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 II – Containing Sub Volumes II.A – II.H

Site Selection Reports for
Studies 6, 10, 11, 12, 14, 15, 16 and 25

September 14, 2015

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Volume II.A

Study 6 – Water Quality Monitoring Study

Revised Site Selection Report and Sampling and Analysis Plan

Updated Study Report

September 14, 2015

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TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 6
Water Quality Study

Revised Monitoring Site Selection and Sampling & Analysis Plan

In support of Federal Energy Regulatory Commission Relicensing of:

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

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April 29, 2015

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1. INTRODUCTION

TransCanada Hydro Northeast, Inc. (TransCanada) filed with the Federal Energy Regulatory Commission (FERC) a Notice of Intent on October 31, 2012, to initiate the relicensing of its Wilder (FERC No. 1892), Bellows Falls (FERC No. 1855), and Vernon Hydroelectric Projects (FERC No. 1904), collectively referred to as Projects. These three Projects are situated on the Connecticut River and occupy portions of the states of Vermont and New Hampshire (Appendix A). The Wilder Project is located at river mile (RM) 217.4 in the towns of Hartford, VT, and Lebanon, NH. The Bellows Falls Project is the next downstream hydroelectric project on the Connecticut River and is located at RM 173.7 in the towns of Bellows Falls, VT, Rockingham, VT, and Walpole, NH. The Vernon Project is situated in the towns of Vernon, VT and Hinsdale, NH at RM 141.9.

In accordance with the Integrated Licensing Process (ILP), the U.S. Fish and Wildlife Service (FWS), New Hampshire Department of Environmental Services (NHDES), New Hampshire Fish and Game (NHFGD), Vermont Agency of Natural Resources (VANR), and the Connecticut River Watershed Council (CRWC) requested a water quality monitoring study be conducted to determine the operational effects of the Projects on water quality in the Connecticut River. On August 14, 2013, TransCanada filed with FERC a Revised Study Plan (RSP). Study 6 of the RSP contained the plan for conducting the requested Water Quality Monitoring and Continuous Temperature Monitoring Study. On December, 31, 2013, TransCanada filed with FERC proposed revisions to the study, which included removing the additional continuous temperature monitoring transect at the Vernon forebay from April 1 through November 15 because of the closure of the Vermont Yankee Nuclear Power Plant in 2014. Continuous transect monitoring at this location is still planned during a 10-day, low-flow period.

On February 21, 2014, FERC issued its Study Plan Determination for the aquatic relicensing studies, approving the revised Water Quality Monitoring and Continuous Temperature Monitoring Study. The revised study plan included a commitment by TransCanada to develop a Sampling and Analysis Plan (Plan). This Plan describes the planned field sampling activities, and details Quality Control/Quality Assurance (QA/QC) provisions to ensure the data collected will be usable for water quality standard attainment decisions, and for subsequent analyses. The Plan is being provided to the NHDES and VANR (the two state Section 401 Water Quality Certification agencies) for comment and approval prior to study implementation.

The methods and procedures described in this Plan were developed based on the FERC approved RSP, and procedures outlined and described in the U.S. Geological Survey Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting (USGS, 2006), the 2012 Baseline Water Quality Study of the Projects filed with FERC on October 7, 2013 (Normandeau, 2013), the Vermont Department of Environmental Conservation, Water Quality Division Field Methods Manual (VTDEC, 2012), and other resource agency standard operating procedures for water quality and temperature monitoring.

2. STUDY GOAL AND OBJECTIVES

The purpose of this Sampling and Analysis Plan is to describe and detail water quality and temperature monitoring and sampling protocols, procedures, laboratory analyses, data management, QA/QC, data analysis, and reporting that will be conducted associated with the approved RSP. The overall goal of the study is to determine potential effects of the Projects on water quality parameters of water temperature, dissolved oxygen (DO), conductivity, turbidity, pH, nutrients, and chlorophyll-*a*.

The specific goals and objectives of the study are to:

- Characterize water temperature upstream of the project impoundments, within the project impoundments, tailraces, Bellows Falls bypass reach, and selected tributaries;
- Characterize water temperature, DO, specific conductivity, turbidity, and pH of the Projects forebays, tailraces, and Bellows Falls bypass reach;
- Characterize water temperature, DO, specific conductivity, turbidity, and pH of the Projects impoundment and upstream areas during a 10-day low-flow (<3 X 7Q10), high temperature (preferably over 23°C) period;
- Describe water temperature, DO, specific conductivity, turbidity, and pH stratification of the Projects impoundments, upstream areas, forebays, tailraces, and Bellows Falls bypassed reach;
- Characterize nitrate/nitrite, total nitrogen, total phosphorus, total Kjeldahl nitrogen, and chlorophyll-*a* of the Projects forebays;
- Determine potential impacts of the Wilder, Bellows Falls, and Vernon Projects on water quality and temperature as they relate to Project operations;
- Document whether the Connecticut River in the vicinity of the Projects is in compliance with VT and NH surface water quality standards.

By adhering to this Plan results from the study will provide the information needed to enable the resource agencies and other stakeholders to understand how continued operation of the Projects may affect water quality and temperatures of the Connecticut River in the vicinity of the Projects.

3. STUDY AREAS AND STUDY SITES

The study area consists of the Wilder, Bellows Falls, and Vernon impoundments as well as riverine locations upstream of the impoundments, project tailraces, the Bellows Falls bypassed reach, and key tributaries. As specified in the RSP, 16 mainstem and 10 tributary sampling stations are included in the study, which span the distance from riverine and tributary areas upstream of the Wilder impoundment to the Vernon tailrace. Thirteen of the 16 mainstem stations are the same stations sampled in 2012 (Normandeau, 2013). Table 3-1 lists the mainstem sampling stations and Table 3-2 lists the 10 tributary sampling locations. Appendix A figures depict the location of each station.

4. METHODS

To achieve the study goals and objectives described above, continuous temperature monitoring, continuous water quality monitoring, vertical profile measurements, and impoundment water column sampling will be done throughout the study. The planned sampling activities described in the RSP are described in Table 4-1. The equipment, calibration procedures, and field sampling specifics are discussed in more detail below.

4.1 Continuous Temperature Monitoring

4.1.1 Equipment

Continuous temperature monitoring will be conducted using HOBO® Water Temp Pro v2 (Model U22-001) loggers. This logger is ideal for extended deployments because it is submersible up to 120 meters (m), has an operating range of -40 to 70°C, has enough memory for over 42,000 individual temperature measurements, and has a battery life to last 6 years at 1-minute measurement intervals. Specifications for this logger are provided in Table 4-2.

4.1.2 Calibration

The HOBO Water Temperature Pro v2 Loggers (Model U22-001) are factory, multipoint calibrated. Therefore, no additional calibration is necessary prior to or during deployment. However, a hand-held NIST-certified thermometer will be used to check sensor accuracy. Checks will be made upon deployment, monthly, and at retrieval, which will verify the accuracy of the logger claimed by the manufacturer; this is consistent with the procedure in USGS (2006) and MassDEP (2009).

4.1.3 Field Sampling Specifications

Water temperature (°C) at all stations will be continuously monitored *in situ* every 15 minutes from April 1 or as soon as it is safe to deploy monitors through November 15, 2015 or sooner if it becomes unsafe to collect additional data. In addition, continuous water temperature monitoring will occur along transects at the monitoring stations within the impoundments during the 10-day, low-flow period. The low-flow sampling will generally commence when mean daily water temperatures equal or exceed 23°C and average daily flows are estimated to be at or near their lowest level (preferably at or below 3 x 7Q10, weather dependent) during the low flow sampling period. All sampling stations will be located and re-occupied by handheld GPS unit with a 10-foot horizontal level of accuracy.

A literature search revealed no standard operating procedure for continuous temperature-only loggers for the states of Vermont and New Hampshire; therefore, deployment of the continuous temperature loggers will generally follow procedures employed by the Massachusetts Department of Environmental Protection (MassDEP), Division of Watershed Management Standard Operating Procedure of Continuous Temperature Monitoring using Temperature-only Loggers (MassDEP, 2009). Each logger will be deployed at a representative, well-mixed location in the vicinity of the predetermined sampling station, and at a sufficient distance downstream of the mixing zone of any tributary. In the tributaries, all loggers will be encased in 9-12 inch perforated (3/4 inch holes) protective housing (PVC pipe), attached to a concrete cinder block(s) using coated steel cable, heavy-duty zip ties, and/or polypropylene rope. The cinder block(s) will anchor the logger to the riverbed and will be tethered to an immovable object on shore with polypropylene rope or coated steel cable. At the mainstem locations the loggers will be encased in a perforated PVC protective housing, deployed at approximately 25% depth from the water surface when set, and suspended from a buoy that is anchored to the riverbed by cinder blocks. During each site visit the loggers will be reset at approximately 25% depth from the water surface. So as not to interfere with the whitewater boating study (Study 31), the logger in the bypassed reach will be deployed in a similar manner as the loggers at the tributary stations in a representative well-mixed zone behind larger boulders for protection. When the mainstem stations are to be occupied by multi-parameter datasondes (described below) the continuous temperature loggers will be replaced by the datasondes. At mainstem transect stations during the 10-day, low-flow period, loggers will be suspended from a buoy at 1 m depth, mid-depth, and 1 m above the riverbed and anchored to the riverbed with concrete cinder blocks. The logger 1 m above the riverbed will be suspended in the water column using gillnet floats and tethered to the anchor and main buoy line.

Site visits will occur to inspect the loggers, download data, and obtain replicate spot temperature measurements for QA/QC purposes. Initially, and site conditions permitting, weekly site visits will occur in the first two weeks of the study to ensure the loggers are secure and functioning properly. Once it is confirmed that loggers are secure and functioning properly, biweekly visits to tributary stations will occur thereafter for the remainder of the study period. Biweekly visits will occur at the mainstem stations until June 1 when the loggers will be visited weekly (June 1 – September 30) and concurrently with the multiparameter datasondes weekly site visits described below. Biweekly visits will continue for the remainder of the study (October 1 – November 15) after the multiparameter datasondes are removed. Replicate spot measurements will be collected adjacent to each continuous data logger on a monthly basis using a NIST-certified thermometer to confirm logger accuracy (USGS, 2006; MassDEP, 2009). Prior to departing from each station the data will be visually inspected to assure the logger is functioning correctly. The logger will be replaced immediately if the data appear to deviate from what can normally be expected or if the replicate NIST reading differs by more than ±0.5°C (MassDEP, 2009). GPS coordinates, photo documentation, general condition of the loggers, and QA/QC measurement checks will be recorded on a field datasheet during scheduled site visits.

4.1.4 Stations

As described in Table 4-1, all stations along the mainstem of the Connecticut River and the tributaries will be occupied during the full field season for various types of measurements. In addition, transects will be set up for temperature monitoring during the low-flow period at stations 06-W-04, 06-W-03, 06-W-02, 06-W-01, 06-BF-04, 06-BF-03, 06-BF-02, 06-BF-01, 06-V-04, 06-V-03, 06-V-02, and 06-V-01.

4.2 Continuous Monitoring with Multi-parameter Datasondes

4.2.1 Equipment

Continuous monitoring of temperature (°C), DO (% saturation and mg/L), specific conductivity (µS/cm), pH (Units), and turbidity (NTU) will be conducted using YSI 6920 V2 multi-parameter sondes or newer model. The YSI 6920 V2 multi-parameter sonde is suitable for this study because it can be deployed up to a depth of 61 m, the sensors can collect accurate and precise data when water temperatures are between -5 to 50°C, and at a logging rate of 15-minute intervals, the sonde battery can last approximately 30 days (at 20°) and record up to 150,000 individual readings. Pertinent specifications for the YSI 6920 V2 sonde are presented in Table 4-2.

4.2.2 Calibration

The YSI 6920 V2 multi-parameter sonde used for continuous water quality monitoring will be calibrated in the laboratory using calibration standards, as per the manufacturer's directions, and tested by a one-point calibration (two-point calibration for pH probe) immediately prior to initial deployment (USGS, 2006). These sondes will then be tested and, if needed, recalibrated in the field during weekly site visits (site conditions permitting) concurrent with data downloads. Upon retrieval during the weekly site visits, a replicate reading will be taken alongside a calibrated sonde to assess drift. Each sensor will then be cleaned following manufacturer recommendations, returned to the water, and another reading will be taken alongside the recently calibrated sonde. If the readings of the deployed sonde are within acceptable calibration criteria (Table 4-3) they will be returned to the water without recalibration. If the deployed sonde readings are outside the acceptable calibration criteria (Table 4-3), the sonde will recalibrated and retested alongside the calibrated sonde. Sondes or sensors that fail calibration will be immediately replaced. All calibration data, field replicate data, and other testing/maintenance information will be recorded on field datasheets. All calibration equipment and standard solutions will be kept clean, stored in protective cases during transport, and protected from extreme temperatures. Table 4-4 provides each sensor calibration method, frequency, and solutions. The calibration solutions are NIST traceable.

4.2.3 Field Sampling Specifications

Water temperature (°C), DO (% saturation, mg/L), specific conductivity (µS/cm), pH (Units), and turbidity (NTU) will be collected continuously at 15-minute intervals at the tailrace (06-W-TR, 06-BF-TR, 06-V-TR), forebay (06-W-01, 06-BF-01, 06-V-01), and Bellows Falls bypassed reach (06-BF-BR) stations from June 1 through September 30, 2015. In addition, continuous data will be collected at all mainstem impoundment and upstream extent areas (06-W-04, 06-W-03, 06-W-02, 06-BF-04, 06-BF-03, 06-BF-02, 06-V-04, 06-V-03, and 06-V-02 during the 10-day low-flow period; this period will also be covered at the other mainstem stations as sondes are deployed continuously throughout the summer. The sites will be initially located using a hand-held GPS unit, then by deployed buoys described below.

Each multi-parameter sonde will generally be deployed following procedures described the 2012 Baseline Water Quality Study (Normandeau, 2013), the MassDEP Division of Watershed Management Standard Operating Procedure of Multi-Probe Sonde Deployment for Continuous Unattended Water Quality Data Collection (MassDEP, 2007), and the USGS Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting (USGS, 2006). Prior to deployment a vertical dissolved oxygen and water temperature profile will be conducted to determine if the site is stratified or unstratified. At the predefined sampling stations, each sonde will be placed at a location that is representative of the river cross-section in the vicinity of the predetermined station. The sondes will be deployed at approximately 25% of the depth when set when the station is unstratified or near the bottom of the epilimnion but above the metalimnion when the station is stratified using an anchor and buoy system, where a heavy anchor is secured to the channel substrate so as not to move during periods of high flow and a line of coated steel cable running to the buoy at the water surface. If the weekly profiles collected at 1 m intervals (described below) show potential for stratification a profile of 0.5 m will be conducted prior to deployment of the instruments during the 10-day, low flow sampling period to ensure an accurate placement of the logger near the bottom of the epilimnion. The sonde deployed in the Bellows Falls bypassed reach will be situated in a representative, well-mix area behind larger boulders for protection from recreational boaters (Study 31). Except for those sondes deployed in the tailraces, the instruments will be attached to the buoy with a weighted dropper line to ensure a consistent recording depth. At the tailrace stations, the sonde will be affixed to mainline cable running from the anchor to the buoy because this configuration is more secure (Normandeau, 2013).

Weekly site visits will occur to periodically inspect the sonde for biofouling, data download, sensor cleaning, calibration, and obtain replicate measurements for QA/QC purposes. GPS coordinates and photo documentation will be obtained and general condition of the logger and battery life will be recorded in a field notebook or field datasheet. If the buoy is determined to move from the original set location, it will be moved back to the original location and secured.

4.3 Instantaneous Vertical Profile Monitoring with Multi-parameter Datasondes

4.3.1 Equipment

Instantaneous, vertical profiles of temperature (°C), DO (% saturation and mg/L), specific conductivity (µS/cm), pH (Units), and turbidity (NTU) will be collected using a YSI 6920 V2 multi-parameter sonde or newer model with a 75 ft cable. The YSI 6920 V2 multi-parameter is the same instrument model used for the continuous water quality monitoring described above. Specifications for the instrument are provided in Table 4-2.

4.3.2 Calibration

The YSI 6920 V2 multi-parameter sonde used for the instantaneous vertical profile water quality monitoring will be calibrated in the laboratory using calibration standards, as per the manufacturer's directions, and tested by a one-point calibration (two-point calibration for pH probe) immediately at the start and end of each sampling day. All calibration data, field replicate data, and other testing/maintenance information will be recorded in field datasheets. All calibration equipment and standard solutions will be kept clean, stored in protect cases during transport and protected from extreme temperatures. Table 4-4 provides each sensor calibration method and frequency.

4.3.3 Field Sampling Specifications

Temperature (°C), DO (% saturation and mg/L), specific conductivity (µS/cm), pH (Units), and turbidity (NTU) profiles will be collected on a weekly basis, and concurrent with other field sampling efforts, from June 1 through September 30, 2015, to characterize thermal and chemical stratification at all 16 mainstem stations. Because of the geographic extent of the study area, it will not be feasible to conduct the weekly profiles in the three impoundments on the same day, but with conditions permitting, the profiles will be conducted within 3 consecutive days during each sampling week. The sites will be initially located using a hand-held GPS unit, then by deployed buoys discussed above. If the buoy is determined to have moved from the original set location, it will be moved back to the original location and resecured.

The instantaneous vertical profile data will generally be collected following the methodology described in the 2012 Baseline Water Quality Study (Normandeau, 2013). At a predetermined sampling station the boat will be allowed to drift with the current to control depth of the instrument and to represent the same parcel of water. After calibration and starting at the water surface, measurements will be taken at 1 m depth increments until the instrument reaches the river bottom with the last reading taken approximately 0.5 m above the river bottom. Readings will be allowed to stabilize before a measurement is taken and before proceeding to the next depth increment. At least once per profile a replicate measurement will be collected at a random depth interval. All data along with approximate locations of the thermocline/chemocline (if present) will be recorded on field datasheets. If the weekly profiles collected at 1 m intervals show potential for stratification a profile of 0.5-m will be conducted prior to deployment of the instruments during the 10-day, low flow sampling period to ensure an accurate placement of the logger near the bottom of the epilimnion.

4.4 Impoundment Water Column Sample Collection and Laboratory Analysis

4.4.1 Equipment

Impoundment water column samples of nitrate/nitrite, total nitrogen, total phosphorus, total Kjeldahl nitrogen and chlorophyll-*a* for laboratory analysis will be collected using a long weighted plastic hose marked in 1-m increments that has an inside diameter of ⅝ inch. Hose samples are generally collected to obtain vertical composite samples in lakes or very slow moving rivers (VTDEC, 2012). Once the profile sample is collected, the water in the hose will be emptied into a 5-gallon, clean, acid and distilled water rinsed bucket (VTDEC, 2012).

4.4.2 Calibration

The equipment used in the field to collect the profile water sample requires no calibration; however, to reduce the likelihood of contamination, the hose and bucket will be rinsed twice with distilled water prior to taking a profile sample (VTDEC, 2012). Laboratory equipment used for the subsequent laboratory analyses are calibrated independently by the laboratory retained to perform the analyses (see Section 4.4.4).

4.4.3 Field Sampling Specifications

Impoundment water column samples of nitrate/nitrite, total nitrogen, total phosphorus, total Kjeldahl nitrogen and chlorophyll-*a* for laboratory analysis will be collected at the Wilder (06-W-01), Bellows Falls (06-BF-01), and Vernon (06-V-01) forebays weekly from June 1 through September 30, 2015.

The impoundment water column samples will be collected following the method described in the Vermont Department of Environmental Conservation Water Quality Division's Field Methods Manual (VTDEC, 2012). Prior to taking a sample, the depth of the river will be determined using a portable depth sounder. The profile water sample will be collected by lowering a long hose (⅝ inch inside diameter) weighted at one end and marked in 1 m increments into the water column slowly and evenly until it is approximately 1 m off the river bottom. The sample within the tube will be retrieved by capping/kinking the vented end to prevent the sample from flowing out of the tubing, slowly raising the tube from the weighted end to the surface, and transferring the sample to the rinsed 5-gallon bucket. The sample is thoroughly mixed before being decanted into labelled, sterile sample containers provided by the laboratory, and chilled on ice or placed in a refrigerator before being transferred to the laboratory. At the end of the field day, the chlorophyll-*a* samples will be filtered through 0.45-µm cellulose filters, and frozen until transfer to the laboratory with the other samples. For quality control purposes a field duplicate will be collected for every 10 samples collected (since there are 54 water samples throughout the study period, there will be an additional six field duplicates). Stations for the collection of field duplicates will be chosen randomly throughout the study period and will be located in each impoundment providing two duplicate samples per impoundment.

Samples will be sent to the laboratory for analysis after samples at all three stations have been collected during each sampling week. All samples will be collected and transported under a chain-of-custody, which will be documented with a chain-of-custody form. Table 4-5 presents a summary of the required preservation, holding times, reporting limits, and analysis methods.

4.4.4 Laboratory Analysis

The Louis Berger Group contracted with Eastern Analytical, Inc. (Concord, NH) to perform the nitrate/nitrite, total nitrogen, total phosphorus, total Kjeldahl nitrogen and chlorophyll-a laboratory analyses. Eastern Analytical, Inc. is a laboratory that specializes in analyzing surface water and is certified in all New England states. The laboratory's reporting limits and analysis methods for the specified analytes are presented in Table 4-5.

5. DATA MANAGEMENT AND DATA QA/QC

5.1 Data Management

All data from the continuous water temperature data loggers and continuous multi-parameter datasondes will be downloaded to a HOBO® Waterproof Shuttle (U-DTW-1) or YSI 650 MDS handheld display and logging device during each station visit, then exported and backed-up to a rugged field laptop. Data collected during the instantaneous, vertical profile measurements will be recorded on field datasheets. Laboratory data will be provided in electronic format by the contracted laboratory. Flow and project operations data including hourly generation, impoundment elevation at each dam, and discharge will be provided by TransCanada. Associated water level changes within river reaches will then be calculated. Flow data will be obtained from USGS Streamflow gages at West Lebanon, NH (Station No. 01144500) and Walpole, NH (Station No. 01154500). Estimated flow in the Bellows Falls bypassed reach during spillage will be provided by TransCanada. During periods of non-spill the flow in the bypassed reach is assumed to be due to leakage, which was determined to be approximately 300 cfs during the instream flow study (Study 9) in 2014. Weather data will also be obtained from area National Oceanic and Atmospheric Administration (NOAA) weather stations. Periodically throughout the study period, the data and field notes will be transferred or manually transcribed from field notebooks and/or datasheets to a spreadsheet database for further review, QA/QC, and analysis.

5.2 Data QA/QC

All field-collected data will undergo a thorough QA/QC review process to ensure the accuracy and completeness of the dataset. Standard methods and QA/QC procedures for all water quality monitoring referred to and described in this Plan will be adhered to, ensuring that the resulting data will be accurate, precise, comparable, and representative. Data quality objectives for this study include: actual measurements obtained pre- and post- deployment have a relative percent difference ≤10% to that of the field replicate collected with a NIST certified thermometer or recently calibrated multi-parameter sonde; and, 80% of all measurements collected must pass the QA/QC process.

The continuous temperature and water quality datasets will be initially reviewed and analyzed for outliers, aberrant measurements, and missing data to ensure the collected data is valid. Corresponding field and spot QA measurements will then be compared to determine if data correction is required for a specific time interval. The data correction procedure is discussed below.

For the continuous temperature-only loggers, the decision will be made to accept the temperature logger data if the temperature recording of the logger is within +/- 0.5 °C of the corresponding NIST thermometer reading (MassDEP, 2009). If the difference between the logger and NIST thermometer readings exceeds +/-0.5 °C the logger will be replaced and the temperature time-series from the replaced logger will be corrected following a two-point variable correction based on percent error as described in USGS (2006). The two-point correction uses a weighted-linear correction (prorated by time) whereby the first data point in the time-series would have no correction applied while the last data point will be corrected to the same percent difference as the total fouling and calibration drift error.

For the continuous water quality dataset obtained from the deployed YSI 6920 V2 multi-parameter datasondes, the data may require correction to adjust for instrument drift and biofouling effects on sensor readings. The decision to apply a correction will be based on criteria described in USGS (2006) and summarized in Table 4-3. The criteria uses pre- and post-instrument cleaning as well as instrument calibration offsets to determine fouling and calibration drift errors for a given period of instrument deployment. If the combined instrument error exceeds the criteria in Table 4-3 (e.g., the absolute values for fouling error and calibration drift error for DO is >0.3 mg/L), a weighted-linear correction will be applied to the dataset for the identified period. The specified period for correction the first data point in the time-series would have no correction applied while the last data point will be corrected to the same percent difference as the total fouling and calibration drift error. Therefore, the resulting final dataset will represent the dataset with corrections applied.

Any data point that does not pass QA/QC review and cannot be corrected will be flagged and removed from the final dataset.

6. DATA ANALYSIS

Data in the final water quality dataset will be compared to Vermont and New Hampshire surface water quality standards. Applicable Vermont and New Hampshire surface water quality standards are presented in Table 6-1. The final dataset will also be compared to flow and project operations described above. Historical daily average and daily weather data at area NOAA weather stations will also be compared to the water quality dataset. In addition, average daily and average daily historical flows (1972-2014) at the West Lebanon, NH and North Walpole, NH USGS gages for the period of the study will be used to develop flow duration curves to determine if flows observed throughout the study period are representative of historical flows. Average daily flows during the low flow period will be compared to estimated 7Q10 flows at each project dam. Time series plots will be developed to illustrate how water quality parameters vary relative to flow observed throughout the study period. The possible effects of different flow and weather conditions during the different days that the weekly instantaneous profiles are conducted will also be analyzed. The water quality results from the 2012 Baseline Water Quality Study (Normandeau, 2013) will be used to compare weather and flow conditions between the two sets of water quality data. Finally, the information acquired will be used to qualify and quantify water quality data for the study area, including background and tributary inflows, and evaluate whether project operations may affect water quality. Water quality data collected in other aquatic resource studies may be included in the water quality dataset, as applicable.

7. REPORTING

At the conclusion of the study and following QA/QC of the data a draft final report will be prepared that describes the methods and analyses, and presents the results and findings of the study. The draft report will also compare the results to those of the 2012 Baseline Water Quality Study (Normandeau, 2013), and will be made available to stakeholders for review and comment. As applicable, stakeholder comments of the draft final report will be incorporated into the final report and included as an appendix of the final report along with a comment and response summary.

The final water quality dataset will be provided to the NHDES in a Microsoft Excel format for inclusion into the NHDES Environmental Monitoring database and will be presented in the standard units of the monitoring database (e.g., µS/cm for specific conductivity). If corrections are applied to the dataset to form the final dataset, the uncorrected dataset will also be provided to NHDES. Discussion and conclusions regarding project effects on water quality and any proposed enhancement and mitigation will be presented in either the Preliminary License Proposal (PLP) or Draft License Applications (DLAs) for the Projects. Exhibit E of the final license application will include modified results and conclusions, as appropriate, in response to stakeholder comments on the PLP or DLAs.

8. SCHEDULE AND CONSULTATION

This plan is submitted to the VANR and NHDES for comment and approval. Agency comments will be integrated into a final version of the Sampling and Analysis Plan. Following approval of this Sampling and Analysis Plan by the VANR and NHDES, the study will commence the first week in April 2015 or as soon as weather and river conditions are safe to deploy the continuous temperature loggers, and will continue through November 15, 2015 or sooner if weather and river conditions become unsafe to collect additional data. The exact start and end dates will depend on safe conditions for unit deployment and retrieval.

9. LITERATURE CITED

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Table 3-1: Connecticut River mainstem water temperature and water quality sampling stations.

Station ID	Latitude	Longitude	Approx. Depth (ft)	Description
Wilder				
06-W-04	44.12440	-72.04270	6-10	Above the Wilder impoundment at about River Mile (RM) 265
06-W-03	44.08397	-72.03933	7-9	Wilder upper impoundment at 259.0
06-W-02	43.88204	-72.17256	24-26	Wilder mid-impoundment at RM 236.0
06-W-01	43.66877	-72.30223	44-46	Wilder forebay at RM 217.5
06-W-TR	43.66618	-72.30520	3.3	Wilder tailrace, below dam and powerhouse at RM 217.3
Bellows Falls				
06-BF-04	43.48855	-72.37969	5	Above the Bellows Falls impoundment, 0.5 miles upstream of the Cornish Boat Landing
06-BF-03	43.39375	-72.40301	9-11	Bellow Falls upper impoundment
06-BF-02	43.27513	-72.41183	10-12	Bellows Falls mid-impoundment at RM 184.4
06-BF-01	43.13808	-72.44861	40-42	Bellows Falls forebay at RM 173.8
06-BF-BR	43.13620	-72.44041	2	Bellows Falls bypass reach, approximately 100 feet north of railroad bridge
06-BF-TR	43.13154	-72.44180	3.4	Bellow Falls tailrace, below dam and powerhouse at RM 172.9
Vernon				
06-V-04	43.09771	-72.44044	3.2	Above Vernon impoundment at about RM 171.6
06-V-03	43.06180	-72.45514	7-9	Vernon upper impoundment at 167.4
06-V-02	42.92468	-72.52491	15-17	Vernon mid-impoundment at RM 154.1
06-V-01	42.77294	-72.51202	52-54	Vernon forebay at RM 142.0
06-V-TR	42.76932	-72.51408	3.5	Vernon tailrace, below dam and powerhouse at RM 141.8

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Table 3-2: Connecticut River tributary water temperature sampling stations.

Station ID	State	Latitude†	Longitude†	Approx. Depth (ft) ††	River
Wilder					
06-W-T02	VT	43.98730	-72.13880	4-5	Waits River
06-W-T01	VT	43.77015	-72.24578	1.5	Ompompanoosuc River
Bellows Falls					
06-BF-T05	VT	43.65822	-72.33658	2	White River
06-BF-T04	NH	43.63502	-72.31906	2.5	Mascoma River
06-BF-T03	NH	43.39180	-72.38586	1.5	Sugar River
06-BF-T02	VT	43.27137	-72.45718	2.5	Black River
06-BF-T01	VT	43.19180	-72.48599	2	Williams River
Vernon					
06-V-T03	VT	43.12399	-72.44099	2	Saxton River
06-V-T02	NH	43.12314	-72.42458	1	Cold River
06-V-T01	VT	42.88340	-72.58697	1	West River

†Coordinates are in decimal degrees.
††Based on measurement during field reconnaissance by Louis Berger on November 14/15, 2014.

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Table 4-1: Summary of water quality parameters, frequency, and duration to be monitored at each sampling station.

Task	Stations	Frequency	Duration[†]	Description
Continuous Water Temperature Monitoring	All mainstem (n=16) All tributaries (n=10)	15-minute	April 1 – November 15	• Task collects water temperature data using only the HOBO Water Temp Pro v2 logger. • One logger per station, placed at approximately 25% depth below water surface at mainstem stations and at river bottom at tributary stations.
Low-Flow Transect Continuous Water Temperature Monitoring	06-W-04, 06-W-03, 06-W-02, 06-W-01, 06-BF-04, 06-BF-03, 06-BF-02, 06-BF-01, 06-V-04, 06-V-03, 06-V-02, 06-V-01	15- minute	10-day Low Flow between June 1 and September 30	• Task uses HOBO Water Temp Pro v2 logger. • Task collects water temperature data along transects perpendicular to flow. • Each transect has three stations (river right, mid-channel, and river left). • Loggers will be placed 1 m below the water surface, mid-depth, and 1 m above bottom.
Continuous Monitoring with Multi-parameter Sondes	06-W-01, 06-W-TR, 06-BF-01, 06-BF-TR, 06-BF-BR, 06-V-01, 06-V-TR	15- minute	June 1 – September 30	• Task uses YSI 6920 V2 multi-parameter water quality sonde. • Task collects water temperature, dissolved oxygen, specific conductivity, pH, and turbidity. • Sonde deployed at approximately 25% depth below water surface if not stratified or near the bottom of epilimnion (but above metalimnion when stratified).
Low-Flow Continuous Monitoring with Multi-parameter Sondes	06-W-04, 06-W-03, 06-W-02, 06-BF-04, 06-BF-03, 06-BF-02, 06-V-04, 06-V-03, 06-V-02	15-minute	10-day Low Flow between June 1 and September 30	• Task uses YSI 6920 V2 multi-parameter water quality sonde. • Task collects water temperature, dissolved oxygen, specific conductivity, pH, and turbidity. • Sonde deployed at approximately 25% depth below water surface if not stratified or near the bottom of epilimnion (but above metalimnion when stratified).
Instantaneous Vertical Profile Monitoring with Multi-parameter Sonde	All mainstem (n=16)	Weekly	June 1 – September 30	• Task uses YSI 6920 V2 multi-parameter water quality sonde. • Task collects water temperature, dissolved oxygen, specific conductivity, pH, and turbidity in 1-m increments to river bottom.
Impoundment Water Column Sample Collection for Laboratory Analysis	06-W-01 06-BF-01 06-V-01	Weekly	June 1 – September 30	• Task uses a long, weighted plastic tube to collect a composite sample of the water column. The tube or the weight shall not touch or disturb the river bottom. • Samples are sent to a laboratory for the analysis of nitrate/nitrite, total nitrogen, total phosphorus, total Kjeldahl nitrogen and chlorophyll-*a*.

[†]Deployment and duration depend on site access and safe field conditions.

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Table 4-2: Water temperature and water quality monitoring equipment specifications.

Parameter/Sensor	Specification	Description
HOBO® Water Temp Pro v2 (U22-001)		
Temperature (°C)	Range	-40 to 70 °C in air; 50 °C maximum in water
	Accuracy	±0.21 °C (0 to 50 °C)
	Resolution	0.02 °C at 25 °C
Battery Life		6 years at 1-minute logging intervals
Depth Rating		120 m
Memory		Approx. 42,000 measurements
YSI 6920 V2 Multi-parameter Sonde		
Temperature (°C)	Sensor Type	Thermistor
	Range	-5 to 50 °C
	Accuracy	±0.15 °C
	Resolution	0.01 °C
Dissolved Oxygen, % saturation	Sensor Type	ROX™ Optical
	Range	0 to 500 % air saturation
	Accuracy	At 0 to 200 %, ±1 % of reading or 1 % air saturation, whichever is greater; At 200 to 500 % air saturation, ±15 % of reading
	Resolution	0.1% air saturation
	Temp. Range	-5 to 50 °C
Dissolved Oxygen, mg/L	Sensor Type	ROX™ Optical
	Range	0 to 50 mg/L
	Accuracy	At 0 to 20 mg/L ±0.1mg/L, or 1% of reading, whichever is greater; At 20 to 50 mg/L ±15 % of reading
	Resolution	0.01 mg/L
	Temp. Range	-5 to 50 °C
pH	Sensor Type	Glass combination electrode
	Range	0 to 14 units
	Accuracy	± 0.2 units
	Resolution	0.01 units
	Temp. Range	-5 to 50 °C
Turbidity	Sensor Type	Optical, 90° scatter with mechanical cleaning
	Range	0 to 1000 NTU
	Accuracy	±2 % reading or 0.3 NTU whichever is greater
	Resolution	0.1 NTU
	Temp. Range	-5 to 50 °C
Conductivity (corrected to 25°C)	Sensor Type	4 electrode cell with autoranging
	Range	0 to 100 mS/cm
	Accuracy	±0.5 % of reading + 0.001 mS/cm
	Resolution	0.001 mS/cm to 0.1 mS/cm (range dependent)
	Temp. Range	-5 to 50 °C
Operating Environment		Fresh, sea, polluted water; -5 to 50°C; up to 61m depth
Memory		Approx. 150,000 readings
Power		8 AA-alkaline batteries/12 V DC external
Battery Life		Approx. 30 days at 15-minute logging interval and 20°C
Weight		3.74 lbs.

Table 4-3: Continuous water quality monitor calibration and correction criteria for YSI 6920 V2 Multi-parameter Sondes.

Parameter	Correction Criteria[††]
Temperature	± 0.2 °C
Specific Conductance	± 5 µS/cm or ±3 % of the measured value, whichever is greater
Dissolved Oxygen	± 0.3 mg/L
pH	± 0.2 pH unit
Turbidity	± 0.5 turbidity unit or ± 5 % of the measured value, whichever is greater

†Source: USGS, 2006.
††The correction is applied when the absolute value of the fouling error plus the absolute value of the calibration drift error exceeds the value listed. Fouling error and calibration drift error will be calculated following USGS, 2006.

Table 4-4: YSI 6920 V2 Multi-parameter Sonde calibration method, solutions and frequency.

Sensor	Calibration Method	Calibration Solutions	Calibration Frequency
Continuous Monitoring Sondes			
Temperature	Default factory	Not applicable	Not applicable
Dissolved Oxygen	Saturated air[1]	Not applicable	• Initial deployment • Weekly at time of data download
Specific Conductivity	One point[2]	1000 µS/cm	
pH	Two point[3]	pH of 4, 7, and 10	
Turbidity	Two point[4]	0 NTU and 126 NTU	
Instantaneous Monitoring Sondes			
Temperature	Default factory	Not applicable	Not applicable
Dissolved Oxygen	Saturated air[1]	Not applicable	• At start of sampling day • At end of sampling day
Specific Conductivity	One point[2]	1000 µS/cm	
pH	Two point[3]	pH of 4, 7, and 10	
Turbidity	Two point[4]	0 NTU and 126 NTU	

[1]For ROXTM optical type dissolved oxygen sensors YSI does not recommend using 2-point calibration with zero dissolved oxygen solution unless the sensor does not meet the accuracy requirements at low DO values and, under operating conditions, it can be certain that a medium of zero dissolved oxygen can be generated.

[2]The YSI conductivity system is very linear over its range of 0-100mS/cm. YSI does not recommend using calibrations other than 10 mS/cm (10,000 µS/cm) for all environmental applications.[3]YSI recommends a two-point calibration between a pH of 7 and 10 because the majority of all water types in the environment have a pH between 7 and 10. A pH standard of 4 may be used in calibration if a pH of less than 7 is regularly observed.

[4]YSI recommends a two-point calibration with 0 NTU and 126 NTU standard solutions for most applications.

Table 4-5: Profile water sample required preservation, holding times, laboratory reporting limits, and analysis methods

Analytes	Sample Type	Preservation	Maximum Holding Time (days)	Laboratory Reporting Limit (RL)	Analysis Method
Nitrate and Nitrite	Water	Cool 4°C	28	0.05 mg/L	EPA 353.2
Total Nitrogen	Water	Cool 4°C	28	0.5 mg/L	SM 4500orgC/NO3
Total Phosphorus	Water	Cool 4°C	28	0.002 mg/L	EPA 365.1
Total Kjeldahl Nitrogen	Water	Cool 4°C	28	0.5 mg/L	SM 4500Norg/NH3D
Chlorophyll-*a*	Water/Filter	Frozen	30	0.5 mg/m^3	10200H3

Table 6-1: Applicable Vermont and New Hampshire surface water quality standards for the mainstem Connecticut River. *

Class	Designated Uses	Parameter	Standard
***Vermont*[†]**			
B	Fully supports aquatic biota, wildlife and aquatic habitat; Good to excellent aesthetics; Suitable public water supply with filtration and disinfection, irrigation of crops, primary contact recreation, boat, fishing, other recreation	Temperature	Change or rate of change in temperature, either upward or downward, shall not exceed 1°F from ambient temperatures and be controlled to ensure full support of aquatic biota, wildlife, and aquatic habitat uses.
		Dissolved Oxygen	Not less than 6 mg/l and 70% saturation.
		Specific Conductivity	None.
		pH	Between 6.5 and 8.5 standard units.
		Turbidity	None in such amounts or concentrations that would prevent the full support of uses, and not to exceed 10 NTU as an annual average under dry weather base-flow conditions.
		Nutrients	Nitrates not to exceed 5.0 mg/L as NO_3-N at flows exceeding low median monthly. Phosphorus is to be limited so that they will not contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses.
***New Hampshire*[††]**			
B	Acceptable for fishing, swimming and other recreational purposes and, after adequate treatment, for use as water supplies	Temperature	Any increase shall not be such as to appreciably interfere with the uses assigned to this class.
		Dissolved Oxygen	Daily average at least 75% saturation; instantaneous minimum of 5.0 mg/L.
		Specific Conductivity	None.
		pH	6.5 to 8.0, unless due to natural causes.
		Turbidity	Not exceed naturally occurring conditions by more than 10 NTUs.
		Nutrients	Nitrogen none in such concentrations that would impair any existing or designated uses, unless naturally occurring. Phosphorus none in such concentrations that would impair any existing or designated uses, unless naturally occurring.

†Source: VANR, 2014.
††Source: NHCAR, 2008.
* Temperature standards also apply to tributaries.

APPENDIX A

MONITORING LOCATION FIGURES

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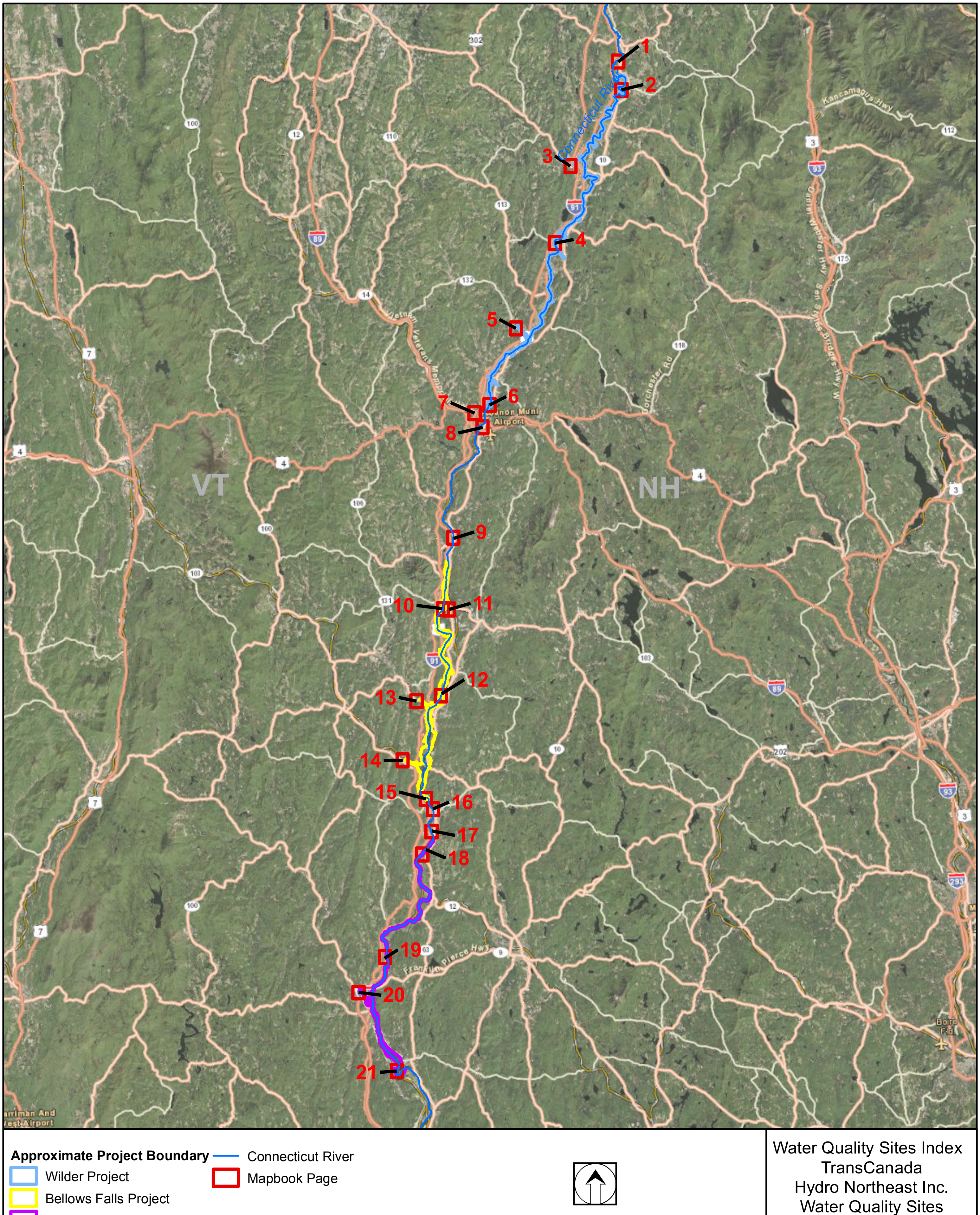

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Normandeau Team
(4-29-2015)

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Approximate Project Boundary

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Feet

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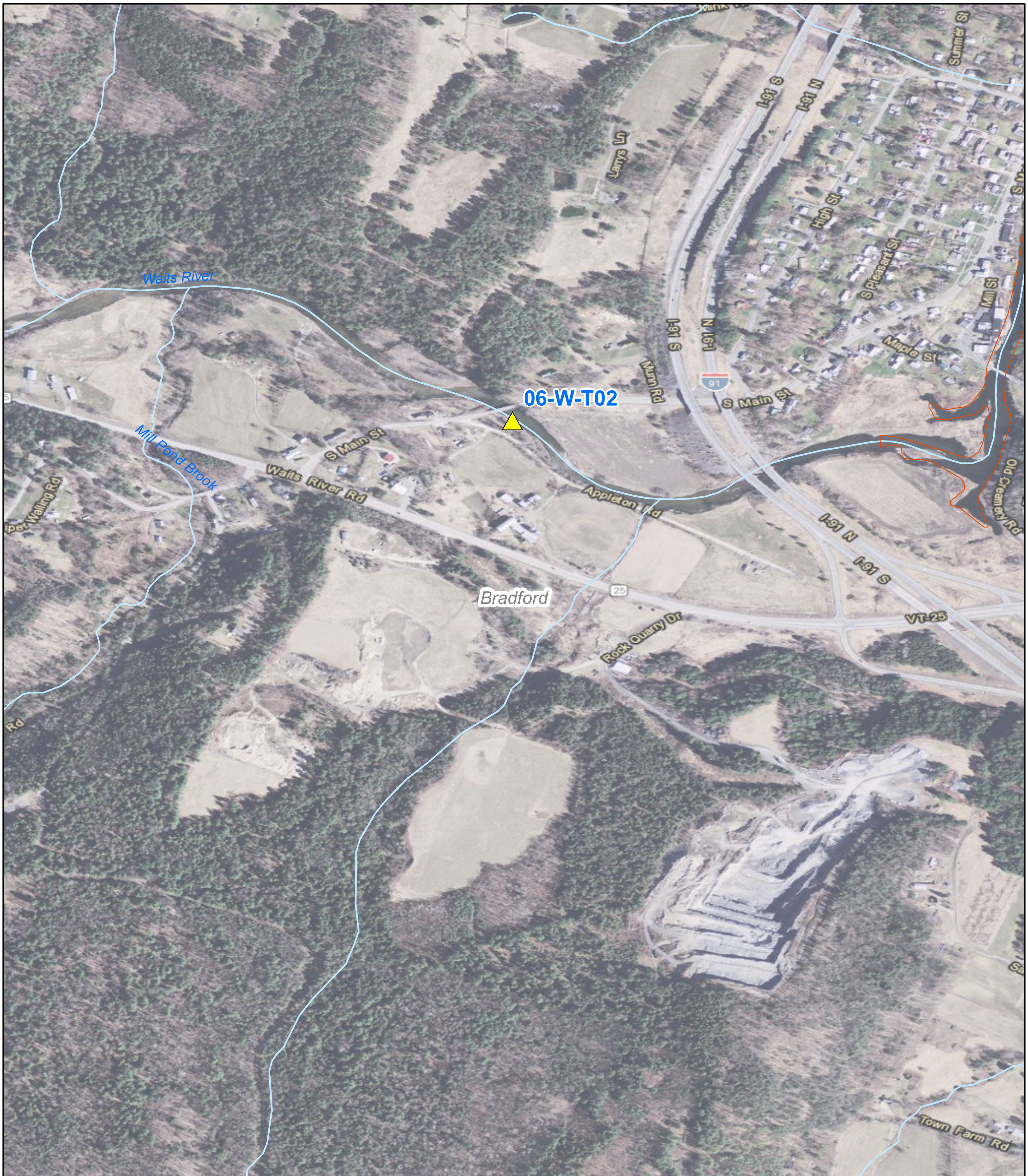

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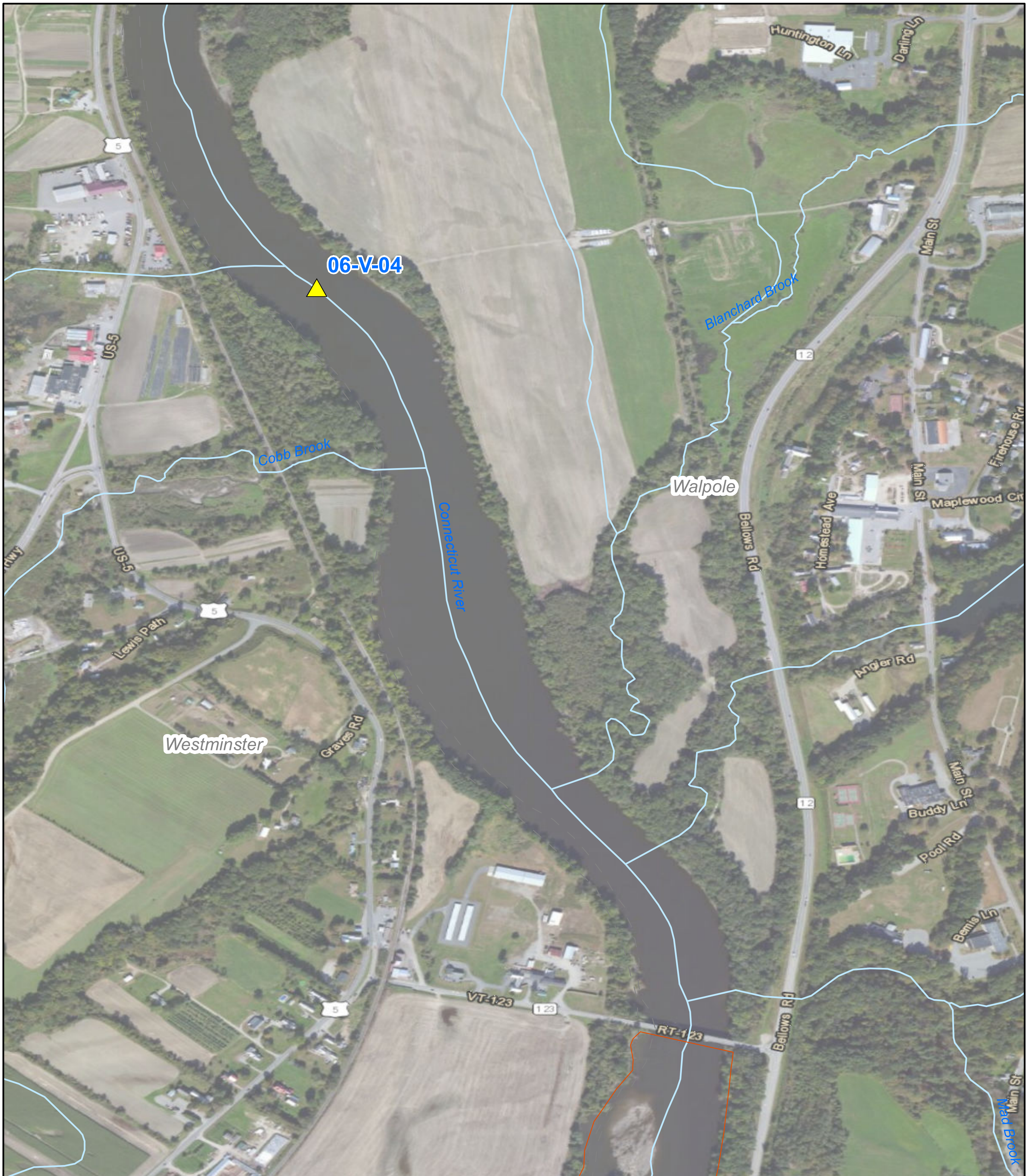

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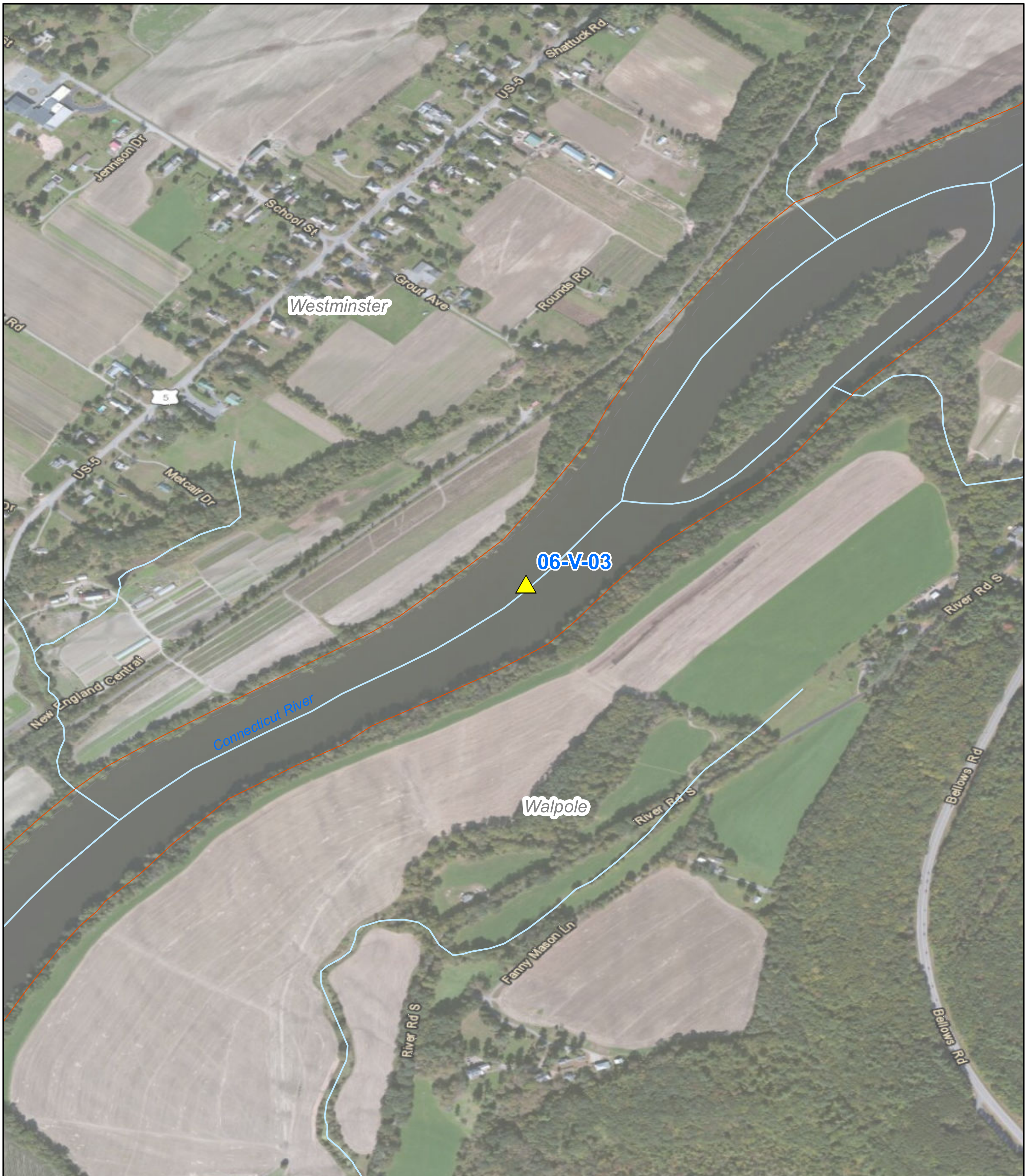

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UNITED STATES OF AMERICA

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 II.B

Study 10 – Fish Assemblage Study

Revised Site Selection Report

Updated Study Report

September 14, 2015

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TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 10
Fish Assemblage Study

Revised Site Selection 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 Road
Bedford, NH 03110

February 3, 2015

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1. INTRODUCTION

Operations at the Wilder, Bellows Falls, and Vernon Projects potentially affect the availability of instream habitat on which fish species depend. Habitat for fish species may be related to project operations in terms of flow (water depth and velocity and their timing, duration, frequency, and rate of change), as well as the interactions of flow with other habitat variables such as substrate, vegetation, and cover. Operations both upstream (i.e., impoundment levels) and downstream (i.e., flow fluctuations) may affect habitat, which may consequently lead to changes in the distribution, abundance, and behavior of fish species.

