TransCanada
In business to deliver

US Northeast Hydro Region
Portsmouth Hydro Office
One Harbour Place, Suite 330
Portsmouth NH 03801

tel 603-559-5513
web www.transcanada.com

March 31, 2016

VIA ELECTRONIC FILING
Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Re: TransCanada Hydro Northeast Inc.'s Updated Study Report Meeting Summary Project Nos. 1892-026, 1855-045, and 1904-073

Dear Secretary Bose:

TransCanada Hydro Northeast Inc. ("TransCanada") is the owner and licensee of the Wilder Hydroelectric Project (FERC No. 1892), the Bellows Falls Hydroelectric Project (FERC No. 1855), and the Vernon Hydroelectric Project (FERC No. 1904). The current licenses for these projects each expire on April 30, 2019. On October 31, 2012, TransCanada initiated the Integrated Licensing Process (ILP) by filing with the Federal Energy Regulatory Commission ("FERC" or "Commission") its Notice of Intent to seek new licenses for each project, along with a separate Pre-Application Document for each project.

With this filing, TransCanada submits its March 17-18, 2016 Updated Study Report (USR) Meeting Summary for the three projects, as required by 18 C.F.R. §5.15(c)(3). The Meeting was held at TransCanada's offices in Wilder Vermont, with WebEx and call-in capability for participants who could not attend in person. Based upon scheduling consultation with FERC relicensing staff and previous selected dates for similar USR meetings for FirstLight Project No. 1889 and No. 2485, TransCanada's meeting was held slightly beyond fifteen days of filing the USR Study Report (ISR) as required by 18 C.F.R. §5.15(c)(2). The most recent USR was filed on March 1, 2016 in accordance the Revised Process Plan and Schedule for the ILP issued September 14, 2015 by the Commission.

The attached meeting summary includes a copy of the presentation slides from each day of meetings, meeting notes of discussion and questions and the list of meeting attendees..

If there are any questions regarding the information provided in this filing or the process, please contact John Ragonese at 603-498-2851 or by emailing john_ragonese@transcanada.com.

Sincerely,

John

John L. Ragonese
FERC License Manager

Attachment: Updated Study Report Meeting Summary

cc: Interested Parties List (distribution through email notification of availability and download from TransCanada's relicensing web site www.transcanada-relicensing.com).

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 Meeting Summary

March 31, 2016

TRANSCANADA HYDRO NORTHEAST INC.
UPDATED STUDY RESULTS MEETING
MARCH 17 – 18, 2016

The March 17 - 18, 2016 Updated Study Results meeting was held at TransCanada's Renewable Operations Center in Wilder, Vermont. The attendee lists for each day follow the meeting notes for each day.

After introductions, TransCanada summarized its proposed schedule for study reports. The proposal was filed with the March 1, 2016 Updated Study Report. Brandon Cherry indicated that FERC will issue official process plan in April, and stakeholders can file comments on that schedule/process plan. Summaries and discussion of all 33 studies then took place over the 2-day meeting.

Studies 1-3: Erosion Studies. John Field, Field Geology

Study 1 – Historical Riverbank Position and Erosion Study, report filed March 1, 2016: Mapping from 2014 was completed in late 2015 as part of Study 3. Re-photographs of sites were taken in 2015, resulting in 162 photo matches from historical to current. Historical photos were taken of erosion sites at the time, not of stable banks that may have eroded since. There are pitfalls in comparing data from different years (e.g., different individuals who mapped, different levels of effort, definitions of erosion at the time).

Study 2 – Riverbank Transect Study, report not yet filed: At 21 sites, 8 rounds of monitoring were conducted from 11/13 – 09/15. At each site, we monitored a single cross section only, which may not capture all erosion occurring at a site. We were able to get a sense of timing, pace and magnitude of erosion within each site. Of 21 sites, only 3 showed any recession at the top of bank. Several more showed material moving from mid-slope to toe of slope. The data is being analyzed now for inclusion in the study report.

Study 3 – Riverbank Erosion Study, report not yet filed: In 2014 we mapped about 250 miles of river bank and assigned categories for bank stability (these will be available in GIS). Erosion is a multi-stage cyclic process that can occur at different rates and with different multiple potential causes. Stakeholders had been concerned about "piping" and while there is some evidence of true piping, we believe that some people may be referring to notching and undercutting which is much more common in the study area than true piping which was < 1% of all banks in the study area. Overall, about 40% of banks are showing some type of erosion. Analysis is ongoing and includes potential impacts on erosion from tributaries, channel/valley constrictions, soil type, avulsions, etc. as well as project operations. We will look at the distribution of erosion in the study area relative to these factors.

Discussion:

Matt Carpenter: Will you look at adjacent (buffer area) land uses as part of analysis? Answer ("A"): We've already done riparian buffer mapping and that will be included in the study report (Study 3).

John Bruno: The USGS maps (in Study 1 report, appendix A) showed locations with and without erosion that seem to be different than what is happening now.
A: That study's maps only represented a 1958 – 1978 historic information based comparison. Study 3 will include more recent comparisons based upon our field work associated with this study.

John Mudge: Were the armored sites armored with or without the new geotextile fabric?
A: We are not sure in each case and there may be no way to know.

John Mudge: Study 1 characterizations were based only on 1958-78? How will that be included in Study 3, particularly the Lyme NH site? [John Ragonese: clarifies that Study 1 was based on historical data only. Study 3 looks at current conditions in the context of the historical information presented in Study 1.]
A: Yes, Study 3 will include 2014 data as well. That site in Study 1 was indicated as still stable in 1978. In 2014, we likely mapped it as armored since that had likely been done. If it hadn't been armored by 2014, it would have been mapped as de-stabilized. If the older data did not distinguish between stable and unstable because it had been armored, we don't have any way to tell now when the armor was placed (before or after 1958). All we can say is that it is armored today.

John Bruno: There is also a difference between engineered armor design vs. just dumping rock in a spot.
Eric Davis: The Study 1 presentation showed erosion by study area and impoundment (slide 6) but there are not tables in the report. Will that be included in the Study 3 report? It would be interesting to know what time of year each of the historical and current assessments were done.
A: Yes, we will provide that along with a thorough description of how erosion was mapped in comparison to how historical mapping was done, but there is very little description of how it was done in the past. To the extent that we have the information, we will include time of year in the Study 3 report.

Andrea Donelon: In Study 1, the aerial photos in Appendix B are interesting, I understand that you picked those sites because they had a lot of changes.
A: Study 1 included only 11 examples (Appendix C) and Study 3 will include more than we can present here.

Matt Carpenter: Are you looking at locations where recent armoring has affected erosion?
A: We could do that analysis, but if there is erosion near armoring, we cannot necessarily assign the cause as armor. We can conceptually describe why and/or how armoring can influence erosion but there is no peer-reviewed literature that documents that cause-effect relationship.

Ross McIntyre: Subsidence (e.g., in Lyme) would not necessarily show up on aerial photos. Subsidence could also be measured with laser level or even tying a string along a transect, better than aerial photos, to get better information.
A: We also had bank photos, not just aerial photos. Aerials would still show land surface even if they subsided. Mapping that we did should show it as eroding unless it was a long time ago. We can also use LiDAR which was flown as part of TC relicensing. NH is going to fly LiDAR for the whole Connecticut River basin.

Study 4 – Hydraulic Modeling Study, report filed March 1, 2016 - Lissa Robinson, GEI

Jim McClammer: Are your elevations in the model based on the LiDAR that TransCanada collected?
A: Yes, LiDAR and river bathymetry that was conducted as part of Study 7 (Aquatic Habitat Mapping). The model database links these two sub-databases. Both are very precise with LiDAR < 1 ft, and bathymetry about 0.1 ft.

Study 5 – Operations Modeling Study, report not yet filed – Semiu Lawal, Hatch

Melissa Grader: I couldn’t tell from the schematic (in the report) if the additional reaches were in impoundments/riverine or both?
A: Both. The number was selected because the model runs on an hourly time step. Routing analysis indicated how long it took water to move and then we selected the closest nodes to represent one-hour time frames between nodes.

Andrea Donelon: Slide 72 (FirstLight schematic). Does it make any difference to TC’s model that Northfield Mountain’s tailwater comes in upstream of Miller’s River?
A: No, the model schematic depicts the relationship between discharge at Vernon and the water elevation of the Turners Falls reservoir. The Miller’s is simply indicated as an inflow into the Turners Falls Reservoir system.

Andrea Donelon: Slide 73- is there a typo? Turner’s Falls operating range is 176 – 185 ft.
A: Correct, but the PAD stated that FirstLlight tries not to go below 179 ft. The model was constrained based on how FirstLight typically operates.

John Warner: Have you had conversations with FirstLight to verify?
Mark Wamser (representing First Light): Yes FirstLight and TC have exchanged information.

John Warner: TC included Northfield and Turners in your model, and you are just looking at what the Turners Falls constraints and backwater effects are?
A: The purpose was to add the Vernon riverine reach which wasn’t already in the operations model. We are trying to capture something we might do, within the

context of Turners Falls operation. TC will also want to evaluate what FirstLight's alternatives might be and how they might affect the Vernon riverine.

Mark Wamser: Slide 74, where physically is that [information presented] location?
A: At Turners Falls dam.

Bob Nasdor: Have you looked at different scenarios yet?
A: That happens after we get the operations model data to the resource studies and analyze that (as baseline conditions) as part of completing study reports (by mid-May timeframe). After that stakeholders can look at those reports and perhaps suggest operational changes. You can comment on those as you review study reports.

Matt Carpenter: If a minimum flow is identified for say, some spawning fish, can you go back and look at the 5 modeled years to see where it dropped below that flow?
A: We can put alternative constraints in the model and/or look at what the operation is now for comparison (e.g., flow duration curves).

Eric Davis: In the rule curve graphics, sometimes operations fall outside of the rule curve, what drives those?
A: For instance on the Moore rule curve (slide 67). These are not necessarily "hard" rules, more like guidelines. In some cases, there might have been a minimum flow requirement from storage that had to be met regardless of the operational rule curve guideline, but these are not physical constraints.

Study 6 – Water Quality Monitoring Study, report filed March 1, 2016 – Matt Burak, Louis Berger

Gabe Gries: We heard during studies 14/15 (in the October 2015 meeting) that visibility was poor, but that is very different from what your turbidity values would indicate.
A: Studies 14/15 mostly occurred prior to this study's work. Also, Study 6 monitors were deployed at 25% below the surface and in mid-channel vs. studies 14/15 which occurred at the surface in shallow areas closer to banks, in tributaries, and in backwaters.

Melissa Grader: Do you know if the dissolved oxygen issues in 2012 were from impoundment stratification?
A: Yes, there were periods of limited or brief stratification in some locations in 2012 and that information was included in the 2012 report. Results comparing 2012 and 2015 are in the Study 6 report.

Eric Davis: One of the primary goals was to determine how project operations affect water quality parameters. Other than the 10-day low flow period, project operations are left out of graphs in the report. For instance, temperature graphs don't show project operations. Could you break graphs down into monthly time periods and include project operations (in an appendix)? In the tables (e.g. 5.4-2) weekly means

are presented with weekly difference in mean temp between the up and downstream stations (forebay and tailrace). It would be helpful to know the maximum difference and % of time that the 1-degree change was exceeded, and as split out by generation and min flow periods (and spill). And VANR would like a copy of the raw data.
A: We will take a look at those requests and adjust the final report to the extent reasonable and will get VANR the raw data as soon as practical [data was emailed to VANR on March 18, 2016].

Study 7 – Aquatic Habitat Mapping Study, initial report filed Sept 2014 with ISR, final report filed March 2, 2015. No comments received.

Study 8 – Channel Morphology and Benthic Habitat Study, interim report filed March 2, 2015 – Mike Chelminski, Stantec

Lael Will: Have you evaluated or quantified embeddedness along the reaches (similar to slide 97)?
A: We have not yet, that is a good suggestion and we could include the difference between the two monitoring rounds. We will look into that and adjust the final report to the extent reasonable.

Studies 30 – 32, reports filed March 1, 2016 – Jot Spenda, Louis Berger

Study 30 – Recreation Facility Inventory, Use & Needs Assessment:

We discovered a typo in slide 104 (corrected in the version filed with these notes). Bellows Falls has 4 not 5 TransCanada recreation sites.

Tom Christopher: Did you characterize the portages as part of the study?
A: Yes, the study report includes that information - via interviews to the extent we could interview visitors and we looked at lengths of the existing portages.

Gabe Gries: What happens now with recreation? How do you decide what boat launches get improved or fixed, for example?
A: First we may get comments and suggestions based on the study report. Also, based on the types of interest and current/future uses – what opportunities will there be? The Recreation Management Plan (RMP) will be developed as part of license application. Sometimes those plans are filed as conceptual only and then get finalized later as part of new license compliance.

Brandon Cherry: There is a formal process as part of licensing for the public to comment on the RMP.

Bob Nasdor: How did you deal with the bypassed reach at Bellows Falls? How do you get at the question of need for additional river access there?

A: The study plan did not include the bypassed reach because there is no legal public access there, no recreational use of the bypass exists, and TC doesn't have ownership except at the fence line behind their N. Walpole office.

Gabe Gries: The study found that 43% surveyed wanted lower water level fluctuation and another 43% wanted about the same level of fluctuation.
A: We need to be very clear whether we are talking about flow vs. water elevation, and at what locations (impoundment vs. riverine), along with the user type expressing the opinion (e.g., fishermen vs boaters). The survey question was not related to specific visits but included the interviewee's general comments.

Andrea Donelon: The report evaluates all the campsites along the river, but doesn't include estimates of usage numbers of each campsite, yet Tables 7-2 to 7-4 had data on multi-day canoeists.
A: We did not try to estimate the number of users at all campsites, but we did spot counts and looked at log books at the campsites which may not reflect all usage. We also went later in the season and looked at wear and tear, footprints, etc.

Andrea Donelon: The Governor Hunt area was evaluated in both TC and FirstLight studies and TC's estimate of use is 30,000+ and FL's estimate was 1,800 or so.
A: Different methodologies were used with differing visit days/times. TC lumped together visitors to the fish ladder, through canoeists, etc. We recorded traffic data for the entire year, sent survey people out for spot counts and interviews, counted average group size and used a traffic counter, and extrapolated to the annual numbers.

Study 31 – Whitewater Boating Flow Assessment:

Bob Nasdor: What was the contribution from the White River and Ottauquechee to Sumner Falls? Is there any data addressing the typical contribution of those sources on a monthly basis?
A: The flows at the time of the study are included in the report. Longer term data is available from the USGS stream gage. We will look at providing additional flow data.

Bob Nasdor: Thanked TC and Berger for a well done study and all the effort that went into the study's work. Question related to "optimal" flow not being a flow that was boated.
A: We used data from two different questions on the survey where people could report optimal flows that weren't boated as well as boated flows.

Tom Christopher: Also thanked TC and Berger, and stated that the study shows that these areas are boatable if, in the case of Bellows Falls, the barrier dam was removed. He also expressed interest again in a whitewater park at Bellows Falls.

Eric Davis: The models include a lag time and the whitewater report included a 2-hour lag time from the USGS gage in W. Lebanon to Sumner Falls. The report says a noon release from Wilder would create a peak more than 2 hours later.
A: The whitewater study didn't really quantify the time lag, but it ought to match up pretty well, and we observed the flows increasing in that time interval. Relatively speaking it is in that range of ~ 2 hours to stabilize (rather than just arrive).

Bob Nasdor: What was noteworthy about Sumner Falls was that there were different features that provided varying levels of enjoyment at different flows.

Study 32 – Bellows Falls Aesthetic Flow Study:

Videos should have been filed with the study report and will be filed with FERC, and we can also provide DVDs if stakeholders want them.
No questions or comments on this study.

Studies 25 – 29, reports not yet filed except for Study 27 filed September 14, 2015: Sarah Allen, Normandeau

All of the terrestrial studies are in the project effects assessment stage using output from the Operations Model. Otherwise there is nothing new to report on them.

Study 25 – Dragonfly and Damselfly Inventory and Assessment
Study 26 – Cobblestone and Puritan Tiger Beetle Survey
Study 27 – Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study
Study 28 – Fowler's Toad Survey
Study 29 – Northeastern Bulrush Survey

No questions or comments on any of these studies.

Study 19 – American Eel Downstream Passage Assessment, report not yet filed: Doug Royer and Steve Adams, Normandeau

Slide 145 was revised after the meeting to make corrections (24, and 44 eels available from Wilder and Bellows respectively that were monitored at Vernon) and to add the number of eels that passed each project (45 of 50 passed Wilder, 93 of 98 total from Bellows Falls and Wilder passed Bellows Falls, 112 of 188 total from Vernon, Bellows Falls, and Wilder passed Vernon).

Alex Haro: Since fish came from out of basin, there has been a concern that they would actually move downstream. Can you give a general impression of movements after release and temperature/flows in general?
A: Travel times were relatively short, and most fish passed the projects. Perhaps 2 of 50 released at each project did not pass.

Matt Carpenter: From Wilder 28 got to Bellows Falls and 24 got to Vernon. Do you know what happened to those fish that were not detected?
A: The purpose of the study was to look at passage at each project individually, not cumulatively, so fish were not tracked from dam to dam.

Alex Haro: Can you describe the quarantine process and shipment? I understand they were shipped on ice.
A: Quarantine was 30 days in each lot and a total of 60 fish were subjected to pathology testing. Once pathology reports were received, fish were flown, then trucked within 24 hours to the sites, and then received one or more days of onsite acclimation. There was some mortality in transport.

Matt Carpenter: Can you give us an idea of survival?
A: Survival was very good through Francis turbines, worse through Kaplans. Bellows Falls survival was very high. The issue at Unit 3 at Wilder, is that it provides the attraction water to the fish ladder via a stilling well/basin that may have a grate in it, that wasn't well understood in advance.

Study 20 – American Eel Downstream Migration Timing Assessment, report not yet filed: Doug Royer, Normandeau

Lael Will: During the fish passage monitoring (Study 17) if any adult eels were seen going downstream those should be included in this evaluation.
A: While we could distinguish relative size of eels going downstream in Study 17, we could not discern if those were silvered and actually migrating, or not.

Bill Connelly: Are you planning on filing this report by May 15?
A: Yes but pending some FirstLight information from their first year study (not both years). Our study plan says we'd file a supplement if FirstLight's data isn't available.

Alex Haro: I have some downstream timing data that could be added.
A: We'd be happy to receive that and incorporate it as applicable.

Study 11 – American Eel Survey, report filed March 1, 2016: Drew Trested, Normandeau

We note that the study report conclusion section says 1,551 eels passed upstream at Vernon (net number) via Study 17. The final net upstream number was 1,545. The Study 11 report was written before Study 17 final numbers were as a result of re-analysis of some data.

Gabe Gries: Were there any eels that were observed but not caught?
A: No, we only observed those 3, and caught all of them.

Gabe Gries: The study variance in the report noted that portable efishing samples were done during the day due to safety concerns, but those constituted a large percentage of samples.
A: At other projects, we have done a lot of efishing during the day and have seen lots of eels. There could be a small difference, but we don't believe that impacted study results.

Lael Will: Are you going to include the Study 17 results in this study?
A: We mentioned Study 17 results in the study report, but this report is a survey only. Study 17 is a "gateway" versus a broader geographic survey.

Alex Haro: To Lael's point – there are a lot of eels coming up the system and passage has improved at Holyoke so that in the next 10-20 years we would expect densities to increase over time.

Matt Carpenter: Were the tributaries open or did they have barriers, etc?
A: They were the larger tributaries and we tried to survey throughout the project-affected tributary reaches.

Matt Carpenter: The study proves eels are at low density, although they could be located throughout the basin. In the past NHFGD looked for eels just below the barriers in tributaries but in this case, those are outside the project area.

Study 21 – Shad Telemetry Study, report not yet filed: Doug Royer, Normandeau

Bill Connelly: Were trawls done at the surface or obliquely?
A: It depended on conditions, and could be from surface to about 10 feet deep. The majority were surface to 1-2 ft deep since water current kept the nets higher in the water column.

Melissa Grader: If you didn't identify splashing, how did you identify spawning locations?
A: We tracked the tagged fish to the spawning areas.

John Warner: slide 165 says "shad eggs were collected in all study areas".
A: Yes, study area meaning where tracked shad were found spawning. There were no pre-selected study areas for the spawning portion of this study.

Alex Haro: Going back to the telemetry through the fishway – was the assumption if fish reached the window that they made successful passage, because there is <100% efficiency in the upper portion of ladders.
A: All radio tagged fish that passed the window eventually exited the ladder based on receivers upstream of the exit of the ladder. That will be in the report [slide 161 edited to read "and passed upstream of the fishway."]

Study 22 – Downstream Migration of Juvenile American Shad at Vernon, report not yet filed: Chris Gurshin, Doug Royer, Steve Adams, Normandeau

Melissa Grader: The 6-8 meters shown is the distance off the bottom, does that correlate to the bottom of the louvers?
A: Yes

Bill Connelly: Regarding position in beam (slide 178), each “blob” is part of a single school or is each blob a school or group?
A: the echogram showing angular position in beam coded on color scale. The outlined "blobs" represent schools of fish and the shift from red to blue and vice versa indicate movement in and out of beam in a north-south or east-west direction.

Bill Connelly: Did you do automated or manual data review?
A: We first looked at volume backscatter as a relative acoustic index of shad abundance, which was easily processed via automated routines. We found that peaks in backscatter associated with weather and high flow events made it difficult to distinguish from peaks due to fish runs. As a result we began manually classifying echogram regions as schools by first sub sampling and bracketing the time series to describe shape of the time series signal representative of schooling fish. We are in the process of finishing processing and filling in the gaps.

Alex Haro: If fish passage was proportional to flow, did most fish go through the turbines?
A: Yes, generally.

Melissa Grader: If untagged fish were staging and the tagged fish moved quickly, what does that mean? Were those tagged fish behaving differently?
A: Keep in mind that hydroacoustics monitored 24/7 during the study period. Tagged fish were put out in evenings, which is when the literature tends to indicate they are migrating, which maximizes the potential that they won’t stage and also to minimize predation.

John Ragonese: Your release groups included untagged fish and what was that size?
A: Roughly 20 – 30 more fish in each group.

Matt Carpenter: Did passage routes include each unit?
A: No, we monitored units 1-4 as a group, units 5-8 as a group, units 9-10 as a group to get relative proportion.

Study 23 – Fish Impingement, Entrainment, and Survival Study, report not yet filed: Drew Trested, Normandeau

Alex Haro: I assume for some species you might not have swim speed data?

A: That is correct. We are using a surrogate with comparable body size and similar life history characteristics, to supplement the information that we do have.

Study 33 – Cultural and Historic Resources Study, portions have been filed, portions not yet filed: Suzanne Cherau, PAL

Scott Dillon: Vermont SHPO will provide comments on the phase 1B report and phase 2 scope of work proposals you filed. Based on a brief look, it seems that landowner permission was lacking especially those with erosion.
A: We tried different methods to reach landowners (certified letters, phone calls, etc.). We got a lot of response through accepting the letter but not contacting us back with permission. This is not surprising to TC, our land agent has made a number of efforts to meet with them. It was a systematic process we used.

Scott Dillon: We will look at the report information and will have comments on that.
A: We may want to revisit sites in a Historic Properties Management Plan.

Frank Winchell: FERC did talk with the Narragansett Tribe and they want FERC to give them authorization to get back with TC. So continue to try and make contact with them. I understand that you've done due diligence in trying to contact them.
A: Since then, nothing has happened with regard to the tribe.

Frank Winchell: There is interest in sacred stone landscapes/features. We still want that kind of setting to be documented, whether it is colonial, historic, or cultural.
A: We're doing the best we can, but we're not marking 250 miles of stone walls, however, we are trying to identify those elements that would be important to tribes.

Brandon Cherry: FERC will need to wait for the reports to see what might be needed.

John Ragonese: Friday 03/18 meeting: We will pick up with studies not covered today as planned (10, 12, 16, 17), then the studies planned for tomorrow: 13, 18, 9, 24.

March 17, 2016 meeting attendees, including those who identified themselves on the telephone/WebEx:

Name	Affiliation	Name	Affiliation
Bill Connelly	FERC	Scott Dillon	VT SHPO
Brandon Cherry	FERC	Andrea Donelon	CRWC
John Baummer	FERC	Chris Yurek	CRWC
Steve Kartalia	FERC	Owen David	NHDES
Frank Winchell	FERC	John Ragonese	TransCanada
Nick Ettema	FERC	Jen Griffin	TransCanada
Gregg Comstock	NHFGD	Erin O'Dea	TransCanada

TRANSCANADA HYDRO NORTHEAST INC.
UPDATED STUDY RESULTS MEETING
MARCH 17 – 18, 2016

Name	Affiliation	Name	Affiliation
Jim Kennedy	CRJC	Pat Mock	TransCanada
Jim McClammer	CRJC	John Field	Field Geology
John Bruno	CRJC, landowner	Lissa Robinson	GEI
Jeff Crocker	VANR	Stu Bridgeman	Hatch
Eric Davis	VANR	Semiu Lawal	Hatch
Bob Nasdor	American Whitewater	Mike Chelminski	Stantec
Tom Christopher	NEFLOW	Bernward Hay	Louis Berger Group
Nora Doyle-Burr	Valley News	Matt Burak	Louis Berger Group
Lael Will	VTFWD	Jot Splenda	Louis Berger Group
Gabe Gries	NHFGD	Sarah Allen	Normandeau
Matt Carpenter	NHFGD	Drew Trested	Normandeau
John Mudge	Landowner	Steve Adams	Normandeau
O Ross McIntyre	Landowner	Charles Soucy	Normandeau
John Warner	FWS	Doug Royer	Normandeau
Melissa Grader	FWS	Chris Gurshin	Normandeau
Katie Kennedy	TNC	Steve Leach	Normandeau
Alex Haro	USGS	Jen Bryant	Normandeau
Kevin Mendik	NPS	Maryalice Fischer	Normandeau
Mark Wamser	Gomez & Sullivan		

Friday March 18, 2016 - Summaries and discussion of studies continued.

Study 16 – Sea Lamprey Spawning Assessment, interim report filed March 1, 2016 : Steve Leach, Normandeau

Lael Will: You were able to positively identify redds in August?
A: Yes, they were quite recognizable in August.

Gabe Gries: For some of the spawning studies (studies 14/15), for say fallfish nests, you used 0.5 ft or 1.0 water depth to cover a nest [clarification by Mark Allen – we only used that if an adult was guarding the nest.]
A: In this study, we kept it at the elevation of the nest. Also we looked at May 15 – July 15 season conservatively, we looked at passage, water temperature, and when we saw no more evidence of spawning.

Lael Will: You are confident that the May-July period covered the entire incubation period?
A: Yes, from water temperature and the literature, that is supported. We suspect that fish would have had to spawn by the first of July, so we figured a 2-week gestation period. We could look at extending the period of analysis. There would not have been lower water since the operations wouldn't have changed from the earlier to later time period.

Gabe Gries: Percent of time exposed, e.g., 25.3% what does that refer to?
A: 25.3% of WSE observations based on the nearest water level logger (from studies 14/15) period of record, not necessarily the entire study period. We are also reporting frequency and duration.

Gabe Gries: You could add # of hours.
A: That could be included in the final report and the same thing will happen with output from the Operations Model

Melissa Grader: With regard to the geodata, each point is a nest?
A: Yes.

Melissa Grader: How coarse is the habitat data since some sites show up as sand/silt/clay in the goedata background?
A: It could be that the bathymetry/riverine mapping was done at a different time of year than the LiDAR so the terrestrial/water line doesn't match up correctly in the geodata. [Jen Bryant clarified that what we are seeing on the screen at the meeting is Arc Desktop with more capability to show than Arc Explorer.]

Gabe Gries: 26% of sites with "moderate" project effects, includes sites with no nests?
A: No, upon evaluation of no evidence of spawning, we assumed no project effects.

John Warner: “No project effects” at 10 sites does that mean no habitat or no nests? Suitable habitat is suitable habitat regardless of whether there is a nest. We need an understanding of project effects at the suitable habitat.
A: That is more appropriate for the habitat studies (e.g., Study 9 - Instream Flow). If we were to add a lot of lamprey to the system, would they spawn at all the available habitat? We are not assessing project effects on spawning potential or habitat, we are only assessing project effects on what we observed for spawning.

Lael Will: Part of the study was to locate suitable habitat. You should break out suitable habitat vs not suitable, etc.
A: Understood, we will clarify that in the final report.

Gabe Gries: The 2nd goal of the study was to assess if the projects affect success of spawning. So where do we go from here?
A: That goal wasn’t met, we were unable to assess that due to nest caps silting in. Because we didn’t collect ammocoetes doesn’t mean spawning wasn’t successful. Collection incidental to other studies also provides some data. We will discuss it in the final report. It may be that we pull in more data from other studies, operations etc. In general, there is no evidence either way. We based the study goal on a method that we thought would work, and it didn’t (the nest capping) so we don’t have an answer.

John Warner: Some of this may be unnecessary for this study if the instream flow study (Study 9) tends to agree with this study. If not, we may need to look more closely.
A: Yes, we agree about Study 9. For this study’s interim report, periods of exposure assume that the nest was occupied throughout the whole season, which we feel is a conservative assumption.

Lael Will: With all these studies, there is a theme of “if a fish went outside of project-affected areas” it is not included in analysis. How was that determined in the field, I am not seeing a clear description in the study report.
A: One of the earlier studies had established the project extents into the tributaries. For the resident spawning (studies 14/15), we had a map of approximate project WSEs, we also looked at vegetation lines, and water level logger data that didn’t show any diurnal changes in WSE (which would result from project ops). We can clarify this in the reports.

Gabe Gries (on behalf of Matt Carpenter): Can you use the hydraulic model or habitat studies to supplement?
A: The hydraulic model doesn’t accurately depict water elevation in backwaters if there is a restriction (e.g., culvert) and doesn’t account for tributary elevation.

Gabe Gries (Matt C.): Which sites seemed to be most important in terms of spawning success?

A: Lamprey go to where lamprey are. This suggests that lamprey spawning sites, particularly due to repeated use, are productive.

Andrea Donelon: Downstream of Vernon the FirstLight study said they found 7 nests and capped them. Was there any coordination of effort between TC and FirstLight?
A: We communicated but did not coordinate directly. FirstLight's nests that they capped would not have overlapped with ours, but they could have assessed the same nests.

Based on a comment, slide 10 first bullet was clarified that 4 sites were determined not to have suitable habitat (4/23 = 17%) and no spawning activity (including nest presence) was identified for 3 sites (3/23 = 13%). The final report will be clarified as well.

Study 17 – Upstream Passage of Riverine Fish Species Assessment, report not yet filed: Steve Leach, Normandeau

Gabe Gries: For the upstream vs downstream counts, how much of those are the same fish going back and forth? Are fish using the ladders to not only go up, but also down?
A: Yes, net downstream would indicate more fish went downstream overall.

Katie Kennedy: Then the net value is not the true number.
A: That is correct, but it is the best metric we have.

John Warner: At places where we actually trap fish, that activity restricts movement too. If you changed the orientation of gates at the counting windows, would that change?
A: Some of that crowding is intended in order to move them through the window. The same thing could be occurring throughout the ladder, we just don't know.

Lael Will: Do you have the click history data for all species?
A: Yes we do. The "other species" category includes mostly channel catfish, and could also indicate poor viewing times due to turbidity, etc.

Melissa Grader: For shad, is there delineation between juveniles and adults?
A: We will have to follow up with the techs who did the counting on that.

Lael Will: How about silver eels?
A: The problem is "silver" we can't tell that, we can only tell size not maturation.

John Warner: The FWS inspection to Wilder saw entrance issues, pool imbalances, perhaps debris etc. that might impede weaker swimmers. FWS wants to come back this year before startup of ladders in the spring. Vernon had been assessed and

modified. Bellows had not been assessed. The issue would be whether or not the ladders were operated efficiently enough to pass fish as Vernon does.
A. Wilder is an automated and complicated system. After that inspection in the fall, we shut down Wilder briefly (to be in the report) and found it full of debris, not so much operational issues. The ladder had been running continuously pulling debris off the water for months. In hindsight, we could maybe have done more inspections/cleaning during the study. All the operations were fine and the ladder had been cleaned and inspected prior to the season. Not every bay was off balance, indicating debris rather than operations. If we were to run the ladders year round, they would collect debris and need to be cleaned often. It is not cheap to shut them down as they are all confined spaces, etc.

Study 18 – American Eel Upstream Passage Assessment, report filed March 1, 2016: Steve Leach, Normandeau

Based on comments, slide 65 was updated to clarify the single eel observed in the dewatered Wilder fish ladder and “most Vernon eels” changed to just the 49% value.

Melissa Grader: Does this data (on slide 65) include study 17 counts of sizes?
A: No, but the report includes information from Study 17.

Gabe Gries: Is Site 4 at Bellows Falls above or below the fish barrier dam?
A: It is well below the barrier (as shown on the GIS map projected during the meeting). The barrier was an unsafe location, and had too much flow going over it.

John Warner: In the study conclusions, do you think your assessment techniques were sufficient to find eels if they were going to some of those locations but you didn’t see them?
A: Yes we do think our assessment techniques were sufficient. We did a very systematic assessment modified by safety concerns at all three projects. We never expected to see much at Wilder or Bellows.

Eric Davis: Study 17 numbers are much higher than Study 11 or Study 18 numbers, suggesting that there are more than were found in surveys.
A: That may suggest that they are moving out of the project area once they pass the fish ladders.

Gabe Gries: In the deep channels at Stebbins Island, you can find large eels.
A: This study was looking at the areas just below the dams.

Gabe Gries: Where do we go from here? Keep fish ladders open all year, or find aggregation points?
A: We need to identify the best aggregation points to determine passage needs and feasibility.

Eric Davis: The two study objectives were to identify points of congregation and install ramps. With the fishways operating, would there be points of congregation if the fishways were not operating?
A: We responded to study requests. The fishways are operated by requirements. It is up to agencies to tell us what you want done, and we can consider it. The luxury is we don't have to do it on April 1 or at today's meeting, due to the later season.

John Warner: If the ladder was not going to be operated for resident species, then a separate eel ramp would be needed, maybe inside the fish ladder or an alternative eelway.
Eric Davis: We know that both eels and residents used the Vernon ladder.
A: We might not agree that the Vernon fish ladder needs to be run for residents, do they need to pass? Do residents even need attraction flows – if so, how much flow? And how does that relate to eels? The ultimate goal is eel passage and we may or may not be running the ladder to accomplish that. It may be an eel trap, count, etc. Agencies should provide ideas to us.

Study 9 – Instream Flow Study, interim report filed March 1, 2016: Steve Eggers, Normandeau

The Chase Island 2D model is now calibrated and ready to run (not included in interim report but will be in final report). We are interested in habitat time series and dual flow analysis: how many species and which life stages should be modeled, across 5 hydrologies (operations model years) and flow combinations.

John Warner: There are different ways to depict the data (graphics), the plan views and threshold graphs are not in the report. What type of process is there to get to those for review?
A: Agencies don't have an existing preference?

John Warner: I don't personally.
Katie Kennedy: I like both thresholds and plan views.
A: Best to use a digital platform rather than in the report in pdf, so that you can flip through and see the changes.

John Warner: With regard to which species and life stages, agencies can think about that.
A: We should plan a series of discussions/meetings after report has been reviewed to move ahead.

Katie Kennedy: As part of that you could look at the USGS sustainable yield estimator (available free online). I would like to see the "natural regime" used to provide a frame of reference for comparison of potential resource objectives to come up with alternatives.
A: The baseline and frame of reference is not the natural regime, it is current operations.

Eric Davis: Even in a natural flow regime, habitat won't be optimized at all points.
Katie Kennedy: The instream flow model may show an optimal habitat at a flow for a species/life-stage within relevant time constraints. It assumes optimal habitat is available 100% of the time during that period, when in reality it would fluctuate and would not be optimal 100% of the time.
A: If the natural regime didn't have that habitat then the species wouldn't be supported at all.

