver maple, red maple green ash, eastern cottonwood, and American sycamore (*Platanus occidentalis*) in the overstory; glossy buckthorn in the understory; and an herbaceous cover of ostrich fern, moneywort (*Lysimachia nummularia*), and sensitive fern. Glossy buckthorn overwhelmingly dominated the shrub layer of this cover type and this characteristic was the main difference between the deciduous forested wetlands, and deciduous forested and scrub/shrub wetlands.

This cover type was at an early to mid-successional stage with canopy heights of 60 to 90 feet and canopy closures of 60 to 80 percent. Structural diversity ranged from medium to high and patchiness ranged from low to high. Very few snags were present. Fine litter consisted of a thin cover of leaves and coarse litter when present, and was composed of scattered deadfalls and downed limbs. Substrates were silt and sandy-silt, and indicative of hydric soil conditions. Elevations of these wetlands relative to the estimated high water level ranged from 1 foot or less up to 3 feet, but all appeared to be periodically flooded based on evidence of scour and flood debris.

Aquatic Bed

The aquatic bed cover type was the most abundant wetland cover type, comprising 903 acres (Table 5.1-2). Aquatic beds were typically composed of floating and submerged aquatic vegetation and grew abundantly in shallow water zones in the lower ends of all three impoundments as well as in the mouths of the larger tributary streams. Aquatic bed vegetation also occurred in the upper reaches of the impoundments as small patches and narrow discontinuous bands in shallow water along the edges of the river. Many of these more riverine aquatic beds were too small to map. Most species were found in all three impoundments and many of the same species predominated in the three impoundments including white water lily (*Nymphaea odorata*), Eurasian water-milfoil (*Myriophyllum spicatum*), water celery (*Vallisneria americana*), waterweed (*Elodea canadensis*), and water stargrass (*Heteranthera dubia*). Also common were coontail (*Ceratophyllum demersum*), chara (*Chara vulgaris*), clasping-leaved pondweed (*Potamogeton perfoliatus*), large-leaved pondweed (*Potamogeton amplifolius*), snailseed pondweed (*Potamogeton spirillus*), and brittle naiad (*Najas flexilis*). Emergent wetland plants such as pickerel weed (*Pontederia cordata*), duck potato (*Sagittaria latifolia*), soft-stem bulrush (*Schoenoplectus tabernaemontani*), and wild rice (*Zizania palustris*) were common in shallow water along the margins of this cover type.

Aquatic beds typically were found in silty-sandy substrates, with vegetative cover varying from dense floating and mid-column cover with 100 percent canopy closure to relatively sparse cover with little or no floating-leaved canopy. Species composition varied between areas and was influenced by factors such as water depth and current. For example, white water lily was usually found in more protected areas with slower currents and shallow depths, whereas water celery was able to grow abundantly in areas with faster currents to observed water depths of up to eight feet.

Riverbank

The upland riverbank cover type was typically located along the river at the edge of an agricultural field. Most of these areas were regularly to annually flooded and actively eroding along the base. Vegetation cover was frequently uncommon at the base of the bank within the zone that appeared to correspond with water level fluctuations associated with project operations. The vegetation became more dense above that zone, and typically consisted of early successional species. This cover type resembled an old field community but included both upland and hydrophytic plants. Invasive plant species were often found along the riverbanks. Commonly occurring species were boxelder, staghorn sumac (*Rhus typhina*), bush honeysuckle, multiflora rose (*Rosa multiflora*), Canada goldenrod (*Solidago canadensis*), rough bluegrass (*Poa trivialis*), evening primrose (*Oenothera biennis*), giant goldenrod (*Solidago gigantea*), crown-vetch (*Securigera varia*), and reed canary grass (*Phalaris arundinacea*). Upland riverbanks were also characterized by silty and sandy substrates, an absence of litter, and low structural diversity and patchiness. Some of the riverbank communities included steep slopes, occasionally undercut at the top of the bank, that provided nesting locations for belted kingfishers (*Ceryle alcyon*) and bank swallows (*Riparia riparia*).

In Bellows Falls impoundment, the riverbank often consisted of a near monoculture of reed canary grass, starting at the lower vegetated edge and extending between 5 and 8 feet upslope. Along the free flowing reach of the river below Wilder Dam, the riverbank was typically dominated by common scrub/shrub and emergent wetland species. Plant species present included speckled alder, heart-leaved willow (*Salix rigida*), blue joint (*Calamagrostis canadensis*), deer tongue grass (*Dichanthelium clandestinum*), reed canary grass, meadow horsetail, fringed sedge, and purple loosestrife. This cover type began at the lower vegetated edge and extended 10 to 15 feet upslope. The shoreline along this zone was frequently rocky and deposits of various sized drift wood and other wrack were common. Of particular note was the abundance of obedient plant (*Physostegia virginiana*) that were observed in bloom along the lower scour zone on both the Vermont and New Hampshire shorelines in the riverbank cover type (see Appendix B).

5.2 Floodplains

Approximately 3,218 acres of floodplains were delineated based on a combination of elevation and evidence of flooding (Table 5.2-1). In most areas, floodplains extended beyond the 200-foot study zone (see example in Panel 6 of the Maps). Floodplains were more prevalent along the shores of the three impoundments compared to the riverine sections. Almost half of all floodplains occurred in Bellows Falls impoundment. Wilder and Vernon impoundments had approximately 28% and 24% of the total floodplains, respectively.

Table 5.2-1. Acres of floodplain in the study area.

Floodplains	Wilder	Wilder Riverine	Bellows Falls	Bellows Falls Riverine	Vernon	Total	Percent of Total
Upland							
Natural	209.9	7.1	233.8	8.3	176.5	635.1	19.7%
Agriculture	178.7		498.9	27.3	3.6	860.0	26.7%
Wetland	493.1	6.9	715.1	3.9	174.3	1,548.2	48.1%
Developed	6.8		51.6		16.8	149.6	4.7%
Riverine	3.8	0.7	8.4	3.3	339.8	25.2	0.8%
Acres	892.2	14.7	1,507.7	42.8	760.6	3218.1	100.0%
Percentage of Total	27.7%	0.5%	46.8%	1.3%	23.6%	100.0%	

The cover types of the floodplains were predominantly in natural cover or agriculture; approximately 48% were in wetland cover, 27% were in agriculture, and 20% were in natural upland cover. Developed land uses formed a minor component (<5% cover, primarily in Vernon impoundment). Typically, floodplains were confined to less than ten feet above the local scour zone, which was assumed to represent average high water. The floodplains were relatively flat, and often showed flooding features such as wet depressions and evidence of scour and deposition. In some instances, evidence of flooding on the aerial photos indicated floodplains occurred above the relative ten foot contour and were consequently included in the study. These will be verified with the results of Study 1 (Historical Riverbank Position and Erosion Study) hydrologic data from Studies 4 and 5, the hydraulic and operations modeling studies which are not yet completed.

5.3 Wetland Assessment

Function and values assessments (Section 4.4) were performed for the six most common wetland types in the study area to determine the principal functions and values provided by each of these habitats. Study area wetlands provide all of the 13 functions and values evaluated by the Highway Methodology; however, not all of them occurred at a principal level (Table 5.3-1). Widely occurring principal functions consisted of flood flow alteration, sediment/toxicant retention, nutrient removal, sediment/shoreline stabilization, and wildlife habitat. Occurring less commonly at a principal level were the groundwater recharge/discharge, fish/shellfish habitat and production export functions, and the visual quality/aesthetics value. The recreation, educational/scientific, and uniqueness/heritage values were not determined to occur at a principal level in any of the study area wetlands.

Emergent wetlands provide the most functions at a principal level in the study area followed by aquatic bed, scrub/shrub, and forested wetlands, which provide many of the same functions at principal levels. Scrub/shrub-emergent and forested-scrub/shrub wetlands provide the least number of principal functions, but are also uncommon habitats in the study area, and therefore, fewer of these habitats were available for assessment.

Table 5.3-1. Wetland functions and values provided by predominant wetland cover types in the study area.

Wetland Functions	Aquatic Bed	Emergent	Scrub/Shrub	Scrub/Shrub Emergent	Forested	Forested Scrub/Shrub
Groundwater Recharge/Discharge		✓		✓		
Flood flow Alteration		✓	✓	✓	✓	✓
Fish and Shellfish Habitat	✓	✓				
Sediment/ Toxicant Retention	✓	✓	✓		✓	✓
Nutrient Removal	✓	✓	✓		✓	
Production Export	✓	✓				
Sediment/Shoreline Stabilization	✓	✓	✓	✓	✓	
Wildlife Habitat		✓	✓		✓	✓
Wetland Values						
Recreation	These values are not provided at a Principal level by any wetland type.					
Educational/ Scientific Value						
Uniqueness/ Heritage						
Visual Quality/Aesthetics	✓	✓				
Endangered Species Habitat	✓	✓	✓		✓	

The portion of the Connecticut River watershed that drains to the project-affected area is heavily forested but also includes a considerable amount of agricultural land and urban and suburban lands. Together, these land uses and associated impervious surfaces result in an increased volume of storm runoff containing sediment, nutrients, toxicants and other contaminants. These same land uses occur within the project-affected area along with several municipal sewage treatment plants that discharge to the Connecticut River, and are the justification for many of the wetland types having a principal rating for the sediment/toxicant retention, nutrient removal, and sediment/shoreline stabilization functions. These ratings were concentrated within the emergent and aquatic bed wetland types, which are regularly or continually in contact with river water, and predominate in the zone affected most by natural flooding and hydropower related water fluctuations. Similarly, principal ratings were given to a number of woody wetlands for the sediment/shoreline stabilization and/or flood flow alteration functions. These wetlands were located in landscape positions that were suitable for these functions such as along the river shoreline or along tributaries.

Aquatic bed and emergent wetland types accounted for all the principal ratings for the fish/shellfish habitat and production export functions. The lower reaches of all three impoundments, in particular, were characterized by a lush growth of aquatic and emergent wetland vegetation, which provides abundant biomass for the riverine food web as well as spawning, nursery and foraging areas for a wide variety of fish and invertebrates.

All of the study area wetlands provide some degree of wildlife habitat and especially as part of larger surrounding upland/wetland habitat complexes. Forested wetlands scored the most principal ratings for this function due to the generally large extent and structural diversity of these habitats.

Wetland values were provided by many of the wetlands, but not at the principal level except for the visual quality/aesthetics value for aquatic beds and emergent marshes. This principal rating resulted from the widespread abundance of the visually appealing white water lily (*Nymphaea odorata*), which is a floating-leaved aquatic plant that occurred in large numbers throughout the aquatic bed wetlands in the lower reaches of the impoundments and which was visible from many locations. Many of the large emergent wetlands were also ascribed a principal level for visual quality/aesthetic value due to their diversity of structure in the predominantly forested landscape of the region.

5.4 Rare, Threatened, and Endangered Species

Of the 163 Element Occurrences remaining on the VTNHI and NHNHB lists that were not included (due to position, rank or elevation) in the 2012 rare plant survey (Normandeau 2013a), 88 had been located since 1990 and 75 had not been observed since that date. This study's analysis focused on the 88 more recent (post-1990) observations. Of the 88 recent Element Occurrences, 46 occurred within the 2014 Study Area, and 42 occurred more landward of it. Seven Element Occurrences were confirmed during the 2014 field verification, including five silver maple-wood nettle-ostrich fern floodplain communities, and two rare species, black maple (*Acer nigrum*) and obedient plant (*Physostegia virginiana*). Another Element Occurrence of silver maple-wood nettle-ostrich fern floodplain community recorded in the study area was noted within a very marginal cover type of mixed hardwood and conifers. Located in association with a small drainage, this Element Occurrence was determined to be too small and too marginal to include as a confirmed record. A larger component of the community may occur further inland (outside of the study area), but it was not surveyed.

Table 5.4-1. Rare species and exemplary community survey results from the 2012 rare vegetation survey (Normandeau, 2013a) and the 2014 habitat mapping effort.

State	2012 Survey	2014 Survey				Total
		Recent EOs within Study Area			Historic EOs	
		Confirmed	Did not check	Outside Study Area		
NH	118	5	32	29	50	234
VT	64	2	7	13	25	111
Total	182	7	39	42	75	345

In addition to the recorded obedient plant Element Occurrence, this species was frequently observed on much of the riverbank and on many of the sparsely vegetated bars within the study area during both the 2012 (Normandeau 2013a) and 2014 field surveys.

5.5 Invasive and Exotic Species

Twenty-seven plant species designated as invasive, non-native species and one additional plant considered potentially invasive were documented in the study area as a result of this study's habitat mapping and the 2012 rare species and exemplary community survey (Normandeau, 2013a). Over 163 acres discrete stands of invasives were mapped. The majority of species occurred in more than one impoundment (Table 5.5-1). The most abundant and widely distributed species were Phragmites (*Phragmites australis*), Japanese knotweed (*Fallopia japonica*), purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinacea*), bush honeysuckles (*Lonicera* sp.), glossy buckthorn (*Frangula alnus*), oriental bittersweet (*Celastrus orbiculatus*), and Eurasian water-milfoil (*Myriophyllum spicatum*). Phragmites, purple loosestrife, and reed canary grass are typically found in wetlands while Eurasian water-milfoil is an aquatic plant. Japanese knotweed and oriental bittersweet are typically upland species, and glossy buckthorn grows equally well in both wetlands and uplands.

Table 5.5-1. Invasive plants observed in the study area.[1]

Common Name	Scientific Name	Location	Growth Form
Climbing nightshade	*Solanum dulcamara*	Vernon, Wilder	Herb
Black locust	*Robinia pseudoacacia*	Vernon	Tree
Brittle naiad	*Najas minor*	Bellows, Wilder	Submerged Aquatic
Bush Honeysuckles	*Lonicera morrowii/tartarica*	All impoundments	Shrub
Canada bluegrass [2]	*Poa compressa*	Study area	Forb
Coltsfoot	*Tussilago farfara*	Bellows	Herb
Common buckthorn	*Rhamnus cathartica*	Vernon, Wilder	Tree
Phragmites	*Phragmites australis*	All impoundments	Forb
Crown-vetch [3]	*Securigera varia*	Wilder	Herb
Dames Rocket	*Hesperis matronalis*	Wilder riverine	Herb
Eurasian water-milfoil	*Myriophyllum spicatum*	All impoundments	Submerged Aquatic
Forget-me-not	*Myosotis scorpiodes*	All impoundments	Herb
Garden Loosetrife [2]	*Lysimachia vulgaris*	Study area	Herb
Glossy Buckthorn	*Frangula alnus*	All impoundments	Shrub
Japanese Barberry	*Berberis thunbergii*	All impoundments	Shrub
Japanese Knotweed	*Fallopia japonica*	All impoundments	Herb
Japanese Stilt grass	*Microstegium vimineum*	Wilder riverine	Forb
Mile-a-Minute vine	*Persicaria perfoliata*	All impoundments	Vine
Moneywort	*Lysimachia nummularia*	Vernon, Bellows	Herb
Multiflora Rose	*Rosa multiflora*	All impoundments	Shrub
Oriental Bittersweet	*Celastrus orbiculatus*	All impoundments	Vine
Purple Loosestrife	*Lythrum salicaria*	All impoundments	Herb
Reed Canary Grass	*Phalaris arundinacea*	All impoundments	Forb
Russian Olive	*Elaeagnus angustifolia*	Wilder	Shrub
Spotted knapweed	*Centaurea biebersteinii*	Vernon	Herb
Swallow-wort [2]	*Cynanchum cf louisaea*	Study area	Vine
Winged euonymus (Burning bush)	*Euonymus alata*	Vernon	Shrub
Yellow Flag Iris	*Iris pseudacorus*	All impoundments	Herb

[1] Invasive Plant Atlas of New England (IPANE), 2014.
[2] Observed in the study area during the 2012 rare, threatened, and endangered plant and exemplary natural community field surveys (Normandeau, 2013a).
[3] New Hampshire Department of Agriculture List of Restricted Species (Watch List).

Japanese knotweed was the most widespread species, with dense stands mapped along the shoreline and on islands throughout the study area and in a variety of habitats. Seventy-nine acres were mapped in the field. In areas with minimal canopy, this species was mapped in well-defined stands. It was common along the edges of agricultural fields bordering the river, on riverbanks, and disturbed slopes. It also occurred as discrete smaller patches within larger, typically forested plant communities. In these locations, the stands were noted but not mapped.

Approximately 35 acres of Phragmites-dominated scrub/shrub and emergent cover were mapped in the study area. This species forms clonal stands in herbaceous wetlands, frequently forming dense monocultures to the exclusion of native species. These larger stands were most prevalent in the extensive emergent wetlands found in the lower reaches of Vernon impoundment. Approximately two-thirds of the Phragmites found in the study area occurred in Vernon (22.8 acres), with lesser amounts, and smaller stands in Wilder (7.3 acres) and Bellows Falls (4.7 acres). Additional smaller stands were occasionally observed during field surveys, but were too small to be mapped. These smaller stands were more frequent in the middle reaches of Bellows Falls and Vernon impoundments. This species was relatively infrequent on the riverine reaches.

Purple loosestrife was widespread in a variety of open habitats throughout the study area, including emergent wetlands, riverbanks, and gravel bars. Where it occurred, this species was typically low in density, and seldom dominated the plant community.

Reed canary grass was also widely distributed throughout the study area in dense, small patches, predominantly on riverbanks and in emergent and scrub/shrub wetlands. Forget-me-not was also prevalent on many riverbanks and wetland edges throughout the study area.

Common invasive shrub species included the bush honeysuckles, glossy buckthorn, multiflora rose, and Japanese barberry. One or more of these species were encountered in most forested and shrub stands, including both wetlands and uplands. The distribution within a cover type was typically diffuse, but occasionally stands of an acre or more were observed, such as the dense cover of Japanese barberry on Stebbins Island.

Oriental bittersweet occurred along much of the riverbank throughout the forested cover types. It was prevalent in both wetlands and uplands, forming dense, climbing vines in the tree canopy. This is a light-limited species, and as such, became less dense or absent in the interior of the more shaded interiors of forest stands.

Eurasian milfoil was prevalent in all three impoundments, particularly in quiet coves. Where it occurred, it tended to be abundant and dominated the mid-column flora. Brittle naiad was also widespread in quiet coves.

5.6 Bald Eagle Nesting and Winter Roosting Habitat

In the 2014 breeding season, NHA documented nine nests within the study area, eight of which were active (NHA 2014a). This was an increase from six nests (five active) in 2012 when NHA began tracking nests on the Connecticut River, and seven nests (six active) in 2013. Productivity of the nests in the study area was 0.8, 0.7, and 0.6 fledged young per nest in 2012, 2013, and 2014, respectively. While the overall productivity of these nest is lower than for nests throughout the entire watershed (NHA 2012, 2013, 2014a), the decrease in 2014 was reflected across the entire watershed. Cold weather and heavy snow in March likely depressed hatching rates throughout Vermont and New Hampshire in 2014.

The current active nests are located in Piermont, Plainfield, and Hinsdale (two nests), NH; and in Newbury, Hartford, Rockingham, and Dummerston, VT (Table 5.6-1). All known locations of nests are within approximately 125 feet of the Connecticut River shoreline.

Table 5.6-1. Bald eagle nest tree locations and conditions, based on NHA data (NHA, 2014b).

Town	Dist to River	Setting	Tree Type	Tree Condition	DBH	Predator Guard?	Years Active
Newbury, VT	~ 200 ft	Bank Tributary	White Pine	Live	Unknown	No	2012, 2013, 2014
Piermont, NH	Unknown	Unknown	Unknown	Unknown	Unknown	No	2014
Hartford, VT	>25 ft	River bank	White Pine	Live	unknown	No	2012, 2013, 2014
Plainfield, NH	~ 25 ft	River bank	White Pine	Live	unknown	No	2012, 2013, 2014
Claremont, NH	>25 ft	River bank	White Pine	Live	unknown	No	none
Rockingham, VT	>125 ft	Upland	Cottonwood	Live	unknown	yes	2012, 2013, 2014
Dummerston, VT	>25 ft	River bank	White Pine	Dead	unknown	no	2014
Hinsdale, NH	>100 ft	Small island	White Pine	Live	unknown	no	2014
Hinsdale, NH	~125 ft	Upland	White Pine	Live	25 inches	yes	2012, 2013, 2014

The precise location of the Piermont nest is unknown, though activity of adults and fledgling indicate that it is in a stand of white pine on an oxbow. There are no conserved lands within 250 feet of any nest, but five of the known locations are essentially on the river bank, which is partially protected from new development by statute in both Vermont and New Hampshire. The two active nests in Hinsdale are located on land that is also essentially undevelopable. Of the known-location, active nests, six are in live white pines, one is in a dead white pine, and one is in a live cottonwood. The diameter of the nest tree at breast height is available for only one tree. Predator guards have been placed on two nest trees (Table 5.6-1).

The NHNHB data identified one known winter roosting area within the study area, located in Hinsdale, NH, near Vernon Dam. Aerial photo interpretation followed by field verification identified 12 additional softwood stands that appear to offer suitable winter roosting conditions: six in Vermont; and six in New Hampshire (Figure 5.6-1). They are all located essentially on the riverbank, with two located on tributary inlets (Mink Brook and Clay Brook) and two located on islands (Gilman Island, and an unnamed island in Lyme, New Hampshire). These potentially suitable winter roosting sites are relatively evenly distributed throughout the study area, and although the distribution is not extensive in comparison to the entire size of the study area, winter roosting habitat is unlikely to be a limiting resource. Bald eagles are highly mobile using multiple roosts in the course of a winter, and communal roosting behavior is common (Beuhler, 2000). Use of a particular potentially suitable stand would likely in part be a function of the amount and location of winter open water on the river. The known winter roosting area mapped by NHNHB is located directly below Vernon Dam, where dam operations likely maintain open water across a range of winter temperature and weather conditions.

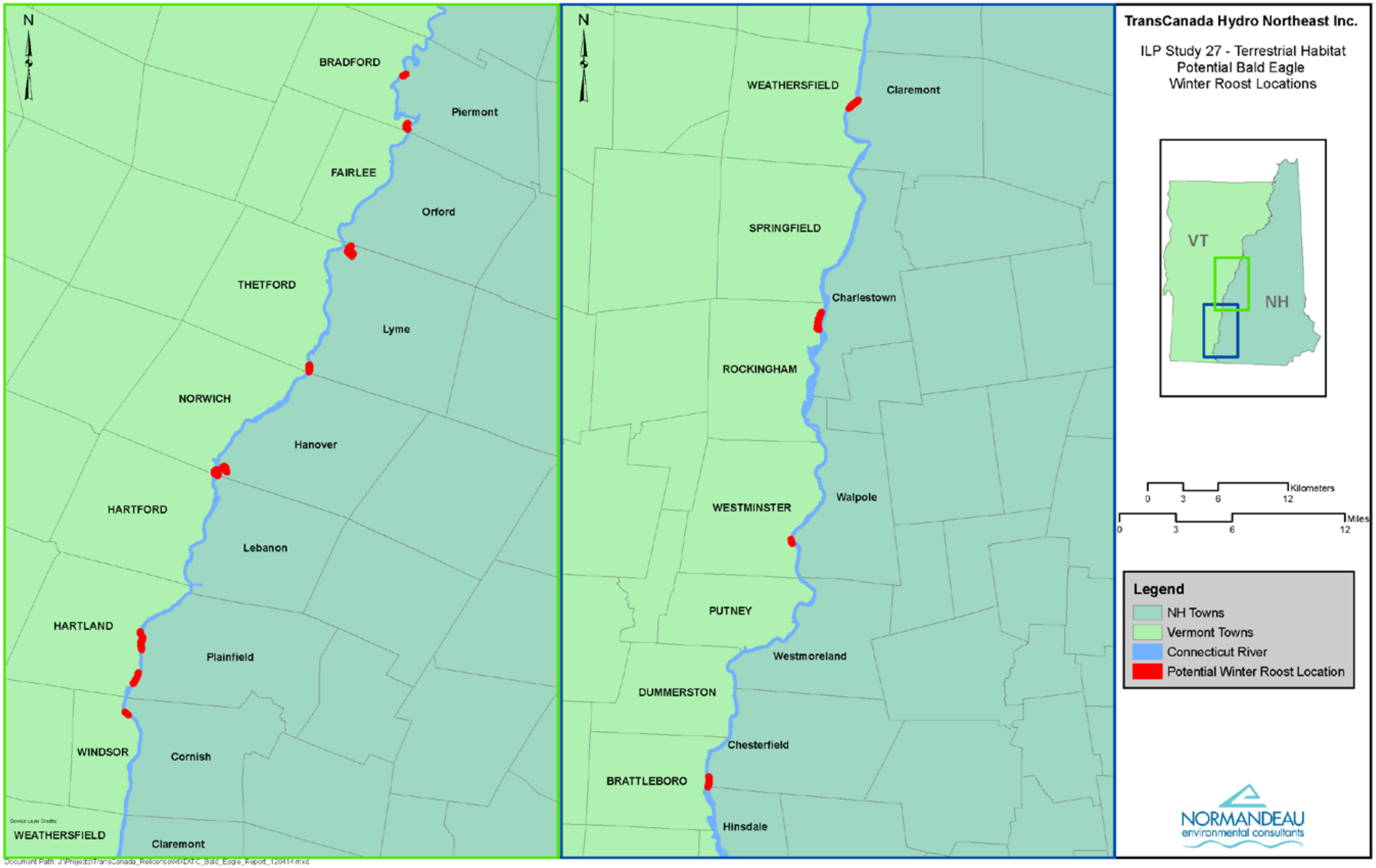

Figure 5.6-1. Approximate locations of potential bald eagle winter roosts in the study area.