Revised Study Plan (RSP) 10, as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination, specified that a subset of the project-affected area would be studied. This report has been revised in response to comments received from the aquatics working group at a December 17, 2014 site selection consultation meeting. This revised report provides a summary of the data analysis and criteria used to select the proposed subset of locations to be examined in detail during 2015.

In addition, the following selected sites were modified to correct for a habitat type misclassification error discovered after issuance of the draft site selection report, which impacted a limited number of ‘boulder’ map-units. Those locations were reclassified and where necessary random selection of the appropriate habitat type was rerun; however, there was no impact on the number of study sites in each substrate type as a result:

- Wilder Riverine (summer) site 10-WR058 replaced with 10-WR043
- Wilder Riverine (fall) site 10-WR058 replaced with 10-WR043
- Bellows Impoundment (spring) sites 10-B073, 10-B075, and 10-B087 replaced with 10-B022, 10-B023, and 10-B027
- Bellows Impoundment (summer) sites 10-B054, 10-B062, and 10-B072 replaced with 10-B069, 10-B092, and 10-B093
- Bellows Impoundment (fall) sites 10-B070, 10-B084, and 10-B089 replaced with 10-B044, 10-B059, and 10-B060

2. STUDY AREA

Sampling will be conducted to characterize the baseline fish assemblage within project-affected areas from the upper extent of the Wilder impoundment to approximately 1.5 miles downstream of Vernon dam, as well as in the Bellows Falls bypassed reach. This approximately 120-mile reach of the Connecticut River was divided into seven geographic reaches delineated based on a combination of general river morphology and project structures. These geographic reaches are as follows:

- Wilder impoundment (RM 262.4 - 217.4);
- Wilder downstream riverine corridor (RM 217.4 – 199.7);
- Bellows Falls impoundment (RM 199.7 – 173.7);
- Bellows Falls bypassed reach (approximately 3,500 feet long);
- Bellows Falls downstream riverine corridor (RM 173.7 – 167.9);
- Vernon impoundment (RM 167.9 – 141.9); and
- Downstream of Vernon dam to the downstream extent of Stebbins Island (RM 141.9 – 140.4).

3. SITE SELECTION PROCESS

As stated in the RSP, the selection of sampling locations was stratified based on habitat characteristics. Habitat characteristics for project-affected areas were recorded as part of Study 7 (Aquatic Habitat Mapping). Pertinent data collected during that study included side-scan sonar mapping and classification of bottom substrates as well as mesohabitat and dominant substrate classification of habitat units within the Wilder, Bellows Falls, and Vernon riverine sections and Bellows Falls bypassed reach (Normandeau 2014).

Prior to the selection of study locations, each geographic reach (or stratum) was delineated into 500-meter map-unit segments using ArcGIS. Within each map-unit, the substrate present was quantified. An overall dominant habitat type was assigned based on the proportions of varying substrates present within each individual unit. For example, if a particular 500-meter map-unit was determined to contain 70% cobble-gravel, 25% sand-silt-clay, and 5% boulder then a dominant habitat type of cobble-gravel was assigned. For map-units with existing side-scan substrate data (primarily in the impoundment reaches), the dominant habitat type was assigned using that information. For map-units where mesohabitat mapping was conducted (primarily in the riverine reaches), the proportional contribution of mesohabitat units identified in the field during Study 7 in 2013 (i.e., run, riffle, glide, etc.) was first determined. The dominant substrate type identified at the time of the field survey within each mesohabitat unit was then substituted for mesohabitat unit from Study 7, and the resulting proportions of varying substrate types present were used to make the determination of dominant habitat type within the 500-meter map-unit. For example, if 70% of the area of a particular map-unit was represented by one run mesohabitat unit and the remaining 30% was represented by one pool mesohabitat habitat unit, with the run being dominated by cobble-gravel substrate and the pool being dominated by sand-silt-clay, then a dominant habitat type of cobble-gravel was assigned. In some instances, both side-scan substrate data and mesohabitat mapping data were available for a particular map-unit. In those cases, dominant habitat type was determined from the side-scan substrate data.

In accordance with the RSP, the total number of sampling locations within each geographic reach were randomly placed proportional to habitat type frequency (e.g., if 50 percent of a particular geographic reach is cobble-gravel habitat than 50 percent of the total number of sampling locations for that geographic reach would be randomly placed within that habitat type). As long as habitat is available, effort was made to ensure that a minimum of three sampling locations are placed within each strata (i.e., habitat type) within a particular geographic reach.

Sampling segments were randomly selected for each of the three sampling periods (spring: May-June, summer: July-August, and fall: September-October). Following selection of the 500-meter map-units in each geographic reach, sampling bank (east or west) was also randomly selected. In some cases, tributary or backwater sites identified during 2014 in Study 13 – Tributary and Backwater Fish Access and Habitats were present on the same selected bank, and are therefore included in this study to be sampled for fish assemblage during 2015. The upstream extent of sampling within a tributary will be determined by the ability of available gear types to effectively sample the habitat as well as visual observations made by the field crew at the time of sampling to identify the apparent upper bound of the project-affected portion of the tributary. Observations made by field biologists transiting the study reach during 2013 and 2014 as part of data collection for Studies 7, 9, and 13 were considered during the preliminary selection process of sampling gears from the suite of techniques identified in the RSP (boat electrofish, pram electrofish, back pack electrofish, experimental gill net, trap net, and beach seine). The sampling methods identified for each sampling location in this report are to be considered preliminary. Modifications to those methodologies may be necessary due to field conditions at the specific locations at the time of sampling.

Substrate acreage, percent of total acreage by substrate type and the resulting dominant habitat type for each map-unit is presented in the Revised Studies 10 and 12 Substrate Data Attachment (separate document).

3.1 Wilder Impoundment

A total of 156 map-units were placed within the Wilder impoundment extending from map-unit 10-W001 at the upper extent of the impoundment (RM 262.4) to map-unit 10-W156 located at Wilder dam. Existing side-scan survey data was used to determine dominant habitat type for the majority of map-units (151 of 156). There was no habitat data available for the remaining 5 map-units, located at the upstream end of the Wilder impoundment. Habitat data was not collected at those five locations in Study 7 due to lack of access for the survey boat.

The percentages of habitat type within the 3,028 acres mapped by side-scan sonar were used to determine the spatial distribution of 15 sampling locations in the impoundment. Results from the Study 7 impoundment mapping are presented in Table 3.1-1 and indicate that the majority of habitat in the impoundment is dominated by sand-silt-clay and cobble-gravel. Lesser amounts of boulder, rip rap, ledge and woody debris habitat are also present. For the purposes of placing sampling locations in the impoundment, the total number of locations (15) were allocated following a habitat-type frequency distribution of 76% in map-units dominated by sand-silt-clay, 15% in map-units dominated by cobble-gravel and 9% in map-units dominated by boulder and/or rip rap. Totals were then adjusted so that a minimum of three sample locations were placed within each strata (i.e., habitat type) within a particular geographic reach. When adjusted to account for existing habitat proportions and minimum number of samples within each habitat strata, nine map-units dominated by sand-silt-clay, three map-units dominated by cobble-gravel and three map-units dominated by boulder-rip rap were selected for sampling.

Of the 151 map-units considered for sampling, 146 were dominated by sand-silt-clay and five were dominated by cobble-gravel. There were no map-units where the boulder-rip rap substrate types were proportionally dominant. To address this, map-units were sorted based on the proportional contribution of boulder-rip rap habitat and locations within the upper quartile of presence were used as the basis for random selection. Table 3.1-2 presents information for the 15 map-units selected for sampling. Figure 3.1-1 presents the spatial distribution of the 15 sampling locations during the spring, summer, and fall sampling periods. Based on existing field crew knowledge of water depths and boat access (both ramps and in-river transit), the anticipated sampling methods for selected sampling locations are presented in Table 3.1-3. It is expected that the Wilder impoundment will be characterized by deeper water depths and slower velocities than those observed in the downstream riverine section. When those conditions as well as the relative ease of accessing selected sampling locations are considered, fish assemblage sampling in the Wilder impoundment will likely consist primarily of boat electrofishing combined with gill net sampling within map-units dominated by all habitat types (sand-silt-clay, cobble-gravel, boulder-rip rap). Results of the random bank selection (east vs. west), and information on tributary or backwater presence, are also presented in Table 3.1-3.

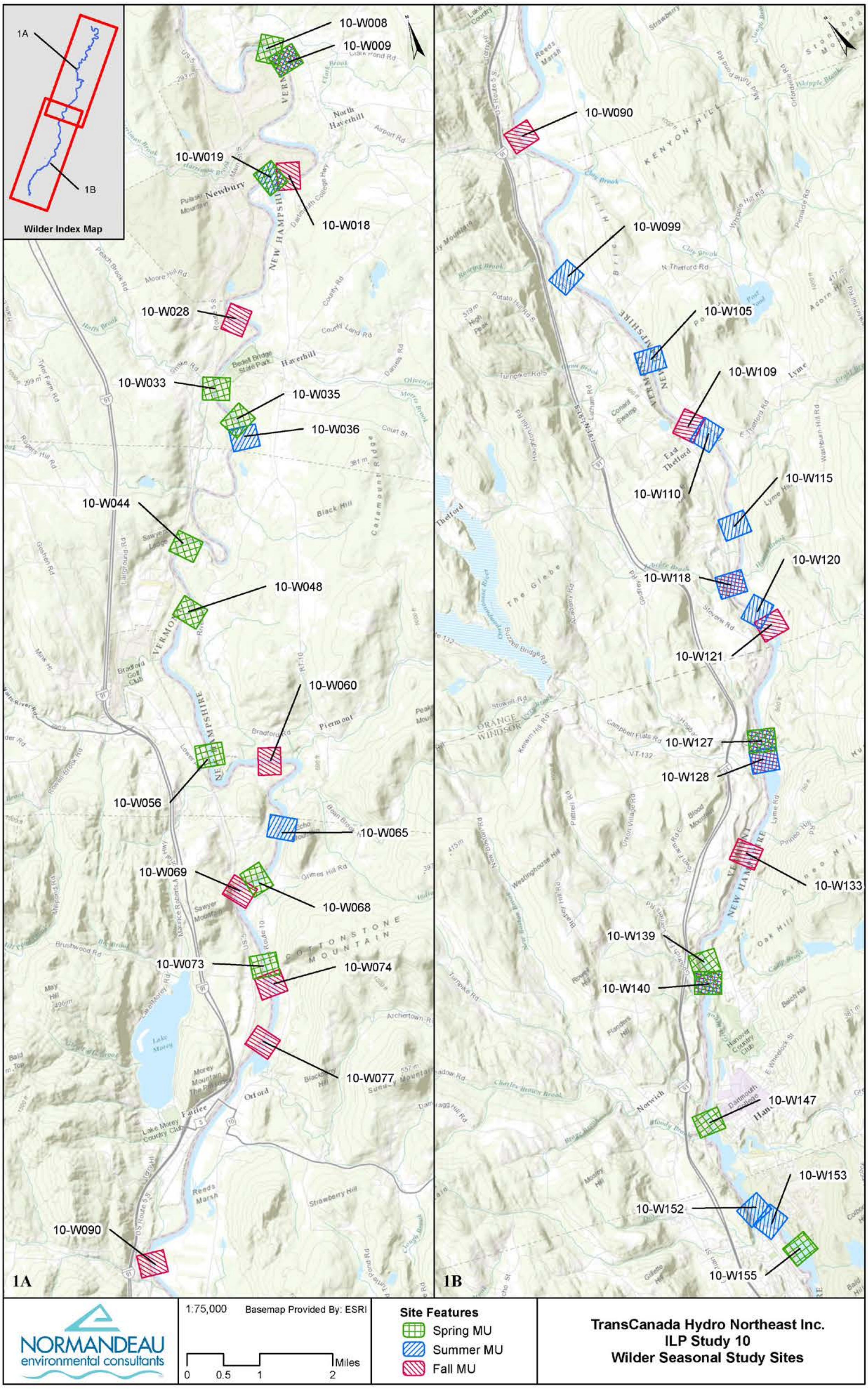

Figure 3.1-1. Map-units selected for fish assemblage sampling within the Wilder impoundment, 2015.

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Table 3.1-1. Total area (acres) and percent of total area for aquatic habitat types mapped using sonar imagery within Wilder impoundment (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	2,308.9	76.2%
gravel/cobble	450.1	14.9%
boulder	100	3.3%
rip rap	52.6	1.7%
ledge	26.1	0.9%
woody debris	90.7	3.0%
TOTAL	3,028.5	100.0%

Table 3.1-2. Substrate composition and resulting dominant habitat type for map-units randomly selected in the Wilder impoundment.

Sampling Season	Map Unit	Substrate Type (acres/%)														Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		Boulder		Rip Rap		Ledge		Woody Debris		No Data		
Spring	10 – W008	5.3	41.7%	5.6	44.1%	0.6	4.7%	0	0.0%	0	0.0%	1.2	9.4%	0	0.0%	Gravel, Cobble
	10 – W009	4.7	38.8%	5.2	43.0%	1	8.3%	0.4	3.3%	0.1	0.8%	0.7	5.8%	0	0.0%	Boulder
	10 – W019	11.8	90.1%	0.4	3.1%	0.4	3.1%	0	0.0%	0	0.0%	0.5	3.8%	0	0.0%	Sand, Silt, Clay
	10 – W033	11	80.9%	2.4	17.6%	0.1	0.7%	0	0.0%	0	0.0%	0.1	0.7%	0	0.0%	Sand, Silt, Clay
	10 – W035	17.7	97.8%	0.3	1.7%	0	0.0%	0	0.0%	0	0.0%	0.1	0.6%	0	0.0%	Sand, Silt, Clay
	10 – W044	14.5	69.4%	4	19.1%	1.1	5.3%	0	0.0%	0.4	1.9%	0.9	4.3%	0	0.0%	Sand, Silt, Clay
	10 – W048	7.9	54.5%	1.3	9.0%	4	27.6%	0	0.0%	0.3	2.1%	1	6.9%	0	0.0%	Boulder
	10 – W056	15.6	94.0%	0.5	3.0%	0	0.0%	0.1	0.6%	0	0.0%	0.4	2.4%	0	0.0%	Sand, Silt, Clay
	10 – W068	13.8	92.0%	0	0.0%	0	0.0%	0.1	0.7%	0	0.0%	1.1	7.3%	0	0.0%	Sand, Silt, Clay
	10 – W073	14.9	93.1%	0	0.0%	0.3	1.9%	0	0.0%	0.2	1.3%	0.6	3.8%	0	0.0%	Sand, Silt, Clay
	10 - W127	5.9	33.0%	10.1	56.4%	0.5	2.8%	0.9	5.0%	0.2	1.1%	0.3	1.7%	0	0.0%	Gravel, Cobble
	10 - W139	7.4	43.8%	6.9	40.8%	1.7	10.1%	0.7	4.1%	0.2	1.2%	0	0.0%	0	0.0%	Boulder
	10 - W140	4.8	30.0%	8.5	53.1%	0.4	2.5%	1	6.3%	0.5	3.1%	0.8	5.0%	0	0.0%	Gravel, Cobble
	10 - W147	11.7	58.5%	4.9	24.5%	1.2	6.0%	2.1	10.5%	0.1	0.5%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 - W155	43.5	87.3%	2.8	5.6%	1.3	2.6%	0.5	1.0%	1.7	3.4%	0	0.0%	0	0.0%	Sand, Silt, Clay
Summer	10 – W009	4.7	38.8%	5.2	43.0%	1	8.3%	0.4	3.3%	0.1	0.8%	0.7	5.8%	0	0.0%	Boulder
	10 – W019	11.8	90.1%	0.4	3.1%	0.4	3.1%	0	0.0%	0	0.0%	0.5	3.8%	0	0.0%	Sand, Silt, Clay

Sampling Season	Map Unit	Substrate Type (acres / %)														Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		Boulder		Rip Rap		Ledge		Woody Debris		No Data		
	10 – W036	13.3	70.7%	3.8	20.2%	0.9	4.8%	0	0.0%	0	0.0%	0.8	4.3%	0	0.0%	Sand, Silt, Clay
	10 – W065	12.1	77.1%	0.9	5.7%	1.8	11.5%	0.2	1.3%	0	0.0%	0.7	4.5%	0	0.0%	Sand, Silt, Clay
	10 – W099	14.9	85.1%	1.2	6.9%	0.7	4.0%	0.2	1.1%	0	0.0%	0.5	2.9%	0	0.0%	Sand, Silt, Clay
	10 - W105	10	64.9%	2.7	17.5%	0.8	5.2%	0	0.0%	0.2	1.3%	1.7	11.0%	0	0.0%	Sand, Silt, Clay
	10 - W110	14.6	76.8%	3	15.8%	0.2	1.1%	0.7	3.7%	0	0.0%	0.5	2.6%	0	0.0%	Sand, Silt, Clay
	10 - W115	17.3	83.2%	2.4	11.5%	0	0.0%	0.1	0.5%	0	0.0%	1	4.8%	0	0.0%	Sand, Silt, Clay
	10 - W118	7.8	47.6%	6	36.6%	0	0.0%	1.5	9.1%	0	0.0%	1.1	6.7%	0	0.0%	Sand, Silt, Clay
	10 - W120	15.8	76.0%	3	14.4%	0.1	0.5%	0.4	1.9%	0.1	0.5%	1.4	6.7%	0	0.0%	Sand, Silt, Clay
	10 - W127	5.9	33.0%	10.1	56.4%	0.5	2.8%	0.9	5.0%	0.2	1.1%	0.3	1.7%	0	0.0%	Gravel, Cobble
	10 - W128	6.3	29.3%	14.1	65.6%	0.4	1.9%	0.2	0.9%	0	0.0%	0.5	2.3%	0	0.0%	Gravel, Cobble
	10 - W140	4.8	30.0%	8.5	53.1%	0.4	2.5%	1	6.3%	0.5	3.1%	0.8	5.0%	0	0.0%	Gravel, Cobble
	10 - W152	16.5	64.7%	4.9	19.2%	2.7	10.6%	1.1	4.3%	0	0.0%	0.3	1.2%	0	0.0%	Boulder
	10 - W153	23.9	85.4%	1	3.6%	2.2	7.9%	0.4	1.4%	0.5	1.8%	0	0.0%	0	0.0%	Boulder
Fall	10 – W009	4.7	38.8%	5.2	43.0%	1	8.3%	0.4	3.3%	0.1	0.8%	0.7	5.8%	0	0.0%	Boulder
	10 – W018	12	88.2%	0	0.0%	1.5	11.0%	0	0.0%	0	0.0%	0.1	0.7%	0	0.0%	Sand, Silt, Clay
	10 – W028	10.1	69.2%	4	27.4%	0.3	2.1%	0.1	0.7%	0	0.0%	0.1	0.7%	0	0.0%	Sand, Silt, Clay
	10 – W060	10.6	77.4%	2.4	17.5%	0	0.0%	0	0.0%	0	0.0%	0.7	5.1%	0	0.0%	Sand, Silt, Clay
	10 – W069	12.1	69.9%	0.6	3.5%	1.9	11.0%	0.9	5.2%	0	0.0%	1.8	10.4%	0	0.0%	Sand, Silt, Clay
	10 – W074	13.6	61.3%	3.3	14.9%	0.9	4.1%	0	0.0%	0.7	3.2%	3.7	16.7%	0	0.0%	Sand, Silt, Clay
	10 – W077	12.9	79.1%	0	0.0%	2.1	12.9%	0.1	0.6%	0	0.0%	1.2	7.4%	0	0.0%	Boulder
	10 – W090	9.2	63.4%	3.5	24.1%	0.3	2.1%	1	6.9%	0.1	0.7%	0.4	2.8%	0	0.0%	Sand, Silt, Clay
	10 - W109	14.2	79.8%	3	16.9%	0	0.0%	0.4	2.2%	0	0.0%	0.2	1.1%	0	0.0%	Sand, Silt, Clay
	10 - W118	7.8	47.6%	6	36.6%	0	0.0%	1.5	9.1%	0	0.0%	1.1	6.7%	0	0.0%	Boulder
	10 - W121	14.3	86.1%	0.8	4.8%	0.2	1.2%	0.8	4.8%	0	0.0%	0.5	3.0%	0	0.0%	Sand, Silt, Clay
	10 - W127	5.9	33.0%	10.1	56.4%	0.5	2.8%	0.9	5.0%	0.2	1.1%	0.3	1.7%	0	0.0%	Gravel, Cobble
	10 - W128	6.3	29.3%	14.1	65.6%	0.4	1.9%	0.2	0.9%	0	0.0%	0.5	2.3%	0	0.0%	Gravel, Cobble
	10 - W133	17.4	73.4%	5.5	23.2%	0	0.0%	0.7	3.0%	0	0.0%	0.1	0.4%	0	0.0%	Sand, Silt, Clay
	10 - W140	4.8	30.0%	8.5	53.1%	0.4	2.5%	1	6.3%	0.5	3.1%	0.8	5.0%	0	0.0%	Gravel, Cobble

Table 3.1-3. Sampling bank, anticipated sampling methods, and location type of map units randomly selected in the Wilder impoundment.

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
Spring	10 – W008	West	Boat Electrofish	Gill Net		Mainstem		
	10 – W009	West	Boat Electrofish	Gill Net		Mainstem		
	10 – W019	West	Boat Electrofish	Gill Net		Mainstem		
	10 – W033	East	Boat Electrofish	Gill Net		Mainstem		
	10 – W035	West	Boat Electrofish	Gill Net	CT-W-1.08	Minor Trib		2
	10 – W044	East	Boat Electrofish	Gill Net		Mainstem		
	10 – W048	East	Boat Electrofish	Gill Net		Mainstem		
	10 – W056	West	Boat Electrofish	Gill Net		Mainstem		
	10 – W068	West	Boat Electrofish	Gill Net		Mainstem		
	10 – W073	East	Boat Electrofish	Gill Net	CT-W-1.26	Backwater		0
	10 - W127	West	Boat Electrofish	Gill Net		Mainstem		
	10 - W139	West	Boat Electrofish	Gill Net		Mainstem		
	10 - W140	West	Boat Electrofish	Gill Net		Mainstem		
	10 - W147	East	Boat Electrofish	Gill Net		Mainstem		
	10 - W155	West	Boat Electrofish	Gill Net		Mainstem		
Summer	10 – W009	West	Boat Electrofish	Gill Net		Mainstem		
	10 – W019	East	Boat Electrofish	Gill Net		Mainstem		
	10 – W036	East	Boat Electrofish	Gill Net		Mainstem		
	10 – W065	West	Boat Electrofish	Gill Net		Mainstem		
	10 – W099	West	Boat Electrofish	Gill Net		Mainstem		
	10 - W105	East	Boat Electrofish	Gill Net	CT-W-1.42	Minor Trib		2
	10 - W110	West	Boat Electrofish	Gill Net		Mainstem		
	10 - W115	West	Boat Electrofish	Gill Net		Mainstem		
	10 - W118	East	Boat Electrofish	Gill Net		Mainstem		1
	10 - W120	West	Boat Electrofish	Gill Net	CT-W-1.53	Backwater		0
	10 - W127	West	Boat Electrofish	Gill Net		Mainstem		
	10 - W128	East	Boat Electrofish	Gill Net		Mainstem		
	10 - W140	West	Boat Electrofish	Gill Net		Mainstem		
	10 - W152	East	Boat Electrofish	Gill Net		Mainstem		
	10 - W153	West	Boat Electrofish	Gill Net		Mainstem		
Fall	10 – W009	East	Boat Electrofish	Gill Net		Mainstem		
	10 – W018	West	Boat Electrofish	Gill Net		Mainstem		

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
	10 – W028	East	Boat Electrofish	Gill Net		Mainstem		
	10 – W060	East	Boat Electrofish	Gill Net		Mainstem		
	10 – W069	West	Boat Electrofish	Gill Net		Mainstem		
	10 – W074	West	Boat Electrofish	Gill Net	CT-W-1.23	Minor Trib		1
	10 – W077	West	Boat Electrofish	Gill Net		Mainstem		
	10 – W090	East	Boat Electrofish	Gill Net		Mainstem		
	10 - W109	East	Boat Electrofish	Gill Net		Mainstem		
	10 - W118	East	Boat Electrofish	Gill Net	CT-W-1.47	Minor Trib		1
	10 - W121	West	Boat Electrofish	Gill Net	CT-W-1.53	Backwater		0
	10 - W127	East	Boat Electrofish	Gill Net		Mainstem		
	10 - W128	West	Boat Electrofish	Gill Net	CT-W-1.57	Minor Trib		2
	10 - W133	East	Boat Electrofish	Gill Net	CT-W-1.59	Backwater		0
	10 - W140	East	Boat Electrofish	Gill Net	CT-W-1.62	Minor Trib		1

3.2 Wilder Riverine Reach

Sixty map-units were placed within the Wilder riverine reach extending from map-unit 10-WR001 at the Wilder tailrace to map-unit 10-WR060 located at RM 199.7. Existing mesohabitat survey data was used to determine dominant habitat type for 51 of the 60 map-units. There was no available substrate classification data for 9 map-units since river bottom visibility was obscured at those locations during mesohabitat mapping (due to water depth, turbulence, etc.). The percentages of habitat type within the approximately 1,068 acres mapped in Study 7 were used to determine the spatial distribution of 12 sampling locations in the reach. Results from the Study 7 mesohabitat mapping are presented in Table 3.2-1 and indicate that the majority of habitat in the reach is primarily cobble-gravel with lesser amounts of sand-silt-clay and boulder habitat. For the purposes of placing sampling locations in the reach, the total number of locations (12) was allocated following a habitat-type frequency distribution of 70% in map-units dominated by cobble-gravel, 23% in map-units dominated by sand-silt-clay, and 7% in map units dominated by boulder. When adjusted to account for existing habitat proportions and minimum number of samples within each habitat strata, five map-units dominated by cobble-gravel, four map-units dominated by sand-silt-clay, and three map-units dominated by boulder were selected for sampling in the Wilder riverine reach.

Of the 51 map-units considered for sampling, 39 were dominated by cobble-gravel, nine were dominated by sand-silt-clay, and three were dominated by boulder. Table 3.2-2 presents information for the 12 map-units selected for sampling. Figure 3.2-1 presents the spatial distribution of the 12 sampling locations. Based on existing field crew knowledge of water depths and boat access (both ramps and in-river transit), the anticipated sampling methods for selected sampling locations are presented in Table 3.2-3. It is expected that the Wilder riverine reach will be characterized by shallower water depths and faster velocities than those observed in the Wilder impoundment. When relatively shallow depth conditions, increased current, and site access are considered, fish assemblage sampling in the Wilder riverine section will likely consist primarily of pram electrofishing combined with beach seining in map-units dominated by sand-silt-clay and cobble-gravel habitats. Map-units in the Wilder riverine section dominated by boulder- rip rap substrate will likely be sampled by pram electrofishing. Gill nets (lack of suitable depth and increased current), trap nets (increased current) and beach seine (non-uniform bottom substrate) are not appropriate for sampling boulder-rip rap habitat in the Wilder riverine reach. Results of the random bank selection (east vs. west), and information on tributary or backwater presence, are also presented in Table 3.2-3.

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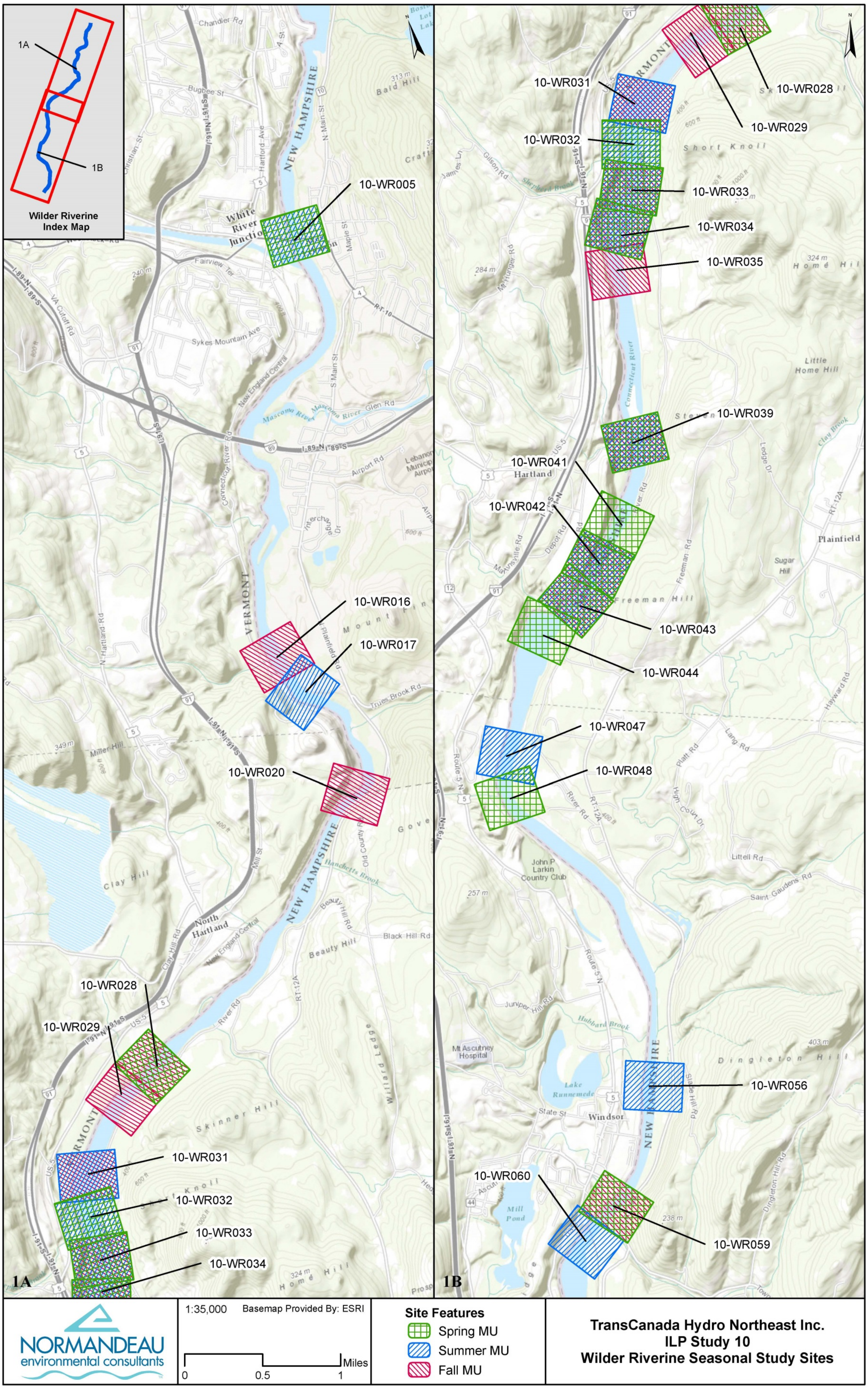

Figure 3.2-1. Revised Map-units selected for fish assemblage sampling within the Wilder riverine reach, 2015.

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Table 3.2-1. Total area (acres) and percent of total area for aquatic habitat types mapped using sonar imagery within the Wilder riverine reach (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	217.0	20.3%
gravel/cobble	625.3	58.5%
boulder	66.7	6.2%
no data	159.8	14.9%
TOTAL	1068.9	100.0%

Table 3.2-2. Revised Substrate composition and resulting dominant habitat type for map-units randomly selected in the Wilder riverine reach.

Sampling Season	Map Unit	Substrate Type (acres/ %)								Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		Boulder		No Data		
Spring	10 – WR005	10.4	71.7%	4.1	28.3%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 – WR028	14.8	67.9%	0	0.0%	0	0.0%	7	32.1%	Sand, Silt, Clay
	10 – WR032	23.2	100.0%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 – WR033	7.4	37.2%	0	0.0%	12.5	62.8%	0	0.0%	Boulder
	10 – WR034	13.3	47.7%	5.6	20.1%	9	32.3%	0	0.0%	Sand, Silt, Clay
	10 – WR039	0	0.0%	16	100.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 – WR041	0	0.0%	9.2	55.4%	7.4	44.6%	0	0.0%	Gravel, Cobble
	10 – WR042	0	0.0%	0	0.0%	14.3	100.0%	0	0.0%	Boulder
	10 – WR043	0	0.0%	5.8	35.4%	10.6	64.6%	0	0.0%	Boulder
	10 – WR044	4.7	20.8%	15.5	68.6%	0	0.0%	2.4	10.6%	Gravel, Cobble
	10 – WR048	0	0.0%	16.4	100.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 – WR059	0	0.0%	17.8	100.0%	0	0.0%	0	0.0%	Gravel, Cobble
Summer	10 – WR005	10.4	71.7%	4.1	28.3%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 – WR017	0	0.0%	14.6	100.0%	0	0.0%	0	0.0%	Gravel, Cobble

Sampling Season	Map Unit	Substrate Type (acres/ %)								Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		Boulder		No Data		
	10 – WR031	28.4	100.0%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 – WR032	23.2	100.0%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 – WR033	7.4	37.2%	0	0.0%	12.5	62.8%	0	0.0%	Boulder
	10 – WR034	13.3	47.7%	5.6	20.1%	9	32.3%	0	0.0%	Sand, Silt, Clay
	10 – WR039	0	0.0%	16	100.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 – WR042	0	0.0%	0	0.0%	14.3	100.0%	0	0.0%	Boulder
	10 – WR043	0	0.0%	5.8	35.4%	10.6	64.6%	0	0.0%	Boulder
	10 – WR047	0	0.0%	18.9	100.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 – WR056	5.5	25.5%	16.1	74.5%	0	0.0%	0	0.0%	Gravel, Cobble
	10 – WR060	9.9	49.3%	10.2	50.7%	0	0.0%	0	0.0%	Gravel, Cobble
Fall	10 – WR016	0	0.0%	8.3	51.2%	7.6	46.9%	0.3	1.9%	Gravel, Cobble
	10 – WR020	0	0.0%	14.1	100.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 – WR028	14.8	67.9%	0	0.0%	0	0.0%	7	32.1%	Sand, Silt, Clay
	10 – WR029	19.9	100.0%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 – WR031	28.4	100.0%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 – WR033	7.4	37.2%	0	0.0%	12.5	62.8%	0	0.0%	Boulder
	10 – WR034	13.3	47.7%	5.6	20.1%	9	32.3%	0	0.0%	Sand, Silt, Clay
	10 – WR035	0	0.0%	17.5	100.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 – WR039	0	0.0%	16	100.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 – WR042	0	0.0%	0	0.0%	14.3	100.0%	0	0.0%	Boulder
	10 – WR043	0	0.0%	5.8	35.4%	10.6	64.6%	0	0.0%	Boulder
	10 – WR059	0	0.0%	17.8	100.0%	0	0.0%	0	0.0%	Gravel, Cobble

Table 3.2-3. Sampling bank, anticipated sampling methods, and location type of map units randomly selected in the Wilder riverine reach.

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
Spring	10 – WR005	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR028	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR032	West	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR033	West	Pram Electrofish	-		Mainstem		
	10 – WR034	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR039	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR041	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR042	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR043	West	Pram Electrofish	-		Mainstem		
	10 – WR044	West	Pram Electrofish	-	CT-WR-2.11	Major Trib	Lulls Brook	3
	10 – WR048	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR059	East	Pram Electrofish	Beach Seine	CT-WR-2.19	Major Trib	Mill Brook NH	4
Summer	10 – WR005	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR017	West	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR031	West	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR032	West	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR033	West	Pram Electrofish	-		Mainstem		
	10 – WR034	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR039	West	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR042	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR043	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR047	West	Pram Electrofish	-	CT-WR-2.12	Minor Trib		2
	10 – WR056	West	Pram Electrofish	Beach Seine	CT-WR-2.17	Minor Trib		1
	10 – WR060	East	Pram Electrofish	Beach Seine		Mainstem		
Fall	10 – WR016	West	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR020	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR028	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR029	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR031	West	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR033	West	Pram Electrofish	-		Mainstem		
	10 – WR034	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR035	East	Pram Electrofish	Beach Seine		Mainstem		

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
	10 – WR039	East	Pram Electrofish	Beach Seine		Mainstem		
	10 – WR042	East	Pram Electrofish	-		Mainstem		
	10 – WR043	West	Pram Electrofish	-		Mainstem		
	10 – WR059	East	Pram Electrofish	Beach Seine	CT-WR-2.19	Major Trib	Mill Brook NH	4

3.3 Bellows Falls Impoundment

A total of 93 map-units were placed within the Bellows Falls impoundment extending from map-unit 10-B001 at the upper extent of the impoundment (RM 199.7) to map-unit 10-B093 located at the Bellows Falls dam. Existing side-scan survey data was used to determine dominant habitat type for the majority of map-units within the impoundment (88 of 93). Existing mesohabitat survey data was used to determine dominant habitat type for 4 map-units, and a combination of side-scan and mesohabitat survey data was used for the remaining map unit.

The percentages of habitat type within the 2,921 acres mapped by side-scan sonar were used to determine the spatial distribution of 12 sampling locations in the impoundment. Results from the Study 7 impoundment mapping are presented in Table 3.3-1 and indicate that the majority of habitat in the impoundment is dominated by sand-silt-clay and cobble-gravel. Lesser amounts of boulder, rip rap, ledge and woody debris habitat are also present. For the purposes of placing sampling locations in the impoundment, the total number of locations (12) were allocated following a habitat-type frequency distribution of 84% in map-units dominated by sand-silt-clay, 12% in map-units dominated by cobble-gravel and 4% in map-units dominated by boulder and/or rip rap. Totals were then adjusted so that a minimum of three sample locations were placed within each strata (i.e., habitat type) within a particular geographic reach. When adjusted to account for existing habitat proportions and minimum number of samples within each habitat strata, 6 map-units dominated by sand-silt-clay, 3 map-units dominated by cobble-gravel and 3 map-units dominated by boulder-rip rap were selected for sampling.

Of the 93 map-units considered for sampling, 80 were dominated by sand-silt-clay and 13 were dominated by cobble-gravel. There were no map-units where the boulder-rip rap substrate types were proportionally dominant. To address this, map-units were sorted based on the proportional contribution of boulder-rip rap habitat and locations within the upper quartile of presence were used as the basis for random selection. Table 3.3-2 presents information for the 12 map-units selected for sampling. Figure 3.3-1 presents the spatial distribution of the 12 sampling locations during the spring, summer, and fall sampling periods. Based on existing field crew knowledge of water depths and boat access (both ramps and in-river transit), the anticipated sampling methods for selected sampling locations are presented in Table 3.3-3. It is expected that the Bellows Falls impoundment will be characterized by deeper water depths and slower velocities than those observed in the downstream riverine section. When those conditions as well as the relative ease of accessing selected sampling locations are considered, fish assemblage sampling in the impoundment will likely consist primarily of boat electrofishing combined with gill net sampling within map-units dominated by all habitat types (sand-silt-clay, cobble-gravel, boulder-rip rap). Results of the random bank selection (east vs. west), and information on tributary or backwater presence, are also presented in Table 3.3-3.

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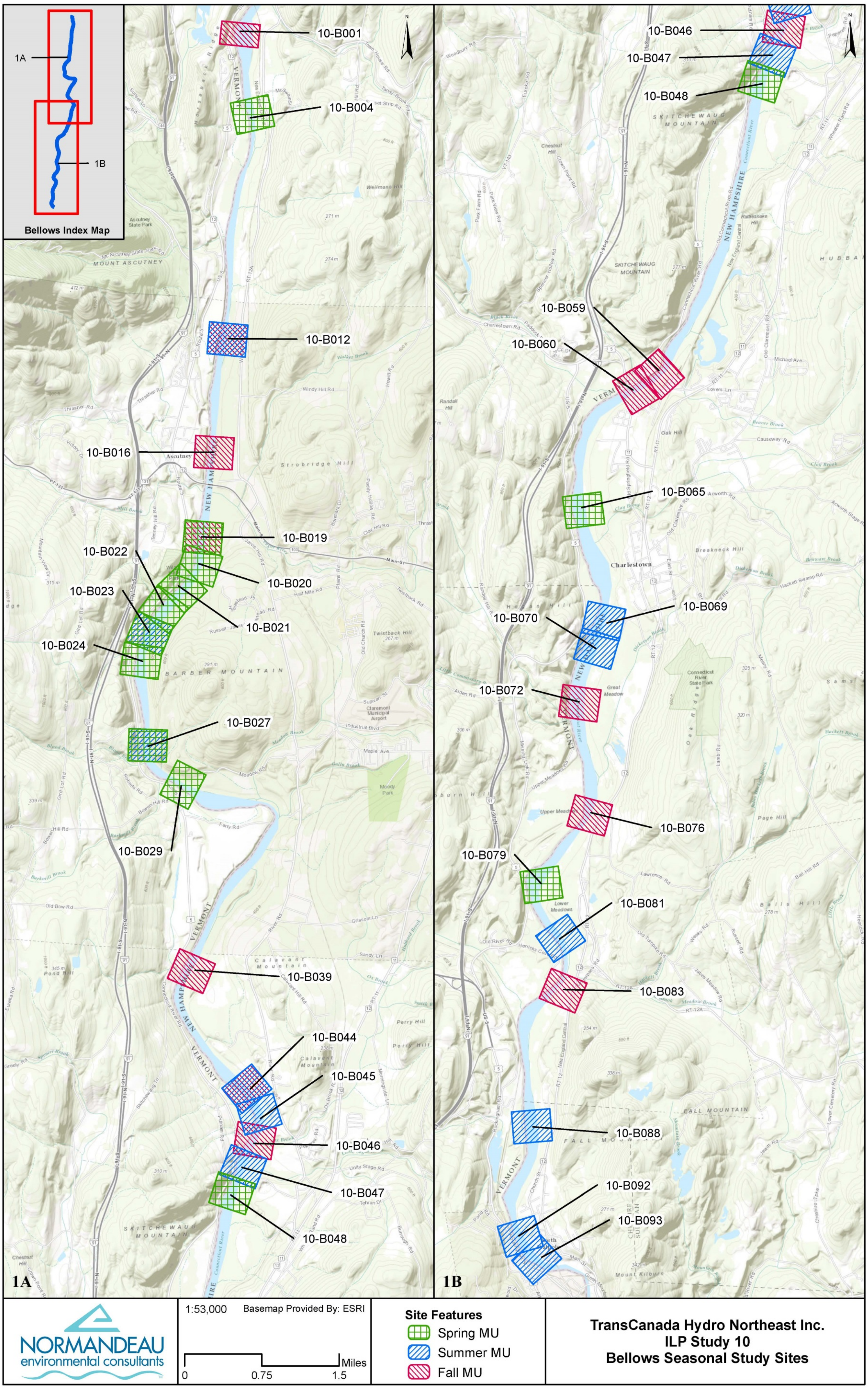

Figure 3.3-1. Revised Map-units selected for fish assemblage sampling within the Bellows Falls impoundment, 2015.

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Table 3.3-1. Total area (acres) and percent of total area for aquatic habitat types mapped using sonar imagery within Bellows Falls impoundment (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	2,450.90	83.9%
gravel/cobble	348.7	11.9%
boulder	49.9	1.7%
rip rap	25.4	0.9%
ledge	3.8	0.1%
woody debris	43	1.5%
TOTAL	2,921.80	100.0%

Table 3.3-2. Revised Substrate composition and resulting dominant habitat type for map-units randomly selected in the Bellows Falls impoundment.