Jim McClammer: Clearly the river is an artificial system. We don't have data on the natural regime so there is no point of comparison with the natural regime. It comes down to which species and life stages are important, and which are we going to operate the projects for, and optimize flows for.
Katie Kennedy: I'm trying to develop some compromise solutions so that we don't over-optimize.
A: We need to focus on the direction in which we are currently going and the needs we have now to move along with this study.

John Warner: Probably after April 30. We expect to have comments and will caveat that there is more discussion needed.
A: This report/study is a work in progress. If there are things we can do between now and then that would facilitate the process, then we should discus those.

Jeff Crocker: One thing would be riffles – there are few and they are the most sensitive – could those be pulled out separately from runs and see those suitability curves?
A: We can do that for discussion purposes as well as in the final report.

John Warner: Also the thresholds and plan views. Thresholds could be different (e.g., 0.75 vs 0.5 as shown).
A: That can be done interactively in SEFA, can change thresholds etc.

Eric Davis: Do CSI graphs (plan views) include all life stages and species?
A: No, they include the 3 variables (depth, velocity, substrate).

Melissa Grader: What is the orientation of the transects?
A: Transects run from upstream to downstream and we can add the actual transect names (pool, glide, etc.). The transects show the weighting of habitat – width on the graphs are wetted width based on flow, height of the graphs are based on weighting.

Study 24 – Dwarf Wedgemussel and Co-occurring Mussel Study, Phase 1 and Phase 2 reports previously filed: Ethan Nedeau, Biodrawversity and Mark Allen, Normandeau

Katie Kennedy: What were your criteria for determining who was an expert?
A: There aren't that many and they were all contacted for the most part.

Melissa Grader: will the report include the individual responses?
A: We have all those documents and could provide them in an appendix to the final report.

Study 10 – Fish Assemblage Study, report filed March 1, 2016: Drew Trested, Normandeau

Melissa Grader: What if you selected by mesohabitat type rather than substrate?
A: Using substrate we made sure that all substrate types were represented.

Gabe Gries: I would like to see species lists by reach, sample location, etc.
A: That information is in Appendix G of the report.

Melissa Grader: Can you provide geodata by site with catch list?
A: The raw data is in the report appendices in Excel, we'd rather not spend a lot of time creating that information in GIS, since people may want different information at different sites.

Gabe Gries: Can you do a combined over all seasons CPUE/CPUA?
A: Yes we can do that in the final report or provide it to agencies.

Gabe: Were gill nets used during day or night?
A: We did 2-hr night sets for gill nets.

Gabe Gries: Why were only 3 backwaters sampled?
A: We first randomly picked map units. Then from the whole list of tributaries and backwaters (developed as part of study 13), if any of those landed within the map unit, we sampled in those.

Gabe Gries: Matt Carpenter wants to come and look at the bridle shiner and other uncommon species that were preserved.
A: Yes, he is welcome to come to Normandeau's Bedford NH lab and view them anytime.

Gabe Gries: Why did you have only one netter in a boat? The study plan said netters (plural), but the study used only one and based on NHFG work we have used two netters.

A: Yes, we only had one scap netter in impoundments for boat efishing, and we kept that consistent throughout the study.

Lael Will: Can you present more of the data graphically? Any plans to look at fish species composition in depths of sample?
A: Yes, we can look at depth. We will see if the data can be provided graphically.

Study 12 – Tessellated Darter Survey, report filed March 1, 2016: Drew Trested, Normandeau

Katie Kennedy: Did you use habitat mapping for substrate classifications?
A: No, we used diver observations for substrate types and then we lumped sand, silt, and clay together.

Katie Kennedy: You did SCUBA/ snorkeling rather than electrofishing or benthic trawling?
A: Yes, we had originally proposed a couple of methods, but then wanted to keep a consistent method.

Study 13 – Tributary and Backwater Fish Access and Habitats Study, report filed previously: Drew Trested, Normandeau

Gabe: Where did the 12 hours per day come from?
A: We had to start somewhere. The idea behind it was that there is daily fluctuation, but rather than have a longer than 1-day window we looked at it within a sub-day range. This provides for at least half of each day of access during the spring.

Lael: Would it be a big deal to put a logger at CT-W-1.59 in the spring to ground truth?
A: The 2014 data is ground truthed. We don’t have a different operating regime in the summer/fall vs in the spring outside of high flows beyond generating capacity.

Eric: There is a disconnect between the field data and predicted model WSE data. Field data indicates access (e.g. at site W-1.59).
A: Yes, in this site example the model doesn’t match the field measured data since the model doesn’t cross exactly at the backwater and also doesn’t account for the culvert. Do you agree that this site is not a problem for access?
Eric: Yes.

Gabe Gries: Can you get us something? A copy of the presentation, or a write up for the approach?
A: Yes we can do that.

Gabe: The only other thing we had commented on in the report before. We had talked about the < 0.5 ft and TC had added the 25% of the time. NHFGD and VANR suggestion was if it is < 0.5 ft at any point you should look at it more.

A: Understood, and the actual percentages of time for each site during the field study is included in the report (table 6.1-3).

Studies 14/15 – Resident Fish Spawning, interim report filed March 1, 2016: Mark Allen, Normandeau

Lael Will: What was the approach you used for looking at WSE vs incubation period? For white sucker you'd start at that point in time and work forward vs for some species you might work backward in time. We want to understand the approach for white sucker.
A: In the report, we state that based on the water temperature before and after we had the observation, and given that range, how long we would expect the egg incubation to go.

Gabe Gries: can you be more specific on angling?
A: The goal was always to visually observe nests/spawning. We started to employ angling and we saw pike/pickerel but never saw any groupings that looked to be spawning. We used lures to try and capture ripe adults in case we were missing spawning. We caught one ripe one and unripe ones.

Lael Will: Do you feel you were a little too late for pike/pickerel?
A: The periodicity figures in the report illustrate this. We weren't out at the very beginning when pike/pickerel spawn but we didn't miss the spawning period based on temperature range. And we did catch a few larger pike. We went based on literature temperatures.

Gabe Gries: The report mentions perch egg dewatering for "several hours", what is that time period based on other than professional judgment?
A: We could pick a criterion, but we kept it purposely ambiguous because we don't know if there is a critical time period or what that is. No literature reference was found.

Lael Will: In the report you took 2 elevations of perch egg masses in some cases and then took the mean. It would be more conservative to use only the upper elevation and you'd want to be consistent to do that.
A: Only one of the four crews took two elevations, the others took only the upper elevation. We can modify that analysis.

Lael Will: For the incubation period based on temperature, graphs show 50% of incubation time before/after egg observation, but not knowing exactly when a fish spawned, you could be contracting the overall time period, and you may need to start the clock when you first saw an egg.
A: We could modify it by looking at the incubation time based on temperature. In most cases it won't make a difference, and keep in mind the early time periods were mostly high flows.

Gabe Gries: I have seen black crappie spawning in lakes at 2-4 ft of depth. In terms of reasons why you may not have seen them: the crappie fishery in Hinsdale and at Hunts and Retreat meadows is phenomenal in the spring. Both this winter and last winter on the north side of causeway, there were schools of 100's to 1000's of black crappie. But I understand the visibility issues in the study. Gear bias as well, angling using lures, etc. I'm not surprised that the numbers of black crappie were low given these aspects.

Lael Will: For fallfish, you took elevations at the mound bottom and project effects was based on WSE at the base of mound, maybe it needs to be 6 inches above or some buffer.
A: We only found one reference that fry migrated to the front of the mound but didn't go up higher into the mound. We can look at it, but pretty sure that none of the sites would fall into that category. There are higher velocities below the dams in addition to more WSE fluctuation.

Lael Will: On the fallfish incubation graphs, you did 10 days prior to and 5-6 days after. I understand the change for species that need an adult.
A: For fallfish it was not a 50/50 split (in time before/after observation) like for other species. Our assumption for fallfish was that temperature earlier would be colder, and the length of time was based on the temperature we measured.

Lael Will: We may be disagreeing with the yellow perch approach, and it would be more conservative if there is uncertainty, and to have some sort of confidence interval.
A: We can revisit the yellow perch.

Gabe Gries: If you could expand on protective elevations for other species like you did for yellow perch that would be helpful.
A: That was a special behavioral thing for that species, and we could think about how to apply that to other species. That is included for most species in table 6.4-2 of the report for the sites.

March 18, 2016 meeting attendees, including those who identified themselves on the telephone/WebEx:

Name	Affiliation	Name	Affiliation
Bill Connelly	FERC	Andrea Donelon	CRWC
Brandon Cherry	FERC	Chris Yurek	CRWC
John Baummer	FERC	Owen David	NHDES
Jeff Crocker	VANR	John Ragonese	TransCanada
Eric Davis	VANR	Jen Griffin	TransCanada
Lael Will	VTFWD	Drew Trested	Normandeau
Gabe Gries	NHFGD	Mark Allen	Normandeau
John Warner	FWS	Steve Leach	Normandeau
Melissa Grader	FWS	Jen Bryant	Normandeau

Name	Affiliation	Name	Affiliation
Katie Kennedy	TNC	Maryalice Fischer	Normandeau
Tara Bamford	North Country Council	Doug Hjorth	Louis Berger Group
Jim McClammer	CRJC		

Wilder, Bellows Falls, and Vernon Project Relicensing

Updated Study Results Meeting: March 17 – 18, 2016

TransCanada

Agenda - March 17, 2016

Study No.	Study Title	Study Lead
1	Historical Riverbank Position and Erosion Study (Report filed 03/01/2016)	John Field
2	Riverbank Transect Study (Report not yet filed)	John Field
3	Riverbank Erosion Study (Report not yet filed)	John Field
4	Hydraulic Modeling Study (Report filed 03/01/2016)	Lissa Robinson
5	Operations Modeling Study (Report not yet filed)	Stu Bridgeman, Semiu Lawal
6	Water Quality Study (Report filed 03/01/2016)	Bernward Hay, Matt Burak
7	Aquatic Habitat Mapping Study (Report filed 03/02/2015) – nothing to report	n/a
8	Channel Morphology and Benthic Habitat Study (Preliminary report filed 03/02/2015)	Mike Chelminski
Break ~ 10:45 – 11:00		
30	Recreation Facility Inventory and Use & Needs Assessment (Report filed 03/01/2016)	Jot Splenda
31	Whitewater Boating Flow Assessment (Report filed 03/01/2016)	Jot Splenda
32	Bellows Falls Aesthetic Flow Study (Report filed 03/01/2016)	Jot Splenda
25	Dragonfly and Damselfly Inventory and Assessment (Report not yet filed)	Sarah Allen
26	Cobblestone and Puritan Tiger Beetle Survey (Report not yet filed)	Sarah Allen
27	Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study (Report filed 09/14/2015)	Sarah Allen
28	Fowler's Toad Survey (Report not yet filed)	Sarah Allen
29	Northeastern Bulrush Survey (Report not yet filed)	Sarah Allen
Lunch ~ 12:15 – 12:45 pm - brought in		

Agenda – March 17, 2016 Continued

Study No.	Study Title	Study Lead
10	Fish Assemblage Study (Report filed 03/01/2016)	Drew Trested
11	American Eel Survey (Report filed 03/01/2016)	Drew Trested
12	Tessellated Darter Survey (Report filed 03/01/2016)	Drew Trested
16	Sea Lamprey Spawning Assessment (Preliminary report filed 03/01/2016)	Steve Leach
17	Upstream Passage of Riverine Fish Species Assessment (Report not yet filed)	Steve Leach
Break ~ 2:00 – 2:15		
19	American Eel Downstream Passage Assessment (Report not yet filed)	Doug Royer, Steve Adams
20	American Eel Downstream Migration Timing Assessment (Report not yet filed)	Doug Royer, Steve Leach
21	American Shad Telemetry Study (Report not yet filed)	Doug Royer
22	Downstream Migration of Juvenile American Shad – Vernon (Report not yet filed)	Chris Gurshin Doug Royer, Steve Adams,
23	Fish Impingement, Entrainment and Survival Study (Report not yet filed)	Drew Trested
33	Cultural and Historic Resources Study (some reports not yet filed)	Suzanne Cherau, Don Shannon

Questions
Agenda for March 18, 2016
Meeting summary to be filed, comments on USR due , and schedule for additional reporting

TransCanada

Questions and Discussion

Proposed Process Plan

Meeting summary to be filed by April 1

- Comment period ends May 2

For additional study reports and/or addendums to be filed by May 16:

- Meeting to be scheduled (around Memorial Day)
- Meeting summary within 15 days of meeting
- Comment period ends July 15

For additional study reports and/or addendums to be filed from May – August 1:

- Meeting(s) to be scheduled
- Meeting summary(ies) within 15 days of meetings
- Comment period ends October 1

Studies 1-3

Historical Riverbank Position and Erosion Study

Riverbank Transect Study

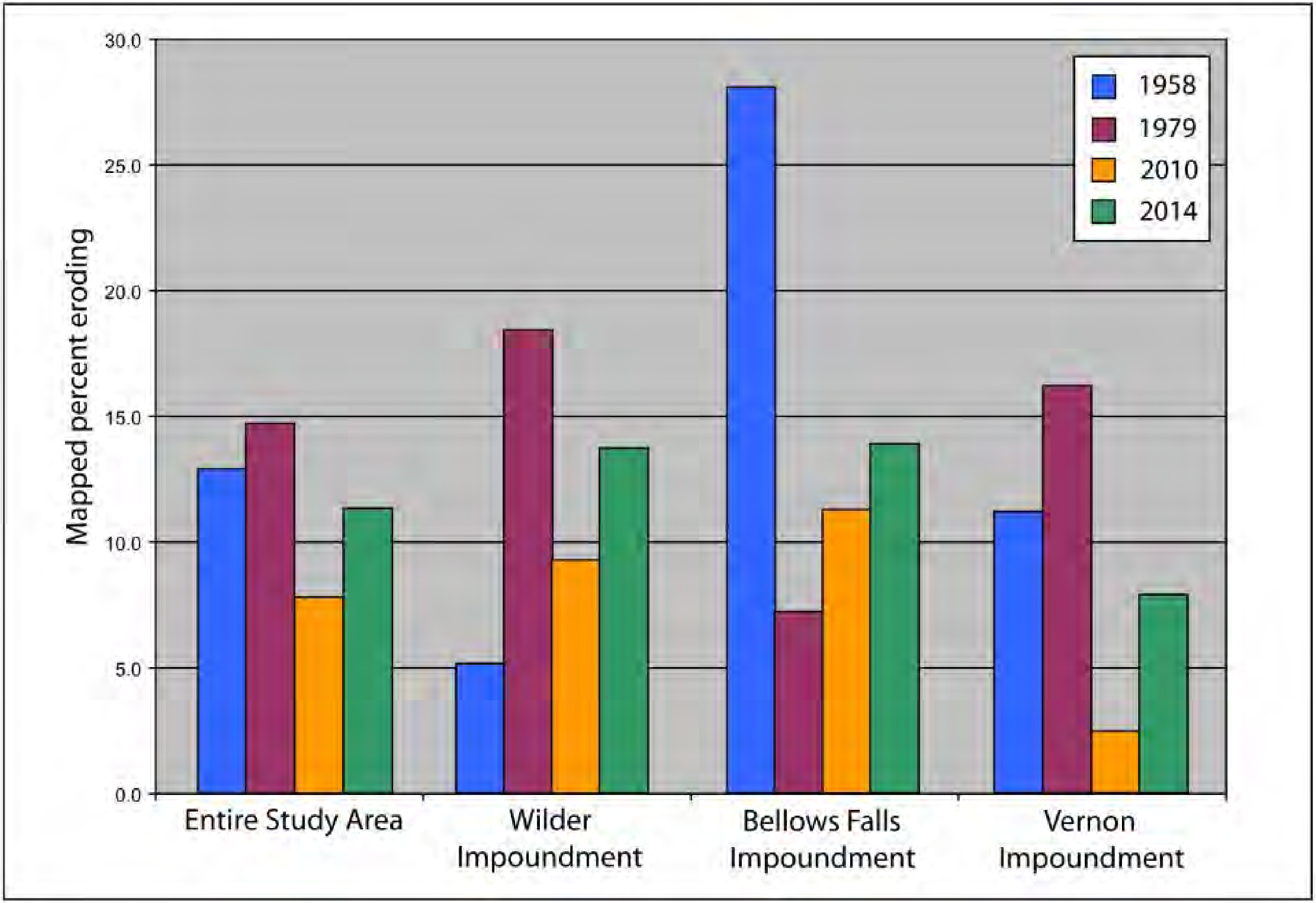
Riverbank Erosion Study

Study 1 – Historical Riverbank Position and Erosion Study

Study 1 is complete and has been submitted

- Comparisons of erosion between 1958, 1978-79, and 2014

Study 1 – Historical Riverbank Position and Erosion Study

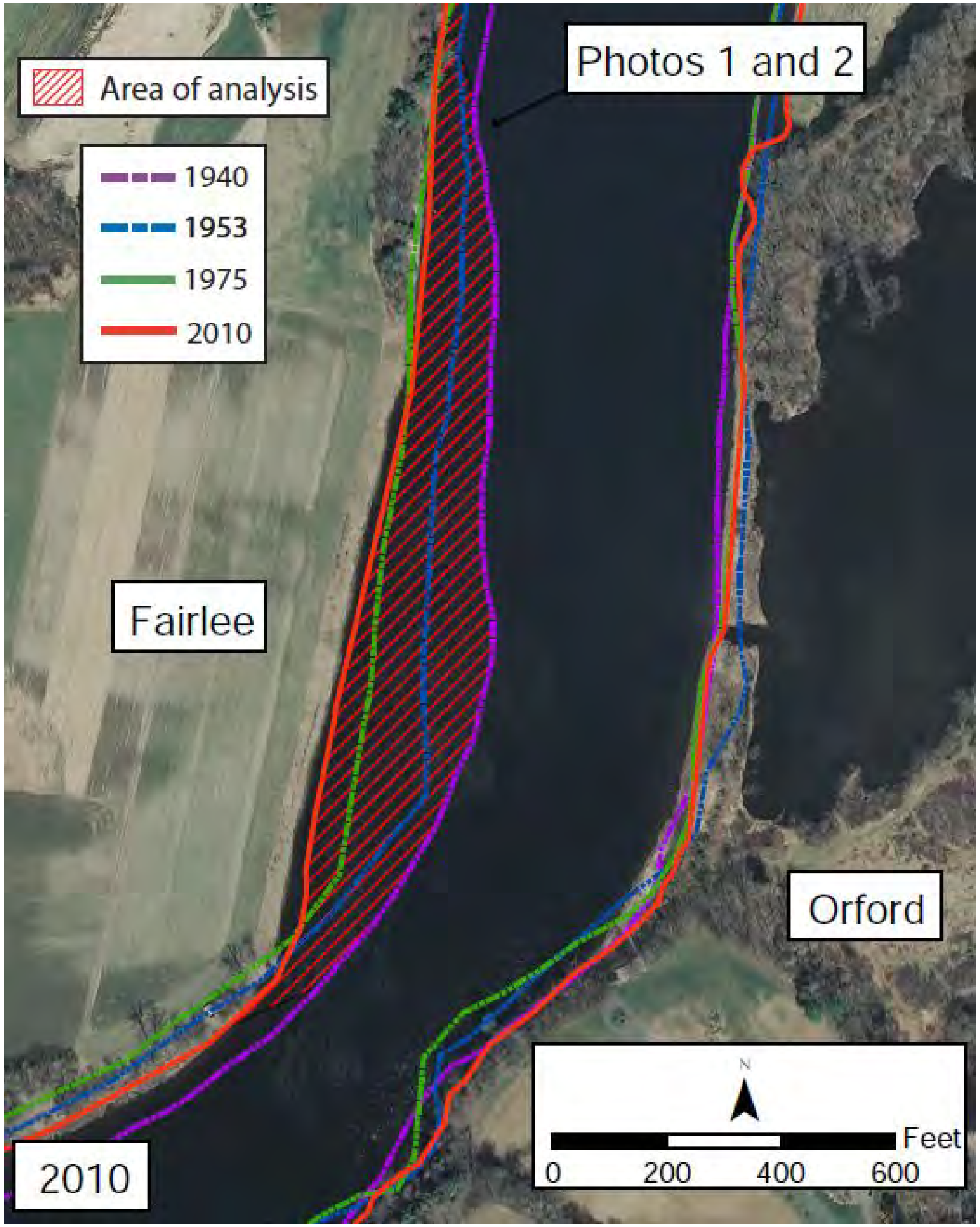


TransCanada

Study 1 – Historical Riverbank Position and Erosion Study

- Georectified historical aerial photographs from 1940’s, 1950’s, and 1970’s, and compared with 2010
- Numerous types of changes characterized but thorough analysis to be part of Study 3

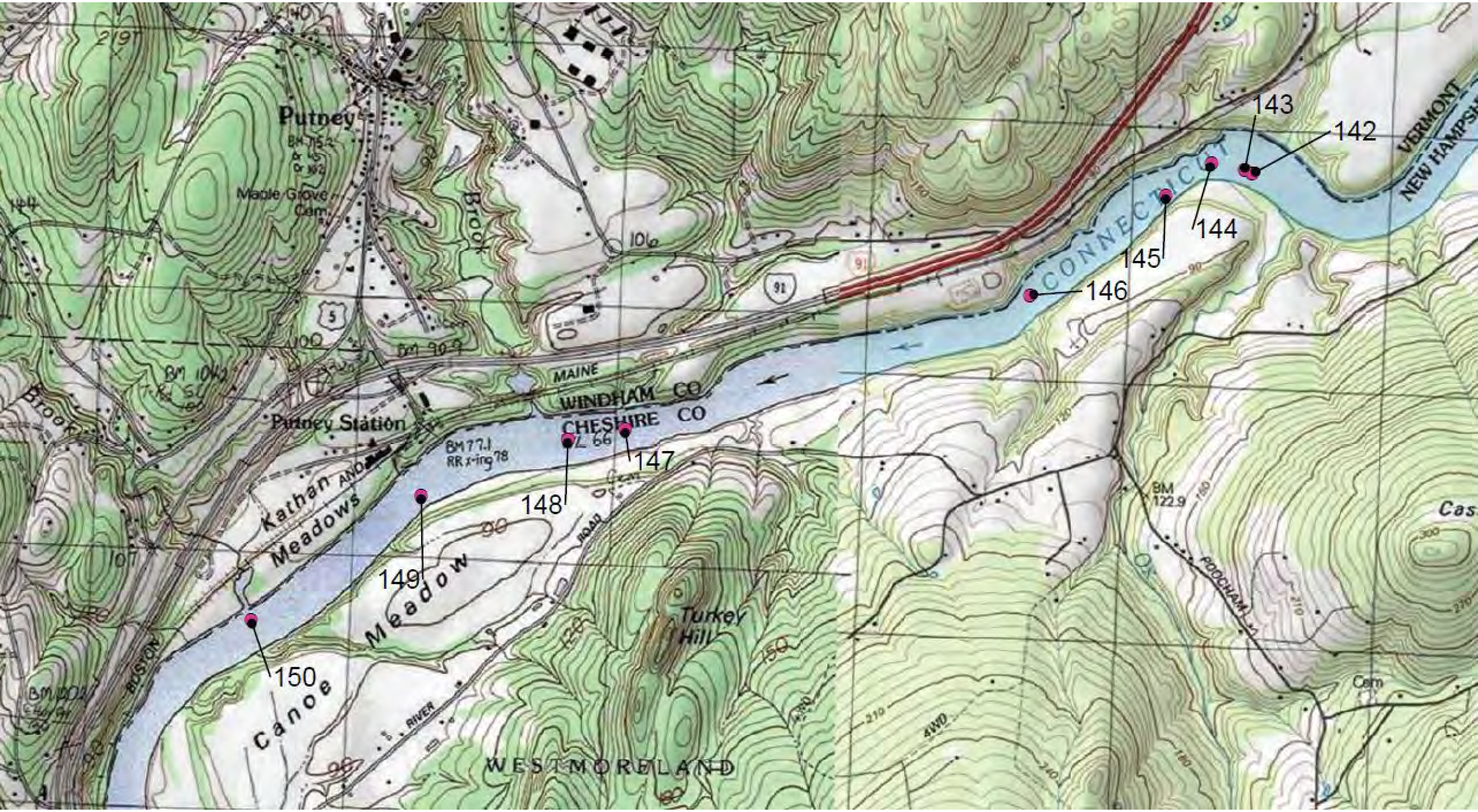
Study 1 – Historical Riverbank Position and Erosion Study



Study 1 – Historical Riverbank Position and Erosion Study

- Ground photographs of erosion sites from 1950’s to 1990’s were rephotographed in 2015
- 162 photo matches obtained
- Numerous sites show increased vegetation and stabilization

Study 1 – Historical Riverbank Position and Erosion Study



TransCanada

Study 1 – Historical Riverbank Position and Erosion Study

Near Putney, VT

1964 - 5644U

2015 - 53

Study 2 –Riverbank Transect Study

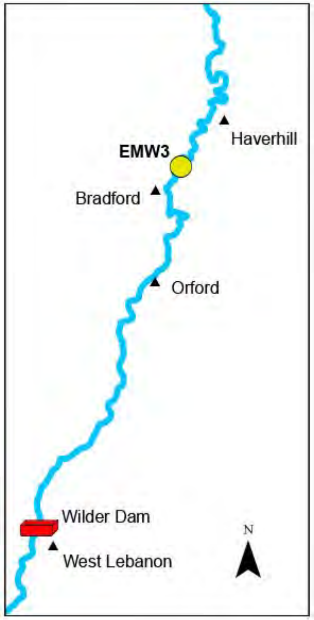
Study 2 fieldwork is complete

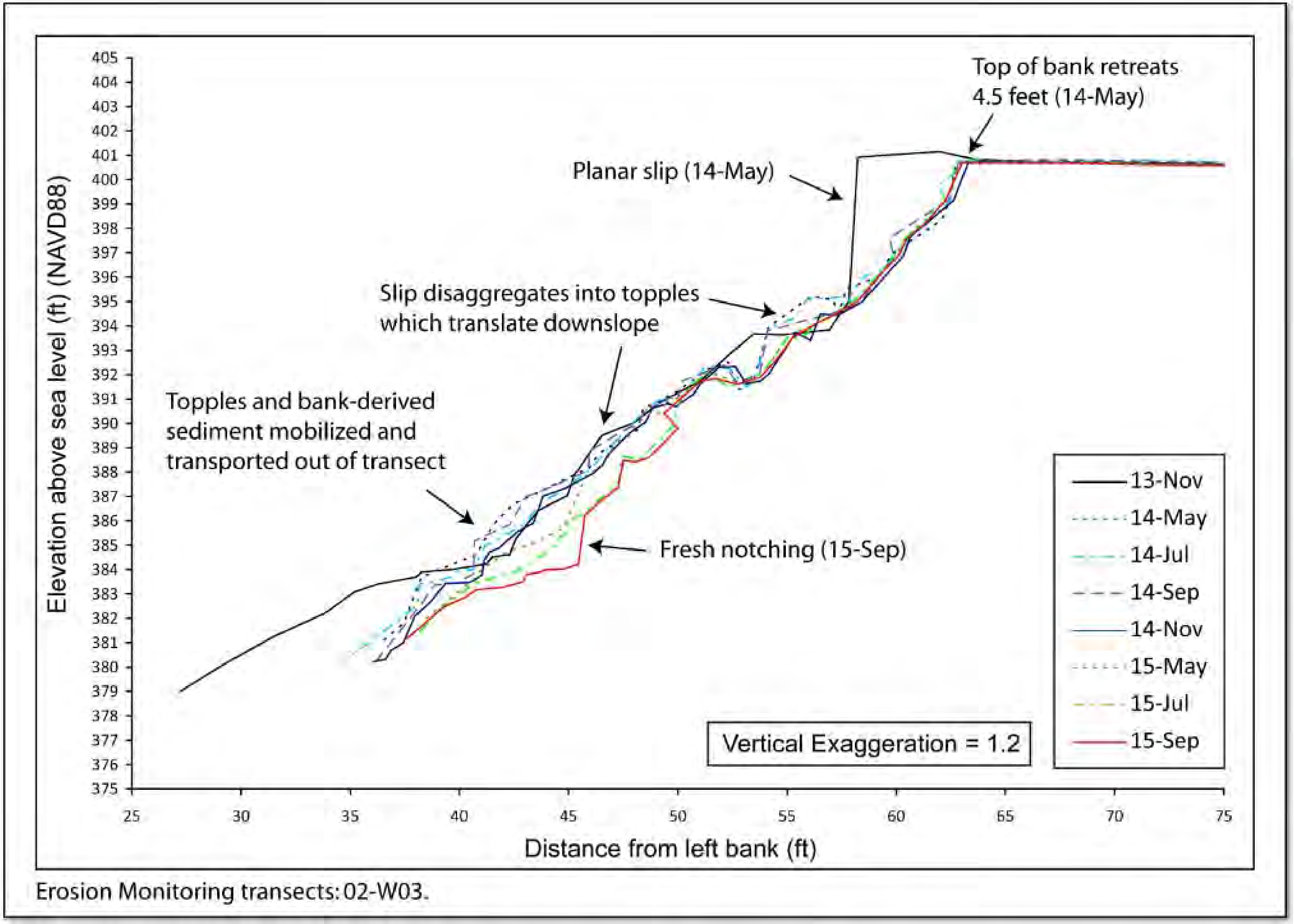
- Eighth round of monitoring at 21 sites completed in September 2015
- Water level monitoring ended in November 2015

Remaining Activities

- Document changes that occurred during the monitoring period.
- Data from water-level monitoring will be processed and elevations linked to stratigraphic columns to identify possible links to erosion.
- Preparation of the study report detailing the amount, timing, and possible causes for erosion (pending study 3 and modeling) at the 21 monitoring sites.

Study 2 –Riverbank Transect Study





Erosion Monitoring transects: 02-W03.

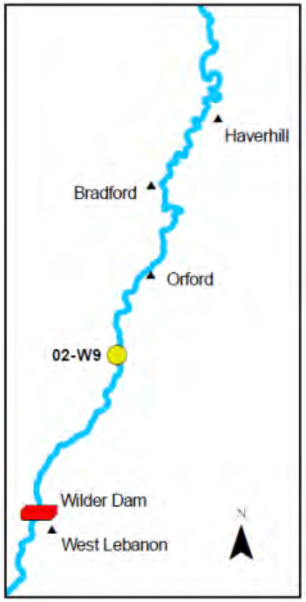
Bradford, VT (Bellevance Site)

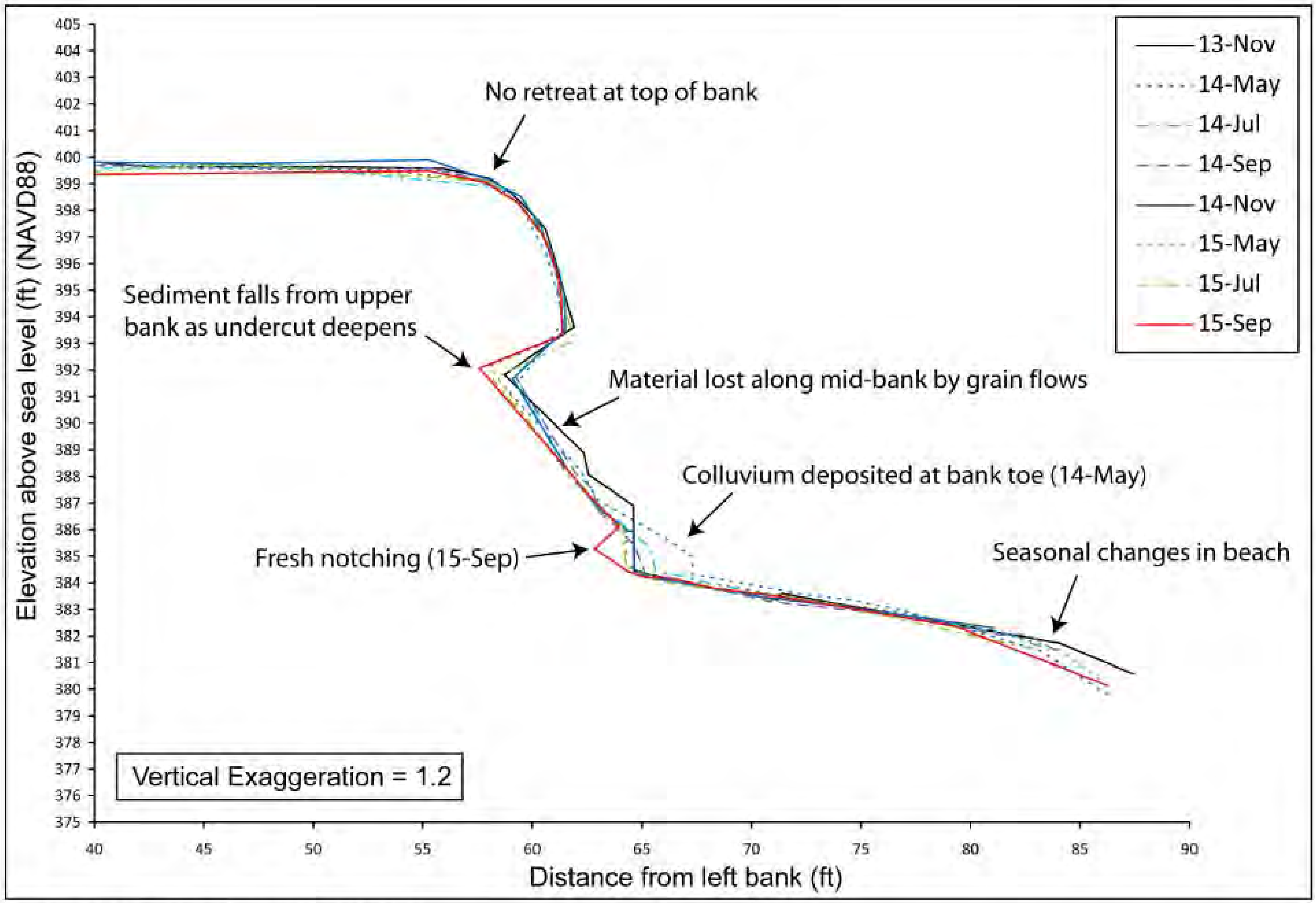
Study 2 –Riverbank Transect Study

Study 2 –Riverbank Transect Study

TransCanada

Study 2 –Riverbank Transect Study





Erosion Monitoring transects: 02-W09.