Table 5.6-2. Characteristics of potential bald eagle winter roosts identified during field surveys.

State	Town	Aspect	Source of Wind Protection	Age Class of Stand	Canopy Height (ft) Estimated	Perch Access	Dominant Species	Largest DBH (Ft) (estimated)	Land Use Surrounding Stand	Approx. distance to nearest human activity
NH	Piermont	West	Hill Behind	Mixed	100	Moderate	white pine	1.5	Ag lands	200 ft
NH	Plainfield	East	Large Stand Behind	Even	100	Clear	white pine	4	Ag lands	250 ft
NH	Lyme	East	Hill Behind	Mixed	75	Clear	white pine	2	Softwood	0
NH	Lyme	East		Mixed	75	Moderate	white pine	3	Softwood	0.5 mi
NH	Hanover	East	Hill Behind	Mixed	75	Clear	white pine	3	Mixed forest	2 mi
NH	Claremont	West	Large Stand Behind	Even	80	Clear	white pine	2	Softwood	1 mi
VT	Hartland	East	Hill Behind	Even	100	Clear	white pine/ hemlock	3	Mixed Forest	50 ft
VT	Windsor	East	Hill Behind	Even	70	Clear	white pine	2	Railroad, golf course, gravel pit	100 ft
VT	Hartland	East	Hill Behind	Mixed	80	Clear	white pine	3	Upland slope behind	200 ft
VT	Bradford	East	Hill Behind	Even	80	Clear	white pine	3	Softwood	0.5 mi
VT	Rockingham	East	Large Stand Behind	Even	80	Moderate	white pine	3	Softwood	1 mi
VT	Westminster	East	Hill Behind	Even	70	Clear	white pine	2	Low density Residential, Route 5	325 ft

5.7 Wildlife

A total of 87 species of wildlife were recorded during incidental observations in this study, as well as other species specific surveys (Studies 26 and 28, for Tiger Beetles and Fowler's Toad, respectively). See Appendix C for a complete list of species observed in the study area.

Bird activity was relatively light throughout the field surveys throughout the study area. Twelve species of wading birds and waterfowl were recorded between April and August, 2014. Three species of waterfowl were observed throughout the impoundments. Common merganser (*Mergus merganser*) was observed in throughout the study area and a brood of six young were observed in the Vernon impoundment. Wood duck (*Aix sponsa)* was observed in multiple backwater and floodplain areas throughout the Bellows Falls impoundment and mallards (*Anas platyrhynchos)* were noted in both Wilder and Vernon impoundments. Other waterfowl species including Canada geese (*Branta Canadensis)* and double crested cormorants (*Phalacrocora auritus)* were abundant in all three impoundments.

Shoreline-dependent species were noted throughout the study area. Spotted sandpiper (*Actitis macularia)* was frequently seen along the water's edge on both protected and exposed shoreline and gravel bars throughout the river. Bank swallow colonies were relatively common throughout the Wilder and Vernon impoundments on eroded banks where protected colonies could be established. Figures 5.7-1 and 5.7-2 illustrate a typical bank swallow colony in the study area.

Belted kingfisher (*Ceryle alcyon*), great blue heron (*Ardea herodias*), and green heron (*Butorides virescens*) were common throughout the study area. These species were usually noted perching on trees and, when disturbed, would leave the roost tree and fly up or downstream from the observer's location. Great egrets (*Ardea alba)* were observed only once in the lower reaches of the Vernon impoundment near the dam.

Bald eagle juveniles and adults were observed in multiple locations throughout the study area, as were numerous other species of raptors: turkey vulture, osprey, red-tailed hawk, broad-winged hawk, American kestrel, and a peregrine falcon (Vernon impoundment). The importance of the Connecticut River corridor for bird migration was evident when flocks and individual passerines were observed, including mixed warbler flocks in May and June and common nighthawk in August. Other wildlife observations included beaver lodges and dams in backwaters and evidence of bank dens on the mainstem, mostly in the three impoundments. Muskrat were observed in the larger emergent marshes, primarily in the lower Vernon impoundment. American toads, spring peepers, green frogs and bullfrogs were observed or heard in most of the quieter waters with emergent wetlands and aquatic beds. See Study Report 28 for Fowler's toad survey results. A white-tailed deer fawn on Chase Island indicates the value of protected locations for nursery habitat. Tracks of raccoon, deer, mink, possum and mice were frequently observed along the shorelines.

Figure 5.7-1. Bank swallow holes established in an eroded riverbank in Vernon impoundment.

6.0 ASSESSMENT OF PROJECT OPERATIONS

An overall assessment of the potential effects of project operations will be included in the Draft License Applications since results from other ILP studies will be needed to complete that assessment. Relevant studies include the erosion studies (Studies 1, 2, and 3), Hydraulic Modeling Study (Study 4), and the Operations Modeling Study (Study 5). None of these studies are complete at this time.

Preliminary hydrologic data collected to date provide information to allow making some general assumptions regarding the effects of project operations on the vegetation communities mapped in this study. The following discussion is based on field observations during this study in combination with evaluation of LiDAR elevation data, flow duration curves, short-term water level logger data and a general understanding of how the river water levels respond to various flows.

For discussion purposes, the following assumptions have been made:

- Project operations have the potential to affect vegetation communities when river flows are above the FERC-prescribed minimum flows and below high water events resulting in spill.

- The exceedance curves of average daily flows constructed from TransCanada operations data from January 1, 1972 to September 30, 2011 are representative of typical conditions (Section 3.5.2 of each Project's PAD[TransCanada 2012a, 2012b, 2012c]).

- The water level logger data collected in 2013 as part of Study 7 – Aquatic Habitat Mapping (TransCanada 2015) provide adequate representation of the range of water level fluctuations caused by project operations (excluding periods of spill at each project).

Vegetation communities, particularly along large river systems, can be hydrologically and physically influenced by the river in multiple ways, including flooding by periodic high waters due to snowmelt and high precipitation; scour by ice, water and debris; short-term water level fluctuations; and low flow conditions. On a regulated system such as the Connecticut River in the project area, larger water inputs which exceed the capacity of the dams during snowmelt and precipitation determine the flood levels and scour events, while impoundment elevation changes and discharge from normal project operations affect the short-term water level fluctuations and low flow water levels. This analysis focuses only on water levels that coincide with project operations (excluding spill).

Hydraulic modeling outputs from ILP Study 4 and operations modeling outputs from ILP Study 5 may allow for refinement of the observations described below, and may provide specificity on the relationship between project operations and water levels at a particular point of interest or concern. . Aspects such as frequency and extent of inundation, and the timing of the influences of project operations versus high flow events will provide a better understanding of the relative position of key communities along the river and project operations.

6.1 Water Level Fluctuation

Water levels at various locations within the study area were derived from water level loggers deployed from late July-November 2013 in mainstem, tributary, and backwater locations as part of ILP Study 7 – Aquatic Habitat Mapping (TransCanada 2015). Within each impoundment, water level fluctuations tend to vary with location. In general, mainstem water levels in the lower reaches closer to the dams were influenced by project operations and varied up to 2.9, 2.7 and 2.4 feet typically for Wilder, Bellows Falls, and Vernon impoundments, respectively. Backwaters in the lower impoundments had water levels that fluctuated 3.3, 2.8, and 2.3 feet for Wilder, Bellows Falls, and Vernon impoundments, respectively. The upper portions of the impoundments exhibit more riverine characteristics and experience higher fluctuations: 7.0, 6.6 and 2.4 feet for Wilder, Bellows Falls, and Vernon impoundments, respectively; generally due to upstream inflow rather than reservoir fluctuation.

In the riverine sections below project dams, mainstem water levels under normal project operations based upon the logger data fluctuated up to 7.1 ft below Wilder and Bellows Falls, and 6.3 feet below Vernon (the Vernon riverine section is also influenced by the downstream Turners Falls Project's operations). Water surface elevation (WSE) and water level fluctuation data at representative locations and at the example sites described in the sections below are included in Tables 6.1-1 and 6.2-1, respectively.

Table 6.1-1. Water level fluctuation characteristics at selected sites under typical project operations (non-spill) based on water level logger data.

Study 7 Site ID#	Water Level Logger Location	Project Operations Influenced Water Levels		
		WSE min (ft)	WSE max (ft)	Water Level Fluctuation (ft)
Upper Impoundment Mainstem Locations				
1	Upper Wilder Impoundment at Haverhill NH	382.6	389.6	7.0
39	Upper Bellows Falls Impoundment downstream of Chase Island	289.5	296.1	6.6
60	Upper Vernon Impoundment near East Putney Brook	219.2	221.6	2.4
Lower Impoundment Mainstem Locations				
26	Lower Wilder Impoundment at Pine Park, Hanover NH	381.4	384.0	2.9
49	Lower Bellows Falls Impoundment upstream of Williams River	287.9	290.6	2.7
70	Lower Vernon Impoundment near Ash Swamp Brook	217.4	219.8	2.4
Backwaters in Lower Impoundments				
25	Wilder Impoundment downstream of Ompompanoosuc River	380.9	384.2	3.3
50	Bellows Falls Impoundment at Herrick's Cove	288.0	290.8	2.8
69	Vernon Impoundment at Ash Swamp Brook	217.2	219.5	2.3
Riverine Reaches Below dams				
32	Wilder Riverine between Burnap's Island and Sumner Falls	313.9	321.0	7.1
53	Bellows Falls Riverine just downstream of project	221.9	229.0	7.1
73	Vernon Riverine at the tip of Vernon Neck	180.8	187.1	6.3

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6.2 Vegetation Community Adaptations

The vascular vegetation communities bordering the river in the study area can be described according to their position relative to water level fluctuation zones. There is a wide diversity of vegetative communities along the Connecticut River that reflects the varying conditions that occur throughout the study area (Appendix D). As expected, submerged aquatic vegetation occurred almost exclusively below the lower limit of water level fluctuations. Emergent and scrub-shrub wetlands were most commonly found within the zone exposed to project-related water level fluctuations. Wetlands higher in the hydrologic gradient, primarily forested wetlands, were typically located above project-related water levels, as were other riparian vegetation bordering the river. By virtue of its location, the vegetation in the riparian zone must be able to tolerate occasional flooding, and in the case of floodplains, this vegetation is specifically adapted to annual flooding events and other high flows. These various communities and their positions relative to water surface elevations under normal project operations are described in more detail below.

Aquatic Vegetation

Aquatic vegetation is susceptible to desiccation and scour, therefore it proliferates in areas that are protected from strong currents and are not exposed at low flow water levels. In the study area, the most well developed aquatic communities occurred in backwaters and the mouths of large tributaries, where they are both protected from scour and high currents, but are situation in sufficient water depth to remain flooded at low water levels.

Examples are in the West River backwater in the lower Vernon impoundment (Figure 6.1) and the mouth of the Williams River in the lower Bellows Falls impoundment (Figure 6.2). Wilder has relatively few large backwaters and protected coves, therefore has fewer large aquatic beds, but does have a number of small ones in the mouths of tributaries, such as the Lake Morey Brook backwater (Figure 6.3). As described in section 5.1.2, riverine aquatic beds were also prevalent in the upper reaches of the three impoundments. Riverine aquatic beds are typically linear in shape forming narrow bands along the edges of the more riverine sections of the impoundments, and were dominated by species such as wild celery that are able to tolerate the stronger currents typical of the upper impoundments. Submerged aquatic vegetation was much less common, and no beds were large enough to map on the truly riverine sections below the dams, where scour and current are too strong for most species to persist.

Emergent and scrub-shrub wetlands

Emergent and scrub-shrub wetlands were observed throughout the study area in protected locations such as coves and tributaries, and on the downstream side of islands. These wetland cover types tend to be tolerant of short- and long-term inundation, but are vulnerable to scour by currents and ice, as reflected by their prevalence in protected locations. Examples include the coves associated with the

West River (Figure 6.1), the Williams River (Figure 6.2), and the Lake Morey Brook backwater (Figure 6.3). The water levels during the periods influenced by project operations fluctuated a maximum of 2.2 ft in the West River backwater, 2.8 ft in the Williams River backwater and 3.6 ft in the Lake Morey Brook backwater. As described in Section 5.1.2, deep-marsh emergent vegetation such as pickerel weed, cattail and soft-stem bulrush, dominated in the lower elevations of the projects' operational zones, anecdotally appearing to seldom be exposed at low water levels. Emergent and low scrub-shrub vegetation was often intermingled at slightly higher elevations (Figure 6.4, and was observed to experience frequent inundation and water level fluctuation. Tall scrub-shrub wetlands were yet higher in elevation, and were observed to be inundated or saturated to a lesser extent, although still frequently.

Emergent and scrub-shrub wetlands were generally absent from sections of the study area that experience strong river currents likely associated with seasonal spring runoff and rainfall events as well as project operations. This was evident along sections of the mainstem riverbanks, and on the leading tips of islands where vegetation was generally sparse or absent (Figure 6.5). Some species such as sand willows (*Salix* spp.), dogbane, obedient plant, and cardinal flower (*Lobelia cardinalis*) were found with low sparse cover across areas observed to experience frequent inundation and scour. These species have adapted to tolerate active conditions to some extent, although they are periodically destroyed during flood events (e.g., above project operations flows). Such communities are unable to compete in more heavily vegetated areas.

Forested Wetlands

Forested wetlands in the Northeast are not adapted to tolerate prolonged or frequent inundation. This was observed in the study area where forested wetlands occurred either on terraces or tributary mouths above the zone of normal project operations. Within the 200-foot study limit, forested wetlands were typically small in size and seldom occurred along the riverbank. They were more frequently found adjacent to beaver impoundments or backwaters that were flooded only during high water events (Figure 6.3). They also were found at tributary mouths where signs of flooding were limited to larger debris and sediment deposits typically associated with flood events.

Floodplain Forests

Floodplain forests are an important resource in the study area. Most occurred on terraces that were higher in elevation than the typical zone of project operations and therefore above the influence of project-related water level fluctuations. An exception was silver maple floodplain forest, some of which occurred on several islands and low terraces adjacent to the river, for example near a low island in Hinsdale NH (Figure 6.6) where water levels fluctuated 2.4 feet in the mainstem river and 2.3 feet in the backwater, under normal project operations. Silver maple can tolerate prolonged and frequent inundation as long as the site supports well-drained soils. Several low-lying sites were observed that showed evidence of periodic inundation or saturation near the zone of project operations. Most other silver maple floodplain forests appeared to be well above the zone of project operations, and demonstrated classic annual or flood evidence based on scour marks, sediment deposition in the soils and large flood debris trapped in trees or bushes.

Upland and Riparian Habitats

The remainder of undeveloped habitats bordering the river were clearly above areas that are affected by normal project operations. These include upland riverbanks, riparian habitats, and agricultural fields (Figures 6.7 and 6.8). The vegetation in these habitats is not adapted to frequent inundation or scour, but it can generally tolerate floods and infrequent scour. These communities provide important substrate stabilization when such events occur.

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Table 6.2-1. Water level fluctuation characteristics at representative vegetation community sites under typical project operations (non-spill) based on water level logger data.

Study 7 Site ID#	Water Level Logger Location	Project Operations Influenced Water Levels		
		WSE min (ft)	WSE max (ft)	Water Level Fluctuation (ft)
West River Backwater (Figure 6.1)				
65	Mainstem upstream of West River	217.4	219.6	2.2
66	West River ~ ¼ mi upstream of confluence	217.3	219.5	2.2
67	West River backwater	217.4	219.6	2.2
Williams River Backwater (Figure 6.2)				
50	Herrick's Cove backwater	288.0	290.8	2.8
79	Williams River backwater adjacent to confluence	289.5	291.5	2.0
80	East side backwater across from Willams River confluence	288.5	290.8	2.3
Lake Morey Brook Backwater (Figure 6.3)				
14	Mainstem north of Orford NH	381.4	385.2	3.8
15	Backwater south of Fairlee VT	381.5	385.1	3.6
Ash Swamp Brook Backwater (Figure 6.6)				
69	Ash Swamp Brook backwater	217.2	219.5	2.3
70	Mainstem near Ash Swamp brook	217.4	219.8	2.4

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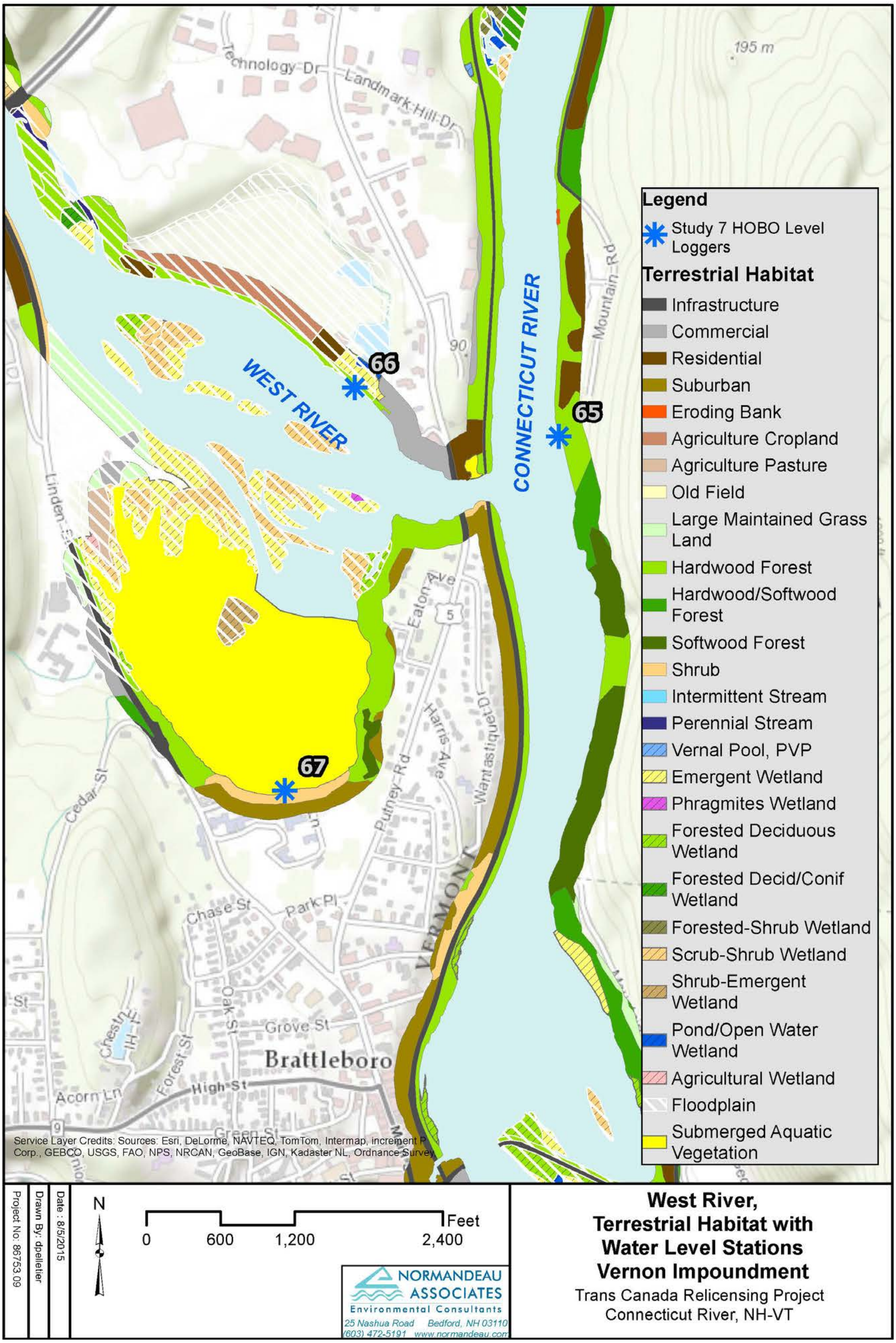

Figure 6.1. Aquatic, emergent and scrub-shrub development associated with the West River in the Vernon Project.

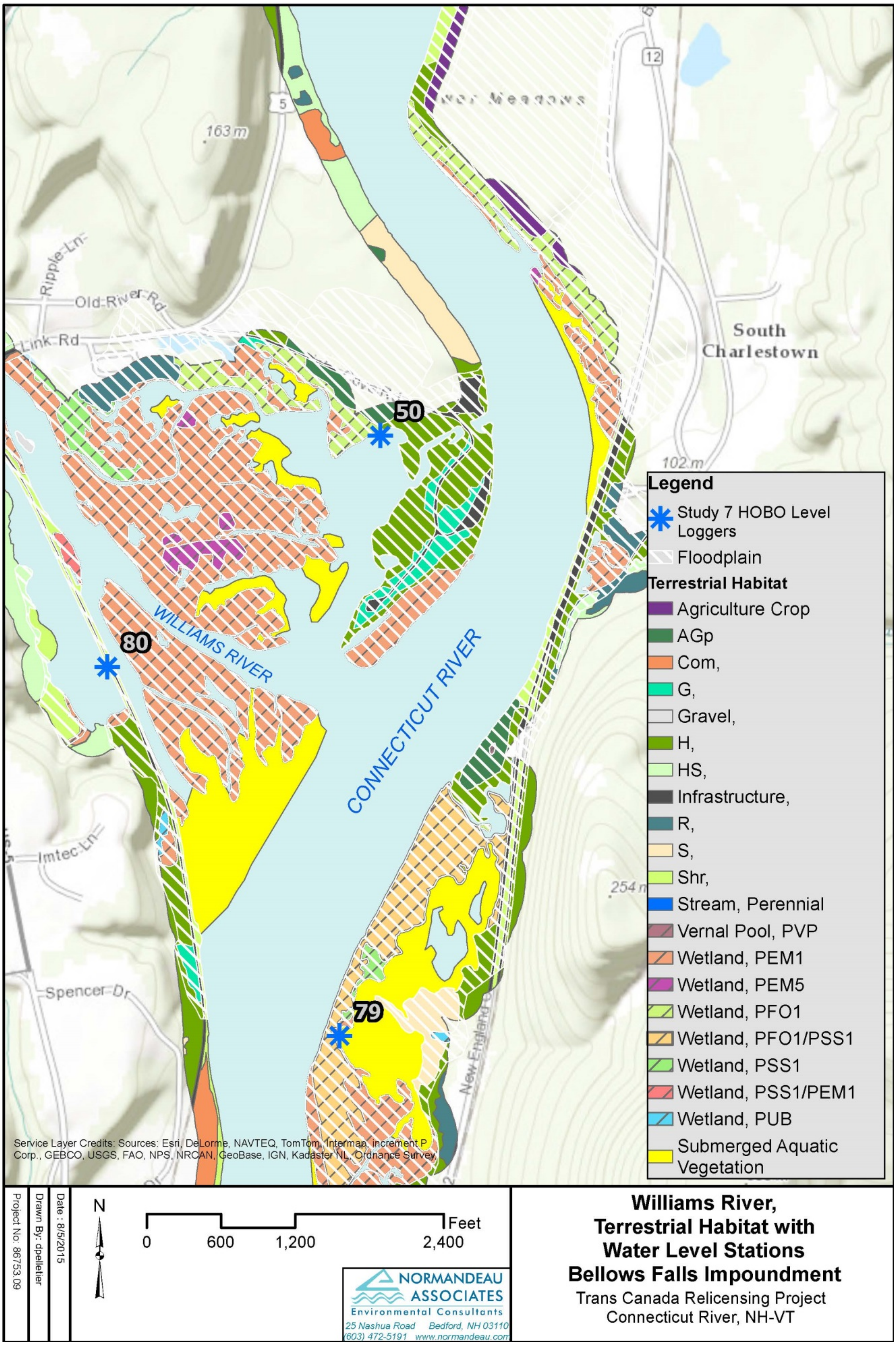

Figure 6.2. Aquatic, emergent and scrub-shrub development associated with the Williams River in the Bellows Falls Project.