Sampling Season	Map Unit	Substrate Type (acres/ %)														Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		Boulder		Rip Rap		Ledge		Woody Debris		No Data		
Spring	10 – B004	3.7	9.5%	15.4	39.7%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	19.7	50.8%	Gravel, Cobble
	10 – B019	27.8	95.5%	0.5	1.7%	0.1	0.3%	0.4	1.4%	0	0.0%	0.3	1.0%	0	0.0%	Sand, Silt, Clay
	10 – B020	20.7	84.1%	2.4	9.8%	0.1	0.4%	0.7	2.8%	0	0.0%	0.7	2.8%	0	0.0%	Sand, Silt, Clay
	10 – B021	6	37.7%	2.6	16.4%	6.1	38.4%	0.1	0.6%	0.1	0.6%	1	6.3%	0	0.0%	Sand, Silt, Clay
	10 – B022	4.8	31.6%	4.8	31.6%	4.8	31.6%	0	0.0%	0	0.0%	0.8	5.3%	0	0.0%	Boulder
	10 – B023	1.7	9.0%	14.5	77.1%	1.6	8.5%	0	0.0%	0	0.0%	1	5.3%	0	0.0%	Boulder
	10 – B024	8.1	39.3%	11.2	54.4%	0.1	0.5%	0	0.0%	0	0.0%	1.2	5.8%	0	0.0%	Gravel, Cobble
	10 – B027	8.3	50.3%	4.7	28.5%	3.2	19.4%	0	0.0%	0.2	1.2%	0.1	0.6%	0	0.0%	Boulder
	10 – B029	13.5	72.2%	5.1	27.3%	0	0.0%	0	0.0%	0	0.0%	0.1	0.5%	0	0.0%	Sand, Silt, Clay
	10 – B048	6.5	24.1%	20	74.1%	0.2	0.7%	0.1	0.4%	0	0.0%	0.2	0.7%	0	0.0%	Gravel, Cobble
	10 – B065	39	98.2%	0.4	1.0%	0	0.0%	0	0.0%	0	0.0%	0.3	0.8%	0	0.0%	Sand, Silt, Clay
	10 – B079	46.8	99.6%	0.2	0.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
Summer	10 – B012	9.9	42.3%	12.1	51.7%	0.1	0.4%	0	0.0%	0.2	0.9%	1.1	4.7%	0	0.0%	Gravel, Cobble
	10 – B023	1.7	9.0%	14.5	77.1%	1.6	8.5%	0	0.0%	0	0.0%	1	5.3%	0	0.0%	Gravel, Cobble
	10 – B027	8.3	50.3%	4.7	28.5%	3.2	19.4%	0	0.0%	0.2	1.2%	0.1	0.6%	0	0.0%	Sand, Silt, Clay
	10 – B044	25.5	89.5%	0	0.0%	2.1	7.4%	0	0.0%	0	0.0%	0.9	3.2%	0	0.0%	Sand, Silt, Clay
	10 – B045	24.1	84.6%	3.6	12.6%	0	0.0%	0	0.0%	0	0.0%	0.8	2.8%	0	0.0%	Sand, Silt, Clay

Sampling Season	Map Unit	Substrate Type (acres / %)														Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		Boulder		Rip Rap		Ledge		Woody Debris		No Data		
	10 – B047	1.4	6.3%	16.9	75.8%	3.6	16.1%	0	0.0%	0.3	1.3%	0.1	0.4%	0	0.0%	Gravel, Cobble
	10 – B069	23.7	72.9%	6.5	20.0%	1.2	3.7%	1	3.1%	0	0.0%	0.1	0.3%	0	0.0%	Boulder
	10 – B070	42.8	97.9%	0	0.0%	0	0.0%	0.9	2.1%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 – B081	19.7	72.2%	7.6	27.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 – B088	41.9	95.0%	1.5	3.4%	0.1	0.2%	0	0.0%	0	0.0%	0.6	1.4%	0	0.0%	Sand, Silt, Clay
	10 – B092	13.3	55.4%	7.9	32.9%	0.8	3.3%	1.8	7.5%	0	0.0%	0.2	0.8%	0	0.0%	Boulder
	10 – B093	14.9	62.3%	6.7	28.0%	1.4	5.9%	0.8	3.3%	0	0.0%	0.1	0.4%	0	0.0%	Boulder
Fall	10 – B001	0	0.0%	15.5	61.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	9.8	38.7%	Gravel, Cobble
	10 – B012	9.9	42.3%	12.1	51.7%	0.1	0.4%	0	0.0%	0.2	0.9%	1.1	4.7%	0	0.0%	Gravel, Cobble
	10 – B016	17.5	82.9%	3	14.2%	0	0.0%	0	0.0%	0	0.0%	0.6	2.8%	0	0.0%	Sand, Silt, Clay
	10 – B019	27.8	95.5%	0.5	1.7%	0.1	0.3%	0.4	1.4%	0	0.0%	0.3	1.0%	0	0.0%	Sand, Silt, Clay
	10 – B039	27.1	95.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1.3	4.6%	0	0.0%	Sand, Silt, Clay
	10 – B044	25.5	89.5%	0	0.0%	2.1	7.4%	0	0.0%	0	0.0%	0.9	3.2%	0	0.0%	Boulder
	10 – B046	10.9	45.8%	12	50.4%	0.4	1.7%	0	0.0%	0.2	0.8%	0.3	1.3%	0	0.0%	Gravel, Cobble
	10 – B059	8.2	39.6%	8.2	39.6%	2.9	14.0%	1.1	5.3%	0	0.0%	0.3	1.4%	0	0.0%	Boulder
	10 – B060	8.7	42.6%	9.6	47.1%	0.8	3.9%	0.8	3.9%	0.1	0.5%	0.4	2.0%	0	0.0%	Boulder
	10 – B072	46.1	99.6%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0.2	0.4%	0	0.0%	Sand, Silt, Clay
	10 – B076	28.4	94.4%	0.5	1.7%	0.5	1.7%	0	0.0%	0.6	2.0%	0.1	0.3%	0	0.0%	Sand, Silt, Clay
	10 – B083	19.1	53.8%	15.9	44.8%	0	0.0%	0.4	1.1%	0	0.0%	0.1	0.3%	0	0.0%	Sand, Silt, Clay

Table 3.3-3. Sampling bank, anticipated sampling methods, and location type of map units randomly selected in the Bellows Falls impoundment.

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
Spring	10 – B004	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B019	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B020	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B021	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B022	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B023	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B024	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B027	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B029	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B048	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B065	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B079	West	Boat Electrofish	Gill Net	CT-B-3.27	Minor Trib		2
Summer	10 – B012	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B023	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B027	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B044	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B045	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B047	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B069	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B070	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B081	East	Boat Electrofish	Gill Net	CT-B-3.28	Minor Trib		2
	10 – B088	East	Boat Electrofish	Gill Net	CT-B-3.32	Backwater		0
	10 – B092	East	Boat Electrofish	Gill Net	CT-B-3.35	Minor Trib		2
	10 – B093	East	Boat Electrofish	Gill Net		Mainstem		
Fall	10 – B001	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B012	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B016	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B019	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B039	West	Boat Electrofish	Gill Net	CT-B-3.11	Major Trib		3
	10 - B044	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B046	East	Boat Electrofish	Gill Net	CT-B-3.12	Major Trib	Ox Brook	3
	10 – B059	East	Boat Electrofish	Gill Net		Mainstem		

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
	10 – B060	East	Boat Electrofish	Gill Net		Mainstem		
	10 – B072	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B076	West	Boat Electrofish	Gill Net		Mainstem		
	10 – B083	East	Boat Electrofish	Gill Net		Mainstem		

3.4 Bellows Falls Bypassed Reach

Due to the short length of the reach (~3,500 feet), only two 500-m map-units were placed within the Bellows Falls bypassed reach. Map-unit 10-BF001 extends from the base of the Bellows Falls dam downstream to the fish barrier. Map-unit 10-BF002 extends from the fish barrier downstream to the confluence with the mainstem. Existing mesohabitat survey data was used to determine dominant habitat type for both map-units. Boulder was the dominant substrate type within each of the 14 mesohabitat units identified during 2013 field mapping and as a result was the dominant habitat type assigned to both map-units in the bypassed reach (Table 3.4-1).

As stated in the RSP, three randomly selected 500-m map-units were to be selected for sampling within the Bellows Falls bypassed reach. The results of the random sampling selection for the bypassed reach are presented in Table 3.4-2. Based on the lack of boat access and difficult access, it is anticipated that sampling within the bypassed reach will be conducted by pram electrofishing.

Table 3.4-1. Total area (acres) mapped during mesohabitat mapping within the Bellows Falls bypassed reach (Normandeau 2014) and resulting dominant habitat types assigned to each map-unit.

Map Unit	Area (acres)	Dominant Habitat
10 - BR001	7.01	Boulder
10 - BR002	4.54	Boulder

Table 3.4-2. Map-units, sampling bank, and anticipated sampling methods in the Bellows Falls bypassed reach.

Sampling Season	Map Unit	Sample Bank	Dominant Habitat	Primary Gear
Spring	10 - BF001	East	Boulder	Pram Electrofish
	10 - BF001	West	Boulder	Pram Electrofish
	10 - BF002	West	Boulder	Pram Electrofish
Summer	10 - BF001	West	Boulder	Pram Electrofish
	10 - BF002	East	Boulder	Pram Electrofish
	10 - BF002	West	Boulder	Pram Electrofish
Fall	10 - BF001	East	Boulder	Pram Electrofish
	10 - BF001	West	Boulder	Pram Electrofish
	10 - BF002	East	Boulder	Pram Electrofish

3.5 Bellows Falls Riverine Reach

A total of 20 map-units were placed within the Bellows Falls riverine reach extending from map-unit 10-BR001 at the Bellows Falls tailrace to map-unit 10-BR020 located at RM 167.9. Existing side-scan survey data was used to determine dominant habitat type for 6 of the 20 map-units. Existing mesohabitat survey data was used to determine dominant habitat type for 13 map-units, and a combination of side-scan and mesohabitat survey data was used in determination of 1 map-unit.

The percentages of habitat type within the approximately 415 acres mapped in Study 7 were used to determine the spatial distribution of 12 sampling locations in the reach. Results from the Study 7 mesohabitat mapping are presented in Table 3.5-1 and indicate that the majority of habitat in the reach is primarily dominated by cobble-gravel. Lesser amounts of sand-silt-clay habitat are also present. For the purposes of placing sampling locations in the reach, the total number of locations (12) was allocated following a habitat-type frequency distribution of 83% in map-units dominated by cobble-gravel and 17% in map-units dominated by sand-silt-clay. When adjusted to account for existing habitat proportions and minimum number of samples within each habitat strata, ten map-units dominated by cobble-gravel and two map-units dominated by sand-silt-clay were selected for sampling.

Of the 20 map-units considered for sampling, 18 were dominated by cobble-gravel and 2 were dominated by sand-silt-clay. Table 3.5-2 presents information for the 12 map-units selected for sampling. Figure 3.5-1 presents the spatial distribution of the 12 sampling locations. Based on existing field crew knowledge of water depths and boat access (both ramps and in-river transit), the anticipated sampling methods for selected sampling locations are presented in Table 3.5-3. It is expected that the Bellows Falls riverine reach will be characterized by shallower water depths and faster velocities than those observed upstream in the impoundment. When relatively shallow depth conditions, increased current, and site access are considered, fish assemblage sampling in the Bellows Falls riverine section will likely consist primarily of pram electrofishing combined with beach seining in map-units dominated by sand-silt-clay and cobble-gravel habitats. Results of the random bank selection (east vs. west), and information on tributary or backwater presence, are also presented in Table 3.5-3.

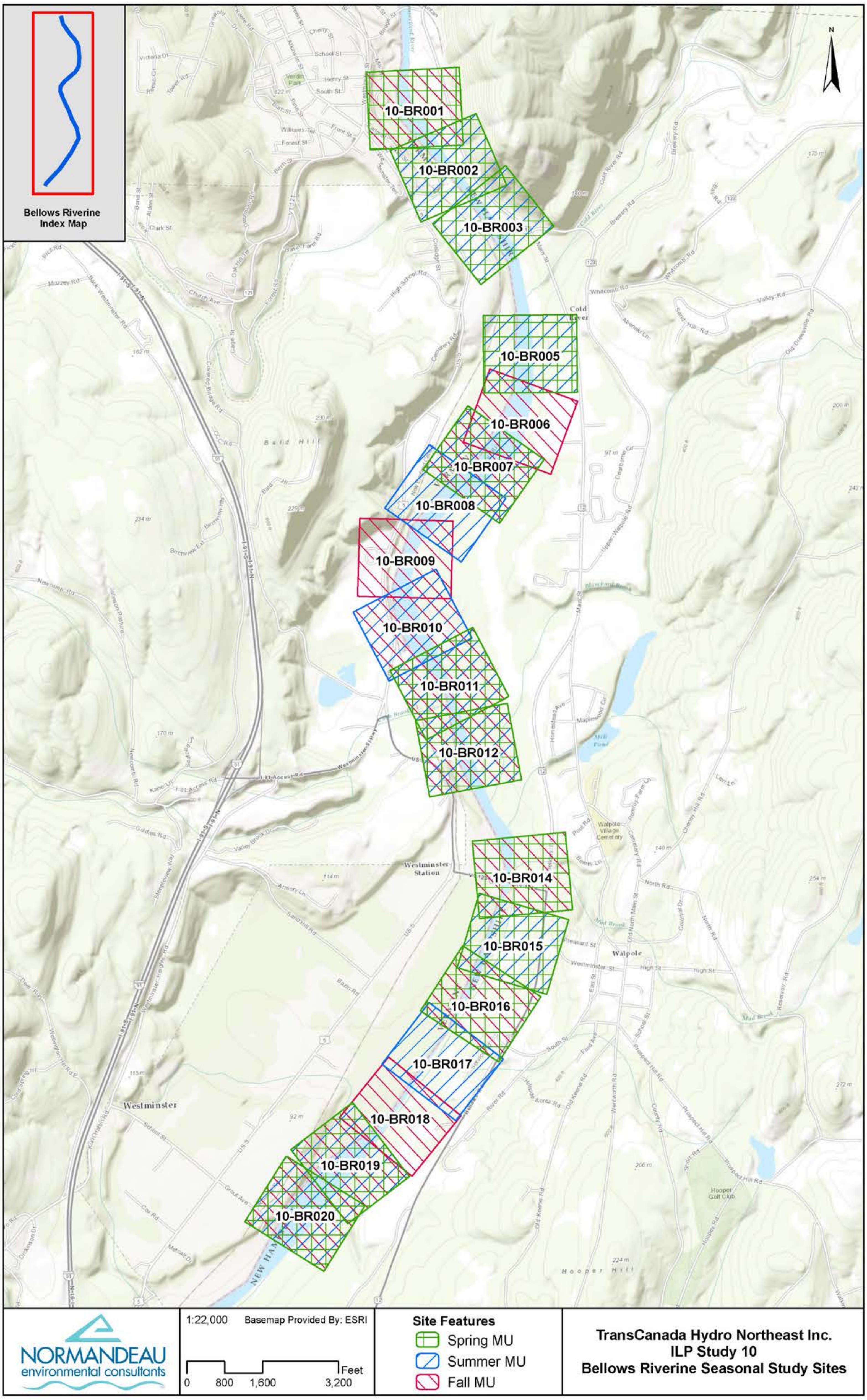

Figure 3.5-1. Map-units selected for fish assemblage sampling within the Bellows Falls riverine reach, 2015.

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Table 3.5-1. Total area (acres) and percent of total area for aquatic habitat types mapped during sonar image collections and mesohabitat mapping within the Bellows Falls riverine reach (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	44.3	10.7%
gravel/cobble	343.2	82.7%
boulder	2.0	0.5%
rip rap	2.5	0.6%
ledge	0.0	0.0%
woody debris	5.8	1.4%
no data	17.1	4.1%
TOTAL	415.0	100.0%

Table 3.5-2. Substrate composition and the resulting dominant habitat type for map-units randomly selected in the Bellows Falls riverine reach.

Sampling Season	Map Unit	Substrate Type (acres/%)														Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		Boulder		Rip Rap		Ledge		Woody Debris		No Data		
Spring	10 - BR001	0	0.0%	31	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR002	0	0.0%	22.2	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR003	0	0.0%	17.3	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR005	0	0.0%	15.7	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR007	0	0.0%	15.3	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR011	11.9	66.9%	5.9	33.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 - BR012	12.3	54.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	10.1	45.1%	Sand, Silt, Clay
	10 - BR014	0.7	3.4%	13.2	63.5%	0.2	1.0%	2.3	11.1%	0	0.0%	0.4	1.9%	4	19.2%	Gravel, Cobble
	10 - BR015	3.5	14.6%	19.6	82.0%	0.3	1.3%	0.1	0.4%	0	0.0%	0.4	1.7%	0	0.0%	Gravel, Cobble
	10 - BR016	0.6	2.4%	22.6	89.7%	1.3	5.2%	0	0.0%	0	0.0%	0.7	2.8%	0	0.0%	Gravel, Cobble
	10 - BR019	3.9	13.4%	24.2	82.9%	0.2	0.7%	0	0.0%	0	0.0%	0.9	3.1%	0	0.0%	Gravel, Cobble
	10 - BR020	8.1	28.1%	19.4	67.4%	0	0.0%	0.1	0.3%	0	0.0%	1.2	4.2%	0	0.0%	Gravel, Cobble
Summer	10 - BR002	0	0.0%	22.2	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR003	0	0.0%	17.3	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR005	0	0.0%	15.7	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble

Sampling Season	Map Unit	Substrate Type (acres / %)														Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		Boulder		Rip Rap		Ledge		Woody Debris		No Data		
	10 - BR007	0	0.0%	15.3	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR008	0	0.0%	16.4	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR010	0	0.0%	16.5	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR011	11.9	66.9%	5.9	33.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 - BR012	12.3	54.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	10.1	45.1%	Sand, Silt, Clay
	10 - BR015	3.5	14.6%	19.6	82.0%	0.3	1.3%	0.1	0.4%	0	0.0%	0.4	1.7%	0	0.0%	Gravel, Cobble
	10 - BR017	1.4	6.1%	20.2	88.6%	0	0.0%	0	0.0%	0	0.0%	1.2	5.3%	0	0.0%	Gravel, Cobble
	10 - BR019	3.9	13.4%	24.2	82.9%	0.2	0.7%	0	0.0%	0	0.0%	0.9	3.1%	0	0.0%	Gravel, Cobble
	10 - BR020	8.1	28.1%	19.4	67.4%	0	0.0%	0.1	0.3%	0	0.0%	1.2	4.2%	0	0.0%	Gravel, Cobble
Fall	10 - BR001	0	0.0%	31	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR006	0	0.0%	17.2	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR007	0	0.0%	15.3	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR009	0	0.0%	14.9	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR010	0	0.0%	16.5	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Gravel, Cobble
	10 - BR011	11.9	66.9%	5.9	33.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	Sand, Silt, Clay
	10 - BR012	12.3	54.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	10.1	45.1%	Sand, Silt, Clay
	10 - BR014	0.7	3.4%	13.2	63.5%	0.2	1.0%	2.3	11.1%	0	0.0%	0.4	1.9%	4	19.2%	Gravel, Cobble
	10 - BR016	0.6	2.4%	22.6	89.7%	1.3	5.2%	0	0.0%	0	0.0%	0.7	2.8%	0	0.0%	Gravel, Cobble
	10 - BR018	1.9	8.4%	19.6	86.7%	0	0.0%	0.1	0.4%	0	0.0%	1	4.4%	0	0.0%	Gravel, Cobble
	10 - BR019	3.9	13.4%	24.2	82.9%	0.2	0.7%	0	0.0%	0	0.0%	0.9	3.1%	0	0.0%	Gravel, Cobble
	10 - BR020	8.1	28.1%	19.4	67.4%	0	0.0%	0.1	0.3%	0	0.0%	1.2	4.2%	0	0.0%	Gravel, Cobble

Table 3.5-3. Sampling bank, anticipated sampling methods, and location type of map units randomly selected in the Bellows Falls riverine reach.

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
Spring	10 - BR001	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR002	West	Pram Electrofish	Beach Seine	CT-BR-4.01	Major Trib	Saxtons River	5
	10 - BR003	West	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR005	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR007	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR011	West	Pram Electrofish	Beach Seine	CT-BR-4.03	Minor Trib		2
	10 - BR012	West	Pram Electrofish	Beach Seine	CT-BR-4.04	Major Trib	Cobb Brook	3
	10 - BR014	West	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR015	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR016	West	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR019	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR020	West	Pram Electrofish	Beach Seine		Mainstem		
Summer	10 - BR002	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR003	West	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR005	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR007	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR008	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR010	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR011	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR012	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR015	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR017	East	Pram Electrofish	Beach Seine	CT-V-5.03	Minor Trib		2
	10 - BR019	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR020	East	Pram Electrofish	Beach Seine	CT-V-5.05	Minor Trib		1
Fall	10 - BR001	West	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR006	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR007	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR009	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR010	West	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR011	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR012	East	Pram Electrofish	Beach Seine		Mainstem		

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
	10 - BR014	East	Pram Electrofish	Beach Seine	CT-V-5.02	Minor Trib	Mad Brook	2
	10 - BR016	West	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR018	West	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR019	East	Pram Electrofish	Beach Seine		Mainstem		
	10 - BR020	West	Pram Electrofish	Beach Seine		Mainstem		

3.6 Vernon Impoundment

A total of 93 map-units were placed within the Vernon impoundment extending from map-unit 10-V001 at the upper extent of the impoundment (RM 167.9) to map-unit 10-V093 located at Vernon dam. Existing side-scan survey data was used to determine dominant habitat type for all map-units within the impoundment.

The percentages of habitat type within the 3,137 acres mapped by side-scan sonar in Study 7 were used to determine the spatial distribution of 12 sampling locations. Results from the Study 7 impoundment mapping are presented in Table 3.6-1 and indicate that the majority of habitat in the impoundment is dominated by sand-silt-clay and cobble-gravel. Lesser amounts of boulder, rip rap, ledge and woody debris habitat are also present. For the purposes of placing sampling locations in the impoundment, the total number of locations (12) were allocated following a habitat-type frequency distribution of 76% in map-units dominated by sand-silt-clay, 15% in map-units dominated by cobble-gravel and 9% in map-units dominated by boulder and/or rip rap. Totals were then adjusted so that a minimum of three sample locations were placed within each strata (i.e., habitat type) within a particular geographic reach. When adjusted to account for existing habitat proportions and minimum number of samples within each habitat strata, 6 map-units dominated by sand-silt-clay, 3 map-units dominated by cobble-gravel and 3 map-units dominated by boulder-rip rap were selected for sampling.

Of the 93 map-units considered for sampling, 73 were dominated by sand-silt-clay and 20 were dominated by cobble-gravel. There were no map-units where the boulder-rip rap substrate types were proportionally dominant. To address this, map-units were sorted based on the proportional contribution of boulder-rip rap habitat and locations within the upper quartile of presence were used as the basis for random selection. Table 3.6-2 presents information for the 12 map-units selected for sampling. Figure 3.6-1 presents the spatial distribution of the 12 sampling locations. Based on existing field crew knowledge of water depths and boat access (both ramps and in-river transit), the anticipated sampling methods for selected sampling locations are presented in Table 3.6-3. It is expected that the Vernon impoundment will be characterized by deeper water depths and slower velocities than those observed in the adjacent Bellows Falls riverine section. When those conditions as well as the relative ease of accessing selected sampling locations are considered, fish assemblage sampling in the Vernon impoundment will likely consist primarily of boat electrofishing combined with gill net sampling within map-units dominated by all habitat types (sand-silt-clay, cobble-gravel, boulder-rip rap). Results of the random bank selection (east vs. west), and information on tributary or backwater presence, are also presented in Table 3.6-3.

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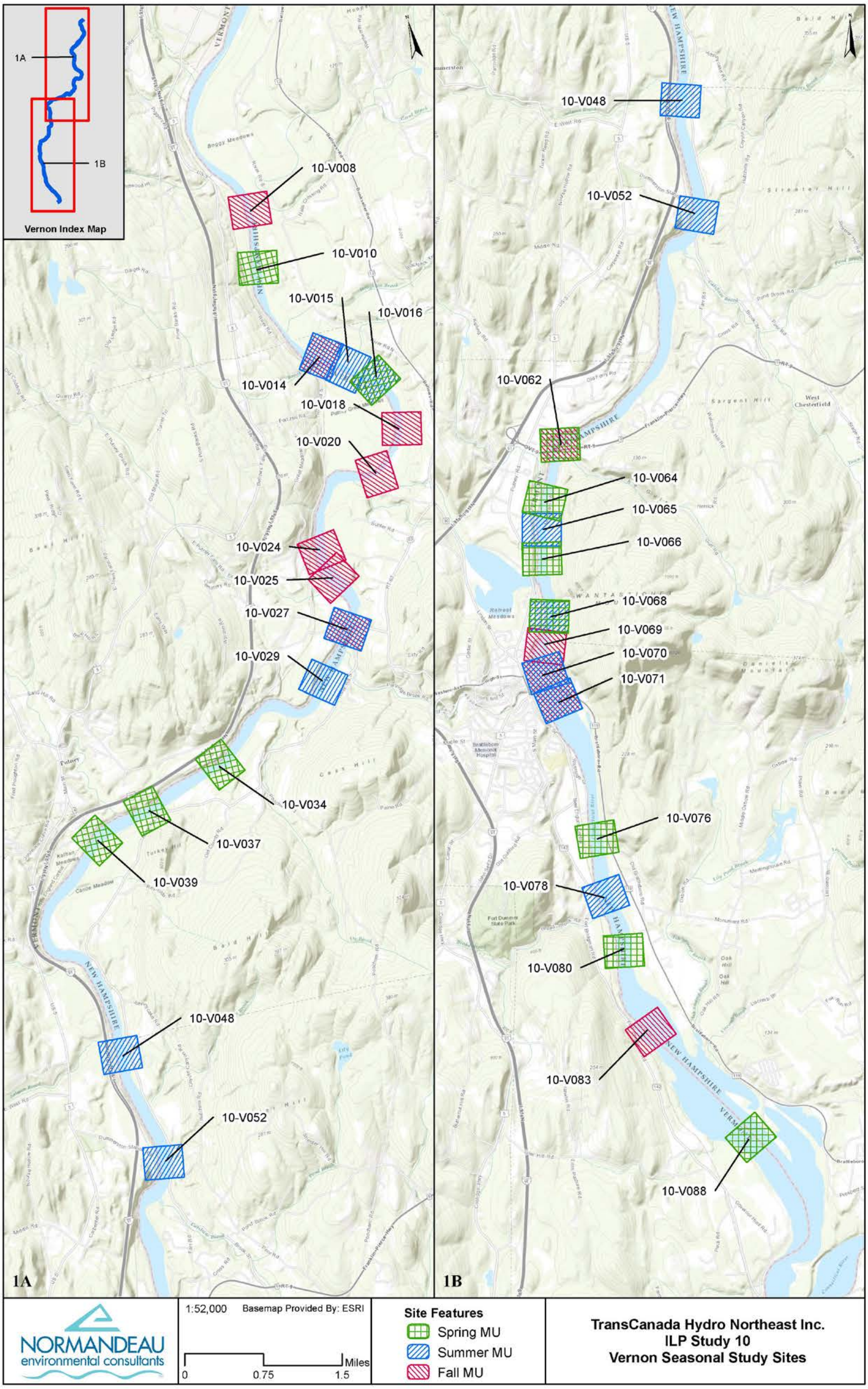

Figure 3.6-1. Map-units selected for fish assemblage sampling within the Vernon impoundment, 2015.

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Table 3.6-1. Total area (acres) and percent of total area for aquatic habitat types mapped using sonar imagery within Vernon impoundment (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	2,273.1	72.5%
gravel/cobble	653.6	20.8%
boulder	53.8	1.7%
rip rap	44.3	1.4%
ledge	27.2	0.9%
woody debris	85.2	2.7%
TOTAL	3,137.2	100.0%

Table 3.6-2. Substrate composition and the resulting dominant habitat type for map-units randomly selected in the Vernon impoundment.

Sampling Season	Map Unit	Substrate Type (acres/%)												Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		Boulder		Rip Rap		Ledge		Woody Debris		
Spring	10 – V010	8.7	38.7%	12.3	54.7%	0	0.0%	0.3	1.3%	0	0.0%	1.2	5.3%	Gravel, Cobble
	10 – V016	19.9	84.0%	3.3	13.9%	0	0.0%	0	0.0%	0	0.0%	0.5	2.1%	Sand, Silt, Clay
	10 – V034	7.9	44.1%	6.2	34.6%	2.6	14.5%	0	0.0%	0	0.0%	1.2	6.7%	Boulder
	10 – V037	15.5	79.5%	3.3	16.9%	0.5	2.6%	0	0.0%	0	0.0%	0.2	1.0%	Sand, Silt, Clay
	10 – V039	17.8	74.5%	2.4	10.0%	1.1	4.6%	0.1	0.4%	0.9	3.8%	1.6	6.7%	Sand, Silt, Clay
	10 – V062	8.9	39.2%	9	39.6%	1.2	5.3%	1.1	4.8%	2.5	11.0%	0	0.0%	Boulder
	10 – V064	3.7	20.3%	12.8	70.3%	0.4	2.2%	0.4	2.2%	0.6	3.3%	0.3	1.6%	Gravel, Cobble
	10 – V066	1.3	6.8%	15.8	82.7%	0.4	2.1%	0.7	3.7%	0.5	2.6%	0.4	2.1%	Gravel, Cobble
	10 – V068	7.6	37.3%	8.4	41.2%	2.7	13.2%	0.6	2.9%	0.1	0.5%	1	4.9%	Boulder
	10 – V076	17.5	78.5%	3.2	14.3%	0	0.0%	0	0.0%	1.2	5.4%	0.4	1.8%	Sand, Silt, Clay
	10 – V080	19.6	69.8%	7	24.9%	0	0.0%	0	0.0%	0.7	2.5%	0.8	2.8%	Sand, Silt, Clay
	10 – V088	56.1	99.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0.4	0.7%	Sand, Silt, Clay
Summer	10 – V014	13.2	54.8%	9.9	41.1%	0.6	2.5%	0	0.0%	0	0.0%	0.4	1.7%	Sand, Silt, Clay
	10 – V015	15.9	77.2%	3.5	17.0%	0	0.0%	0	0.0%	0	0.0%	1.2	5.8%	Sand, Silt, Clay
	10 – V016	19.9	84.0%	3.3	13.9%	0	0.0%	0	0.0%	0	0.0%	0.5	2.1%	Sand, Silt, Clay
	10 – V027	8.4	50.0%	4.1	24.4%	1.7	10.1%	0.2	1.2%	2.1	12.5%	0.3	1.8%	Sand, Silt, Clay
	10 – V029	15.8	70.2%	4.3	19.1%	0	0.0%	0	0.0%	0	0.0%	2.4	10.7%	Sand, Silt, Clay
	10 – V048	8.6	45.3%	7.7	40.5%	1.4	7.4%	0	0.0%	0.8	4.2%	0.5	2.6%	Gravel, Cobble

Sampling Season	Map Unit	Substrate Type (acres/ %)												Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		Boulder		Rip Rap		Ledge		Woody Debris		
	10 – V052	15.6	68.7%	2.9	12.8%	3	13.2%	0.1	0.4%	0	0.0%	1.1	4.8%	Boulder
	10 – V065	0.7	4.0%	13.5	76.7%	1	5.7%	0.4	2.3%	1.4	8.0%	0.6	3.4%	Gravel, Cobble
	10 – V068	7.6	37.3%	8.4	41.2%	2.7	13.2%	0.6	2.9%	0.1	0.5%	1	4.9%	Gravel, Cobble
	10 – V070	38.8	74.5%	9.3	17.9%	0.9	1.7%	0.4	0.8%	0.2	0.4%	2.5	4.8%	Boulder
	10 – V071	29.9	71.5%	8	19.1%	1.3	3.1%	1.2	2.9%	0.2	0.5%	1.2	2.9%	Boulder
	10 – V078	20.5	74.5%	5.7	20.7%	0.3	1.1%	0.2	0.7%	0.3	1.1%	0.5	1.8%	Sand, Silt, Clay
Fall	10 – V008	9.7	44.5%	10.8	49.5%	0	0.0%	0	0.0%	0	0.0%	1.3	6.0%	Gravel, Cobble
	10 – V014	13.2	54.8%	9.9	41.1%	0.6	2.5%	0	0.0%	0	0.0%	0.4	1.7%	Sand, Silt, Clay
	10 – V018	15.9	74.6%	3.3	15.5%	0.6	2.8%	0	0.0%	0	0.0%	1.5	7.0%	Sand, Silt, Clay
	10 – V020	16.5	69.9%	6.3	26.7%	0	0.0%	0.4	1.7%	0	0.0%	0.4	1.7%	Sand, Silt, Clay
	10 – V024	10.2	45.1%	11.8	52.2%	0.2	0.9%	0.1	0.4%	0	0.0%	0.3	1.3%	Gravel, Cobble
	10 – V025	17.2	59.3%	11.1	38.3%	0	0.0%	0	0.0%	0	0.0%	0.7	2.4%	Sand, Silt, Clay
	10 – V027	8.4	50.0%	4.1	24.4%	1.7	10.1%	0.2	1.2%	2.1	12.5%	0.3	1.8%	Boulder
	10 – V062	8.9	39.2%	9	39.6%	1.2	5.3%	1.1	4.8%	2.5	11.0%	0	0.0%	Gravel, Cobble
	10 – V069	19.8	72.0%	5.1	18.5%	0.9	3.3%	0.5	1.8%	0.9	3.3%	0.3	1.1%	Boulder
	10 – V070	38.8	74.5%	9.3	17.9%	0.9	1.7%	0.4	0.8%	0.2	0.4%	2.5	4.8%	Boulder
	10 – V071	29.9	71.5%	8	19.1%	1.3	3.1%	1.2	2.9%	0.2	0.5%	1.2	2.9%	Sand, Silt, Clay
	10 – V083	28.9	91.7%	1.2	3.8%	0.2	0.6%	0.6	1.9%	0	0.0%	0.6	1.9%	Sand, Silt, Clay

Table 3.6-3. Sampling bank, anticipated sampling methods, and location type of map units randomly selected in the Vernon impoundment.

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
Spring	10 – V010	West	Boat Electrofish	Gill Net		Mainstem		
	10 – V016	West	Boat Electrofish	Gill Net		Mainstem		
	10 – V034	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V037	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V039	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V062	East	Boat Electrofish	Gill Net	CT-V-5.36	Minor Trib		2
	10 – V064	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V066	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V068	West	Boat Electrofish	Gill Net		Mainstem		

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
	10 – V076	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V080	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V088	East	Boat Electrofish	Gill Net		Mainstem		
Summer	10 – V014	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V015	East	Boat Electrofish	Gill Net	CT-V-5.14	Major Trib	Aldrick Brook	3
	10 – V016	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V027	West	Boat Electrofish	Gill Net		Mainstem		
	10 – V029	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V048	West	Boat Electrofish	Gill Net	CT-V-5.28	Major Trib	Salmon Brook	3
	10 – V052	West	Boat Electrofish	Gill Net		Mainstem		
	10 – V065	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V068	West	Boat Electrofish	Gill Net		Mainstem		
	10 – V070	West	Boat Electrofish	Gill Net	CT-V-5.42	Major Trib	Whetstone Brook	4
	10 – V071	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V078	East	Boat Electrofish	Gill Net		Mainstem		
Fall	10 – V008	West	Boat Electrofish	Gill Net		Mainstem		
	10 – V014	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V018	West	Boat Electrofish	Gill Net	CT-V-5.11	Minor Trib		2
	10 – V020	West	Boat Electrofish	Gill Net		Mainstem		
	10 – V024	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V025	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V027	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V062	West	Boat Electrofish	Gill Net		Mainstem		
	10 – V069	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V070	West	Boat Electrofish	Gill Net	CT-V-5.42	Major Trib	Whetstone Brook	4
	10 – V071	East	Boat Electrofish	Gill Net		Mainstem		
	10 – V083	East	Boat Electrofish	Gill Net		Mainstem		

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3.7 Vernon Riverine Reach

A total of five map-units were placed within the Vernon riverine reach extending from map-unit 10-VR001 at the Vernon tailrace to map-unit 10-VR005 located at RM 140.4. Existing mesohabitat survey data was used to determine dominant habitat type for each of the five map-units.

The percentages of habitat type within the approximately 101 acres of mesohabitat mapped in Study 7 were used to determine the spatial distribution of the three sampling locations in the reach. Results from the Study 7 mesohabitat mapping are presented in Table 3.7-1 and indicate that the majority of habitat in the reach is primarily dominated by cobble-gravel. Lesser amounts of sand-silt-clay habitat are also present. For the purposes of placing sampling locations in the reach, the total number of locations (three) was allocated following a habitat-type frequency distribution of 66% in map-units dominated by cobble-gravel and 33% in map-units dominated by sand-silt-clay. When adjusted to account for existing habitat proportions, two map-units dominated by cobble-gravel and one map-unit dominated by sand-silt-clay were selected for sampling.

Of the five map-units considered for sampling, four were dominated by cobble-gravel and one was dominated by sand-silt-clay. Table 3.7-2 presents information for the three map-units selected for sampling. Figure 3.7-1 presents the spatial distribution of the three sampling locations during the spring, summer, and fall sampling periods. Based on existing field crew knowledge of water depths and boat access (both ramps and in-river transit), the anticipated sampling methods for selected sampling locations are presented in Table 3.7-3. Boat access is available for the relatively short study reach downstream of Vernon dam and although flow velocities will likely be greater than those observed upstream in the Vernon impoundment, the range of water depths encountered will be comparable. As a result, fish assemblage sampling in the Vernon riverine reach will likely consist primarily of boat electrofishing combined with gill net sampling. Results of the random bank selection (east vs. west), and information on tributary or backwater presence, are also presented in Table 3.7-3.

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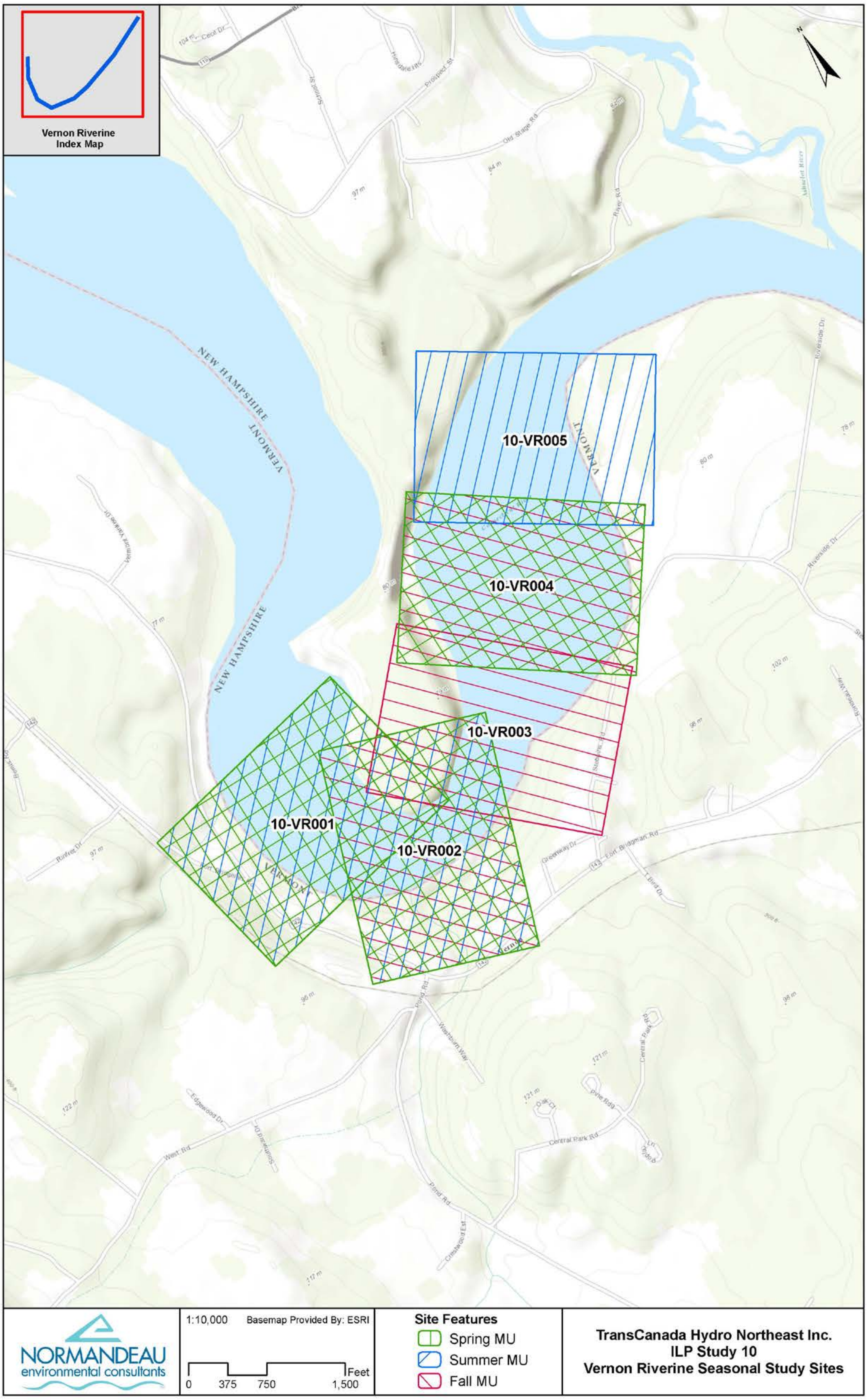

Figure 3.7-1. Map-units selected for fish assemblage sampling within the Vernon riverine reach, 2015.

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Table 3.7-1. Total area (acres) and percent of total area for aquatic habitat types based on substrate information collected during mesohabitat mapping in the Vernon riverine reach (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	32.1	26.3%
gravel/cobble	70.8	57.9%
no data	19.4	15.8%
TOTAL	122.3	100.0%

Table 3.7-2. Substrate composition and dominant habitat type for map-units randomly selected in the Vernon riverine reach.

Sampling Season	Map Unit	Substrate Type (acres/ %)						Dominant Habitat
		Sand-Silt-Clay		Gravel-Cobble		No Data		
Spring	10 - VR001	1.9	11.3%	14.9	88.7%	-	-	Gravel, Cobble
	10 - VR002	15.3	64.8%	8.3	35.2%	-	-	Sand, Silt, Clay
	10 - VR004	6.7	19.8%	16.4	48.4%	10.8	31.9%	Gravel, Cobble
Summer	10 - VR001	1.9	11.3%	14.9	88.7%	-	-	Gravel, Cobble
	10 - VR002	15.3	64.8%	8.3	35.2%	-	-	Sand, Silt, Clay
	10 - VR005	0.2	0.7%	20.4	73.1%	7.3	26.2%	Gravel, Cobble
Fall	10 - VR003	7.9	39.5%	10.8	54.0%	1.3	6.5%	Gravel, Cobble
	10 - VR002	15.3	64.8%	8.3	35.2%	-	-	Sand, Silt, Clay
	10 - VR004	6.7	19.8%	16.4	48.4%	10.8	31.9%	Gravel, Cobble

Table 3.7-3. Sampling bank, anticipated sampling methods, and location type of map units randomly selected in the Vernon riverine reach.

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
Spring	10 - VR001	West	Boat Electrofish	Gill Net	CT-VR-6.01	Minor Trib		2
	10 - VR002	West	Boat Electrofish	Gill Net	CT-VR-6.02	Major Trib		3
	10 - VR002	West	Boat Electrofish	Gill Net	CT-VR-6.03	Minor Trib		-99

Sampling Season	Map Unit	Sample Bank	Primary Gear	Secondary Gear	Study 13 ID	Location Type	GNIS Name	Stream Order
	10 - VR004	East	Boat Electrofish	Gill Net		Mainstem		
Summer	10 - VR001	East	Boat Electrofish	Gill Net		Mainstem		
	10 - VR002	West	Boat Electrofish	Gill Net	CT-VR-6.02	Major Trib		3
	10 - VR002	West	Boat Electrofish	Gill Net	CT-VR-6.03	Minor Trib		-99
	10 - VR005	East	Boat Electrofish	Gill Net		Mainstem		
Fall	10 - VR002	West	Boat Electrofish	Gill Net	CT-VR-6.02	Major Trib		3
	10 - VR002	West	Boat Electrofish	Gill Net	CT-VR-6.03	Minor Trib		-99
	10 - VR003	West	Boat Electrofish	Gill Net		Mainstem		
	10 - VR004	East	Boat Electrofish	Gill Net		Mainstem		

4. FIELD SAMPLING METHODOLOGIES

Fish assemblage sampling will be conducted on a seasonal basis (spring; May-June, summer; July-August, and fall; September-October). As described in the RSP, relative abundance will be analyzed on a seasonal basis. Sampling methods will ultimately be determined by site conditions (i.e., water depth, current velocity, crew/boat access) but preliminary selection of appropriate gear for each geographic river reach and habitat type is presented above from the suite of techniques identified in the RSP (boat electrofish, pram electrofish, back pack electrofish, experimental gill net, trap net, and beach seine). Table 4.1 presents the full list of locations by river reach and season. The total number of dominant habitats sampled by season is included in Table 4.2.

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Table 4.1. Revised Spatial and temporal distribution of 500-m map-units located in the study area.

River Reach	Map Unit	Downstream Coordinate		Sample Bank	Season		
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)		Spring	Summer	Fall
Wilder Impoundment	10 – W008	-72.031653	44.100738	West	1		
	10 – W009	-72.030903	44.097096	West	1	1	
	10 – W009	-72.029681	44.097299	East			1
	10 – W018	-72.042792	44.079400	West			1
	10 – W019	-72.047050	44.078142	West	1		
	10 – W019	-72.046647	44.077307	East		1	
	10 – W028	-72.063400	44.053161	East			1
	10 – W033	-72.078040	44.039738	East	1		
	10 – W035	-72.074843	44.032430	West	1		
	10 – W036	-72.076287	44.028940	East		1	
	10 – W044	-72.103163	44.013496	East	1		
	10 – W048	-72.107119	44.000229	East	1		
	10 – W056	-72.113896	43.971587	West	1		
	10 – W060	-72.094308	43.968476	East			1
	10 – W065	-72.102482	43.953739	West		1	
	10 – W068	-72.114636	43.947475	West	1		
	10 – W069	-72.118936	43.944476	West			1
	10 – W073	-72.116249	43.928238	East	1		
	10 – W074	-72.118014	43.924323	West			1
	10 – W077	-72.127342	43.915514	West			1
	10 – W090	-72.172081	43.879382	East			1
	10 – W099	-72.186887	43.851899	West		1	
	10 - W105	-72.183414	43.828647	East		1	
	10 - W109	-72.183310	43.814268	East			1
	10 - W110	-72.183315	43.809925	West		1	
	10 - W115	-72.194769	43.792775	West		1	
	10 - W118	-72.204415	43.783802	East		1	1
	10 - W120	-72.202460	43.776023	West		1	
	10 - W121	-72.203171	43.772461	West			1
	10 - W127	-72.203171	43.772461	West	1	1	
	10 - W127	-72.224163	43.755515	East			1
	10 - W128	-72.224773	43.751300	East		1	
	10 - W128	-72.229031	43.752939	West			1
	10 - W133	-72.247600	43.739467	East			1

River Reach	Map Unit	Downstream Coordinate		Sample Bank	Season		
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)		Spring	Summer	Fall
	10 - W139	-72.275248	43.728171	West	1		
	10 - W140	-72.278964	43.725377	West	1	1	
	10 - W140	-72.277284	43.724417	East			1
	10 - W147	-72.299121	43.702220	East	1		
	10 - W152	-72.302328	43.683265	East		1	
	10 - W153	-72.302729	43.679306	West		1	
	10 - W155	-72.304794	43.671362	West	1		
Wilder Riverine	10 – WR005	-72.313012	43.648621	East	1	1	
	10 – WR016	-72.333770	43.612128	West			1
	10 – WR017	-72.330175	43.608756	West		1	
	10 – WR020	-72.332365	43.598650	East			1
	10 – WR028	-72.367599	43.580303	East	1		1
	10 – WR029	-72.372227	43.578317	East			1
	10 – WR031	-72.380529	43.572682	West		1	1
	10 – WR032	-72.380303	43.568516	West	1	1	
	10 – WR033	-72.382256	43.564811	West	1	1	1
	10 – WR034	-72.380693	43.560492	East	1	1	1
	10 – WR035	-72.379812	43.556885	East			1
	10 – WR039	-72.378632	43.541024	East	1		1
	10 – WR039	-72.380657	43.540706	West		1	
	10 – WR041	-72.383521	43.533310	East	1		
	10 – WR042	-72.386083	43.529758	East	1	1	1
	10 – WR043	-72.389679	43.526552	East		1	
	10 – WR043	-72.391149	43.527536	West	1		1
	10 – WR044	-72.393437	43.523781	West	1		
	10 – WR047	-72.399132	43.512466	West		1	
	10 – WR048	-72.395026	43.508667	East	1		
	10 – WR056	-72.381819	43.481178	West		1	
	10 – WR059	-72.386938	43.470303	East	1		1
	10 – WR060	-72.392114	43.467800	East		1	
Bellows Falls Impoundment	10 – B001	-72.392698	43.464629	West			1
	10 – B004	-72.388794	43.452740	East	1		
	10 – B012	-72.398333	43.421325	West		1	1
	10 – B016	-72.398735	43.405268	East			1
	10 – B019	-72.401091	43.393350	East	1		1
	10 – B020	-72.403298	43.389443	East	1		

River Reach	Map Unit	Downstream Coordinate		Sample Bank	Season		
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)		Spring	Summer	Fall
	10 – B021	-72.408167	43.386781	East	1		
	10 – B022	-72.412672	43.384418	West	1		
	10 – B023	-72.413265	43.38007	East	1		
	10 – B023	-72.415092	43.380683	West		1	
	10 – B024	-72.413893	43.376261	East	1		
	10 – B027	-72.412858	43.364443	East		1	
	10 – B027	-72.414682	43.36453	West	1		
	10 – B029	-72.404096	43.360840	East	1		
	10 – B039	-72.409677	43.333318	West			1
	10 – B044	-72.394219	43.316819	East		1	
	10 – B044	-72.396379	43.315613	West			1
	10 – B045	-72.393008	43.312483	East		1	
	10 – B046	-72.396372	43.308576	East			1
	10 – B047	-72.400405	43.305438	West		1	
	10 – B048	-72.402909	43.301789	West	1		
	10 – B059	-72.423522	43.260996	East			1
	10 – B060	-72.428512	43.259019	East			1
	10 – B065	-72.438623	43.241742	West	1		
	10 – B069	-72.433021	43.225995	East		1	
	10 – B070	-72.434192	43.221949	East		1	
	10 – B072	-72.441114	43.215020	West			1
	10 – B076	-72.440582	43.199535	West			1
	10 – B079	-72.445974	43.189560	West	1		
	10 – B081	-72.441224	43.182760	East		1	
	10 – B083	-72.444092	43.174351	East			1
	10 – B088	-72.447703	43.155678	East		1	
	10 – B092	-72.451052	43.140594	East		1	
	10 – B093	-72.44722	43.138211	East		1	
Bellows Falls Bypassed Reach	10 - BF001	-72.440197	43.135921	East	1		1
	10 - BF001	-72.440290	43.135926	West	1	1	1
	10 - BF002	-72.439782	43.131475	East		1	1
	10 - BF002	-72.442295	43.131573	West	1	1	
Bellows Falls Riverine	10 - BR001	-72.437180	43.127345	East	1		
	10 - BR001	-72.440637	43.127294	West			1
	10 - BR002	-72.436816	43.123922	West	1		

River Reach	Map Unit	Downstream Coordinate		Sample Bank	Season		
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)		Spring	Summer	Fall
	10 - BR002	-72.435104	43.124416	East		1	
	10 - BR003	-72.433225	43.120494	West	1	1	
	10 - BR005	-72.430811	43.112879	East	1	1	
	10 - BR006	-72.433242	43.108962	East			1
	10 - BR007	-72.437008	43.106711	East	1	1	1
	10 - BR008	-72.440689	43.104859	East		1	
	10 - BR009	-72.441854	43.101254	East			1
	10 - BR010	-72.439282	43.098040	East		1	
	10 - BR010	-72.441171	43.097368	West			1
	10 - BR011	-72.438879	43.093755	West	1		
	10 - BR011	-72.437124	43.094378	East		1	1
	10 - BR012	-72.438235	43.089993	West	1		
	10 - BR012	-72.435715	43.090282	East		1	1
	10 - BR014	-72.435315	43.082667	West	1		
	10 - BR014	-72.432712	43.082791	East			1
	10 - BR015	-72.434136	43.078592	East	1	1	
	10 - BR016	-72.439861	43.076227	West	1		1
	10 - BR017	-72.441281	43.071980	East		1	
	10 - BR018	-72.446796	43.070131	West			1
	10 - BR019	-72.448783	43.065658	East	1	1	1
	10 - BR020	-72.454108	43.064334	West	1		1
	10 - BR020	-72.451696	43.063154	East		1	
Vernon Impoundment	10 – V008	-72.460989	43.037280	West			1
	10 – V010	-72.462924	43.029471	West	1		
	10 – V014	-72.451133	43.016588	East		1	1
	10 – V015	-72.446932	43.013880	East		1	
	10 – V016	-72.444227	43.010223	West	1		
	10 – V016	-72.442131	43.011004	East		1	
	10 – V018	-72.445880	43.002947	West			1
	10 – V020	-72.453217	43.000544	West			1
	10 – V024	-72.462880	42.989223	East			1
	10 – V025	-72.460487	42.986016	East			1
	10 – V027	-72.465672	42.978673	West		1	
	10 – V027	-72.464156	42.977913	East			1
	10 – V029	-72.471456	42.971830	East		1	
	10 – V034	-72.495800	42.965816	East	1		

River Reach	Map Unit	Downstream Coordinate		Sample Bank	Season		
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)		Spring	Summer	Fall
	10 – V037	-72.511472	42.962299	East	1		
	10 – V039	-72.521112	42.959340	East	1		
	10 – V048	-72.526986	42.929905	West		1	
	10 – V052	-72.525372	42.914205	West		1	
	10 – V062	-72.550659	42.882849	East	1		
	10 – V062	-72.552548	42.882811	West			1
	10 – V064	-72.553346	42.875073	East	1		
	10 – V065	-72.553360	42.871187	East		1	
	10 – V066	-72.553099	42.867220	East	1		
	10 – V068	-72.554530	42.859308	West	1	1	
	10 – V069	-72.551588	42.854786	East			1
	10 – V070	-72.555715	42.851071	West		1	1
	10 – V071	-72.548743	42.848374	East		1	1
	10 – V076	-72.544025	42.828495	East	1		
	10 – V078	-72.541802	42.820893	East		1	
	10 – V080	-72.539571	42.812913	East	1		
	10 – V083	-72.533375	42.802676	East			1
	10 – V088	-72.514393	42.788420	East	1		
Vernon Riverine	10 - VR001	-72.514785	42.764960	West	1		
	10 - VR001	-72.512152	42.765314	East		1	
	10 - VR002	-72.508423	42.764394	West	1	1	1
	10 - VR003	-72.502921	42.766599	West			1
	10 - VR004	-72.504060	42.772393	East	1		1
	10 - VR005	-72.499385	42.774580	East		1	
Total Number of Study Sites					**69**	**69**	**69**

Table 4.2. Number of study sites by season and substrate type.