TransCanada

Lyme, NH (Mudge Site)

Study 2 –Riverbank Transect Study

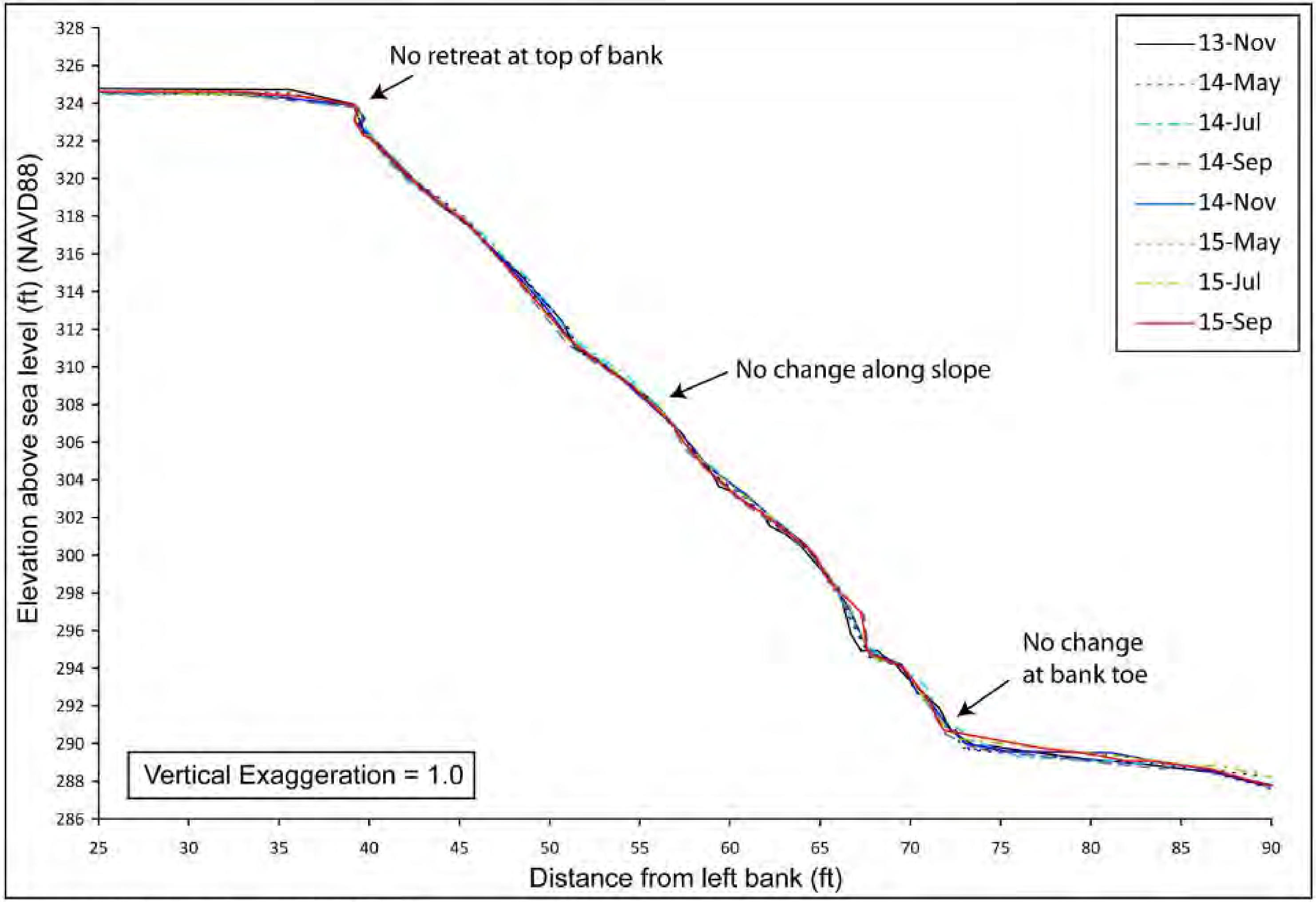
Study 2 –Riverbank Transect Study

May 2014

July 2014

Study 2 –Riverbank Transect Study

Study 2 –Riverbank Transect Study



No retreat at top of bank

No change along slope

No change at bank toe

Vertical Exaggeration = 1.0

Erosion Monitoring transects: 02-B09.

Walpole, NH (Mr. G's Site)

Study 2 –Riverbank Transect Study

Study 2 –Riverbank Transect Study

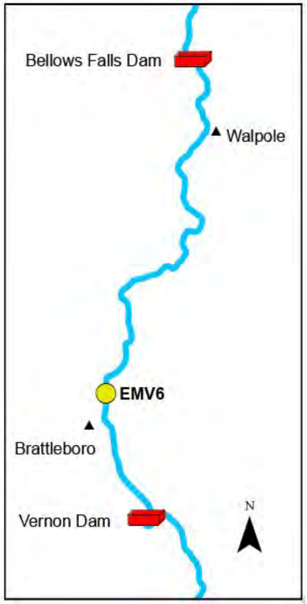
02-B09 in 1964 and 2015

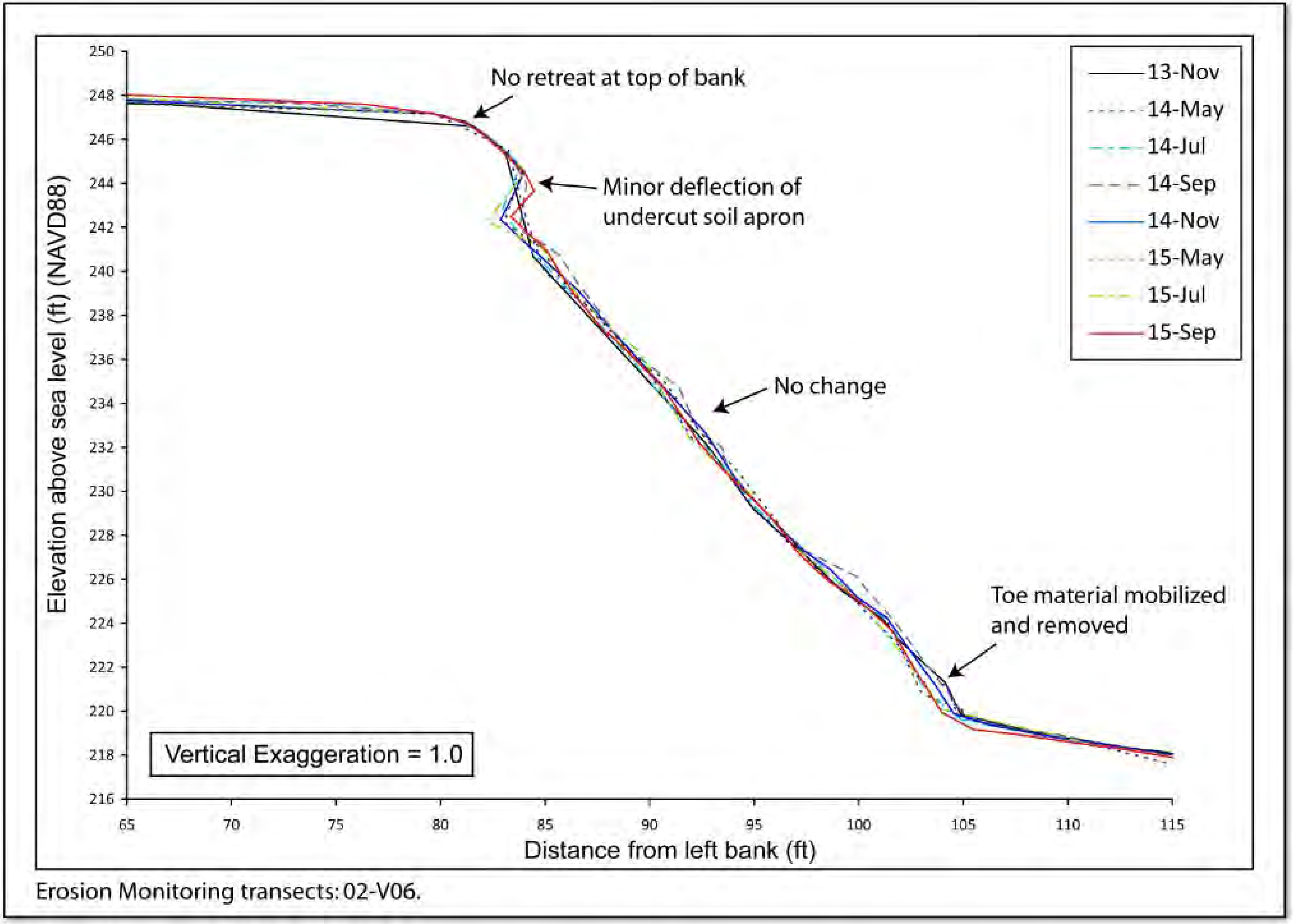
Study 2 –Riverbank Transect Study

1968

TransCanada

Study 2 –Riverbank Transect Study





No retreat at top of bank

Minor deflection of undercut soil apron

No change

Toe material mobilized and removed

Erosion Monitoring transects: 02-V06.

Chesterfield, NH (LaCroix Site)

Study 2 –Riverbank Transect Study

Study 3 –Riverbank Erosion Study

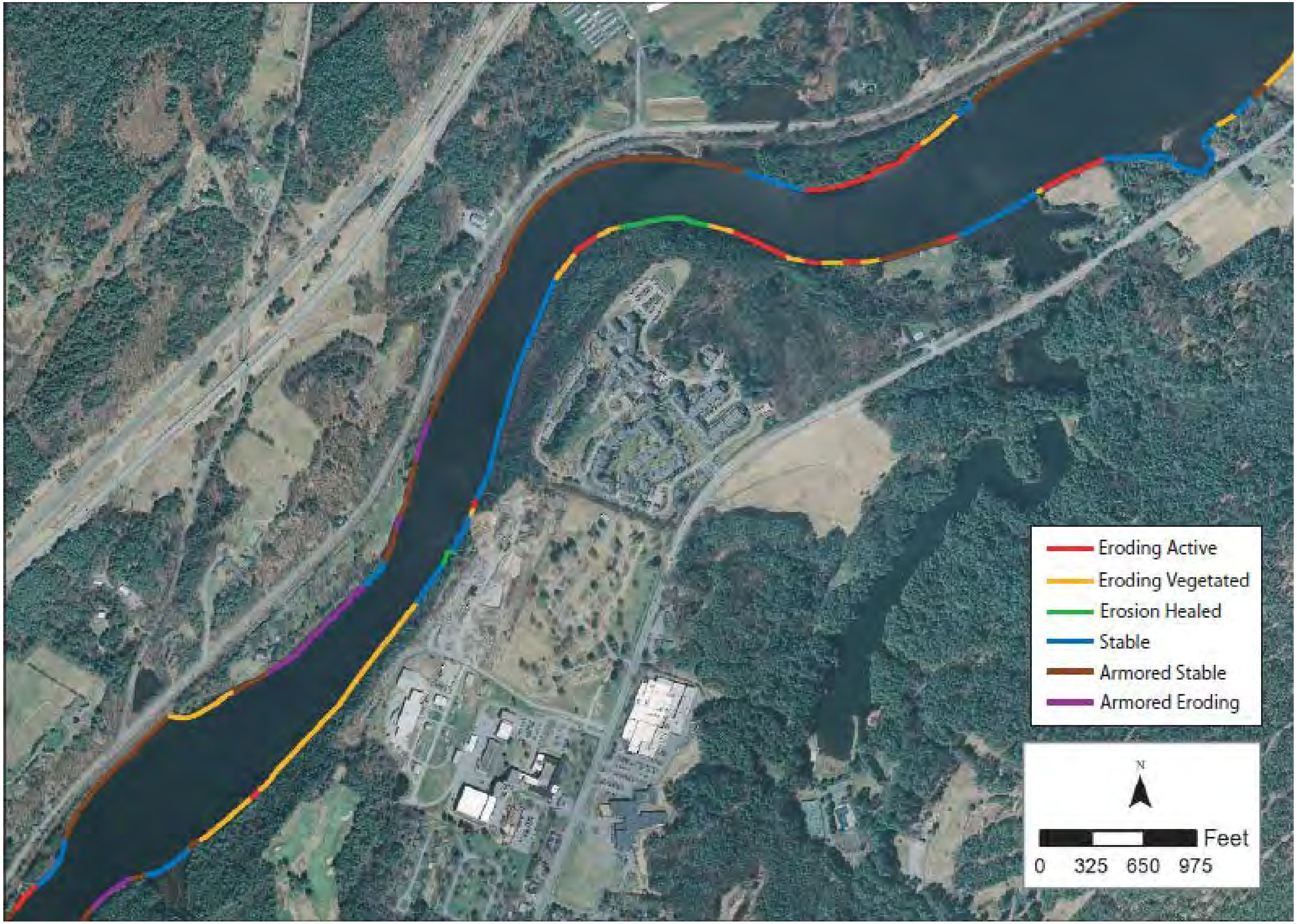
Study 3 fieldwork is complete

Erosion mapping and supplementary surveying completed

Remaining Activities

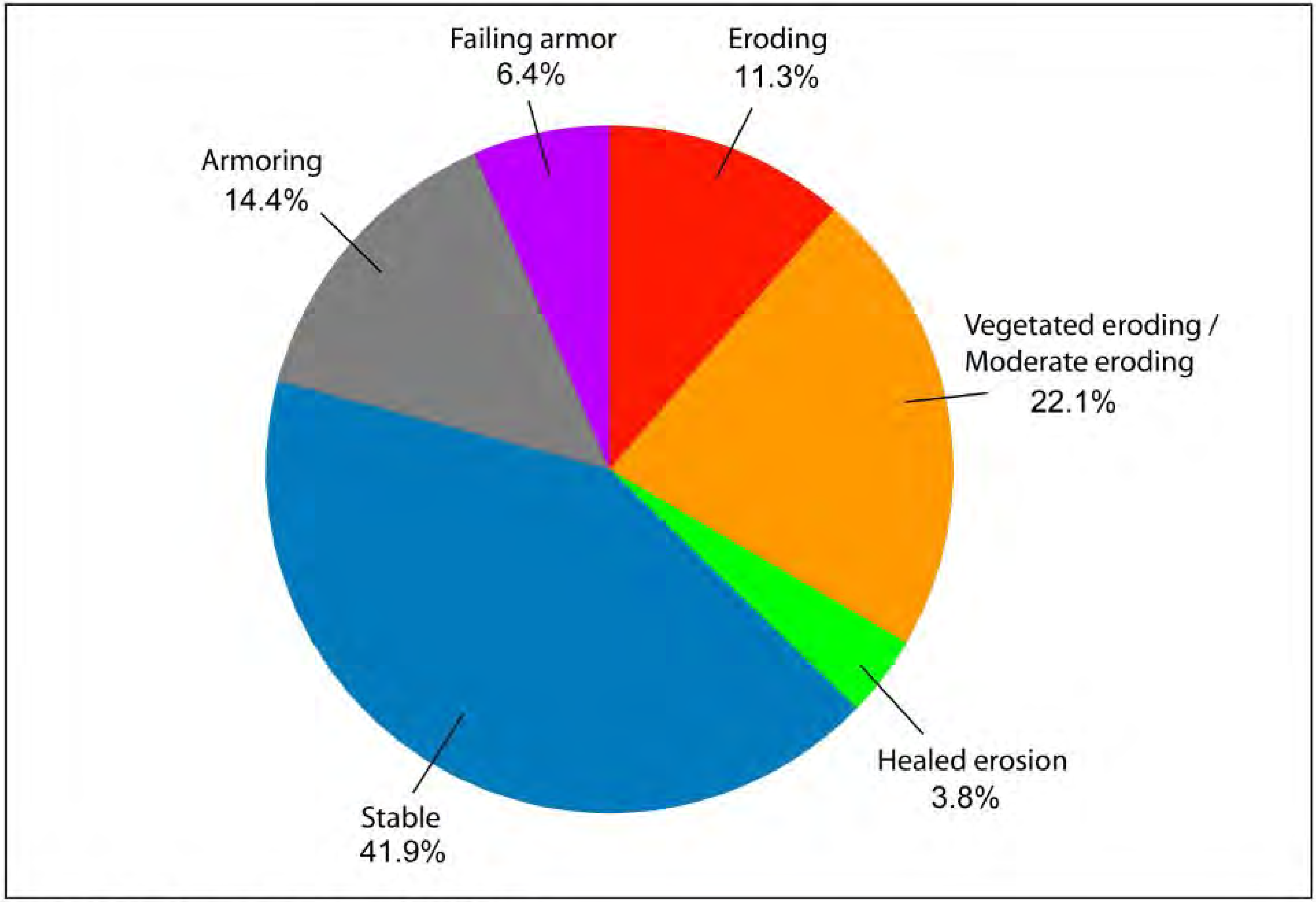
- Analyze erosion and determine influence of tributaries, valley constrictions, soil type, project operations, etc.
- Review of hydraulic and operations modeling (Studies 4 and 5) and bathymetry (from Study 7) to identify potential causes of erosion (e.g., areas of high shear stress values).
- Analyze survey data to establish erosion rates at a couple sites with previous surveys
- Issue study report

Study 3 –Riverbank Erosion Study



Wilder Impoundment
(Norwich. VT/Hanover, NH)

Study 3 –Riverbank Erosion Study



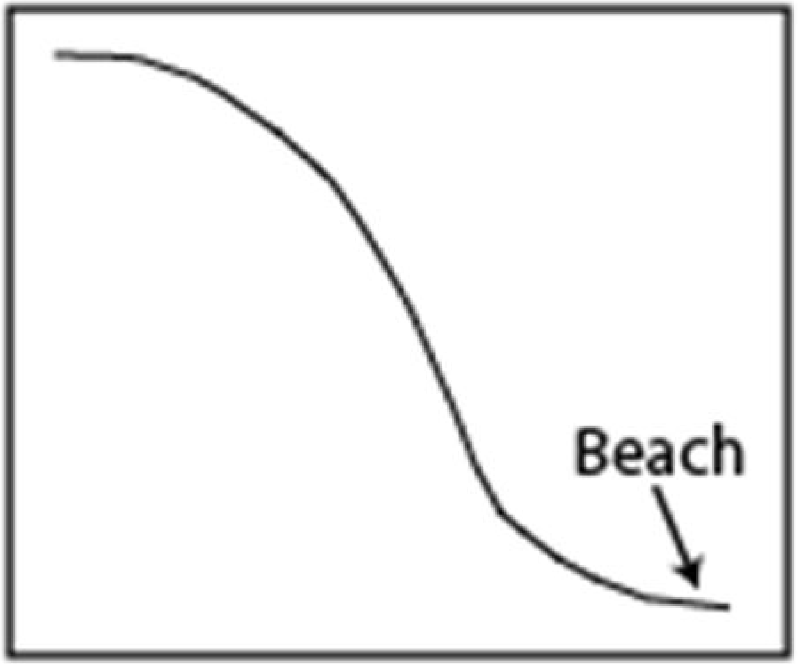
2014 stability mapping - entire study area

Study 2 –Riverbank Transect Study

Study 2 –Riverbank Transect Study

Erosion is a multi-stage cyclic process

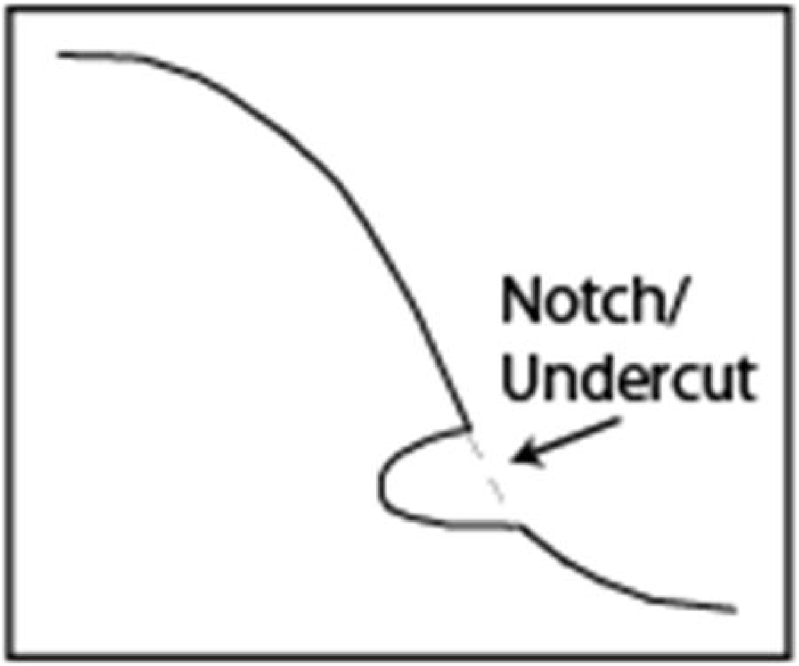
Stage 1



Stable bank

Study 3 –Riverbank Erosion Study

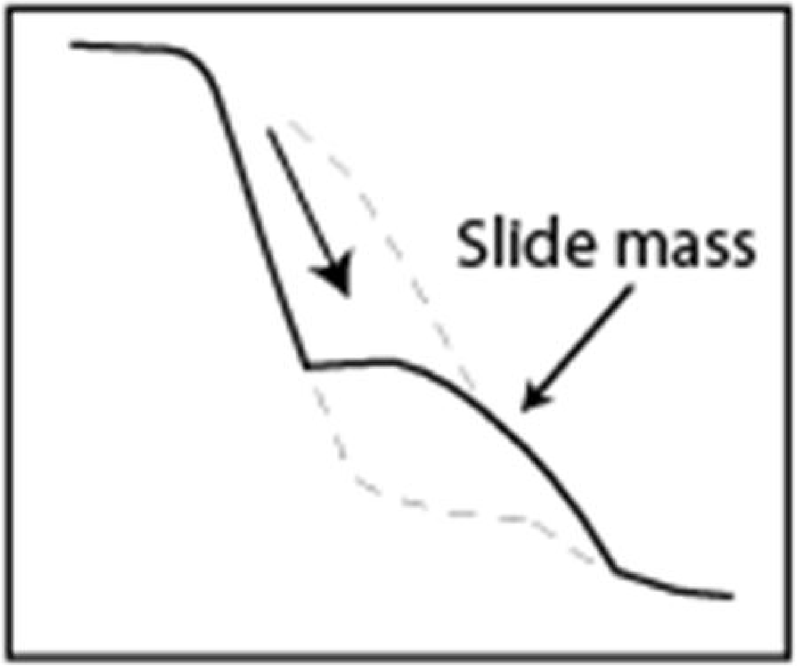
Stage 2



Notching/Undercutting

Study 3 –Riverbank Erosion Study

Stage 3

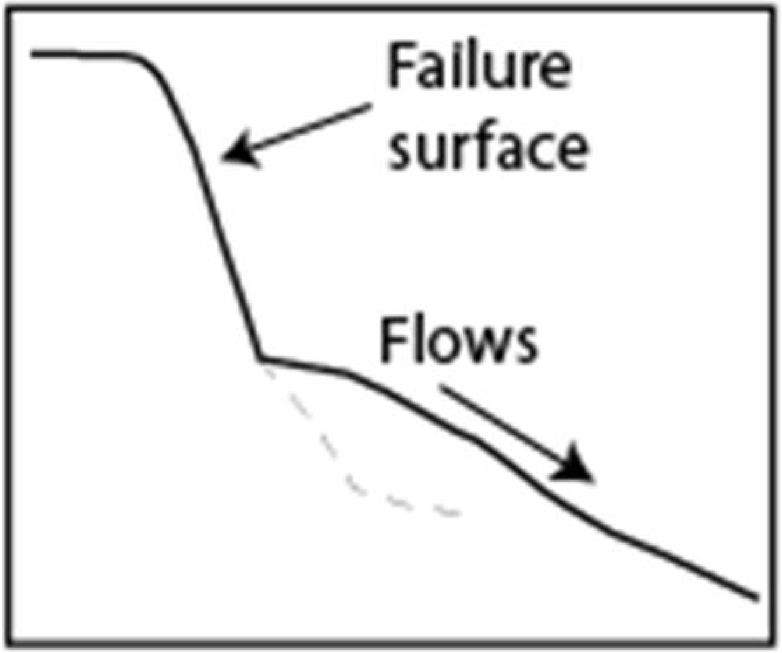


Sliding/Toppling

TransCanada

Study 3 –Riverbank Erosion Study

Stage 4

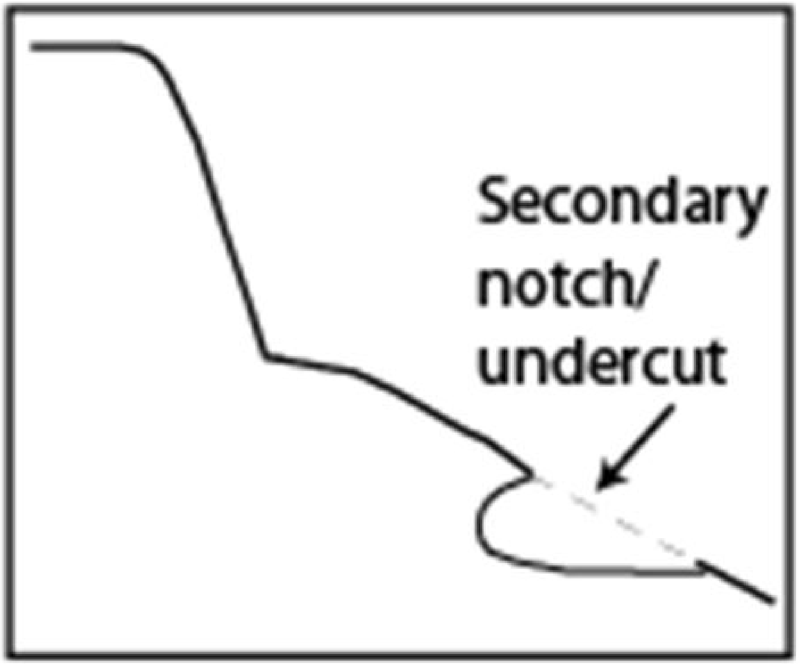


Flows

TransCanada

Study 3 –Riverbank Erosion Study

Stage 5

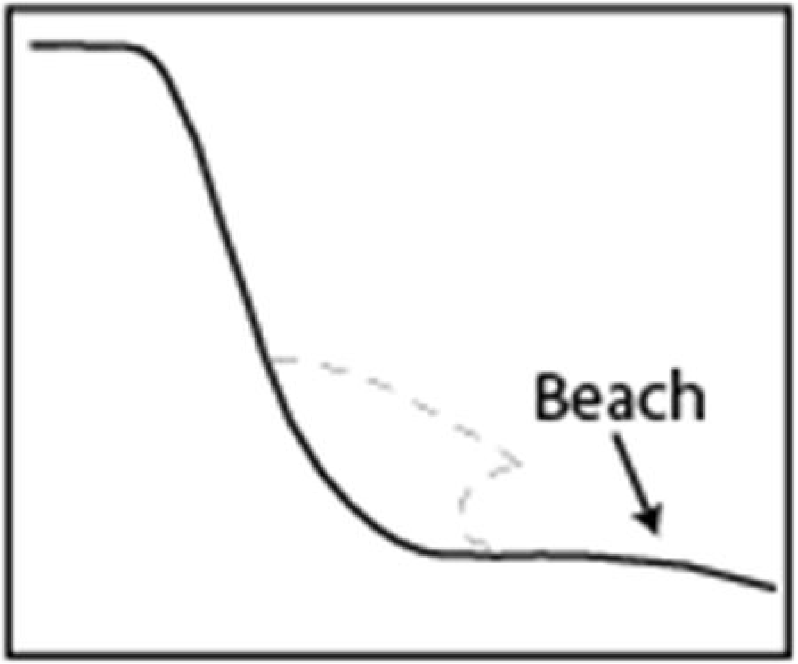


Secondary notching/ Material removal

TransCanada

Study 3 –Riverbank Erosion Study

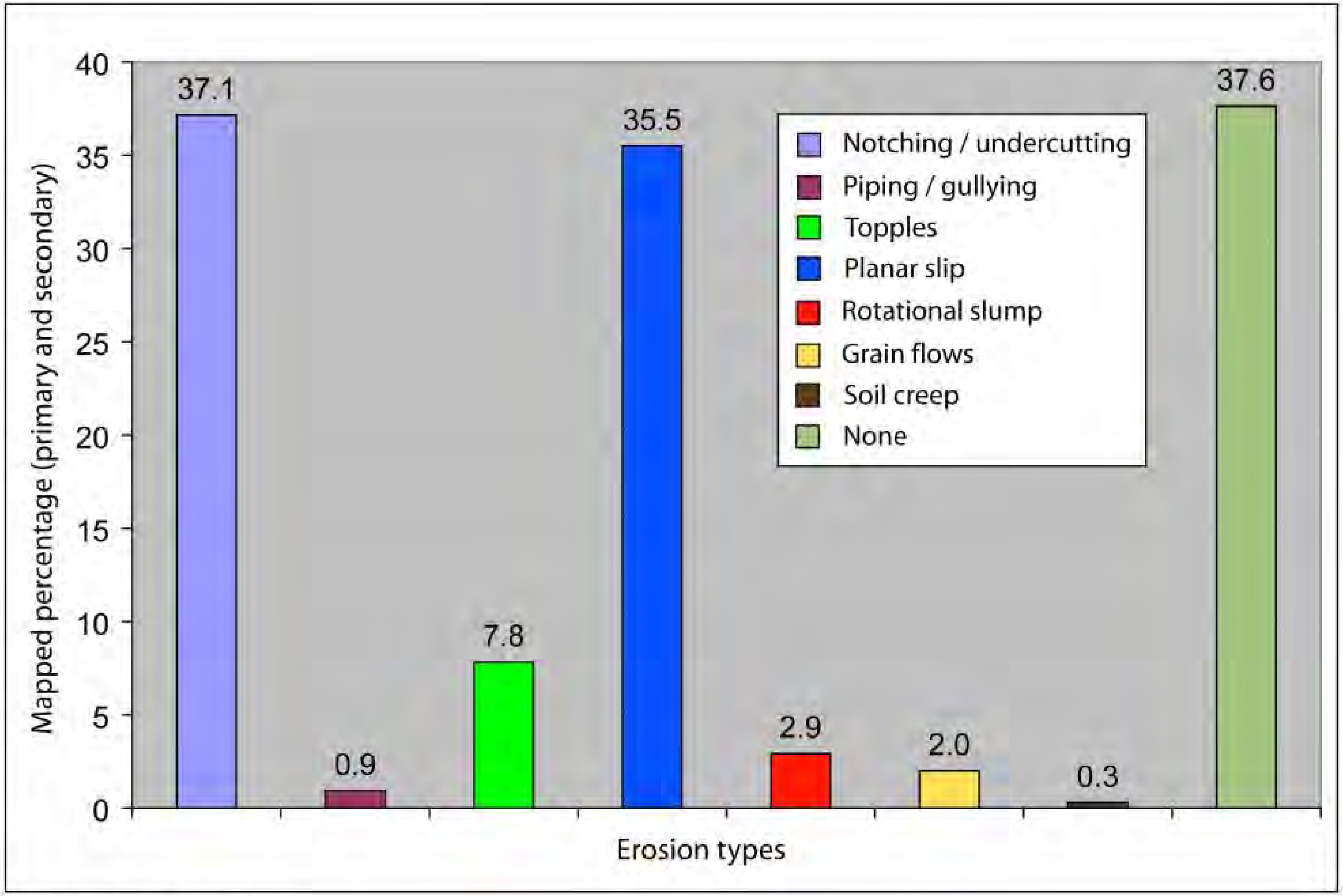
Stage 6



Restabilization/Reset

TransCanada

Study 3 –Riverbank Erosion Study



Erosion type mapping

TransCanada

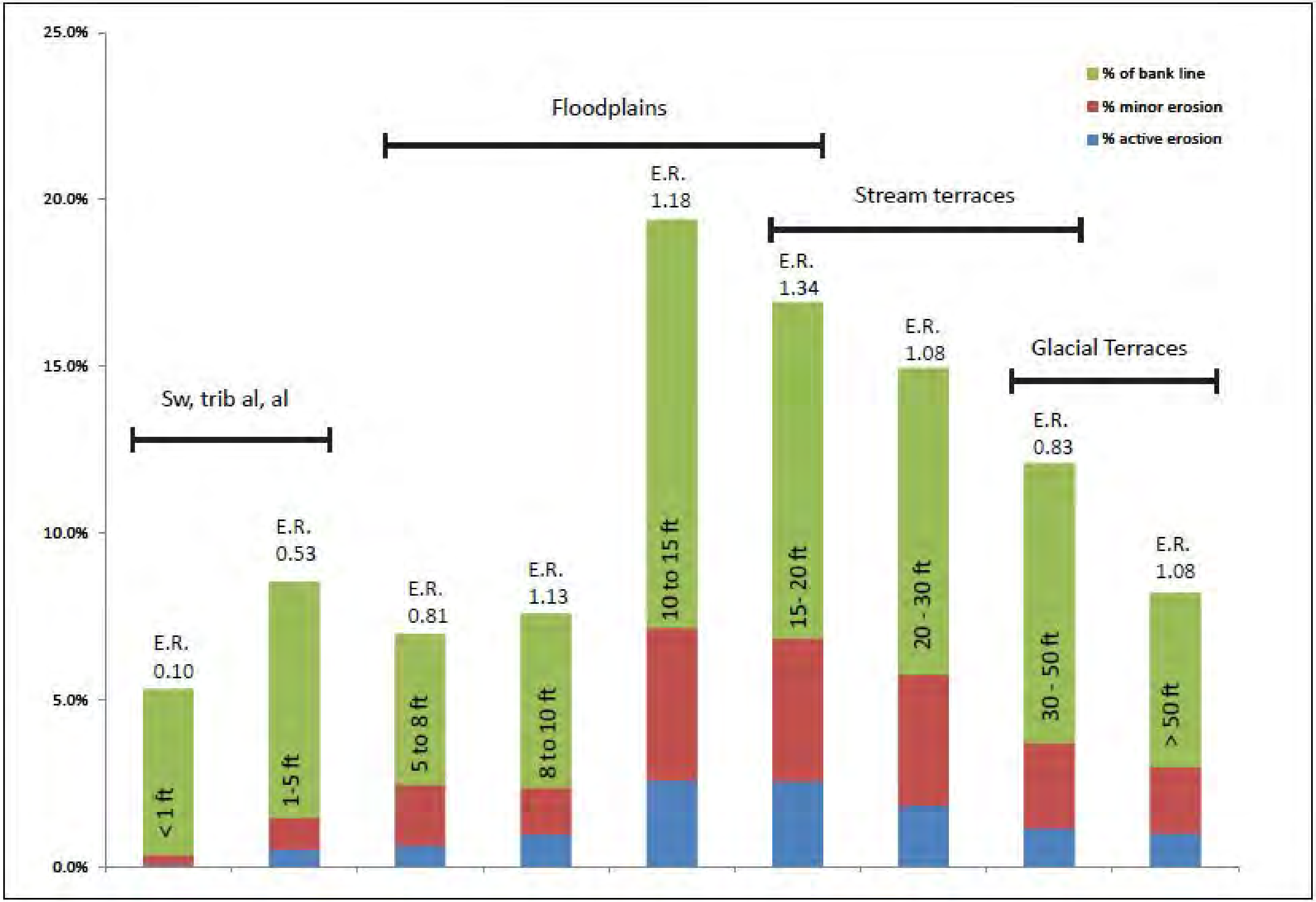
Study 3 –Riverbank Erosion Study

Analysis of erosion to be completed

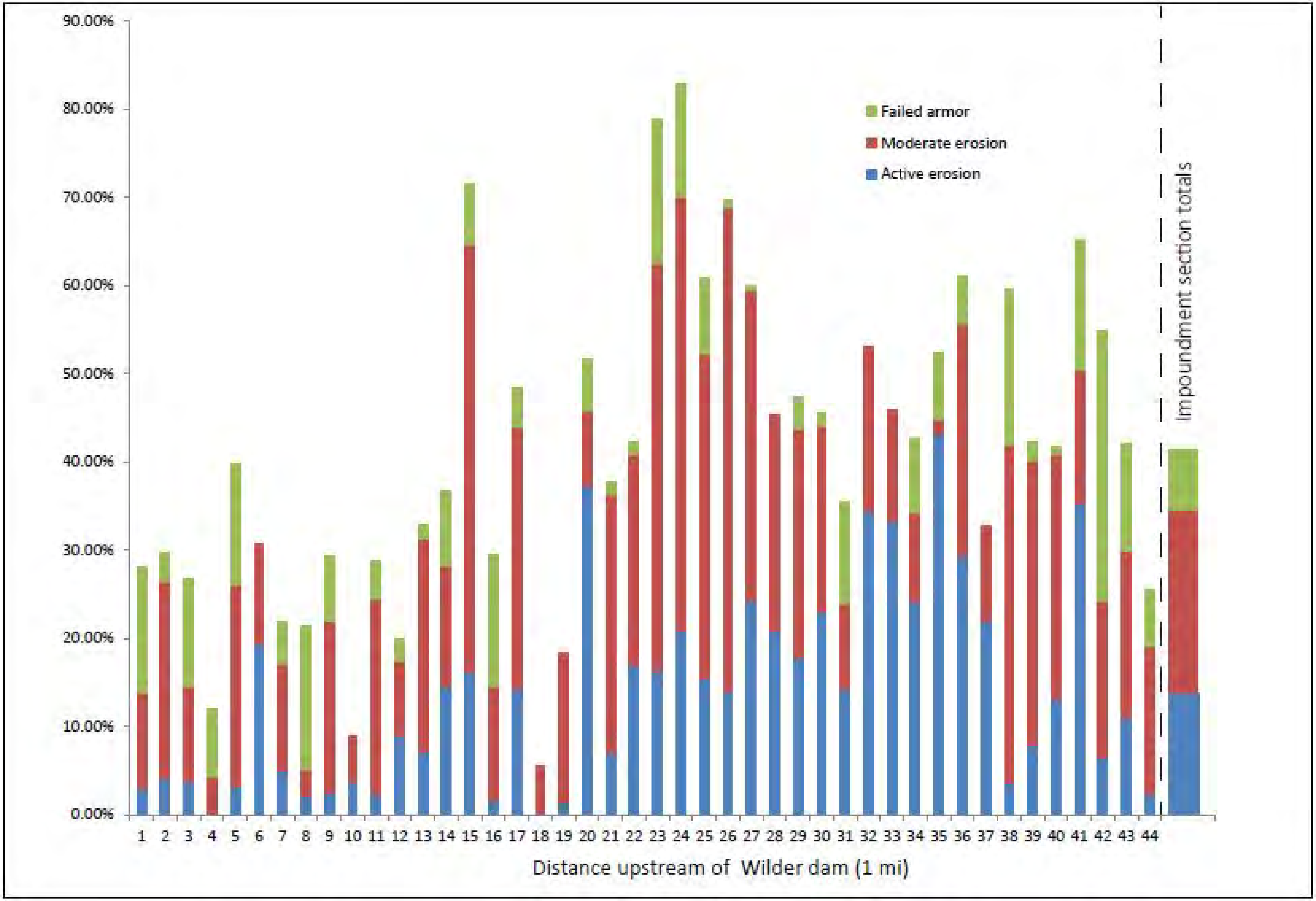
Potential impact of:

- tributary inputs
- channel constrictions
- soil types
- channel position
- avulsions
- project operations (based on modeling)

Study 3 –Riverbank Erosion Study



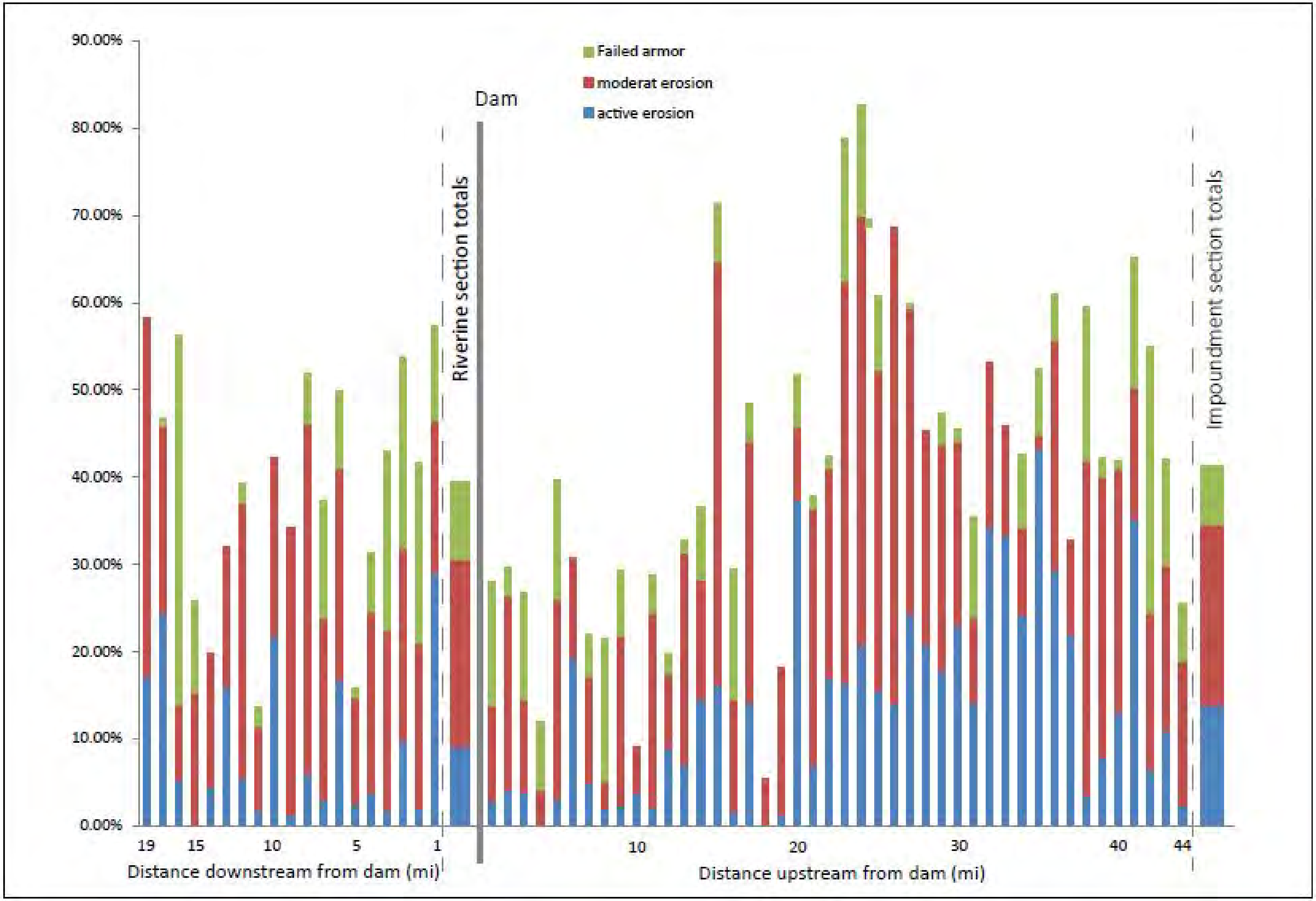
Study 3 –Riverbank Erosion Study



TransCanada

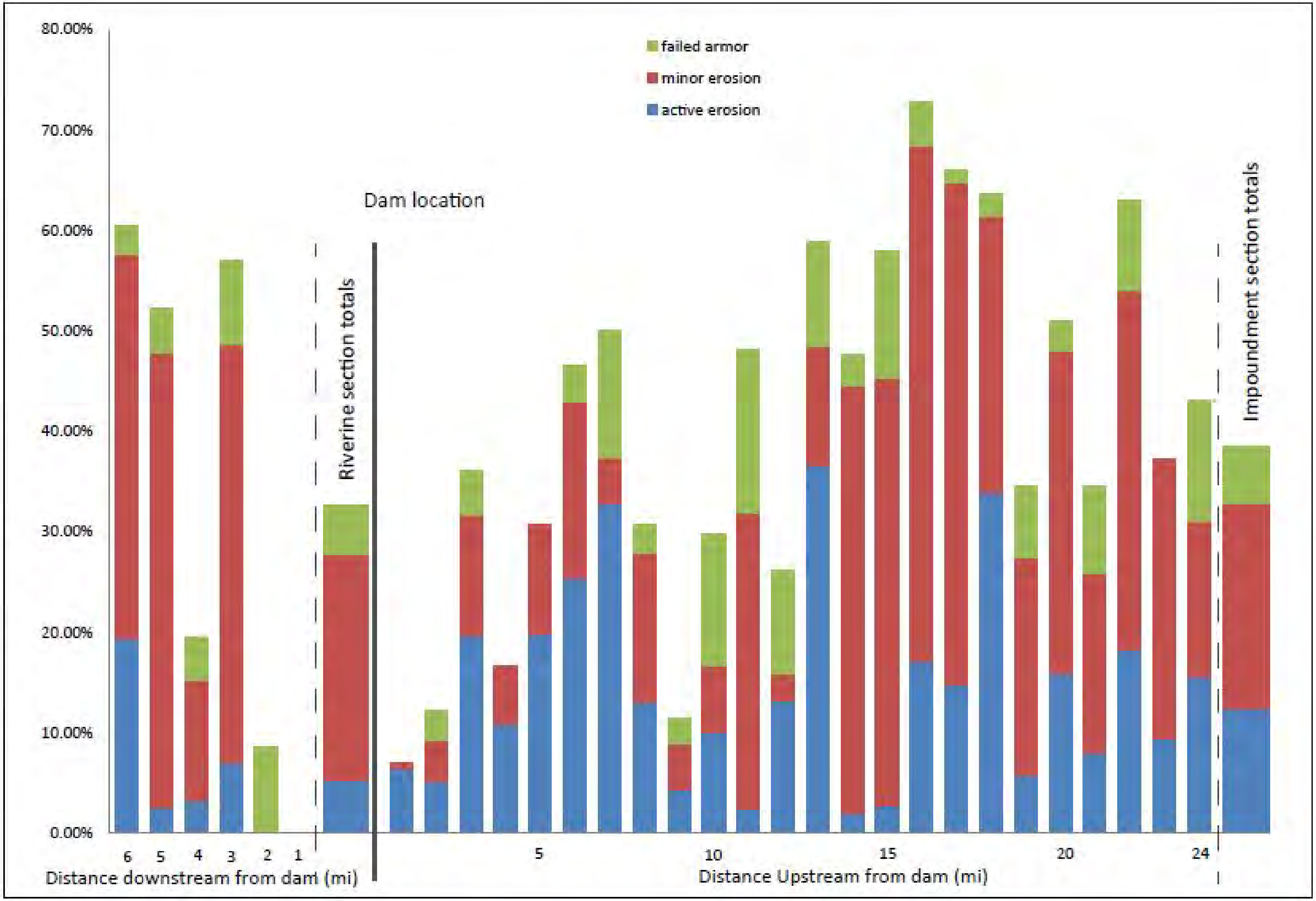
Wilder

Study 3 –Riverbank Erosion Study



Wilder

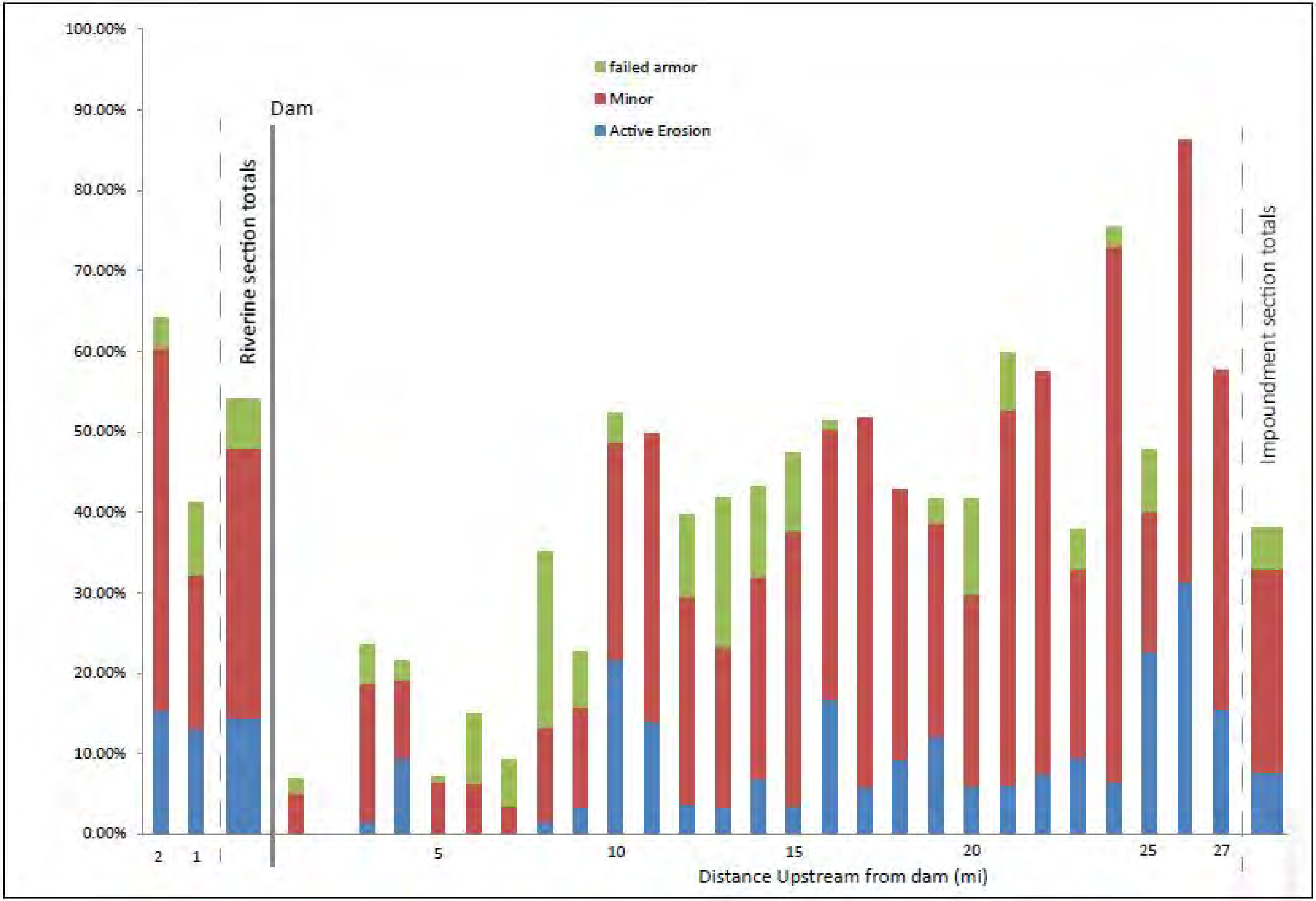
Study 3 –Riverbank Erosion Study



TransCanada

Bellows Falls

Study 3 –Riverbank Erosion Study



Vernon

Study 3 –Riverbank Erosion Study

Study 4

Hydraulic Modeling

Study 4 – Hydraulic Model

Objective:

Develop a hydraulic model of the Lower Connecticut River to assist in the evaluation of the effects of project operations on aquatic, terrestrial, and geologic resources.

- **Initial screening of project effects**
- **Operations Model refinement (Study 5)**

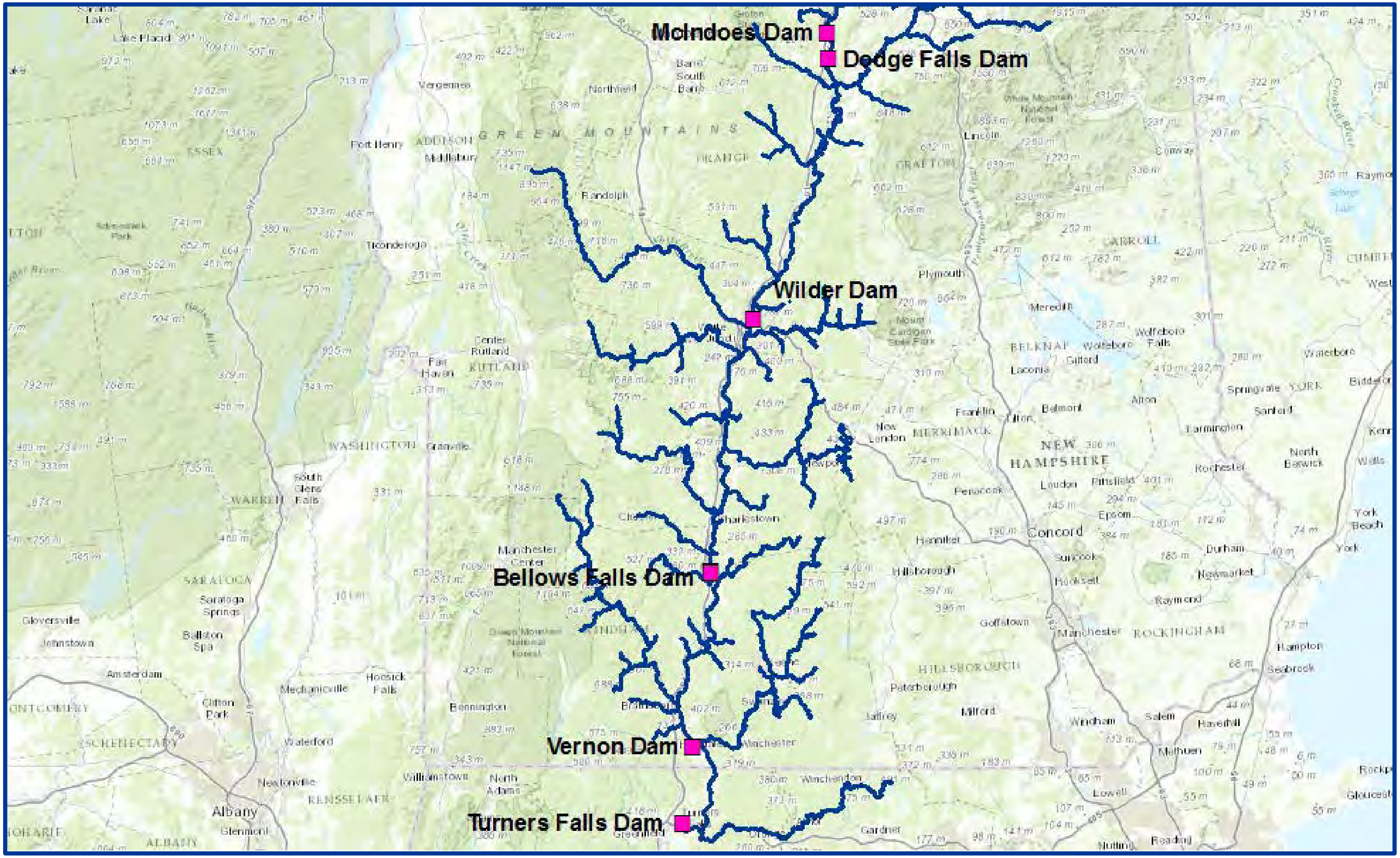
TransCanada

Study 4 – Hydraulic Model Steps

- ✓ **Set up hydraulic model**
  - ✓ Model inputs
  - ✓ Calibration and validation
- ✓ **Provide model output**
  - ✓ Velocity comparison
  - ✓ Lag time (for operations model routing)
  - ✓ Rating curves (WSEL, flow, velocity, etc.)
- ✓ **Prepare study report**

Alternative scenarios (as needed)

Study 4 – Hydraulic Model

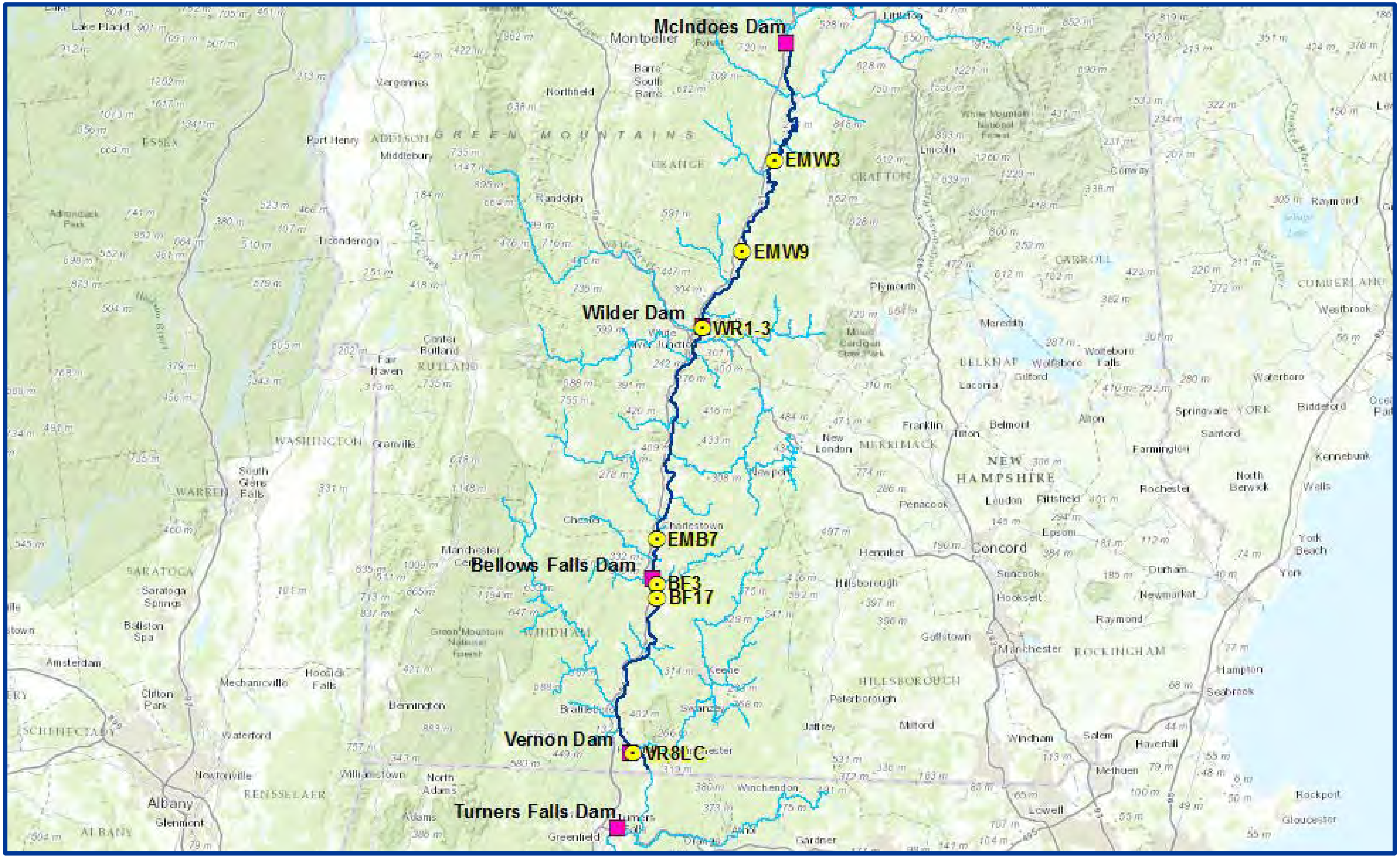


Study 4 – Hydraulic Model Steps

- ✓ **Set up hydraulic model**
  - ✓ Model inputs
  - ✓ Calibration and validation
- ✓ **Provide model output**
  - ✓ Velocity comparison
  - ✓ Lag time (for operations model routing)
  - ✓ Rating curves (WSEL, flow, velocity, etc.)
- ✓ **Prepare study report**

Alternative scenarios (as needed)

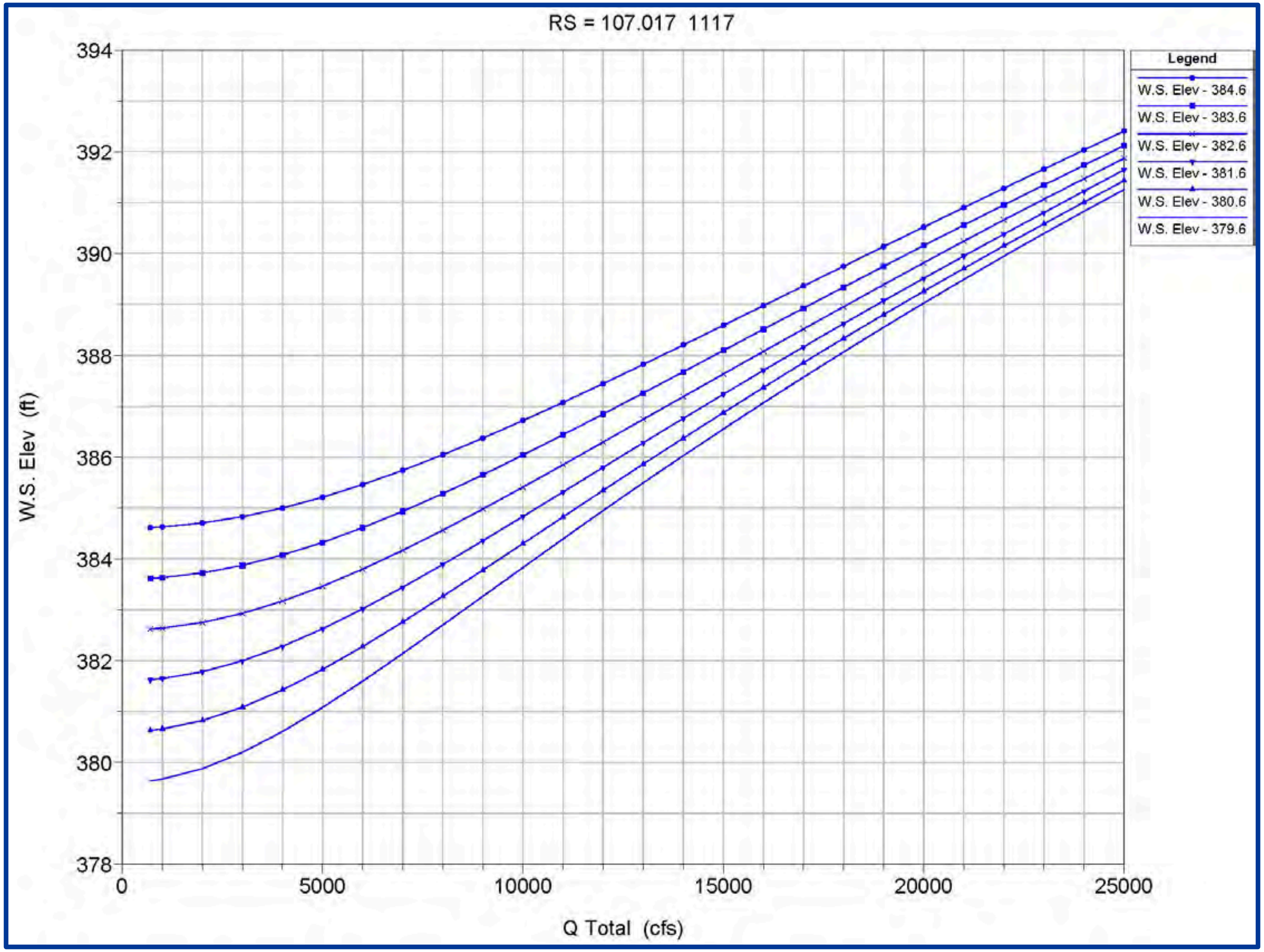
Study 4 – Velocity Comparison



Study 4 – Velocity Comparison

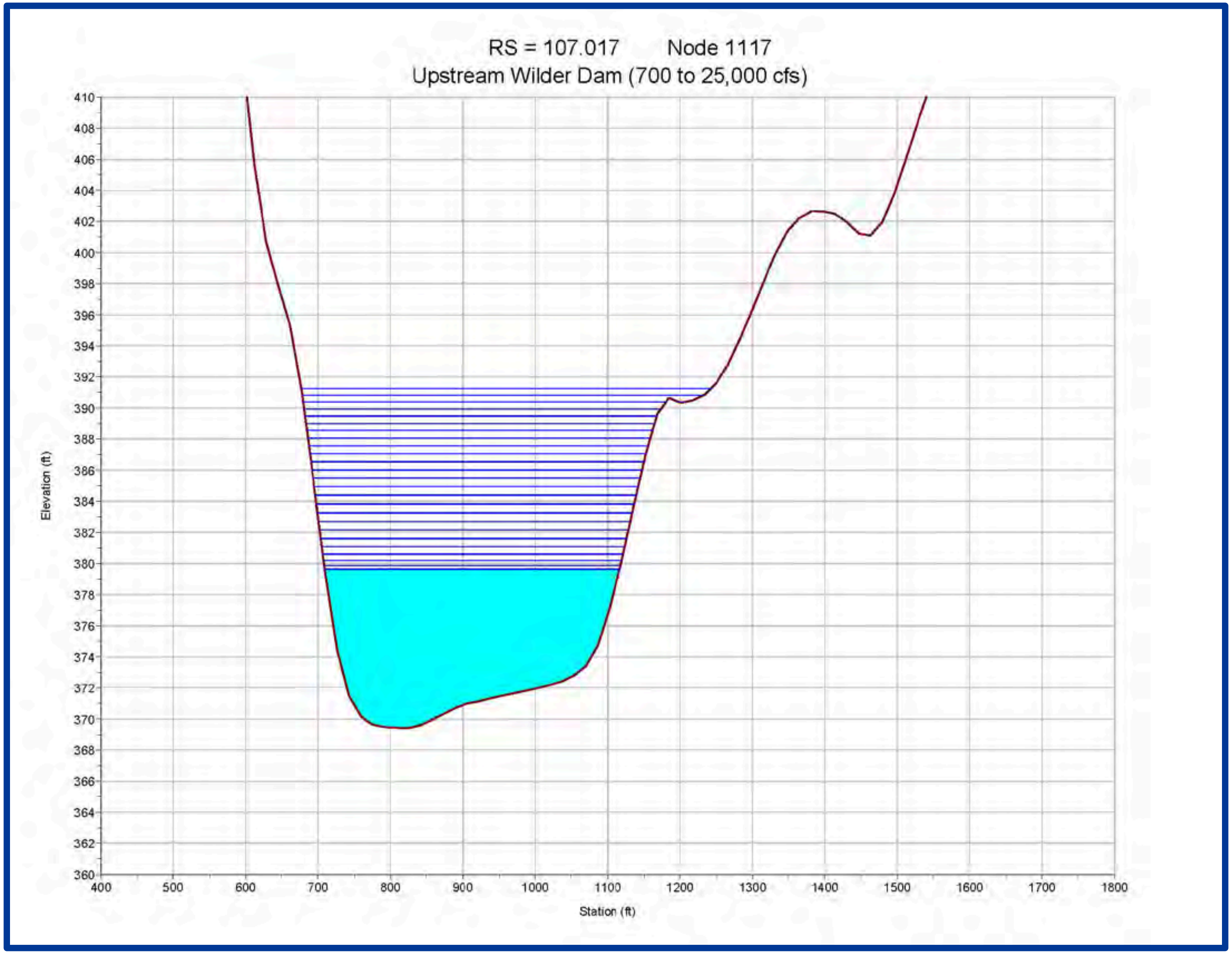
Velocity Location	Observed Flow (cfs)	Observed Velocity (ft/s)	HEC-RAS Velocity (ft/s)	Description
EMW3	2,689	0.6	0.4 to 0.6	Wilder Impoundment
EMW9	4,985	0.7	0.6 to 0.8	Wilder Impoundment
WR1-3	11,540	1.3	1.9	Wilder Riverine
EMB7	8,559	0.7	0.6 to 0.8	Bellows Falls Impoundment
BF3	11,969	2.1	2.1	USGS gage 01154500
BF17	12,044	2.7	2.5 to 2.7	Bellows Riverine
VR8LC	8,289	2.3	1.1 to 2.3	Vernon Riverine

Study 4 – Rating Curves



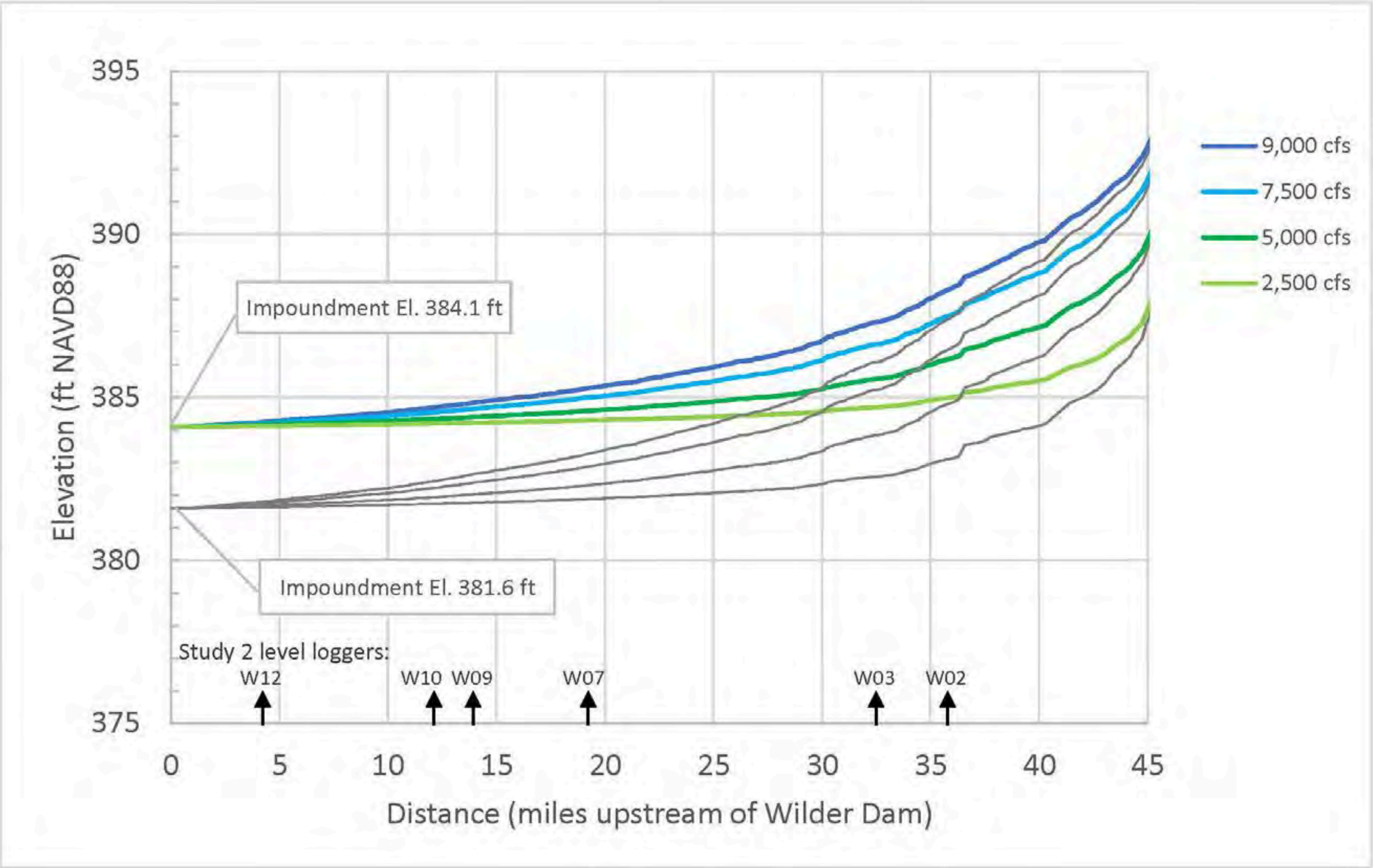
TransCanada

Study 4 – Rating Curve at Cross Section



TransCanada

Study 4 – Water Surface Elevations (normal operating range)

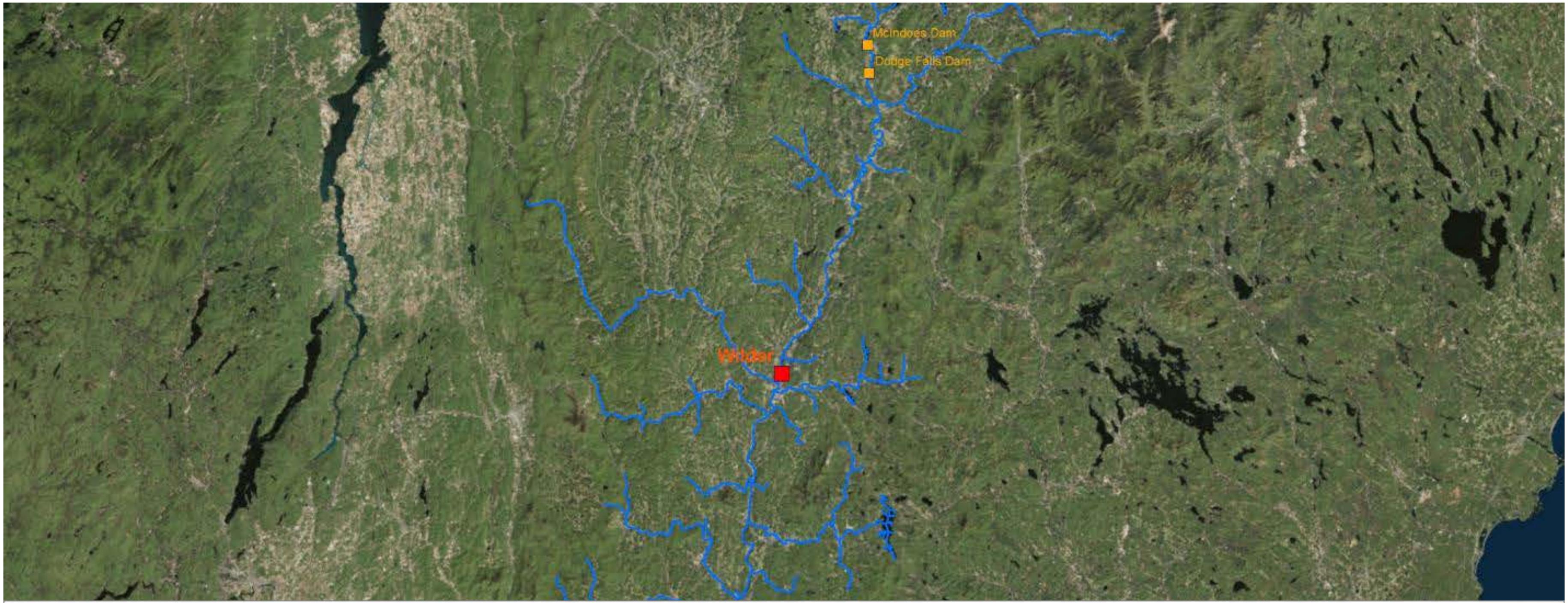


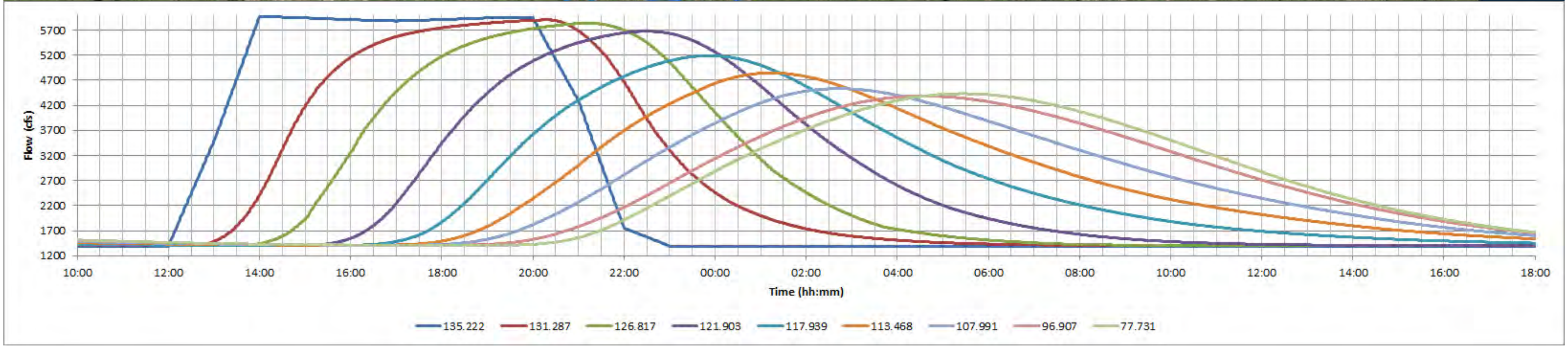
TransCanada

Study 4 – Water Surface Elevations (high inflows)

TransCanada

Study 4 – Hydraulic Model Lag Time





Study 4 – Hydraulic Model

Develop hydraulic model of the Lower Connecticut River to assist in the evaluation of the effects of project operations on aquatic, terrestrial, and geologic resources.