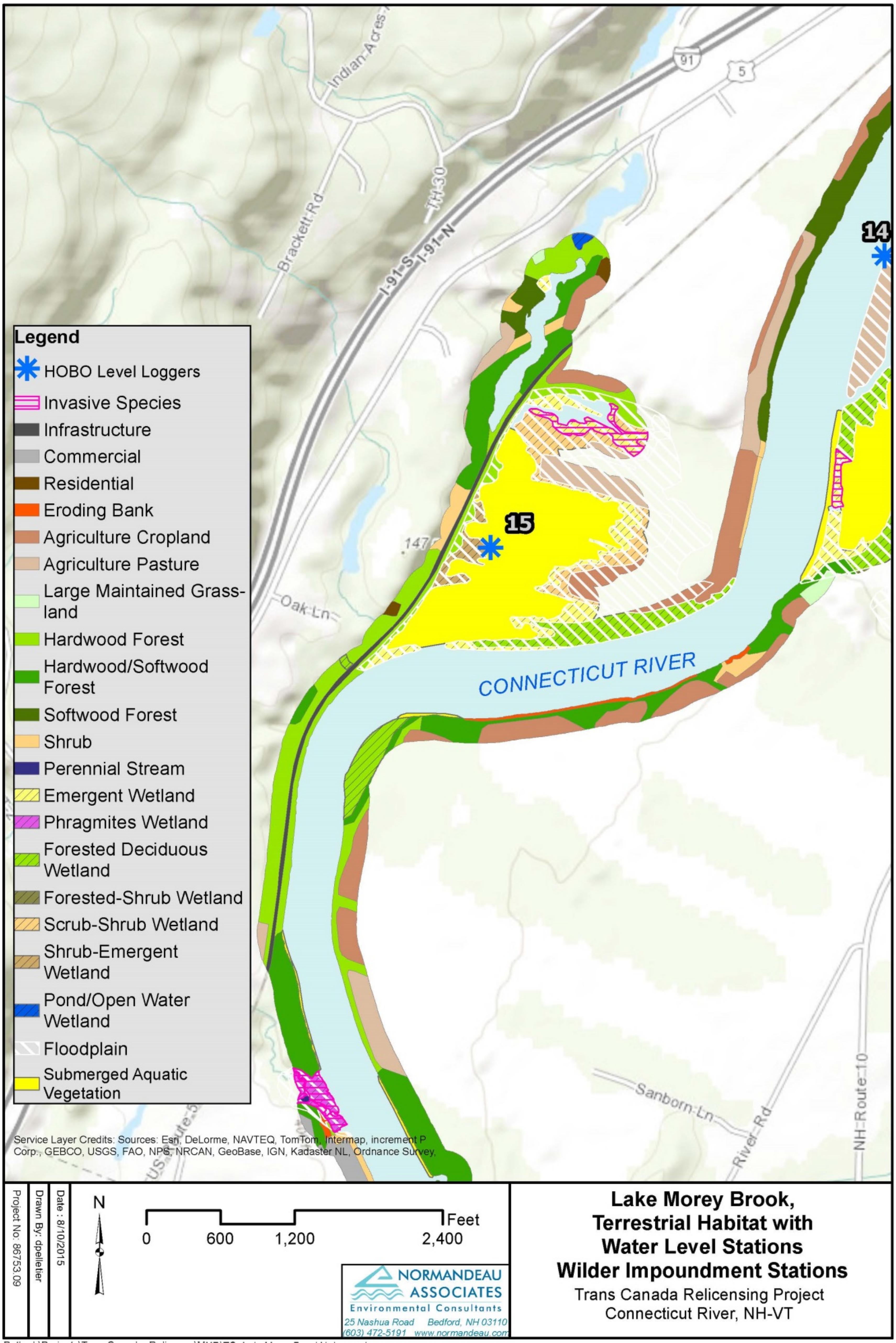

Figure 6.3. Aquatic, emergent and scrub-shrub development associated with the Lake Morey Brook backwater in the Wilder Project

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Figure 6.4. An example of zonation along the hydrologic gradient of aquatic, emergent and scrub-shrub communities in Hinsdale cove, lower Vernon Project.

Figure 6.5. An example of sparse scrub-shrub habitat observed to be frequently flooded on Chase Island in the upper Bellows Falls Project

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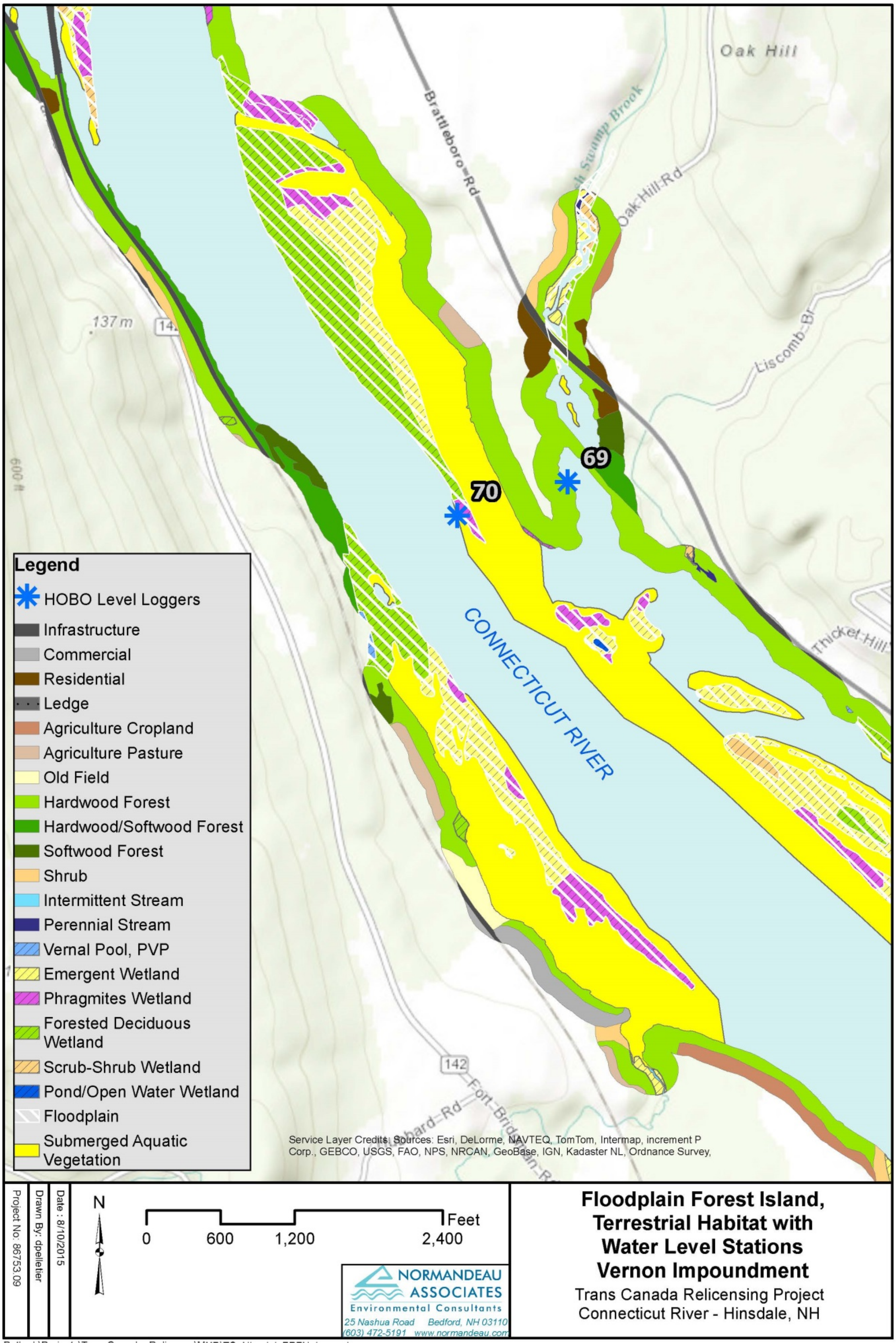

Figure 6.6. An example of low forested floodplain setting in Hinsdale, NH.

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Figure 6.7. Upland riverbank community in Vernon, showing zonation of vegetation approximately associated with water level fluctuations. The effects of periodic flooding and scour are evident in the lower portion of the bank and absent in the upper.

Figure 6.8. Japanese knotweed-dominated upland riverbank community bordering agricultural fields in the Wilder Project.

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Appendix A

List of Invasive Plant Species in New England from IPANE (2012)

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List of Invasive Plant Species in New England from IPANE (2012)

*Bold indicates invasive plants observed in the study area.

Scientific Name	Common Name
Acer ginnala Maxim.	Amur maple
Acer platanoides L.	Norway maple
Acer pseudoplatanus L.	Sycamore maple
Aegopodium podagraria L.	Goutweed
Ailanthus altissima (Mill.) Swingle	Tree of heaven
Aira caryophyllea L.	Silver hairgrass
Alliaria petiolata (Bieb.) Cavara & Grande	Garlic mustard
Allium vineale L.	Wild garlic
Alnus glutinosa (L.) Gaertner	European black alder
Amorpha fruticosa L.	False indigo
Ampelopsis brevipedunculata (Maxim.) Trautv.	Porcelainberry
Anthriscus sylvestris (L.) Hoffm.	Wild chervil
Arthraxon hispidus (Thunb.) Makino	Hairy jointgrass
Berberis thunbergii DC.	**Japanese barberry**
Berberis vulgaris L.	Common barberry
Bromus tectorum L.	Drooping brome-grass
Butomus umbellatus L.	Flowering rush
Cabomba caroliniana A. Gray	Fanwort
Callitriche stagnalis Scop.	Pond water-starwort
Cardamine impatiens L.	Narrowleaf bittercress
Carex kobomugi Ohwi	Japanese sedge
Celastrus orbiculatus Thunb.	**Oriental bittersweet**
Centaurea biebersteinii DC.	**Spotted knapweed**
Chelidonium majus L.	Celandine
Cirsium arvense (L.) Scop.	Canada thistle
Cirsium palustre (L.) Scop.	Marsh thistle
Cynanchum louiseae Kartesz & Gandhi	**Black swallow-wort**
Cynanchum rossicum (Kleo.) Barbarich	Pale swallow-wort
Cytisus scoparius (L.) Link	Scotch broom
Datura stramonium L.	Jimsonweed
Egeria densa Planchon	Brazilian waterweed

Scientific Name	Common Name
Eichhornia crassipes (Mart.) Solms	Water hyacinth
Elaeagnus angustifolia L.	**Russian olive**
Elaeagnus umbellata Thunb.	Autumn olive
Elsholtzia ciliata (Thunb.) Hylander	Crested late-summer mint
Epilobium hirsutum L.	Hairy willow-herb
Euonymus alata (Thunb.) Sieb.	**Winged euonymus**
Euphorbia cyparissias L.	Cypress spurge
Euphorbia esula L.	Leafy spurge
Frangula alnus Mill.	**Glossy buckthorn**
Froelichia gracilis (Hook.) Moq.	Slender snake cotton
Geranium thunbergii Sieb. & Zucc. ex Lindl. & Paxton	Thunberg's geranium
Glaucium flavum Crantz	Yellow hornpoppy
Glechoma hederacea L.	Ground ivy
Glyceria maxima (Hartman) Holmburg	Reed mannagrass
Heracleum mantegazzianum Sommier & Levier	Giant hogweed
Hesperis matronalis L.	**Dame's rocket**
Humulus japonicus Sieb. & Zucc.	Japanese hops
Hydrilla verticillata (L. f.) Royle	Hydrilla
Hydrocharis morsus-ranae L.	European frogbit
Hypericum prolificum L.	Shrubby St. Johnswort
Impatiens glandulifera Royle	Ornamental jewelweed
Iris pseudacorus L.	**Yellow iris**
Kochia scoparia (L.) Schrader	Common kochia
Lepidium latifolium L.	Perennial pepperweed
Ligustrum obtusifolium Sieb. & Zucc.	Border privet
Ligustrum ovalifolium Hassk.	California privet
Ligustrum sinense Lour.	Chinese privet
Ligustrum vulgare L.	European privet
Lonicera japonica Thunb.	Japanese honeysuckle
Lonicera maackii (Rupr.) Herder	Amur honeysuckle
Lonicera morrowii A. Gray	**Morrow's honeysuckle**
Lonicera tatarica L.	**Tatarian honeysuckle**
Lonicera x bella Zabel	Bell's honeysuckle

Scientific Name	Common Name
Lonicera xylosteum L.	Dwarf honeysuckle
Luzula luzuloides (Lam.) Dandy & Wilmott	Oakforest woodrush
Lychnis flos-cuculi L.	Ragged robin
Lysimachia nummularia L.	**Moneywort**
Lysimachia vulgaris L.	**Garden loosestrife**
Lythrum salicaria L.	**Purple loosestrife**
Marsilea quadrifolia L.	European waterclover
Microstegium vimineum (Trin.) A. Camus	**Japanese stilt grass**
Miscanthus sinensis Anderss.	Eulalia
Myosotis scorpioides L.	**Forget-me-not**
Myriophyllum aquaticum (Vell.) Verdc.	Parrotfeather
Myriophyllum heterophyllum Michx.	Variable-leaf watermilfoil
Myriophyllum spicatum L.	**Eurasian watermilfoil**
Najas minor Allioni	**Brittle water-nymph**
Nymphoides peltata (Gmel.) Kuntze	Yellow floating heart
Onopordum acanthium L.	Scotch thistle
Ornithogalum umbellatum L.	Star-of-Bethlehem
Paulownia tomentosa (Thunb.) Sieb. & Zucc.	Princess tree
Phalaris arundinacea L.	**Reed canary grass**
Phragmites australis (Cav.) Trin. ex Steud.	**Common reed**
Pistia stratiotes L.	Water lettuce
Poa compressa L.	**Canada bluegrass**
Polygonum caespitosum Blume	Bristled knotweed
Fallopia japonica Sieb. & Zucc.	**Japanese knotweed**
Polygonum perfoliatum L.	**Mile-a-minute vine**
Polygonum sachalinense F. Schmidt ex Maxim.	Giant knotweed
Populus alba L.	White poplar
Potamogeton crispus L.	Curly-leaved pondweed
Pueraria montana var. lobata (Willd.)	Kudzu
Ranunculus ficaria L.	Fig buttercup
Ranunculus repens L.	Creeping buttercup
Rhamnus cathartica L.	**Common buckthorn**
Robinia pseudoacacia L.	**Black locust**

Scientific Name	Common Name
Rorippa microphylla (Boenn. ex Reichenb.) Hyl. ex A.& D. Löve	Onerow yellowcress
Rorippa nasturtium-aquaticum (L.) Hayek	Watercress
Rosa multiflora Thunb. ex Murr.	**Multiflora rose**
Rosa rugosa Thunb.	Rugosa rose
Rubus phoenicolasius Maxim.	Wineberry
Rumex acetosella L.	Sheep sorrel
Salvinia molesta Mitchell Complex	Salvinia
Senecio jacobaea L.	Tansy ragwort
Silphium perfoliatum L.	Cup plant
Solanum dulcamara L.	**Bittersweet nightshade**
Trapa natans L.	Water chestnut
Tussilago farfara L.	**Coltsfoot**
Valeriana officinalis L.	Garden heliotrope
Veronica beccabunga L.	European speedwel

Appendix B

Representative Cover Class Photolog

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Submerged aquatic vegetation Wilder, VT. 8/6/2014.

Emergent wetlands Charlestown, NH. 7/29/2014

Emergent wetlands, Walpole, NH. 7/29/2014

Scrub-shrub/emergent wetland, Norwich, VT. 8/7/2014

Scrub-shrub wetland, Hinsdale, NH. 7/23/2014

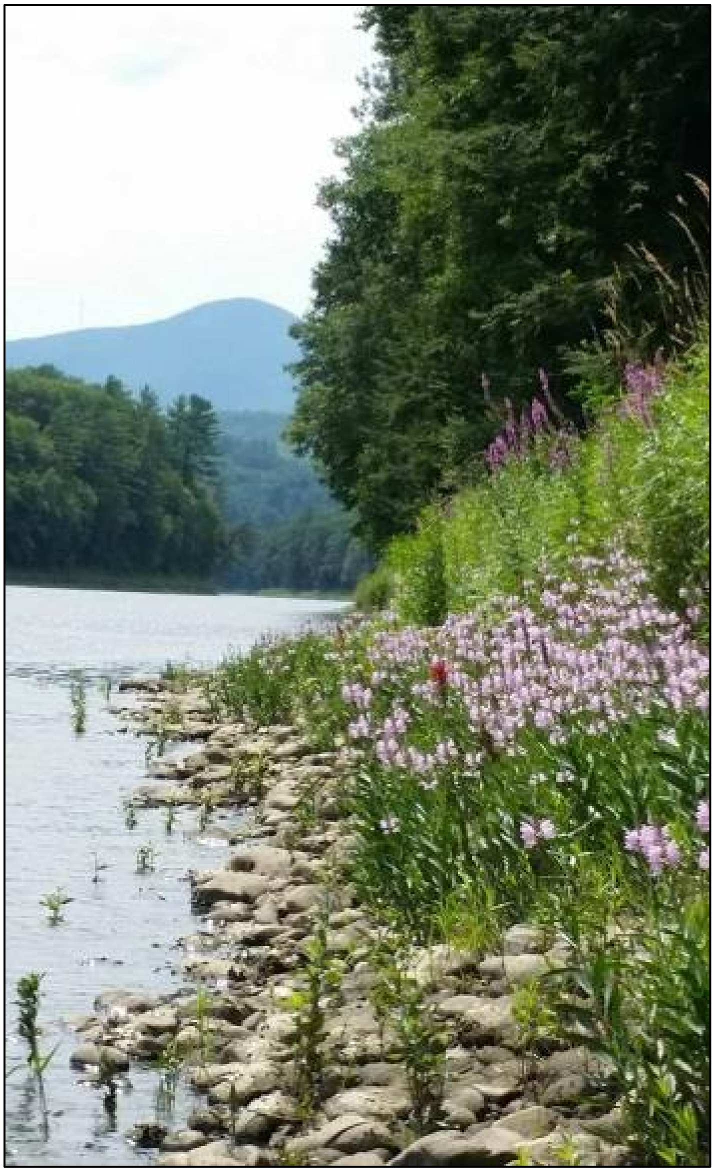
Scrub-shrub wetland, Westmoreland, NH. 7/26/2014

Deciduous forested/scrub shrub wetland, Rockingham, VT. 7/29/2014

Deciduous forested wetland, Charlestown, NH. 7/29/2014

Mixed deciduous-conifer wetland, Lyme, NH. 8/8/2014

Riverbank below agricultural field, Fairlee, VT. 8/9/2014



Riverbank, Harts Island. August 12, 2014

Riverbank, Westmoreland, NH. 7/25/2014

Shrub dominated riverbank, Charlestown, NH 7/30/2014


Hardwood forest on Wilder riverine section. Hartland, VT. 8/12/2014


Hardwood forest on Bellows Falls riverine section. Westminster, VT. 8/20/2014

Hardwood/softwood forest, Charlestown, NH. 7/30/2014

Softwood forest, Rockingham, VT. 7/29/2014

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Appendix C

Wildlife Species Observed throughout the Study Area

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Yellow highlighted species are typically dependent on wetlands or open water.

Birds

Common Name	Latin Name
American Crow	*Corvus brachyrhynchos*
American Goldfinch	*Spinus tristis*
American Kestrel	*Falco sparvarious*
American Redstart	*Setophaga ruticilla*
American Robin	*Turdus migratorius*
American Woodcock	*Scolopax minor*
Bald Eagle	*Haliaeetus leucocephalus*
Bank Swallow	*Riparia riparia*
Barn Swallow	*Hirundo rustica*
Belted Kingfisher	*Megaceryle alcyon*
Black-and-White Warbler	*Mniotilta varia*
Blackburnian Warbler	*Setophaga fusca*
Black-capped Chickadee	*Poecile atricapillus*
Black-throated Blue Warbler	*Setophaga caerulescens*
Black-throated Green Warbler	*Setophaga virens*
Blue Jay	*Cyanocitta cristata*
Blue-headed Vireo	*Vireo solitarius*
Bobolink	*Dolichonyx oryzivorus*
Broad-winged Hawk	*Buteo platypterus*
Brown Creeper	*Certhia americana*
Brown-headed Cowbird	*Molothrus ater*
Canada Goose	*Branta canadensis*
Cedar Waxwing	*Bombycilla cedrorum*
Chestnut-sided Warbler	*Setophaga pensylvanica*
Common Merganser	*Mergus merganser*
Common Nighthawk	*Chordeiles minor*
Common Raven	*Corvus corax*
Common Yellowthroat	*Geothlypis trichas*
Double-crested Cormorant	*Phalacrocorax auritus*
Downy Woodpecker	*Picoides pubescens*
Eastern Kingbird	*Tyrannus tyrannus*
Eastern Phoebe	*Sayornis phoebe*
Eastern Wood-Pewee	*Contopus virens*
European Starling	*Sturnus vulgaris*
Fish Crow	*Corvus ossifragus*
Gray Catbird	*Dumetella carolinensis*
Great Blue Heron	*Ardea herodias*
Great Crested Flycatcher	*Myiarchus crinitus*

Common Name	Latin Name
Great Egret	*Ardea alba*
Green Heron	*Butorides virescens*
Hairy Woodpecker	*Picoides villosus*
Hermit Thrush	*Catharus guttatus*
House Wren	*Troglodytes aedon*
Killdeer	*Charadrius vociferus*
Mallard	*Anas platyrhynchos*
Mourning Dove	*Zenaida macroura*
Northern Cardinal	*Cardinalis cardinalis*
Northern Flicker	*Colaptes auratus*
Northern Waterthrush	*Parkesia noveboracensis*
Osprey	*Pandion haliaetus*
Ovenbird	*Seiurus aurocapilla*
Peregrine Falcon	*Falco peregrinus*
Pileated Woodpecker	*Dryocopus pileatus*
Red-bellied Woodpecker	*Melanerpes carolinus*
Red-eyed Vireo	*Vireo olivaceus*
Red-tailed Hawk	*Buteo jamaicensis*
Red-winged Blackbird	*Agelaius phoeniceus*
Rock Dove	*Columba livia*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Rough-legged Hawk	*Buteo lagopus*
Ruby-throated Hummingbird	*Archilochus colubris*
Scarlet Tanager	*Piranga olivacea*
Song Sparrow	*Melospiza melodia*
Spotted Sandpiper	*Actitis macularius*
Tree Swallow	*Tachycineta bicolor*
Turkey Vulture	*Cathartes aura*
Veery	*Catharus fuscescens*
Wild Turkey	*Meleagris gallopavo*
Winter Wren	*Troglodytes hiemalis*
Wood Duck	*Aix sponsa*
Wood Thrush	*Hylocichla mustelina*
Yellow-bellied Flycatcher	*Empidonax flaviventris*

Mammals

Common Name	Latin Name
American Beaver	*Castor canadensis*
Gray Squirrel	*Scirius carolinensis*
Mink	*Mustela vison*
Muskrat	*Ondatra zibethicus*
Opossum	*Didelphis virginiana*
Red Fox	*Vulpes vulpes*
Red Squirrel	*Sciurus vulgaris*
White-tailed Deer	*Odocoileus virginianus*

Amphibians

Common Name	Latin Name
American Bullfrog	*Lithobates catesbeianus*
American Toad	*Anaxyrus americanus*
Fowlers Toad	*Bufo fowleri*
Gray Tree Frog	*Hyla versicolor*
Green Frog	*Lithobates clamitans melanota*
Spring Peeper	*Pseudacris crucifer*
Wood Frog	*Lithobates sylvaticus*