Substrate Type	Spring	Summer	Fall
Sand-Silt-Clay	28	28	28
Cobble-Gravel	26	26	26
Boulder	15	15	15
Total	69	69	69

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5. LITERATURE CITED

Normandeau (Normandeau Associates, Inc.). 2014. ILP Study 7 Aquatic Habitat Mapping Initial Study Report. Prepared for TransCanada Hydro Northeast Inc. September 15, 2014.

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APPENDIX A – REVISED SUBSTRATE CALCULATIONS FOR STUDIES 10 AND 12

(Excel Workbook Filed Separately as Volume II.J of this USR)

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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 II.C

Study 11 – American Eel Survey

Revised Site Selection Report

Updated Study Report

September 14, 2015

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TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 11
American Eel Survey

Revised Site Selection Report

In support of Federal Energy Regulatory Commission Relicensing of:

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

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February 3, 2015

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1. INTRODUCTION

Evidence exists that American eels are moving upstream of the Vernon, Bellows Falls, and Wilder dams; however, the distribution and relative abundance of American eels in the mainstem habitat upstream and in the project areas remains unknown. The goal of Study 11- American Eel Survey is to provide baseline data relative to the presence of American eel upstream in the project-affected areas.

Revised Study Plan (RSP) 11, as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination, specified that a subset of the project-affected area would be studied for the presence of American eels. This report has been revised in response to comments received from the aquatics working group at a December 17, 2014 site selection consultation meeting. This revised report provides a summary of the data analysis and criteria used to select the proposed subset of locations to be examined in detail during 2015.

The following map-units were modified as a result of consultation including moving the upstream-most riverine map units closer to each dam:

- Wilder riverine reach: removed site 11-WR002 and replaced with site 11-WR001
- Bellows Falls riverine reach: removed site 11-BR004 and replaced with site 11-BR001
- Vernon riverine reach: added site 11-VR0001

The following tributary sites were modified as a result of consultation:

- Wilder dam to Bellows Falls dam reach: removed site 11–B029T (Jabes Hackett Brook) and replaced with site 11–WR002T (White River)
- Wilder dam to Bellows Falls dam reach: removed site 11–B004T (Mill Brook-VT side) and replaced with site 11–B002T (Sugar River)
- Bellows Falls dam to Vernon dam reach: removed site 11–V004T (unnamed) and replaced with site 11–V040T (West River)
- Bellows Falls dam to Vernon dam reach: removed site 11–V048T (Ash Swamp Brook) and replaced with site 11–V042T (Whetstone Brook)
- Bellows Falls dam to Vernon dam reach: removed site 11–V024T (Sacketts Brook) and replaced with site 11–V018T (Partridge Brook)

2. STUDY AREA

Surveys will be conducted to determine the presence and relative abundance of American eels in the project-affected waters upstream of each dam from the upper extent of Wilder impoundment downstream to Vernon dam (Study 18 – Upstream

Passage of American Eel will evaluate eel presence in project tailrace areas and the Bellows Falls bypassed reach). This approximately 120-mile reach of the Connecticut River was divided into five mainstem geographic reaches delineated based on a combination of general river morphology and project structures. These geographic reaches are as follows:

- Wilder impoundment (RM 262.4 - 217.4);
- Wilder downstream riverine corridor (RM 217.4 – 199.7);
- Bellows Falls impoundment (RM 199.7 – 173.7);
- Bellows Falls downstream riverine corridor (RM 173.7 – 167.9); and
- Vernon impoundment (RM 167.9 – 141.9).

3. SITE SELECTION PROCESS

3.1. Mainstem Reaches

The selection of mainstem sampling locations was based on a stratified random sampling design. Prior to the selection of study locations, each geographic reach (or stratum) was delineated into 500-meter map-unit segments using ArcGIS. As stated in the Revised Study Plan (RSP), the total number of randomly selected map-units within each mainstem stratum was proportional to the contribution of the total length of that stratum to the entire study reach. This approach resulted in a total of 101 selected map-unit segments: 37 in the Wilder impoundment, 15 in the riverine section downstream of Wilder, 22 in the Bellows Falls impoundment, 5 in the riverine section downstream of Bellows Falls, and 22 within the Vernon impoundment. Within each selected map-unit, a river bank (east or west) was randomly selected for sampling.

3.2. Tributary Habitat

Surveys for the presence and abundance of American eel were also specified in the RSP to occur in tributary habitat within the limits of the project-influenced areas upstream of each dam. As part of an ArcGIS assessment associated with Study 13 -Tributary and Backwater Fish Access, conducted in 2014, a total of 146 tributaries were identified entering the project area from the upper extent of Wilder impoundment downstream to Vernon dam. As specified in the RSP, 24 tributaries were selected: 7 upstream of Wilder, 9 upstream of Bellows Falls, and 8 upstream of Vernon. Since eels prefer larger, slow moving streams (Scarola 1987; Langdon et al. 2006), the selection process for tributaries focused on tributaries classified as major. The total length of the project-affected area up into each selected tributary was estimated in ArcGIS.

4. SITE SELECTION

4.1. Wilder Impoundment

A total of 156 map-units were placed within the Wilder impoundment extending from map-unit 10-W001 at the upper extent of the impoundment (RM 262.4) to map-unit 10-W156 located at Wilder dam at RM 217.4. Thirty-seven 500-m map-units were randomly selected for sampling and are presented in tabular format in Table 4.1-1 and graphically in Figure 4.1-1. Sixteen major tributaries enter the Connecticut River upstream of Wilder dam of which seven locations were randomly selected for sampling. Table 4.1-2 presents each of the major tributaries within the Wilder impoundment. Streams are also identified in the table by their ID# assigned in 2014 in Study 13 – Tributary and Backwater Access. Tributaries selected for eel sampling are highlighted in the table and presented graphically in Figure 4.1-1.

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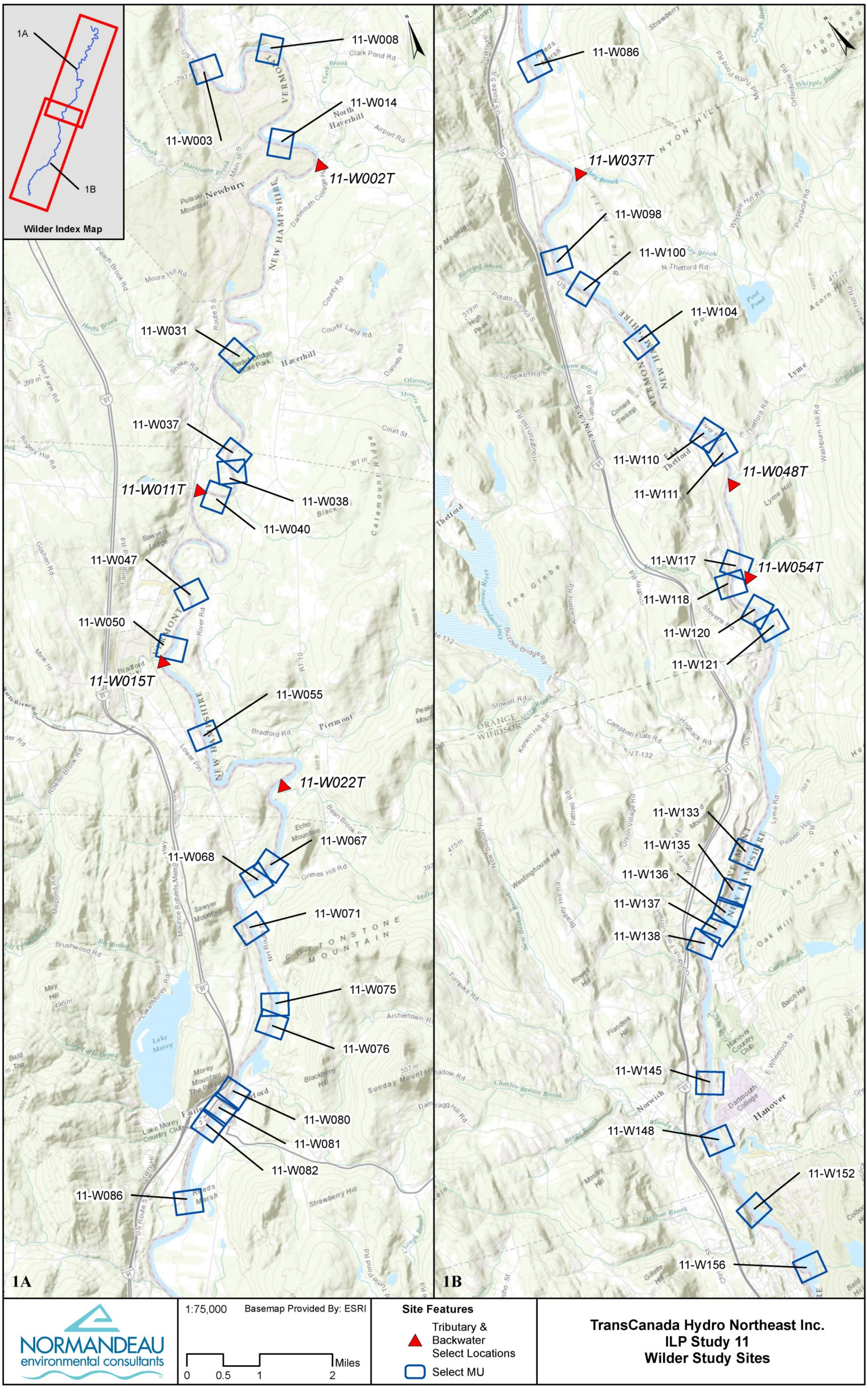

Figure 4.1-1. Map-units selected for America eel sampling within the Wilder impoundment, 2015.

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Table 4.1-1. Randomly selected map-units within the Wilder impoundment.

Map Unit	Sample Bank	Downstream Coordinate	
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
11 - W003	West	-72.052502	44.100648
11 - W008	East	-72.030980	44.101548
11 - W014	West	-72.036978	44.082584
11 - W031	West	-72.072831	44.046419
11 - W037	West	-72.082072	44.027498
11 - W038	East	-72.080222	44.023015
11 - W040	West	-72.089844	44.023806
11 - W047	East	-72.102327	44.002890
11 - W050	East	-72.114761	43.994463
11 - W055	West	-72.112886	43.975376
11 - W067	West	-72.109467	43.948122
11 - W068	West	-72.114636	43.947475
11 - W071	East	-72.115560	43.936420
11 - W075	East	-72.117981	43.920348
11 - W076	East	-72.121659	43.917040
11 - W080	East	-72.138638	43.906908
11 - W081	West	-72.144212	43.905656
11 - W082	West	-72.148838	43.903372
11 - W086	West	-72.159507	43.889003
11 - W098	West	-72.188101	43.856207
11 - W100	West	-72.184838	43.848049
11 - W104	West	-72.182846	43.832548
11 - W110	East	-72.181489	43.810385
11 - W111	East	-72.182506	43.806104
11 - W117	West	-72.202111	43.787693
11 - W118	East	-72.204415	43.783802
11 - W120	West	-72.202460	43.776022
11 - W121	East	-72.201405	43.772266
11 - W133	East	-72.247599	43.739466
11 - W135	West	-72.258414	43.737020
11 - W136	West	-72.263013	43.734784
11 - W137	West	-72.268446	43.734533
11 - W138	West	-72.273026	43.732192
11 - W145	West	-72.294940	43.709206
11 - W148	West	-72.302425	43.698767
11 - W152	East	-72.302328	43.683265
11 - W156	East	-72.302037	43.667387

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Table 4.1-2. Major tributaries within the Wilder impoundment and the subset identified for sampling (indicated with bold/shade).

Site ID		Stream Name	Stream Order	Location		Reach Length (m)
Study 11	Study 13[1]			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)	
11 - W002T	**CT-W-1.02**	**Clark Brook**	**3**	**-72.030968**	**44.077717**	**278**
11 - W007T	CT-W-1.07	Oliverian Brook	4	-72.06342	44.048331	
11 - W011T	**CT-W-1.11**	**Halls Brook**	**4**	**-72.091649**	**44.024377**	**693**
11 - W015T	**CT-W-1.15**	**Waits River**	**5**	**-72.116406**	**43.994523**	**1270**
11 - W021T	CT-W-1.21	Eastman Brook	3	-72.090587	43.967195	
11 - W022T	**CT-W-1.22**	**Indian Pond Brook**	**3**	**-72.096067**	**43.963445**	**321**
11 - W029T	CT-W-1.29	Jacobs Brook	3	-72.127425	43.910746	
11 - W033T	CT-W-1.33	unnamed	3	-72.167219	43.891085	
11 - W037T	**CT-W-1.37**	**Clay Brook**	**3**	**-72.16642**	**43.869146**	**1353**
11 - W045T	CT-W-1.45	unnamed	3	-72.185038	43.841715	
11 - W048T	**CT-W-1.48**	**Grant Brook**	**3**	**-72.186158**	**43.801778**	**729**
11 - W054T	**CT-W-1.54**	**Hewes Brook**	**3**	**-72.198335**	**43.78525**	**344**
11 - W058T	CT-W-1.58	Ompompanoosuc River	5	-72.229812	43.75205	
11 - W073T	CT-W-1.73	Bloody Brook	3	-72.305154	43.703158	
11 - W074T	CT-W-1.74	Mink Brook	4	-72.299582	43.696193	
11 - W075T	CT-W-1.75	Dothan Brook	3	-72.306479	43.683514	

[1] Tributaries identified (but not necessarily selected for study) in Study 13 that correspond to this study's selected sites.

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4.2. Wilder Dam to Bellows Falls Dam

Between Wilder and Bellows Falls dams, the Wilder riverine reach stretches from the Wilder tailrace downstream to RM 199.7 and the Bellows Falls impoundment stretches from RM 199.7 downstream to Bellows Falls dam at RM 173.7. Sixty map-units were placed within the Wilder riverine reach (map-unit 10-WR001 at the upstream end to map-unit 10-WR060 at the downstream end). Ninety-three map-units were placed within the Bellows Falls impoundment (map-unit 10-B001 at the upper extent of the impoundment to map-unit 10-B093 located at Bellows Falls dam). Selected sampling locations for the Wilder riverine reach (n = 15) are presented in tabular format in Table 4.2-1 and graphically in Figures 4.2-1 and 4.2-2. The first map-unit immediately downstream of Wilder Dam was purposively selected for sampling whereas the remaining locations were randomly selected. Randomly selected sampling locations for the Bellows Falls impoundment (n=22) are presented in tabular format in Table 4.2-2 and graphically in Figure 4.2-2.

Twenty-five major tributaries enter the Connecticut River between the Wilder and Bellows Falls dams of which nine locations were randomly selected. Table 4.2-3 presents each of the major tributaries between the Wilder and Bellows Falls dams. Tributaries selected for eel sampling are highlighted in Table 4.2-3 and presented graphically in Figures 4.2-1 and 4.2-2. Streams are also identified in the table by their ID# assigned in 2014 in Study 13 – Tributary and Backwater Access.

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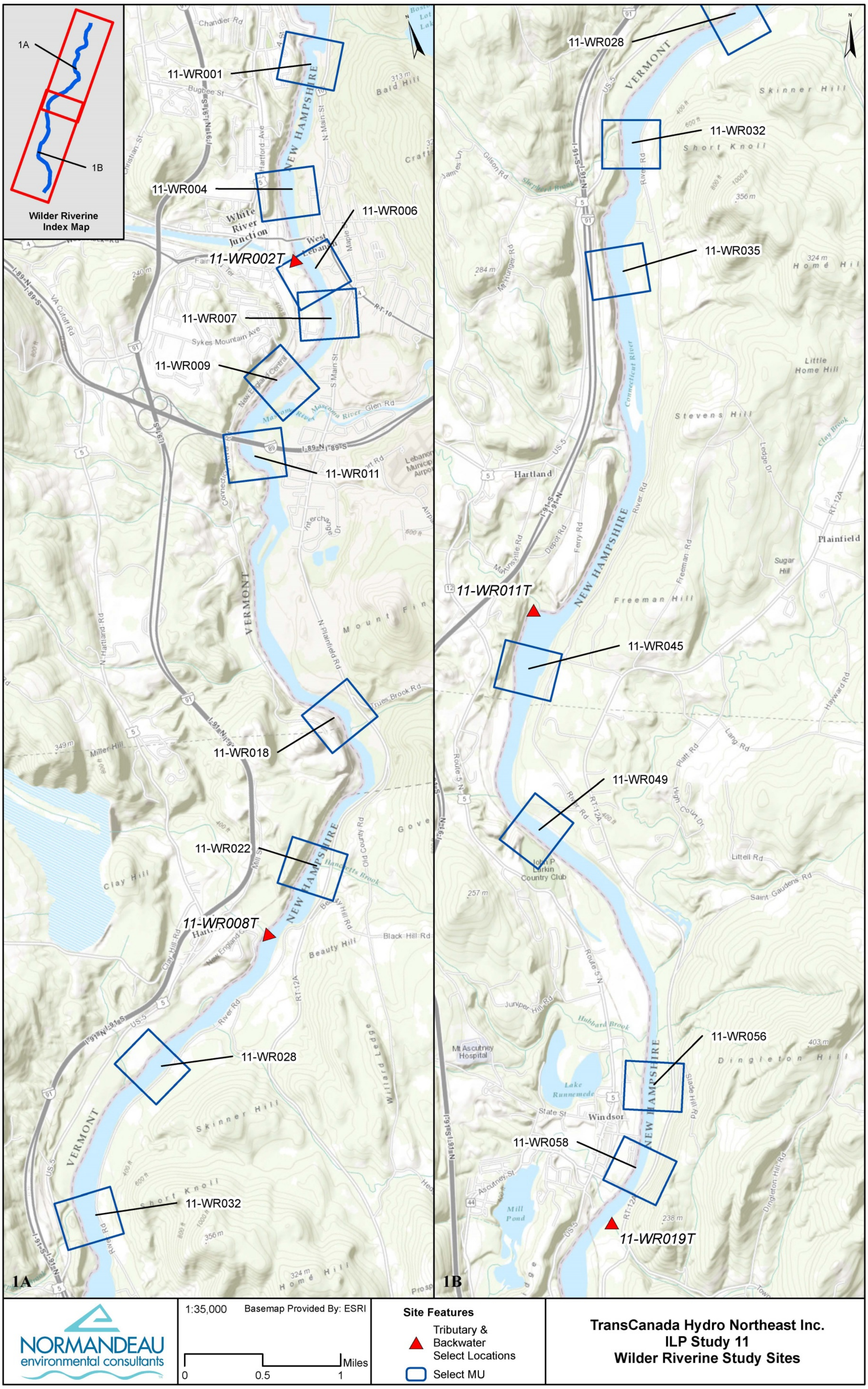

Figure 4.2-1. Revised Map-units selected for America eel sampling within the Wilder riverine reach, 2015.

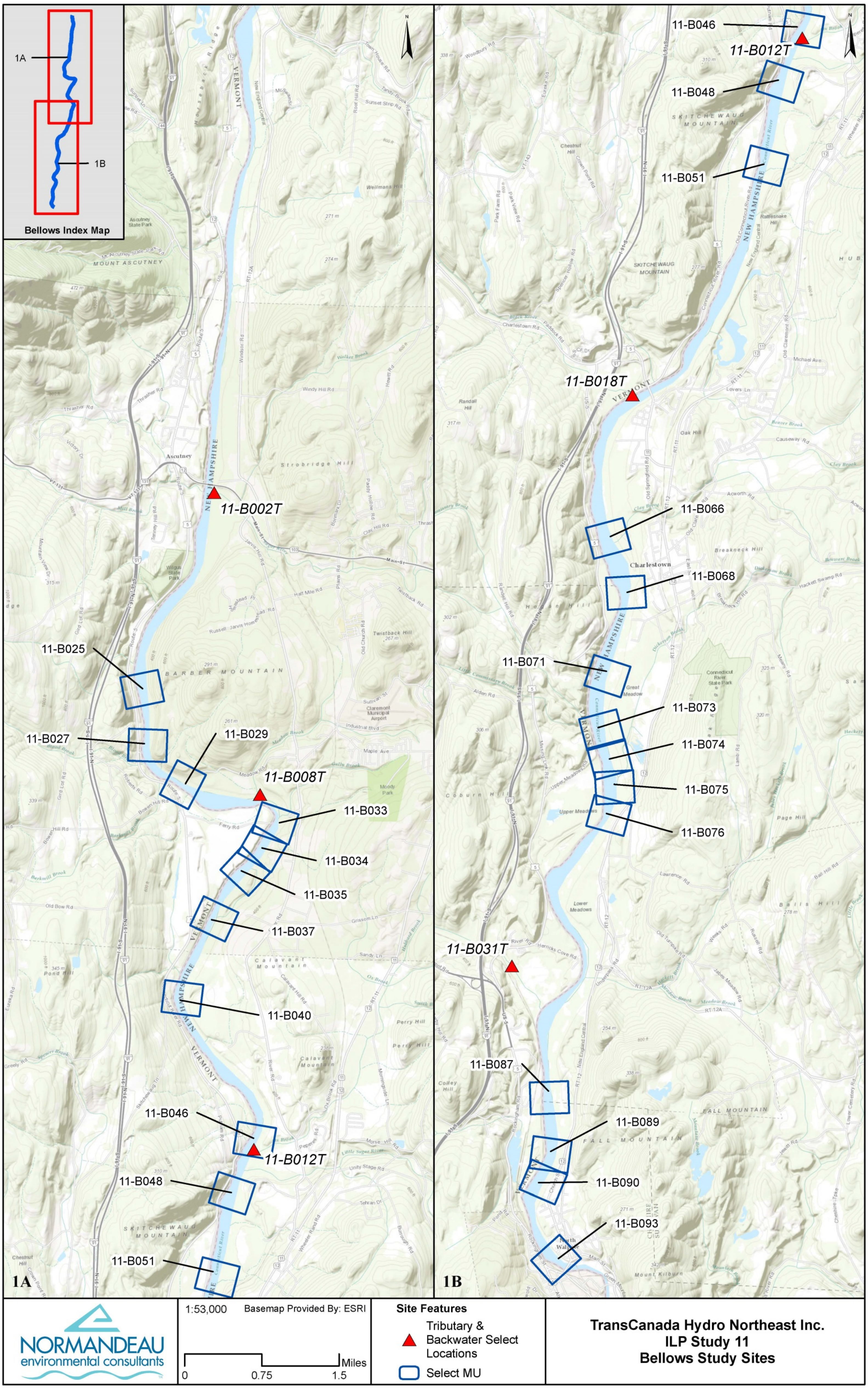

Figure 4.2-2. Revised Map-units selected for America eel sampling within the Bellows Falls impoundment, 2015.

Table 4.2-1. Revised Randomly selected map-units within the Wilder riverine reach.

Map Unit	Sample Bank	Downstream Coordinate	
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
11 – WR001	East	-72.305491	43.663394
11 - WR004	East	-72.313128	43.652533
11 - WR006	East	-72.312177	43.644865
11 - WR007	East	-72.313696	43.640758
11 - WR009	West	-72.324827	43.637899
11 - WR011	West	-72.327508	43.630489
11 - WR018	East	-72.326946	43.605430
11 - WR022	West	-72.340962	43.593646
11 - WR028	East	-72.367599	43.580303
11 - WR032	West	-72.380303	43.568515
11 - WR035	East	-72.379811	43.556885
11 - WR045	East	-72.394118	43.519826
11 - WR049	East	-72.391110	43.506467
11 - WR056	East	-72.379397	43.481037
11 - WR058	East	-72.383251	43.473392

Table 4.2-2. Randomly selected map-units within the Bellows Falls impoundment.

Map Unit	Sample Bank	Downstream Coordinate	
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
11 - B025	East	-72.412955	43.372575
11 - B027	West	-72.414631	43.364527
11 - B029	West	-72.405442	43.359096
11 - B033	East	-72.390549	43.353052
11 - B034	East	-72.393104	43.349397
11 - B035	East	-72.396808	43.346143
11 - B037	West	-72.404516	43.340438
11 - B040	East	-72.407391	43.328662
11 - B046	West	-72.398322	43.308865
11 - B048	East	-72.399531	43.300884
11 - B051	East	-72.403316	43.289324
11 - B066	West	-72.437577	43.237601
11 - B068	West	-72.434704	43.230155
11 - B071	East	-72.436056	43.218103
11 - B073	East	-72.436530	43.211314
11 - B074	East	-72.434889	43.207188
11 - B075	West	-72.438873	43.202854
11 - B076	West	-72.440582	43.199534
11 - B087	West	-72.452465	43.159590
11 - B089	West	-72.453235	43.151847
11 - B090	West	-72.457619	43.149278
11 - B093	West	-72.448667	43.137311

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Table 4.2-3. Revised Major tributaries between the Wilder and Bellows Falls dams and the subset identified for sampling (indicated with bold/shade).

Site ID		Stream Name	Stream Order	Location		Reach Length (m)
Study 11	Study 13[1]			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)	
11 - WR002T	**CT-WR-2.02**	**White River**	**6**	**-72.31521**	**43.648842**	**Unknown**
11 - WR003T	CT-WR-2.03	Mascoma River	5	-72.326427	43.635817	
11 - WR005T	CT-WR-2.05	Kilburn Brook	3	-72.330028	43.626219	
11 - WR006T	CT-WR-2.06	Bloods Brook	4	-72.327478	43.606535	
11 - WR008T	**CT-WR-2.08**	**Ottauquechee River**	**5**	**-72.346058**	**43.590471**	**436**
11 - WR011T	**CT-WR-2.11**	**Lulls Brook**	**3**	**-72.393608**	**43.527828**	**512**
11 - WR014T	CT-WR-2.14	Blow-me-down Brook	3	-72.379393	43.494023	
11 - WR016T	CT-WR-2.16	Hubbard Brook	3	-72.380482	43.488232	
11 - WR018T	CT-WR-2.18	Mill Brook Vt	4	-72.38701	43.47221	
11 - WR019T	**CT-WR-2.19**	**Mill Brook NH**	**4**	**-72.386094**	**43.470803**	**107**
11 - B002T	**CT-B-3.02**	**Sugar River**	**6**	**-72.399662**	**43.401959**	**579.3**
11 - B004T	CT-B-3.04	Mill Brook	3	-72.401286	43.401488	
11 - B007T	CT-B-3.07	Barkmill Brook	3	-72.412279	43.362394	
11 - B008T	**CT-B-3.08**	**Meadow Brook**	**3**	**-72.392633**	**43.359371**	**N/A**
11 - B011T	CT-B-3.11	unnamed	3	-72.409091	43.33408	
11 - B012T	**CT-B-3.12**	**Ox Brook**	**3**	**-72.395968**	**43.309573**	**58**
11 - B013T	CT-B-3.13	Little Sugar River	4	-72.397391	43.307044	
11 - B016T	CT-B-3.16	Beaver Brook	4	-72.414353	43.268439	
11 - B017T	CT-B-3.17	Spencer Brook	4	-72.425695	43.261823	
11 - B018T	**CT-B-3.18**	**Black River**	**5**	**-72.430747**	**43.260163**	**2680**
11 - B022T	CT-B-3.22	Clay Brook	4	-72.431264	43.234287	
11 - B024T	CT-B-3.24	Commissary Brook	3	-72.440597	43.213887	
11 - B029T	CT-B-3.29	Jabes Hackett Brook	4	-72.441475	43.178613	
11 - B031T	**CT-B-3.31**	**Williams River**	**5**	**-72.45725**	**43.180528**	**2100**
11 - B034T	CT-B-3.34	unnamed	3	-72.45712	43.152808	

[1] Tributaries identified (but not necessarily selected for study) in Study 13 that correspond to this study's selected site

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4.3. Bellows Falls Dam to Vernon Dam

Between Bellows Falls and Vernon dams, the Bellows Falls riverine reach stretches from the Bellows Falls tailrace downstream to RM 167.9 and the Vernon impoundment stretches from RM 167.9 downstream to Vernon dam at RM 141.9. Twenty map-units were placed within the Bellows Falls riverine reach (map-unit 10-BR001 at the upstream end to map-unit 10-BR020 at the downstream end. Ninety-three map-units were placed within the Vernon impoundment (map-unit 10-V001 at the upper extent of the impoundment to map-unit 10-V093 located at Vernon dam). Selected sampling locations for the Bellows Falls riverine reach (n = 5) are presented in tabular format in Table 4.3-1 and graphically in Figures 4.3-1 and 4.3-2. The first map-unit immediately downstream of Bellows Falls dam was purposively selected for sampling whereas the remaining locations were randomly selected. Randomly selected sampling locations for the Vernon impoundment (n = 22) are presented in tabular format in Table 4.3-2 and graphically in Figure 4.3-2.

Twenty-two major tributaries enter the Connecticut River between the Bellows Falls and Vernon dams of which eight locations were randomly selected. Table 4.3-3 presents each of the major tributaries between the Bellows Falls and Vernon dams. Tributaries selected for eel sampling are highlighted in Table 4.3-3 and presented graphically in Figures 4.3-1 and 4.3-2. Streams are also identified in the table by their ID# assigned in 2014 in Study 13 – Tributary and Backwater Access.

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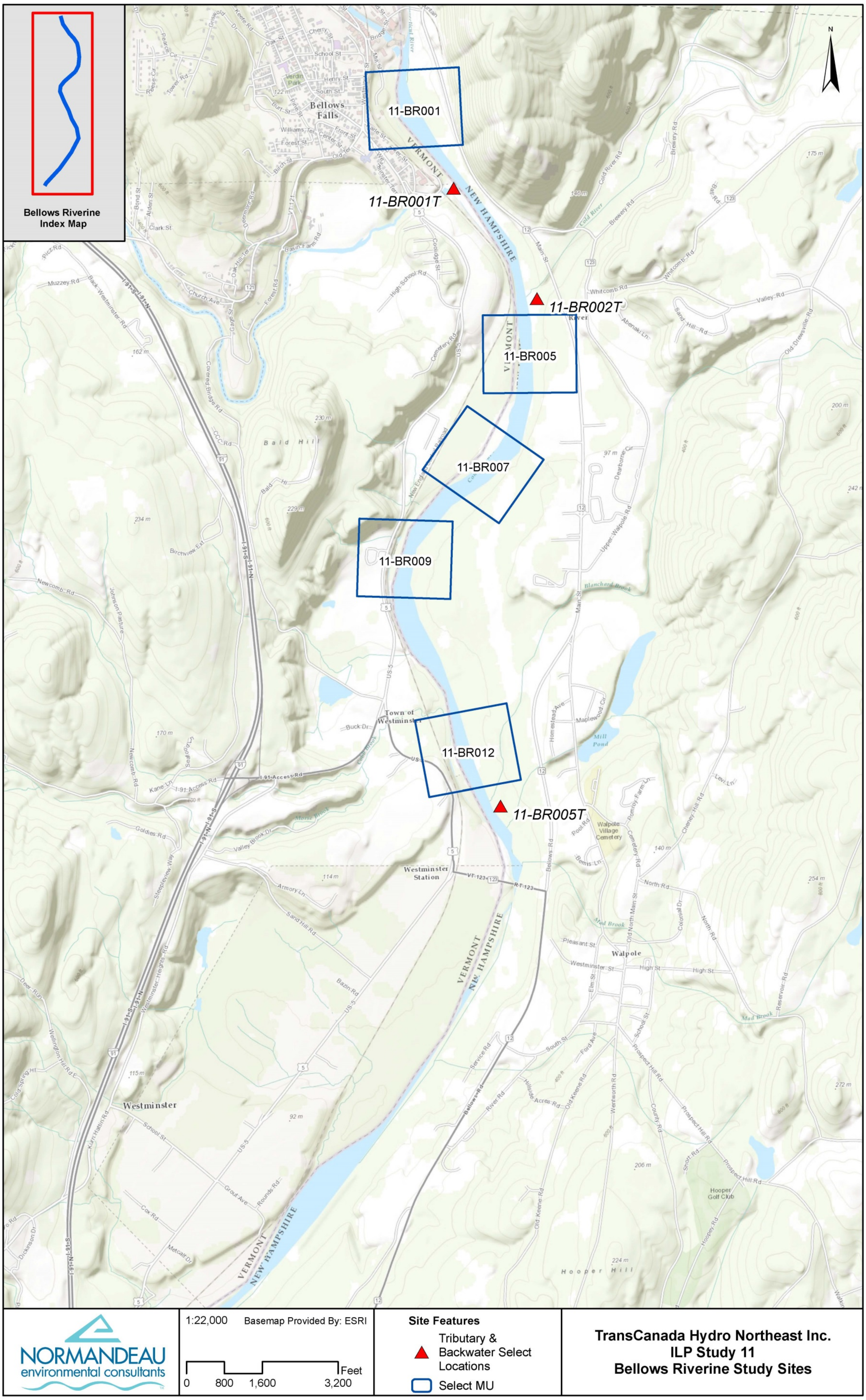

Figure 4.3-1. Revised Map-units selected for America eel sampling within the Bellows Falls riverine reach, 2015.

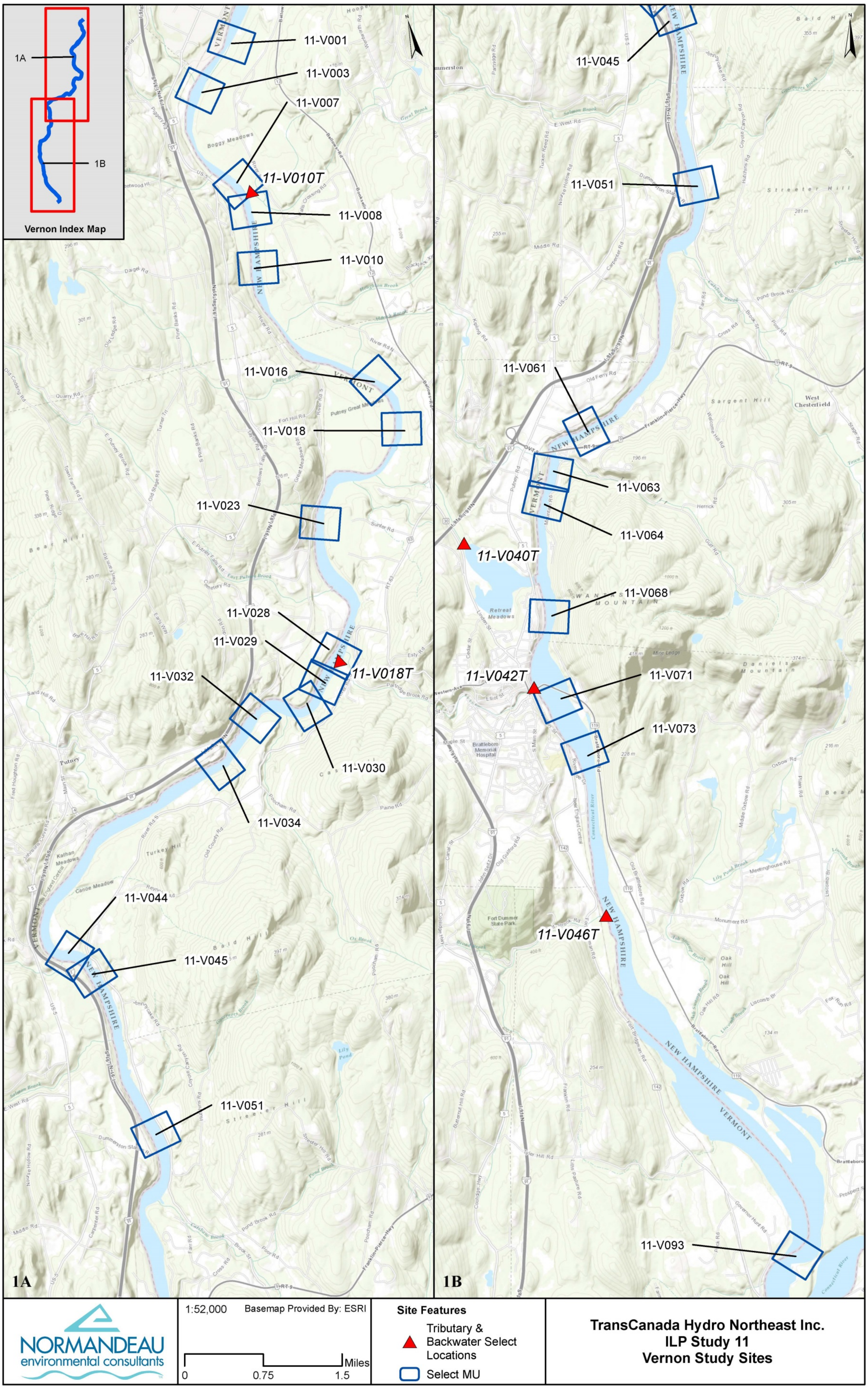

Figure 4.3-2. Revised Map-units selected for America eel sampling within the Vernon impoundment, 2015.

Table 4.3-1. Revised Randomly selected map-units within the Bellows Falls riverine reach.

Map Unit	Sample Bank	Downstream Coordinate	
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
11 – BR001	East	-72.437171	43.127345
11 - BR005	West	-72.432934	43.112911
11 - BR007	West	-72.438569	43.107571
11 - BR009	East	-72.441853	43.101253
11 - BR012	East	-72.435714	43.090281

Table 4.3-2. Randomly selected map-units within the Vernon impoundment.

Map Unit	Sample Bank	Downstream Coordinate	
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
11 - V003	East	-72.463788	43.054903
11 - V007	West	-72.460655	43.040752
11 - V008	West	-72.460988	43.037280
11 - V010	East	-72.460663	43.029111
11 - V016	West	-72.444227	43.010222
11 - V018	East	-72.442991	43.002415
11 - V023	West	-72.464761	42.993445
11 - V028	West	-72.469667	42.976049
11 - V029	East	-72.471455	42.971829
11 - V030	West	-72.478117	42.972826
11 - V032	East	-72.486203	42.969760
11 - V034	West	-72.496489	42.967053
11 - V044	East	-72.526732	42.946202
11 - V045	East	-72.525044	42.942047
11 - V051	West	-72.524275	42.917824
11 - V061	West	-72.548545	42.886566
11 - V063	West	-72.553643	42.879225
11 - V064	East	-72.553345	42.875072
11 - V068	East	-72.552985	42.859224
11 - V071	West	-72.553622	42.846987
11 - V073	East	-72.545523	42.840635
11 - V093	West	-72.514698	42.771953

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Table 4.3-3. Revised Major tributaries between the Bellows Falls and Vernon dams and the subset identified for sampling (indicated with bold/shade).

Site ID		Stream Name	Stream Order	Location		Reach Length (m)
Study 11	Study 13[1]			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)	
11 - BR001T	**CT-BR-4.01**	**Saxtons River**	**5**	**-72.437392**	**43.124848**	**285**
11 - BR002T	**CT-BR-4.02**	**Cold River**	**5**	**-72.431083**	**43.118314**	**541**
11 - BR004T	CT-BR-4.04	Cobb Brook	3	-72.438781	43.094376	
11 - BR005T	**CT-BR-4.05**	**Blanchard Brook**	**3**	**-72.435189**	**43.089057**	**13**
11 - BR006T	CT-BR-4.06	unnamed	3	-72.433801	43.087675	
11 - V004T	CT-V-5.04	unnamed	3	-72.450288	43.068487	
11 - V010T	**CT-V-5.10**	**Great Brook**	**3**	**-72.458572**	**43.041899**	**141**
11 - V012T	CT-V-5.12	Houghton Brook	3	-72.458772	43.022242	
11 - V014T	CT-V-5.14	Aldrick Brook	3	-72.449569	43.015152	
11 - V016T	CT-V-5.16	Mill Brook	4	-72.454413	42.999953	
11 - V017T	CT-V-5.17	East Putney Brook	4	-72.46362	42.986186	
11 - V018T	**CT-V-5.18**	**Partridge Brook**	**4**	**-72.466342**	**42.976335**	**482.1**
11 - V020T	CT-V-5.20	Ox Brook	3	-72.477905	42.970949	
11 - V024T	CT-V-5.24	Sacketts Brook	4	-72.514281	42.963625	
11 - V026T	CT-V-5.26	Canoe Brook	3	-72.530961	42.946975	
11 - V028T	CT-V-5.28	Salmon Brook	3	-72.526038	42.933915	
11 - V032T	CT-V-5.32	Catsbane Brook	3	-72.526188	42.911684	
11 - V037T	CT-V-5.37	unnamed	3	-72.554108	42.877883	
11 - V040T	**CT-V-5.40**	**West River**	**6**	**-72.568873**	**42.871931**	**1,706.4**
11 - V042T	**CT-V-5.42**	**Whetstone Brook**	**4**	**-72.556527**	**42.851768**	**93.4**
11 - V046T	**CT-V-5.46**	**Broad Brook**	**4**	**-72.544266**	**42.820078**	**504**
11 - V048T	CT-V-5.48	Ash Swamp Brook	3	-72.52757	42.801549	

1 Tributaries identified (but not necessarily selected for study) in Study 13 that correspond to this study's selected sites

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4.4. Downstream of Vernon Dam

As requested during the site selection consultation meeting, the first map-unit immediately downstream of Vernon dam was purposively selected for American eel boat electrofish sampling (Table 4.4-1).

Table 4.4-1. Newly selected map-unit within the Vernon riverine reach.

Map Unit	Sample Bank	Downstream Coordinate	
		X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
11 - V001	East	-72.455665	43.060274

5. FIELD SAMPLING METHODOLOGIES

Each mainstem sampling location will consist of a 500-m shoreline transect along either the east or west bank of the river. All mainstem map-units in impoundments will be boat electrofished along one shoreline. It is likely that electrofish sampling in some riverine areas will need to be conducted by pram due to the difficulty in getting an electrofish boat into the reaches. In addition to electrofish sampling, a set of 2 baited eel traps will be deployed at all locations for a 24-hr period.

Table 5.1. Summary of 500-m map-units and number of all survey locations selected for sampling.

River Reach	Description	Total Number 500-m Map-units	Selected Number 500-m Map-units
RM 217.4-262.4	Wilder Impoundment	156	37
RM 199.7-217.4	Riverine Downstream of Wilder Dam	60	15
RM 173.7-199.7	Bellows Falls Impoundment	93	22
RM 167.9-173.7	Riverine Downstream of Bellows Falls Dam	20	5
RM 141.9-167.9	Vernon Impoundment	93	22
RM 140.4-141.9	Riverine Downstream of Vernon Dam	1	-
RM 140.4-262.4	Total	423	101

Similar to mainstem sampling, tributaries will be sampled using a combination of electrofishing (likely using a pram unless suitable boat access exists) and 24-hr deployments of 2 baited eel pots at each site. Where the full length of the project-affected reach is less than 500 m, the entire distance will be sampled. In selected tributaries where the full length of the project-affected reach is greater than 500 m, sampling will take place within a randomly selected 500-m reach placed between the confluence and the upper end of the project-affected area (as determined by visual observations made at the time of sampling by field crew).

Table 5.2. Summary of major tributaries and number of tributary survey locations selected for sampling.

River Reach	Description	Total Number of Major Tributaries	Selected Number of Major Tributaries
RM 217.4-262.4	Wilder Impoundment	16	7
RM 173.7-217.4	Wilder dam to Bellows Falls dam	25	9
RM 141.9-173.7	Bellows Falls dam to Vernon dam	22	8
RM 140.4-262.4	Total	63	24

6. LITERATURE CITED

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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 II.D

Study 12 – Tessellated Darter Survey

Revised Site Selection Report

Updated Study Report

September 14, 2015

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TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 12
Tessellated Darter Survey

Revised Site Selection Report

In support of Federal Energy Regulatory Commission Relicensing of:

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

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February 3, 2015

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LIST OF TABLES

1. INTRODUCTION

Operations at the Wilder, Bellows Falls, and Vernon Projects potentially affect the availability of instream habitat on which the tessellated darter depends. Habitat for tessellated darters may be related to the project operations in terms of flow (water depth and velocity, and their timing, duration, frequency, and rate of change), as well as the interactions of flow with other habitat variables such as substrate, vegetation, and cover. Operations both upstream (i.e., impoundment levels) and downstream (i.e., flow fluctuations) may affect habitat, which may consequently lead to changes in the distribution, abundance, and behavior of tessellated darter. Those changes could, in turn, potentially affect the federally listed as endangered dwarf wedgemussel.

Revised Study Plan (RSP) 12, as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination, specified that a subset of the project-affected area would be studied. This report has been revised in response to comments received from the aquatics working group at a December 17, 2014 site selection consultation meeting. This revised report provides a summary of the data analysis and criteria used to select the proposed subset of locations to be examined in detail during 2015.

The following selected sites were modified as a result of consultation:

- Wilder impoundment: following confirmation of similar habitat type, replaced map-unit 12-W073 with map-unit 12-W074.

- Bellows Falls impoundment: following confirmation of similar habitat type, replaced map-unit 12-B025 with map-unit 12-B030.

- Vernon impoundment: following confirmation of similar habitat type, replaced map-unit 12-V080 with map-unit 12-V076.

- For all affected map-units, more evenly distributed some or all transects across areas having the same habitat type. Affected map units are:

    - Wilder Impoundment: 12–W020, 12–W031, 12–W047, 12–W057, 12–W059, 12–W107, 12–W110, 12–W115, 12–W140, 12-W147.
    - Wilder Riverine: 12-WR004, 12-WR009, 12-WR023, 12-WR032, 12-WR046, 12-WR056, 12-WR058.
    - Bellows Falls Impoundment: 12-B003, 12-B020, 12-B066, 12-B076, 12-B089.
    - Bellows Falls Riverine: 12-BR016, 12-BR019.
    - Vernon Impoundment: 12-V017, 12-V020, 12-V033, 12-V079, 12-V089.
    - Vernon Riverine: 12-VR002, 12-VR003, 12-VR005.

These site and transect changes are indicated in Section 3 tables and figures.

2. STUDY AREA

Sampling will be conducted to characterize the distribution and relative abundance of tessellated darter within project-affected areas from the upper extent of the Wilder impoundment to approximately 1.5 miles downstream of Vernon dam. This approximately 120-mile reach of the Connecticut River was divided into six geographic reaches delineated based on a combination of general river morphology and project structures. These geographic reaches are as follows:

- Wilder impoundment (RM 262.4 - 217.4);
- Wilder downstream riverine corridor (RM 217.4 – 199.7);
- Bellows Falls impoundment (RM 199.7 – 173.7);
- Bellows Falls downstream riverine corridor (RM 173.7 – 167.9);
- Vernon impoundment (RM 167.9 – 141.9); and
- Downstream of Vernon dam to the downstream extent of Stebbins Island (RM 141.9 – 140.4).

3. SITE SELECTION PROCESS

As stated in the RSP, the selection of sampling locations for tessellated darter distribution and relative abundance was stratified based on habitat characteristics. Habitat characteristics for project-affected areas were recorded as part of Study 7 - Aquatic Habitat Mapping. Pertinent data collected during that study included side-scan sonar mapping and classification of bottom substrates as well as mesohabitat and dominant substrate classification of habitat units within the Wilder, Bellows Falls and Vernon riverine sections (Normandeau 2014).