- **Initial screening of project effects**
- **Operations Model refinement (Study 5)**

Study 5

Operations Modeling

Study 5 – Operations Model

Overview:

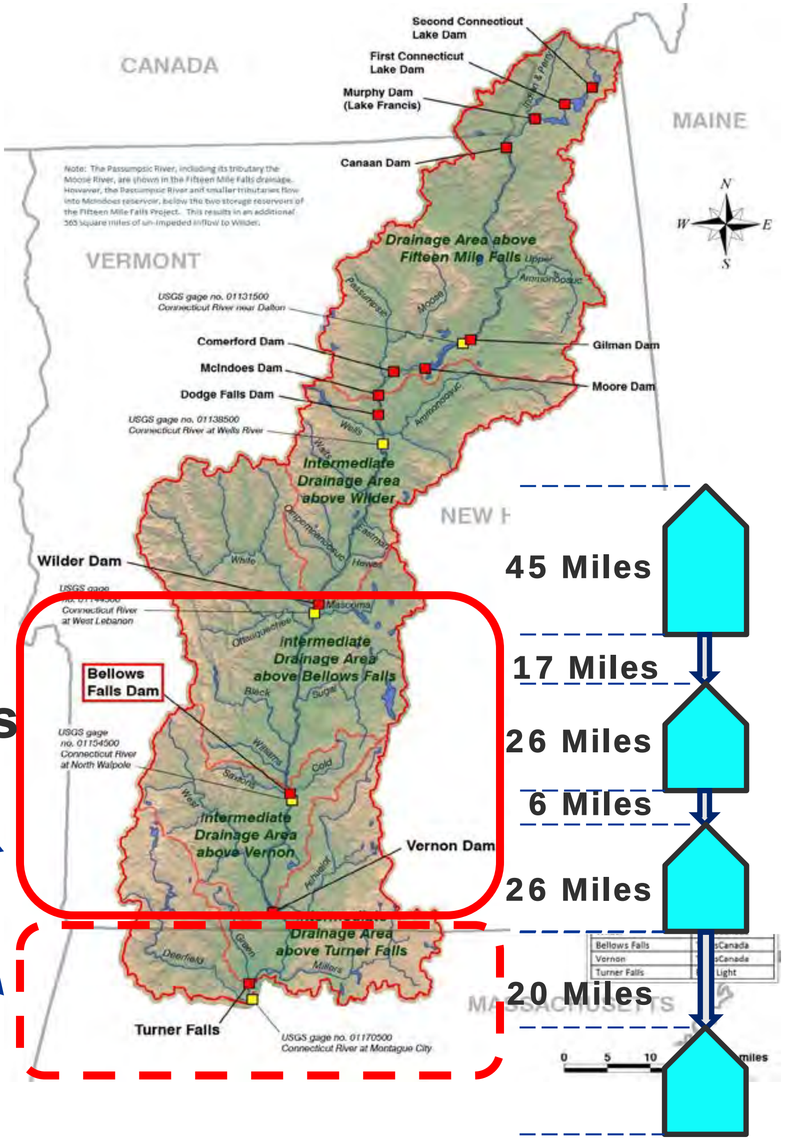
- Operations model (Vista DSS^{TM}) simulates detailed hourly operation of all TransCanada water control facilities on the Connecticut River
- Simulation is based on input hydrologic sequence and defined operational situation

Objective:

- To develop a time-series database of hourly water levels and flows for various selected operational scenarios
- The values will be available at many locations on the river system, including the three projects and identified areas of interest (econodes)
- These data will enable other studies to assess the effects of project operations on aquatic, terrestrial, and geologic resources at locations of interest

Study 5 - Project Location

Study Focus



45 Miles

17 Miles

26 Miles

6 Miles

26 Miles

20 Miles

Wilder

Bellows Falls

Vernon

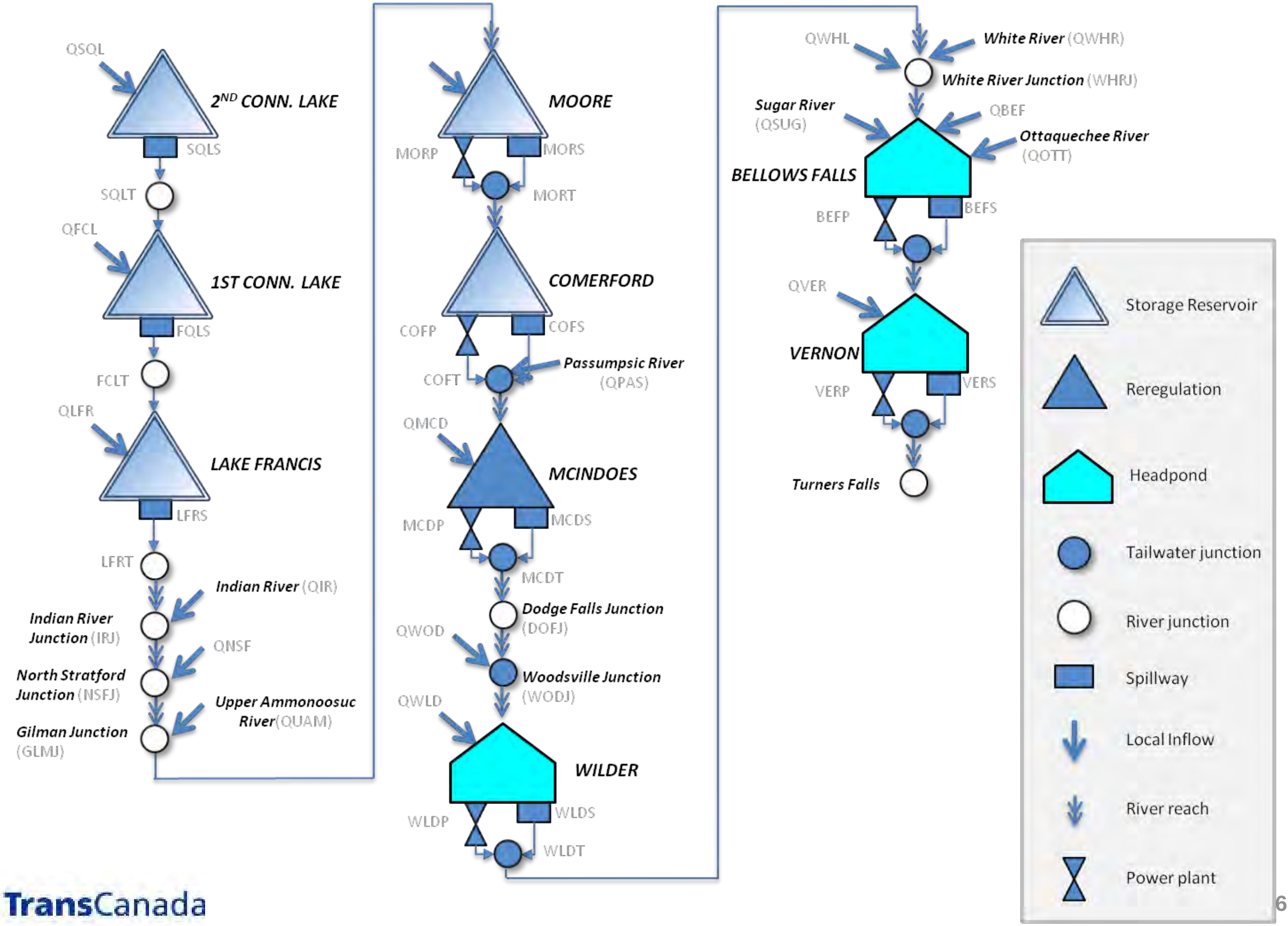
Turner Falls / Northfield Mountain

TransCanada

Study 5 – Study Update

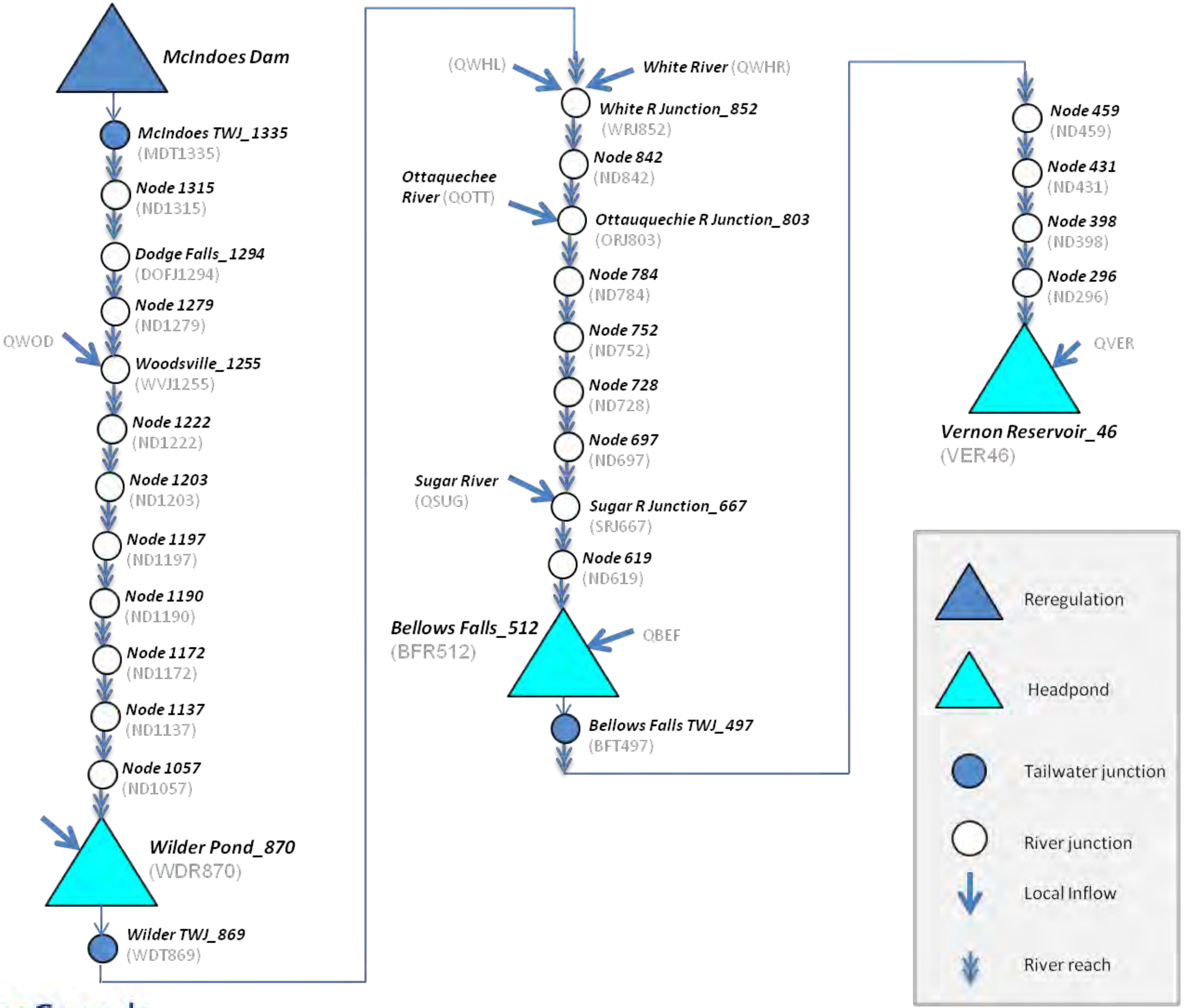
- Updated the model configuration by subdividing the primary river reaches into a number of shorter sub-reaches, resulting in 19 additional river reaches;
- Calibrated the operations model river reach routing equation coefficients using the routed flows derived from Study 4 HEC-RAS model;
- Re-ran base case operations with the updated model in order to:
  - Simulate the flows in the added river reaches;
  - Confirm that operations results are consistent with the original base case.
- Defined econode locations identified by resource leads and the associated water level rating curves from Study 4 HEC-RAS model.
- Enhanced model functionality for processing complex habitat index relationships
- Defined econode habitat indices provided by resource leads

Study 5 - Vista DSS Schematic



TransCanada

Study 5 - Vista DSS Schematic – Additional Sub reaches



McIndoes Dam

McIndoes TWJ_1335 (MDT1335)

Node 1315 (ND1315)

Dodge Falls_1294 (DOFJ1294)

Node 1279 (ND1279)

QWOD

Woodsville_1255 (WVJ1255)

Node 1222 (ND1222)

Node 1203 (ND1203)

Node 1197 (ND1197)

Node 1190 (ND1190)

Node 1172 (ND1172)

Node 1137 (ND1137)

Node 1057 (ND1057)

Wilder Pond_870 (WDR870)

Wilder TWJ_869 (WDT869)

(QWHL)

White River (QWHR)

White R Junction_852 (WRJ852)

Node 842 (ND842)

Ottaquechee River (QOTT)

Ottauquechie R Junction_803 (ORJ803)

Node 784 (ND784)

Node 752 (ND752)

Node 728 (ND728)

Node 697 (ND697)

Sugar River (QSUG)

Sugar R Junction_667 (SRJ667)

Node 619 (ND619)

Bellows Falls_512 (BFR512)

QBEF

Bellows Falls TWJ_497 (BFT497)

Node 459 (ND459)

Node 431 (ND431)

Node 398 (ND398)

Node 296 (ND296)

QVER

Vernon Reservoir_46 (VER46)

▲ Reregulation

▲ Headpond

● Tailwater junction

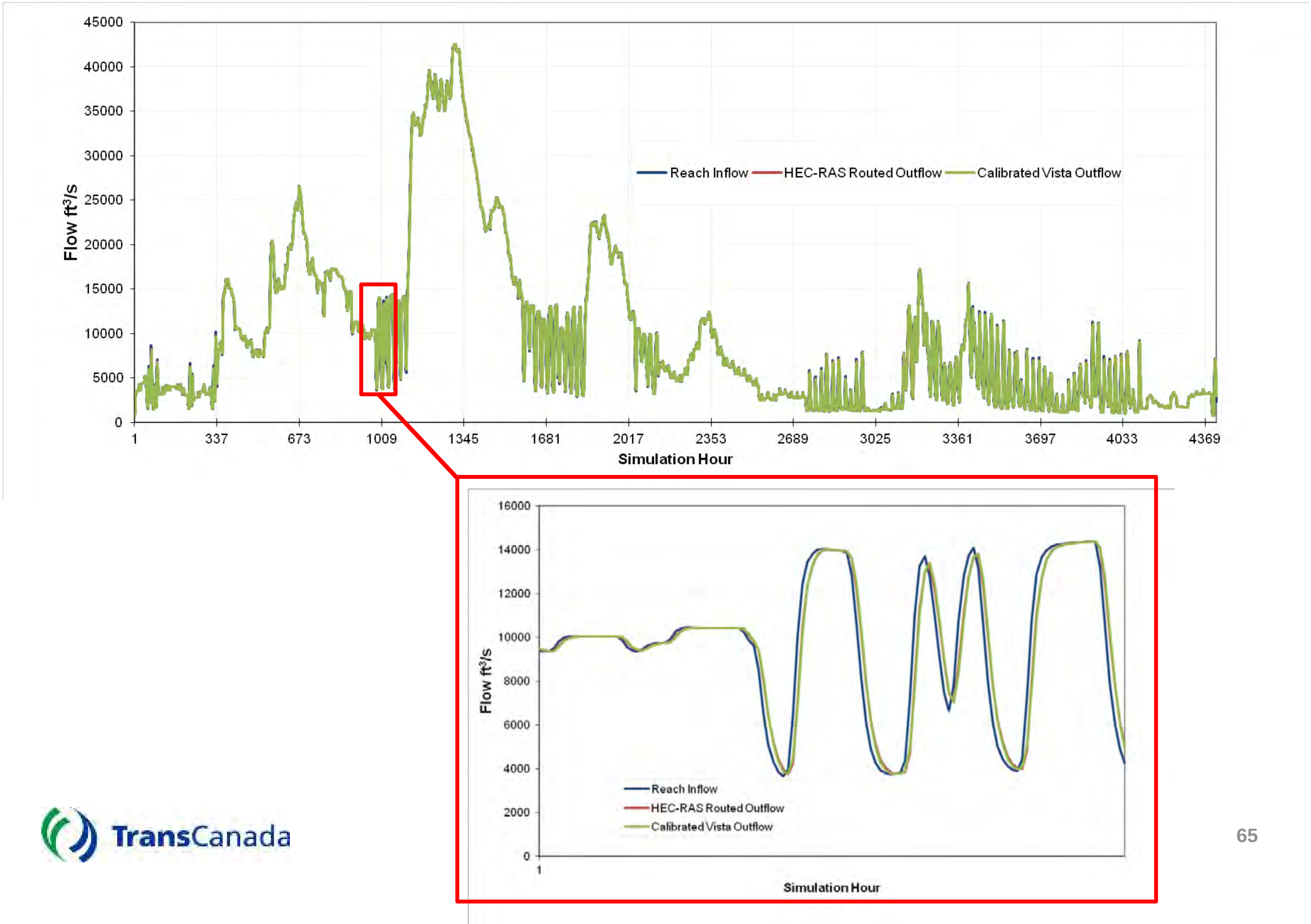
○ River junction

↓ Local Inflow

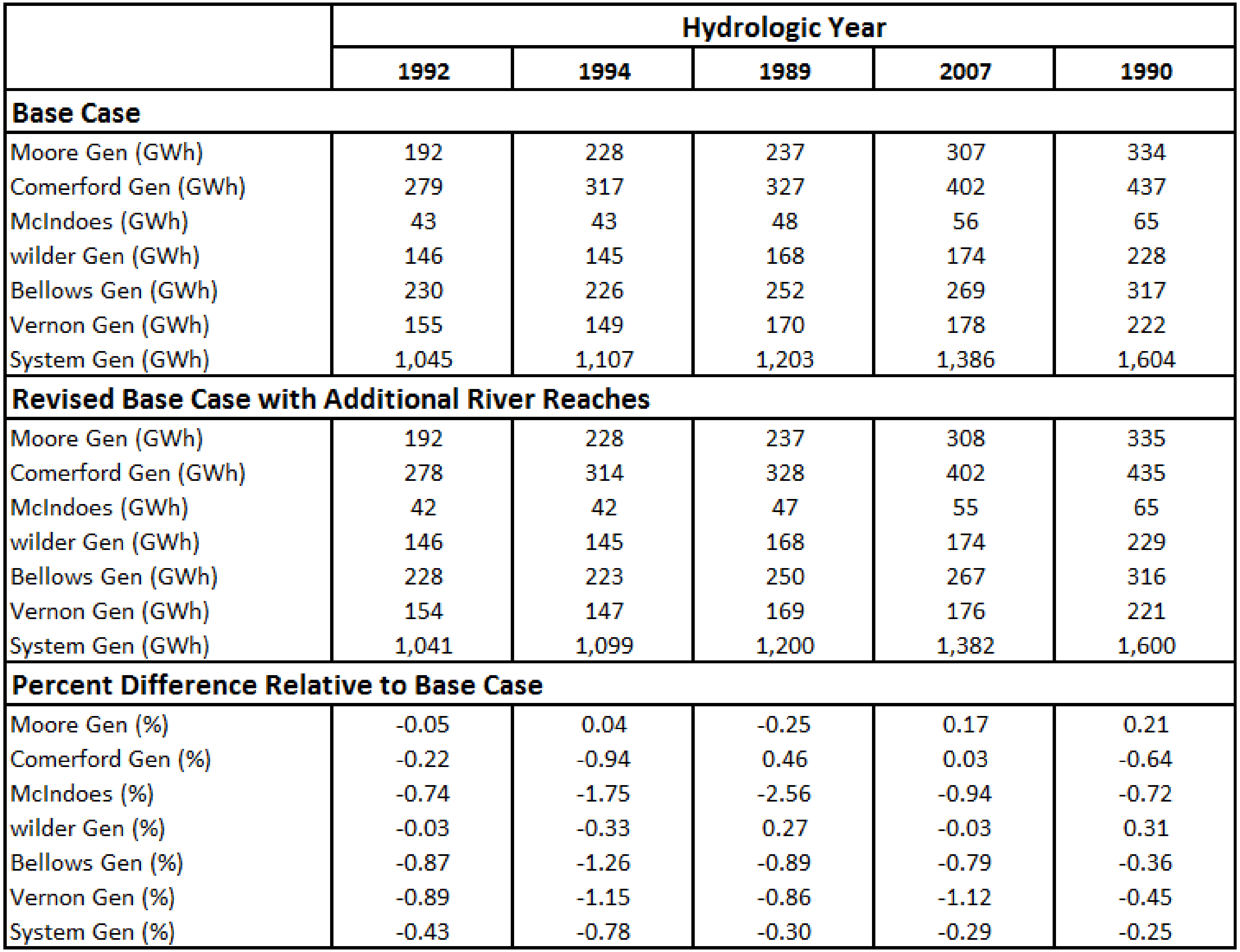
↓ River reach

TransCanada

Study 5 – Sample River Reach Calibration to HEC-RAS Data

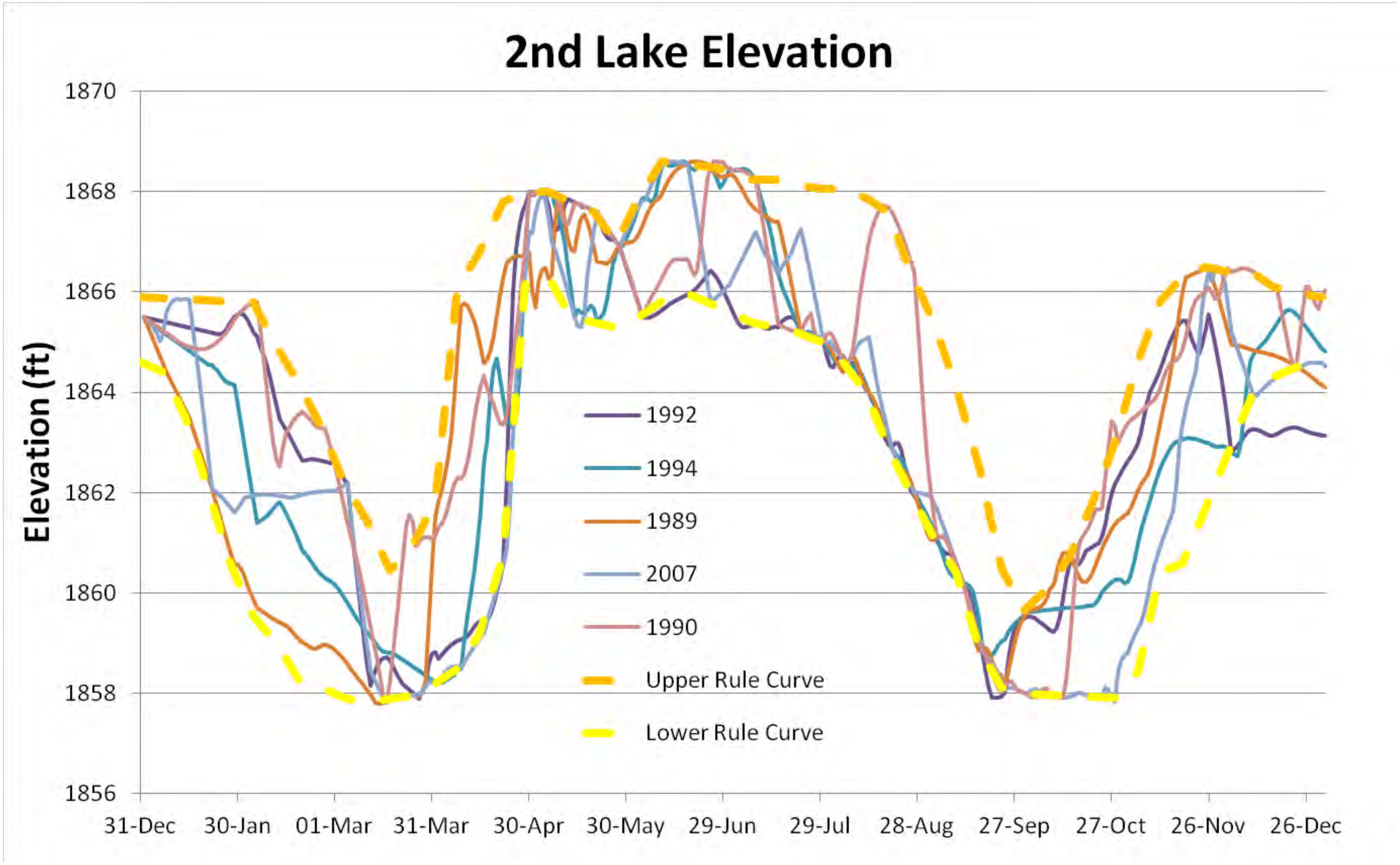


Study 5 – Comparison between Base Case and Base Case Re-Run



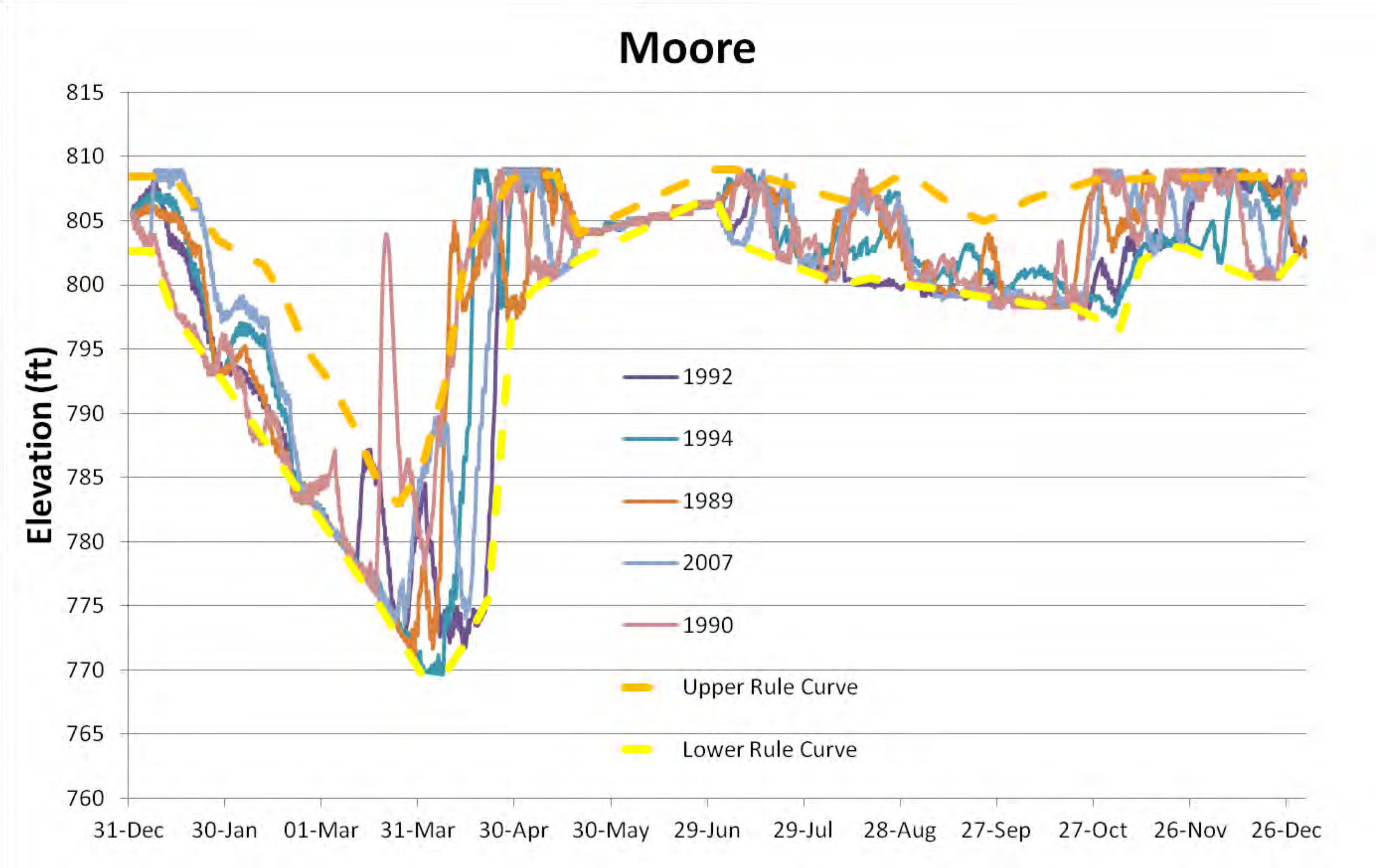
	Hydrologic Year				
	1992	**1994**	**1989**	**2007**	**1990**
Base Case					
Moore Gen (GWh)	192	228	237	307	334
Comerford Gen (GWh)	279	317	327	402	437
McIndoes (GWh)	43	43	48	56	65
wilder Gen (GWh)	146	145	168	174	228
Bellows Gen (GWh)	230	226	252	269	317
Vernon Gen (GWh)	155	149	170	178	222
System Gen (GWh)	1,045	1,107	1,203	1,386	1,604
Revised Base Case with Additional River Reaches					
Moore Gen (GWh)	192	228	237	308	335
Comerford Gen (GWh)	278	314	328	402	435
McIndoes (GWh)	42	42	47	55	65
wilder Gen (GWh)	146	145	168	174	229
Bellows Gen (GWh)	228	223	250	267	316
Vernon Gen (GWh)	154	147	169	176	221
System Gen (GWh)	1,041	1,099	1,200	1,382	1,600
Percent Difference Relative to Base Case					
Moore Gen (%)	-0.05	0.04	-0.25	0.17	0.21
Comerford Gen (%)	-0.22	-0.94	0.46	0.03	-0.64
McIndoes (%)	-0.74	-1.75	-2.56	-0.94	-0.72
wilder Gen (%)	-0.03	-0.33	0.27	-0.03	0.31
Bellows Gen (%)	-0.87	-1.26	-0.89	-0.79	-0.36
Vernon Gen (%)	-0.89	-1.15	-0.86	-1.12	-0.45
System Gen (%)	-0.43	-0.78	-0.30	-0.29	-0.25

Study 5 - Base Case Re-Run – Sample Water Level Compliance with Rule Curves: Most Upstream Reservoir



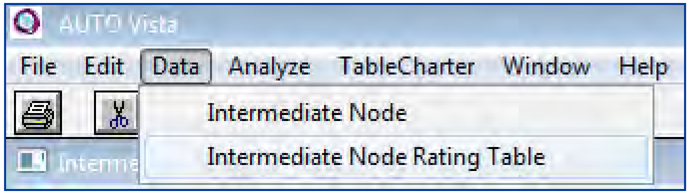
TransCanada

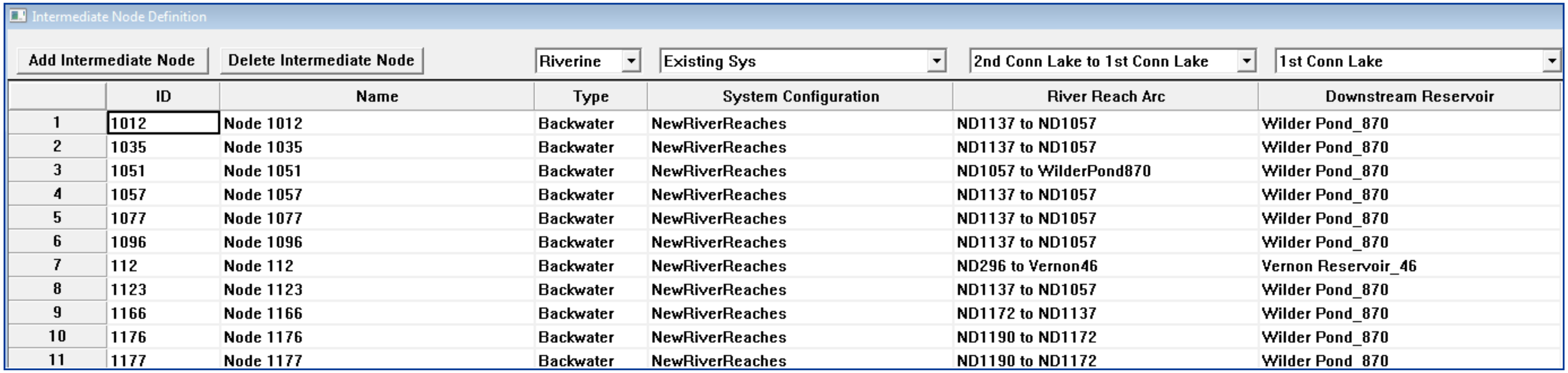
Study 5 - Base Case Re-Run – Sample Water Level Compliance with Rule Curves: Largest Reservoir