Reptiles

Common Name	Latin Name
Common Snapping Turtle	*Chelydra serpentina*

Appendix D

Cover Type Maps

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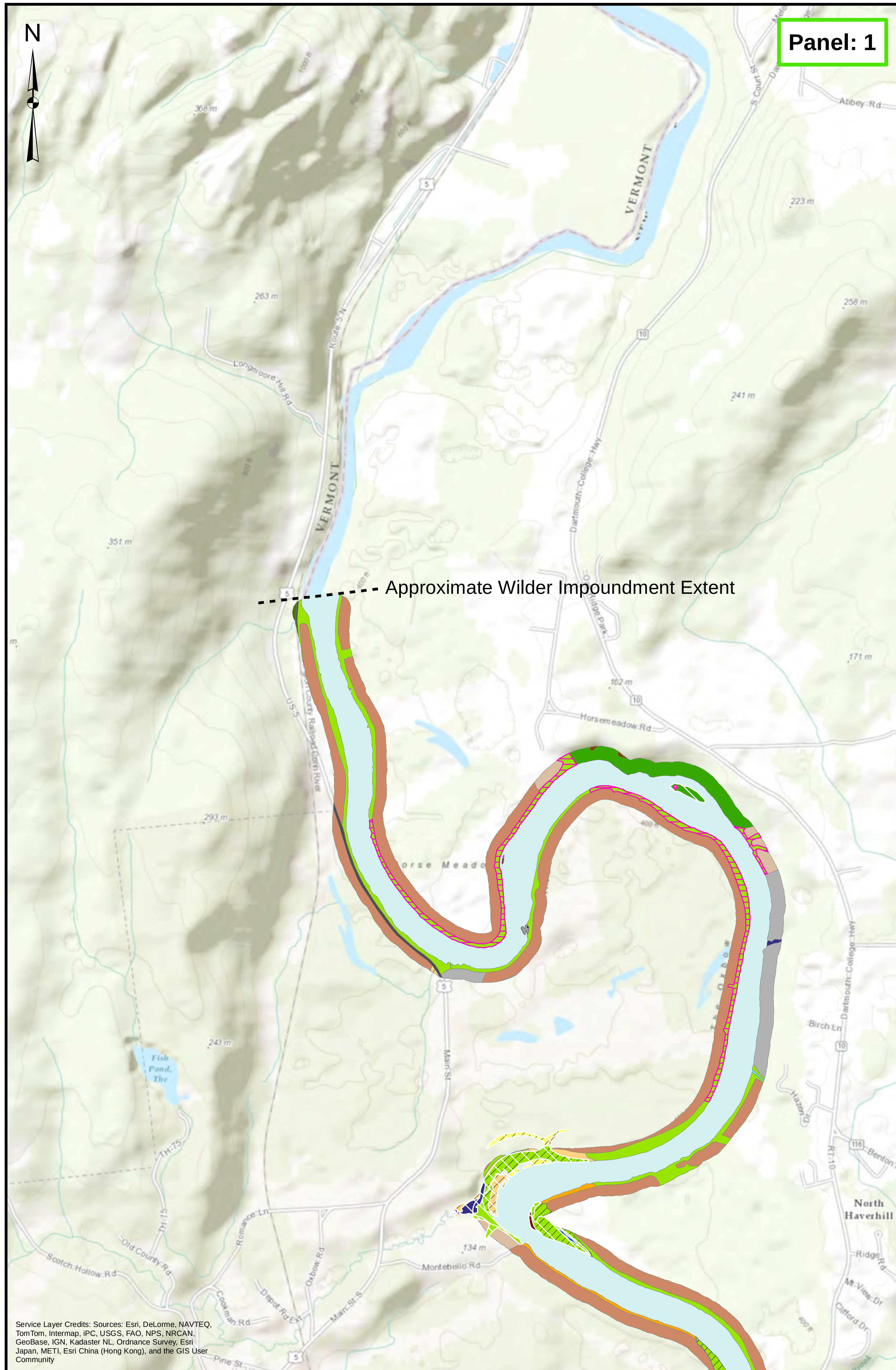
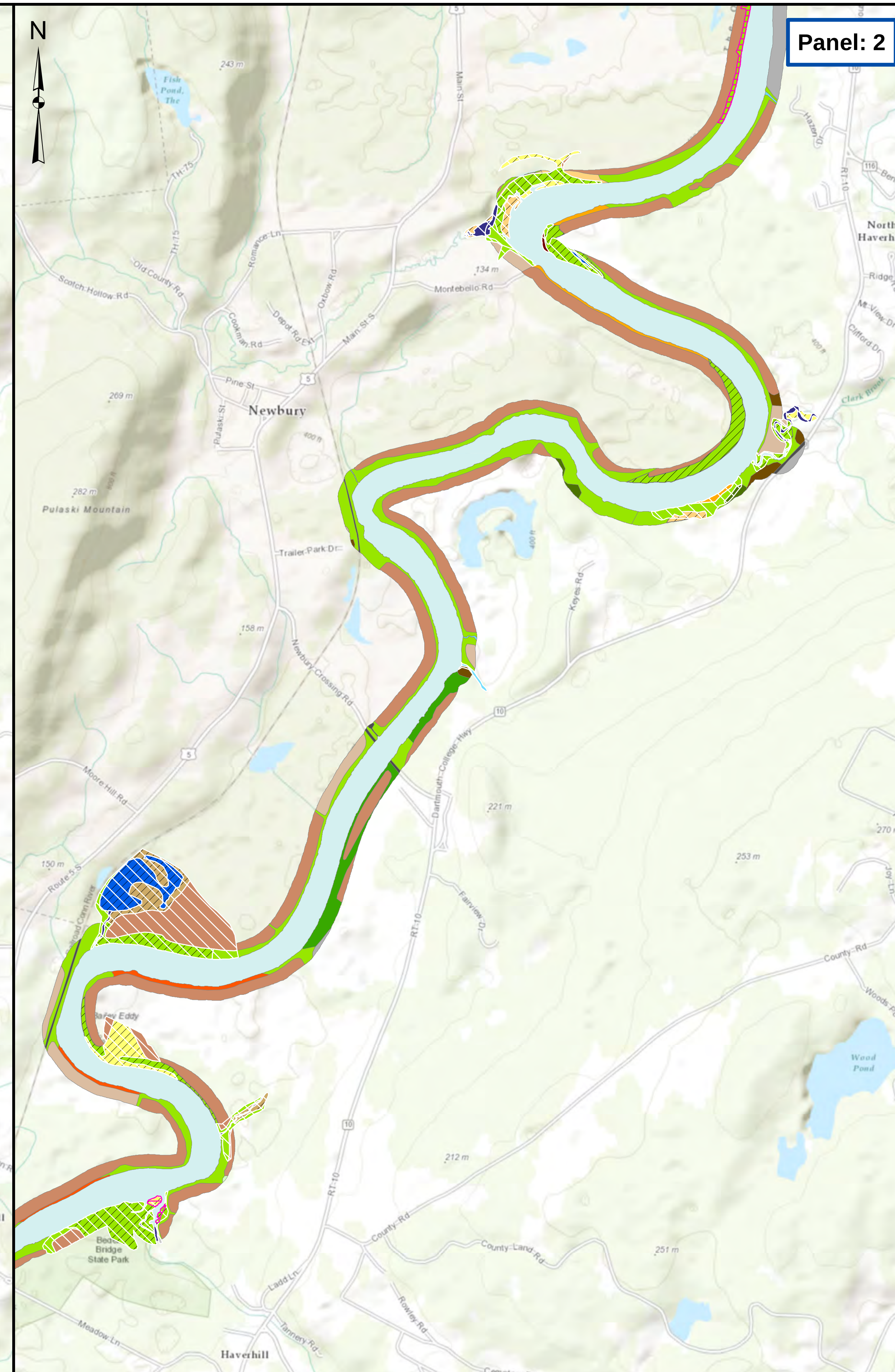
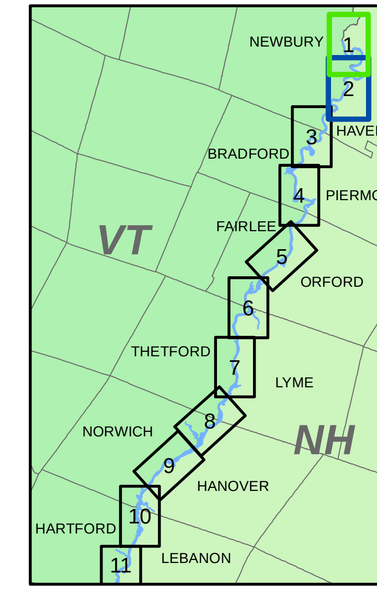
ILP Study 27 - Terrestrial Cover Type and Land Use Maps







0 0.25 0.5 1 Miles

Cover Type

Upland	Wetland	Developed	Riverine
Agriculture Cropland	Emergent	Infrastructure	Sand-Mud
Agriculture Pasture	Phragmites	Commercial	Gravel
Old Field	Forested Deciduous	Residential	Rocky
Large Maintained Grass Land	Forested Decid/Conif	Suburban	Ledge
Shrub	Forested Coniferous	Mineral	Riprap
Hardwood Forest/Shrub	Forested-Emergent		Riverbank
Hardwood Forest	Forested-Shrub		Eroding Bank
Hardwood/Softwood Forest	Scrub-Shrub		
Softwood Forest	Shrub-Emergent		
	Agricultural Wetland		

Aquatic Bed
Pond/Open Water
Potential Vernal Pool
Intermittent Stream
Perennial Stream
Connecticut River

Overlay

Invasive Species
Floodplain

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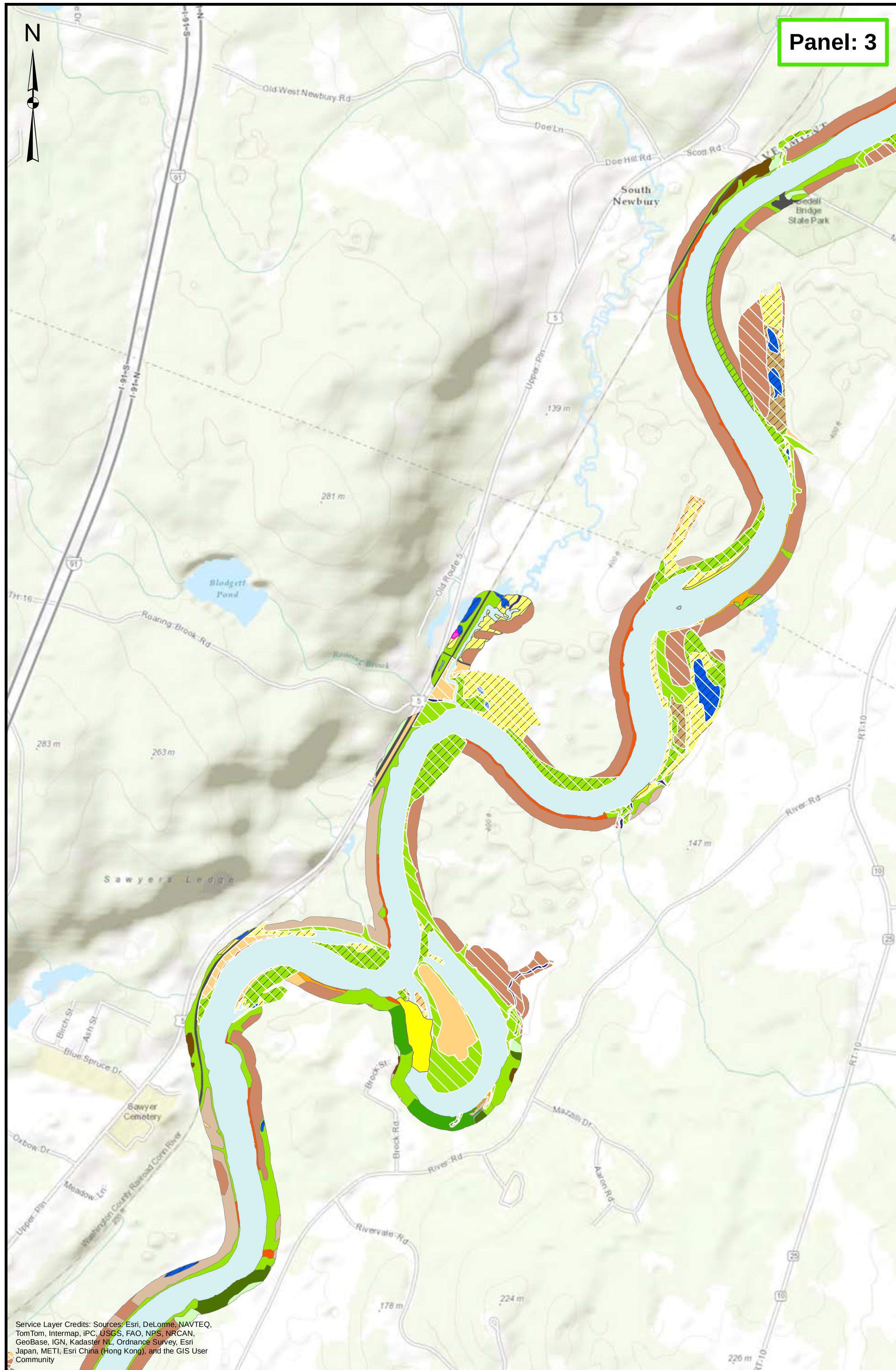
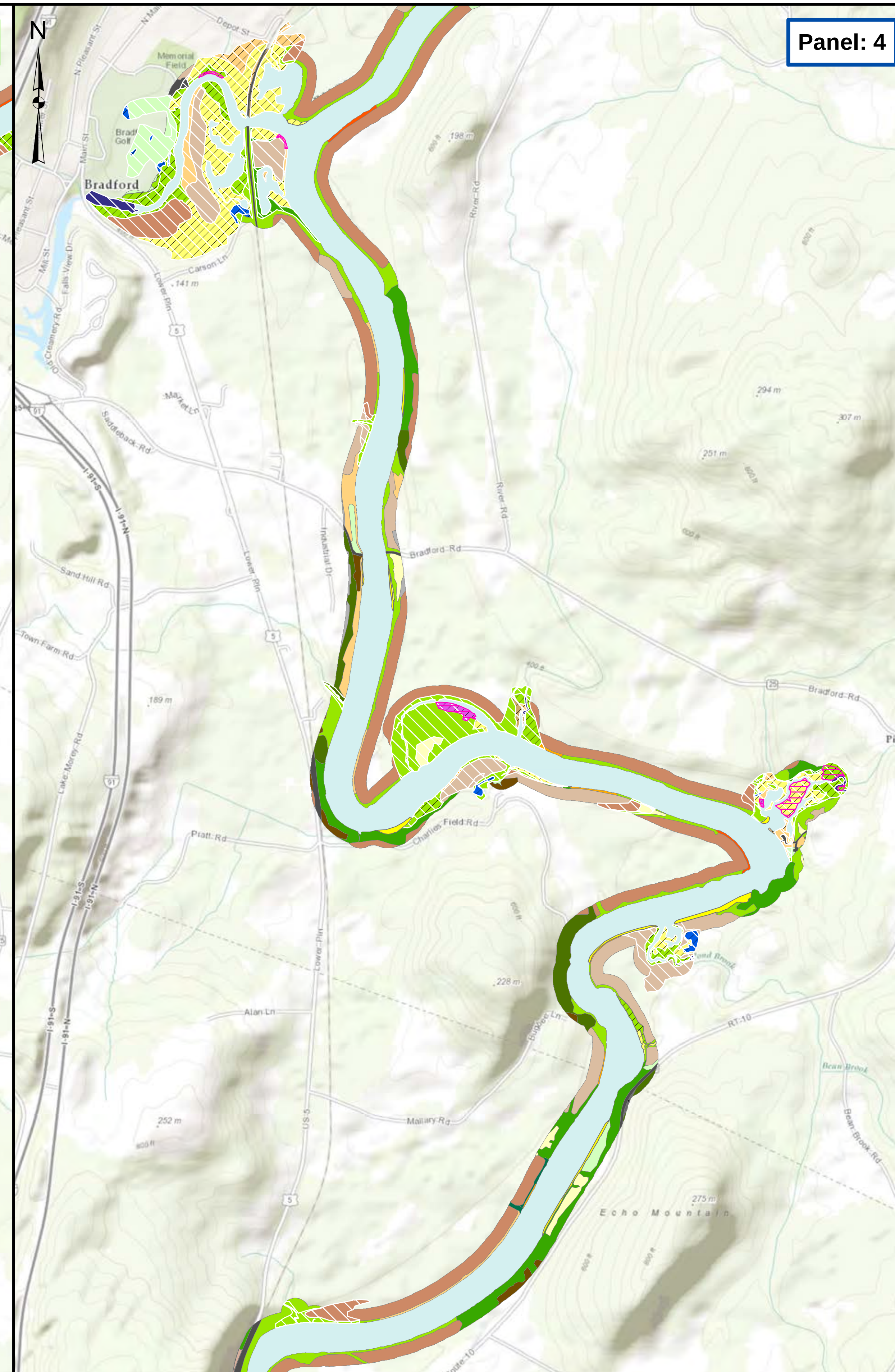
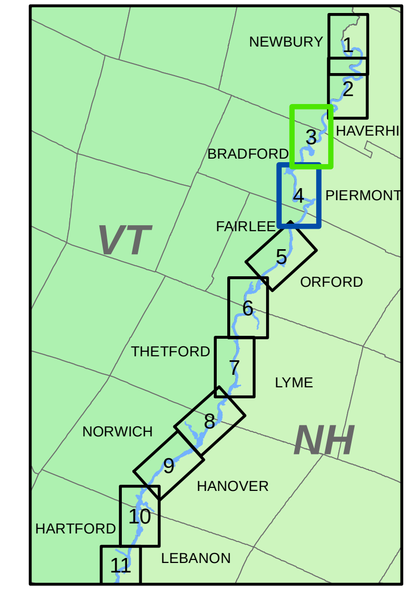
TransCanada Hydro Northeast Inc.

ILP Study 27 - Terrestrial Cover Type and Land Use Maps







0 0.25 0.5 1 Miles

Cover Type

Upland

- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
- Shrub
- Hardwood Forest/Shrub
- Hardwood Forest
- Hardwood/Softwood Forest
- Softwood Forest

Wetland

- Emergent
- Phragmites
- Forested Deciduous
- Forested Decid/Conif
- Forested Coniferous
- Forested-Emergent
- Forested-Shrub
- Scrub-Shrub
- Shrub-Emergent
- Agricultural Wetland
- Aquatic Bed
- Pond/Open Water
- Potential Vernal Pool
- Intermittent Stream
- Perennial Stream
- Connecticut River

Developed

- Infrastructure
- Commercial
- Residential
- Suburban
- Mineral

Riverine

- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay

- Invasive Species
- Floodplain

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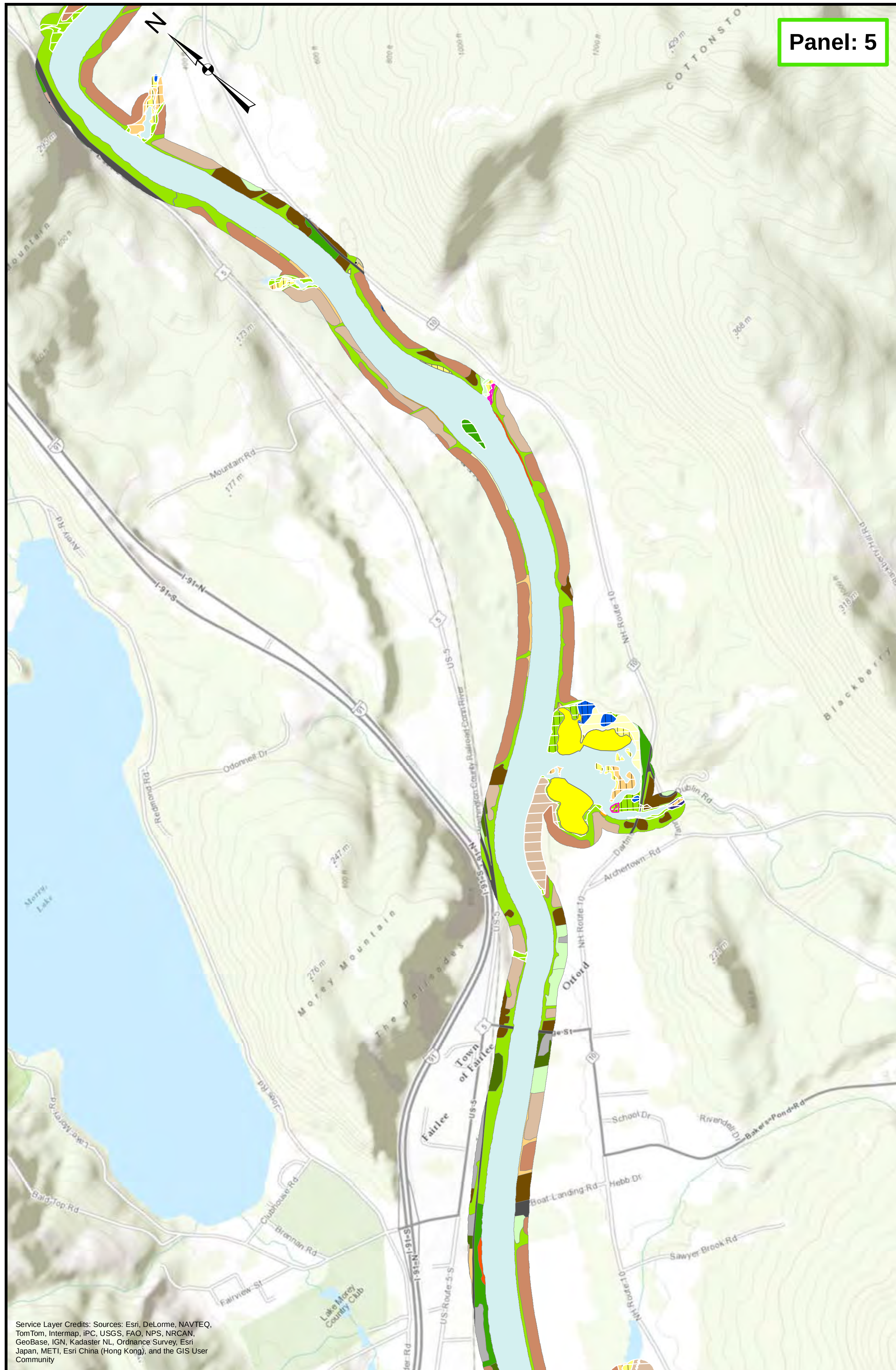

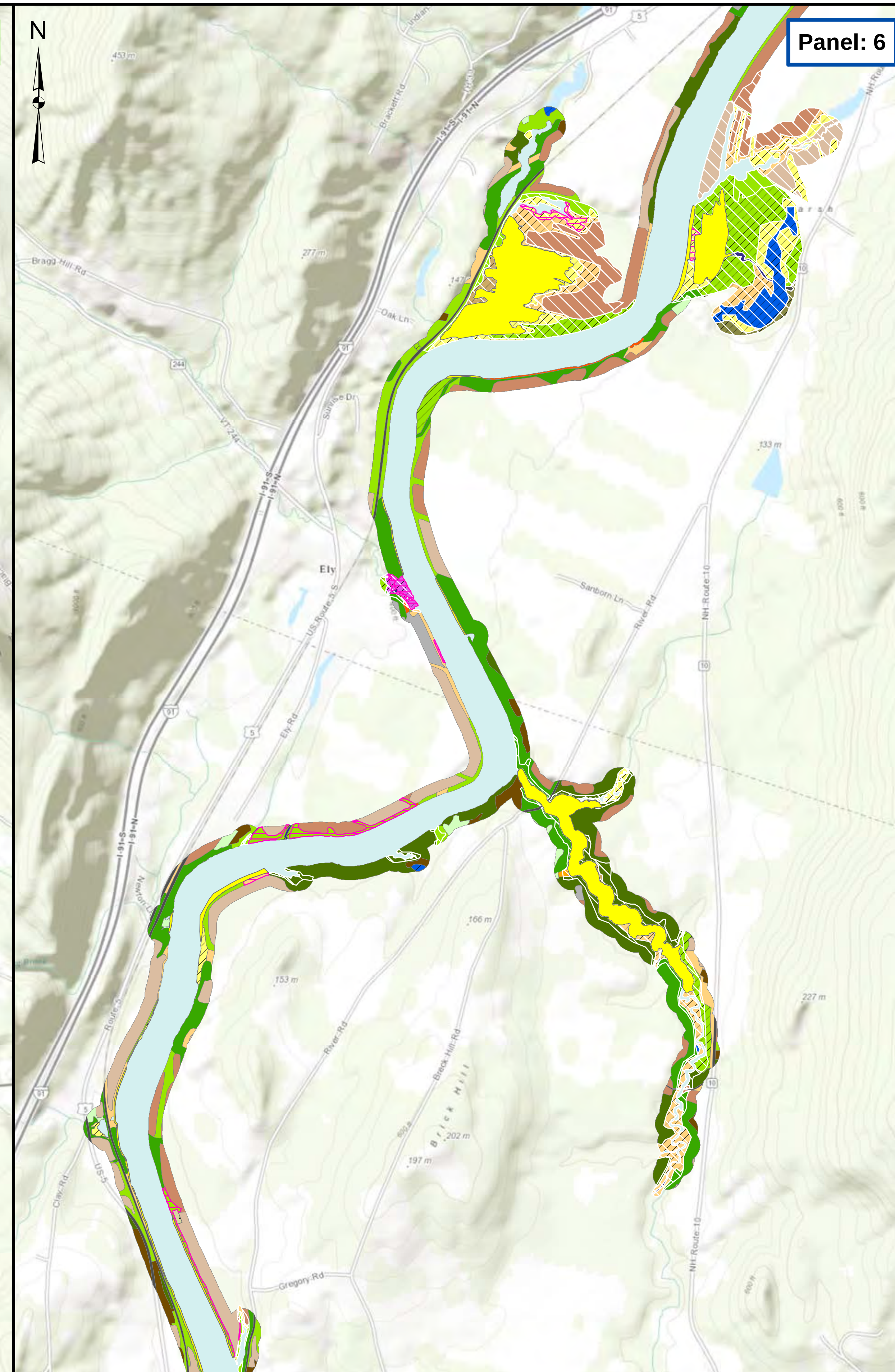

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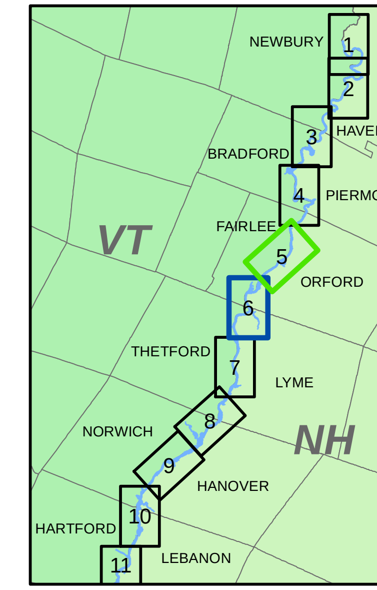
ILP Study 27 - Terrestrial Cover Type and Land Use Maps



0 0.25 0.5 1 Miles

Cover Type

Upland
- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
- Shrub
- Hardwood Forest/Shrub
- Hardwood Forest
- Hardwood/Softwood Forest
- Softwood Forest

Wetland
- Emergent
- Phragmites
- Forested Deciduous
- Forested Decid/Conif
- Forested Coniferous
- Forested-Emergent
- Forested-Shrub
- Scrub-Shrub
- Shrub-Emergent
- Agricultural Wetland

- Aquatic Bed
- Pond/Open Water
- Potential Vernal Pool
- Intermittent Stream
- Perennial Stream
- Connecticut River

Developed
- Infrastructure
- Commercial
- Residential
- Suburban
- Mineral

Riverine
- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay
- Invasive Species
- Floodplain