Prior to the selection of study locations, each geographic reach (or stratum) was delineated into 500-meter map-unit segments using ArcGIS. Within each map-unit, the substrate present was quantified. An overall dominant habitat type was assigned based on the proportions of varying substrates present within each individual unit. For example, if a particular 500-meter map-unit was determined to contain 70% cobble-gravel, 25% sand-silt-clay, and 5% boulder then a dominant habitat type of cobble-gravel was assigned. For map-units with existing side-scan substrate data (primarily in the impoundment reaches), the dominant habitat type was assigned using that information. For map-units where mesohabitat mapping was conducted (primarily in the riverine reaches), the proportional contribution of mesohabitat units identified in the field during Study 7 in 2013 (i.e., run, riffle, glide, etc.) was first determined.

The dominant substrate type identified at the time of the field survey within each mesohabitat unit was then substituted for mesohabitat unit from Study 7, and the resulting proportions of varying substrate types present were used to make the determination of dominant habitat type within the 500-meter map-unit. For example, if 70% of the area of a particular map-unit was represented by one run mesohabitat unit and the remaining 30% was represented by one pool mesohabitat

habitat unit, with the run being dominated by cobble-gravel substrate and the pool being dominated by sand-silt-clay, then a dominant habitat type of cobble-gravel was assigned. In some instances, both side-scan substrate data and mesohabitat mapping data were available for a particular map-unit. In those cases, dominant habitat type was determined from the side-scan substrate data.

The total number of sampling locations within each geographic reach were randomly placed proportional to habitat type frequency (e.g., if 50 percent of a particular geographic reach is cobble-gravel habitat than 50 percent of the total number of sampling locations for that geographic reach would be randomly placed within that habitat type).

For samples collected during visual surveys, the RSP specified that within each 500-m map-unit, a total of three visual survey sample areas would be randomly placed. To accomplish this, a start point (either the upper or lower bound of a particular 500-m map-unit) was randomly selected. Once the start point was determined, three numbers between the values of 1 and 500 were randomly chosen. To ensure that transects were distributed throughout the map-unit, one visual survey area was placed within each third of a selected map-unit (i.e., within 0-166 m of start point, 167-333 m of start point and 334-500 m of start point). Sample areas were then placed at the intervals specified by the three random values with the randomly selected upper or lower bound serving as the start point. Consider an example at map-unit X, where the upper bound (rather than the lower bound) was randomly selected to serve as the start point. Following that determination, one value between 1 and 166, one value between 167 and 333 and one value between 334 and 500 were randomly chosen (e.g., 14, 196, and 414). In this example, visual survey areas within map-unit X would be placed at distances of 14m, 196m, and 414m downstream of map-unit X's upper bound. Once in the field, each visual survey sample area will consist of 5 fixed-radius count locations spaced evenly across the channel (i.e., west bank, 1/3rd channel width, channel midpoint, 2/3rd channel width, east bank). In the event that a visual survey sample area crosses an island, sampling will occur within the channels on both sides.

Substrate acreage and the resulting dominant habitat type for each map-unit is presented in the Revised Study 10 and Study 12 Substrate Data Attachment (separate document).

3.1 Wilder Impoundment

A total of 156 map-units were placed within the Wilder impoundment. Existing side-scan survey data was used to determine dominant habitat type for the majority of map-units (151 of 156). There was no habitat data available for the remaining 5 map-units, located at the upstream end of the Wilder impoundment. Habitat data was not collected at those five locations in Study 7 due to lack of access for the survey boat.

The percentages of habitat type within the 3,028 acres mapped by side-scan sonar were used to determine the spatial distribution of 14 sampling locations in the impoundment. Results from the Study 7 impoundment mapping are presented in

Table 3.1-1 and indicate that the majority of habitat in the impoundment is dominated by sand-silt-clay and cobble-gravel. Lesser amounts of boulder, rip rap, ledge and woody debris habitat are also present. For the purposes of placing sampling locations in the impoundment, the total number of locations (14) were allocated following a habitat-type frequency distribution of 76% in map-units dominated by sand-silt-clay, 15% in map-units dominated by cobble-gravel and 9% in map-units dominated by boulder and/or rip rap. When existing habitat proportions are considered, 11 map-units dominated by sand-silt-clay, two map-units dominated by cobble-gravel and one map-unit dominated by boulder-rip rap were selected for sampling.

Of the 151 map-units with available habitat data, 146 were dominated by sand-silt-clay and five were dominated by cobble-gravel. There were no map-units where the boulder-rip rap substrate types were proportionally dominant. To address this, map-units were sorted based on the proportional contribution of boulder-rip rap habitat, and locations within the upper quartile of presence were used as the basis for random selection. Results of site selection in the Wilder impoundment are presented in Tables 3.1-2 and 3.1-3 and the spatial distribution is presented in Figure 3.1-1.

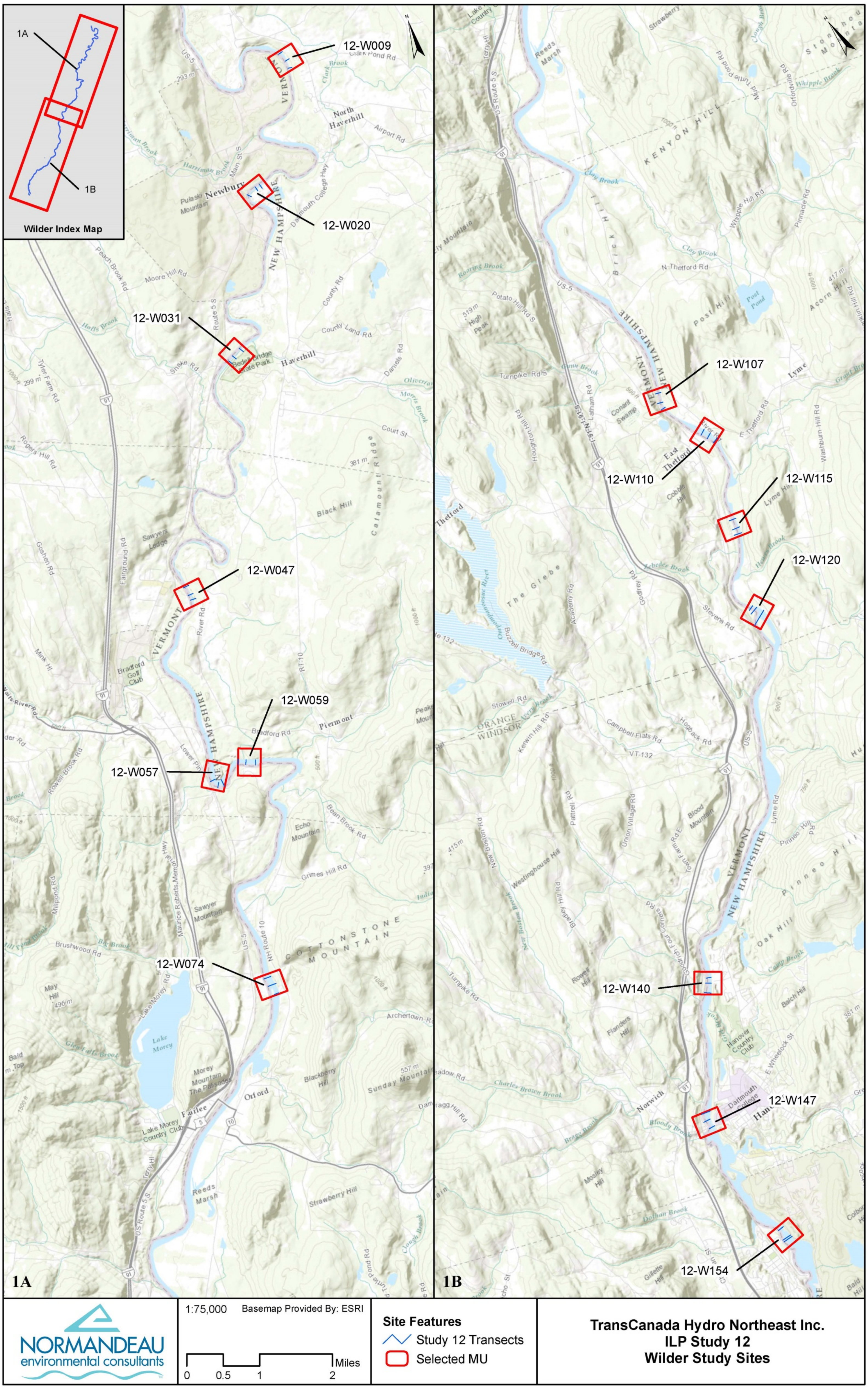

Figure 3.1-1. Revised Tessellated darter survey sites in the Wilder impoundment.

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Table 3.1-1. Total area (acres) and percent of total area for aquatic habitat types mapped using sonar imagery within Wilder impoundment (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	2,308.9	76.2%
gravel/cobble	450.1	14.9%
boulder	100	3.3%
rip rap	52.6	1.7%
ledge	26.1	0.9%
woody debris	90.7	3.0%
TOTAL	3,028.5	100.0%

Table 3.1-2. Revised Substrate composition and resulting dominant habitat type for map-units randomly selected in the Wilder impoundment.

	Substrate Type (acres)							
Map Unit	Sand-Silt-Clay	Gravel-Cobble	Boulder	Rip Rap	Ledge	Woody Debris	No Data	Dominant Habitat
12 - W009	4.7	5.2	1.0	0.4	0.1	0.7	0.0	Gravel, Cobble
12 - W020	16.6	2.3	0.1	0.3	0.0	0.5	0.0	Sand, Silt, Clay
12 - W031	8.1	4.5	0.4	0.0	0.0	0.4	0.0	Sand, Silt, Clay
12 - W047	10.0	4.0	0.1	0.0	0.0	1.3	0.0	Sand, Silt, Clay
12 - W057	19.6	4.8	0.2	0.3	1.8	0.8	0.0	Sand, Silt, Clay
12 - W059	11.3	2.6	0.0	0.0	0.0	0.7	0.0	Sand, Silt, Clay
12 – W074	13.6	3.3	0.9	0.0	0.7	3.7	0.0	Sand, Silt, Clay
12 - W107	7.6	4.1	0.8	0.4	0.0	2.3	0.0	Sand, Silt, Clay
12 - W110	15.7	3.5	0.0	0.2	0.0	0.2	0.0	Sand, Silt, Clay
12 - W115	17.3	2.4	0.0	0.1	0.0	1.0	0.0	Sand, Silt, Clay
12 - W120	13.3	1.4	0.4	0.6	0.0	0.3	0.0	Sand, Silt, Clay
12 - W140	4.8	8.5	0.4	1.0	0.5	0.8	0.0	Gravel, Cobble
12 - W147	11.7	4.9	1.2	2.1	0.1	0.0	0.0	Sand, Silt, Clay
12 - W154	13.2	0.2	8.0	0.6	1.8	0.0	0.0	Boulder

Table 3.1-3. Revised Tessellated darter sampling locations in the Wilder impoundment.

Map Unit	Starting Boundary	Selected Increment	Location	
			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
12 - W009	Upper	57	-72.03132833630	44.10116745470
		268	-72.03018293000	44.09941781380
		450	-72.03015273950	44.09775506820
12 - W020	Upper	128	-72.04840381940	44.07736718630
		239	-72.049727	44.077164
		462	-72.05224379000	44.07633770190
12 - W031	Lower	44	-72.07206768910	44.04625485670
		182	-72.070574	44.046874
		406	-72.06808949660	44.04783078920
12 - W047	Lower	136	-72.10290406070	44.00407224550
		258	-72.10314451470	44.00514943920
		463	-72.10328355940	44.00560695300
12 - W057	Lower	137	-72.11150108630	43.96763424930
		254	-72.112892	43.967547
		409	-72.11392455800	43.96873584480
12 - W059	Lower	113	-72.101151	43.969366
		326	-72.10364120500	43.97005119390
		497	-72.10564609470	43.97060106250
12 – W074	Lower	21	-72.116267	43.924555
		245	-72.116621	43.926491
		427	-72.117262	43.928167
12 - W107	Upper	95	-72.18666	43.824826
		313	-72.187878	43.823067
		456	-72.18822501890	43.82179945030
12 - W110	Upper	138	-72.183705	43.813273
		296	-72.18301844970	43.81194132260
		473	-72.18240947920	43.81041384890
12 - W115	Lower	56	-72.19339671240	43.79301404710
		190	-72.192856	43.794139
		400	-72.19209921810	43.79595646190
12 - W120	Lower	146	-72.20307338050	43.77730438050
		328	-72.20298388450	43.77906212500
		411	-72.20319553830	43.77984204270
12 - W140	Lower	37	-72.27773374440	43.72508147970
		251	-72.27592	43.726483
		371	-72.27496689540	43.72730685880
12 - W147	Upper	19	-72.29848521980	43.70657919420
		205	-72.299571	43.705179
		386	-72.299636	43.703529
12 - W154	Upper	74	-72.30186179470	43.67925495480

Map Unit	Starting Boundary	Selected Increment	Location	
			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
		312	-72.30212478770	43.67712812970
		356	-72.30209337840	43.67673404140

3.2 Wilder Riverine Reach

A total of 60 map-units were placed within the Wilder riverine reach extending from map-unit 12-WR001 at the Wilder tailrace to map-unit 12-WR060 located at RM 199.7. Existing mesohabitat survey data was used to determine dominant habitat type for 51 of the 60 map-units. There was no available substrate classification data for 9 map-units since river bottom visibility was obscured at those locations during mesohabitat mapping (due to water depth, turbulence, etc.). The percentages of habitat type within the approximately 1,068 acres mapped in Study 7 were used to determine the spatial distribution of 8 sampling locations in the reach. Results from the Study 7 mesohabitat mapping are presented in Table 3.2-1 and indicate that the majority of habitat in the reach is primarily cobble-gravel with lesser amounts of sand-silt-clay and boulder habitat. For the purposes of placing sampling locations in the reach, the total number of locations (8) was allocated following a habitat-type frequency distribution of 70% in map-units dominated by cobble-gravel, 23% in map-units dominated by sand-silt-clay, and 7% in map units dominated by boulder. When the existing habitat proportions are considered, five map-units dominated by cobble-gravel, two map-units dominated by sand-silt-clay, and one map-unit dominated by boulder were selected for sampling.

Of the 51 map-units with available data, 39 were dominated by cobble-gravel, eight were dominated by sand-silt-clay, and four were dominated by boulder. Results of site selection in the Wilder riverine reach are presented in Tables 3.2-2 and 3.2-3 and the spatial distribution is presented in Figure 3.2-1.

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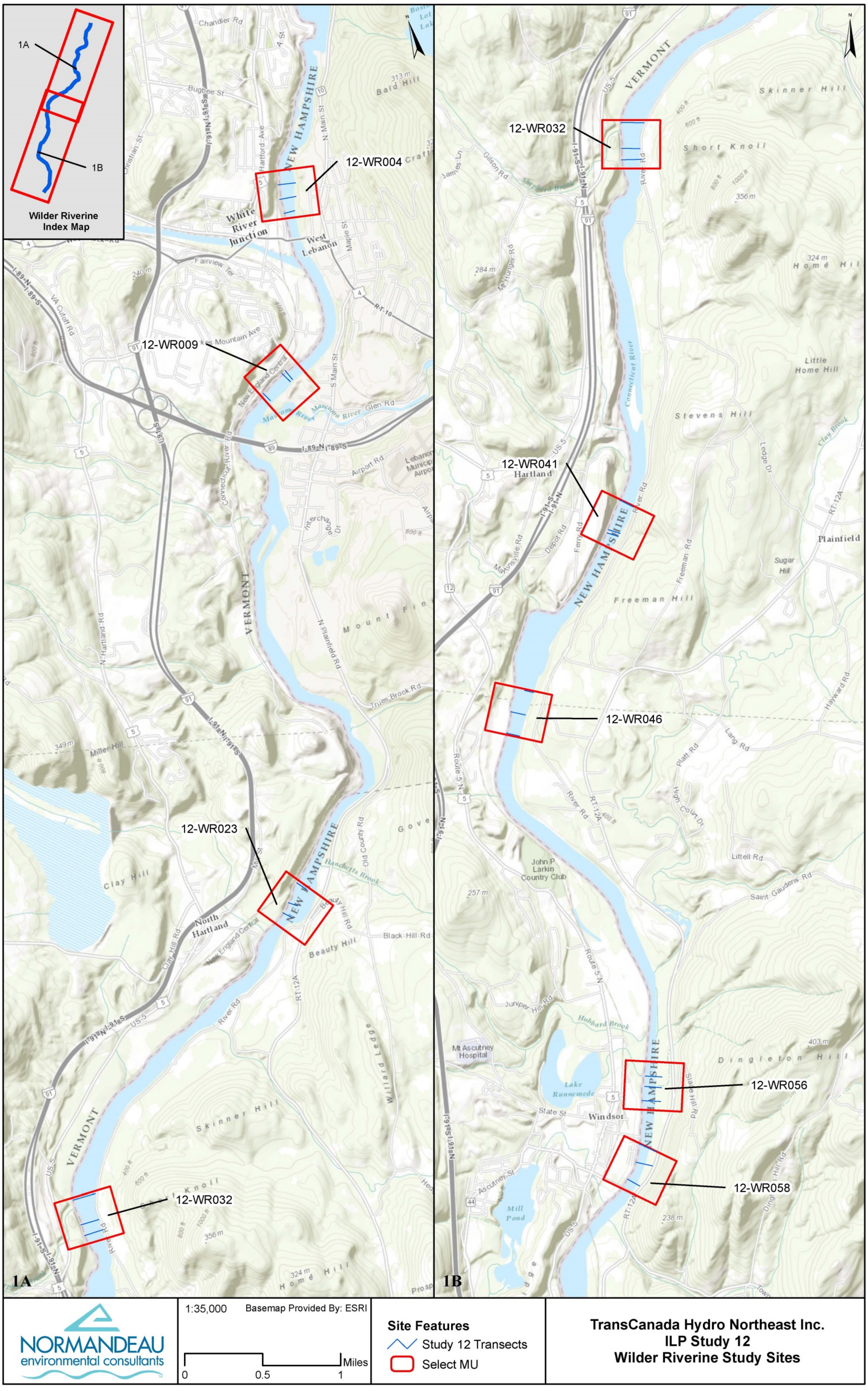

Figure 3.2-1. Revised Tessellated darter survey sites in the Wilder riverine reach.

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Table 3.2-1. Total area (acres) and percent of total area for aquatic habitat types mapped using sonar imagery within the Wilder riverine reach (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	217.0	20.3%
gravel/cobble	625.3	58.5%
boulder	66.7	6.2%
no data	159.8	14.9%
TOTAL	1068.9	100.0%

Table 3.2-2. Substrate composition and resulting dominant habitat type for map-units randomly selected in the Wilder riverine reach.

Map Unit	Substrate Type (acres)				Dominant Habitat
	Sand-Silt-Clay	Gravel-Cobble	Boulder	No Data	
12 - WR004	5.5	7.6	2.7	0.0	Gravel, Cobble
12 - WR009	14.9	0.0	0.0	0.0	Sand, Silt, Clay
12 - WR023	1.4	7.6	0.0	7.5	Gravel, Cobble
12 - WR032	23.2	0.0	0.0	0.0	Sand, Silt, Clay
12 - WR041	0.0	9.2	7.4	0.0	Gravel, Cobble
12 - WR046	1.2	15.8	0.0	0.0	Gravel, Cobble
12 - WR056	5.5	16.1	0.0	0.0	Gravel, Cobble
12 - WR058	17.2	1.8	0.0	0.0	Boulder

Table 3.2-3. Revised Tessellated darter sampling locations in the Wilder riverine reach.

Map Unit	Starting Boundary	Selected Increment	Location	
			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
12 - WR004	Lower	63	-72.31385235220	43.65320179770
		207	-72.313481	43.654489
		357	-72.313011	43.65576
12 - WR009	Upper	144	-72.32061288930	43.63890031560
		181	-72.32104257840	43.63877404580
		464	-72.324186	43.637642
12 - WR023	Upper	28	-72.33999830940	43.59359844460
		235	-72.341803	43.592272
		363	-72.34290594290	43.59146669970
12 - WR032	Upper	26	-72.379016	43.572765
		291	-72.37936777660	43.57036419280
		405	-72.37932566660	43.56933428540
12 - WR041	Upper	9	-72.38134543280	43.53746482790
		322	-72.38299094430	43.53489994840
		359	-72.38320886660	43.53459807220
12 - WR046	Upper	16	-72.39451253850	43.52029538080
		268	-72.395991	43.518302
		485	-72.39671482620	43.51634455470
12 - WR056	Lower	96	-72.38056	43.481961
		240	-72.38027307760	43.48324893200
		350	-72.38016567150	43.48422586470
12 - WR058	Lower	108	-72.38315	43.474442
		331	-72.38171994840	43.47613480240
		494	-72.38118081360	43.47762028450

3.3 Bellows Falls Impoundment

A total of 93 map-units were placed within the Bellows Falls impoundment extending from map-unit 12-B001 at the upper extent of the impoundment (RM 199.7) to map-unit 12-B093 located at the Bellows Falls dam. Existing side-scan survey data was used to determine dominant habitat type for the majority of map-units within the impoundment (88 of 93). Existing mesohabitat survey data was used to determine dominant habitat type for 4 map-units, and a combination of side-scan and mesohabitat survey data was used for the remaining map unit.

The percentages of habitat type within the 2,921 acres mapped by side-scan sonar were used to determine the spatial distribution of 8 sampling locations in the impoundment. Results from the Study 7 impoundment mapping are presented in Table 3.3-1 and indicate that the majority of habitat in the impoundment is dominated by sand-silt-clay and cobble-gravel. Lesser amounts of boulder, rip rap, ledge and woody debris habitat are also present. For the purposes of placing sampling locations in the impoundment, the total number of locations (8) were allocated following a habitat-type frequency distribution of 84% in map-units dominated by sand-silt-clay, 12% in map-units dominated by cobble-gravel and 4% in map-units dominated by boulder and/or rip rap. When existing habitat proportions are considered, 6 map-units dominated by sand-silt-clay, 1 map-unit dominated by cobble-gravel and 1 map-unit dominated by boulder-rip rap were selected for sampling.

Of the 93 map-units with available habitat data, 80 were dominated by sand-silt-clay and 13 were dominated by cobble-gravel. There were no map-units where the boulder-rip rap substrate types were proportionally dominant. To address this, map-units were sorted based on the proportional contribution of boulder-rip rap habitat and locations within the upper quartile of presence were used as the basis for random selection. Results of site selection in the Bellows Falls impoundment are presented in Tables 3.3-2 and 3.3-3 and the spatial distribution is presented in Figure 3.3-1.

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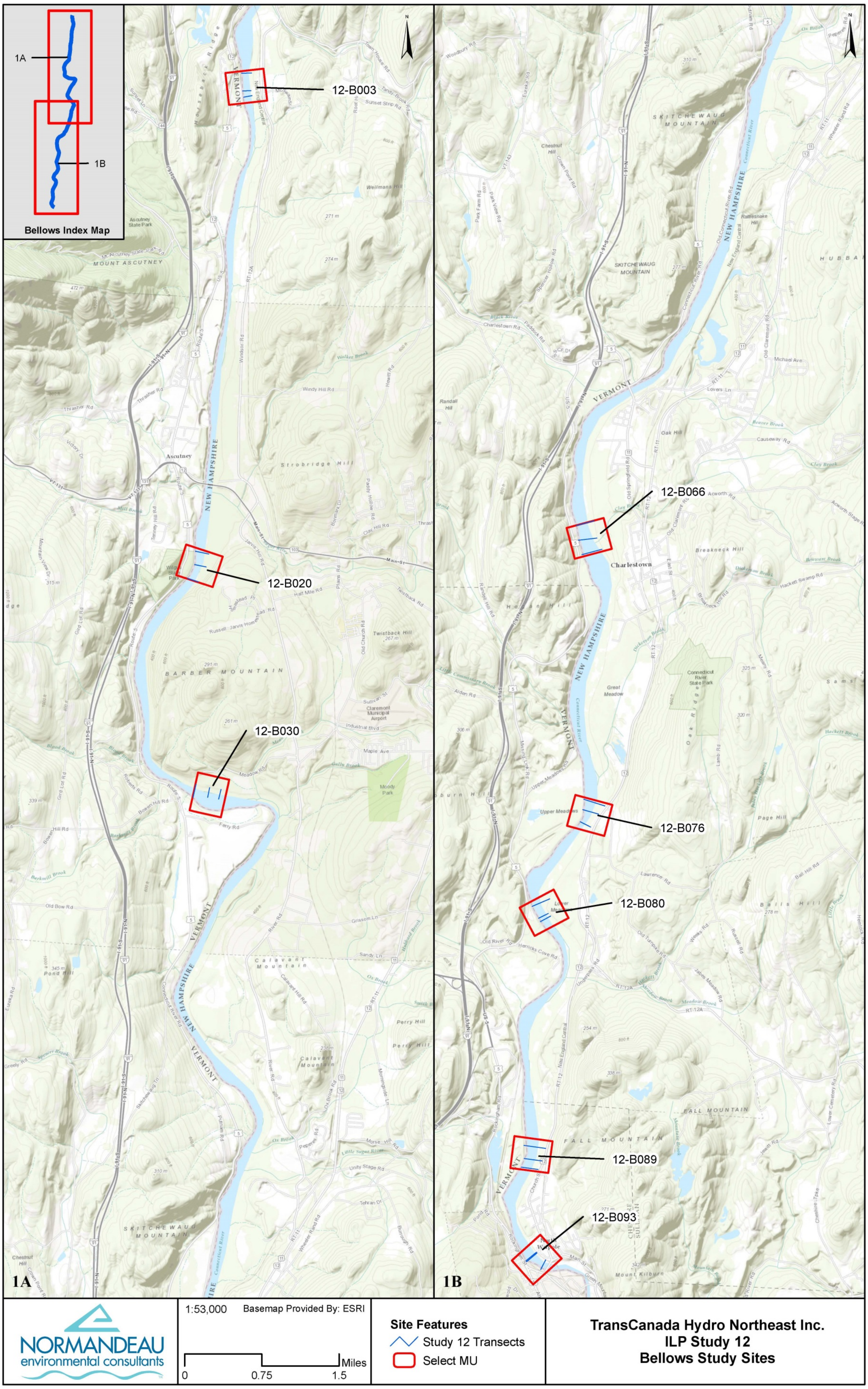

Figure 3.3-1. Revised Tessellated darter survey sites in the Bellows Falls Impoundment.

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Table 3.3-1. Total area (acres) and percent of total area for aquatic habitat types mapped using sonar imagery within Bellows Falls impoundment (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	2,450.90	83.9%
gravel/cobble	348.7	11.9%
boulder	49.9	1.7%
rip rap	25.4	0.9%
ledge	3.8	0.1%
woody debris	43	1.5%
TOTAL	2,921.80	100.0%

Table 3.3-2. Revised Substrate composition and resulting dominant habitat type for map-units randomly selected in the Bellows Falls impoundment.

Map Unit	Substrate Type (acres)							Dominant Habitat
	Sand-Silt-Clay	Gravel-Cobble	Boulder	Rip Rap	Ledge	Woody Debris	No Data	
12 - B003	0.0	17.1	0.0	0.0	0.0	0.0	16.9	Gravel, Cobble
12 - B020	20.7	2.4	0.1	0.7	0.0	0.7	0.0	Sand, Silt, Clay
12 - B030	20.8	7.8	0.0	0.0	0.0	0.6	0.0	Sand, Silt, Clay
12 - B066	36.7	0.0	0.0	0.0	0.0	0.5	0.0	Sand, Silt, Clay
12 - B076	28.4	0.5	0.5	0.0	0.6	0.1	0.0	Sand, Silt, Clay
12 - B080	20.2	7.5	0.1	0.0	0.0	0.8	0.0	Sand, Silt, Clay
12 - B089	36.0	0.9	0.0	0.4	0.0	1.1	0.0	Boulder
12 - B093	14.9	6.7	1.4	0.7	0.0	0.1	0.0	Sand, Silt, Clay

Table 3.3-3. Revised Tessellated darter sampling locations in the Bellows Falls impoundment.

Map Unit	Starting Boundary	Selected Increment	Location	
			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
12 - B003	Upper	38	-72.39088241840	43.46072374940
		311	-72.390942	43.458243
		401	-72.39078323920	43.45744139790
12 - B020	Upper	42	-72.40236004970	43.39357479820
		249	-72.402757	43.391748
		493	-72.404293	43.389764

Map Unit	Starting Boundary	Selected Increment	Location	
			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
12 – B030	Lower	94	-72.400371	43.359601
		271	-72.402539	43.359898
		491	-72.405235	43.360179
12 - B066	Upper	8	-72.43689451850	43.24228386360
		257	-72.43649897540	43.24004701000
		472	-72.435757	43.238205
12 - B076	Lower	97	-72.43862359260	43.20000657250
		312	-72.437538	43.201744
		470	-72.43678	43.203031
12 - B080	Lower	158	-72.44685268460	43.18689753800
		216	-72.44722792100	43.18733562570
		411	-72.44762762920	43.18920075440
12 - B089	Lower	33	-72.45132725240	43.15192337160
		174	-72.450659	43.153127
		378	-72.45022929950	43.15491459390
12 - B093	Upper	157	-72.45158240980	43.13955593170
		170	-72.45147044870	43.13945313510
		385	-72.44930485800	43.13836427350

3.4 Bellows Falls Riverine Reach

A total of 20 map-units were placed within the Bellows Falls riverine reach extending from map-unit 12-BR001 at the Bellows Falls tailrace to map-unit 12-BR020 located at RM 167.9. Existing side-scan survey data was used to determine dominant habitat type for 6 of the 20 map-units. Existing mesohabitat survey data was used to determine dominant habitat type for 13 map-units, and a combination of side-scan and mesohabitat survey data was used in determination of 1 map-unit.

The percentages of habitat type within the approximately 415 acres mapped in Study 7 were used to determine the spatial distribution of 4 sampling locations in the reach. Results from the Study 7 mesohabitat mapping are presented in Table 3.4-1 and indicate that the majority of habitat in the reach is primarily dominated by cobble-gravel. Lesser amounts of sand-silt-clay habitat are also present. For the purposes of placing sampling locations in the reach, the total number of locations (4) was allocated following a habitat-type frequency distribution of 83% in map-units dominated by cobble-gravel and 17% in map-units dominated by sand-silt-clay. When the existing habitat proportions were applied to the predetermined number of sample locations, three map-units dominated by cobble-gravel and one map-unit dominated by sand-silt-clay were selected for sampling. Of the 20 map-units with available habitat data, 18 were dominated by cobble-gravel and 2 were dominated by sand-silt-clay. Results of site selection in the Bellows Falls riverine reach are presented in Tables 3.4-2 and 3.4-3 and the spatial distribution is presented in Figure 3.4-1.

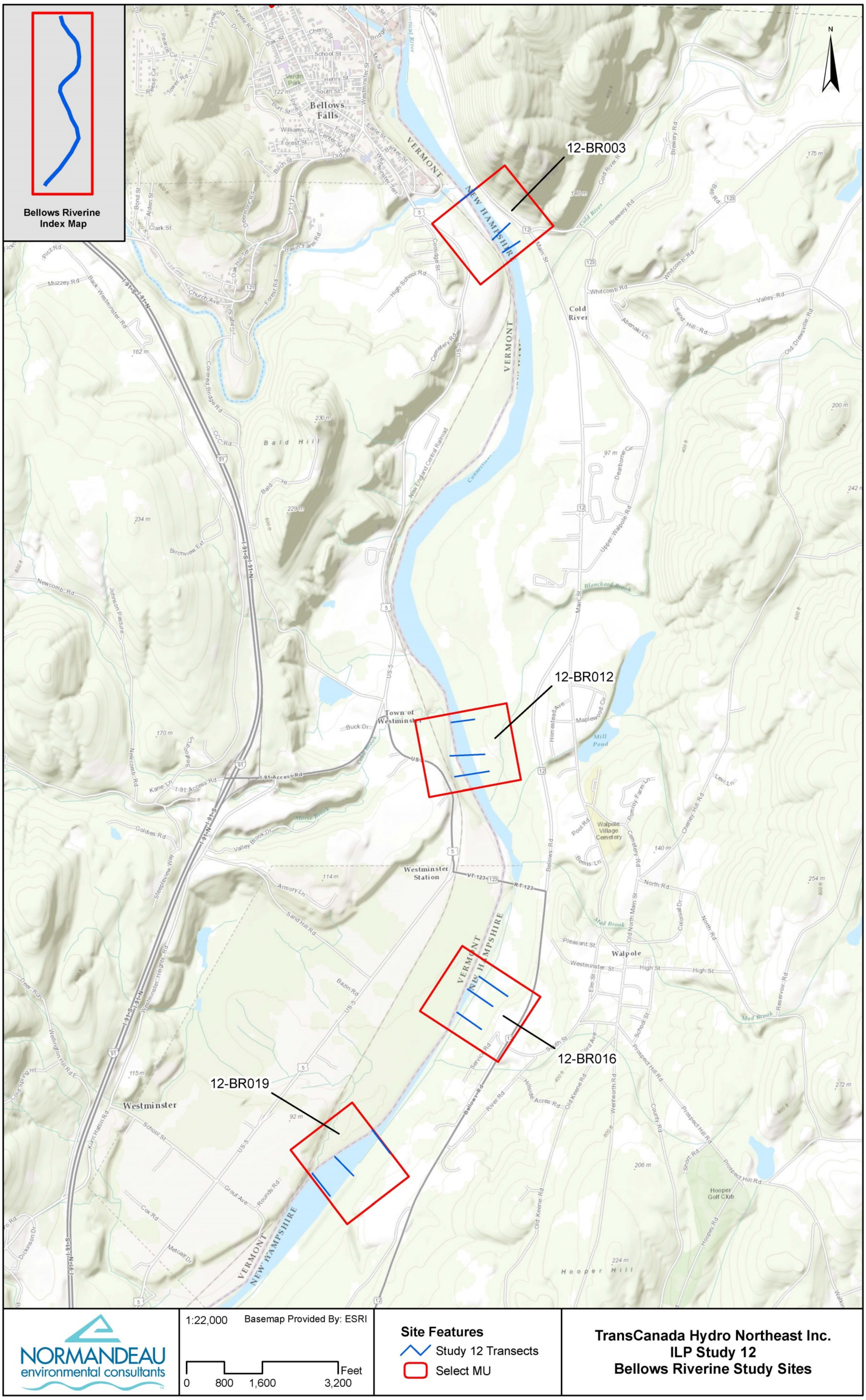

Figure 3.4-1. Revised Tessellated darter survey sites in the Bellows Falls riverine reach

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Table 3.4-1. Total area (acres) and percent of total area for aquatic habitat types mapped during sonar image collections and mesohabitat mapping within the Bellows Falls riverine reach (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	44.3	10.7%
gravel/cobble	343.2	82.7%
boulder	2.0	0.5%
rip rap	2.5	0.6%
ledge	0.0	0.0%
woody debris	5.8	1.4%
no data	17.1	4.1%
TOTAL	415.0	100.0%

Table 3.4-2. Substrate composition and resulting dominant habitat type for map-units randomly selected in the Bellows Falls riverine reach.

Map Unit	Substrate Type (acres)							Dominant Habitat
	Sand-Silt-Clay	Gravel-Cobble	Boulder	Rip Rap	Ledge	Woody Debris	No Data	
12 - BR003	0.0	17.3	0.0	0.0	0.0	0.0	0.0	Gravel, Cobble
12 - BR012	12.3	0.0	0.0	0.0	0.0	0.0	10.1	Sand, Silt, Clay
12 - BR016	0.6	22.6	1.3	0.0	0.0	0.7	0.0	Gravel, Cobble
12 - BR019	3.9	24.2	0.2	0.0	0.0	0.9	0.0	Gravel, Cobble

Table 3.4-3. Revised Tessellated darter sampling locations in the Bellows Falls riverine reach.

Map Unit	Starting Boundary	Selected Increment	Location	
			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
12 - BR003	Lower	67	-72.43299253270	43.12137107220
		182	-72.43374644320	43.12227710790
		500	-72.43627575610	43.12444896970
12 - BR012	Upper	59	-72.43794895370	43.09403863600
		280	-72.43767823450	43.09205863660
		404	-72.43736397220	43.09095278160
12 - BR016	Upper	108	-72.43617481290	43.07863167600
		219	-72.43725	43.078005
		381	-72.438174	43.076682
12 - BR019	Upper	4	-72.44541334030	43.06986012980
		286	-72.44840302880	43.06850240170
		481	-72.450254	43.06747

3.5 Vernon Impoundment

A total of 93 map-units were placed within the Vernon impoundment extending from map-unit 12-V001 at the upper extent of the impoundment (RM 167.9) to map-unit 12-V093 located at Vernon dam. Existing side-scan survey data was used to determine dominant habitat type for all map-units within the impoundment.

The percentages of habitat type within the 3,137 acres mapped by side-scan sonar in Study 7 were used to determine the spatial distribution of 8 sampling locations. Results from the Study 7 impoundment mapping are presented in Table 3.5-1 and indicate that the majority of habitat in the impoundment is dominated by sand-silt-clay and cobble-gravel. Lesser amounts of boulder, rip rap, ledge and woody debris habitat are also present. For the purposes of placing sampling locations in the impoundment, the total number of locations (8) were allocated following a habitat-type frequency distribution of 76% in map-units dominated by sand-silt-clay, 15% in map-units dominated by cobble-gravel and 9% in map-units dominated by boulder and/or rip rap. Totals were then adjusted so that a minimum of three sample locations were placed within each strata (i.e., habitat type) within a particular geographic reach. When the existing habitat proportions were applied to the predetermined number of sample locations, six map-units dominated by sand-silt-clay, 1 map-unit dominated by cobble-gravel and one map-unit dominated by boulder-rip rap were selected for sampling.

Of the 93 map-units considered for sampling, 73 were dominated by sand-silt-clay and 20 were dominated by cobble-gravel. There were no map-units where the boulder-rip rap substrate types were proportionally dominant. To address this, map-units were sorted based on the proportional contribution of boulder-rip rap habitat and locations within the upper quartile of presence were used as the basis for random selection. Results of site selection in the Vernon impoundment are presented in Tables 3.5-2 and 3.5-3 and the spatial distribution is presented in Figure 3.5-1.

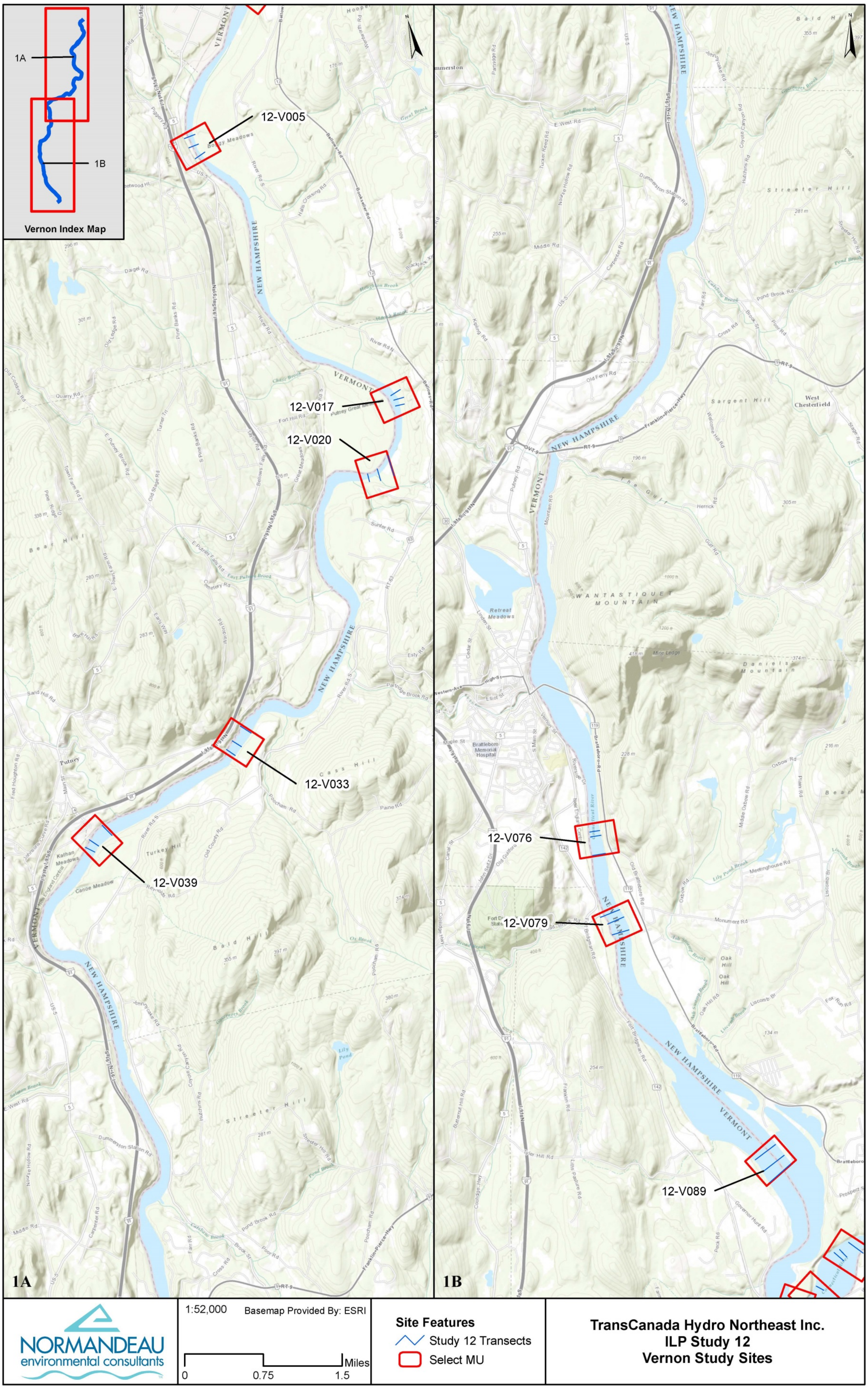

Figure 3.5-1. Revised Tessellated darter survey sites in the Vernon impoundment.

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Table 3.5-1. Total area (acres) and percent of total area for aquatic habitat types mapped using sonar imagery within Vernon impoundment (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	2,273.1	72.5%
gravel/cobble	653.6	20.8%
boulder	53.8	1.7%
rip rap	44.3	1.4%
ledge	27.2	0.9%
woody debris	85.2	2.7%
TOTAL	3,137.2	100.0%

Table 3.5-2. Revised Substrate composition and resulting dominant habitat type for map-units randomly selected in the Vernon impoundment.

	Substrate Type (acres)						
Map Unit	Sand-Silt-Clay	Gravel-Cobble	Boulder	Rip Rap	Ledge	Woody Debris	Dominant Habitat
12 - V005	5.3	15.2	0.0	0.2	0.0	0.8	Gravel, Cobble
12 - V017	12.9	3.8	2.0	0.1	0.0	1.7	Sand, Silt, Clay
12 - V020	16.5	6.3	0.0	0.4	0.0	0.4	Sand, Silt, Clay
12 - V033	15.0	5.4	0.2	0.0	0.3	0.4	Sand, Silt, Clay
12 - V039	17.8	2.4	1.1	0.1	0.9	1.6	Sand, Silt, Clay
12 – V076	17.5	3.2	0.0	0.9	1.2	0.4	Sand, Silt, Clay
12 - V079	26.9	3.9	0.3	0.0	0.2	1.6	Sand, Silt, Clay
12 - V089	47.8	1.7	0.0	0.0	0.0	0.4	Sand, Silt, Clay

Table 3.5-3. Revised Tessellated darter sampling locations in the Vernon impoundment.

Map Unit	Starting Boundary	Selected Increment	Location	
			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
12 - V005	Lower	96	-72.46594523520	43.04857186910
		272	-72.46663	43.050062
		424	-72.46687360980	43.05146738900
12 - V017	Upper	152	-72.44255490180	43.00983110020
		268	-72.44229275060	43.00888921990
		359	-72.442397	43.008025
12 - V020	Lower	119	-72.451749	42.999527
		285	-72.449708	42.999541
		498	-72.44710065520	43.00030888750

Map Unit	Starting Boundary	Selected Increment	Location	
			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
12 - V033	Lower	53	-72.490571	42.968149
		217	-72.48904239090	42.96909312650
		473	-72.48673181290	42.97064301250
12 - V039	Lower	82	-72.52094178880	42.96049622010
		198	-72.51987472980	42.96124576260
		468	-72.51689628740	42.96243383680
12 – V076	Upper	120	-72.545933	42.831736
		198	-72.545772	42.831062
		485	-72.545254	42.828517
12 - V079	Upper	69	-72.54352509040	42.82033997190
		202	-72.542506	42.819347
		400	-72.54162871020	42.81768770760
12 - V089	Lower	8	-72.51305743390	42.78386359310
		191	-72.514244	42.785232
		402	-72.51573408600	42.78681342030

3.6 Vernon Riverine Reach

A total of five map-units were placed within the Vernon riverine reach extending from map-unit 12-VR001 at the Vernon tailrace to map-unit 12-VR005 located at RM 140.4. Existing mesohabitat survey data was used to determine dominant habitat type for each of the five map-units.

The percentages of habitat type within the approximately 101 acres of mesohabitat mapped in Study 7 were used to determine the spatial distribution of the three sampling locations in the reach. Results from the Study 7 mesohabitat mapping are presented in Table 3.6-1 and indicate that the majority of habitat in the reach is primarily dominated by cobble-gravel. Lesser amounts of sand-silt-clay habitat are also present. For the purposes of placing sampling locations in the reach, the total number of locations (3) was allocated following a habitat-type frequency distribution of 66% in map-units dominated by cobble-gravel and 33% in map-units dominated by sand-silt-clay. When the existing habitat proportions were applied to the predetermined number of sample locations, two map-units dominated by cobble-gravel and one map-unit dominated by sand-silt-clay were selected for sampling.

Of the five map-units considered for sampling, four were dominated by cobble-gravel and one was dominated by sand-silt-clay. Results of site selection in the Vernon riverine reach are presented in Tables 3.6-2 and 3.6-3 and the spatial distribution is presented in Figure 3.6-1.

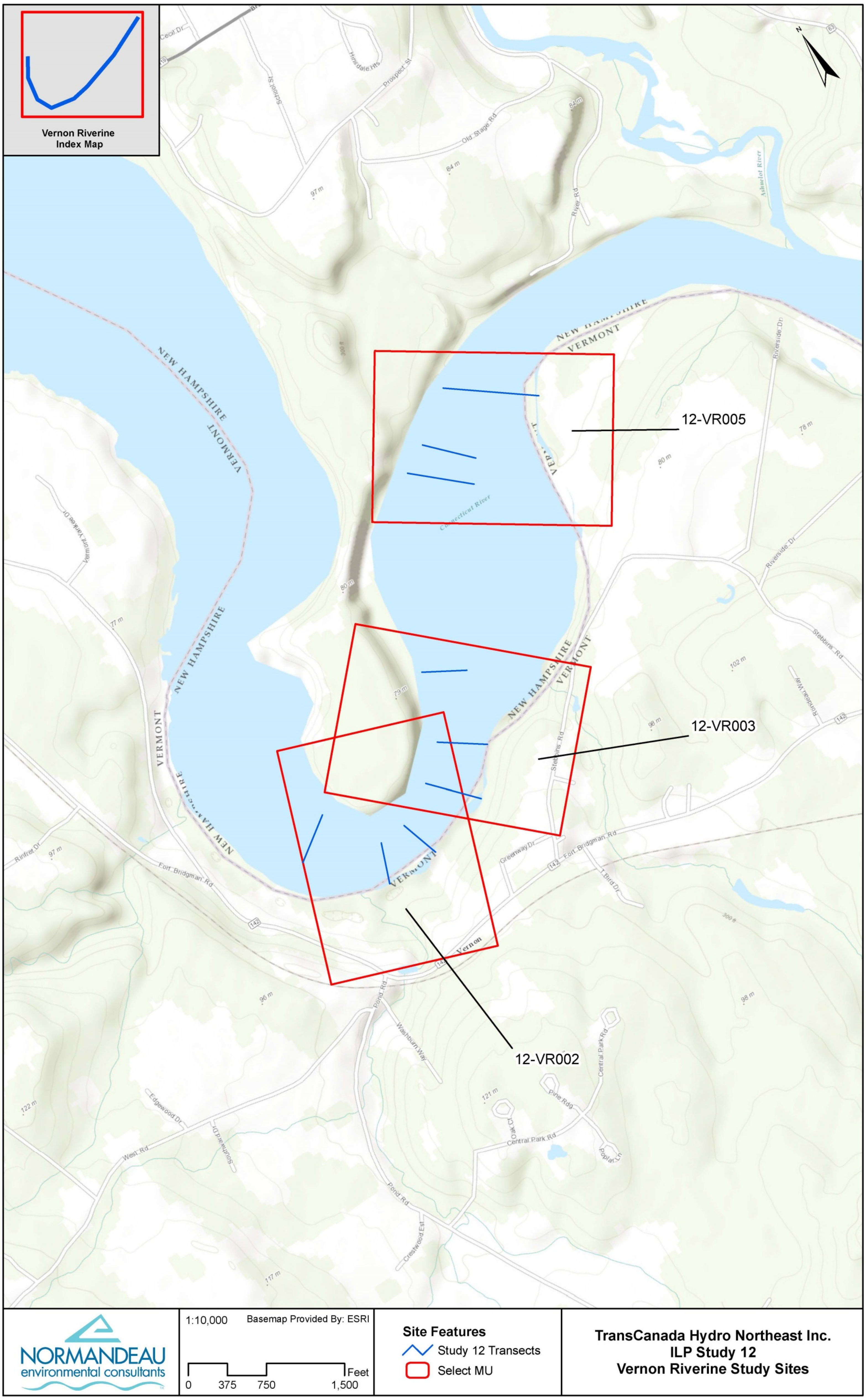

Figure 3.6-1. Revised Tessellated darter survey sites in the Vernon riverine reach.

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Table 3.6-1. Total area (acres) and percent of total area for aquatic habitat types based on substrate information collected during mesohabitat mapping in the Vernon riverine reach (Normandeau 2014).

Habitat Type	Area (acres)	% of Total
sand/silt/clay	32.1	26.3%
gravel/cobble	70.8	57.9%
no data	19.4	15.8%
TOTAL	122.3	100.0%

Table 3.6-2. Substrate composition and resulting dominant habitat type for map-units randomly selected in the Vernon riverine reach.