TransCanada

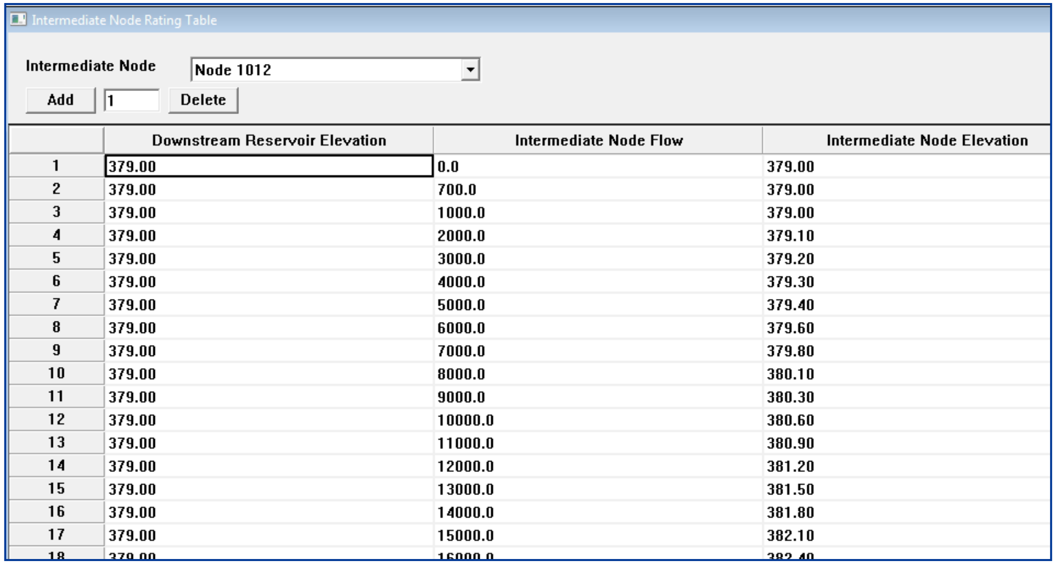
Study 5 – Econode Definition in Vista





Riverine | Existing Sys | 2nd Conn Lake to 1st Conn Lake | 1st Conn Lake

	ID	Name	Type	System Configuration	River Reach Arc	Downstream Reservoir
1	1012	Node 1012	Backwater	NewRiverReaches	ND1137 to ND1057	Wilder Pond_870
2	1035	Node 1035	Backwater	NewRiverReaches	ND1137 to ND1057	Wilder Pond_870
3	1051	Node 1051	Backwater	NewRiverReaches	ND1057 to WilderPond870	Wilder Pond_870
4	1057	Node 1057	Backwater	NewRiverReaches	ND1137 to ND1057	Wilder Pond_870
5	1077	Node 1077	Backwater	NewRiverReaches	ND1137 to ND1057	Wilder Pond_870
6	1096	Node 1096	Backwater	NewRiverReaches	ND1137 to ND1057	Wilder Pond_870
7	112	Node 112	Backwater	NewRiverReaches	ND296 to Vernon46	Vernon Reservoir_46
8	1123	Node 1123	Backwater	NewRiverReaches	ND1137 to ND1057	Wilder Pond_870
9	1166	Node 1166	Backwater	NewRiverReaches	ND1172 to ND1137	Wilder Pond_870
10	1176	Node 1176	Backwater	NewRiverReaches	ND1190 to ND1172	Wilder Pond_870
11	1177	Node 1177	Backwater	NewRiverReaches	ND1190 to ND1172	Wilder Pond_870

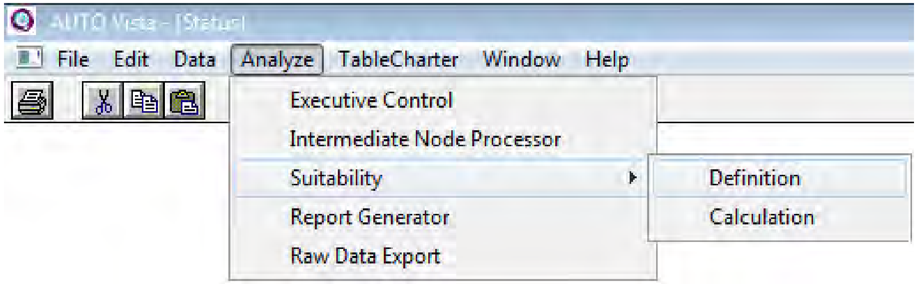


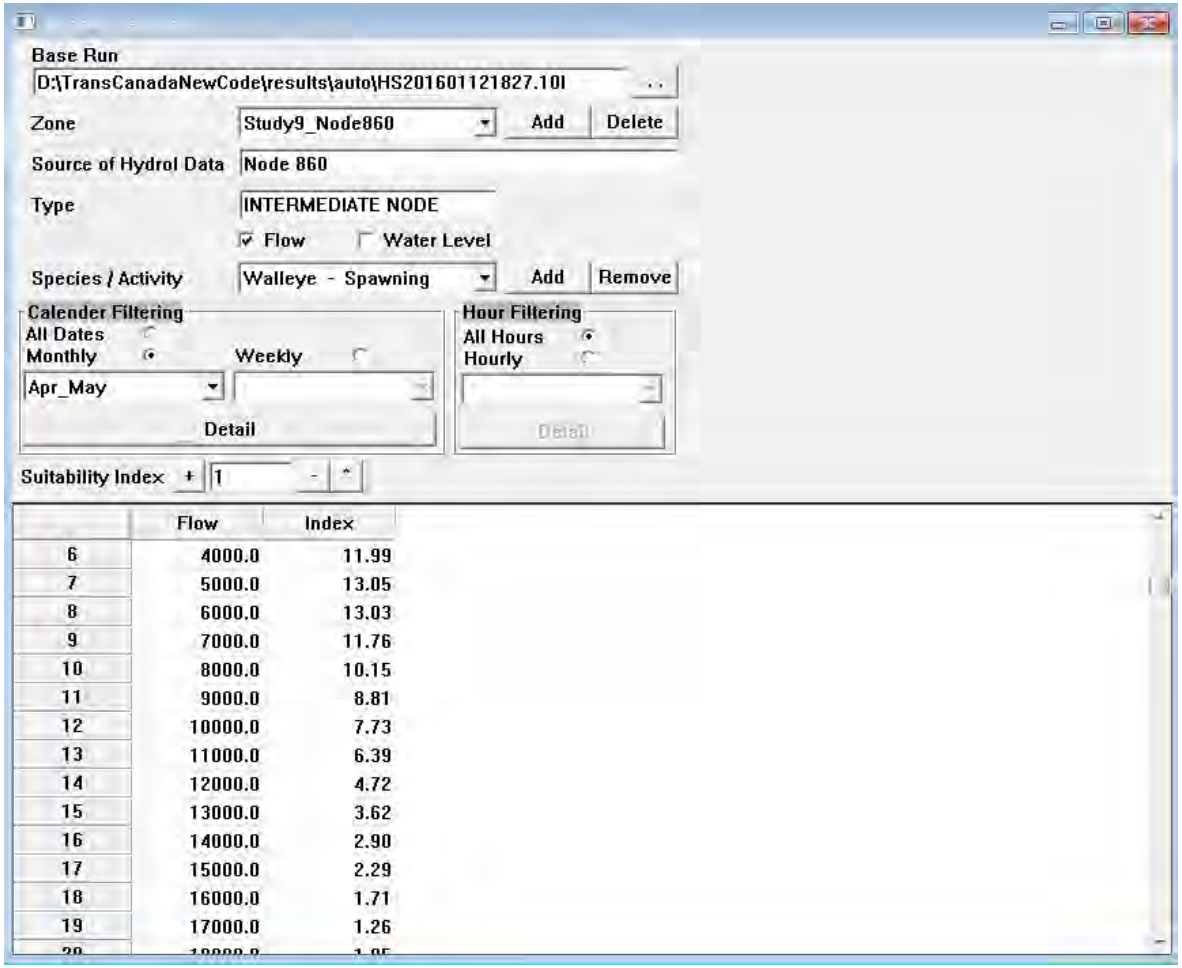
Intermediate Node: Node 1012

1

	Downstream Reservoir Elevation	Intermediate Node Flow	Intermediate Node Elevation
1	379.00	0.0	379.00
2	379.00	700.0	379.00
3	379.00	1000.0	379.00
4	379.00	2000.0	379.10
5	379.00	3000.0	379.20
6	379.00	4000.0	379.30
7	379.00	5000.0	379.40
8	379.00	6000.0	379.60
9	379.00	7000.0	379.80
10	379.00	8000.0	380.10
11	379.00	9000.0	380.30
12	379.00	10000.0	380.60
13	379.00	11000.0	380.90
14	379.00	12000.0	381.20
15	379.00	13000.0	381.50
16	379.00	14000.0	381.80
17	379.00	15000.0	382.10
18	379.00	16000.0	382.40

Study 5 – Suitability Definition





Base Run: D:\TransCanadaNewCode\results\auto\HS201601121827.10I

Zone: Study9_Node860

Source of Hydrol Data: Node 860

Type: INTERMEDIATE NODE

☑ Flow ☐ Water Level

Species / Activity: Walleye - Spawning

Calender Filtering: ○ All Dates ● Monthly ○ Weekly — Apr_May

Hour Filtering: ● All Hours ○ Hourly

Suitability Index: 1

	Flow	Index
6	4000.0	11.99
7	5000.0	13.05
8	6000.0	13.03
9	7000.0	11.76
10	8000.0	10.15
11	9000.0	8.81
12	10000.0	7.73
13	11000.0	6.39
14	12000.0	4.72
15	13000.0	3.62
16	14000.0	2.90
17	15000.0	2.29
18	16000.0	1.71
19	17000.0	1.26

Study 5 – Sample Model Output

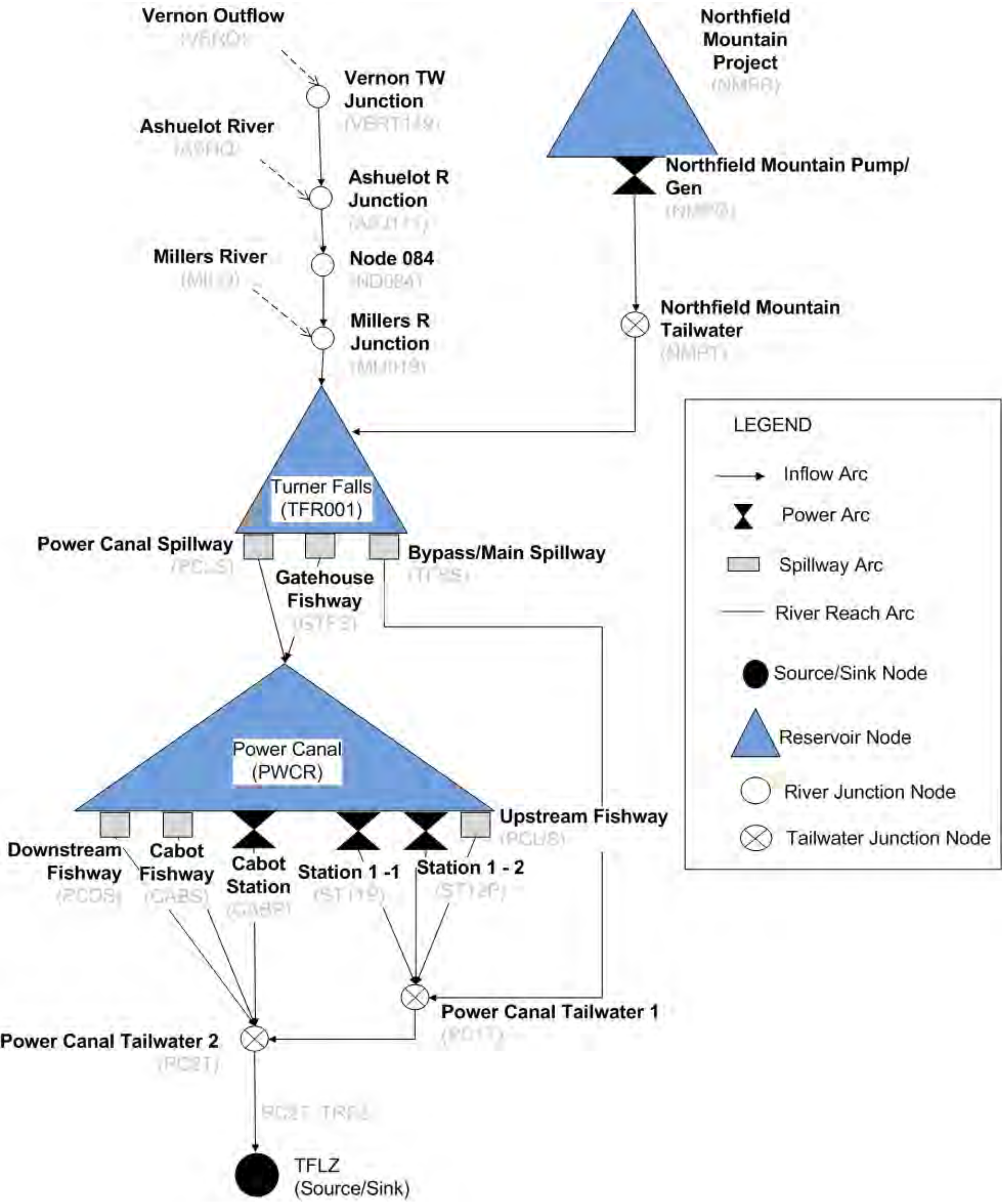
Study No.	No. of Econodes	Model Output
13 – Tributary and Backwater Fish Access and Habitats Study	39	Daily time series of number of hours without access and % time without access
16 – Sea Lamprey Spawning Assessment	28	Hourly time series of water surface elevation
25 – Dragonfly Inventory 26 – Cobblestone Tiger Beetle Survey 28 – Fowlers Toad Survey 29 – Northeastern Bulrush Survey	48 total	Hourly, daily, weekly, monthly and seasonal water surface elevation time series and plots
9 – Instream Flow Study	5	Hourly time series and duration curves of life stages habitat indices for 9 species (total of 25 life stages per location)

Study 5 – Current Activity

Analysis of additional econode habitat indices as requested by resource leads

Operational simulation of FirstLight’s Turner Falls and Northfield Mountain projects for the five selected hydrologic years to enable evaluation of habitat indices below Vernon

Study 5 - Vista DSS FirstLight Schematic



TransCanada

Study 5 - FirstLight Constraints – All Constraints

Reservoir	Operating Range (ft) (Min – Max)
Turner Falls Impoundment	179.0 - 185.0
Power Canal	173.3 - 173.35
Northfield Mountain Upper Reservoir	938.0 - 1,000.5

High Flow Reservoir Profile Operation (Turner Falls)	
Flow (cfs)	**Max Elevation (ft)**
< 25,000	185.0
25,000	184.0
40,000	183.6
53,000	183.08
69,000	182.65
80,000	180.5

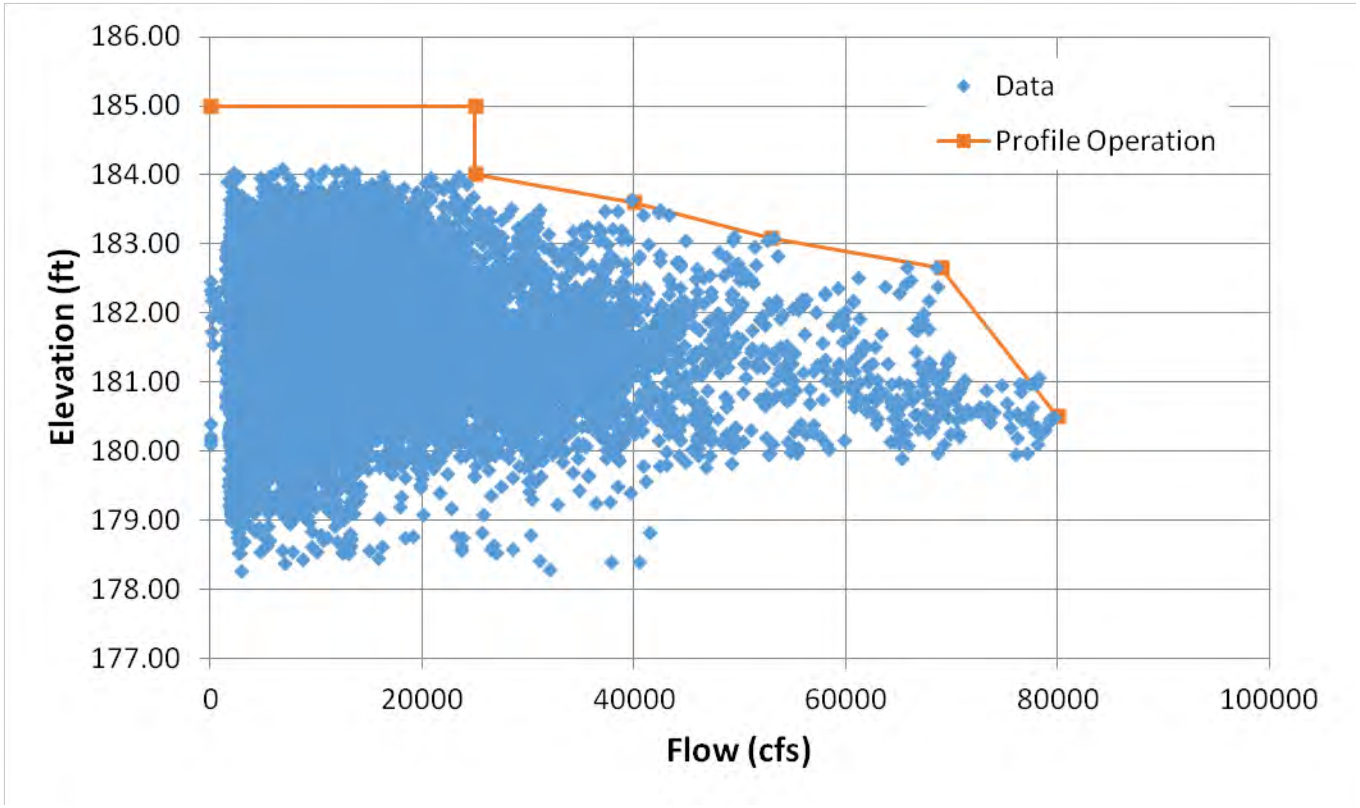
Reservoirs	Combined Minimum Usable Storage (acre-ft)
Turner Falls Impoundment and Northfield Mountain Upper Reservoir	12,318

Site	Discharge Constraint Type	Value (cfs)	From-To
Gatehouse Fishway	Req	235.0	April 1- July 15
Bypass / Main Spillway	Min	400.0 120	April 1- July 15 July 16 to Nov 15
Downstream Fishway	Req	200.0	April 7- Nov 15
Cabot Fishway	Req	33.0	April 1- July 15
Upstream Fishway	Req	18	April 1 – July 15
Turners Falls Total Outflow	Min or Inflow	1433	All year

Study 5 - FirstLight Constraints Flood Rule Constraint

High Flow Reservoir Profile Operation
(Turner Falls)

Flow (cfs)	Max Elevation (ft)
< 25,000	185.0
25,000	184.0
40,000	183.6
53,000	183.08
69,000	182.65
80,000	180.5



2013 -2014 Operations Data

Study 6

Water Quality Study

Study 6 – Water Quality Study

Study Objectives

Characterize:

- Temperature in the river, impoundments, Bellows Falls bypass reach, forebays, tailraces, and the main tributaries
- Dissolved oxygen, conductivity, turbidity, and pH at river stations, including during a 10-day low-flow period
- Nutrient and chlorophyll concentrations at forebay stations

Assess:

- Potential effects of Wilder, Bellows Falls and Vernon Projects on water quality and temperature in the Connecticut River
- Compliance with VT and NH surface water quality standards

Study 6 – Water Quality Study

Field Activities

							Mar-May	Jun-Sep					Oct-Nov
							Cont.	Continuous			Instantaneous		Cont.
	Station ID	Wilder	Bellows F.	Vernon	Location	Date of fisrt deployment	Temp. sonde	Temp. Sonde	Temp. Transect	Multi-Sonde	Vertical profile	Water Sample Core	Temp. sonde
Connecticut River	06-W-04	🟥			upstream	1-May	●	●	7Q10	7Q10	●		●
	06-W-03	🟥			upper imp.	1-May	●	●			●		●
	06-W-02	🟥			mid-imp.	1-May	●	●			●		●
	06-W-01	🟥			lower imp.	7-May	●			●	●	●	●
	06-W-TR	🟥			tailrace	7-May	●			●	●		●
	06-BF-04		🟦		upstream	29-Apr	●	●	7Q10	7Q10	●		●
	06-BF-03		🟦		upper imp.	29-Apr	●	●			●		●
	06-BF-02		🟦		mid-imp.	29-Apr	●	●			●		●
	06-BF-01		🟦		lower imp.	8-May	●			●	●	●	●
	06-BF-BR		🟦		bypassed reach	13-May	●			●			●
	06-BF-TR		🟦		tailrace	21-May	●			●	●		●
	06-V-04			🟩	upstream	30-Apr	●	●	7Q10	7Q10	●		●
	06-V-03			🟩	upper imp.	30-Apr	●	●			●		●
	06-V-02			🟩	mid-imp.	30-Apr	●	●			●		●
	06-V-01			🟩	lower imp.	13-May	●			●	●	●	●
	06-V-TR			🟩	tailrace	6-May	●			●	●		●
Tributaries	06-W-T02	●			Waits R.	25-Mar	●	●					●
	06-W-T01	●			Ompomp. R.	7-Apr	●	●					●
	06-BF-T05		●		White R.	7-Apr	●	●					●
	06-BF-T04		●		Mascoma R.	25-Mar	●	●					●
	06-BF-T03		●		Sugar R.	7-Apr	●	●					●
	06-BF-T02		●		Black R.	25-Mar	●	●					●
	06-BF-T01		●		Williams R.	26-Mar	●	●					●
	06-V-T03			●	Saxton R.	24-Mar	●	●					●
	06-V-T02			●	Cold R.	24-Mar	●	●					●
	06-V-T01			●	West R.	23-Apr	●	●					●

TransCanada

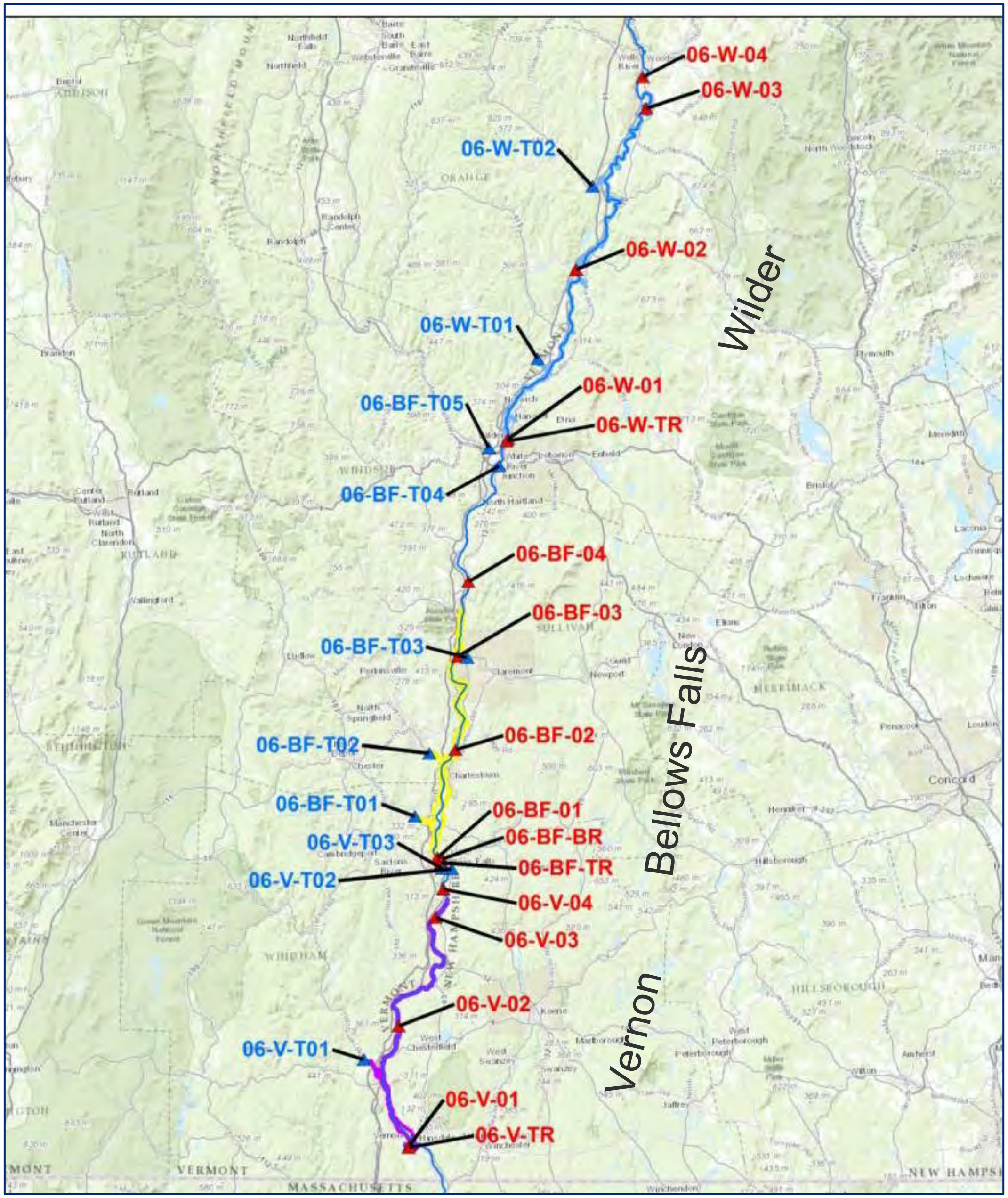
Study 6 – Water Quality Study

Stations

▲ Connecticut River (n=16)

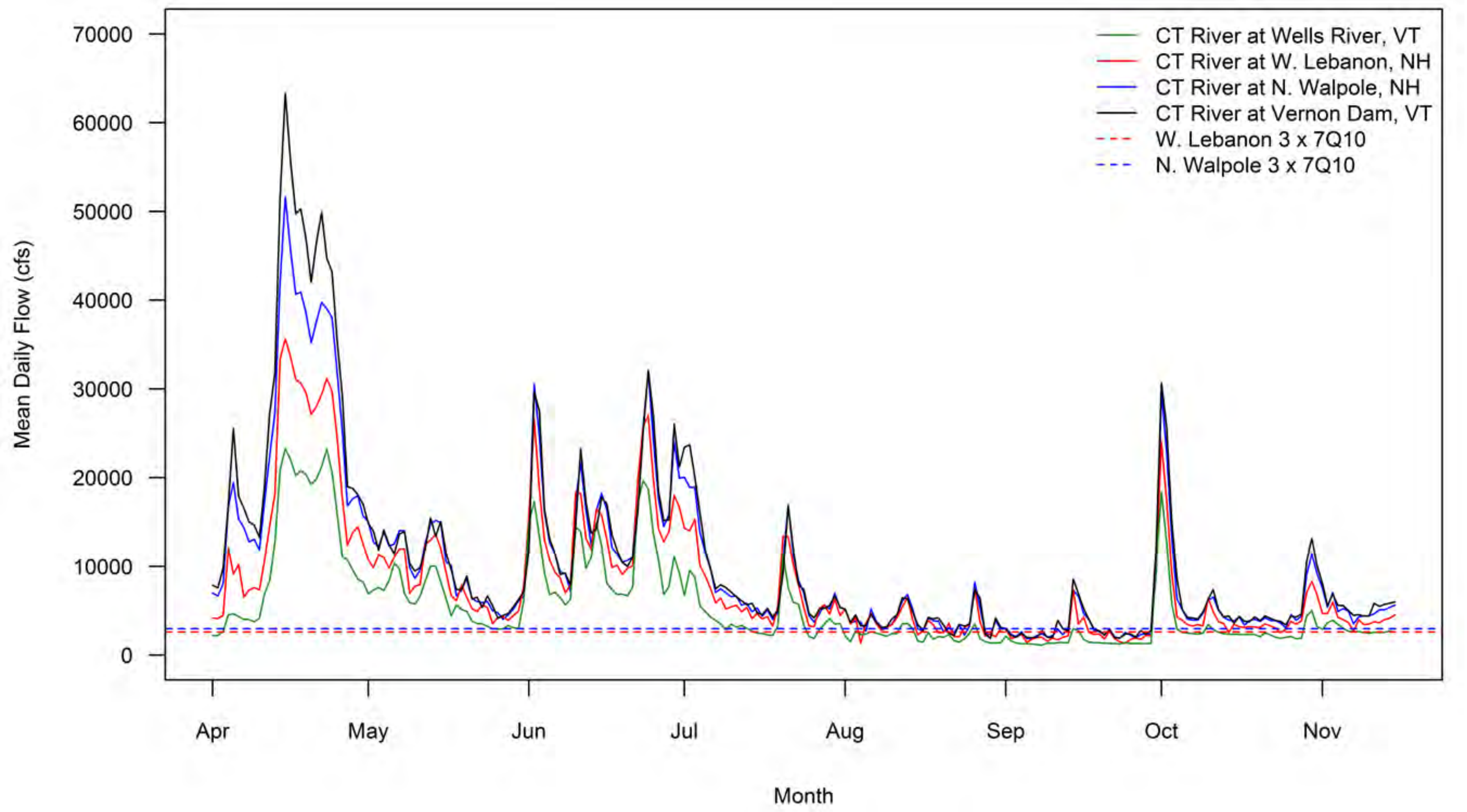
▲ Tributaries (n=10)

- Approximately 120 river miles.