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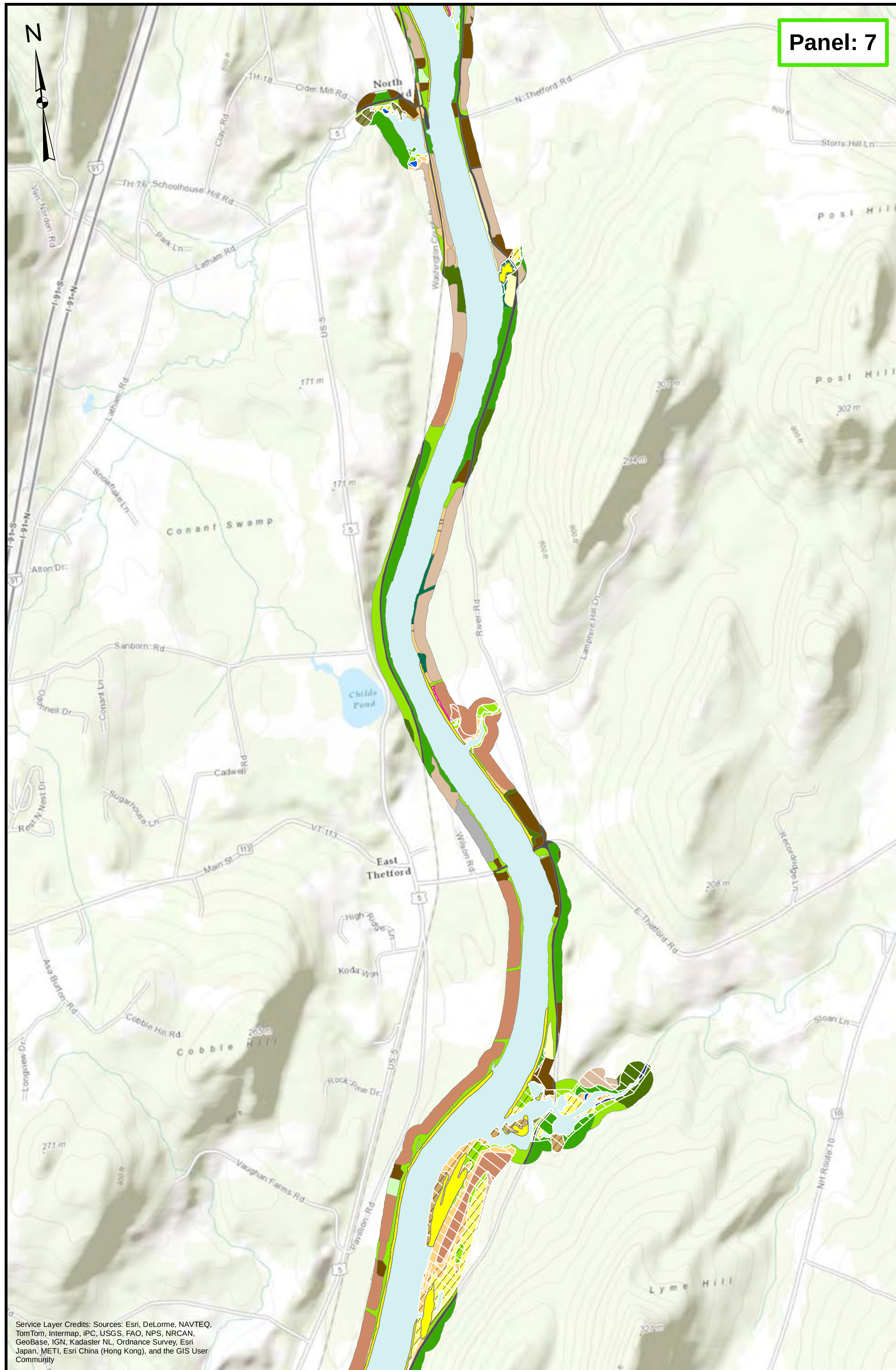
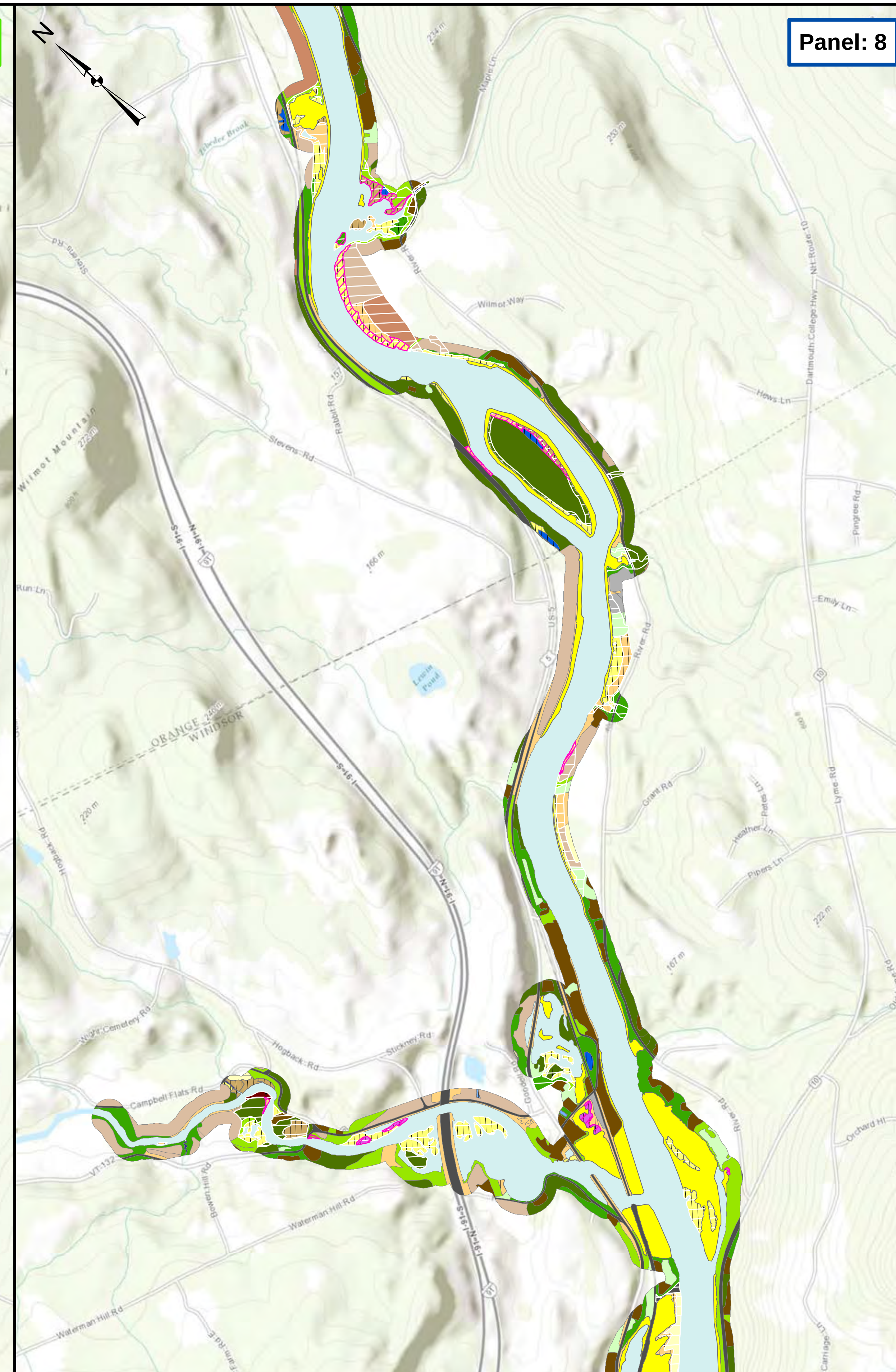
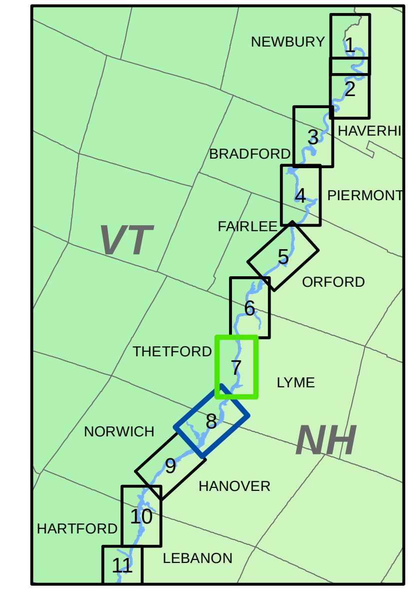
ILP Study 27 - Terrestrial Cover Type and Land Use Maps







0 0.25 0.5 1 Miles

Cover Type

Upland	Aquatic Bed
Agriculture Cropland	Pond/Open Water
Agriculture Pasture	Potential Vernal Pool
Old Field	Intermittent Stream
Large Maintained Grass Land	Perennial Stream
Shrub	Connecticut River
Hardwood Forest/Shrub	**Developed**
Hardwood Forest	Infrastructure
Hardwood/Softwood Forest	Commercial
Softwood Forest	Residential
Wetland	Suburban
Emergent	Mineral
Phragmites	**Riverine**
Forested Deciduous	Sand-Mud
Forested Decid/Conif	Gravel
Forested Coniferous	Rocky
Forested-Emergent	Ledge
Forested-Shrub	Riprap
Scrub-Shrub	Riverbank
Shrub-Emergent	Eroding Bank
Agricultural Wetland	**Overlay**
	Invasive Species
	Floodplain

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Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, iPC, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

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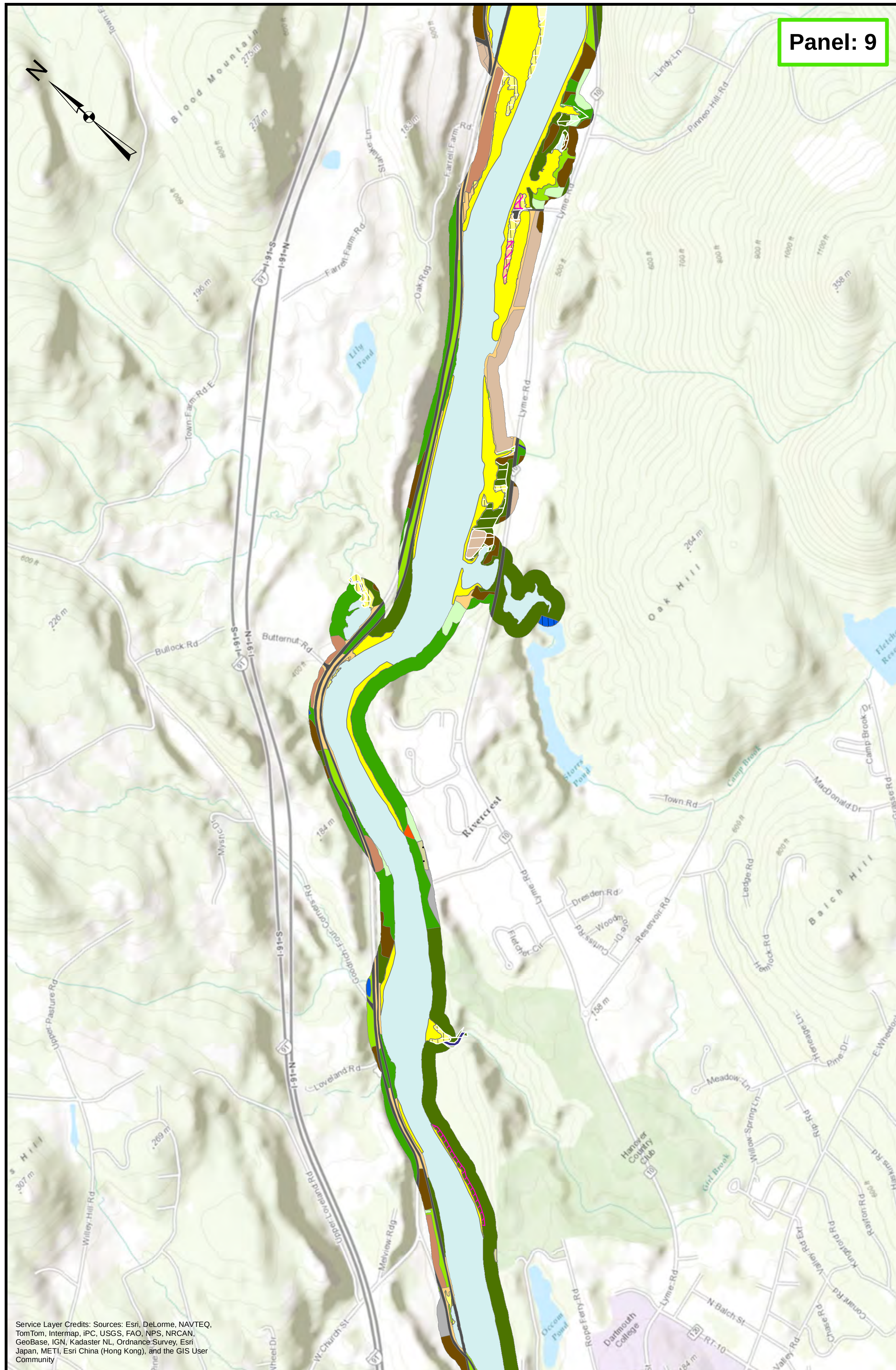

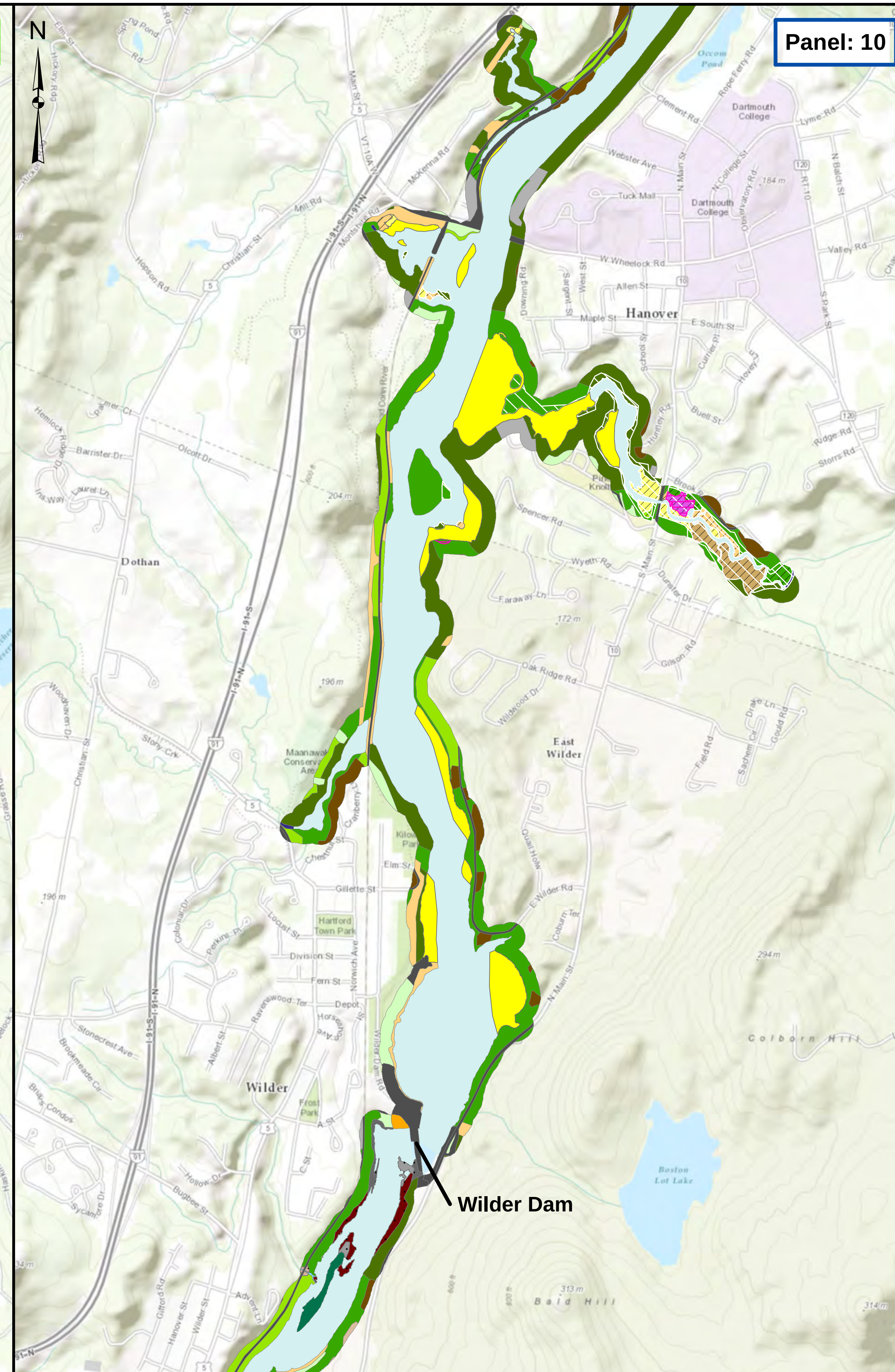

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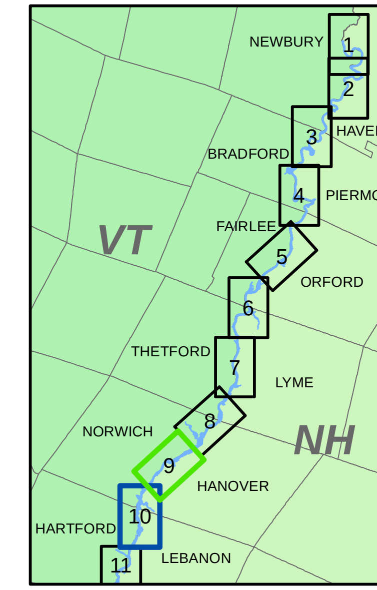
ILP Study 27 - Terrestrial Cover Type and Land Use Maps



0 0.25 0.5 1 Miles

Cover Type

Upland
- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
- Shrub
- Hardwood Forest/Shrub
- Hardwood Forest
- Hardwood/Softwood Forest
- Softwood Forest

Wetland
- Emergent
- Phragmites
- Forested Deciduous
- Forested Decid/Conif
- Forested Coniferous
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- Forested-Shrub
- Scrub-Shrub
- Shrub-Emergent
- Agricultural Wetland

- Aquatic Bed
- Pond/Open Water
- Potential Vernal Pool
- Intermittent Stream
- Perennial Stream
- Connecticut River

Developed
- Infrastructure
- Commercial
- Residential
- Suburban
- Mineral

Riverine
- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay
- Invasive Species
- Floodplain

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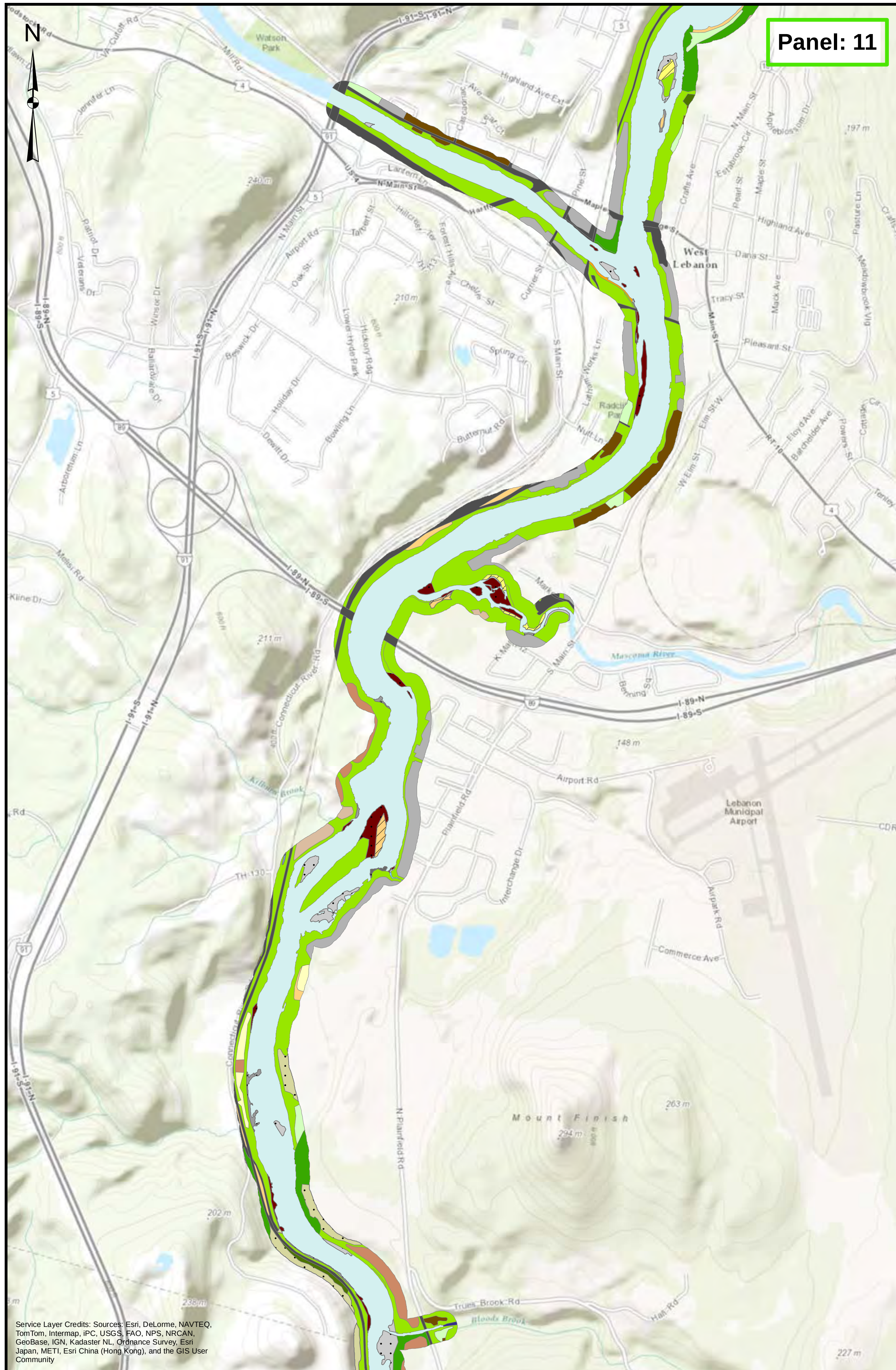

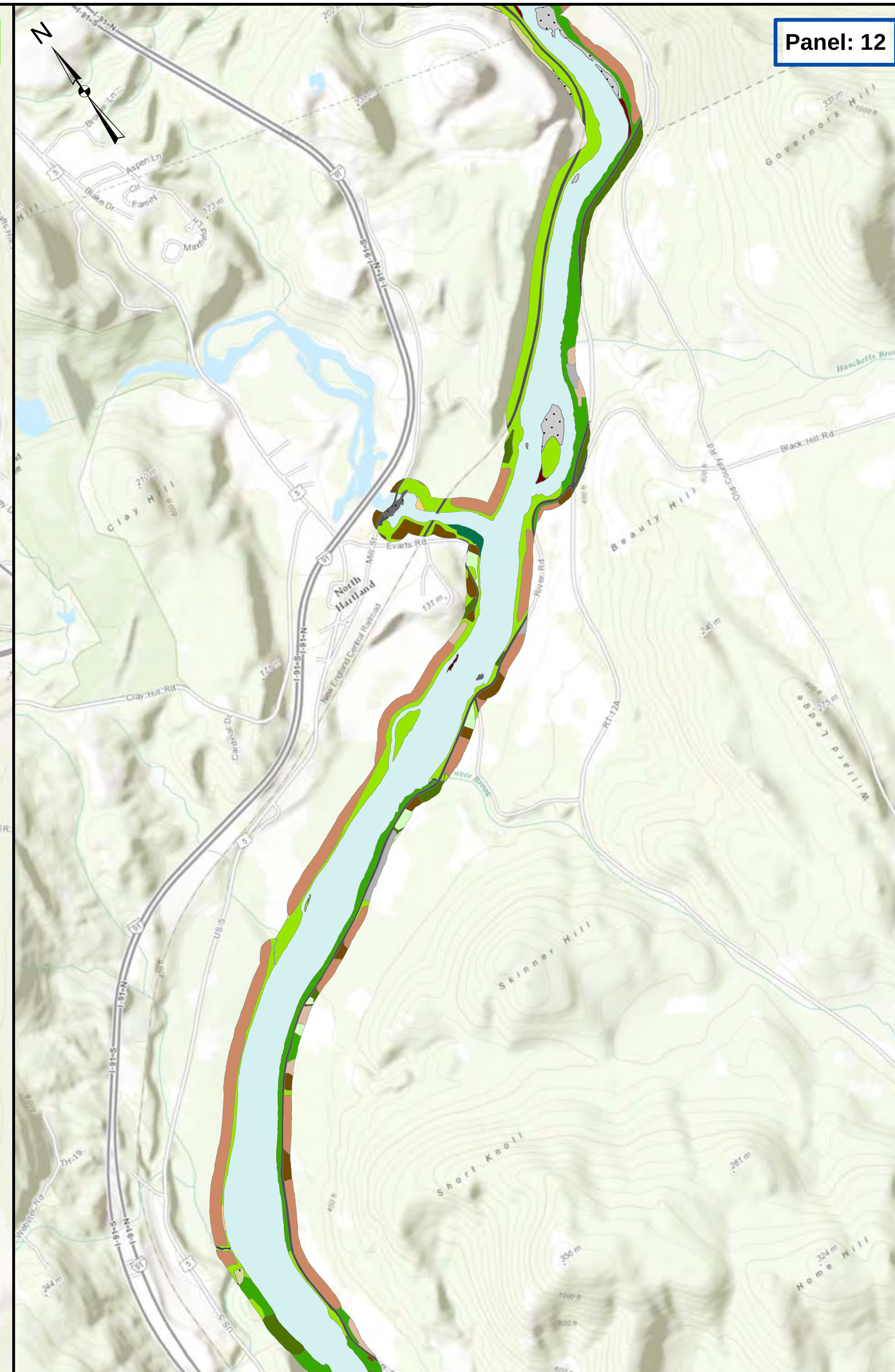

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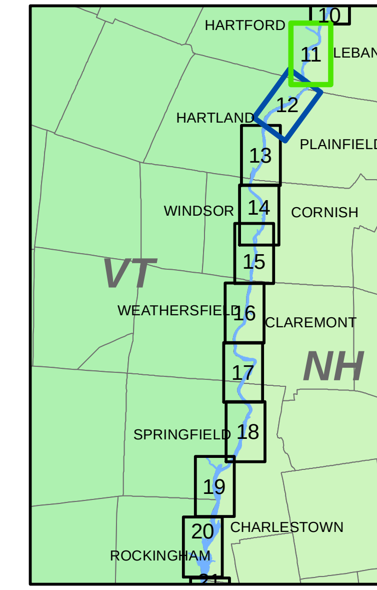
ILP Study 27 - Terrestrial Cover Type and Land Use Maps