Map Unit	Substrate Type (acres)			Dominant Habitat
	Sand-Silt-Clay	Gravel-Cobble	No Data	
12 – VR002	15.3	8.3	-	Sand, Silt, Clay
12 – VR003	7.9	10.8	1.3	Gravel, Cobble
12 – VR005	0.2	20.4	7.3	Gravel, Cobble

Table 3.6-3. Revised Tessellated darter sampling locations in the Vernon riverine reach.

Map Unit	Starting Boundary	Selected Increment	Location	
			X (DD NAD83 UTM Z18N)	Y (DD NAD83 UTM Z18N)
12 - VR002	Upper	71	-72.513489	42.766139
		241	-72.51181895920	42.76453210680
		366	-72.51031395760	42.76456728030
12 - VR003	Lower	101	-72.506255	42.767863
		312	-72.50715307180	42.76602674590
		425	-72.50836587210	42.76511468020
12 - VR005	Lower	112	-72.49931602500	42.77328709290
		304	-72.50174502230	42.77259679450
		398	-72.502538	42.772125

4. FIELD SAMPLING METHODOLOGIES

Based on field observations of summer-fall conditions during 2013 and 2014 in each of the six geographic reaches included in this survey, it is anticipated that the use of visual surveys conducted by snorkel or SCUBA will be effective for assessing distribution and relative abundance at all sampling locations. This single sampling approach will allow for a consistent methodology to be used over all sampling areas and will aid in comparison of abundance estimates across locations. Sampling will be conducted during the late summer months (August-September) to ensure that young-of-year individuals are large enough to be observed and represented in collected samples. Table 4.1 presents a summary of the 135 visual survey areas included in the study.

Table 4.1. Summary of 500-m map-units and the resulting number of visual survey areas selected for sampling.

River Reach	Description	Total Number 500-m Map-units	Selected Number 500-m Map-units	Number Visual Survey Areas per Map-unit	Total Number of Visual Survey Areas
RM 217.4-262.4	Wilder Impoundment	156	14	3	42
RM 199.7-217.4	Riverine Downstream of Wilder Dam	60	8	3	24
RM 173.7-199.7	Bellows Falls Impoundment	93	8	3	24
RM 167.9-173.7	Riverine Downstream of Bellows Falls Dam	20	4	3	12
RM 141.9-167.9	Vernon Impoundment	93	8	3	24
RM 140.4-141.9	Riverine Downstream of Vernon Dam	5	3	3	9
RM 140.4-262.4	Total	427	45	-	135

5. LITERATURE CITED

Normandeau (Normandeau Associates, Inc.). 2014. ILP Study 7 Aquatic Habitat Mapping Initial Study Report. Prepared for TransCanada Hydro Northeast Inc. September 15, 2014.

APPENDIX A – REVISED SUBSTRATE CALCULATIONS FOR STUDIES 10 AND 12

(Excel Workbook Filed Separately as Volume II.J of this USR)

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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 II.E

Study 14 – Resident Fish Spawning in Impoundments Study

Revised Site Selection Report

Updated Study Report

September 14, 2015

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TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 14

Resident Fish Spawning in Impoundments Study

Revised Site Selection Report

In support of Federal Energy Regulatory Commission Relicensing of:

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

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February 3, 2015

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1. INTRODUCTION

Operations at the Wilder, Bellows Falls, and Vernon projects have the potential to affect resident fish spawning success and spawning habitat quality and quantity. Specifically, fluctuating water levels in the three impoundments create a potential for either fish eggs or quality spawning habitat to be dewatered, and/or for some species of fish to abandon nests containing eggs.

Revised Study Plan (RSP) 14, as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination (SPD), specified that a subset of the project-affected area would be studied to evaluate resident fish spawning in the project impoundments. This report has been revised in response to comments received from the aquatics working group at a December 17, 2014 site selection consultation meeting. This report provides a summary of the data analysis and criteria used to select the proposed subset of locations to be examined in detail during 2015. Typographical errors in the draft site selection report were also corrected. The following selected sites were modified or added as a result of consultation:

- The map marker on Figure 5-1 showing the location of backwater 14-WB-016 was moved to the backwater on the north side of the Waits River confluence.
- 4 additional 2nd or 3rd order tributary sites were added (2 in Wilder, 1 each in Bellows Falls and Vernon).
- Jarvis Island was added for assessing smallmouth bass spawning in the Bellows Falls impoundment, based on observations by NHFGD (Gabe Gries, personal communication).

2. STUDY AREA

Sampling will be conducted to characterize the fish spawning habitat and the effects of pool elevation fluctuations on spawning activities within each of the three project reservoirs, including portions of tributaries and backwaters within the impoundments that are affected by project operations. The three project reservoirs, totaling 97 miles in length, are listed below:

- Wilder impoundment (RM 262.4 - 217.4);
- Bellows Falls impoundment (RM 199.7 – 173.7);
- Vernon impoundment (RM 167.9 – 141.9).

3. TARGET SPECIES

The RSP identified 13 fish species for assessment of spawning activities and habitat in the reservoir reaches. Assessing the spawning periodicity, location, and pool fluctuation effects on each species individually would require a vast level of effort; consequently the 13 species were assigned into two “species groups”, where species within each group possess similarities in spawning habitat preferences. Each of the two species groups were then further partitioned according to spawning periodicity (early-spring vs. late-spring). The species groups for reservoir-resident fishes are:

- Backwater/Setback Spawners
    - Early-Spring (northern pike, chain pickerel, and yellow perch)
    - Late-Spring (largemouth bass, bluegill, pumpkinseed, black crappie, spottail shiner, and golden shiner)
- Tributary Confluence Riffle/Shoal Spawners
    - Early-Spring (walleye and white sucker)
    - Late-Spring (smallmouth bass, spottail shiner, and fallfish)

Spawning by each of these species groups will be assessed at study sites selected to maximum the likelihood of encountering spawning adults, and where the potential impacts of pool elevation changes are expected to occur. In addition, and in accordance with FERC’s SPD, spawning habitat data will be collected for eastern silvery minnow, if the species is observed to be present in the impoundments in this or other target species surveys (e.g., Studies 10, 11, 12).

4. SITE SELECTION PROCESS

As stated in the RSP, the selection of sampling locations will entail a combination of purposive sampling in study sites reported to be utilized by spawning adults (based on personal communication with agency biologists and local fishermen), and random sampling in study sites known to possess habitat characteristics meeting the basic spawning requirements for each species group. Habitat characteristics required for spawning (e.g., depth, substrate, vegetation, etc.) were recorded as part of Study 7 - Aquatic Habitat Mapping. Table 4.1 summarizes the basic spawning habitat characteristics for each of the 13 species, arranged according to species group. Appendix A contains detailed descriptions of spawning habitat characteristics for each species.

Prior to the selection of potential study sites, areas were excluded that are not expected to provide significant spawning habitat, e.g. steep banks; silty mid-channel habitat; depths >5 ft deep (normal reservoir fluctuations are 1-2 ft); tributary reaches outside of project operations influence; and areas possessing hazardous working conditions (e.g., immediately above project dams). Large backwaters connected by culverts were also excluded from selection due to the significant reduction in the speed and magnitude of water level changes resulting from the narrow connection to the main channel. Potential study sites that did meet the basic spawning requirements of the two species groups were selected based on several criteria, principally:

- Known presence of spawning (purposive sampling, all species groups)
- Size of potential spawning area (random sampling, all species groups)
- Presence of required habitat characteristics, namely:
  - Backwater habitats with minimal current velocities and significant areas of inundated terrestrial vegetation or submerged aquatic vegetation (early- and late-spring backwater/setback spawners).
  - Riffle habitats in lower tributary reaches possessing moderate to swift current velocities with sand, gravel, or cobble substrates, and shallow shoal or delta habitats at the impoundment confluence (early- and late-spring riffle/shoal spawners).

Random selection of non-purposive study sites was weighted based on tributary size (stream order) or habitat area (acres) of potential spawning habitat in order to maximize both the number and diversity of adult spawners or nests encountered at each sampling location. Larger study sites were also expected to contain a wider and more diverse range of microhabitat attributes than would a small study site. Finally, selection of a fixed number of larger sites would yield a much greater sampling area than would a similar number of small sites, again increasing the likelihood of achieving the goals of this study.

Twelve study sites were selected to assess spawning for the backwater/setback species group, and 16 study sites were selected for the tributary confluence riffle/shoal species group. The selected study sites were distributed among the three project impoundments in proportion to the length of each impoundment and, to the extent possible, distributed evenly between the lower, middle, and upper thirds of each impoundment. Based on these criteria, 6 backwater study sites were selected from the 45-mile Wilder impoundment, and 3 backwater study sites were selected from both the 26-mile long Bellows Falls impoundment and the 26-mile Vernon impoundment. For the tributary confluence spawners, 7 tributary habitats were selected in the Wilder impoundment, 5 in the Bellows Falls impoundment, and 4 in the Vernon impoundment.

To further ensure adequate longitudinal distribution of the study sites, each impoundment was first stratified into lower, middle, and upper thirds prior to selection of study sites. To the extent possible, 2 backwater/setback habitats were selected from lower Wilder Reservoir, 2 from middle Wilder, and 2 from upper Wilder. In like manner, the 3 backwater study sites located in the Bellows Falls and Vernon impoundments will be distributed among the lower, middle, and upper portions of the reservoirs (i.e., one in each third).

Selection of specific study sites began with identification of known spawning areas. For example, reports from NHFGD biologists and fishermen identified 3 backwater locations within the Bellows Falls impoundment where bass nests have been observed and dewatering was reported (Gabe Gries, NHFGD, personal communication). Consequently, these 3 backwaters were purposively selected to represent the backwater species group in the Bellows Falls impoundment. In contrast, no information was available regarding specific spawning locations for bass or other backwater spawners in the Vernon impoundment; consequently all 3 backwater study sites in that study reach were selected randomly, based on reservoir segment (lower, middle, or upper) and spawning habitat surface area.

The acreage of potential spawning habitat for the backwater/setback species groups was determined by outlining all identified backwater habitats using the polygon tool in ArcGIS. The area of potential riffle and shoal spawning habitat at impoundment tributary mouths was approximated by filtering the list of tributaries to those of stream order 4, 5, or 6 to represent “large” tributaries, whereas “medium” tributaries were those of 2nd or 3rd order. Medium-sized tributaries that did not possess a shallow (<5 ft) gravel/cobble dominated delta or shoal (based on Study 7 habitat mapping) were not available for selection. Small (1st order) tributaries were also unavailable for selection due to the expectation that such tributaries would not produce sizeable shoals at the impoundment confluence, nor would they provide a significant area of spawning habitat within the stream channel due to their small size and intermittent flow characteristics. Tributaries not already specifically identified as spawning areas for that species group were selected by random sampling from these tributaries, with greater weight for the larger tributaries than for the medium tributaries.

Table 4.1. Summary of spawning habitat characteristics according to species group[1].

Species		Periodicity		W Temps °C		Mean Velocity fps		Depth ft		Substrate Type		Instream
Group	Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover
Trib Confluence Riffle / Shoal -	Walleye	Apr to May	-	4-16	6-12	<1-7	1-4	0.2-4	1-4	sand, gravel, cobble	gravel	near shore?
Early Spring	White Sucker	Apr-June	April to May	6-18	9-17	<3	0.5-2	0.25-3.3	0.8-2.0	sand, gravel, rock	gravel	none
Trib Confluence Riffle / Shoal -	Spottail Shiner	June to July	-	>18	-	-	-	<30	3-4	sand & gravel shoals (often at trib mouths)	-	-
Late Spring	Fallfish	Apr-June	-	13-19	15-18	<3	<2	0.4-4.5	0.5-3.4	-	gravel & cobble	none
Backwater / Setback -	Northern Pike	Apr to May	-	5-17	7-12	<0.3	<0.3	0.2-12	0.6-4.8	dense submerged vegetation	flooded grasses or sedges	-
Early Spring	Chain Pickerel	Apr to May	-	7-13	-	-	-	1-10	-	inundated vegetation	-	-
	Yellow Perch	Apr to early-May	April	7-15	-	0.0-0.5	0	>0.5	1-5	sand, gravel, rock if veg is absent	rooted or woody vegetation	-
Backwater / Setback - Late Spring	Smallmouth Bass	May-June	mid-May to mid-June	13-23	15-18	-	-	>2	2-10	coarse sand, gravel, cobble	gravel (may have thin layer of silt)	prefers proximity (~1m) to rock or woody cover, sheltered from waves, near shore
	Largemouth Bass	May to July	early to mid-June	13-29	17-18	<0.3	<0.13	<20	1-7	any firm bottom type incl veg	gravel	prefers nearby object & protection from waves
	Black Crappie	May to July	June	13-21	18-20	-	0.0	0.5-6.0	0.9-3.3	mud, sand, gravel w/ SAV	firm substrate	SAV, emergent veg, woody debris, wave protection
	Bluegill	May to Aug	June	17-31	19-27	0.0-1.0	<0.25	1.5-15	0.5-5.0	any firm bottom type incl veg	sand & gravel	protection from waves
	Golden Shiner	May to July	-	20-27	-	-	-	-	-	SAV, sand, organic debris, emergent veg	SAV & algae	-
	Pumpkinseed	May to Aug	June	>20	-	-	0.0	0.5-6.0	0.8-1.7	all types of firm bottom	sand & gravel	SAV, wave protection

[1] See Appendix A for detailed listing of spawning habitat data.

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5. SELECTED STUDY SITES

5.1 Wilder Impoundment

The 45-mile Wilder impoundment contains 32 identified backwater/setback habitats, with 5 large tributaries of stream order 4 or greater but only 2 medium tributaries that possessed confluence shoals dominated by gravel/cobble substrates. As described above, 6 of the 12 study sites for each species group were selected in the Wilder impoundment, based on the relative lengths of the three impoundments. The potential spawning habitat available for each species group and those habitat areas selected for assessment of spawning activity are listed below.

Backwater/Setback Spawners (northern pike, chain pickerel, yellow perch, largemouth bass, bluegill, pumpkinseed, black crappie, spottail shiner, golden shiner)

The 32 backwater/setback habitats potentially available for early-spring and late-spring spawning ranged in size from 0.1 to 43.4 acres, with an average area of 7.0 acres. The backwater/setback habitat located at the mouth of the Waits River was identified by NHFGD as a known spawning area for northern pike and yellow perch (Gabe Gries, NHFGD, personal communication). Consequently, that backwater was purposively selected for assessing this species group to represent the upper segment of Wilder impoundment. The remaining 5 backwater habitats were randomly selected from within the three impoundment segments on the basis of backwater surface area; consequently the mean surface area of the 6 selected backwaters (23 acres) is substantially larger than the mean area of all available backwaters. The 6 backwater habitats selected in this study reach are shown in Figure 5.1, with physical characteristics listed in Table 5.1.

Tributary Confluence Riffle/Shoal Spawners (walleye, white sucker, smallmouth bass, spottail shiner, fallfish)

The Wilder impoundment contains 5 tributaries of stream order 4, 5, or 6. All five of these tributaries were purposively selected to represent potential spawning habitat for the riffle/shoal species group (Figure 5.1 and Table 5.2). Because a sixth large tributary was not available in this impoundment, an additional tributary was added to the Bellows Falls impoundment to yield a total of 12 large tributary-associated riffle/shoal habitats. Only 2 medium tributaries (2^{nd} or 3^{rd} order) in the Wilder impoundment contained shallow gravel/cobble-dominated habitat at the confluence; consequently both of these tributaries were selected for sampling.

5.2 Bellows Falls Impoundment

The 26-mile Bellows Falls impoundment contains 6 identified backwater habitats (all in the middle and lower reaches), 8 large tributaries of stream order 4 or greater, and 5 medium tributaries possessing gravel/cobble shoal habitat. As described above, 3 of the 12 backwater study sites were selected in the Bellows Falls impoundment based on its relative length. The potential spawning habitat available for each species group and those habitat areas selected for assessment of spawning activity are listed below.

Backwater/Setback Spawners (northern pike, chain pickerel, yellow perch, largemouth bass, bluegill, pumpkinseed, black crappie, spottail shiner, golden shiner)

The 6 backwater habitats potentially available for the early-spring and late-spring backwater/setback species group ranged in size from 19 to 97 acres, with an average area of 56 acres. Dewatered bass nests were reported by fishermen in 3 backwaters in the Bellows Falls impoundment (Gabe Gries, NHFGD, personal communication), one in the middle portion of the impoundment, and the other two in the lower third (no backwaters occur in the upper third). Consequently, these 3 backwaters, averaging 71 acres in size, were selected for assessing both the backwater/setback species group. Figure 5.2 shows the location of these backwaters, and physical characteristics are listed in Table 5.1.

Tributary Confluence Riffle/Shoal Spawners (walleye, white sucker, smallmouth bass, spottail shiner, fallfish)

Four of the 8 large tributaries and 1 of the 5 medium tributaries were selected for sampling in the Bellows Falls impoundment to assess the early-spring spawning activities of walleye and suckers and late-spring spawning by smallmouth bass, fallfish, and spottail shiners. In addition, Jarvis Island will also be monitored for spawning by smallmouth bass (and other species), due to its known utilization by spawning bass (Gabe Gries, NHDFG, personal communication). See Figure 5.2 and Table 5.2 for descriptions of these locations.

5.3 Vernon Impoundment

The 26-mile Vernon impoundment contains 8 identified backwater habitats in the middle and lower reaches (none in the upper third), 7 tributaries of stream order 4 or greater, and 7 medium tributaries of 2^{nd} or 3^{rd} order. As described above, 3 of the 12 study sites for the backwaters and 4 of the tributaries were selected in the Vernon impoundment based on its relative length. The potential spawning habitat available for each species group and those habitat areas selected for assessment of spawning activity are listed below.

Backwater/Setback Spawners (northern pike, chain pickerel, yellow perch, largemouth bass, bluegill, pumpkinseed, black crappie, spottail shiner, golden shiner)

The 8 backwater/setback habitats potentially available for this species group ranged in size from 0.5 to 249 acres, with an average area of 53 acres. One backwater habitat was randomly selected from each of the three reservoir segments on the basis of backwater surface area; consequently the mean surface area of the 3 selected backwaters (134 acres) is substantially larger than the mean area of all available backwaters. The 3 backwater habitats selected in this study reach are shown in Figure 5.3, with physical characteristics listed in Table 5.1.

Tributary Confluence Riffle/Shoal Spawners (walleye, white sucker, smallmouth bass, spottail shiner, fallfish)

Fourteen tributary confluences (7 large and 7 medium) were available in the Vernon impoundment to assess early and late-spring spawning by the riffle/shoal species group. Three large tributaries and 1 medium tributary were selected by simple random sampling; these are shown in Figure 5.3 and listed in Table 5.2.

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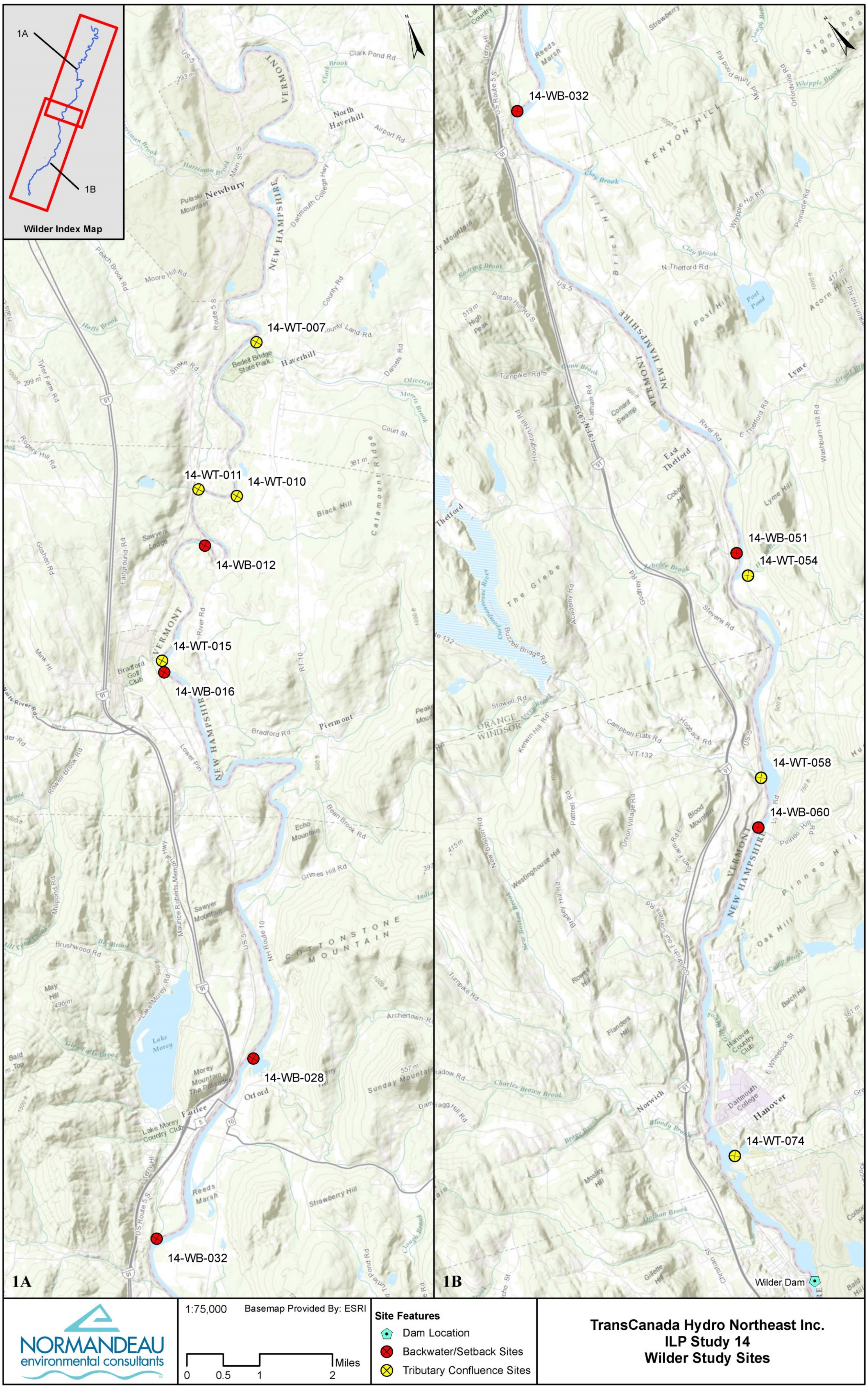

Figure 5.1. Revised Location of backwater and tributary confluence study sites in the Wilder impoundment.

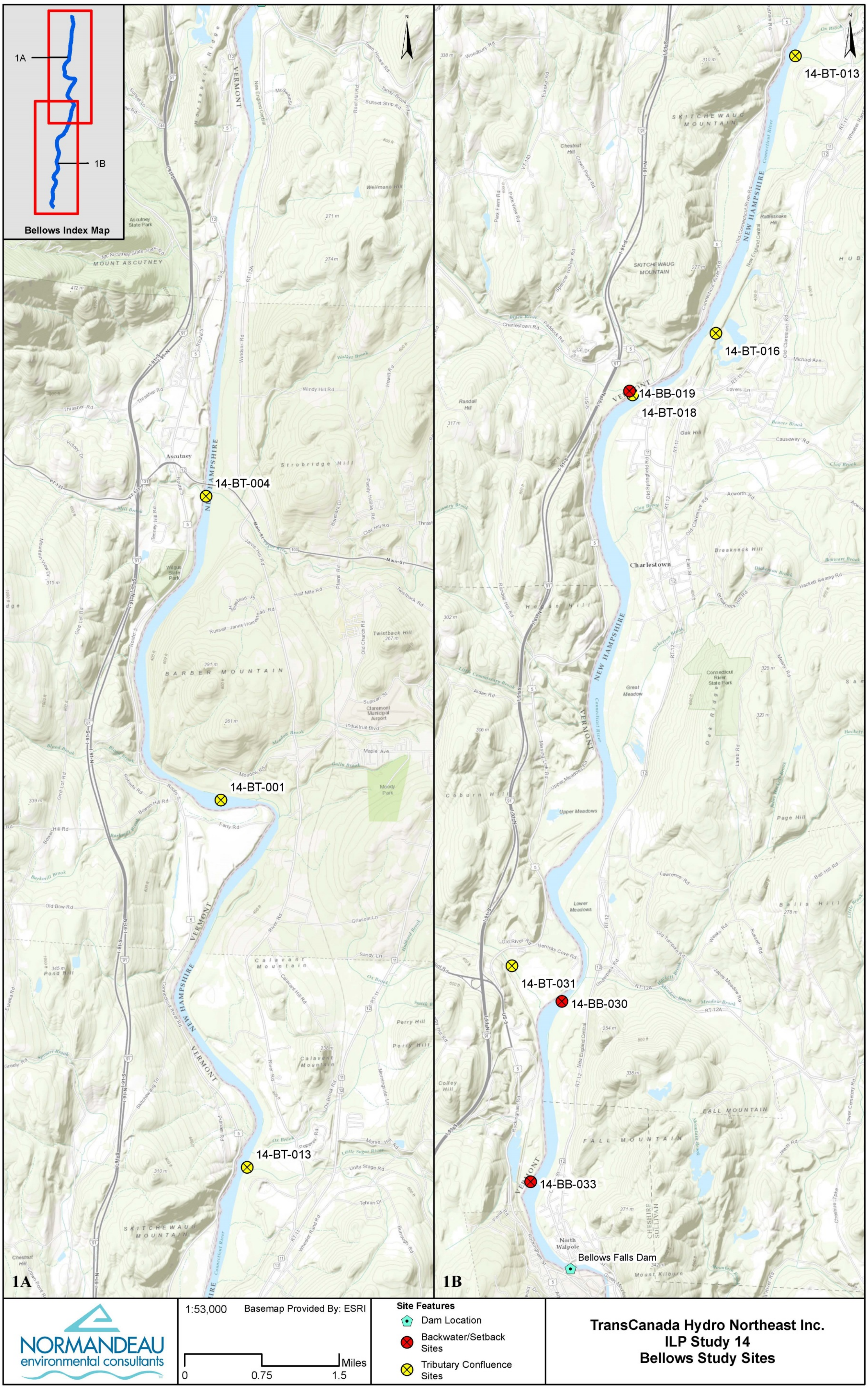

Figure 5.2. Revised Location of backwater and tributary confluence study sites in the Bellows Falls impoundment.

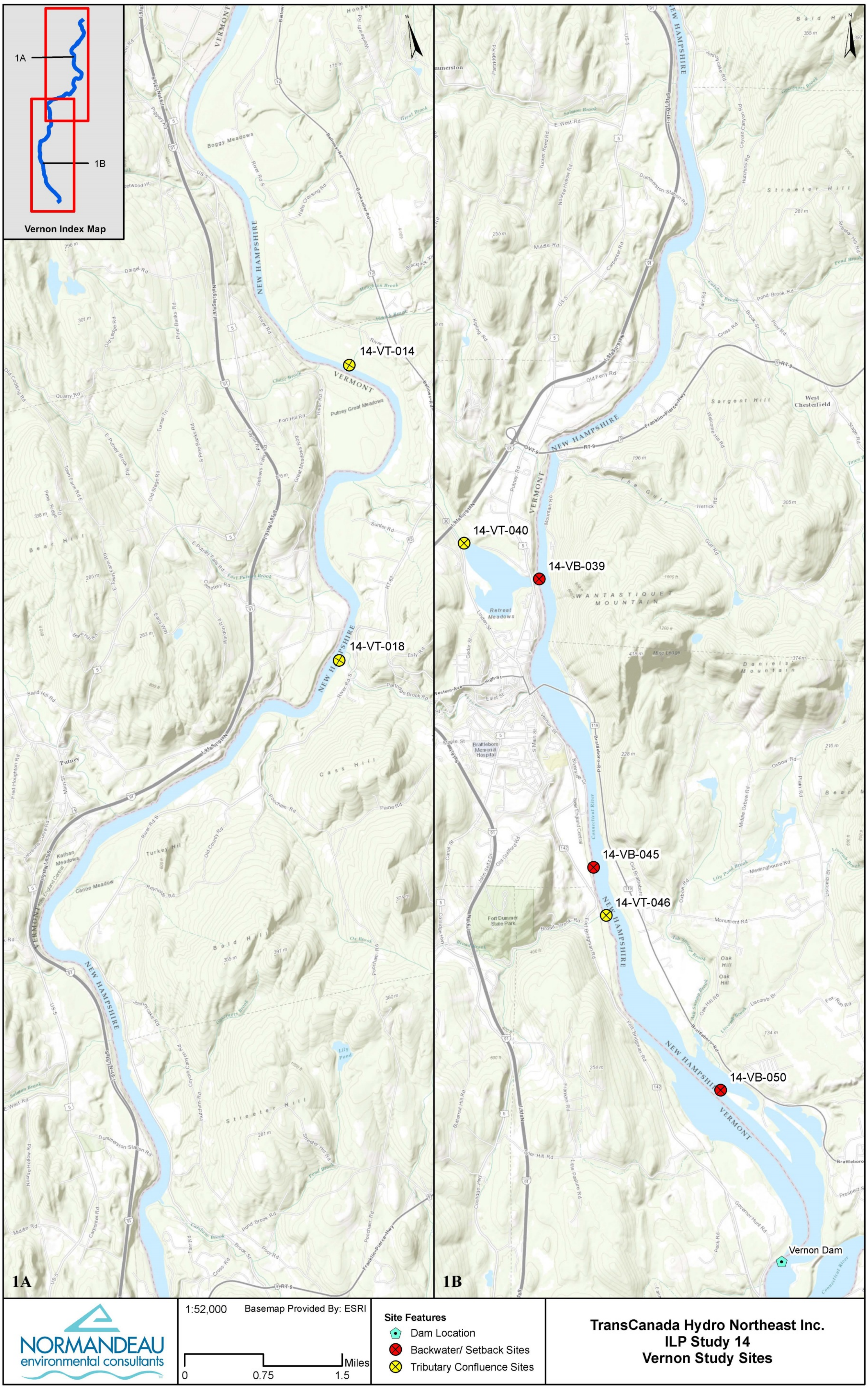

Figure 5.3. Revised Location of backwater and tributary confluence study sites in the Vernon impoundment.

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Table 5.1. Revised Backwater habitats selected in the Wilder (W), Bellows Falls (B), and Vernon (V) impoundments.

Site ID		Backwater	Dominant	Aquatic	Location (DD NAD83 UTM Z18N)	
Study 14	Study 13[1]	Acreage	Substrate[2]	Vegetation[3]	X	Y
14-WB-012	CT-W-1.12	39.3	SA,SI,CL	Va,Ec,Ms	-72.094977	44.013396
14-WB-016	CT-W-1.16	3.2	SA,SI,CL	-	-72.116990	43.996719
14-WB-028	CT-W-1.28	27.9	SA,SI,CL	Va,Ec	-72.128039	43.913843
14-WB-032	CT-W-1.32	43.4	SA,SI,CL	Va,Ec,Ms	-72.169201	43.886168
14-WB-051	CT-W-1.51	5.5	SA,SI,CL	Va,Cd	-72.196970	43.790152
14-WB-060	CT-W-1.60	18.5	SA,SI,CL	Va,Ec	-72.238832	43.744675
14-BB-019	CT-B-3.19	31.8	SA,SI,CL	Va,Ms,Na,Ps	-72.431304	43.260741
14-BB-030	CT-B-3.30	96.9	SA,SI,CL,WD	Ec	-72.447862	43.175331
14-BB-033	CT-B-3.33	84.3	SA,SI,CL	Va,Ms,Na,Ps	-72.454938	43.150119
14-VB-039	CT-V-5.39	78.7	SA,SI,CL	-	-72.554979	42.866687
14-VB-045	CT-V-5.45	73.4	SA,SI,CL,RR	Va,Ms,Na,Ps	-72.546375	42.826753
14-VB-050	CT-V-5.50	249.0	SA,SI,CL	Va,Ms,Na,Ps	-72.523773	42.795531

[1] Backwaters identified (but not necessarily selected for study) in Study 13 that correspond to this study's selected sites.
[2] SA-Sand, SI-Silt, CL-Clay, WD-Woody Debris, RR-Rip Rap
[3] Va = water celery (Vallisneria americana); Ec = waterweed (Elodea canadensis); Ms = Eurasian water-milfoil (Myriophyllum spicatum); Cd = coontail (*Ceratophyllum demersum*); Na = white water lily (*Nymphaea odorata*); Ps (*Potamogeton* spp.)=clasping-leaved pondweed (*Potamogeton perfoliatus*), large-leaved pondweed (*Potamogeton amplifolius*) and snailseed pondweed (*Potamogeton spirillus*)

Table 5.2. Revised Tributary confluences selected in the Wilder (W), Bellows Falls (B), and Vernon (V) impoundments.

Site ID			Stream	Stream	Location (DD NAD83 UTM Z18N)	
Study 14	Study 16[1]	Study 13[2]	Name	Order	X	Y
14-WT-007	n/a	CT-W-1.07	Oliverian Brook	4	-72.063421	44.048340
14-WT-010	n/a	CT-W-1.10	unnamed	2	-72.082269	44.020686
14-WT-011	n/a	CT-W-1.11	Halls Brook	4	-72.091650	44.024386
14-WT-015	n/a	CT-W-1.15	Waits River	5	-72.116407	43.994532
14-WT-054	n/a	CT-W-1.54	Hewes	3	-72.198336	43.785259
14-WT-058	n/a	CT-W-1.58	Ompompanoosuc	5	-72.229813	43.752059
14-WT-074	n/a	CT-W-1.74	Mink Brook	4	-72.299583	43.696202
14-BT-001	n/a	n/a	Jarvis Island	n/a	-72.400187	43.358744
14-BT-004	16-BT-004	CT-B-3.04	Mill	3	-72.401287	43.401497
14-BT-013	16-BT-013	CT-B-3.13	Little Sugar River	4	-72.397392	43.307053
14-BT-016	16-BT-016	CT-B-3.16	Beaver Brook	4	-72.414354	43.268448
14-BT-018	16-BT-018	CT-B-3.18	Black River	5	-72.430748	43.260172
14-BT-031	16-BT-031	CT-B-3.31	Williams River	5	-72.457251	43.180537
14-VT-014	16-VT-014	CT-V-5.14	Aldrick	3	-72.449570	43.015160
14-VT-018	16-VT-018	CT-V-5.18	Partridge Brook	4	-72.466343	42.976344
14-VT-040	16-VT-040	CT-V-5.40	West River	6	-72.568874	42.871940
14-VT-046	16-VT-046	CT-V-5.46	Broad Brook	4	-72.544267	42.820087

[1] Tributaries also selected in Study 16

[2] Tributaries identified (but not necessarily selected for study) in Study 13 that correspond to this study's selected sites.

6. FIELD SAMPLING METHODOLOGIES

Field sampling methodologies will differ somewhat according to species group, and may involve several alternative gear-types. The early-spring and late-spring backwater/setback species group typically spawn in shallow, vegetated habitats. Detection of spawning northern pike and pickerel will principally utilize visual observations from a boat using polarized sunglasses. Boat-mounted electrofishing, seining, and angling may also be employed to supplement visual observations and to determine spawning condition of captured adults. Yellow perch spawning locations will also be assessed by searching for egg ribbons using polarized glasses and view tubes, possibly supplemented by dry-suit equipped snorkelers.

The late-spring backwater/setback species are mostly nesting species, and these will be assessed using surface-oriented visual observations and snorkeling, supplemented by boat electrofishing, angling, and/or seining under conditions of lower visibility. Status of nest-guarding adult Centrarchids (bass and sunfish included) may be assessed over one or more impoundment elevation changes by deploying a remote underwater camera adjacent to an active nest. Review of digital images taken at set intervals (e.g., every 5-10 minutes) over the course of impoundment elevation changes can be used to determine persistence or abandonment of specific nests, and relate the results to minimum nest depths.

Early-spring spawning by walleyes and suckers in the tributary confluence riffle/shoal species group will be assessed using egg blocks placed within the potential spawning areas (the RSP includes additional details on egg block deployment and evaluation). Visual observation of spawning activity by boat or wading will also be employed; however, the nocturnal spawning habitats of walleye will restrict visual methodologies to daytime spawners or nest-builders (e.g., fallfish). Electrofishing or angling may also be employed to capture adults and verify spawning condition.

The spawning habitat and activities of late-spring tributary spawners such as spottail shiners will be assessed using boat or backpack electrofishing and/or seining to capture individuals to verify species and determine spawning condition. Fallfish and smallmouth bass spawning will be assessed by visually identifying (from a boat or by snorkeling) constructed nests, and any adult fish associated with them. As noted above, a subsample of nests that are occupied by adult fish may be monitored over a cycle of water surface fluctuation using a remote camera or by other visual methods. Because smallmouth bass are not expected to construct nests immediately within the main flow of tributaries, visual surveys for bass nests will be extended along the impoundment streambank for 100 to 200 meters above and/or below each tributary confluence, depending upon the shape and extent of the confluence shoal or delta habitat.

Consistent among each study site will be the deployment of water level loggers, which will monitor changes in water surface elevations and water temperatures at 15-minute intervals. Loggers will be placed at each of the spawning study sites were spawning activity is detected. The RSP contains additional details on the deployment of instream loggers. Data collected at each location where spawning occurs (e.g., at adult spawner observations, nest locations, or egg deposition sites) will include water depth; water level and temperature (taken from logger and TC operations records); dominant substrate, vegetation, and instream cover type; water velocity (for riverine locations); observation time, date, and location (recorded with GPS); fish presence and behavior (e.g., active spawning, guarding male, non-target species); egg or fry presence; nest status (e.g., evidence of scour, degree of silt deposition); etc.

Each spawning site will be revisited during the spawning season according to a set schedule, including 3-4 times/week for egg blocks, and 2-3 times/week for the backwater and nesting species.

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APPENDIX A

SPAWNING HABITAT CHARACTERISTICS FOR IMPOUNDMENT SPECIES

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Spawning Habitat Characteristics for Impoundment Species

* Peak - if not specified in document, peak is defined as the range in means from multiple locations/years, or derived from HSC curves as suitabilities >0.5.

	Periodicity		W Temps °C		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation[2]
Smallmouth Bass	late-May to mid-June	late-May	15.5-20.0	-	-	-	2.2-3.3	avg 2.75	gravel & rubble	-	most nests near rocks or logs & protected from waves	S Branch Lk, ME	Neves 1975
	late-May to early-July	-	>16	-	-	-	-	avg 1.8-4.26	silt to gravel	-	>76% of nests near boulders or wood cover	Nova Scotia lakes	McNeill 1995
	-	-	-	-	-	-	-	-	-	-	-	Lk Erie & 2 ON lakes	Ridgeway et al. 1989
	-	early to mid-June	-	15-18	-	-	-	-	-	-	w/in 8 ft of shore	Tadenac Lk, ON	Turner & MacCrimmon 1970
	-	-	-	-	-	-	3-4	-	incl some short aquatic veg	"small rock"	most had boulders, rock ledges, or woody debris nearby	Georgian Bay & Lk Nippising, ON	Tester 1930
	-	late-May to early-July	12.8-20.0	16.1-18.3	-	-	2-20	-	sand, gravel, rock	-	prefers near cover	rivers and lakes in Canada	Scott & Crossman 1998
	late-Apr to late-June	-	>15	-	-	-	-	<6.5	coarse sand, all rock, roots, shells, sticks	0.4-3.1 gravel	prefers proximal rock or wood cover & shelter from waves	WI lakes, lit review	Forbes 1981
	-	-	-	-	-	-	<20	6-10	-	gravel	prefers nearby cover object	WI lakes & ponds	Mraz 1964
	mid-Apr to late-May	-	13.3-22.5	-	-	-	3.6-17.1	7.9-10.5 (range of means)	gravel to rubble	-	80% had rock or woody cover nearby	Bull Shoals Lk, AK	Vogele 1981
	late-Apr to mid-July	-	12.9-22.3	15-18	-	-	>0.0-14.0	2.44-10.0	0.002-10	0.1-3	-	Brownlee Res, ID	Richter 2003

[2] See Literature Cited section following the table.

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation
Largemouth Bass	-	early to mid-June	>15.6	16.7-18.3	-	-	1-4	-	mud, sand, gravel, veg	-	-	rivers and lakes in Canada	Scott & Crossman 1998
	-	-	11.5-29	16-22	<0.3	<0.13	0.5-27	0.98-2.95	mud, sand, gravel, cobble, veg	gravel	protection from wave action	U.S. lakes	Stuber et al. 1982
	-	-	15-24	-	-	-	0.5-18.0	1.1-4.4	all types	gravel	prefers proximity to cover and protection from waves	lakes in U.S.	Heidinger 1976
	-	-	-	16.7-18.3	-	-	-	-	any firm bottom type incl veg	gravel	-	WI lakes & ponds	Mraz 1964
	late-May to mid-June	-	-	-	-	-	0.7-4.26	-	-	-	prefer proximity to wood cover	WI lakes & ponds	Lawson et al. 2011
	-	-	-	-	-	-	-	-	remaining nests in sand, gravel or rocks	68% of nests were in SAV	60% of nests were w/in 4ft of rock or wood cover	2 WI lakes	Weis & Sass 2011.
		-	-	-	-	-	1.05-9.8	-	-	-	-	3 MN lakes	Reed & Pereira 2009
	mid-Apr to late-May	late-Apr	-	-	-	-	2.95-13.1	5.9-6.9	-	-	most nests near woody cover	Bull Shoals, MO	Vogele & Rainwater 1975
	mid-Apr to early June	-	-	-	calm & w/o wave action	0	<1-15+	-	any firm bottom type incl veg	gravel or rock	-	MO lakes	Pflieger 1975
	mid-May to late-June	late-June	15.5-18.3	-	-	-	<8	1-4	sand, gravel, rubble	-	-	lakes in WA	Wydoski & Whitney 2003
	late-Apr to early-June	-	12-20	-	-	-	-	-	-	-	-	Lake Shelbyville, IL	Miller & Storck 1984
	Mar to May	-	-	-	-	-	-	-	mud, gravel, or rock	-	-	Imperial Res, AZ	Weaver 1971
	Apr to early-July	-	-	-	-	-	-	0.5-4.0	any firm bottom type incl veg	-	-	AL ponds	Swingle & Smith 1943

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation
	Apr to June	-	14-24	-	-	-	-	3.2-6.5	sand, gravel, organic debris	-	prefers nearby object	CA lakes	Moyle 1976
	-	-	-	-	0.0-0.56	0.0-0.49	>0.0-15+	0.64-15+	mud, sand, gravel, cobble	gravel	-	U.S. lakes and rivers	Bovee 1978
	May	-	16.7-20.5	-	-	-	0.5-3.6	-	some nests in silt and sand	gravel & rock	73% of nests near SAV	Hudson R estuary, NY	Nack et al. 1993
	late-May to late-June	-	19.5-23	-	0.0-0.05	avg 0.02	0.92-5.74		silt to rock	sand, gravel	near SAV	Hudson R estuary, NY	Nack 1986
Bluegill	-	early-July	<24.5	-	-	-	-	2.5	mud, sand, gravel	-	-	rivers and lakes in Canada	Scott & Crossman 1998
	-	-	17-31	24-27	<0.98	<0.25	3.28-9.8	-	any type	sand & gravel	-	U.S. lakes	Stuber et al. 1982
	-	early-June to early-July	-	19-23	-	-	1.64-16.4	3.28-14.8	-	-	-	Lake Giles, PA	Olson et al. 2008
	-	-	-	-	0.0-1.15	0.0-0.71	1.5-6.5	2.47-5.19	-	silt, sand, gravel	-	-	Bovee 1978
	mid-May to mid-Aug	-	-	-	-	-	<6	-	-	-	-	8 lakes in MI	Beyerle & Williams 1967
	late-May to early-Aug	June	-	-	-	-	-	1-2	any firm bottom type incl veg	gravel	-	MO lakes	Pflieger 1975
	late-May to early-July	-	-	-	-	-	3-6	-	sand	-	-	lakes in MN	Eddy & Underhill 1974
								avg 3.28	firm substrate type	gravel	short, low density aquatic veg	SD lake	Gosch et al. 2006
			>17.2	>26.6					clay, mud, sand, gravel, organics	sand & fine gravel		OH farm ponds	Stevenson et al. 1969
	-	-	19-	-	-	-	-	-	sand	-	-	lakes in WA	Wydoski & Whitney 2003

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation
	Apr to October	-	-	-	-	-	<10	0.5-4.0	any firm bottom type incl veg	gravel	-	AL ponds	Swingle & Smith 1943
	May to Aug	-	-	-	-	-	-	-	mud, gravel, or rock	-	-	Imperial Res, AZ	Weaver 1971
		-	18-	-	-	-	-	0.16-0.50	sand, gravel, organic debris	-	-	CA lakes	Moyle 1976
Pumpkin-seed	late-spring to mid-July	-	20.0-27.8	-	-	-	0.5-1.0	-	all types of firm bottom w SAV	-	SAV	rivers and lakes in Canada	Scott & Crossman 1998
	May to Aug	-	-	-	-	-	-	-	mud & clay (pumpkinseed)	-	-	Hudson River, NY	Orringer 1991
	mid-June to mid-July	-	-	-	-	-	0.6-1.9	0.8-1.7	-	gravel & sml rocks	preferred locations w emergent or aquatic veg	Lincoln Pond, NY	Ingram & Odum 1941
	mid-June to late-July	-	>23	-	-	-	0.65-2.6	avg 1.48	-	pebbles 0.6-1.25"	most nests w/in 1m of cover (but not SAV)	Otsego Lk, NY	Hakala 1994
	early June to early July	-	>20	-	-	-	-	-	-	-	-	Cranberry Pond, MA	Reed 1971
	-	-	-	-	-	-	-	-	all types of firm bottom	sand & gravel	-	-	Danylchuk & Fox 1996
	late-May to June	-	-	-	-	-	3-6	-	sand	-	-	lakes in MN	Eddy & Underhill 1974
		-	>20	-	-	-	<3.3	0.16-0.50	sand, gravel, organic debris	-	-	CA lakes	Moyle 1976
Black Crappie	-	late-May to mid-July	>19	-	-	-	0.8-2.0	-	mud, sand, gravel w SAV	-	-	rivers and lakes in Canada	Scott & Crossman 1998
	-	-	13-21	17.8-20	-	-	-	-	mud, sand, gravel w cover	-	SAV or woody debris	U.S. lakes	Edwards et al. 1982

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation
	-	-	-	avg 21.3	-	-	1.64-3.28	avg 2.79	firm substrates	clay or sand	low density of short SAV	Campus Lk, IL	Phelps et al. 2009
	May to June	-	-	-	-	-	3-6	-	mud	-	-	lakes in MN	Eddy & Underhill 1974
		-	-	-	-	-	0.82-4.92	-	avoided SAV	-	preferred nearby bulrush	3 MN lakes	Reed & Pereira 2009
	-	-	-	-	-	-	1.3-2.6	-	mud, sand, gravel	mud	cattails and woody debris preferred w/o wave action	2 lakes in SD	Pope & Willis 1997
	late-Apr to late-June	mid-June	-	-	-	-	-	-	silt, clay	-	protection from waves	Rathburn Lake, Iowa	Mitzner 1991
	late-Apr to mid-July	late-May	13.4-21.0	18-20	-	-	0.6-32	6.8-15.1	gravel to bedrock	gravel & cobble	-	Brownlee Res, ID	Richter 2001
	May to early-June	-	14.4-17.8	-	-	-	-	-	mud	-	-	lakes in WA	Wydoski & Whitney 2003
	Mar to July	-	14-	-	-	-	<3.3	0.16-0.50	mud or gravel w SAV	-	SAV	CA lakes	Moyle 1976
	-	-	-	-	0.0-1.98	0.0-1.47	0.73-5.0	0.89-3.24	mud, sand, gravel, cobble	-	-	U.S. lakes and rivers	Bovee 1978
Fallfish	Apr to June	-	>14.4	-	-	-	-	-	-	-	-	lakes and rivers in NY	Smith 1985
	-	mid-May	>12.0	-	-	-	-	-	-	-	-	rivers and lakes in Canada	Scott & Crossman 1998
Golden Shiner	May to Aug	-	>20	-	-	-	-	-	SAV & algae	-	-	lakes and rivers in NY	Smith 1985
	May to July	-	-	-	-	-	-	-	SAV & algae	-	-	lakes and rivers in NY	Kraft et al. 2006
	May to July	-	>20	-	-	-	same as LMB (use old nests)	-	SAV & algae	-	-	lakes in Canada	Scott & Crossman 1998
	summer	-	-	-	-	-	-	-	SAV	-	-	lakes in MN	Eddy & Underhill 1974

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation
		-	20-27	-	-	-	may spawn in bass nests	-	SAV, sand, organic debris, emergent veg	SAV	-	lakes and rivers in WI	Becker 1983
	late-Apr to early-June	-	21.1-26.7	-	-	-	-	-	SAV & algae	-	-	lakes in MO	Pflieger 1975
	Mar to Aug	-	>15	>20	-	-	-	-	SAV and organic debris	-	-	lakes in CA	Moyle 1976
Spottail Shiner	June to July	-	-	-	-	-	-	-	sand & gravel at trib mouths	-	-	lakes and rivers in NH	NH Fish & Game species summaries (web)
	June to July	-	-	-	-	-	-	-	sand at trib mouths	-	-	lakes and rivers in NY	Smith 1985
	June to July	-	-	-	-	-	-	-	sand at trib mouths	-	-	lakes and rivers in NY	Kraft et al. 2006
	May to July	-	-	-	-	-	3-4	-	sandy shoals	-	-	lakes in Canada	Scott & Crossman 1998
	late-Apr to Sep	late-May to early-June	+/--18.3	-	-	-	up to 15	-	gravel or sandy shoals, algae	-	-	lakes and rivers in WI (often at trib mouths)	Becker 1983
	June to Sep	mid-June to late-July	-	-	-	-	<30	<18 (most gravid fish)	-	sand	-	great lakes & Kalamazoo R, MI	Wells & House 1974
	late-June to early-July	-	-	-	-	-	-	-	sand and gravel	-	-	lakes in MN	Eddy & Underhill 1974
	May to early-June	-	-	-	-	-	-	-	-	-	-	lakes in MO	Pflieger 1975
	-	May	-	-	-	-	-	-	sand & sml gravel	-	-	Clear Lake, IA	McCann 1959
	June to July	-	-	-	-	-	-	-	sandy shoals	-	-	lakes in NW CAN	McPhail & Lindsey 1970