Study 6 – Water Quality Study

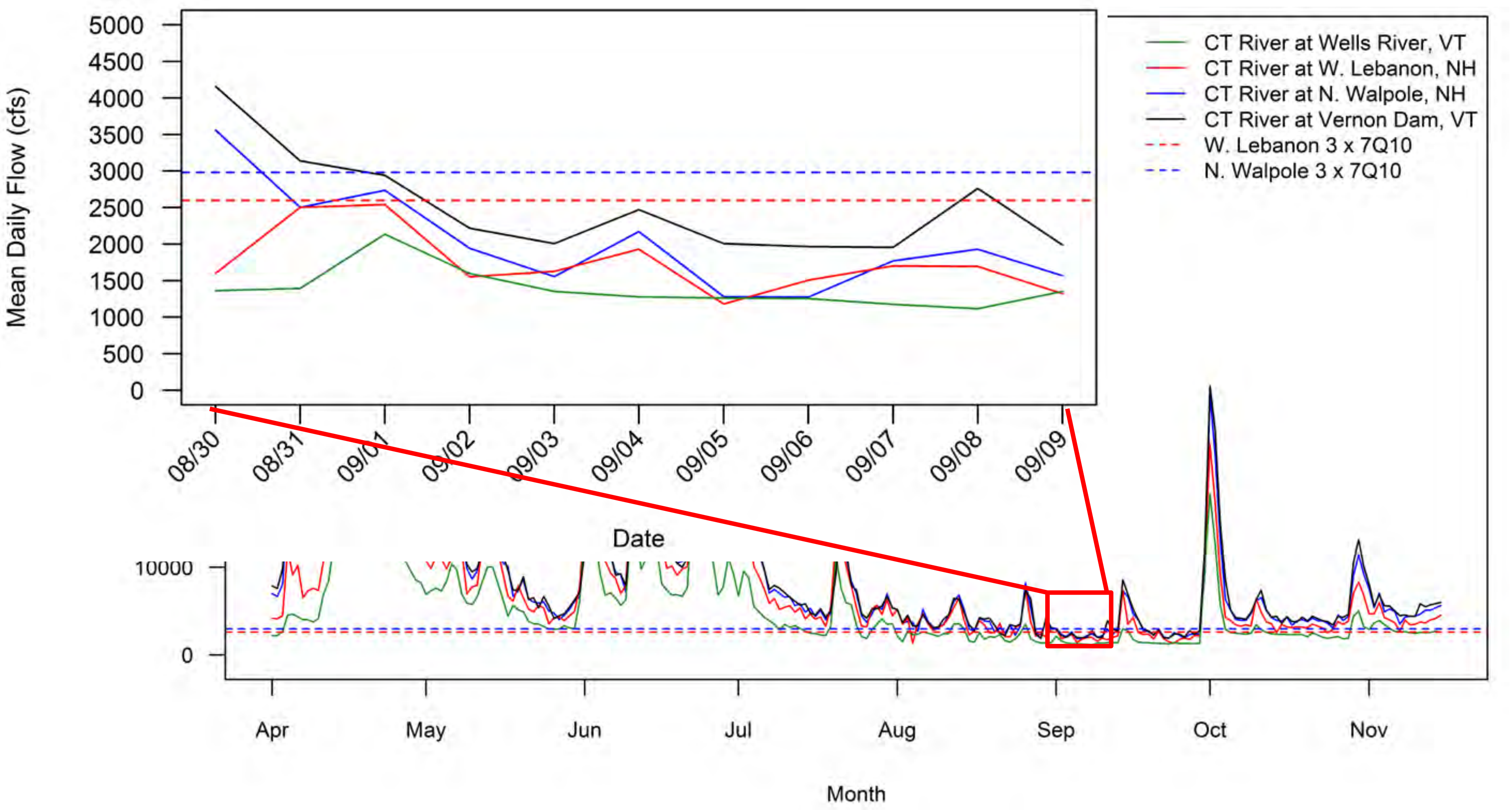
Mean Daily Flow



TransCanada

Study 6 – Water Quality Study

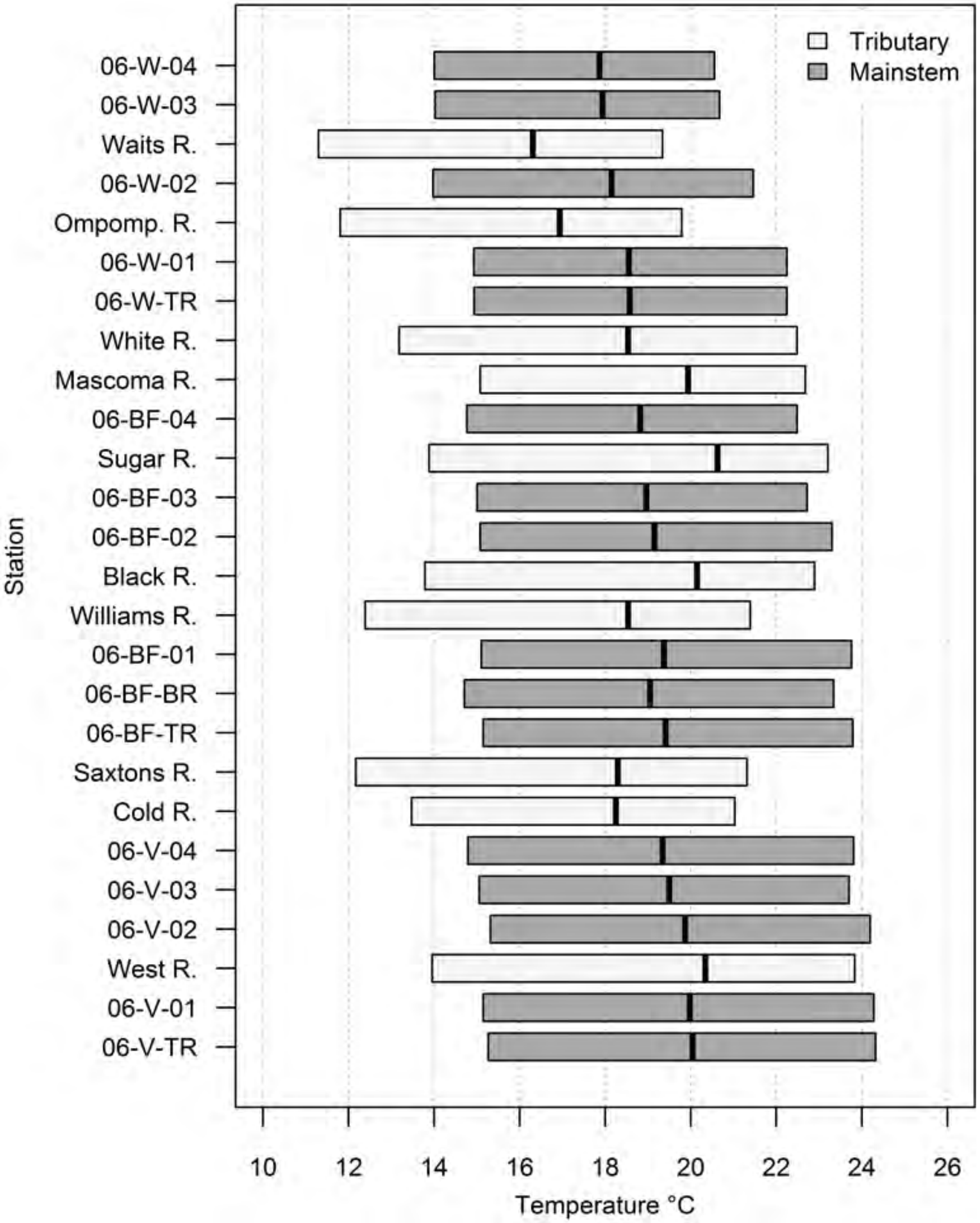
10 Day High Temperature Low-flow Period



Study 6 – Water Quality Study

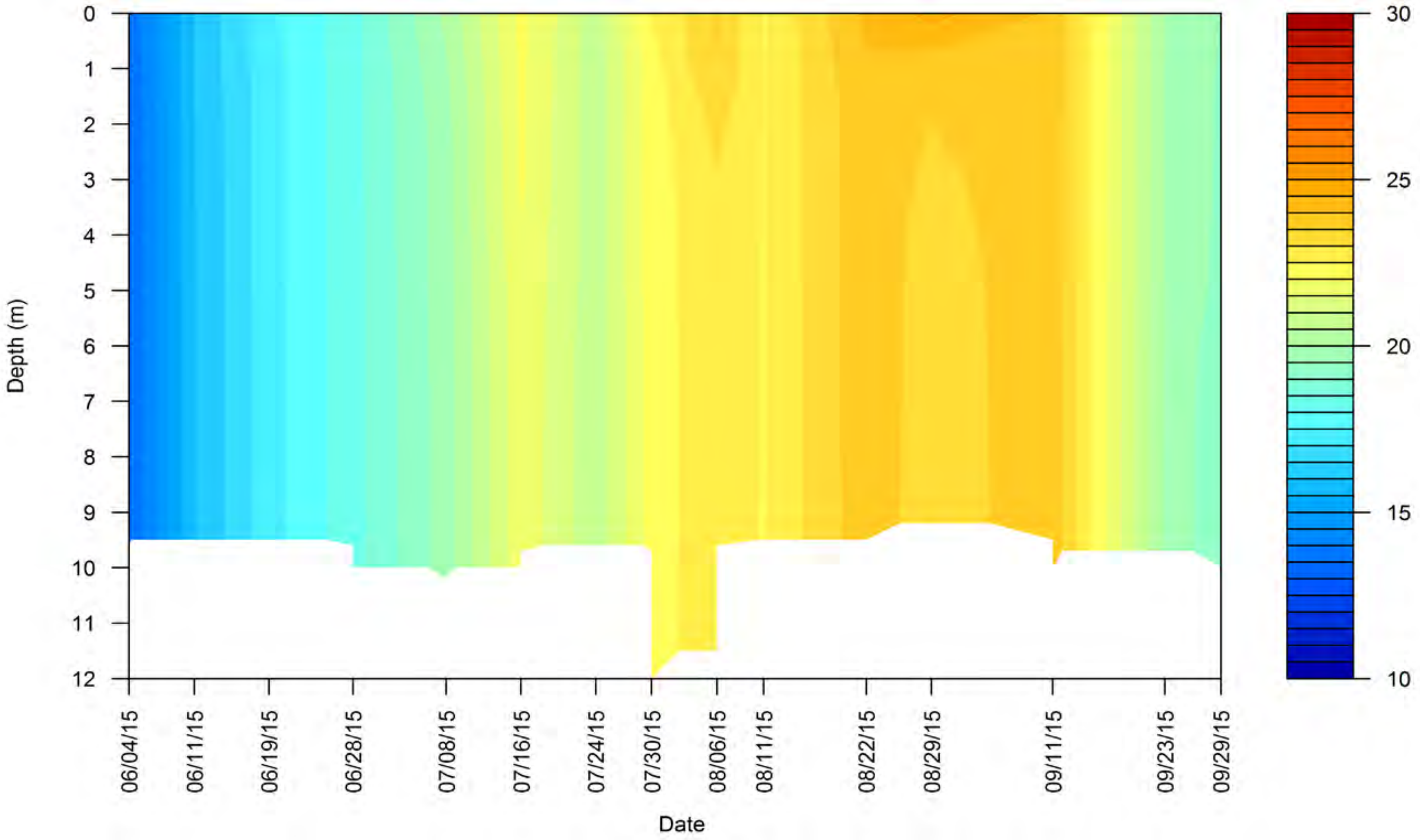
Water Temperature

- Highest in August
- Upstream to downstream warming
- Well-defined diel fluctuations at upstream, upper impoundment, and Bellows Falls bypassed reach stations
- Tributary effects very minor
- 10–day high temp low-flow period
  - Mean temperature 22.1 to 25.5°C
  - Largest temperature difference at forebay stations between surface and bottom loggers (Mean 0.6 to 0.8°C)



Study 6 – Water Quality Study

Water Temperature (ºC) through Time (example station 06-W-01)



Study 6 – Water Quality Study

Water Temperature – Surface Water Quality Standards

Class B Water Quality Standards	
NH	Any increase shall not be such as to appreciably interfere with the uses assigned to this class.
VT	Change or rate of change in temperature, either upward or downward, shall not exceed 1°F (0.56°C) from ambient temperatures due to all discharges and activities and be controlled to ensure full support of aquatic biota, wildlife, and aquatic habitat uses.

- Upstream to downstream warming:
  - Weekly mean temperatures increased ~ 1.0°C for Wilder and Bellows Falls from upstream to tailrace stations (Vernon 0.5°C)
  - Weekly mean difference between forebay and tailrace stations, 0.0 to 0.1°C
  - Naturally occurring in part due to changes in latitude and elevation
  - Tributaries showed similar north to south warming

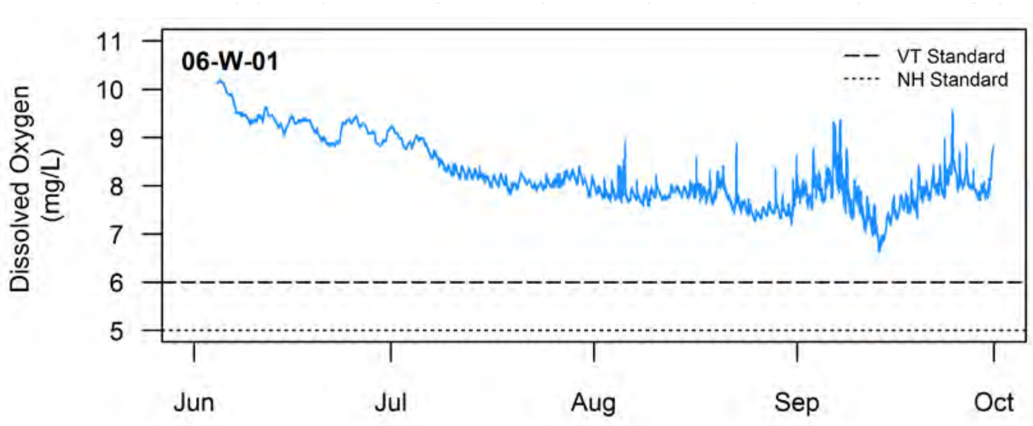
TransCanada

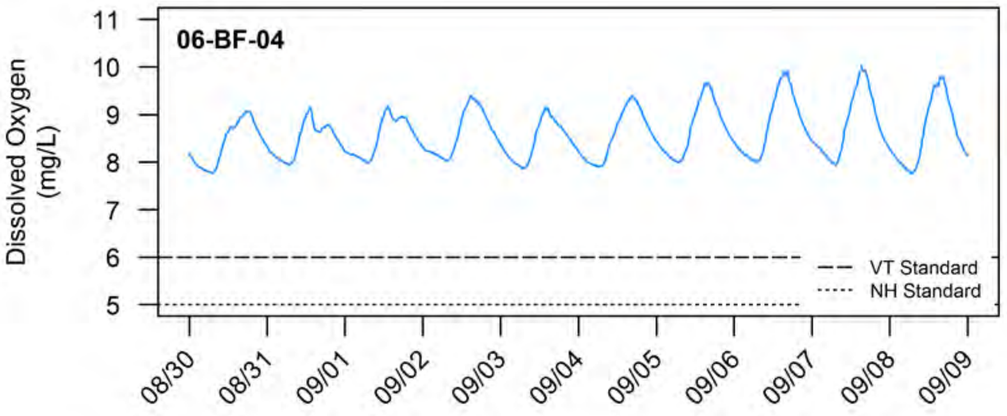
Study 6 – Water Quality Study

Dissolved Oxygen

Class B Water Quality Standards	
NH	Daily average at least 75 percent saturation; instantaneous minimum of 5.0 mg/L.
VT	Not less than 6 mg/l and 70 percent saturation.

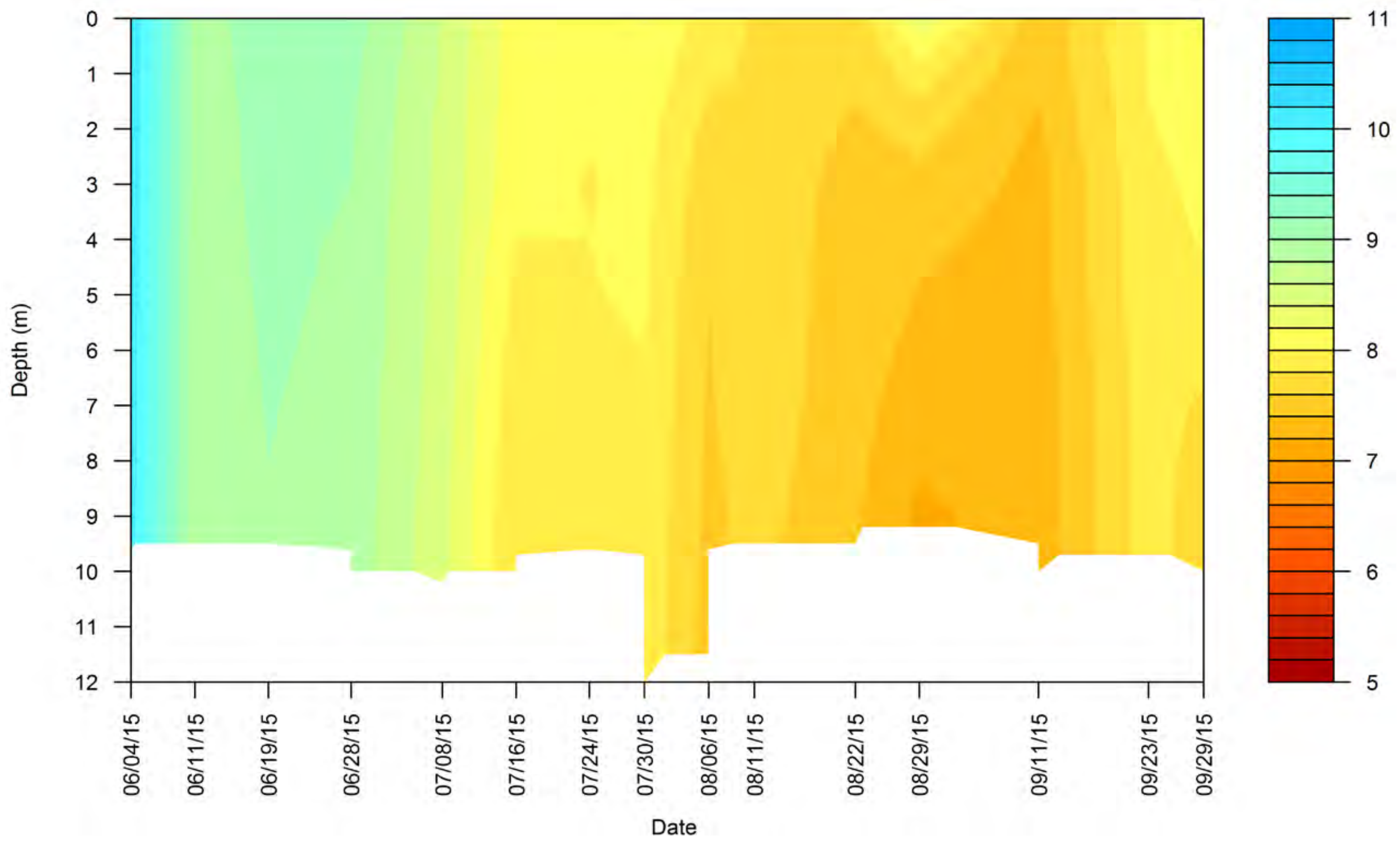
- General decrease to mid-September, increase through fall
- Well-defined diel fluctuations at upstream, upper impoundment, and Bellows Falls bypassed reach
- General decrease from upstream to downstream
- Never fell below state surface water quality standards at any mainstem station:
  - mg/L (inst.): 6.6 to 10.7
  - % sat (inst.): 78.0 to 121.9
  - % sat (daily mean): 81.1 to 113.2





Study 6 – Water Quality Study

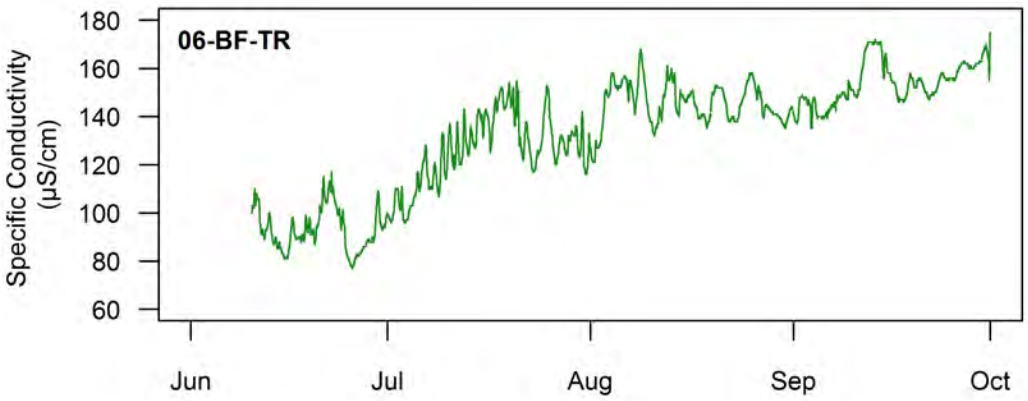
Dissolved Oxygen (mg/L) through Time (example station 06-W-01)

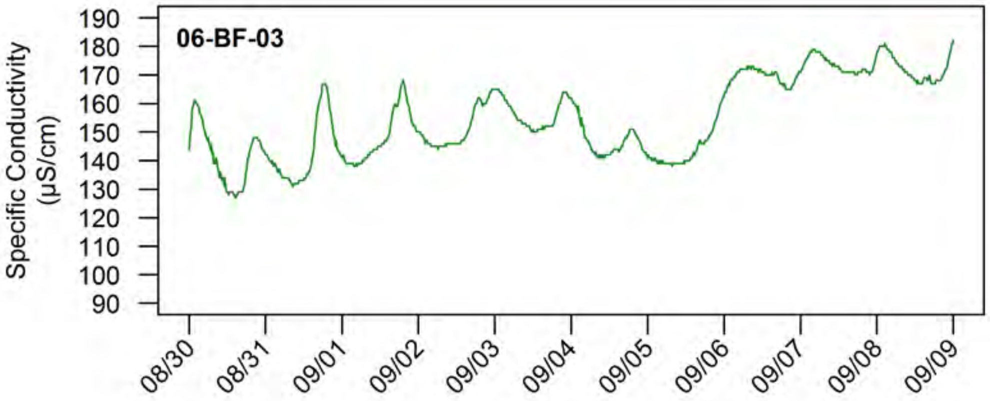


Study 6 – Water Quality Study

Specific Conductivity

- Variable throughout the study
- Generally lowest in late-spring/early summer, highest in mid- to late-summer
- Some diel fluctuations
- Generally higher in upstream and upper impoundment areas of Wilder and Bellows Falls, similar among Vernon stations
- No surface water quality standard

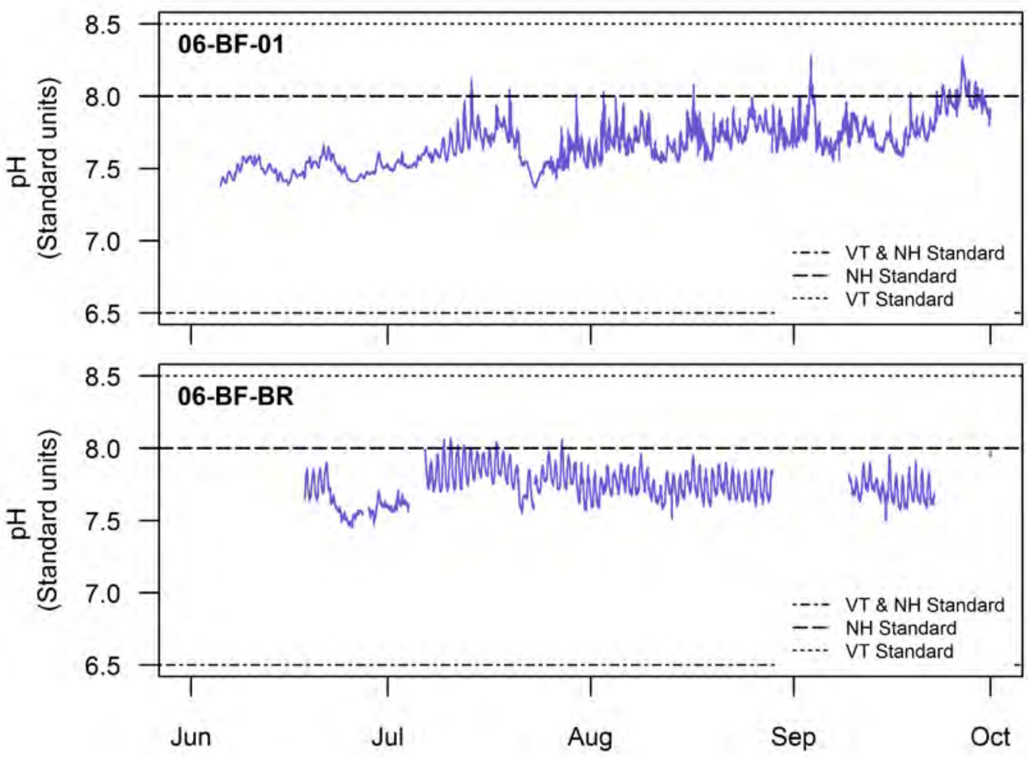




Study 6 – Water Quality Study

pH

- Fairly consistent throughout the study
- Some increase in summer above 8.0
- Slightly basic
    - Wilder: 7.11 to 8.02
    - Bellows Falls: 7.19 to 8.56
    - Vernon: 7.25 to 8.06
- Diel fluctuations at upstream, upper impoundment, and Bellows Falls bypassed reach

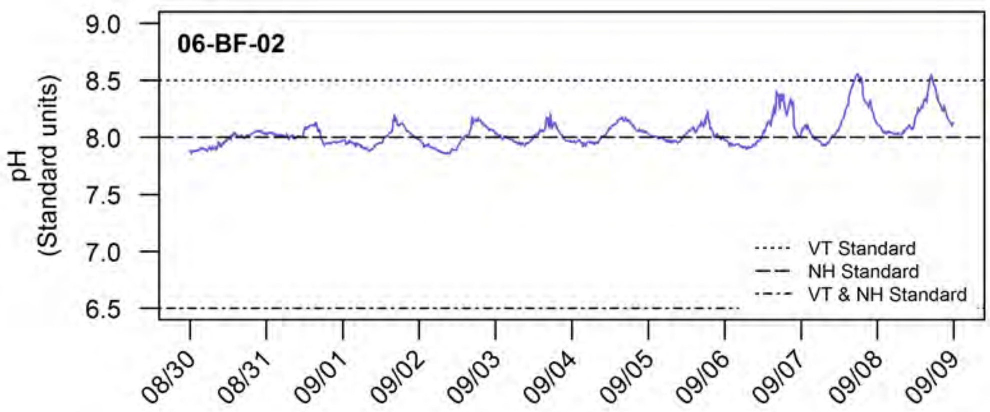


Study 6 – Water Quality Study

pH – Surface Water Quality Standards

- pH were observed to occasionally exceed NH and VT standards
    - 8.01 to 8.56
- 06-W-01, all Bellows Falls, 06-V-04, 06-V-03 and 06-V-01
- Mid-day to late afternoon/early evening in July, August, September
- pH exceedances coincident with high levels of chlorophyll-*a*
- pH never fell below the lower limit (6.5)

Class B Water Quality Standards	
NH	6.5 to 8.0, unless due to natural causes.
VT	Between 6.5 and 8.5 standard units.

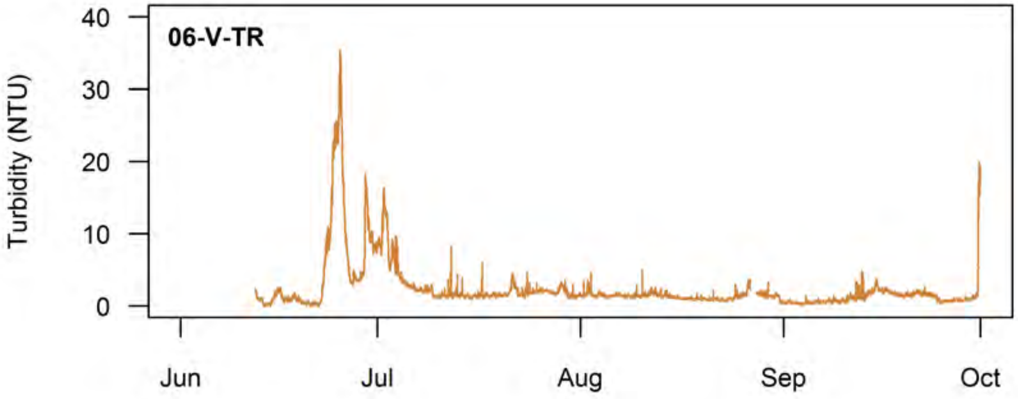


Study 6 – Water Quality Study

Turbidity

- Very low
  - Wilder: 1.0 NTU (mode)
  - Bellows Falls: 1.5 NTU (mode)
  - Vernon: 0.6 NTU (mode)
- Increases occurred throughout the study area during periods of high flow from heavy rains
- No exceedances of state surface water quality standards

Class B Water Quality Standards	
NH	Not exceed naturally occurring conditions by more than 10 NTU.
VT	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.



Study 6 – Water Quality Study

Nutrients & Chlorophyll-*a*

	Wilder (06-W-01)					**Bellows Falls** (06-BF-01)					**Vernon** (06-V-01)				
	Nitrate/Nitrite (as N)	**Total Kjeldahl Nitrogen**	**Total Nitrogen**	**Total Phosphorus (as P)**	**Chlorophyll-*a***	**Nitrate/Nitrite (as N)**	**Total Kjeldahl Nitrogen**	**Total Nitrogen**	**Total Phosphorus (as P)**	**Chlorophyll-*a***	**Nitrate/Nitrite (as N)**	**Total Kjeldahl Nitrogen**	**Total Nitrogen**	**Total Phosphorus (as P)**	**Chlorophyll-*a***
	mg/L				3	mg/L				3	mg/L				3
Mean	**0.16**	**0.40**	**0.46**	**0.013**	**2.2**	**0.15**	**0.44**	**0.49**	**0.014**	**3.2**	**0.13**	**0.41**	**0.45**	**0.019**	**2.9**
Minimum	0.09	<0.50	<0.50	0.008	0.6	0.08	<0.50	<0.50	0.006	<0.50	0.09	0.60	0.72	0.008	0.7
Maximum	0.30	1.20	1.50	0.026	4.7	0.30	1.30	1.47	0.036	6.8	0.18	0.90	1.04	0.096	9.0

Note: Mean calculated assuming 0.25 mg/L for values below the detection limit of <0.50 mg/L.

Water Quality Standards	
NH	No phosphorus or nitrogen in such concentrations that would impair any existing or designated uses, unless naturally occurring.
VT	Total phophorus loading limited so as to not accelerate eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents full support of uses; Nitrates not to exceed 5.0 mg/l as NO_3-N at flows exceeding low median monthly flows.

- Oligotrophic-Mesotrophic, no exceedances of State Surface Water Quality Standards

TransCanada

Study 6 – Water Quality Study

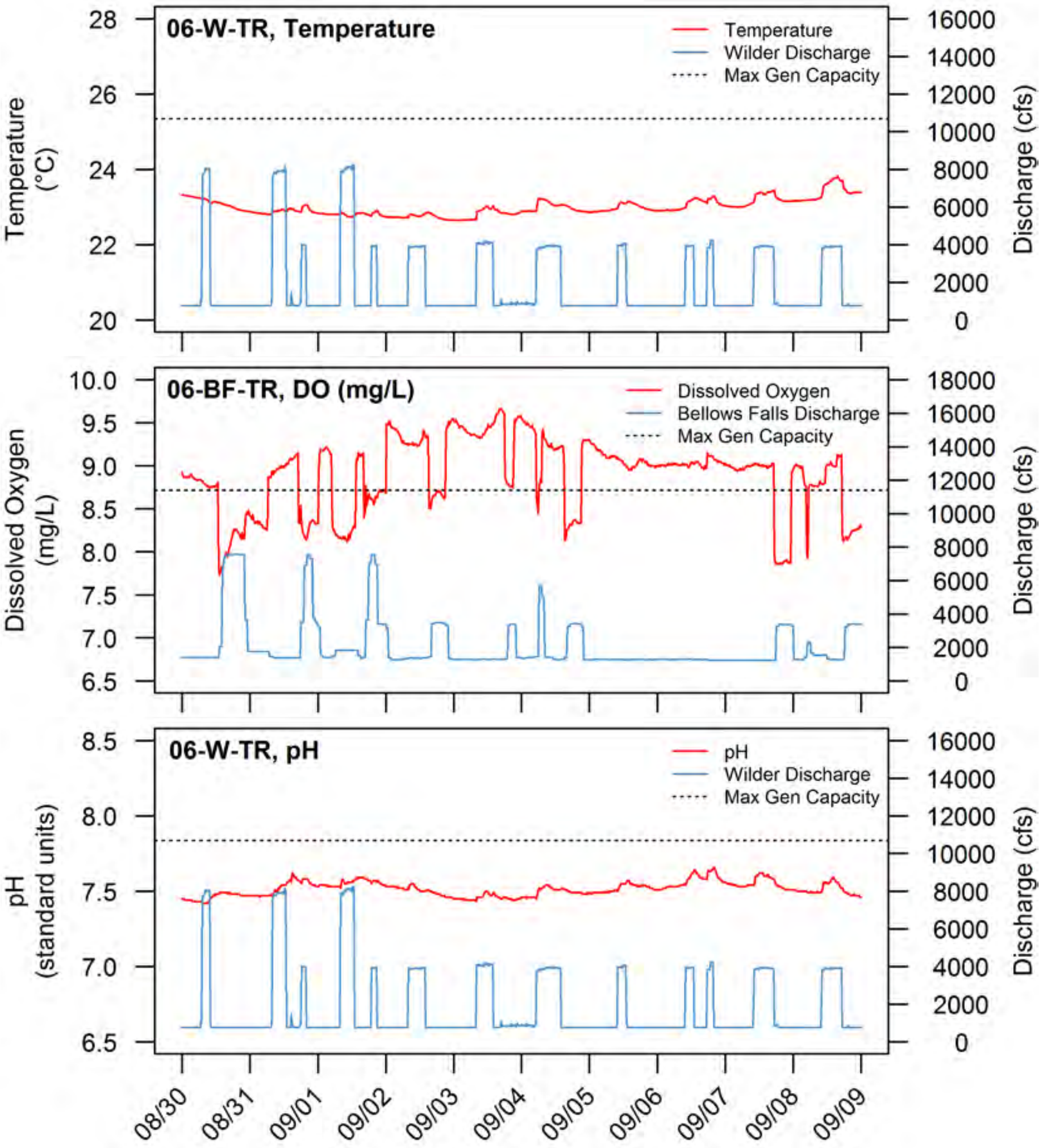
2012 & 2015 Comparison

- 2012 was a lower-flow year than 2015
- Temperature followed a similar temporal and spatial pattern, but overall mean 2012 temperatures were warmer
- DO followed a similar temporal and spatial pattern, and overall mean DO levels were lower in 2012.
    - Strong stratification in 2012 at Bellows Falls forebay; none in 2015
    - Weak stratification in 2015 and 2012 at Wilder forebay
- DO levels briefly fell below VT surface water quality standards of 6.0 mg/L and 70% sat in 2012 at Wilder and Bellows Falls; Bellows Falls also briefly fell below NH standard of 5.0 mg/L
    - 2015 DO levels all within VT and NH state surface water quality standards
- Specific conductivities were generally similar and followed similar patterns
- pH 2012 rose above NH standard of 8.0 at Bellows Falls and fell below VT and NH standard of 6.5 at Wilder and Bellows Falls
    - pH in 2015 rose above NH standard (8.0) at all three project; exceeded VT standard (8.5) at Bellows Falls
- Turbidity not monitored in 2012

Study 6 – Water Quality Study

Summary

- Upstream to downstream warming pattern
- Weak stratification and surface warming at forebay and middle impoundment stations
- Mean DO slightly higher in tailraces of Bellows Falls (0.5 mg/L; 6.0% sat) and Vernon (0.4 mg/L; 5.2% sat) than forebays
- Mean DO slightly lower in tailrace of Wilder than forebay (0.2 mg/L, 0.2% sat)
- Minor changes in temperature, DO, and pH associated with generation; no change observed for specific conductivity or turbidity



Study 6 – Water Quality Study

Conclusion

- The data from both the 2012 and 2015 studies show that, irrespective of the effects of project operations, water quality in project-affected waters supported all designated uses and met applicable Class B VT and NH surface water quality standards for the overwhelming majority of the study period throughout the entire study area.

Study 7

Aquatic Habitat Mapping

Study report was filed March 2, 2015

to date, no comments received.

Study 8

Channel Morphology and Benthic Habitat Study

Study 8 – Channel Morphology and Benthic Habitat Study

Study Summary

Field Data Collection Completed:

- Field studies completed in 2014

Field Data Analysis and Assessment:

- Material size gradation curves, average embeddedness
- Characteristics & distribution of coarse-grained sediment

Evaluations Based on Other Studies:

- Study 4 (Hydraulic Modeling Study)
    - Evaluation of Substrate Stability
    - Request and Receipt of Additional Model Runs to “Bound” Stability Analyses

Study Report Status:

- Submitted Study Report: March 2, 2015
- Preparation of Study Report Addendum is Ongoing

TransCanada

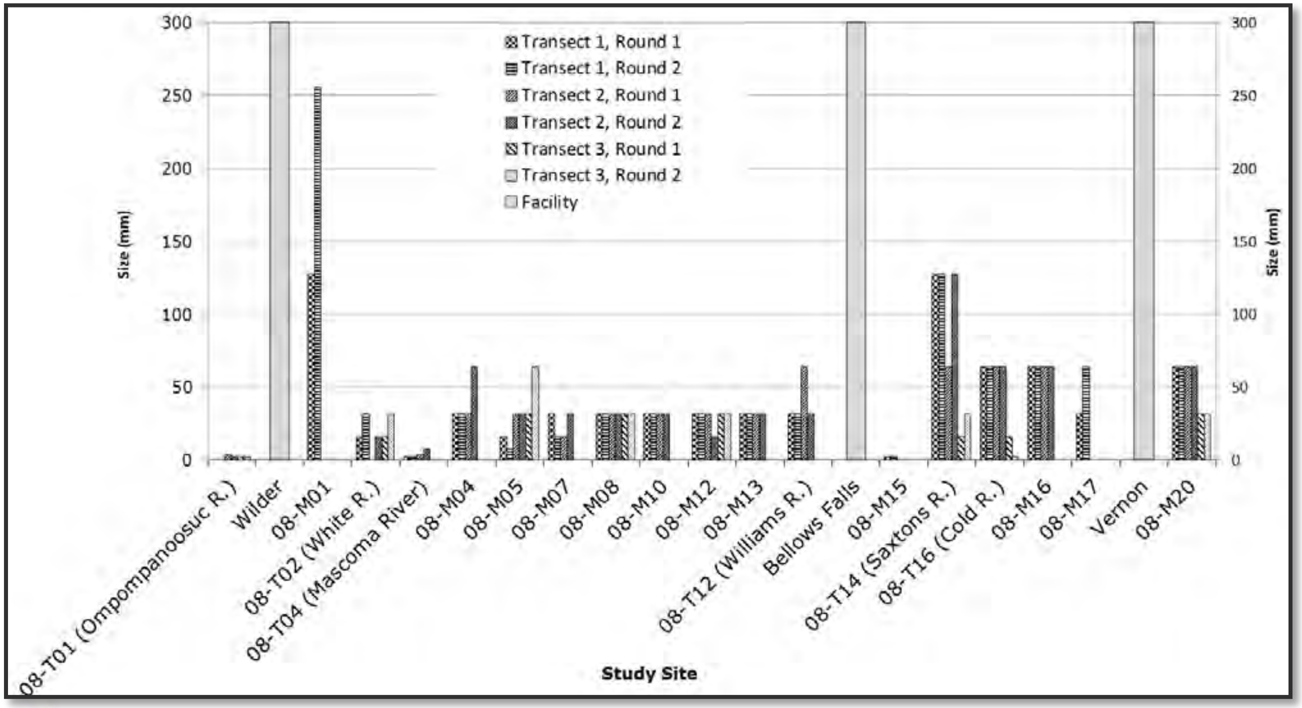
Study Site 08-M07. Mid-channel bar upstream from Sumner Falls (riverine reach below Wilder).

Transect 1 at Study Site 08-M07. Representative substrate.