0 0.25 0.5 1 Miles

Cover Type

Upland
- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
- Shrub
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- Hardwood Forest
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Wetland
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- Phragmites
- Forested Deciduous
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- Forested-Emergent
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- Shrub-Emergent
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Riverine
- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay
- Invasive Species
- Floodplain

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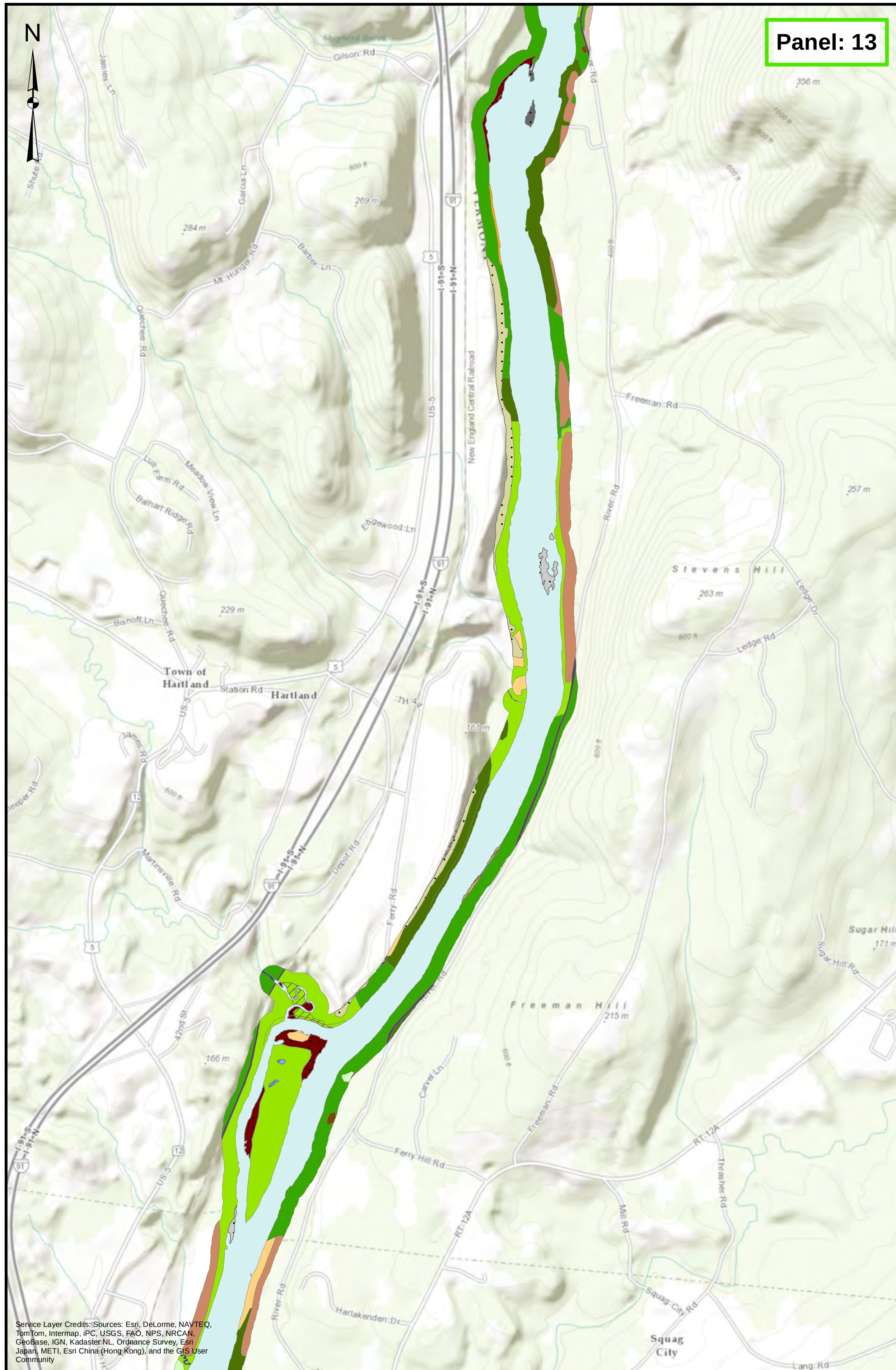
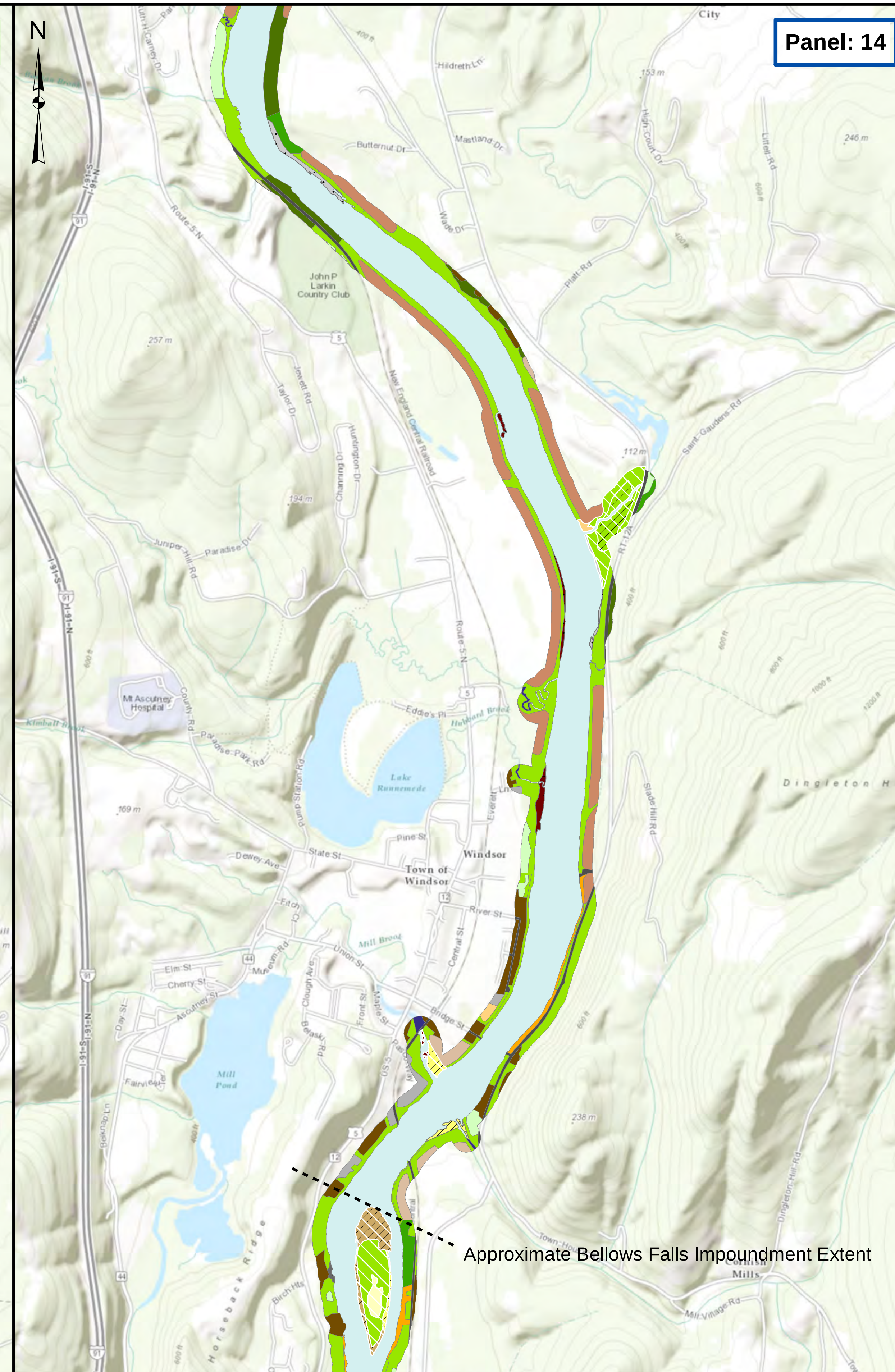
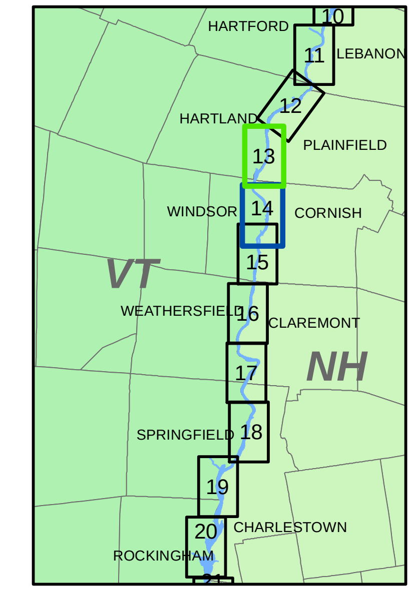
ILP Study 27 - Terrestrial Cover Type and Land Use Maps







0 0.25 0.5 1 Miles

Cover Type

Upland
- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
- Shrub
- Hardwood Forest/Shrub
- Hardwood Forest
- Hardwood/Softwood Forest
- Softwood Forest

Wetland
- Emergent
- Phragmites
- Forested Deciduous
- Forested Decid/Conif
- Forested Coniferous
- Forested-Emergent
- Forested-Shrub
- Scrub-Shrub
- Shrub-Emergent
- Agricultural Wetland

- Aquatic Bed
- Pond/Open Water
- Potential Vernal Pool
- Intermittent Stream
- Perennial Stream
- Connecticut River

Developed
- Infrastructure
- Commercial
- Residential
- Suburban
- Mineral

Riverine
- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay
- Invasive Species
- Floodplain

NORMANDEAU environmental consultants

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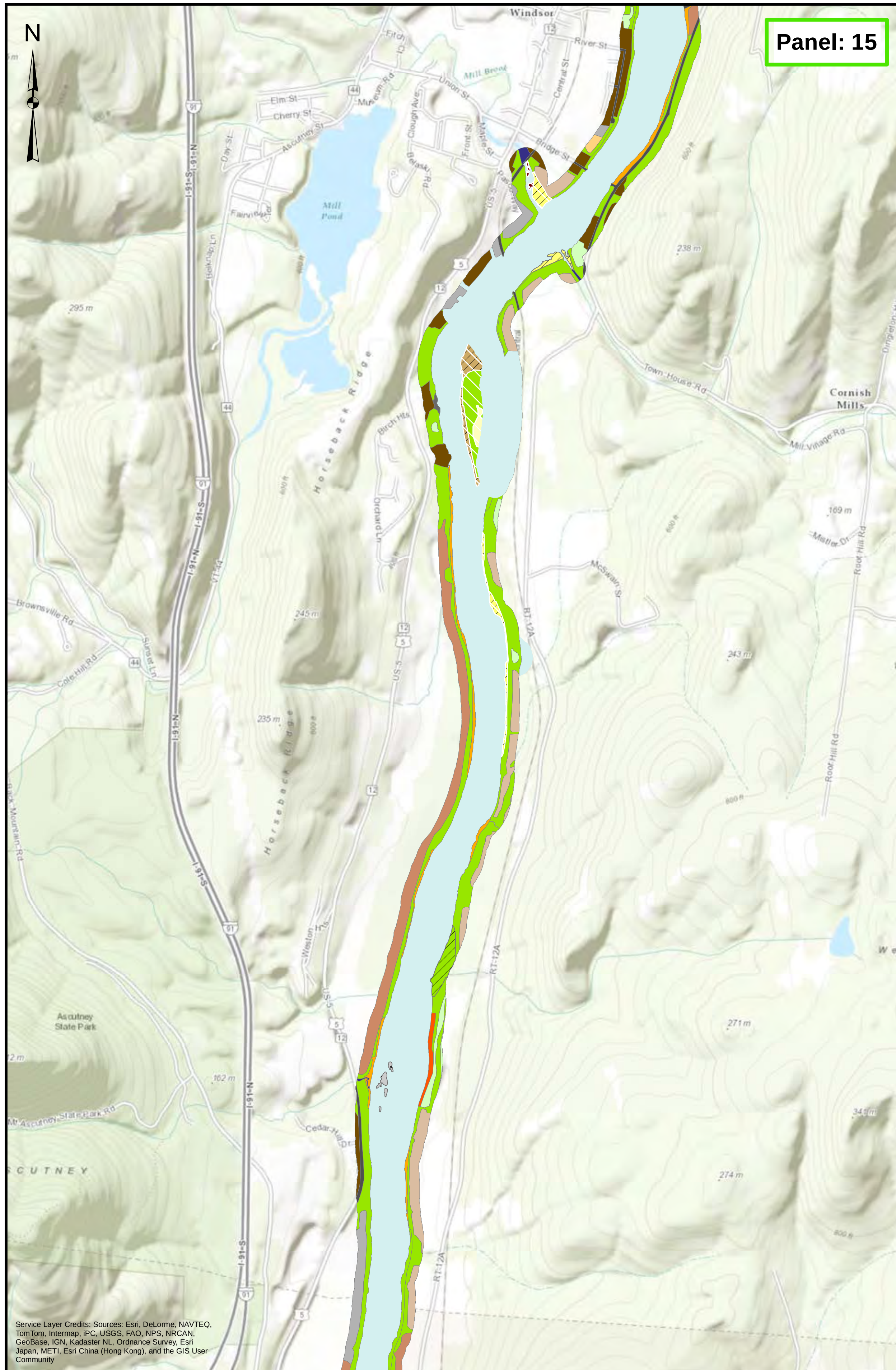
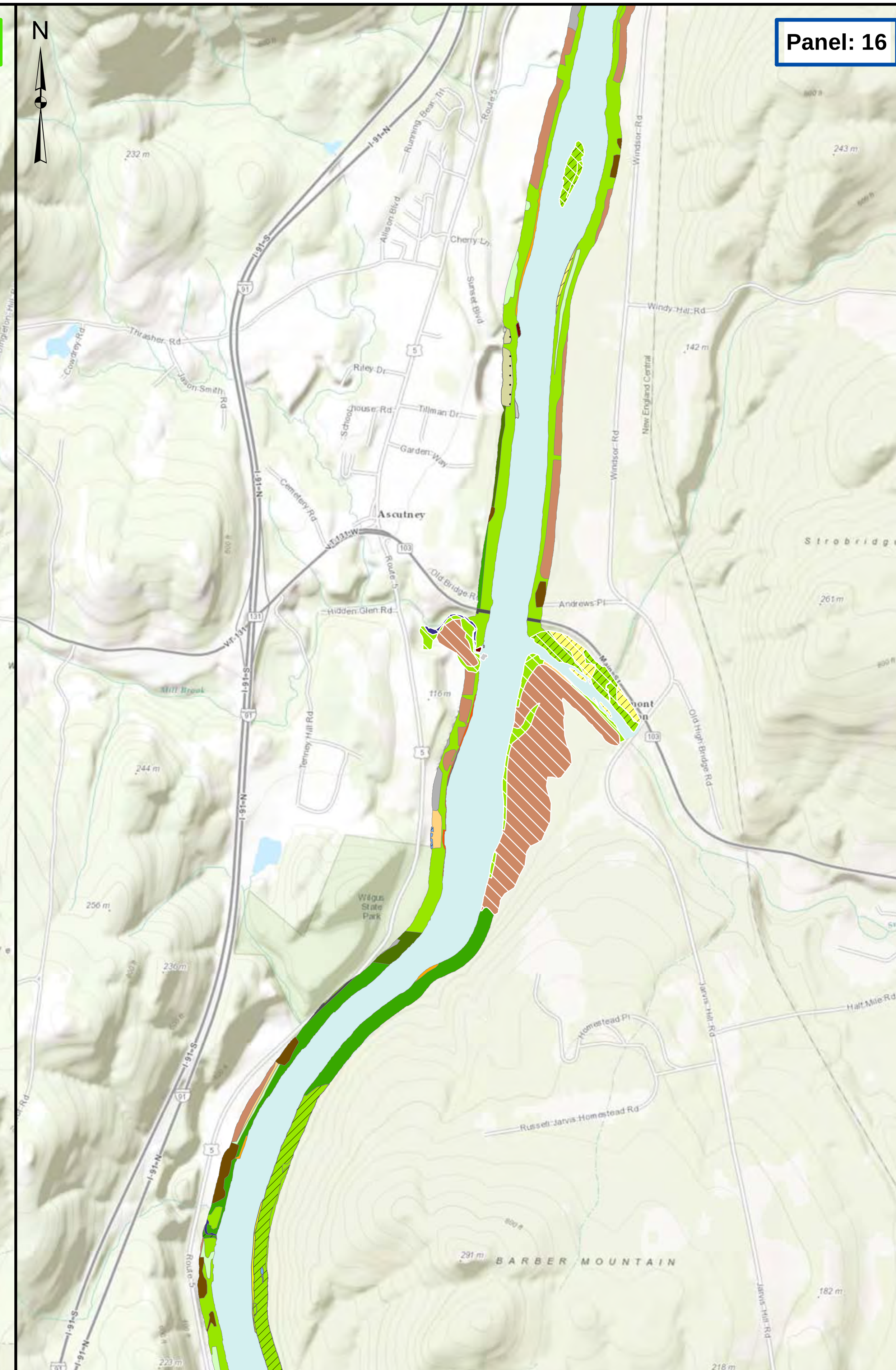
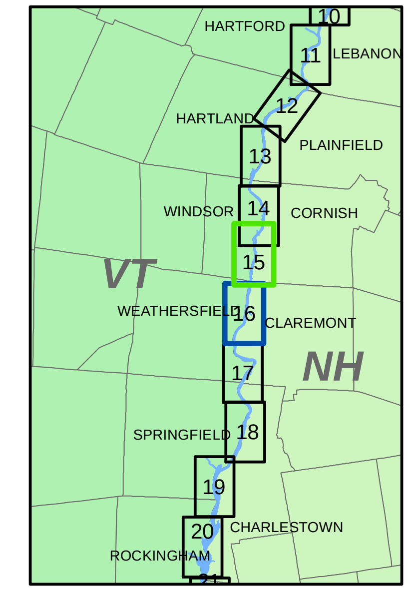




TransCanada Hydro Northeast Inc.

ILP Study 27 - Terrestrial Cover Type and Land Use Maps



0 0.25 0.5 1 Miles

Cover Type

Upland
- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
- Shrub
- Hardwood Forest/Shrub
- Hardwood Forest
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- Softwood Forest

Wetland
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- Shrub-Emergent
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- Potential Vernal Pool
- Intermittent Stream
- Perennial Stream
- Connecticut River

Developed
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- Residential
- Suburban
- Mineral

Riverine
- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay
- Invasive Species
- Floodplain

NORMANDEAU environmental consultants

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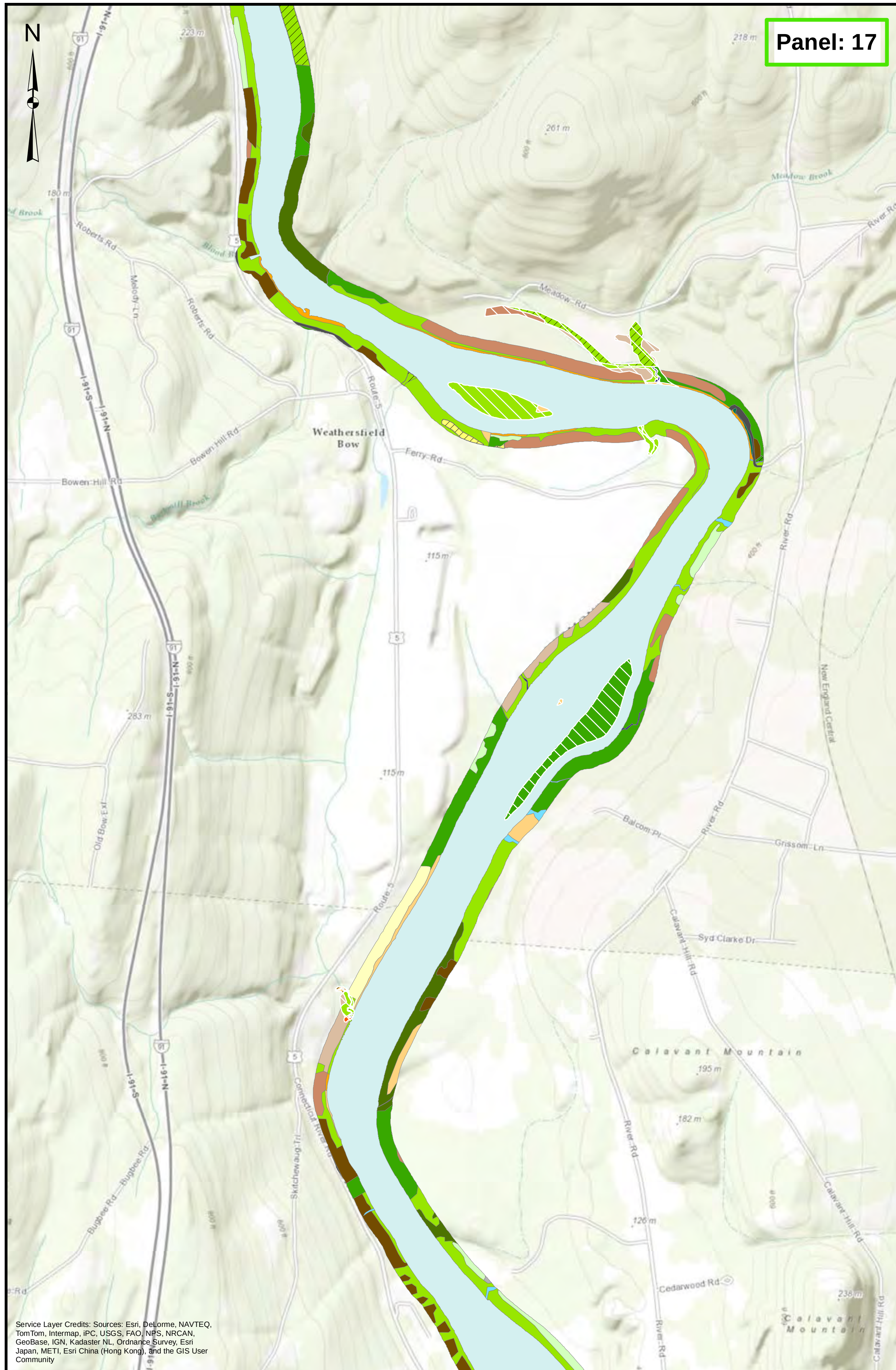