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation
White Sucker	mid-May to early-June	-	-	-	-	-	-	-	-	-	-	Muskellunge Lake, WI	Spoor 1938 (only noted as a source of lake spawning observations)
Walleye	-	-	-	5.0-8.9	n/a	n/a	<3.0	-	-	-	-	New York lakes	Festa et al. 1987 in Bozek et al. 2011
	-	-	2.0-9.0	4.0-6.0	n/a	n/a	-	-	-	-	-	Up Rideau Lk, ON	Environ Applications Group 1980 in Bozek et al. 2011
	-	-	-	-	n/a	n/a	0.66-3.94	-	-	-	-	5 ON lakes	W McCormick (pers comm) in Bozek et al. 2011
	-	-	7.0-10.0	-	n/a	n/a	0.82-3.28	-	-	-	-	Minesing Swamp, ON	Minor 1984 in Bozek et al. 2011
	-	-	-	-	n/a	n/a	<8.2	<3.94	-	-	-	ON lakes	Hartley & Kelso 1991 in Bozek et al. 2011
	-	-	5.5-9.5	-	n/a	n/a	-	-	-	-	-	Lower & Upper Chemung Lk, ON	Wood 1985 in Bozek et al. 2011
	early-Apr to late-June	-	6.7-11.1	-	-	-	-	-	coarse gravel to boulder	-	-	rivers and lakes in Canada	Scott & Crossman 1998
	-	-	-	-	-	-	0.16-4.0	1.0-2.5	sand, gravel, rock	gravel	-	Lk Winnibigoshish, MN	Johnson 1961
	mid-Apr to mid-May	late-Apr	5.3-7.2	9.1-10.0	n/a	n/a	0.26-2.62	-	sand to sml boulder	6.4-149.9 (un-embedded)	spawned near shoreline	Big Crooked Lk, WI	Raabe 2006 in Bozek et al. 2011

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation
	-	-	-	7.0-10.0	n/a	n/a	<5.0	-	-	gravel, cobble, rubble	-	Gogebic Lk, MI	Eschemeyer 1950 in Bozek et al. 2011
	-	-	-	5.0-11.7	n/a	n/a	<30	-	-	-	-	Great Lakes	USFWS 1982 in Bozek et al. 2011
	-	-	2.2-15.5	5.6-7.8	n/a	n/a	0.17-2.49	-	incl emerg aquatic veg	gravel, cobble, rubble	-	Winnebago Lk region, WI	Priegel 1970 in Bozek et al. 2011
	-	-	7.8-8.9	-	n/a	n/a	-	-	-	6.4-149.9	-	Beaver Dam & Red Cedar lakes, WI	Williamson 2008 in Bozek et al. 2011
	-	-	-	7.2-11.1	n/a	n/a	-	-	-	-	-	Lk Osakis, MN	Newburg 1975 in Bozek et al. 2011
	-	-	-	7.8	n/a	n/a	-	-	-	-	-	Lil Cut Food Sioux Lk, MN	Johnson 1971 in Bozek et al. 2011
	-	-	5.6-11.1	6.7-8.9	n/a	n/a	-	-	-	-	-	Canadian lakes	Scott & Crossman 1973 in Bozek et al. 2011
	-	-	-	-	n/a	n/a	-	-	incl roots & emerg aquatic veg	-	-	Tumas Lk, WI	Niemuth et al. 1972
	-	-	-	-	n/a	n/a	<3.28	-	-	-	-	Lk Francis Case, SD	Michaletz 1984 in Bozek et al. 2011
	-	-	6.0-11.0	7.0-9.0	n/a	n/a	0.16-15.08	-	-	-	-	Manitoba lakes	Newbury & Gaboury 1993 in Bozek et al. 2011
	-	-	3.3-11.1	7.2-10.0	n/a	n/a	-	-	-	-	-	Lac La Ronge, SAS	Rawson 1957 in Bozek et al. 2011

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Cover**	**Location**	**Citation**
	-	-	4.4-9.0	7.2-8.9	n/a	n/a	-	-	-	-	-	Lonetree Res, CO	Weber & Imler 1974 in Bozek et al. 2011
	-	-	6.0-8.0	-	n/a	n/a	-	-	-	-	-	Alberta lakes	ADFLW 1986 in Bozek et al. 2011
	-	-	8.9-14.5	-	n/a	n/a	-	-	-	-	-	Alabama lakes	Colby et al. 1979 in Bozek et al. 2011
	-	-	2.2-15.6	-	n/a	n/a	-	-	-	-	-	misc lakes ?	Hokanson 1977 in Bozek et al. 2011
	-	-	3.3-10.0	5.6-6.7	n/a	n/a	-	-	-	-	-	misc lakes ?	Meisenheimer 1988 in Bozek et al. 2011
Yellow Perch	April	-	11-14	-	-	-		-	-	-	-	Waits R, NH	Gabe Gries, NHDFG, pers comm
	mid to late-Apr	-	-	-	-	-	5-12	-	sand, gravel, rock, or veg	-	-	Oneida Lk, NY	Clady & Hutchinson 1975
	mid-Apr to early-May	-	6.7-12.2	-	-	-	-	-	may incl open sand or gravel	rooted or woody vegetation	-	lakes in Canada	Scott & Crossman 1998
	March	-	-	-	-	-	-	-	-	-	-	Chesapeake Bay, MD	Muncy 1962
	-	-	-	-	-	-	<1-46	<1-23	-	-	-	2 lakes in NE PA	Huff et al. 2004
	Apr to June	-	7-13	-	<0.16	-	3.3-12.1	-	-	-	-	U.S. lakes and rivers	Krieger et al. 1983
	-	-	-	-	0.0-0.51	0.0-0.43	0.56-5.55	0.83-4.5	mud, silt, sand	-	-	U.S. lakes and rivers	Bovee 1978
	mid-May to late-June		>6									Lk Michigan, MI	Brazo et al. 1975
	-	-	-	-	-	-	-	-	sand, gravel, cobble	cobble (if veg not present)	-	Lk Michigan, MI	Robillard & Marsden 2001

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Cover**	**Location**	**Citation**
	Apr to early-May		6.7-11.1	-	-	-	-	-	sand, gravel, rock, or veg	SAV or woody debris	-	lakes in WI	Wisconsin DNR species summary
	early to late-May	-	>7.2	-	-	-	-	-	sandy w organic debris or vegetation	-	-	lakes in MN	Eddy & Underhill 1974
	Apr to May	-	12-14	-	-	-	-	-	-	-	-	Ohio?	Kolkovske & Dabrowski 1998
	-	-	11-15	-	-	-	-	-	-	-	-	Lake Erie, OH	Collinsworth & Marschall 2011
	late-Apr to early-June	early to mid-May	6.9-14.4	9-11	-	-	3-22	-	-	woody debris	-	2 reservoirs in MT	EA 1992
Northern Pike	late-Apr to late-May	mid-May	5-13	7-12	-	-	<4.9-8.5	-	SAV & algae (shallow marsh veg unavailable)	-	-	marsh off St Lawrence R, NY	Farrell et al. 1996
	late-Apr to early-June	late-Apr	7.0-13.2	7.0	-	-	<4.9-12.1	-	inundated veg forming a mat over sediments, avoided pure cattails	-	-	bay on St Lawrence R, NY	Farrell 2001
	-	-	-	-	<0.3	-	<3.28	-	-	-	-	St Lawrence R, NY	Osterberg 1985 in Farrell et al. 1996
	-	-	-	-	-	<0.3	-	-	including cattails	inundated marsh not dominated by cattails	-	4 floodplains on St Lawrence R, Quebec	Mingelbier et al. 2008
	April	-	>4.4	9	-	-	>0.6	-	-	-	-	rivers and lakes in Canada	Scott & Crossman 1998
	following ice-out	-	-	-	-		-	-	-	inundated vegetation	-	lakes in NW CAN	McPhail & Lindsey 1970

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation
	-	-	-	-	0.0-1.5	0.0-0.41	0.38-6.0	0.63-4.77	-	-	-	U.S. lakes and rivers	Bovee 1978
	following ice-out	-	>5	-	zero	-	-	-	mud	inundated vegetation	-	lakes in Alaska	Morrow 1980
	-	-	-	-	-	-	<1.7	<0.8	-	marsh vegetation	-	Lake Erie bay, tribs, and pond, OH	Clark 1950
	-	-	-	-	-	-	0.5-1.5	-	-	-	-	-	Williamson 1942, cited in Clark 1950
	late-March to late-Apr	mid-Apr	6.7-16.7	-	-	-	-	-	-	-	-	Green Lk, MN	Bennett 1948
	following ice-out	-	8-13	-	zero	-	0.33-1.48	<01.64	may also use organic debris	dense mat of short vegetation	-	U.S. & Canada	Inskip 1982
	early to late-Apr	-	11.1-17.2	-	-	-	-	-	avoided cattails, also did not utilize SAV	most spawned over dense carex clumps	-	Lake George, MN	Franklin & Smith 1963
	Mar-Apr	-	6.1-8.9	-	-	-	0.2-1.0	-	-	-	-	Lk Chemung, MI	McNamara 1936
	early-Apr to early-May	-	-	-	-	-	-	-	-	-	-	Ball Club Lk, MN	Johnson 1957
	Mar to Apr	-	-	-	-	-	-	-	SAV and algae also used	flooded prairie grass	-	9 lakes and ponds in NE	McCarraher & Thomas 1972
Chain Pickerel	May	-	-	-	-	-	-	-	-	-	-	lakes in Maine	Warner 1973
	Apr to May	-	>8.3	-	-	-	3-10	-	inundated vegetation	-	-	rivers and lakes in Canada	Scott & Crossman 1998
	April	-	7-13	-	-	-	-	-	inundated vegetation	-	-	Patterson Cr, WV	Lewis 1974

	Periodicity		W Temps oC		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation
	-	-	-	-	-	-	1-2	-	inundated vegetation	-	-	-	VA Dept Game & Inland Fisheries website
	Mar to April	-	2.2-22.2	-	-	-	-	-	-	-	-	Long Lk, OH	Armbruster 1959
	Mar to Apr	-	7.2-	-	-	-	-	-	inundated vegetation	-	-	-	South Carolina Dept Natural Resources website

APPENDIX A – LITERATURE CITED

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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 II.F

Study 15 – Resident Fish Spawning in Riverine Sections Study

Revised Site Selection Report

Updated Study Report

September 14, 2015

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TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 15

Resident Fish Spawning in Riverine Sections Study

Revised Site Selection Report

In support of Federal Energy Regulatory Commission Relicensing of:

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

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1. INTRODUCTION

Operations-related, water-level fluctuations downstream of the Wilder, Bellows Falls, and Vernon projects have the potential to affect resident fish spawning success and spawning habitat quality and quantity. Fish eggs or quality spawning habitat could potentially be dewatered, and/or some species of fish could abandon nests containing eggs.

Revised Study Plan (RSP) 15, as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination, specified that a subset of the project-affected area would be studied. This report has been revised in response to comments received from the aquatics working group at a December 17, 2014 site selection consultation meeting. This report provides a summary of the data analysis and criteria used to select the proposed subset of locations to be examined in detail during 2015. The following selected sites were modified or added as a result of consultation:

- The riffle spawning site at the base of the Bellows Falls bypassed reach was moved across the river to the Vermont bank just downstream of the tailrace (15-BR-Bellows).
- The island spawning site at the Bellows Falls bedrock point was moved to the tributary delta at Saxtons River (15-BI-001).

2. STUDY AREA

Sampling will be conducted in the project riverine reaches to characterize the fish spawning habitat and the effects of streamflow fluctuations on spawning activities within each of the three project riverine reaches affected by project operations. The three riverine reaches, totaling 25 miles in length, are listed below:

Wilder reach (RM 217.4 – 199.7);
Bellows Falls reach (RM 173.7 – 167.9);
Bellows Falls bypassed reach (RM 173.7 – ~ 173.0)
Vernon reach (RM 141.9 – 140.4).

The Wilder riverine reach was further divided into three sub reaches: subreach 1 from Wilder dam downstream to the White River confluence (1.5 mi); subreach 2 from White River downstream to Sumner Falls (5.2 mi), and the lowest subreach from Sumner Falls downstream to the Bellows Falls impoundment (11.0 mi).

3. TARGET SPECIES

The RSP identified four fish species for assessment of spawning activities and habitat in the riverine reaches: the early-spring broadcast spawning species (walleyes and white suckers), and the late-spring nest builders (smallmouth bass and fallfish). If identified as representing a significant portion of the riverine fish communities during the fish assemblage study (Study 10), the spawning success of additional fish, such as longnose dace and trout, will also be monitored. Consistent with the approach used for study site selection in Study 14 - Resident Fish Spawning in Impoundments, characteristics describing the spawning periodicity, location, and habitat parameters for these four species were used to assign them into the following two "species groups", in order to focus efforts to detect and assess spawning activities:

- Early-Spring Riffle Spawners (walleyes and white suckers)
- Late-Spring Island/Bar Spawners (smallmouth bass and fallfish)

Walleye and white suckers are both broadcast spawners that spawn in specific locations possessing shallow, rocky substrates with significant current velocities. Smallmouth bass and fallfish spawn later in the spring when they build nests in locations with slow (smallmouth) or moderate (fallfish) water velocities and gravel/cobble substrates. Table 3.1 summarizes available data on spawning periodicity and habitat characteristics for each of these species, with detailed descriptions listed in Appendix A. Spawning by both of these species groups will be assessed at study sites selected to maximize the likelihood of encountering spawning adults, and at sites where the potential impacts of water surface elevation changes are expected to occur.

Table 3.1. Summary of spawning habitat characteristics according to species group.

Species		Periodicity		W Temps °C		Mean Velocity fps		Depth ft		Substrate Type		Instream
Group	Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover
Early-Spring Riffles	Walleye	Apr- May	April	4-16	6-12	<1-7	1-4	0.5-7	1-6	sand, gravel, cobble	gravel	none
	White Sucker	Apr-June	Apr-May	6-18	9-17	<3	0.5-2	0.25-3.3	0.8-2.0	sand, gravel, rock	gravel	none
Late-Spring Island/Bar	Smallmouth Bass	May-June	mid-May to mid-June	13-25	15-20	0.0-1.0	<0.5	>0.5	1.5-4.0	coarse sand, gravel, cobble	gravel	prefers proximity (~1m) to rock or woody cover (upstream if current is present)
	Fallfish	Apr-June	-	13-19	15-18	<3	<2	0.4-4.5	0.5-3.4	-	gravel & cobble	none

See Appendix A for detailed listing of spawning habitat data.

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4. SITE SELECTION PROCESS

As stated in the RSP, the selection of sampling locations entails a combination of purposive sampling in study sites reported to be utilized by spawning adults (based on personal communication with agency biologists or local fishermen, and nest observations noted by Normandeau biologists during 2014 field studies), and random sampling in study sites known to possess habitat characteristics meeting the basic spawning requirements for each species group.

Several of the habitat characteristics required for spawning by these species (e.g., mesohabitat type, dominant substrate, etc.) were recorded as part of Study 7 - Aquatic Habitat Mapping. Prior to the selection of potential study sites, areas were excluded that are not expected to provide significant spawning habitat, including areas dominated by sand or silt substrate; areas >10 ft deep that will not be vulnerable to normal fluctuations in water surface elevations; and areas expected to contain velocities too slow for walleye and sucker spawning (e.g., non-riffles) or too rapid for smallmouth bass spawning (e.g., riffles). Potential study sites that met the basic spawning requirements of the two species groups were then selected based on several criteria, principally:

- Known presence of spawning (purposive sampling, all species groups);
- Size of potential spawning area (random sampling, all species groups); and
- Presence of required habitat characteristics, namely:
    - Riffles dominated by rock (gravel, cobble, or boulder) substrate (early-spring riffle spawners); and
    - Presence of gravel/cobble bars not vulnerable to excessive velocities during normal late spring flow (late-spring island/bar spawners).

Random selection of non-purposive study sites was based on the surface area (acres) of potential spawning riffles for walleyes and suckers, and the relative size of island habitats measured by perimeter, for smallmouth bass and fallfish which utilize the gravel/cobble bars and margin-formed eddies that are characteristic of mid-channel islands. Habitat area was used for random selection in order to maximize both the number and diversity of adult spawners or nests encountered at each sampling location. Larger study sites are also expected to contain a wider and more diverse range of microhabitat attributes than would a small study site. Finally, selection of a fixed number of larger sites will yield a much greater sampling area than will a similar number of small sites, increasing the likelihood of achieving the goals of this study.

Twelve study sites were selected in the study area to assess spawning activities and habitat for each species group. To the extent possible, the 12 study sites were distributed among the three riverine reaches in proportion to the length of each reach. Based on these criteria, and using one extra study site for the short (1.5 mi) Vernon reach, produced the following sample size goals for each of the two species groups:

- Wilder 1 Subreach: 1 site
- Wilder 2 Subreach: 2 sites
- Wilder 3 Subreach: 4 sites
- Bellows Falls Reach: 3 sites
- Vernon Reach: 2 sites

Selection of specific study sites began with identification of known spawning areas. For example, regular electrofishing surveys by NHFGD have routinely captured ripe walleyes in riffle areas just downstream of the three project dams (Gabe Gries, NHFGD, personal communication). Consequently, one of the study sites for walleye/sucker spawning in each riverine reach will be purposively selected from the closest riffle (or other swift, cobble-dominated habitat) below each dam. Other known spawning locations include fallfish nests identified during the selection and measurement of PHABSIM and 2D study sites in Study 9 – Instream Flow. These sites were likewise purposively selected in order to maximize the likelihood of detecting spawning activities and assessing flow-related effects on nest success.

Where actual spawning observations have not been noted, potential study sites were randomly selected based on area of potential spawning habitat. The surface area of potential spawning habitat for the early-spring riffle spawning species group was determined by calculating the area of all riffle habitats identified during the mesohabitat mapping study (Study 7) in ArcGIS. If a riverine reach did not contain enough riffle habitats to fulfill the sample size goals (along with known spawning areas), additional sites were selected from shoal habitats associated with large tributary mouths, which were known or suspected to support spawning by walleyes or suckers.

For late-spring nesting fallfish and smallmouth bass, it was noted that many of the observed fallfish nests were associated with mainstem island habitats. Fishermen reports of bass spawning in the Bellows Falls impoundment also suggested an association between island habitats and spawning for that species. Most islands in each riverine reach possessed large gravel/cobble bars at the island head that may be utilized by fallfish, and the low velocity eddies alongside and below islands may be particularly important to smallmouth bass in riverine reaches. In addition, the split channels associated with islands typically produce more diversity in habitat, with a larger number of shorter habitat units and a higher proportion of bank-related features (e.g., shallow water, shade, woody debris) than in single channel areas. Consequently, study sites selected for the late-spring island/bar spawning species group was based on known observations of nest locations as well as potential spawning area associated with primary (wooded) islands. Selection of islands for the late-spring island/bar spawning species group was based on the availability of island habitats in each reach; if the number of available islands exceeded the sample size goals listed above, islands were randomly selected based on the perimeter around each island.

5. SELECTED STUDY SITES

5.1 Wilder Riverine Reach

The 17.7 mile Wilder riverine reach contains 18 identified riffle habitats, including Sumner Falls, and 6 permanent islands (e.g., islands containing mature trees). Seven of the 12 total study sites for each species group were selected in the Wilder riverine reach, proportionally distributed among the 3 sub reaches. The potential spawning habitat available for each species group and those habitat areas selected for assessment of spawning activity are listed below.

Early-Spring Riffle Spawners (walleye, white sucker)

The single riffle selected in the upper Wilder subreach was the first riffle located below Wilder Dam (Table 5.1, Figure 5.1). Although this riffle is relatively deep in comparison to other riffles, the presence of cobble and bedrock and the elevated water velocities at this location is expected to draw spawning adults. Of the 7 riffles in the second Wilder subreach, one was purposively selected at the base of the White River due to its expected utilization by both walleyes and suckers. The second riffle was randomly selected from the remaining riffles on the basis on riffle area. In the lowest Wilder subreach, the base of Sumner Falls was purposively selected due to its expected effects on upstream migration of spring spawners and its likely use by spawning adults. If conditions at that site appear to be too hazardous for safe deployment of spawning blocks (see Section 6), an alternative riffle will be selected. Three additional riffles were selected in this subreach using the probability-proportional-to-riffle size methodology described above.

Late-Spring Island/Bar Spawners (fallfish, smallmouth bass)

The 7 selected study sites for assessing spawning by the late-spring island/bar species group in the Wilder riverine reach was dictated in part by the known locations of fallfish nesting activities. No fallfish nests were observed in the upper Wilder subreach, consequently one of the two island habitats available in that subreach was randomly selected, with probability of selection based on island perimeter (Table 5.2, Figure 5.1). One possible fallfish nesting location was observed in the second subreach, which happened to occur adjacent to Johnson Island. The only other island located in the second subreach (Burnap's Island) was also selected for spawning assessment. Three fallfish nesting locations were observed in the lower Wilder subreach, one of which was associated with Chase Island, and the other two were associated with bank-associated cobble bars in a run and pool habitat. These three locations were purposively selected to represent the late-spring island/bar species group. The fourth study site in the lower Wilder subreach was located at the only remaining island habitat, Hart Island.

5.2 Bellows Falls Riverine Reach

The 5.8 mile Bellows Falls riverine reach only contains a single mainstem riffle habitat and two island habitats; however other habitat features are present which are expected to provide spawning habitat for each species group. This reach includes the lower portion of the 3,500-ft bypassed reach.

Early-Spring Riffle Spawners (walleye, white sucker)

Three potential spawning areas for walleyes and suckers were purposively selected in the Bellows Falls riverine reach (Table 5.1): the only mainstem riffle existing in that reach, a rocky run habitat just downstream of the powerhouse tailrace, and a swift, rocky run habitat adjacent to a large mid-channel bar formed at the confluence of the Cold River (Figure 5.2). The latter two locations are suspected spawning locations for walleyes (Gabe Gries, NHFGD, personal communication). If conditions at the base of the tailrace channel appear to be too hazardous for safe deployment of spawning blocks (see Section 6), an alternative location will be selected (e.g., the bar at the Saxtons River confluence).

Late-Spring Island/Bar Spawners (fallfish, smallmouth bass)

The two island habitats located in the Bellows Falls riverine reach were both selected for assessing spawning activities by smallmouth bass and fallfish (Table 5.1, Figure 5.2). Although not an island, the third site selected was the area surrounding the confluence of the Saxtons River, which forms a large delta expected to contain abundant eddy habitat (for smallmouth bass spawning) and an assortment of rock substrate materials, potentially useful by fallfish. If boating conditions at any of these spawning sites are deemed unsafe, an alternative location will be selected, such as the large cobble bar and eddy complex at the mouth of the Cold River.

5.3 Vernon Riverine Reach

Like the Bellows Falls reach, the short (1.5 mile) riverine reach below Vernon dam contains only a single riffle and 2 islands; however other habitat features are present which are expected to provide spawning habitat for each species group.

Early-Spring Riffle Spawners (walleye, white sucker)

The Vernon riverine reach contains a single riffle located in the side channel created by the uppermost island (Table 5.1, Figure 5.3). This side channel can be dewatered at times, so eggs deposited by spawning walleyes or suckers may be particularly vulnerable to desiccation at this location. The second location selected to assess riffle spawners in this reach is at the head of the run habitat immediately downstream of the tailrace. This location will contain swift velocities during project generation and is characterized by a rocky substrate, including bedrock ledges.

Late-Spring Island/Bar Spawners (fallfish, smallmouth bass)

The 2 islands in the Vernon riverine reach were both selected to assess spawning by smallmouth bass and fallfish (Table 5.1, Figure 5.3). Both islands contain abundant cobble/gravel shoal habitat for fallfish spawning and margin eddy habitat for bass spawning. Multiple nests (likely lamprey) were observed surrounding Stebbins Island during PHABSIM data collection in the spring of 2014 (Study 9 – Instream Flow); consequently it is expected that habitat conditions may also be suitable for fallfish nesting. As noted above, the side channel associated with the upper island may provide ideal spawning habitat for bass during project generation, but may be subject to dewatering at low flows.

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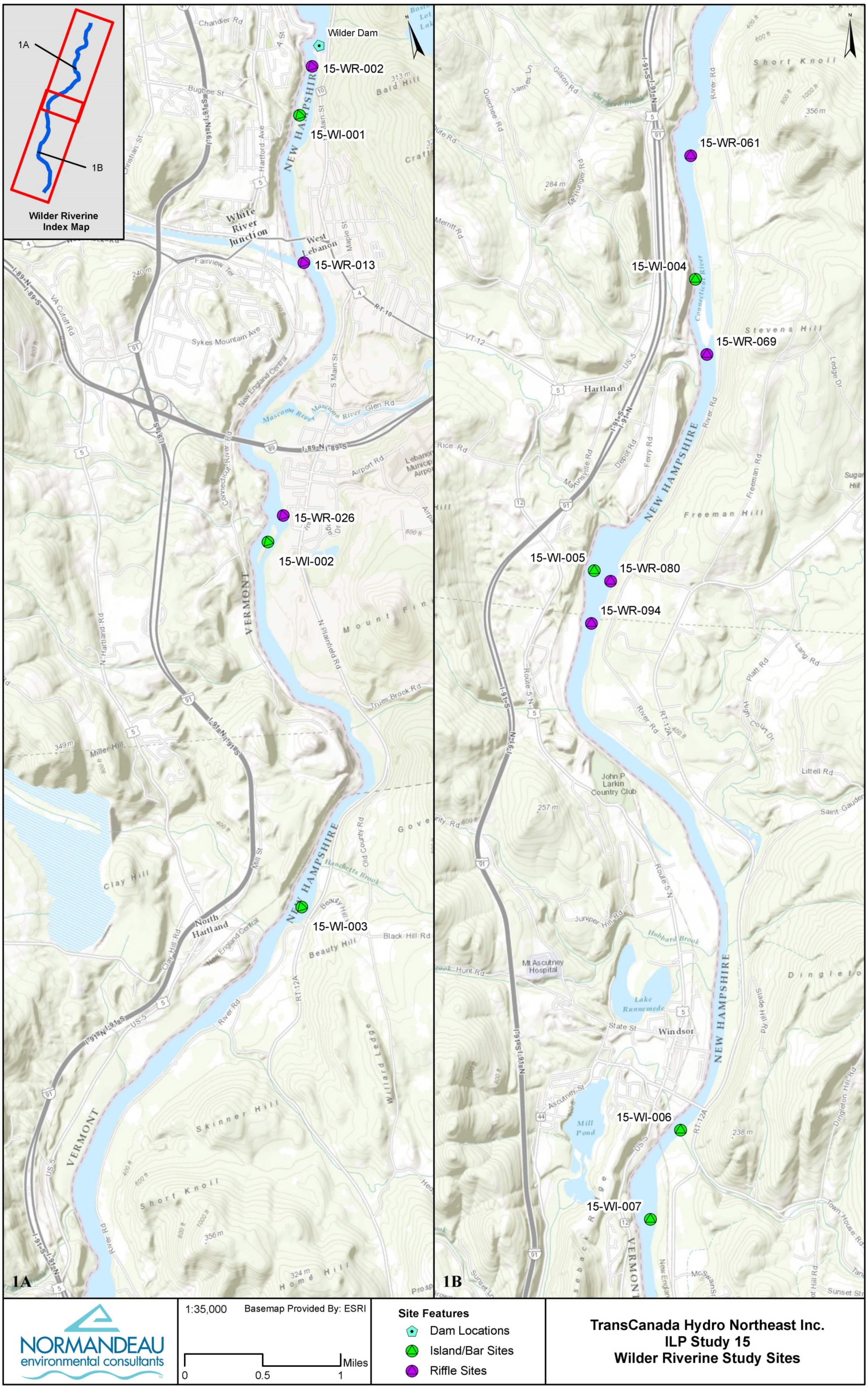

Figure 5.1. Location of riffle and island/bar study sites in the Wilder riverine reach.

Figure 5.2. Revised Location of riffle and island/bar study sites in the Bellows Falls riverine reach.

Figure 5.3. Location of riffle and island/bar study sites in the Vernon riverine reach.

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Table 5.1. Habitat areas selected for assessing spawning by the riffle species group in the Wilder (W), Bellows Falls (B), and Vernon (V) riverine reaches.

Site ID Study 15	MesoHabitat Type	Habitat Size (ac)	Dom/SubD Substrate[1]	Location (DD NAD83 UTM Z18N) X	Y
15-WR-002	Riffle	1.21	CB/GR/BR	-72.305109	43.665343
15-WR-013	Riffle	1.87	GR/SA	-72.314184	43.648322
15-WR-026	Riffle	2.98	CB/GR	-72.327021	43.626740
15-WR-061	base of Sumner falls	-	CB/GR/BR	-72.381033	43.561800
15-WR-069	Riffle	3.27	GR/CB	-72.379756	43.543314
15-WR-080	Riffle	4.73	CB/GR	-72.392952	43.522591
15-WR-094	Riffle	2.43	GR/CB	-72.395573	43.518730
15-BR-Bellows	Below tailrace, VT side	-	CB/GR/BD	-72.442272	43.131177
15-BR-005	Riffle	6.88	CB/GR	-72.434658	43.123160
15-BR-007	Run	10.11	CB/-	-72.432188	43.117495
15-VR-001	Run	7.84	CB/GR/BR	-72.513270	42.768330
15-VR-006	Riffle	0.15	GR/CB	-72.515613	42.766642

[1] SA-Sand, GR-Gravel, CB-Cobble, BD-Boulder, BR-Bedrock

Table 5.2. Habitat areas selected for assessing spawning by the island/bar species group in the Wilder (W), Bellows Falls (B), and Vernon (V) riverine reaches.

Site ID Study 15	Study 16[1]	Island Name	Island Perimeter ft	Island Acreage	Location (DD NAD83 UTM Z18N) X	Y
15-WI-001	16-WL-001	n/a	2704	3.0	-72.308651	43.661409
15-WI-002	16-WL-003	Johnston	5155	8.4	-72.329968	43.624874
15-WI-003	16-WL-004	Burnap's	1527	2.8	-72.340817	43.591786
15-WI-004	n/a	fallfish nest	-	-	-72.380907	43.550322
15-WI-005	16-WL-005	Hart	6274	28.3	-72.394997	43.523613
15-WI-006	n/a	fallfish nest	-	-	-72.381530	43.474960
15-WI-007	16-WL-007	Chase	3526	12.1	-72.390409	43.463315
15-BI-001	n/a	Saxtons R bar	1098[2]	-	-72.437393	43.124857
15-BI-002	16-BL-002	n/a	1155	-	-72.434533	43.081773
15-BI-003	16-BL-003	Dunshee	4224	-	-72.449738	43.066225
15-VI-001	16-VL-001	n/a	3199	8.8	-72.514745	42.766711
15-VI-002	16-VL-002	Stebbins	5965	32.7	-72.502771	42.769141

[1] Sites also selected in Study 16
[2] Approximate length of tributary delta.

6. FIELD SAMPLING METHODOLOGIES

Field sampling methodologies will differ somewhat according to species group and may involve several alternative gear-types. The early-spring riffle spawning species group (walleye and white sucker) will be assessed using egg blocks placed within the potential spawning areas. It is expected that spawning blocks will be re-deployed to different locations within each selected study site if initial block placements do not yield eggs, with initial locations selected based on the assessment of spawning habitat quality as well as expected vulnerability to dewatering (e.g., shallower locations versus deeper locations). See the RSP for additional details on egg block deployment and evaluation. Visual observation of spawning activity by boat or wading will also be employed; however, the nocturnal spawning habitats of walleye will restrict this methodology to daytime spawners. Electrofishing or angling may also be employed to capture adults and verify spawning condition.

The late-spring island/bar spawning species group (fallfish and smallmouth bass) will be assessed using surface-oriented visual observations and snorkeling, supplemented by boat electrofishing, angling, and/or seining under conditions of lower visibility. Status of nest-guarding adult bass or nest-building fallfish may be assessed over one or more tailwater elevation changes by deploying a remote underwater camera adjacent to an active nest. Review of digital images taken at set intervals (e.g., every 5-10 minutes) over the course of project operations and discharge levels can be used to determine persistence or abandonment of specific nests, and relate the results to minimum nest depths.

Consistent among each study site will be the deployment of water level loggers, which will monitor changes in water surface elevations and water temperatures at 15 minute intervals. Loggers will be placed at each of the spawning study sites where spawning activity is detected. The RSP contains additional details on the deployment of instream loggers. Data collected at each location where spawning occurs (e.g., at adult spawner observations, nest locations, or egg deposition sites) will include water depth; water level and temperature (taken from logger and TC operations records); dominant substrate, vegetation, and instream cover type; water velocity; observation time, date, and location (recorded with GPS); fish behavior; egg or fry presence; nest status (e.g., presence of nesting fish, degree of silt deposition); etc.

Each spawning site will be revisited during the spawning season according to a set schedule. Site visits will occur at least 3 times/week for egg blocks, and 2 to 3 times/week for the broadcast and nesting species.

Appendix A

Spawning Habitat Characteristics for Impoundment Species

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Spawning Habitat Characteristics for Impoundment Species

* Peak - if not specified in document, peak is defined as the range in means from multiple locations/years, or derived from HSC curves as suitabilities >0.5.

	Periodicity		W Temps °C		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Cover**	**Location**	**Citation[1]**
White Suckers	late-Mar to mid-June	-	-	-	-	-	-	-	-	-	-	inlets to NY lakes	various cited in Raney & Webster 1942
	March-mid May	-	6+	-	-	-	-	-	-	-	-	St .John R, NB	Doherty et al. 2010
	-	-	-	-	-	-	-	-	-	boulders	-	trib to Gouin Res, Quebec	Dion et al. 1994
	mid-Apr to	late-Apr	6.2-16.8	15.2-16.8	-	-	<3.28	-	sand, gravel, rock	-	-	Jack Lake trib, ON	Corbett & Powles 1983
	mid-April to	late-Apr	3.5-16.6	8.8-16.6	-	-	1-3.28	-	-	-	-	Apsley Cr, ON	Corbett & Powles 1986
	-	early-May to early-June	>10	-	-	-	-	-	-	gravel	-	rivers and lakes in Canada	Scott & Crossman 1998
	March to mid-Apr	early-Apr	11.5-13.0	-	0.16-1.77	-	0.26-1.12	-	0.08-1.54	-	-	small pond outflow, VA	McManamay et al. 2012
	early-Apr to late-May	-	-	-	-	-	-	-	-	-	-	Lake Taneycomo tribs, MO	Wakefield & Beckman 2005
	-	-	10-22.5	-	1.64-1.93	-	0.66-0.82	-	-	med gravel	-	Deer Cr, IN	Curry & Spacie 1984
	early-May to early-June	late-May	-	12.2-15.5	-	-	<0.5	-	-	gravel	-	tribs to BC lakes	Geen 1958
	-	-	-	-	0.0-2.52	0.26-2.02	0.60-3.04	0.84-2.07	sand thru boulder	gravel & cobble	-	U.S rivers	Bovee 1978
	-	-	10-18	-	0.0-3.0	0.58-2.5	>0.0-2.0	0.25-1.38	0.001+	0.01-0.63	-	U.S rivers	Twomey et al. 1984
Walleye	April to early-May	-	4.4-13+	~8-10	-	-		-	-	-	-	Up Conn & Mississquoi Rs, NH	Gabe Gries, NHDFG, pers comm
	-	-	4.0-9.0	-	5.58-9.51	-	<5.74	-	-	-	-	Oswegatchie R, NY	LaPan & Klindt 1995 in Bozek et al. 2011
	-	-	6.1-16.6	9.0-15.0	-	-	-	-	-	-	-	Brandy Br, NY	LaPan 1992 in Bozek et al. 2011
	-	mid to late-Apr	3.5-16.6	4.0-16.6	-	-	0.8-6.5	-	organics, mud, sand, gravel	gravel	-	Apsley Cr & Redmond Cr, ON	Corbett & Powles 1986

[1] See Literature Cited section following the table.

	Periodicity		W Temps °C		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation[1]
	-	-	4.0-14.0	9.0-14.0	3.28-6.56	-	-	-	-	-	-	Consecon & Melville Cr, ON	Schraeder 1980 in Bozek et al. 2011
	-	-	4.5-12.0	8.0-11.0	3.28-4.92	-	0.66-1.64	-	-	-	-	Hoople Cr & Raisin R,ON	Cholmodeley 1985 & Eckersley 1986 in Bozek et al. 2011
	-	-	-	-	0.16-0.66	-	-	-	-	-	-	Minesing, ON	Minor 1984 in Bozek et al. 2011
	-	-	-	-	<3.28	-	-	-	-	-	-	Ontario streams	Ontario MNR in Bozek et al. 2011
	-	-	-	-	-	-	<2.98	-	-	-	-	Georgian Bay tribs, ON	E. McIntyre (pers comm) in Bozek et al. 2011
	-	-	-	-	-	-	<2.49	-	-	-	-	Napanee R, ON	P. Mabee (pers comm) in Bozek et al. 2011
	-	-	-	-	-	-	0.66-6.56	-	-	-	-	Spanish R, ON	W. Selinger (pers comm) in Bozek et al. 2011
	-	-	-	-	-	-	0.66-2.95	-	-	-	-	Talbot R, ON	MacCrimmon & Skobe 1970 in Bozek et al. 2011
	-	-	-	-	-	-	1.97-2.49	-	-	-	-	Tay R, ON	W. McCormick (pers comm) in Bozek et al. 2011
	-	-	3.3-10.0	8.0-9.0	-	-	-	-	-	-	-	Quinte Bay tribs, ON	Payne 1964 in Bozek et al. 2011
	-	-	4.4-10.0	6.1-8.3	-	-	-	-	-	-	-	Bobcaygeon R, ON	Bradshaw & Muir 1960,Wood 1985 in Bozek et al. 2011
	-	-	-	6.0-7.0	-	-	-	-	-	-	-	Constan Cr, ON	Anonymous 1979 in Bozek et al. 2011
	-	-	4.0-13.0	6.0-8.0	-	-	-	-	-	-	-	E Georgian Bay tribs, ON	Kujala 1979 in Bozek et al. 2011
	-	-	-	5.0-7.0	-	-	-	-	-	-	-	Madawaska R, ON	Anonymous 1979 in Bozek et al. 2011
	-	-	7.5-15.0	-	-	-	-	-	-	-	-	Nith R, ON	Timmerman 1995 in Bozek et al. 2011
	-	-	-	6.8-7.5	-	-	-	-	-	-	-	Otonabee R, ON	Maraldo 1986 in Bozek et al. 2011
	-	-	5.0-11.7	7.0-7.8	-	-	-	-	-	-	-	S Nation R, ON	Eckersley 1980 in Bozek et al. 2011
	-	-	4.0-10.0	6.0-8.0	-	-	-	-	-	-	-	Spanish R, ON	W Selinger (pers comm) in Bozek et al. 2011
	early-Apr to late-June	-	6.7-11.1	-	-	-	-	-	coarse gravel to boulder	-	-	rivers and lakes in Canada	Scott & Crossman 1998
	-	-	-	-	0.0-4.66	0.92-2.65	0.30-4.56	1.18-2.49	<0.002-20	0.002-2.5	-	MN rivers	Aadland & Kuitunen 2006
	-	-	7.0-8.5	-	1.15-2.46	-	0.42-2.26	-	-	0.08-10.0	-	WI stream	Stevens 1990 in Bozek et al. 2011
	-	-	-	-	-	-	<3.0	-	-	-	-	Muskegon R,MI	Eschmeyer 1950 in Bozek et al. 2011
	-	-	4.8-10.0	7.7	-	-	-	-	-	-	-	Tittabawassee R,MI	Jude 1992 in Bozek et al. 2011
	-	-	5-24	6-11	0.0-3.6	2.0-3.5	1.0-6.5	1.8-6.0	>0.002	-	-	Yellowstone & Missouri rivers	McMahon et al. 1984
	-	-	-	-	1.97-4.92	-	-	-	-	-	-	Cedar Cr, IA	Paragamian 1989 in Bozek et al. 2011

	Periodicity		W Temps °C		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Range	Peak	Cover	Location	Citation[1]
	-	-	-	8.9-13.9	0.69-1.61	-	-	-	-	-	-	Hamilton Cr, Man	Gibson & Hughes 1977 in Bozek et al. 2011
	-	-	5.0-15.0	8.3-12.2	1.41-3.80	-	1.96-20.0	2.03	incl mussel beds	gravel,rubble	-	Mississippi R, IA	Pitlo 1989 & 2002 in Bozek et al. 2011
	-	-	-	-	-	-	0.98-2.0	-	-	-	-	Hamilton Cr, MAN	Ellis & Giles 1965 in Bozek et al. 2011
	-	-	-	-	-	-	1.97	-	-	-	-	Provo R,UT	Arnold 1961 in Bozek et al. 2011
	-	-	-	-	2.3-10.5	-	0.66-2.95	-	-	-	-	Manitoba rivers	Newbury & Gaboury 1993 in Bozek et al. 2011
	-	-	-	-	-	-	-	-	-	-	-	-	Bovee 1978
	-	-	-	-	0.98-11.48	-	-	-	-	-	-	N.Amer streams	Ich Assoc 1996 in Bozek et al. 2011
	-	-	11	-	-	-	-	-	-	-	-	Cedar R,IA	Paragamian 1989 in Bozek et al. 2011
	-	-	-	-	-	-	-	-	-	gravel, cobble	-	-	Ivan et al. 2010 in Bozek et al. 2011
	-	-	-	-	-	-	-	-	-	gravel	-	-	Chalupnicki et al. 2010 in Bozek et al. 2011
	-	-	-	-	0.0-5.0	1.34-4.4	0.43-6.5	0.67-6.0	-	-	-	see above	geometric mean HSC based on Bozek et al. 2011 datasets (Normandeau pers comm)
Smallmouth Bass	early-June into July	-	17-21	-	-	-	1.5-3.0	-	-	gravel	-	St. Lawrence R, NY	Stone et al. 1954
	early-May to mid-June	-	-	-	-	-	-	-	-	-	-	Mississippi R & Millers Lk, ON	Barthel et al. 2008
	Apr-May	-	<25	-	0.0-2.75	0.0-0.8	>0.5	>1.66	>0.002 incl aq veg stems	0.1-2.5	-	Susquehanna R, PA	Allen 1996
	-	-	-	-	0.0-0.85	0.0-0.2	0.4-2.8	0.45-2.75	-	-	-	WV rivers	Joy et al. 1981
	late-Apr to mid-June	-	15.8-25	-	-	-	-	avgs 1.5-2.8	incl bedrock	gravel	-	3 VA rivers	Surber 1943
	mid-Apr to early-June	-	15-21	-	-	avg 0.13-0.23	-	avg 3.28-3.8	-	-	-	N Anna R, VA	Lukas & Orth 1994
	-	late-May to early-July	12.8-20.0	16.1-18.3	-	-	2-20	-	sand, gravel, rock	-	prefers near cover	rivers and lakes in Canada	Scott & Crossman 1998
	late-Apr to mid-July	mid-June	12.5-23.5	-	-	-	-	-	-	-	-	New R & tribs, VA	Graham & Orth 1986
	-	-	-	-	0.0-0.62	0.0-0.43	1.6-3.8	1.8-3.6	-	-	-	Huron R, MI	Bovee et al. 1994
	-	-	-	-	0.0-0.85	0.0-0.04	0.13-4.69	1.42-2.81	0.002-20	0.002-2.5	vegetation	MN rivers	Aadland & Kuitunen 2006

	Periodicity		W Temps °C		Velocity fps		Depth ft		Substrate Type in		Instream	Data	Source
Species	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Cover**	**Location**	**Citation[1]**
	early-Apr to late-June	late-Apr to mid-June	15.6-	-	-	-	-	-	-	gravel or rubble	-	Courtois Cr, MO	Pflieger 1975
	mid-Apr to early-June	late-Apr to mid-May	16.2-18	14-18	0.0-0.85	avg 0.13-20	0.8-5.9	-	-	pebbles	most nests w/in 1m of boulders or woody debris	Baron Frk Cr, OK	Dauwalter & Fisher 2007
	early-May to mid-June	-	17-?	-	-	<0.07	-	avg 1.2	gravel-bedrock	pea gravel	most nests close to boulders, roots, or woody cover	Indian Cr, OH	Winemiller & Taylor 1982
	late-Mar to mid-Apr	mid to late-Apr	-	17.6	-	-	-	-	-	-	-	channels along Tenn R, AL	Wrenn 1984
	-	-	-	12.7-15.5	-	-	-	-	-	-	-	Columbia R, WA	Henderson & Foster 1957
	-	-	12-26	14-19	0.0-2.75	0.0-1.5	>0.22	>1.56	>0.002	0.1-2.5	-	-	Bovee 1978
Fallfish	-	-	-	-	0.0-0.66	-	>0.0-3.26	-	-	-	-	Lamprey R, NH	Normandeau 2009
	-	-	-	-	0.0-3.0	0.05-2.15	0.4-4.5	0.52-3.4	-	-	-	Merrimack R, NH	Normandeau (date?)
	Apr to June	-	>14.4	-	-	-	-	-	-	-	-	lakes and rivers in NY	Smith 1985
	-	-	13.5-18.5	15.5-18.0	-	-	-	0.33-1.64	-	0.002-2.52	prefers nearby instream cover, overhead cover, or deep water	Mill R, MA (D)	Trial et al. 1983
	late-Apr to mid-June in MA	-	>14.4	-	-	-	-	-	-	pebbles & stones (1-168g wt)	-	Mill & WB Swift rivers, MA	Reed 1971
	mid-Apr to early-June	-	15	-	-	-	-	>1.64	-	-	-	Mill R, MA	Ross & Reed 1978
	early-Apr & mid-May	-	16.2 & 17.9	-	-	-	-	-	-	-	-	Genito Cr, VA & Mill R, MA	Maurakis & Woolcott 1992
	May-June	-	14-19	-	-	-	-	-	-	-	-	Ontario rivers	http://www.ontariofishes.ca/fish_detail.php?FID=58
	-	mid-May	>12.0	-	-	-	-	-	-	-	-	rivers and lakes in Canada	Scott & Crossman 1998

APPENDIX A – LITERATURE CITED

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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 II.G

Study 16 – Sea Lamprey Spawning Assessment

Revised Site Selection Report

Updated Study Report

September 14, 2015

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TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 16

Sea Lamprey Spawning Assessment

Revised Site Selection Report

In support of Federal Energy Regulatory Commission Relicensing of:

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

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February 3, 2015

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1. INTRODUCTION

Operations of the Wilder, Bellows Falls, and Vernon projects may have the potential to cause direct effects on spawning habitat and activity downstream of the projects in riverine portions of the river, from water releases during routine operations. If sea lampreys are actively spawning during operational changes, such as decreased or increased generation, assessing whether these changes adversely affect spawning activity will assist resource agencies in the management of the species.

Revised Study Plan (RSP) 16, as supported by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination, specified that a subset of the project-affected area would be studied. This report has been revised in response to comments received from the aquatics working group at a December 17, 2014 site selection consultation meeting. This report provides a summary of the data analysis and criteria used to select the proposed subset of locations to be examined in detail during 2015. The following selected sites were added as a result of consultation:

- Three additional smaller order tributary sites were added (2 in Bellows Falls impoundment and 1 in Vernon). These sites are:
    - Mill Brook, stream order 3, site# 16-BT-004
    - Blood Brook, stream order 2, site# 16-BT-006
    - Aldrick Brook, stream order 3, site # 16-VT-014

2. STUDY AREA

Sampling will be conducted to characterize the spawning habitat and the effects of streamflow fluctuations on spawning activities of sea lamprey (*Petromyzon marinus*) within each of the three project riverine reaches, and at tributary mouths within the Bellows Falls and Vernon impoundments. As stated in the RSP, sea lamprey are unlikely to be found upstream of Wilder dam, so the Wilder impoundment is not included in the study area. The three riverine reaches, totaling 25 miles in length, and the two impoundments, totaling 52 miles, include:

- Wilder riverine reach (RM 217.4 - 199.7);
- Bellows Falls impoundment (RM 199.7 - 173.7);
- Bellows Falls riverine reach (RM 173.7 - 167.9);
- Vernon impoundment (RM 167.9 - 141.9);
- Vernon riverine reach (RM 141.9 - 140.4).

The Wilder riverine reach was further divided into three subreaches: subreach 1 from Wilder Dam downstream to the White River confluence (1.5 mi); subreach 2 from White River downstream to Sumner Falls (5.2 mi), and the lowest subreach from Sumner Falls downstream to the Bellows Falls impoundment (11.0 mi).

3. TARGET SPECIES

As stated in the RSP, sea lamprey typically spawn in areas of shallow, rapid water with cobble/gravel substrate for their redds and require sandy/muddy bottom in quiet water for their larvae. Other areas of the projects, i.e., impoundments, will most likely not be suitable for lamprey spawning. Specific lamprey spawning sites within the study area will be identified via radio telemetry of individuals.

Tracking of radio-tagged lampreys will be a primary methodology used to locate and assess the spawning habitat characteristics and spawning success of lampreys in the three riverine reaches, as well as in project-affected portions of tributaries entering the lower two impoundments (very few lampreys are expected to pass Wilder dam). Known locations of lamprey spawning will also be used to focus efforts to document spawning habitat. Because telemetry studies have yet to occur, this site selection plan provides an interim protocol for selecting locations where lamprey spawning is likely to occur, based on the known substrate, depth, and water velocity preferences of this species (Appendix A). Because it is anticipated that radiotagged adults will lead survey crews to new locations where actual spawning occurs, we expect to replace some of the unutilized habitat areas (described below) with those new locations where lamprey are actively spawning.

4. SITE SELECTION PROCESS

As stated in the RSP, the selection of sampling locations will entail a combination of purposive sampling in study sites observed to support actual spawning activities identified by radio-tagged adult lampreys, as well as locations reported to be utilized by spawning adults based on nest observations noted by Normandeau biologists over the course of ongoing instream flow studies. In addition, in case of an insufficient number of radio-tagged adult migrants to be tagged in the spring of 2015 (up to 40 in this study, and presumably some portion of 40 fish to be tagged by FirstLight in its study), this plan includes the selection of potential spawning areas known to possess habitat characteristics meeting the basic spawning requirements for this species to supplement radio-tagged fish tracking as needed. Several of the habitat characteristics required for spawning by these species (e.g., mesohabitat type, dominant substrate, etc.) were recorded as part of Study 7 - Aquatic Habitat Mapping and areas containing those characteristics were reviewed for potential site selection.