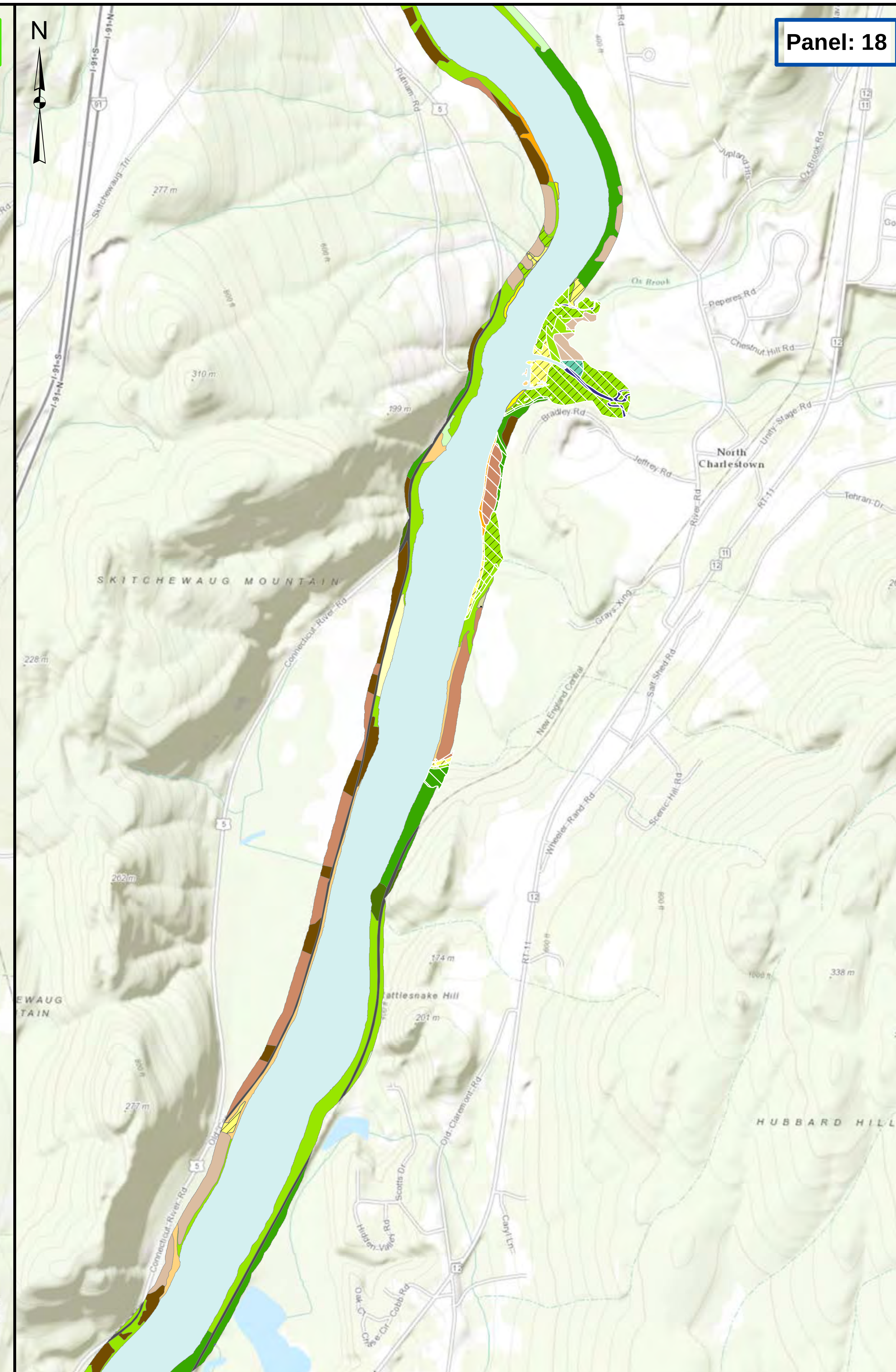

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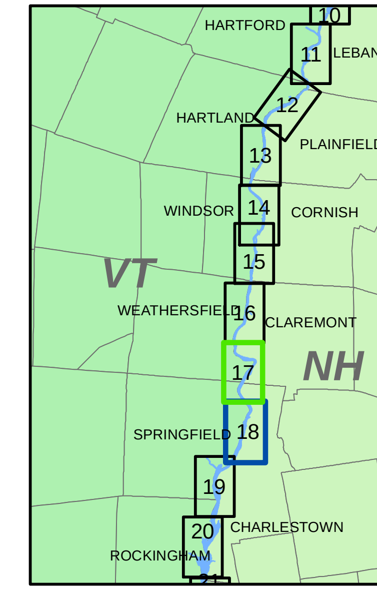
ILP Study 27 - Terrestrial Cover Type and Land Use Maps



0 0.25 0.5 1 Miles

Cover Type

Upland
- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
- Shrub
- Hardwood Forest/Shrub
- Hardwood Forest
- Hardwood/Softwood Forest
- Softwood Forest

Wetland
- Emergent
- Phragmites
- Forested Deciduous
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- Scrub-Shrub
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- Agricultural Wetland

- Aquatic Bed
- Pond/Open Water
- Potential Vernal Pool
- Intermittent Stream
- Perennial Stream
- Connecticut River

Developed
- Infrastructure
- Commercial
- Residential
- Suburban
- Mineral

Riverine
- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay
- Invasive Species
- Floodplain

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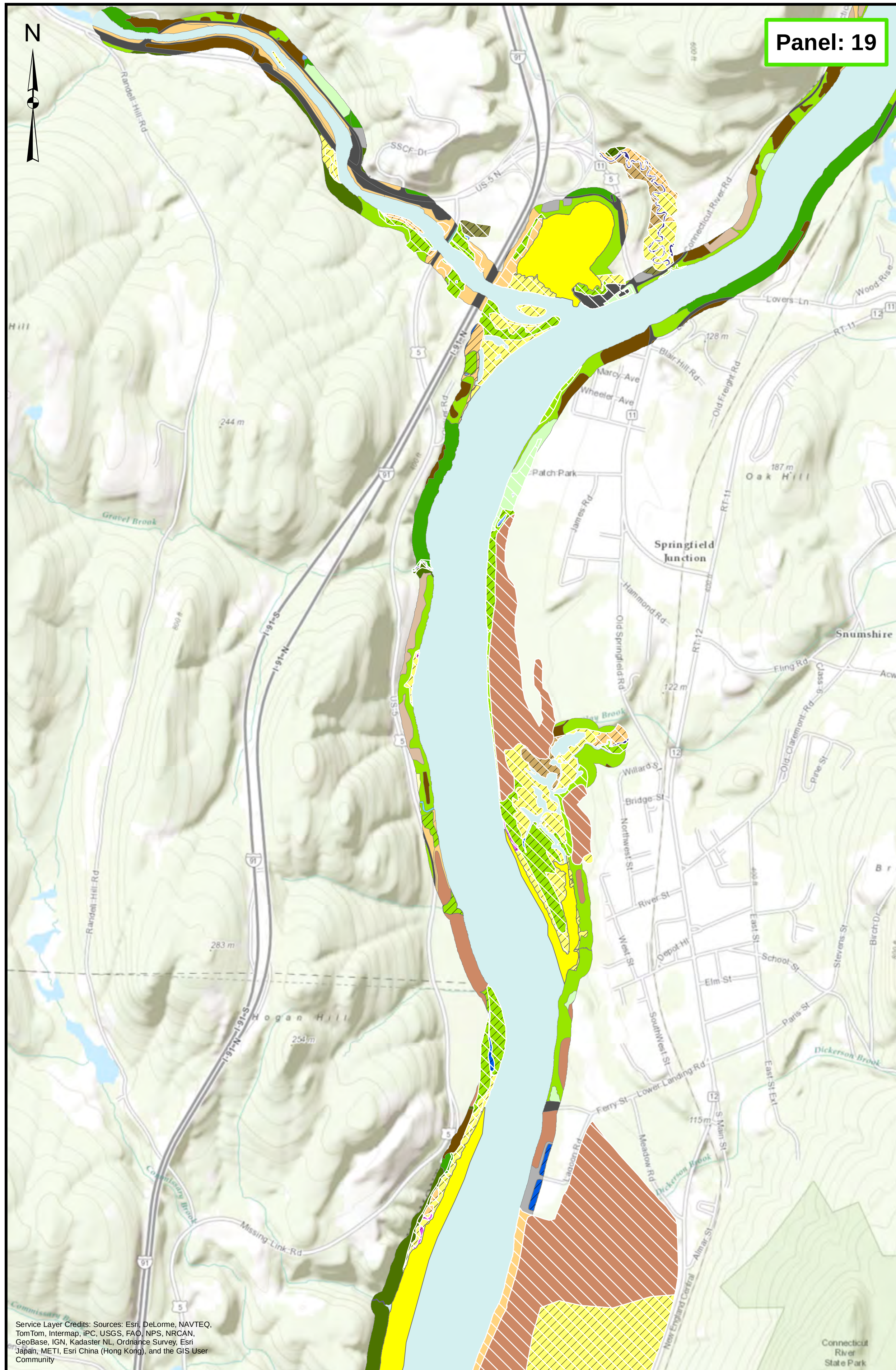
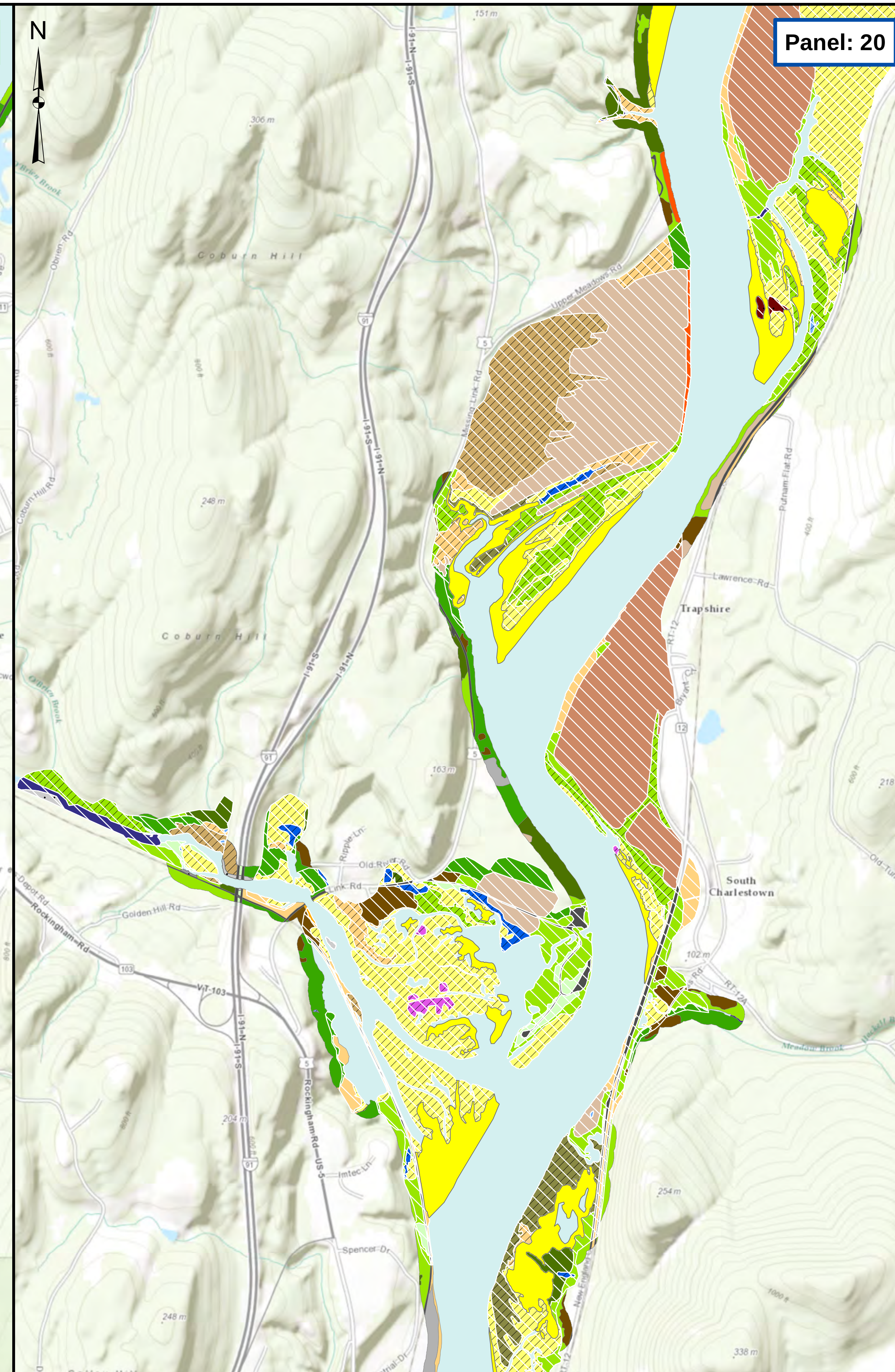
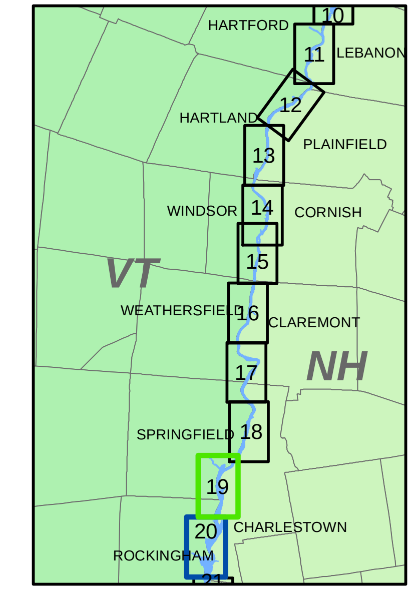
ILP Study 27 - Terrestrial Cover Type and Land Use Maps







0 0.25 0.5 1 Miles

Cover Type

Upland

- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
- Shrub
- Hardwood Forest/Shrub
- Hardwood Forest
- Hardwood/Softwood Forest
- Softwood Forest

Wetland

- Emergent
- Phragmites
- Forested Deciduous
- Forested Decid/Conif
- Forested Coniferous
- Forested-Emergent
- Forested-Shrub
- Scrub-Shrub
- Shrub-Emergent
- Agricultural Wetland

- Aquatic Bed
- Pond/Open Water
- Potential Vernal Pool
- Intermittent Stream
- Perennial Stream
- Connecticut River

Developed

- Infrastructure
- Commercial
- Residential
- Suburban
- Mineral

Riverine

- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay

- Invasive Species
- Floodplain

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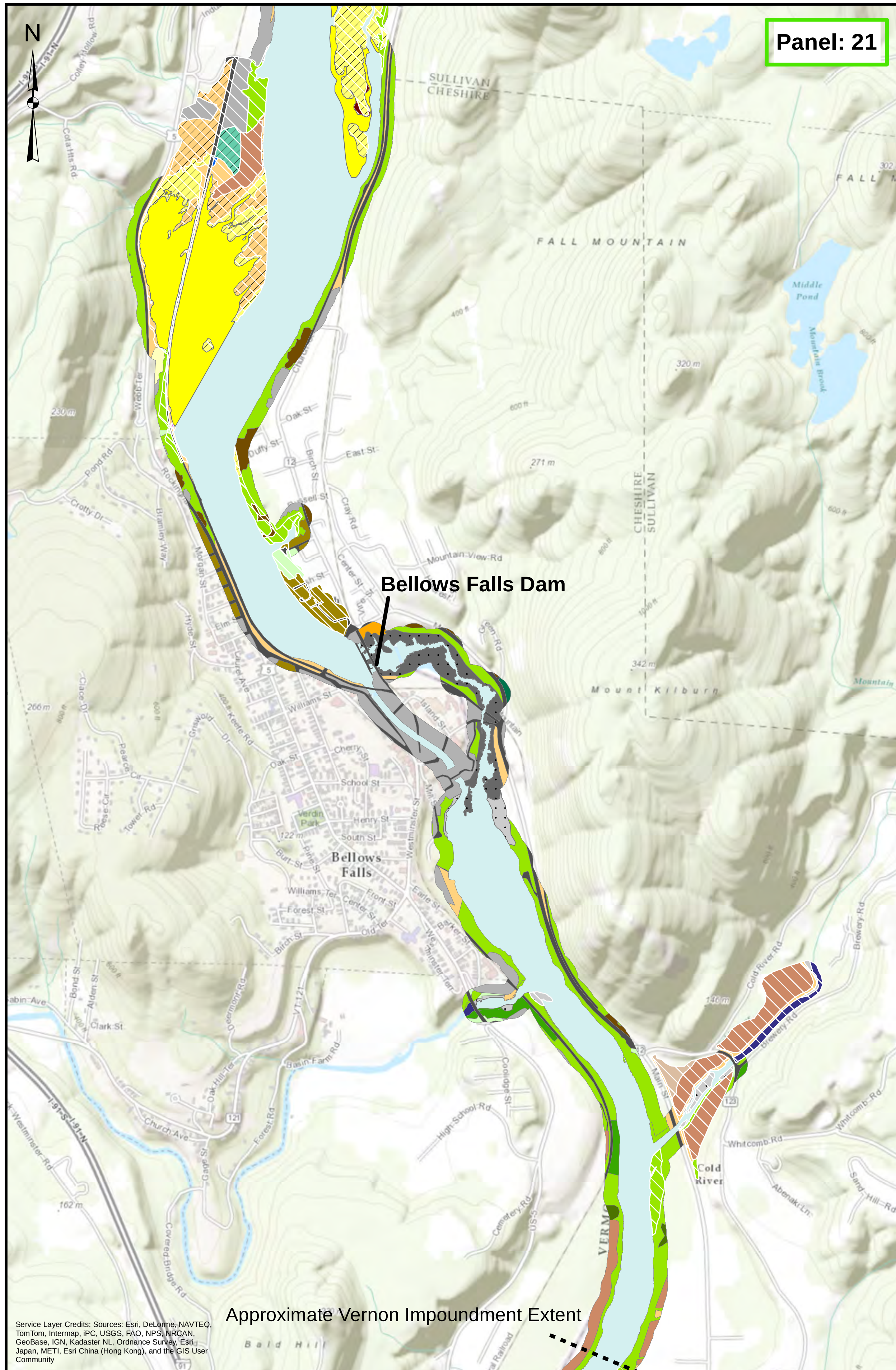
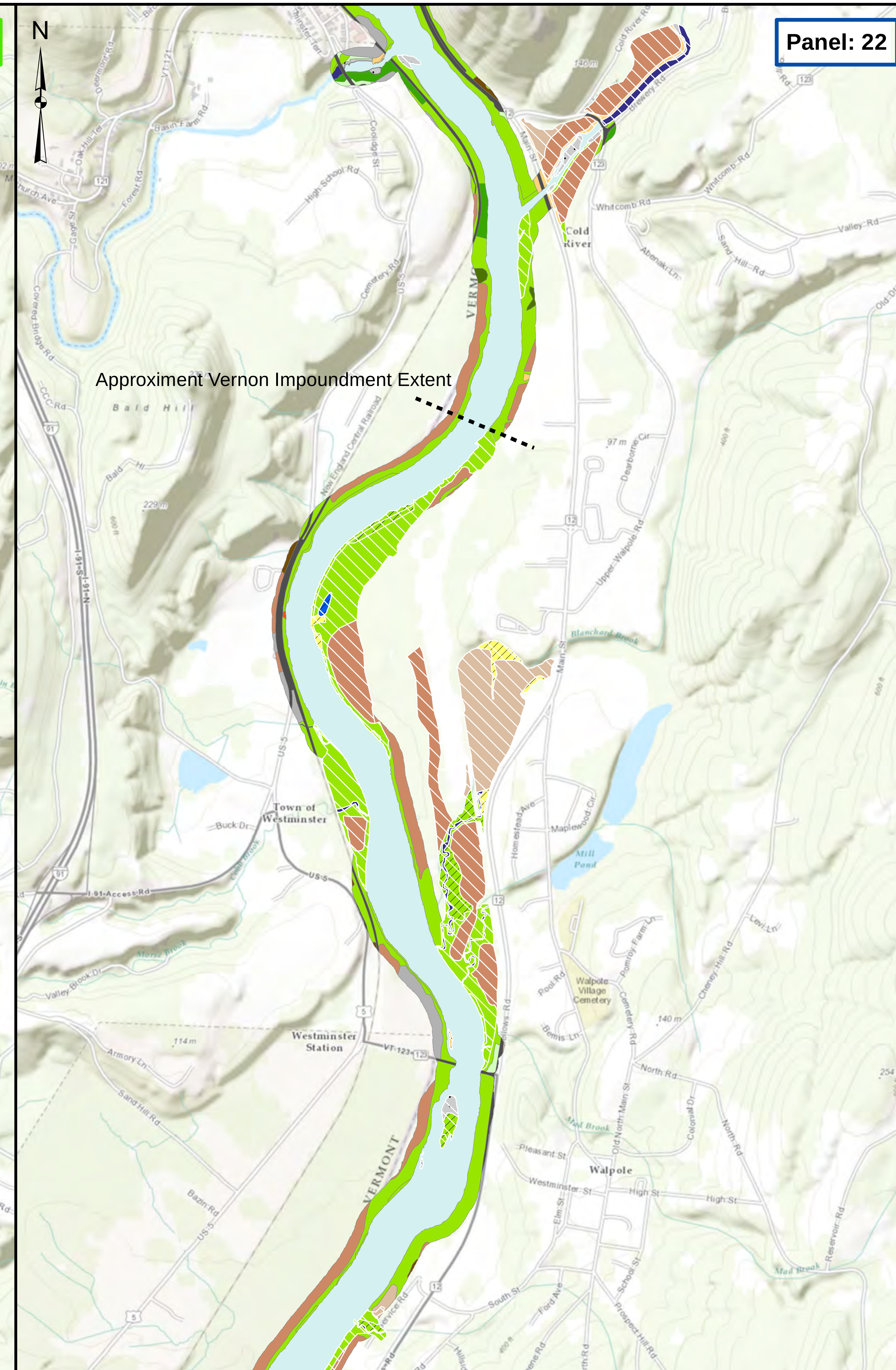
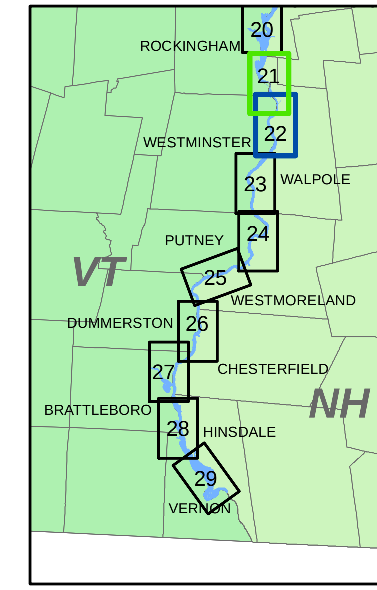
ILP Study 27 - Terrestrial Cover Type and Land Use Maps







0 0.25 0.5 1 Miles

Cover Type

Upland
- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
- Shrub
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Wetland
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- Forested-Emergent
- Forested-Shrub
- Scrub-Shrub
- Shrub-Emergent
- Agricultural Wetland

- Aquatic Bed
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- Potential Vernal Pool
- Intermittent Stream
- Perennial Stream
- Connecticut River

Developed
- Infrastructure
- Commercial
- Residential
- Suburban
- Mineral

Riverine
- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay
- Invasive Species
- Floodplain

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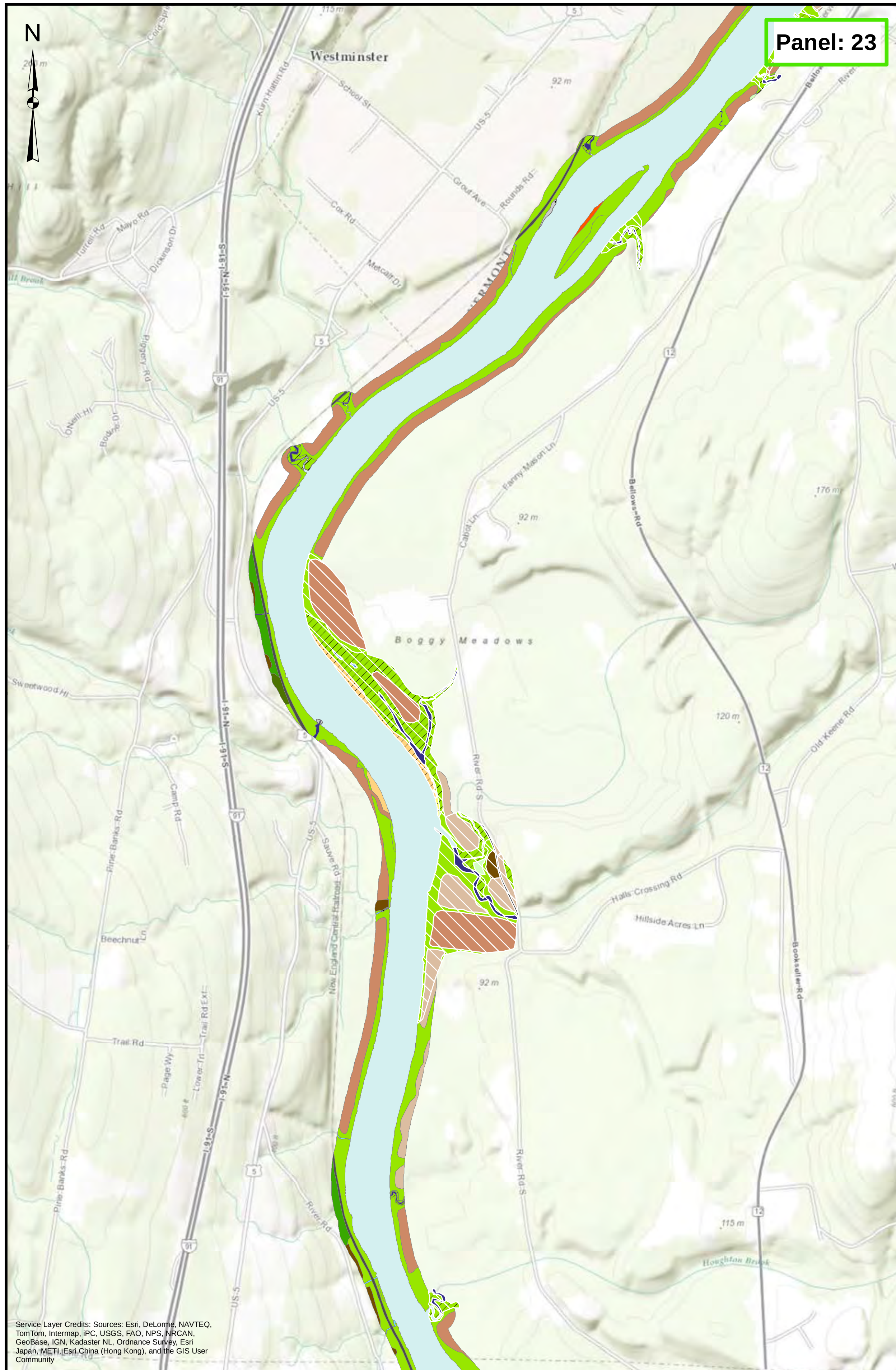

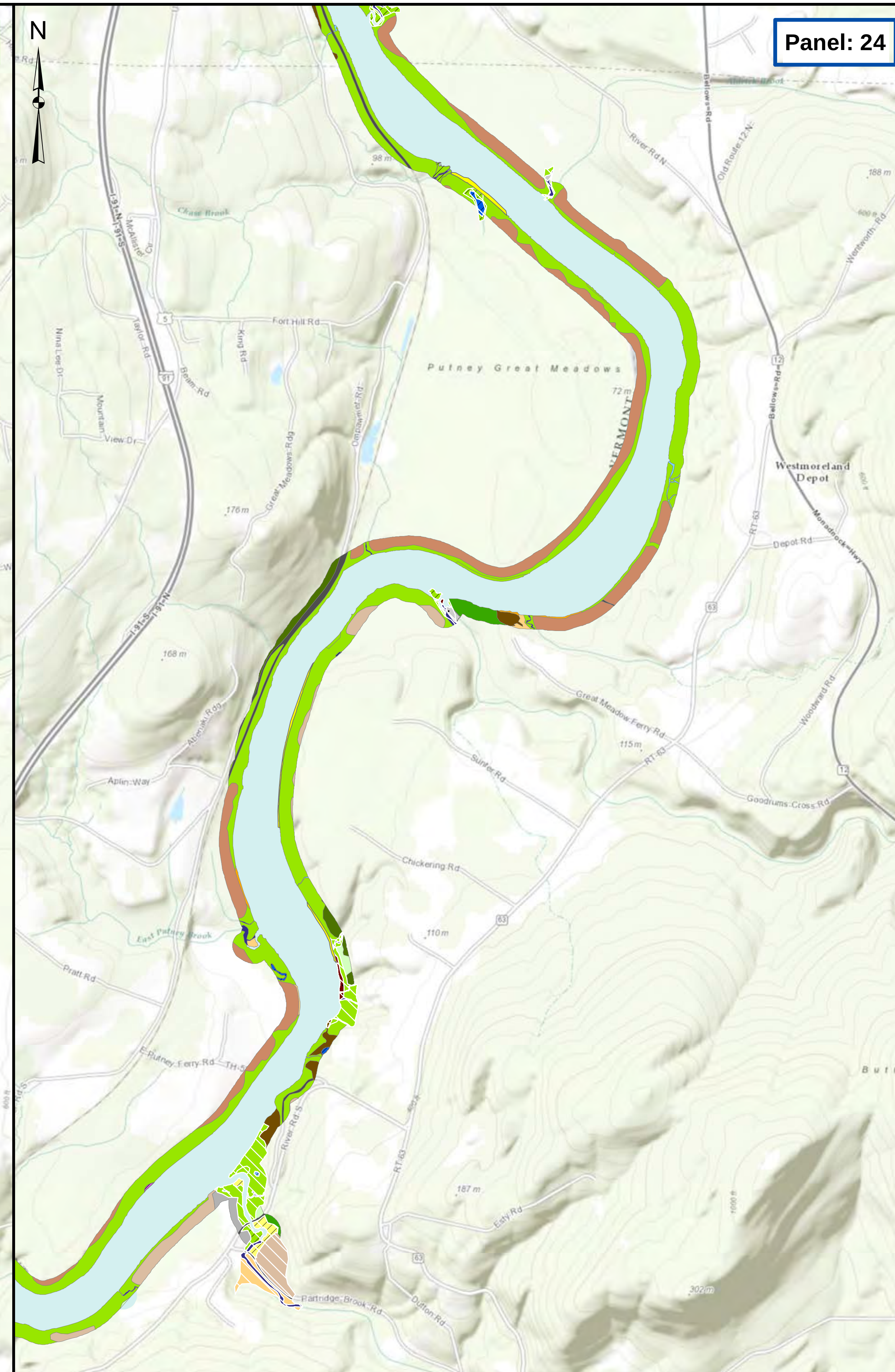

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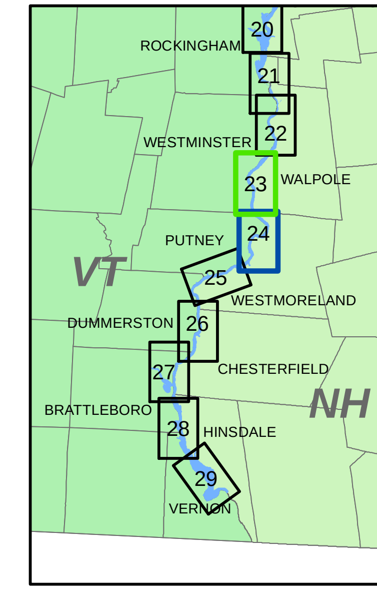
ILP Study 27 - Terrestrial Cover Type and Land Use Maps



0 0.25 0.5 1 Miles

Cover Type

Upland
- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
- Shrub
- Hardwood Forest/Shrub
- Hardwood Forest
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- Softwood Forest

Wetland
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- Aquatic Bed
- Pond/Open Water
- Potential Vernal Pool
- Intermittent Stream
- Perennial Stream
- Connecticut River

Developed
- Infrastructure
- Commercial
- Residential
- Suburban
- Mineral

Riverine
- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay
- Invasive Species
- Floodplain

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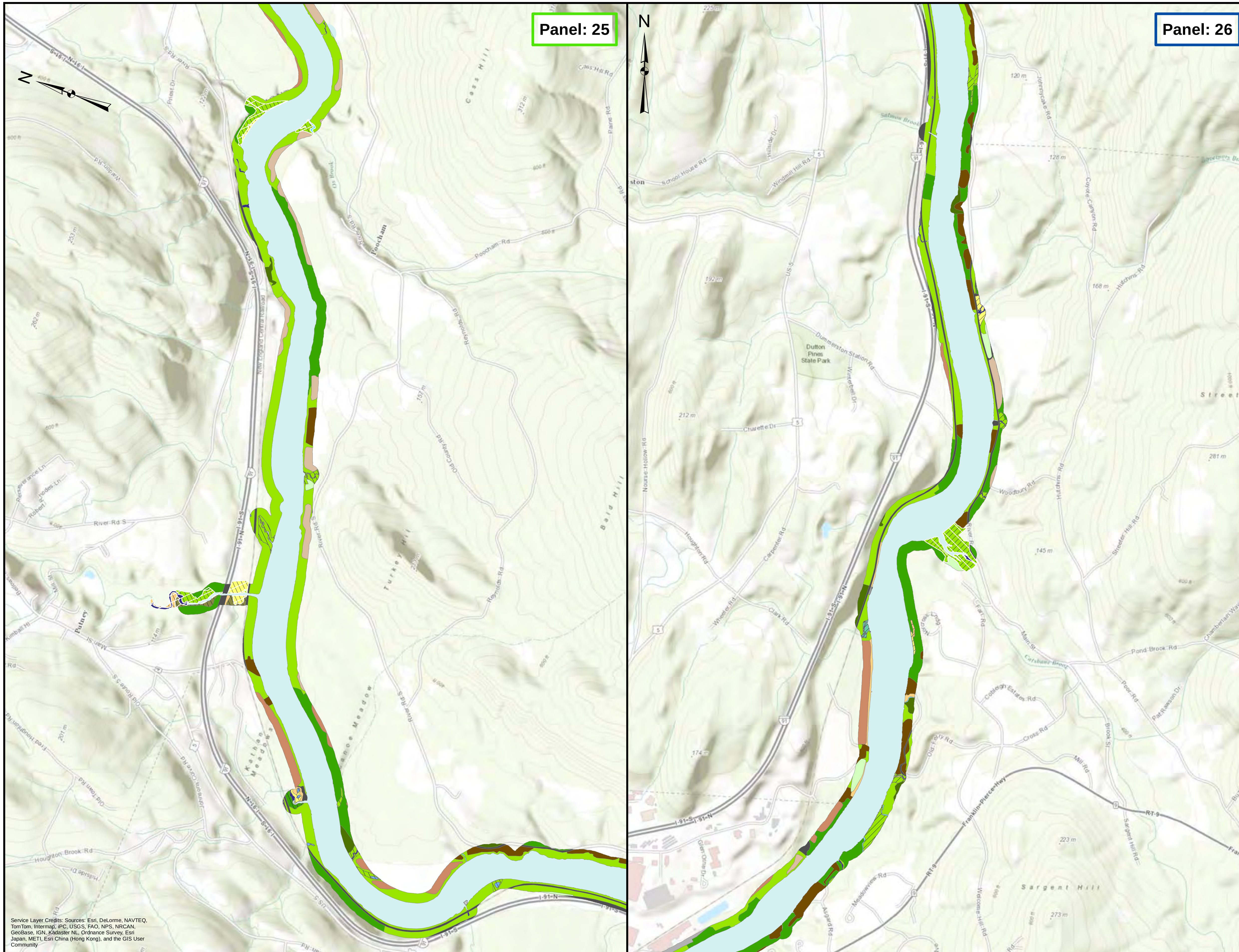
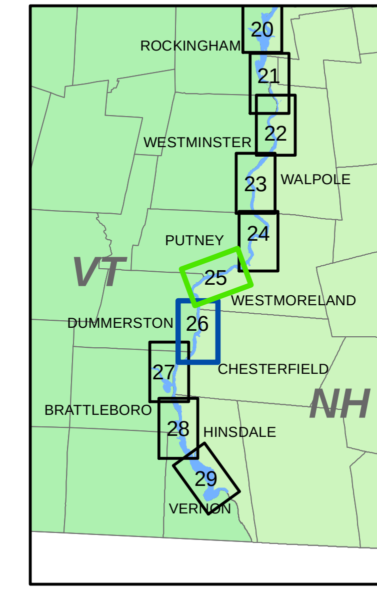


TransCanada Hydro Northeast Inc.

ILP Study 27 - Terrestrial Cover Type and Land Use Maps



0 0.25 0.5 1 Miles

Cover Type

Upland	Wetland	Riverine
Agriculture Cropland	Emergent	Sand-Mud
Agriculture Pasture	Phragmites	Gravel
Old Field	Forested Deciduous	Rocky
Large Maintained Grass Land	Forested Decid/Conif	Ledge
Shrub	Forested Coniferous	Riprap
Hardwood Forest/Shrub	Forested-Emergent	Riverbank
Hardwood Forest	Forested-Shrub	Eroding Bank
Hardwood/Softwood Forest	Scrub-Shrub	
Softwood Forest	Shrub-Emergent	
	Agricultural Wetland	

	Developed	Overlay
Aquatic Bed	Infrastructure	Invasive Species
Pond/Open Water	Commercial	Floodplain
Potential Vernal Pool	Residential	
Intermittent Stream	Suburban	
Perennial Stream	Mineral	
Connecticut River		

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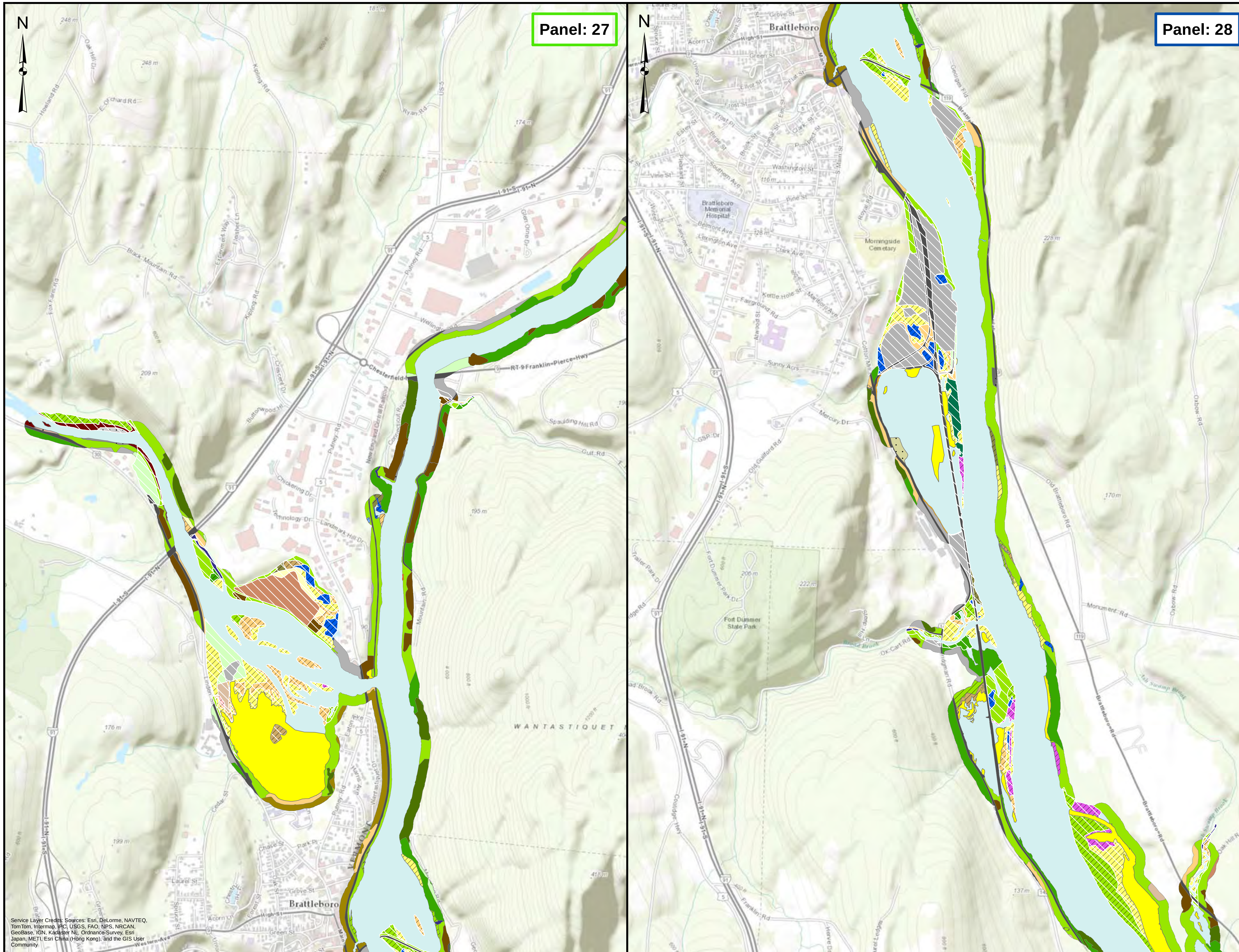

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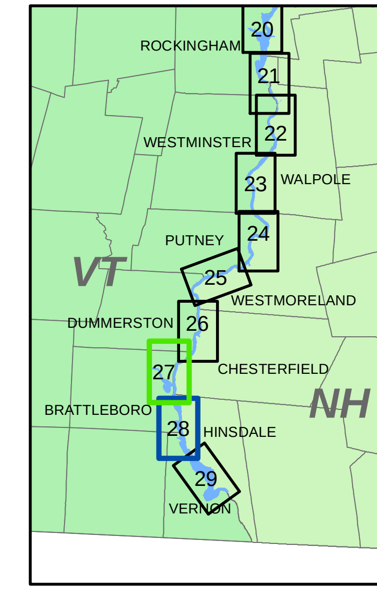
ILP Study 27 - Terrestrial Cover Type and Land Use Maps



0 0.25 0.5 1 Miles

Cover Type

Upland
- Agriculture Cropland
- Agriculture Pasture
- Old Field
- Large Maintained Grass Land
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- Potential Vernal Pool
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- Perennial Stream
- Connecticut River

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- Residential
- Suburban
- Mineral

Riverine
- Sand-Mud
- Gravel
- Rocky
- Ledge
- Riprap
- Riverbank
- Eroding Bank

Overlay
- Invasive Species
- Floodplain

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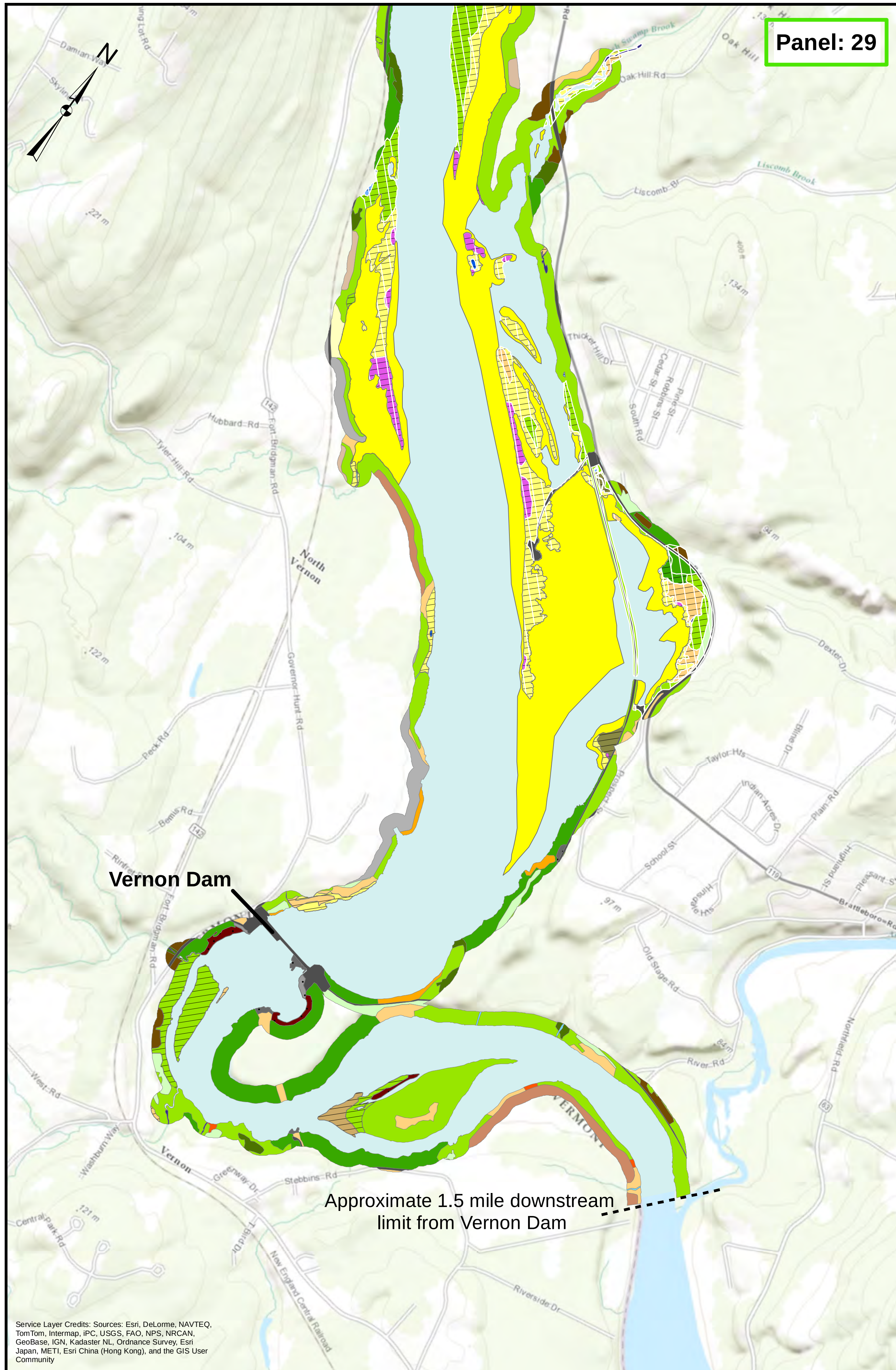

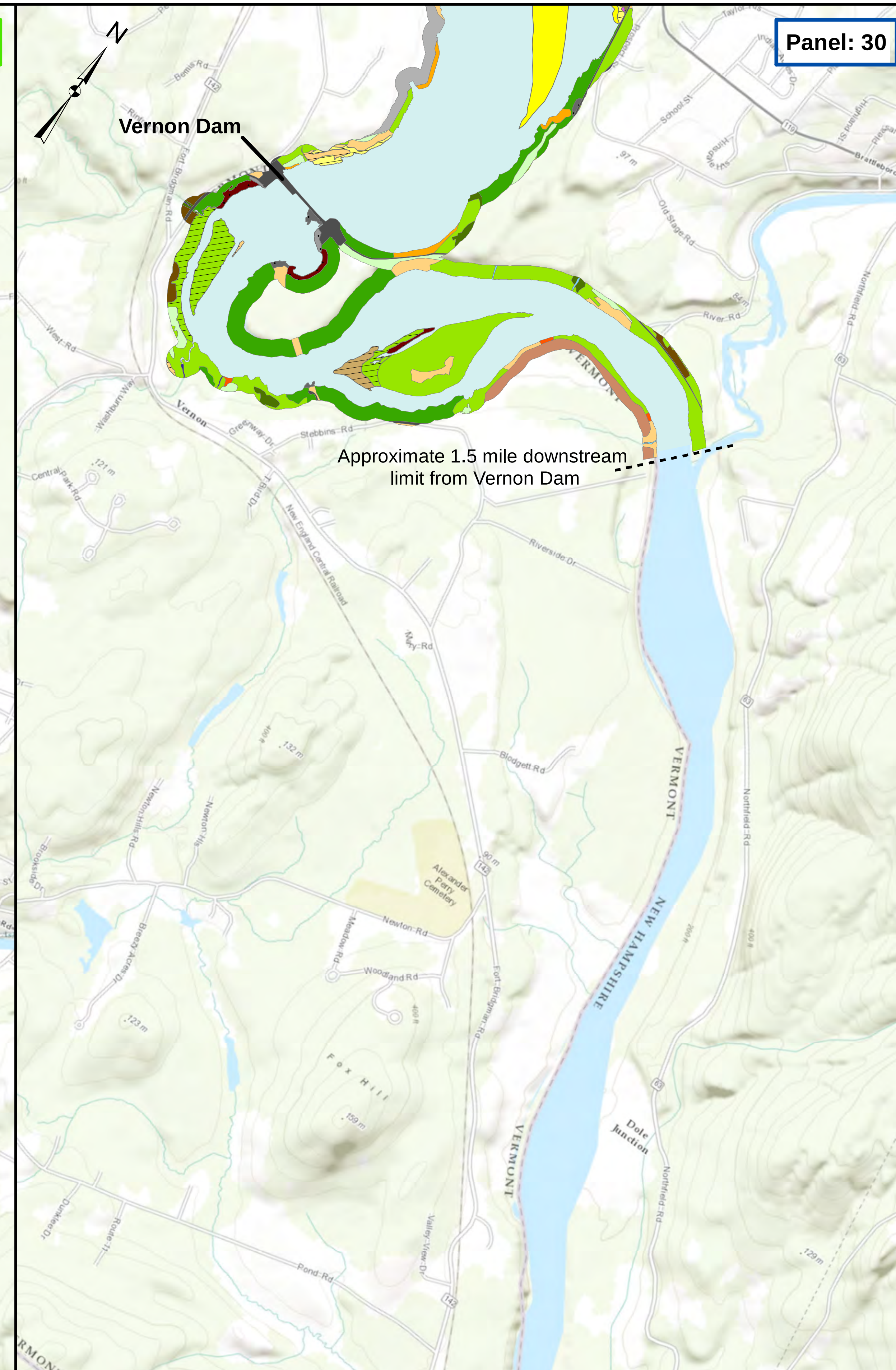

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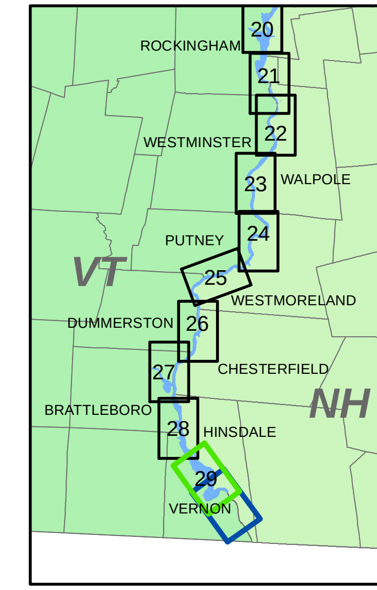
TransCanada Hydro Northeast Inc.

ILP Study 27 - Terrestrial Cover Type and Land Use Maps



0 0.25 0.5 1 Miles

Cover Type

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- Riprap
- Riverbank
- Eroding Bank

Overlay
- Invasive Species
- Floodplain

NORMANDEAU environmental consultants

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