Prior to the selection of potential study sites, areas were excluded that are not expected to provide significant spawning habitat, including areas dominated by sand or silt substrate (which are utilized by rearing ammocoetes, but not by spawning adults); areas >10 ft deep that will not be vulnerable to normal fluctuations in water surface elevations; and areas expected to contain velocities too slow for lamprey spawning (e.g., pool habitats). Potential study sites that met the basic spawning requirements of sea lampreys were then selected based on several criteria, principally:

- Known presence of spawning
    - Locations identified by radio-tagged adults (locations not yet available)
    - Nest locations identified during previous studies
- Presence of required habitat characteristics, namely:
    - Riverine habitats dominated by gravel or cobble substrate with moderate to swift water velocities
    - Impoundment tributary mouths possessing these same characteristics

Because of the large extent of potential habitat containing gravel/cobble substrate and non-zero velocities in the riverine reaches, a subsampling protocol is necessary to focus the selection of potential spawning areas for intensive surveys. Although some elements of random sampling were proposed for selection of spawning study sites for both impoundment (Study 14) and riverine (Study 15) fish species, the combination of known lamprey spawning areas and the availability of complex island habitats is expected to provide sufficient guidance for spawning surveys until the actual locations of radio-tagged individuals is available.

In the two impoundment reaches, random selection of non-purposive study sites was based on tributary size (stream order) to maximize both the number and diversity of adult spawners or nests encountered at each sampling location. Larger tributary confluences are also expected to contain a wider and more diverse range of microhabitat attributes than would a small study site. Finally, selection of a fixed number of larger sites would yield a much greater sampling area than would a similar number of small sites, again increasing the likelihood of achieving the goals of this study.

Twelve habitat-based study sites were selected in the project-affected area to assess spawning activities and habitat for sea lamprey in the riverine reaches, and 11 sites were selected in the impoundment reaches. To the extent possible, the study sites were distributed among the three riverine reaches (and the three Wilder sub reaches) in proportion to the length of each reach, and between the two impounded reaches. Based on these criteria, and giving one extra study site for the short (1.5 mi) Vernon reach, produced the following sample size goals:

- Wilder 1 Sub riverine reach: 1 site
- Wilder 2 Sub riverine reach: 2 sites
- Wilder 3 Sub riverine reach: 4 sites
- Bellows Falls impoundment: 6 sites

- Bellows Falls riverine reach: 3 sites
- Vernon impoundment: 5 sites
- Vernon riverine reach: 2 sites

Selection of specific study sites began with identification of known spawning areas. Lamprey nests were observed in two locations during Study 9 - Instream Flow studies conducted in 2014: one site in the Bellows Falls riverine reach and one site in the Vernon riverine reach. The Vernon site contained multiple nests surrounding Stebbins Island, which illustrated how the complex assemblage of substrate types, mesohabitat types, and depth/velocity characteristics of island habitats are likely to provide many opportunities for lamprey spawning. Most islands in each reach possess large gravel/cobble bars at the island head with moderate velocities in riffle, run, and glide habitats that may be utilized by lampreys. In addition, fine sediments deposited in the low velocity eddies alongside and below islands may be particularly important for rearing ammocoetes after emergence from the gravel/cobble nests. Consequently, initial study sites selected for lamprey spawning were based on known observations of nest locations as well as potential spawning area associated with primary (wooded) islands. Note that most islands selected for assessment of lamprey spawning habitat were also selected for assessing riverine spawning by smallmouth bass and fallfish in Study 15.

In the two impoundment reaches, the area of potential riffle and shoal spawning habitat at tributary mouths was approximated by filtering the list of tributaries to those classified as either “large” tributaries (of stream order 4, 5, or 6) or “medium” tributaries (stream orders 2 or 3), prior to random selection. Medium-sized tributaries that did not possess a shallow (<5 ft) gravel/cobble dominated delta or shoal (based on Study 7 habitat mapping) were not available for selection. Small (1st order) tributaries were also unavailable for selection due to the expectation that such tributaries would not produce sizeable shoals at the impoundment confluence, nor would they provide a significant area of spawning habitat within the stream channel due to their small size and intermittent flow characteristics.

Because the actual utilization of the selected study sites in both the riverine and impoundment areas by spawning lamprey is currently unknown, the study plan proposes to utilize these selected sites to supplement actual spawning areas determined by previous surveys (e.g., two sites in the Vernon riverine reach) and by tracking radio-tagged lampreys to new locations. Consequently, new spawning locations as determined by radio-tagged spawners will replace the potential study sites listed below on a one-for-one basis, unless active lamprey spawning is observed at those locations during initial surveys. Such replacements will consider the type of new habitat (and similar stream order where possible in the case of tributaries) selected by the radio-tagged lampreys. For example, through random sampling Beaver Brook (4th order stream) was selected as a tributary study site in the Bellows Falls impoundment, but Spenser Brook was not. If radio-tagged lampreys are found spawning at the mouth of Spenser Brook (also 4th order), and no evidence of spawning is apparent (based on initial surveys) at Beaver Brook, the Beaver Brook site will be dropped and the Spenser Brook site will be added. In like manner, if radio-tagged lampreys are found to spawn at a previously unidentified bar within the Wilder riverine reach, but not at one of the selected island locations, the island location will be dropped and the new spawning bar will be added. Thus, newly identified spawning sites will be used to replace unused spawning sites having similar habitat characteristics (e.g., island for island, or medium tributary for medium tributary). Given the uncertainty around the number of spawning sites that may be found via radio-tagging, the total number of study sites will be limited to 20 sites.

5. SELECTED STUDY SITES

5.1 Wilder Riverine Reach

The 17.7 mile Wilder riverine reach contains 2 permanent islands (e.g., islands containing mature trees) in each subreach, comprising 6 of the sample size goal of 7 study sites. Consequently, both islands in the upper subreach were selected, as well as a seventh location in the lower subreach in a complex area of non-permanent (low elevation) islands upstream of the Chase Island complex (Table 5.1, Figure 5.1). Although no lamprey nests were observed in the Wilder riverine reach during 2014, each of the 7 locations described above contain an abundance of flowing mesohabitat types (riffles, runs, and/or glides) and extensive areas of cobble/gravel substrate. Each of the 7 study sites also contains still-water pool habitats downstream of the islands that are dominated by sand or silt substrates that may be utilized by post-emergent larvae.

5.2 Bellows Falls Impoundment

The Bellows Falls impoundment contains 8 large tributaries of stream order 4, 5, or 6, and 5 medium tributaries with shallow gravel/cobble shoals. The 4 large tributary and 2 medium tributary study sites selected for assessment of lamprey spawning (Figure 5.2) include -two 5th order tributaries (Black and Williams rivers), two 4th order tributaries (Little Sugar River and Beaver Brook), one 3rd order tributary (Mill Brook), and one 2nd order tributary (Blood Brook). As noted in Table 5.2, 5 of the 6 tributary study sites were also selected for assessing walleye and sucker spawning (Study Plan 14).

5.3 Bellows Falls Riverine Reach

One lamprey nest was observed in the 5.8 mile Bellows Falls riverine reach during 2014. That location along with the two island complexes in the riverine reach are proposed for assessment of lamprey spawning habitat (Table 5.1, Figure 5.3). The two Bellows Falls islands do not have the habitat complexity or the expansive areas of cobble and gravel substrates as do the Wilder (or the Vernon) island habitats, but both islands contain shoal habitat with coarse substrate and run or glide habitat types. The observed nest site was not associated with a permanent island, but was associated with a gravel/cobble shoal.

5.4 Vernon Impoundment

The Vernon impoundment contains 7 large tributaries and 7 medium tributaries, of which 5 were selected at random. Three of the 5 selected tributaries are 4^{th} order (Partridge, Broad, and Sacketts), the West River is a 6^{th} order tributary, and the final selected tributary is Aldrick Brook, a medium (3^{rd} order) tributary (Table 5.2, Figure 5.4). Four of the 5 selected tributaries (excepting Sacketts Brook) will also be assessed for spawning by walleyes and white suckers (Study 14).

5.5 Vernon Riverine Reach

The short (1.5 mile) riverine reach below Vernon dam contains two islands, the larger of which (Stebbins Island) is surrounded by extensive cobble and gravel shoals that contained numerous lamprey nests in 2014 (Table 5.1, Figure 5.5). Although lamprey nests were not observed adjacent to the upper island, that island contains a diversity of mesohabitat and substrate types and the upper end of the side channel is particularly susceptible to dewatering during periods of low flow. Consequently, this location would be ideal for assessing flow effects on lamprey nest success, if nests are built there in 2015.

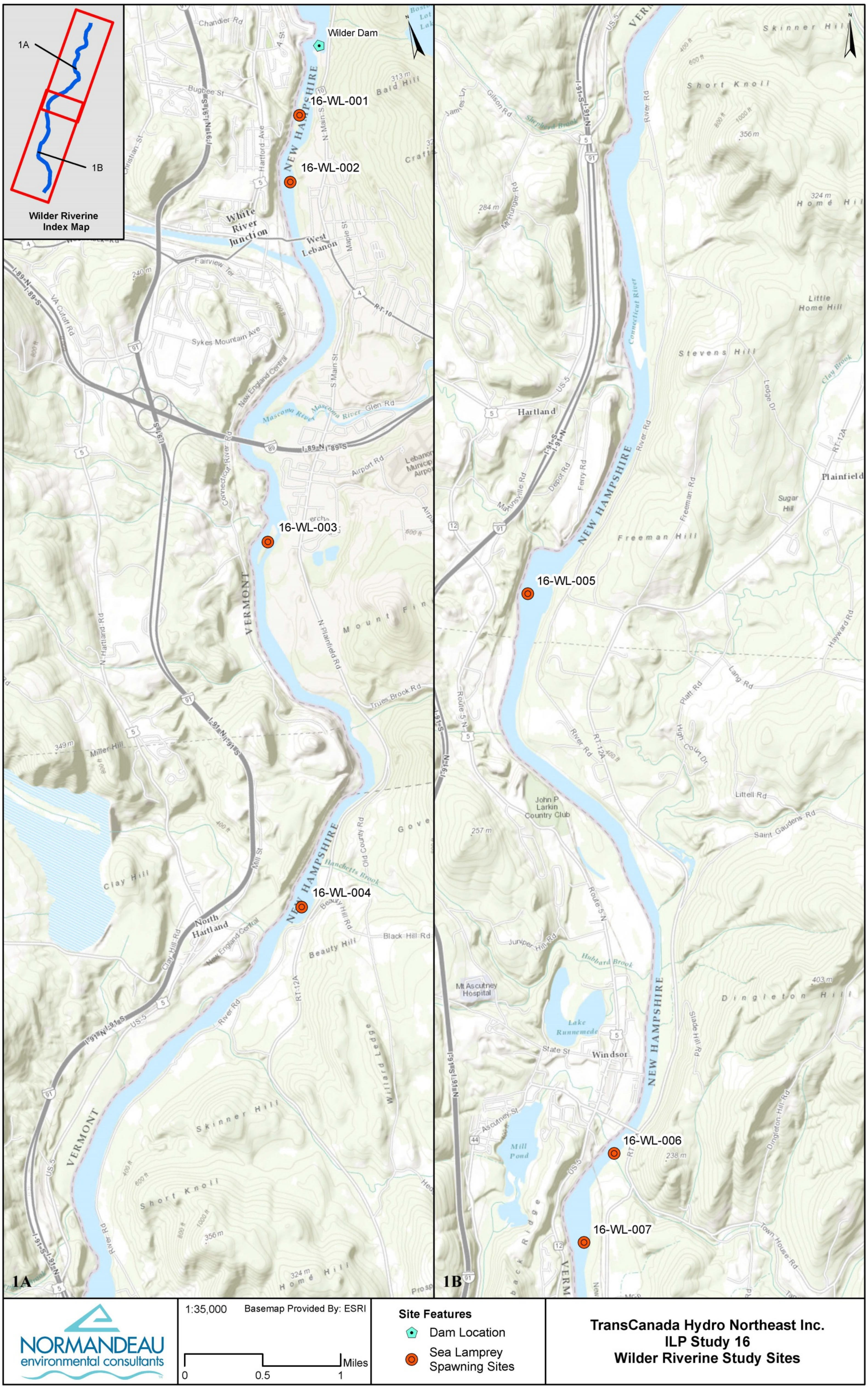

Figure 5.1. Location of study sites in the Wilder riverine reach.

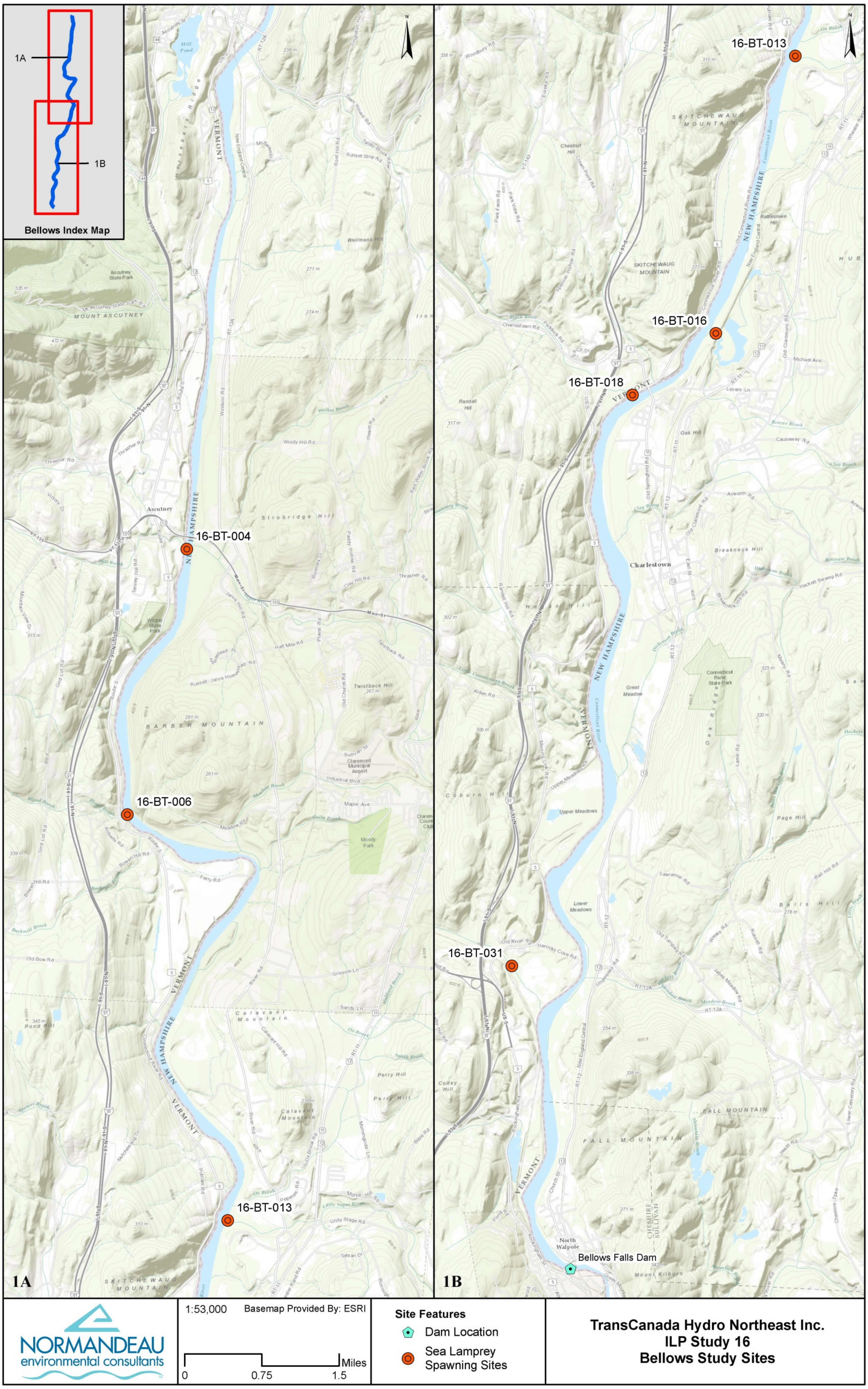

Figure 5.2. Revised Location of study sites in the Bellows Falls impoundment.

Figure 5.3. Location study sites in the Bellows Falls riverine reach.

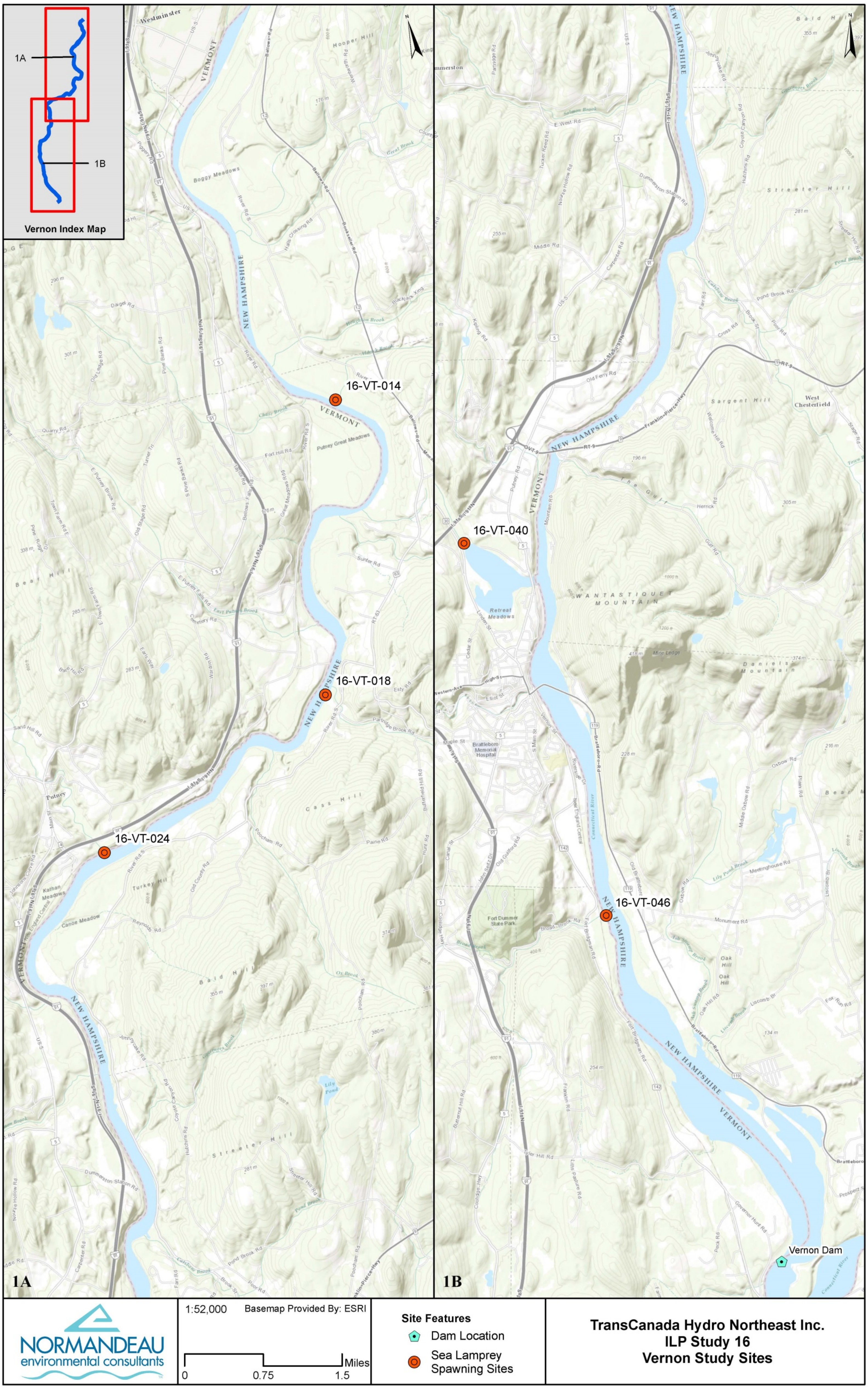

Figure 5.4. Revised Location of study sites in the Vernon impoundment.

Figure 5.5. Location of study sites in the Vernon riverine reach.

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Table 5.1. Habitat areas selected in the Wilder (W), Bellows Falls (B), and Vernon (V) riverine reaches.

Site ID		Island	Island	Island	Location (DD NAD83 UTM Z18N)	
Study 16	Study 15[1]	Name	Perimeter ft	Acreage	X	Y
16-WL-001	15-WI-001	n/a	2704	3.0	-72.308651	43.661409
16-WL-002	n/a	n/a	1318	1.1	-72.312517	43.655811
16-WL-003	15-WI-002	Johnston	5155	8.4	-72.329968	43.624874
16-WL-004	15-WI-003	Burnap's	1527	2.8	-72.340817	43.591786
16-WL-005	15-WI-005	Hart	6274	28.3	-72.394997	43.523613
16-WL-006	n/a	n/a	-	-	-72.386233	43.471477
16-WL-007	15-WI-007	Chase	3526	12.1	-72.390409	43.463315
16-BL-001	n/a	nest site	-	-	-72.441668	43.098007
16-BL-002	15-BI-002	n/a	1155	-	-72.434533	43.081773
16-BL-003	15-BI-003	Dunshee	4224	-	-72.449738	43.066225
16-VL-001	15-VI-001	n/a	3199	8.8	-72.514745	42.766711
16-VL-002	15-VI-002	Stebbins	5965	32.7	-72.502771	42.769141

[1] Sites also selected in Study 15.

Table 5.2. Revised Habitat areas selected in the Bellows Falls (B) and Vernon (V) impoundments.

Site ID			Stream	Stream	Location (DD NAD83 UTM Z18N)	
Study 16	Study 14[1]	Study 13[2]	Name	Order	X	Y
16-BT-004	14-BT-004	CT-B-3.04	Mill	3	-72.401287	43.401497
16-BT-006	n/a	CT-B-3.06	Blood	2	-72.414300	43.364467
16-BT-013	14-BT-013	CT-B-3.13	Little Sugar River	4	-72.397392	43.307053
16-BT-016	14-BT-016	CT-B-3.16	Beaver Brook	4	-72.414354	43.268448
16-BT-018	14-BT-018	CT-B-3.18	Black River	5	-72.430748	43.260172
16-BT-031	14-BT-031	CT-B-3.31	Williams River	5	-72.457251	43.180537
16-VT-014	14-VT-014	CT-V-5.14	Aldrick Brook	3	-72.449570	43.015160
16-VT-018	14-VT-018	CT-V-5.18	Partridge Brook	4	-72.466343	42.976344
16-VT-024	14-VT-024	CT-V-5.24	Sacketts Brook	4	-72.514282	42.963634
16-VT-040	14-VT-040	CT-V-5.40	West River	6	-72.568874	42.871940
16-VT-046	14-VT-046	CT-V-5.46	Broad Brook	4	-72.544267	42.820087

[1] Tributaries also selected in Study 14.
[2] Tributaries identified (but not necessarily selected for study) in Study 13 that correspond to this study's selected sites.

6. FIELD SAMPLING METHODOLOGIES

The RSP contains detailed descriptions of the methodologies proposed for assessing spawning habitat, spawning activities, and nest success of radio-tagged sea lampreys in the study area. For the habitat-based spawning surveys at the sites listed in Tables 5.1 and 5.2, visual surveys for actively spawning lampreys or newly constructed nests will be conducted via boat or wading using polarized sunglasses. Where surface visibility is limited (e.g., due to wind or current-related turbulence), snorkeling or view-tubes may be employed to better view the substrate. Because many of the island study sites are also proposed for assessing spawning by smallmouth bass and fallfish in Studies 14 and 15, sea lamprey surveys will also target identification of spawning activities for those species given the similarity in spawning periodicity.

Once an area within the study area is observed to have sea lamprey spawning activity, either by tracking radiotagged fish, or through surveys of the pre-selected study sites, it will be characterized for substrate, depth, and GPS location and monitored frequently, approximately once every 2 or 3 days, depending on the number of spawning areas found. Water quality (temperature, DO, turbidity, pH, and conductivity) will also be measured at nest locations. Given the uncertainty around the number of spawning sites that may be found via radiotagging, the total number of study sites will be limited to 20 sites. This will likely be a mix of sites identified by tracking up to 40 radiotagged fish (per the RSP, plus some expected portion of FirstLight's 40 tagged fish that may migrate into the study area), supplemented as needed by some or all of the 23 selected habitat survey sites. For instance, if two or more spawning sites are identified in the Vernon riverine reach from radiotagged fish, then no habitat survey sites will be investigated in that reach. Conversely, if no spawning sites are identified via radiotagged fish in that reach, then both of the selected habitat survey sites will be investigated.

Once redds are established within the study sites and spawning activity commences, these redds will be monitored every 2-3 days. A subset of redds will be monitored with water level loggers, which will provide 15-minute information on redd depths throughout multiple flow fluctuations. The subset of lamprey redds selected for water level loggers and for redd caps will bracket the range of observed depths. All redds found within project-affected areas, whether located via radio telemetry or during habitat-based surveys will be enumerated and monitored if feasible.

Environmental variables including water velocity, depth, temperature, exposure, and relative condition of redds/area in active spawning locations will be measured, and the grounds photographed, if possible, over the range of normal project discharges to characterize operational effects. Any changes to the habitat and/or redds will be described and recorded. Embeddedness—the ratio of sand and sediment in gravel—will be characterized and monitored over the life of the active redd for each redd monitored.

Success of spawning by sea lamprey within the study area will be characterized by capping a sub-set of active redds (those where spawning adults were observed) to assess emergence of larvae. If larvae emerge, spawning was successful; if no larvae emerge, spawning was not successful. Emerging larvae from capped redds will be enumerated on a daily basis, and timing of emergence relative to redd construction will be documented. Redds will be characterized as to location, range and average depth, general surrounding substrate, and range and average water velocity.

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APPENDIX A

Spawning Habitat Characteristics for Sea Lamprey

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Summary of spawning habitat characteristics of sea lamprey.

	Periodicity		W Temps °C		Mean Velocity fps		Depth ft		Substrate Type		Instream	Data	Source
Species	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Range**	**Peak**	**Cover**	**Location**	**Citation[1]**
Sea Lamprey	late-May to early-summer	-	-	17-19	-	-	0.82-1.64	-	gravel, cobble	-	-	Maine lakes & rivers	Kircheis 2004
	May to early-June	-	-	-	swift"	-	"shallow"	-	cobble		-	New York lakes & rivers	Kraft et al. 2006
	Apr to July	early-June	-	-	-	-	-	-	-	-	-	New York lakes & rivers	Smith 1985
	-	June	18-23	-	-	"rapid"	<2	<1	gravel <2 in	gravel <1 in	-	Humber R, Ontario	Coventry 1922
	mid-May to mid-June	late-May	18-	-	-	>2	0.33-0.92	-	pea gravel to rubble	gravel 0.5-1.0 in	-	Cayuga Lake, NY	Wigley 1959
	mid-Apr to early-Aug	early to mid-June	11.4-24.4	14.4-15.6	1.3-5.2	>2	0.42-5.5	1.0-2.1	gravel to rubble <5 in	gravel 0.4-2 in	none required	Ocqueoc R, MI	Applegate 1950
	early to late-June	June	-	19-20	-	-	-	-	-	-	-	Penobscot trib, ME	Hogg et al. 2013
	late-Apr to late-June	late-May to mid-June	10.5-24	16-21	-	-	-	-	-	-	-	Conn R, MA	Stier & Kynard 1986
	early to late-June	June	14-24.5	16.5-18.5	-	avg 1.46	0.7-2.2	1.0-1.3	gravel-cobble 2-7 in	-	-	Deerfield R, MA	Yergeau 1983

[1] See Literature Cited section following the table.

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APPENDIX A – LITERATURE CITED

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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 II.H

Study 25 – Dragonfly and Damselfly Inventory and Assessment

Site Selection Report

Updated Study Report

September 14, 2015

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TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 25

Dragonfly and Damselfly Inventory and Assessment

Site Selection Report

In support of Federal Energy Regulatory Commission Relicensing of:

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

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April 28, 2015

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1. INTRODUCTION

Seven of Vermont's Species of Greatest Conservation Need (SGCN) dragonflies and damselflies (odonates) occur in the Wilder, Bellows Falls, and Vernon project-affected areas, and an eighth species may be rare. However, the distribution and habitat of these and other odonate species is not well understood. Project operations may influence odonate assemblages in these areas, primarily via effects on habitat use/suitability, or survival during emergence/eclosion due to water-level fluctuations. This study will document the baseline distribution, relative abundance, habitat, and behavior of emerging and eclosing larvae of both SGCN odonates and the entire river-dependent odonate assemblage found in project-affected areas. These data and data from other studies will be used to assess the potential effects of project operations, particularly water-level fluctuations on these odonate species.

Revised Study Plan (RSP) 25 was approved by stakeholders in 2013 and approved by FERC in its February 21, 2014 Study Plan Determination with the following modifications:

- increase the survey frequency to twice per month (6 surveys), rather than once per month as proposed in the RSP; and
- deploy water level loggers at each survey site.

This site selection report provides a summary of the data analysis and criteria used to select the proposed locations to be examined in detail during 2015. The following selected sites were added to sites previously identified in Hunt (2010) as a result of the site selection process:

- One site in Lyme in the middle of the Wilder impoundment
- One site below the Bellows Falls impoundment.

2. STUDY AREA

The study area includes the Wilder, Bellows Falls, and Vernon impoundments and the two riverine reaches downstream from Wilder dam and Bellows Falls dam, as well as approximately 1.5 miles below Vernon dam. Nine of the sampling sites from Hunt et al. (2010) occur within the study area and will be used in Study 25 to maintain continuity with that study. The nine sites include two in the Wilder impoundment, two downstream from Wilder dam, two in the Bellows Falls impoundment, two in the Vernon impoundment, and one downstream from Vernon dam. Two additional sites were selected to provide wider geographic and habitat diversity, including one toward the middle of the Wilder impoundment, and one downstream of Bellows Falls dam in the riverine section. Overall, odonates will be sampled at eleven sites, four in riverine reaches and seven in the impoundments.

At each study site, a 100-meter sample plot will be established based on two broad considerations: 1) is habitat suitable for odonates, and 2) is habitat representative of conditions within that reach. Field reconnaissance and results of the Aquatic Habitat Mapping Study (Study 7) and the Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study (Study 27) will help with site selection.

3. TARGET SPECIES

The RSP identified eight odonate species to be prioritized: *Gomphus abbreviatus*, *Gomphus quadricolor*, *Gomphus vastus*, *Gomphus ventricosus*, *Ophiogomphus rupinsulensis*, *Stylurus amnicola*, *Stylurus scudderi*, and *Progomphus obscurus*. These species are members of the family Gomphidae, and all were located along the Connecticut River within the project-affected areas during a prior study (Hunt et al, 2010). Larvae of these species are generally found in sandy bottomed stretches of rivers. Eclosing larvae are most often located along undeveloped, preferably steep or undercut, stream banks. Additionally, adults and emerging and eclosing larvae of all other odonate species incidentally encountered will be identified.

4. SITE SELECTION PROCESS

The eleven study sites were selected based on five criteria: availability of larval habitat, availability of eclosure habitat, geographic spread, continuity with Hunt et al (2010), and accessibility. Hunt et al (2010) qualitatively sampled ten sites within the study area. These sites included two in the Wilder impoundment, two in the riverine section below Wilder dam, three in the Bellows Falls impoundment, two in the Vernon impoundment, and one in the riverine section below Vernon dam. For continuity, nine of these study sites were retained for the current study (the third Bellow Falls impoundment site from the 2010 study was dropped). The additional two sites were selected, one in the Wilder impoundment, and one in the riverine section below the Bellows Falls impoundment.

Appropriate larval habitat for the target species consists of fine substrates (sand and silt), with steep, sparsely vegetated banks for eclosing larvae. This habitat type appears to be widespread throughout the study area. Study 7 (Instream Flow Study) mapped benthic substrates within the impoundments. Nearly all of the impoundments and many riverine sections had extensive sand/silt/clay components and the presence of sand substrates was confirmed prior to site placement. The specific study site locations shown on Figures 5.1 through 5.3 were selected based on the aerial imagery, contours, and aquatic and terrestrial habitat maps generated during Study 27 (Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study, draft report in progress). When possible, east-facing banks were selected as most odonates eclose in the early morning (Silsby 2001) and may select morning sunlight for rapid drying. For logistical reasons, when practicable, sample plots were placed in areas easily accessible from existing boat launches. In order to represent a broad range of operational effects, study sites were located at the northern and southern reaches of each impoundment, and in the riverine sections below the dams. Because of the greater length of the Wilder impoundment, an additional site was selected mid-way down the impoundment for more comprehensive geographic coverage.

In May 2015, the eleven sites will be visited to locate the 100-meter sample plots, and to select the five transect locations within each plot prior to the initial survey in June.

5. SELECTED STUDY SITES

5.1 Wilder Impoundment and Riverine Reach

Within the Wilder impoundment, two sites had been previously surveyed by Hunt et al (2010), and were determined to be appropriate for this study. The first site (Wilder Dam, Site 25-03) is located immediately above the hydroelectric station. The second site (Bedell Bridge, Site 25-01) is located near Bedell Bridge State Park in Haverhill, New Hampshire. These sites are located near the upper and lower reaches of the impoundment. A third site (Lyme, Site 25-02) was added approximately halfway between the upper and lower impoundment sites in Lyme, New Hampshire.

Two sites within the 17-mile riverine segment of below Wilder were previously surveyed by Hunt et al. One of these sites was at the mouth of the Mascoma River (West Lebanon, Site 25-04), and the other site was located on Hart’s Island (Plainfield/Cornish, Site 25-05). These sites are geographically representative of the riverine section, and both sites appear appropriate for inclusion in this study. Additionally, Hart’s Island is the only known location along the Connecticut River for one of the target species (*Progomphus obscurus*), and resurveying this location could provide valuable information.

5.2 Bellows Falls Impoundment and Riverine Reach

Within the Bellows Falls impoundment, three sites had been previously surveyed by Hunt et al (2010) and two of these sites were selected. The North Charlestown site (Site 25-06) is located near the northern range of the impoundment, while the southern site (North Walpole, Site 25-07) is located close to the Bellows Falls dam. A third site located at the middle of the impoundment (at Herrick’s Cove) was dismissed as the upper and lower sites will provide broader geographic breadth. No sites in the Bellows Falls riverine reach had been previously surveyed. In order to ensure coverage of the riverine section, a single site (North Westminster, Site 25-08) was placed approximately 1 mile below the dam.

5.3 Vernon Impoundment and Riverine Reach

Within the Vernon project area, three sites had been previously surveyed by Hunt et al (2010). Two of these sites were located in the impoundment and one of the sites was located in the riverine section below the dam. All three of these points appear suitable for inclusion in this study, covering a wide geographic breadth and areas within and downstream of the impoundment. The two points in the impoundment (Brattleboro/Chesterfield-Site 25-09, and Broad Brook-Site 25-10) are widely spaced within the impoundment, and both appear to provide appropriate dragonfly habitat. The project-affected Vernon riverine section is relatively short (approximately 1.5 miles), and the entire area had been previously surveyed. The specific location for this site is estimated to be on the Hinsdale, New Hampshire bank above Stebbins Island (Stebbins Island, Site 25-11).

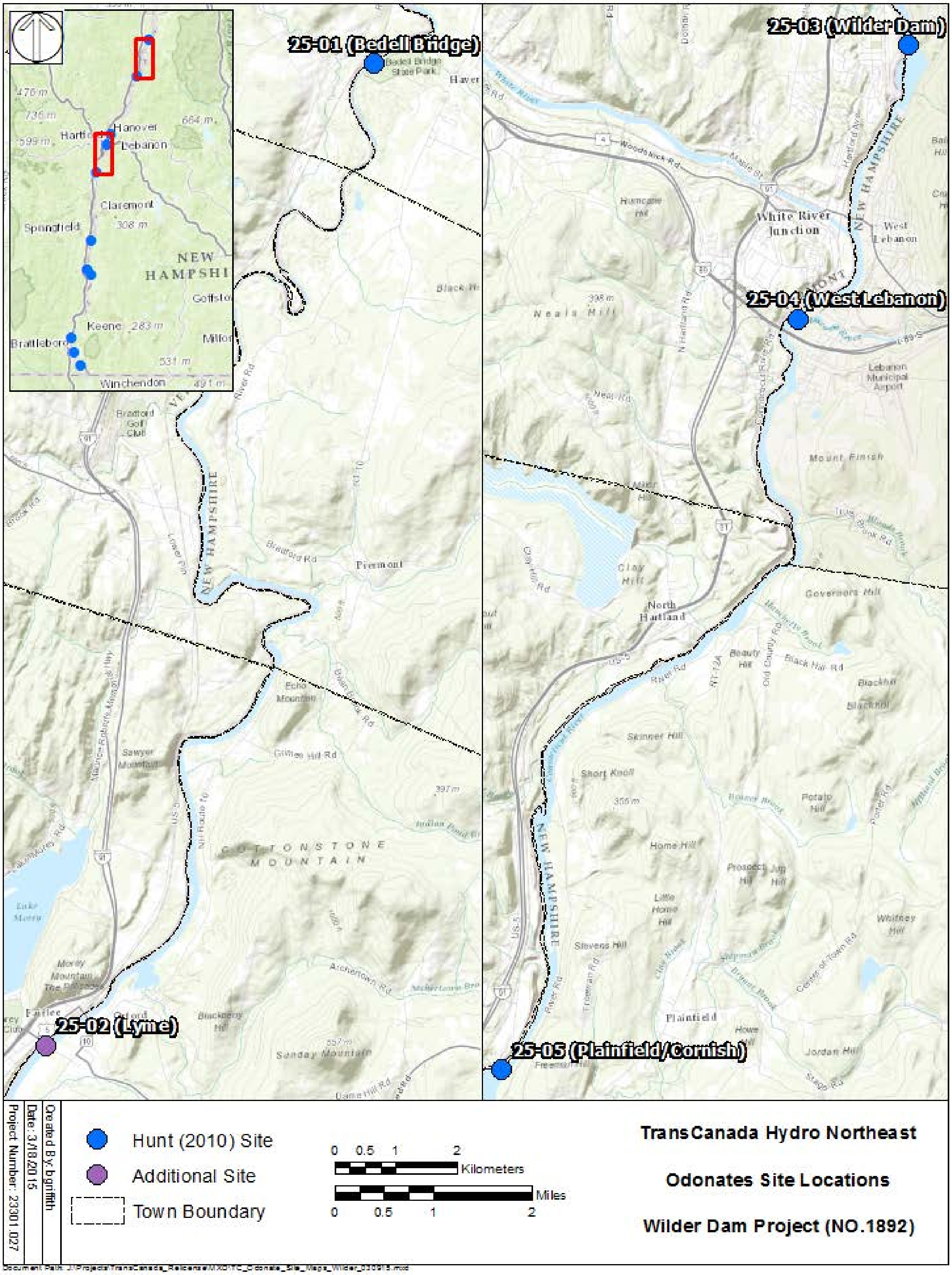

Figure 5.1. Location of odonate study sites in the Wilder Project.

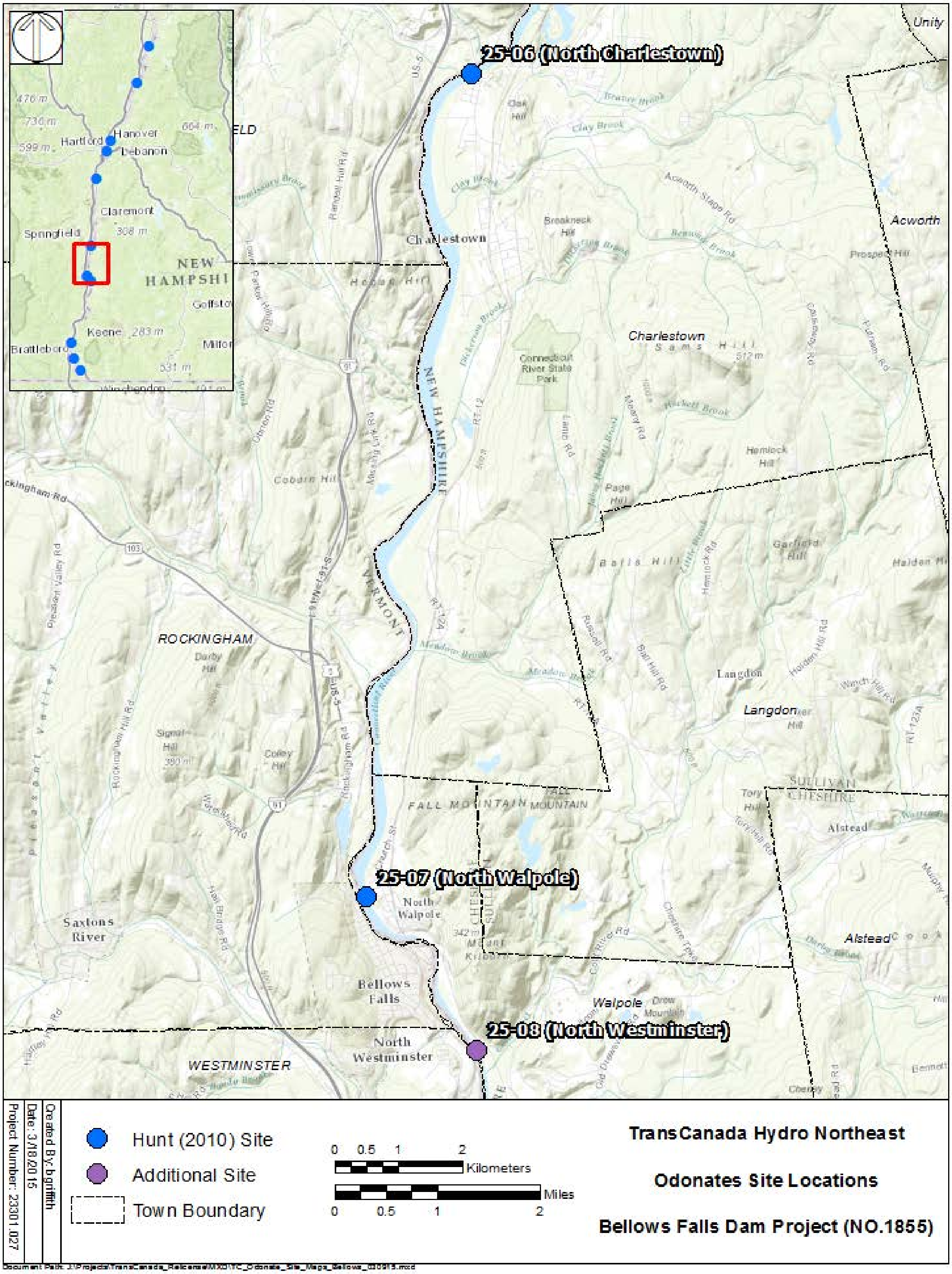

Figure 5.2. Location of odonate study sites in the Bellows Falls Project.

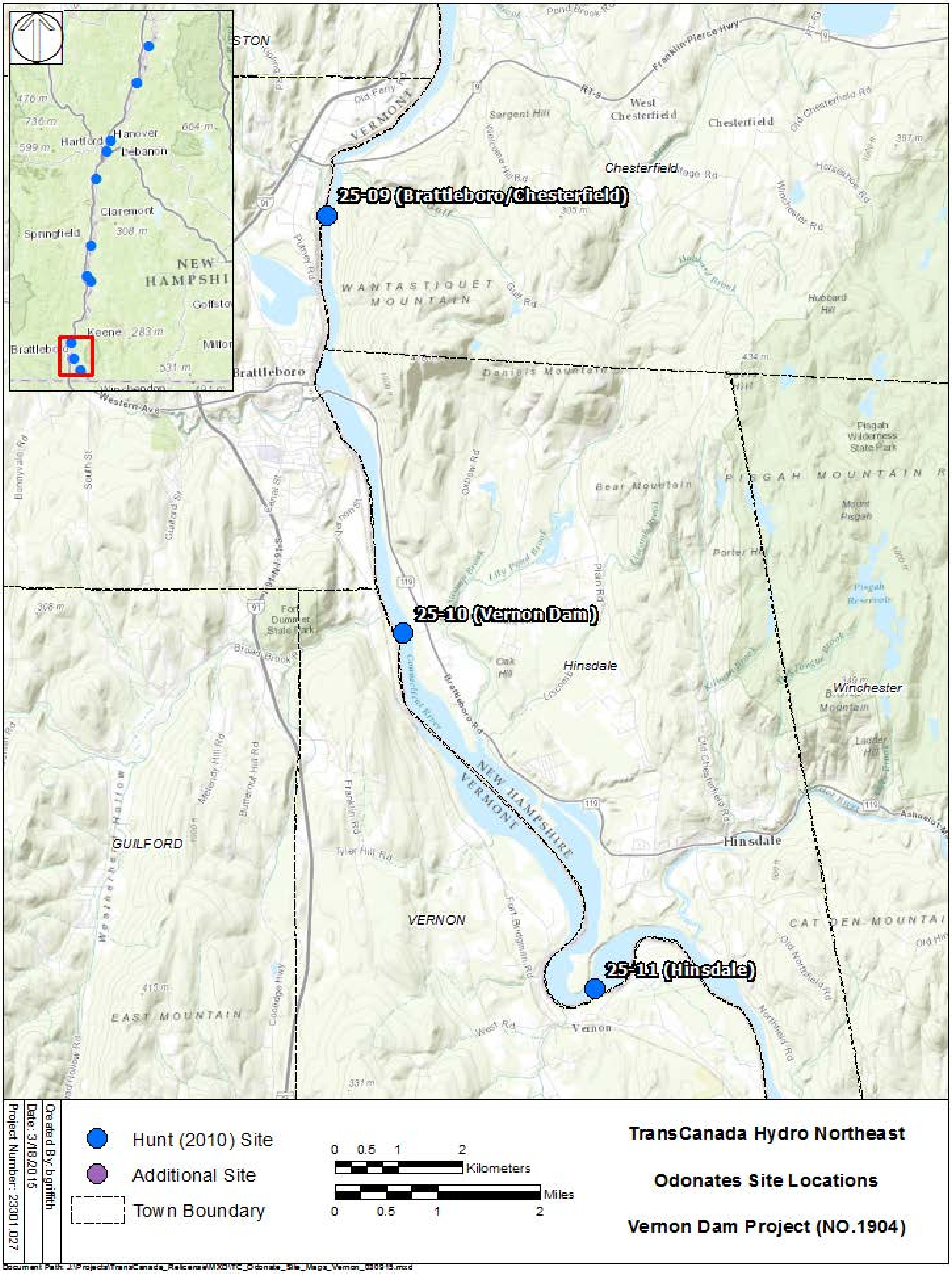

Figure 5.3. Location of odonate study sites in the Vernon Project.

Table 5.1. Study sites for Dragonfly and Damselfly Inventory and Assessment.

Site ID	Site Name	Study Reach	Previously Surveyed	Location (NAD83 UTM Z18N)	
				X	Y
25-01	Bedell Bridge	Wilder Impoundment	Yes	734406	4881080
25-02	Lyme	Wilder Impoundment	No	729044	4865060
25-03	Wilder Dam	Wilder Impoundment	Yes	717504	4839400
25-04	West Lebanon	Wilder-Riverine	Yes	715712	4834930
25-05	Plainfield/Cornish	Wilder-Riverine	Yes	710864	4822670
25-06	North Charlestown	Bellows Falls Impoundment	Yes	708693	4792900
25-07	North Walpole	Bellows Falls Impoundment	Yes	707040	4779940
25-08	North Westminster	Bellows Falls-Riverine	No	708789	4777540
25-09	Brattleboro/ Chesterfield	Vernon Impoundment	Yes	699779	4750060
25-10	Broad Brook	Vernon Impoundment	Yes	700985	4743480
25-11	Stebbins Island	Vernon-Riverine	Yes	703990	4737890

6. FIELD SAMPLING METHODOLOGY DETAILS

Odonate sampling methods will target mature larvae, pre-flight adults (called tenerals), and exuviae. The focus will be on those individuals that have emerged from the water, but there will also be an effort to collect pre-emergent mature larvae by sampling in near-shore shallow water. Basic methods will generally follow Morrison et al. (2006) and Hunt et al. (2010), but with a more quantitative approach. These methods are briefly described below:

- Five 3-meter wide transects will be placed within each of the eleven 100-meter-long survey sites. Transect locations will be determined during a preliminary field visit to maximize the likelihood of detection of eclosing larvae. The long axis of each transect will be perpendicular to the shoreline with the lower end at the estimated low waterline and the upper end terminating 1 meter into dense vegetation or at the top of the riverbank, whichever is less. The upper and lower ends of each transect will be recorded with GPS.

- Within each transect, biologists will thoroughly search for larvae, tenerals, and exuviae. Each individual that is found will be identified in the field (if possible) or put into its own uniquely numbered vial for laboratory identification. The following information will be recorded for each individual:
  - species;

- time when collected;
- surface from which it was collected; and
- horizontal and vertical distance from the observed waterline.

- For each transect sampled on each date, the following habitat information will also be collected:
  - evidence of recent versus current water levels; and
  - representative photos.
- In addition to the transect-specific data, biologists will also describe and photograph aquatic, riparian, and upland habitat along the entire length of the 100-meter sampling sites. For each sampling site, the following will be characterized:
  - types and percent coverage of soil/substrate;
  - types and percent coverage of vegetation;
  - percent coverage of large woody debris or other types of cover;
  - the height, slope, and relative stability of the riverbank; and
  - between transects, the sample plot will be qualitatively inspected for other emerging or eclosing gomphid larvae and exuvia.
- A water level logger will be installed in the vicinity of the survey site at a suitable location to be determined in the field, to ensure representative water levels. The location and elevation of the data logger will be recorded with a Total Station GPS. Water level loggers will be programmed to record in 15-minute increments and data will be downloaded during each survey visit. At each download, the data logger will be checked for functioning and replaced immediately if found to be malfunctioning.
- At each site and on each sampling date, an aquatic D-net will be used to capture larval odonates from a representative range of microhabitats, and the first 50 gomphid larvae with wingbuds captured will be preserved in alcohol for later identification in the laboratory.
- If gomphid larvae are observed in the process of emerging, their position, stage of eclosure, time, and distance walked from the first point of observation to the end of that survey period will be recorded.
- During D-net sampling, the relative abundance of larval odonate prey species captured incidentally, such as larval insects, crustaceans, and aquatic worms will be assessed in the field. Contents of each D-net sample will be poured into a white pan. Invertebrates within will be identified to order and classified using abundance classes as outlined in the rapid bioassessment protocol (Barbour 1999): absent (0), uncommon (1-3 organisms), common

(3-9 organisms), abundant (10-50 organisms), and dominant (>50 organisms).

- All adult odonate specimens will be identified to species either in the field or laboratory, as needed.

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