Study 8 – Channel Morphology and Benthic Habitat Study

Summary of Findings from Field Data Analysis

- Coarse gravel dominant at study sites between Wilder and Bellows Falls Dams
- Very coarse gravel dominant at study sites downstream from Bellows Falls Dam
- Characteristics and influences of tributary sediment supply varies by tributary
- Temporal variability of particle size limited within study period
- Temporal variability of embeddedness trended towards increased embeddedness in Round 2



Median-Diameter Particle Size: Mainstem and Tributary Study Sites

Study 8 – Channel Morphology and Benthic Habitat Study

Desktop Studies

Information from Other Studies

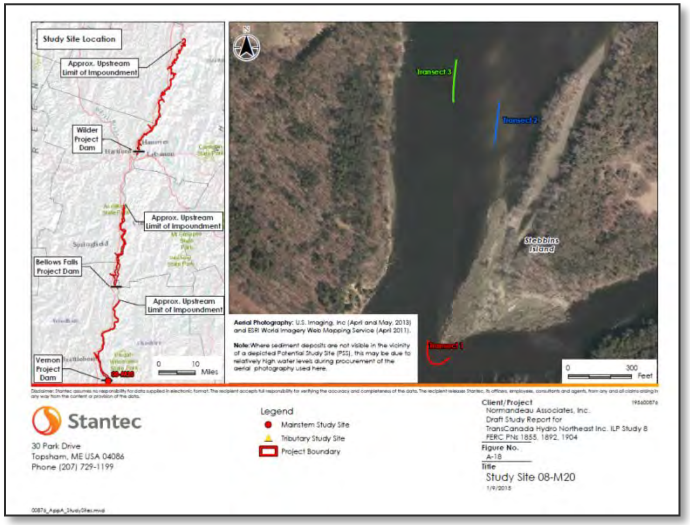
- Study 4 (Hydraulic Modeling Study)
- Other studies reviewed for relevant information

Analysis

- Compare Shear Stress and Critical Shear Stress
- Correlate Modeled Flows with Return Intervals
- Request for Additional Modeling for Bounding Stability

Assessment

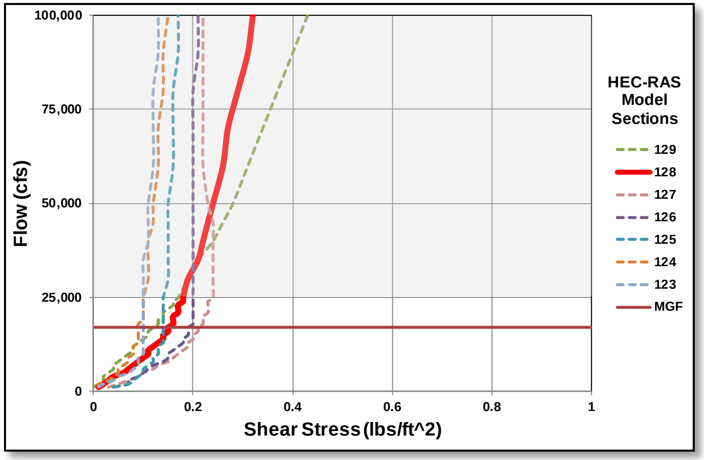
- Temporal and spatial patterns of coarse-grained benthic habitat availability
- Availability and stability of coarse-grained benthic habitat over range of flows



Aerial Photography: U.S. Imaging, Inc (April and May, 2013) and ESRI World Imagery Web Mapping Service (April 2011).

Note: Where sediment deposits are not visible in the vicinity of a depicted Potential Study Site (PSS), this may be due to relatively high water levels during procurement of the aerial photography used here.

Study Site 08-M20. Mid-channel bar downstream from Vernon Dam



Study 4 Data: Study Site 08-M20.

Study 8 – Channel Morphology and Benthic Habitat Study

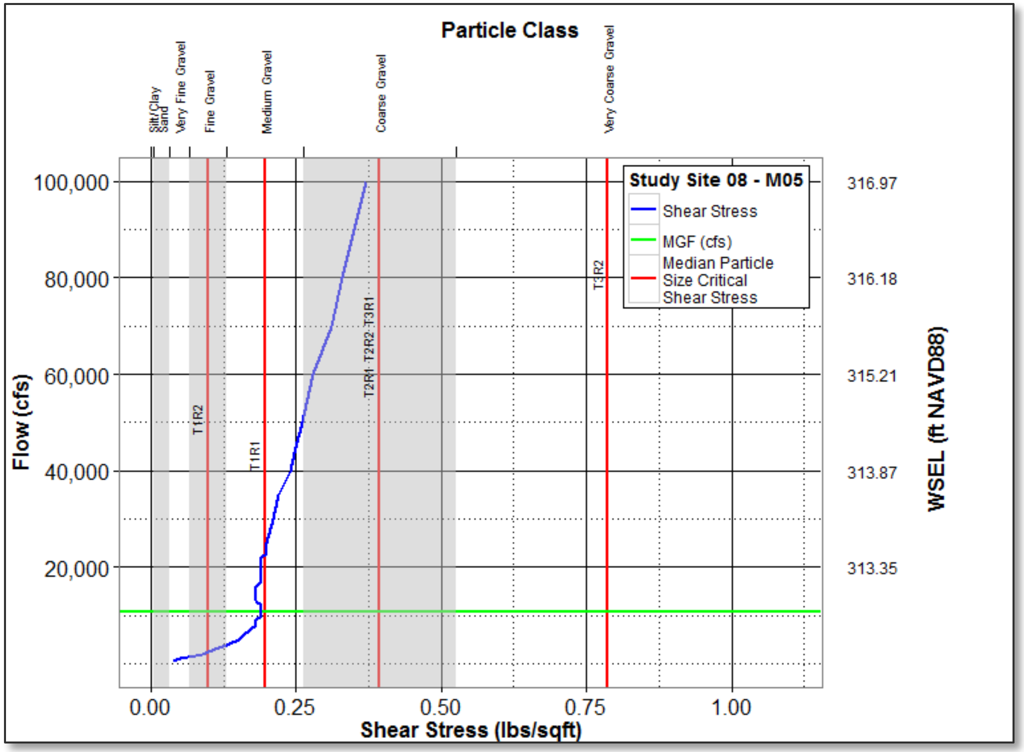
Remaining Activities

Complete Analyses Based on Project Studies

- Shear Stress
- Critical Shear Stress
- Substrate Stability
- Temporal and spatial patterns of coarse-grained benthic habitat availability
- Availability and stability of coarse-grained benthic habitat over range of flows

ASSESSMENT OF PROJECT EFFECTS ON:

- Temporal and spatial patterns of coarse-grained benthic habitat availability
- Availability and stability of coarse-grained benthic habitat over range of flows



Stability Analysis: Study Site 08-M05.

Study 30

Recreation Facility Inventory, Use and Needs Assessment

Study 30 – Recreation Facility Inventory, Use & Needs

Study Objectives

- Characterize
- Assess
- Lay the foundation of Recreation Resource Management Plan

Study Progress:

- 1 year of on-site data collection
- March 2014 – February 2015
- Report filed with FERC March 1, 2016

Study 30 – Recreation Facility Inventory, Use & Needs

Study Results:

- 577 interviews
- 2,702 spot counts
- 4,195 days of traffic count data
- 263 returned mail surveys

- The CT river is a significant feature in Vermont and New Hampshire
- The main reason regional residents don't recreate at or near the Projects
  - Not interested
  - Unable to participate (e.g., health)

TransCanada

Study 30 – Recreation Facility Inventory, Use & Needs

Study Results – continued

- 617,000 recreation days at study sites
- TransCanada Project Recreation
    - Wilder – 5 sites
    - Bellows Falls – 4 sites
    - Vernon – 3 sites
- TransCanada sites contributed nearly 40 percent visitation
- Largest (multi use parks) received the greatest amount of use and not always water oriented

TransCanada

Study 30 – Recreation Facility Inventory, Use & Needs

Study Results – continued

- Public boat launches were below capacity most of the year
- Public site users were satisfied with the type and number of facilities
- Recommendations called for more boat ramps, launches, river access for fishing, park amenities (e.g., tables, benches), and walking trails.
- Routine maintenance and upgrades were documented at many public ramps

Study 31

Whitewater Boating Flow Assessment Bellows Falls and Sumner Falls

TransCanada

Study 31 – Whitewater Boating Flow Assessment

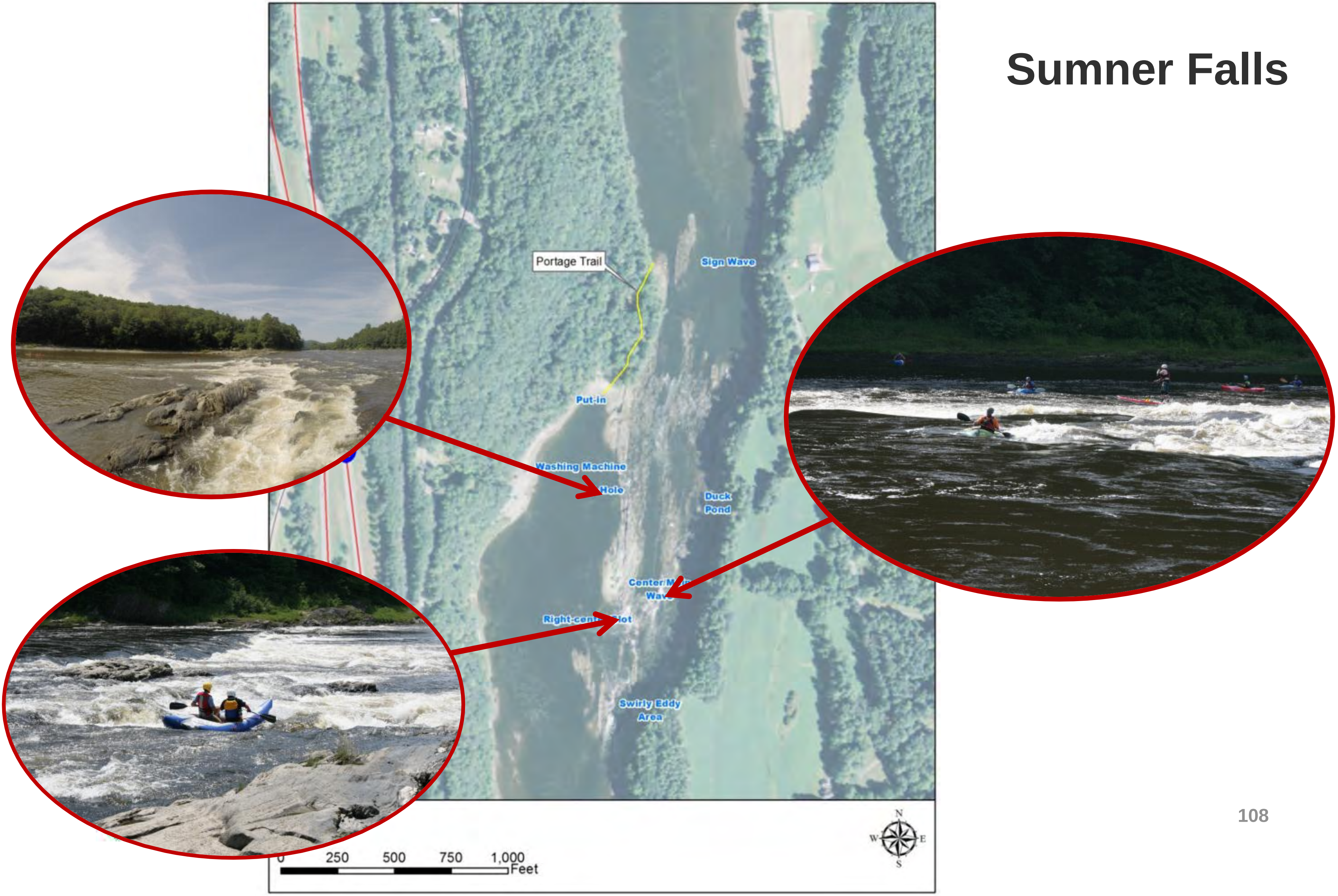
Study Objectives

- Identify recreational paddling opportunities at Sumner Falls and determine the suitability of the Bellows Falls bypassed reach for whitewater boating
- Describe flow-quality relationships at each location and identify acceptable and optimal ranges for each study site
- Describe potential effects of project operations on paddling at each location and identify boaters' sensitivity to current operations regimes (e.g., project discharges ranging from minimum flow to full generation)
- Broadly characterize recreational paddling-relevant hydrology of the existing operating regime and qualitatively describe the relationship between paddling opportunities and project operations

TransCanada

Study 31 – Whitewater Boating Flow Assessment

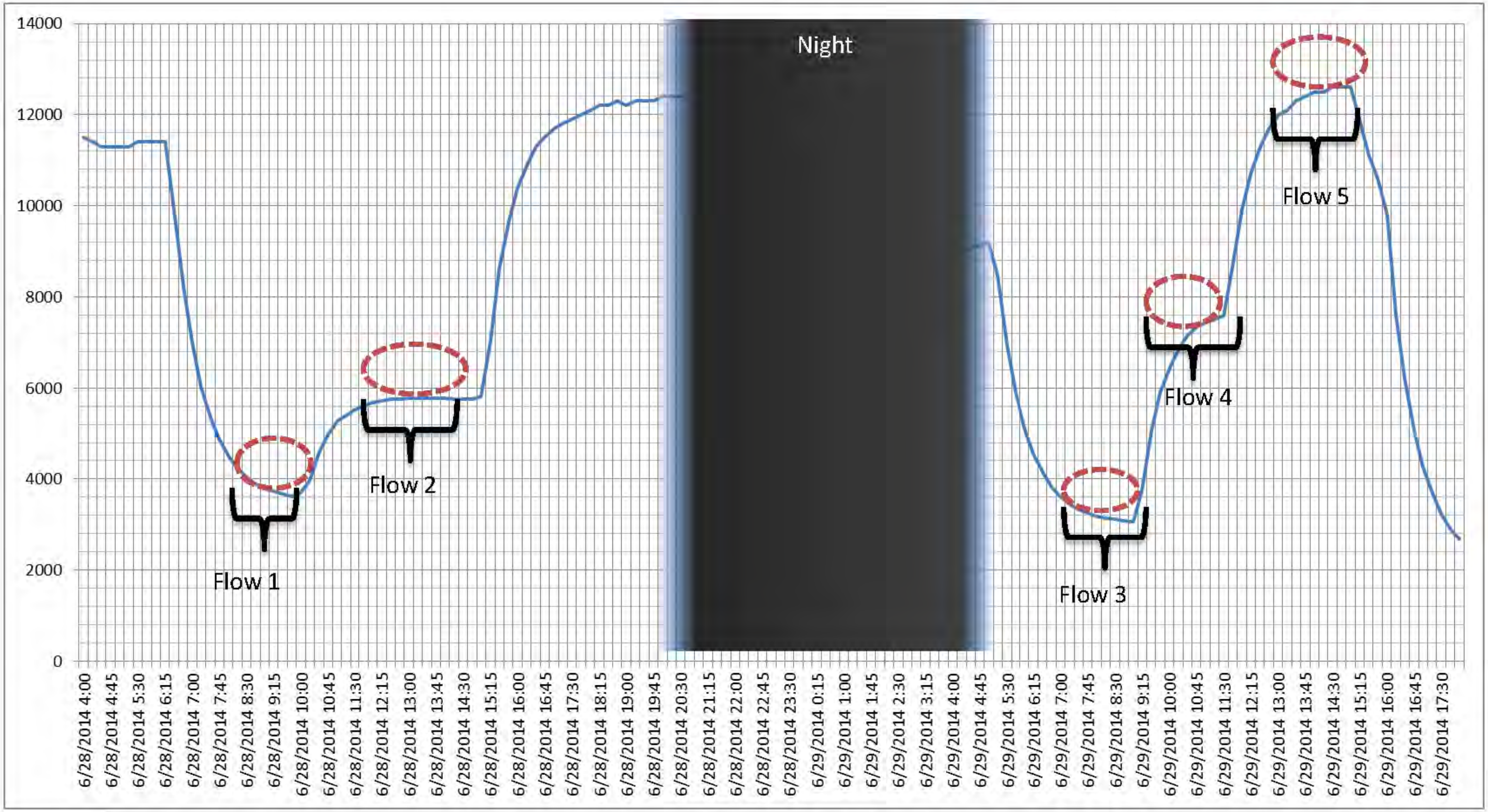
Sumner Falls



Study 31 – Whitewater Boating Flow Assessment

Sumner Falls

West Lebanon gage



TransCanada

Study 31 – Whitewater Boating Flow Assessment

Study Results – Sumner Falls:

- Study conducted June 28 & 29, 2014
- 16 boaters and 5 flow levels
    - 3,750 cfs, 4,700 cfs, 6,700 cfs, 7,800 cfs and 13,000 cfs
- All boaters reported all flows as 'Marginal' or higher with multiple preferred flow levels
- Participant estimates that less than 2,000 cfs would be less than 'Marginal'


Right center slot – 7,800 cfs


Main Wave – 3,750 cfs


Main Wave – 7,800 cfs


d/s Main Wave – 13,000 cfs

TransCanada

Study 31 – Whitewater Boating Flow Assessment

Study Results – Sumner Falls:

- Main Wave - 4,700 – 5,500 cfs
- Sign Wave 13,000 cfs
- 7,800 cfs level received high scores across all boat types and skill levels
- Preferred flow range for Main Wave (4,700-5500) occur briefly almost daily during daylight hours June 1 to Oct 31
- Large offering of diverse opportunities across wide range of flows

Right center slot – 7,800 cfs

Main Wave – 3,750 cfs

Main Wave – 7,800 cfs

d/s Main Wave – 13,000 cfs

TransCanada

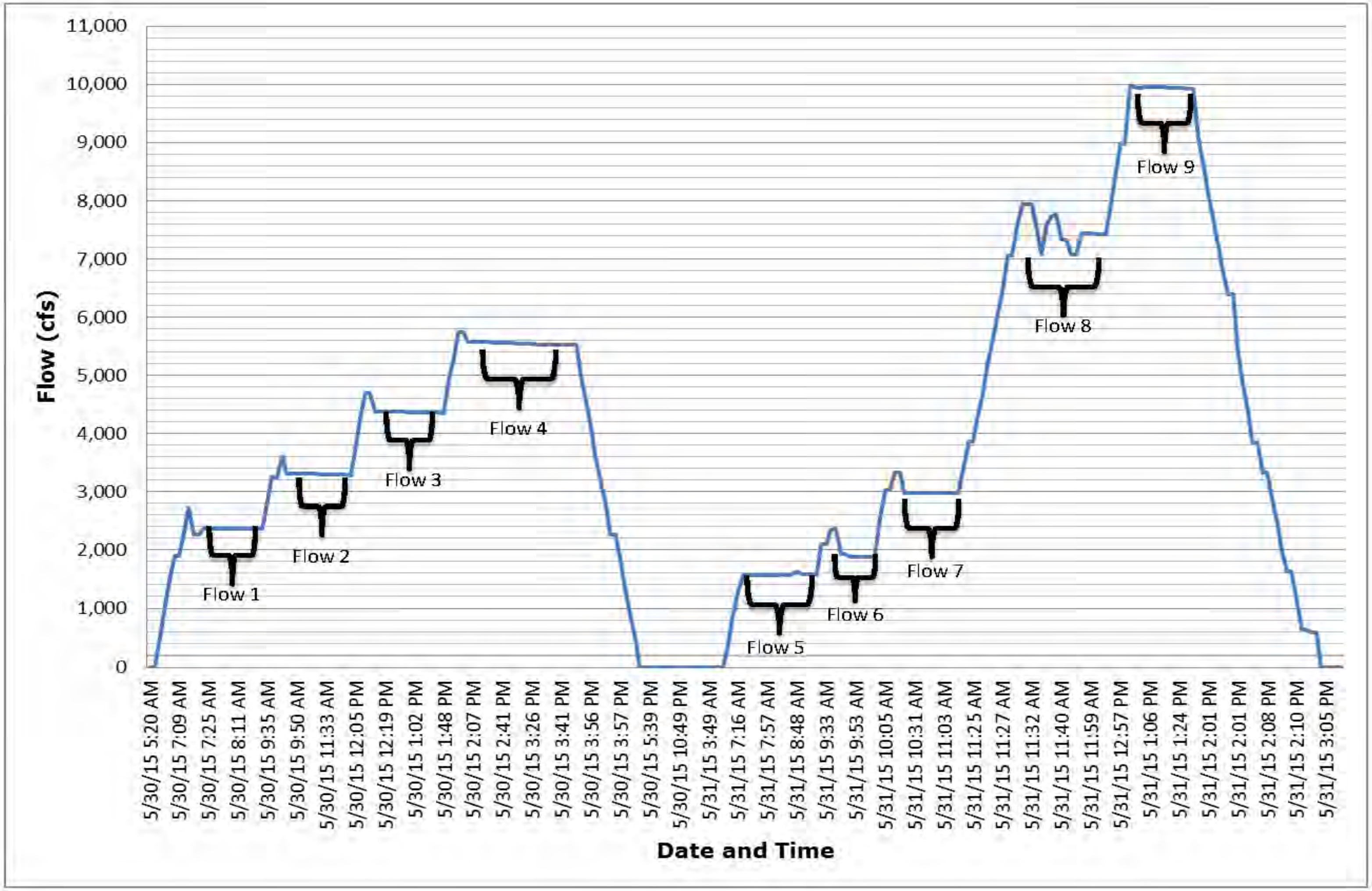
Study 31 – Whitewater Boating Flow Assessment

Bellows Falls

TransCanada

Study 31 – Whitewater Boating Flow Assessment

Bellows Falls



Study 31 – Whitewater Boating Flow Assessment

Study Results – Bellows Falls:

- Study conducted May 30 & 31, 2015
- 11 boaters and 9 flow levels
    - 1,500 cfs, 2,000 cfs, 2,500 cfs, 3,000 cfs, 3,500 cfs, 4,500 cfs, 5,500 cfs, 7,500 cfs and 10,000 cfs
- Ten of 11 boaters reported all flows as 'Marginal' or higher with multiple preferred flow levels
- Less than 'Marginal' rankings were from single boater of 1,500 cfs, 3,000, and 3,500 cfs
- No public access
- Fish barrier dam significant safety hazard

TransCanada

Study 31 – Whitewater Boating Flow Assessment

Study Results – Bellows Falls:

- Comments indicate the reach has 1-3 boatable features
- Two optimal flows
    - 2,020 to 2,900 cfs,
    - 4,370 to 5,560 cfs
- Highest quality experience (weighted average) = 3,880 cfs
- Canoe participants preferred lower flows than kayakers
- Lowest flow evaluated (1,580 cfs) represents Class II-III whitewater which could present safety risks to beginner and novice boaters

TransCanada

Study 32

Bellows Falls Aesthetic Flow Study

Study 32 – Bellows Falls Aesthetic Flow Study

Study Objectives:

- Collect videography and still photography to document the appearance of the bypassed reach under various existing and controlled flows conditions
- Identify populations potentially affected by the aesthetic conditions in the bypassed reach and determine how the interests of these populations relate to the aesthetic conditions
- Identify flow ratings and timing preferences across the full range of potential user groups
- Estimate the costs to provide different levels of flow and assess the trade-offs of the various flows among different populations

Flow Number	Flow Rate
1	~ 125
2	1,580
3	2,370
4	3,300
5	4,370
6	5,560

TransCanada

Study 32 – Bellows Falls Aesthetic Flow Study

Study 32 – Bellows Falls Aesthetic Flow Study

Study Results:

- Photography and video footage captured during whitewater boating study (Study 31) on May 27-28, 2015
- Focus group participants convened on August 20, 2015
- Single flow assessments , comparison surveys, and group discussion
- Only 1 participant indicated that aesthetics were extremely important
- No participants reported it as ‘Neutral’ or lower
- In general, participants reacted more favorably to higher flows; however participants’ preferred flow level ranged within a few scores at each level and no clear preferred level was evident
- One-third of participants noted there are no publically available viewing areas and questioned the need for specific aesthetic flows give the lack of visibility

Study 32 – Bellows Falls Aesthetic Flow Study


Flow no. 1 - Low (125 cfs)


Flow No. 3 - Medium (2,370 cfs)


Flow No. 6 - High (5,560 cfs)


Flow no. 1 - Low (125 cfs)


Flow No. 3 - Medium (2,370 cfs)


Flow No. 6 - High (5,560 cfs)


Flow no. 1 - Low (125 cfs)


Flow No. 3 - Medium (2,370 cfs)


Flow No. 6 - High (5,560 cfs)

Study 25

Dragonfly and Damselfly Inventory and Assessment

Study 25 – Dragonfly and Damselfly Inventory and Assessment

Summary

- Eleven sites were selected to cover geographic extent of the project area and a variety of hydrologic and habitat conditions
- 6 visits during June and July, 2015 to all eleven sites
- Searched five 3-meter wide transects at each site for dragonfly larvae, exuviae, and tenerals (pre-flight dragonflies)
- Over 750 observations of 19 species, with at least 1 observation at each study site
- Six of the eight target listed odonates were observed throughout the projects
- Multiple larvae were observed from emergence to eclosure to flight
- Critical period for emergence is approximately 30 minutes during eclosure

Study 25 – Dragonfly and Damselfly Inventory and Assessment

Rapids Clubtail teneral in Wilder Impoundment (Site 25-02), prior records from Vernon

Arrow Clubtail larva preparing to leave water to eclose

Spine-crowned Clubtail exuvia in Bellows Falls Impoundment (Site 25-08), prior records only from Vernon

Study 25 – Dragonfly and Damselfly Inventory and Assessment

Remaining Activities

- Evaluation of project effects is in progress using:
  - Site-specific elevation and water level logger data, defined by:
    - Upper and lower elevations of occurrence
    - Odonate emergence season: May 15 – Aug 31
    - Time of day for most eclosure: 4 AM – 9 PM
  - Output from Operations Model
- Issue study report

Study 26

Cobblestone and Puritan Tiger Beetle Survey

Study 26 – Cobblestone and Puritan Tiger Beetle Survey

Study Results

- 13 study sites selected and surveyed in 2014
- Cobblestone Tiger Beetle (CTB) observed and photographed at 7 sites
- CTB observed with lower certainty at 3 additional sites
- Study resulted in 2 new CTB VT records (Ascutney Riverbank, West River)
- Reproductive behavior observed (adults clasping) at 4 sites
- Adult cobblestone tiger beetles appeared to have specific habitat requirements preferences related to the size and variability of cobble substrate (5-8 cm), but not to other site characteristics such as vegetative cover or habitat area
- Appropriate habitat and survey observations of cobblestone tiger beetle were most common between Hartland and Westminster, Vermont.
- No Puritan Tiger Beetles observed

Study 26 – Cobblestone and Puritan Tiger Beetle Survey

Burnaps Island, upper Wilder riverine

Study 26 – Cobblestone and Puritan Tiger Beetle Survey

Remaining Activities

- Evaluation of project effects using observations and Operations modeling for the 5 representative years
  - Observed habitat elevation range for adults
    - upper 25% of habitat for larvae
  - For larvae: Seasonal water surface elevations (mean, max, min)
  - For adults: Hourly water surface elevations (June-Aug)
  - Similar data logger levels for West River site
- Determine frequency of habitat inundation and relate to tiger beetle presence
- Issue study report

Study 27

Floodplain, Wetland, Riparian and Littoral Vegetative Habitats Study

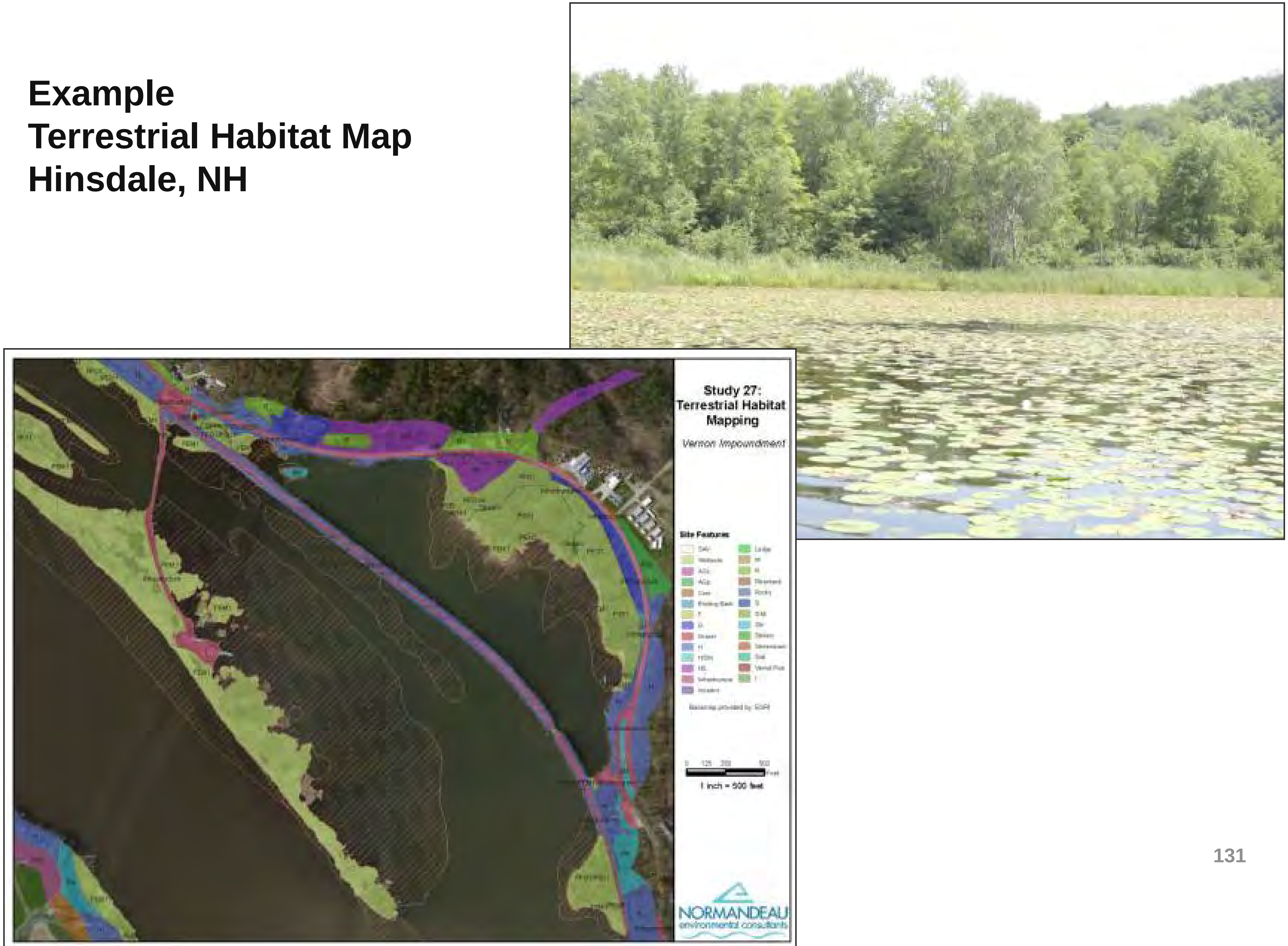
Study 27 – Floodplain, Wetland, Riparian, Littoral Vegetative Habitats

Study Results

- Maps were completed of all terrestrial cover types, floodplains, aquatic vegetation beds, invasives (mostly Phragmites and Japanese Knotweed), and bald eagle winter roosts
- Field verification occurred in June, July, and August 2014 and included incidental wildlife observations of 87 species
- Associated data from the field were tabulated and compiled into a database for future analysis
- Natural features and land uses mapped covered a total of 9,153 acres, and were comprised of upland vegetation cover (62% cover), wetlands and tributary streams (23% cover), developed lands (12% cover), and riverine features (2% cover)
- Report without project effects was filed September 14, 2015.

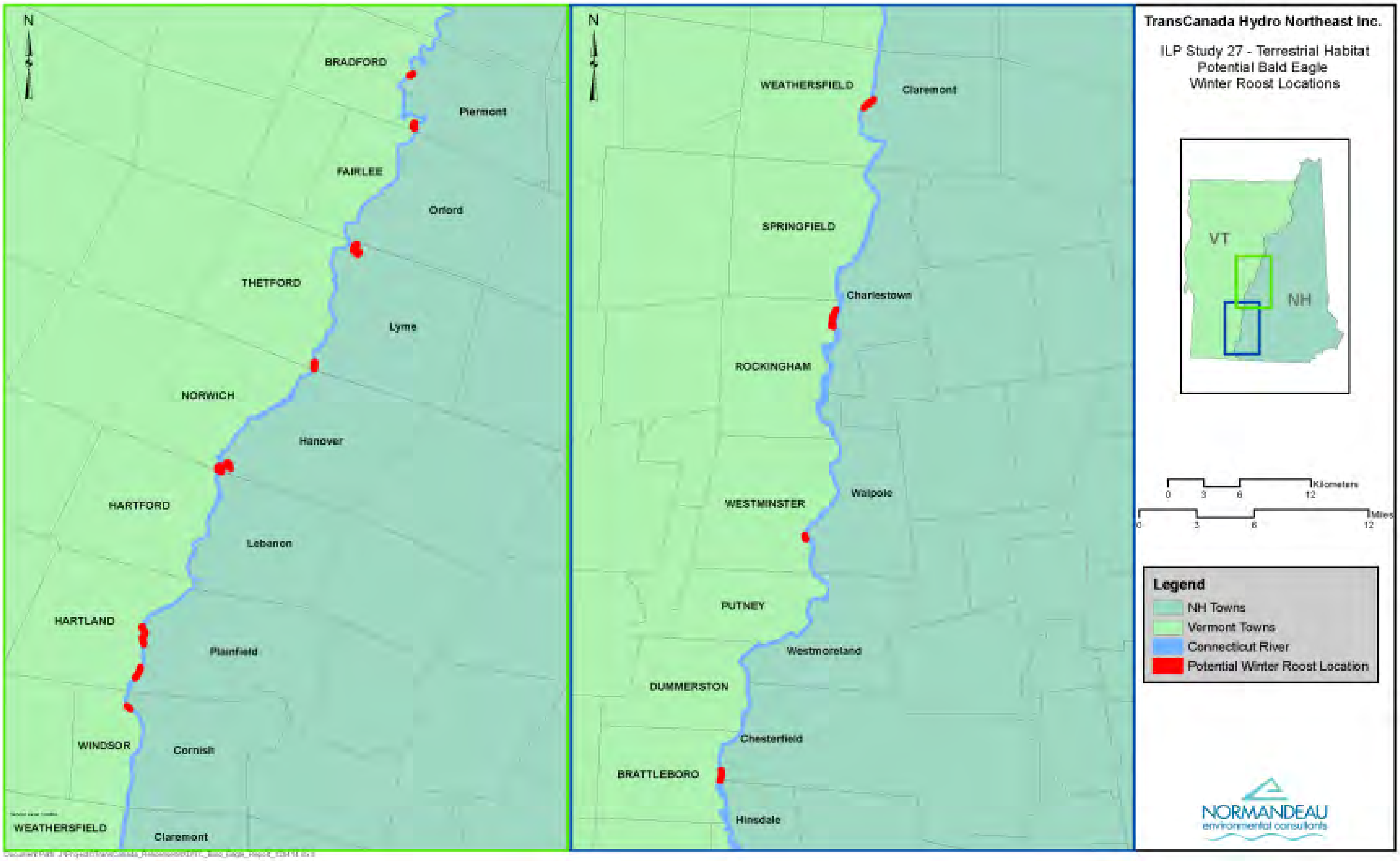
Study 27 – Floodplain, Wetland, Riparian, Littoral Vegetative Habitats

Example
Terrestrial Habitat Map
Hinsdale, NH



Study 27 – Floodplain, Wetland, Riparian, Littoral Vegetative Habitats

Potential Bald Eagle Winter Roost Sites



TransCanada

Study 27 – Floodplain, Wetland, Riparian, Littoral Vegetative Habitats

Remaining Activities

- Evaluate project effects on riparian, floodplain, wetland and littoral habitat and associated wildlife
- Use mapping results, field observations, LiDAR elevations, data loggers, erosion study results and Operations modeling
    - For representative cover types in each impoundment and riverine section:
        - Determine frequency of seasonal and weekly inundation
        - Compare to typical project operations
    - Assess relative influence of average conditions and extreme conditions on individual cover types
    - Identify and quantify those habitats affected by project operations

- Issue final study report

Study 28

Fowler’s Toad Survey

Study 28 – Fowler's Toad Survey

Study Results

- 15 sites surveyed in 2014
  - 11 call survey sites with 3 rounds of site visits.
  - 4 acoustic monitoring sites over 2 – 4 weeks.
- Survey methods consisted of direct listening (call surveys) and acoustic recording
- Fowler's toad was detected in one location – Stebbins Island, (subject to water level fluctuations in Turners Falls impoundment)

NOTES:

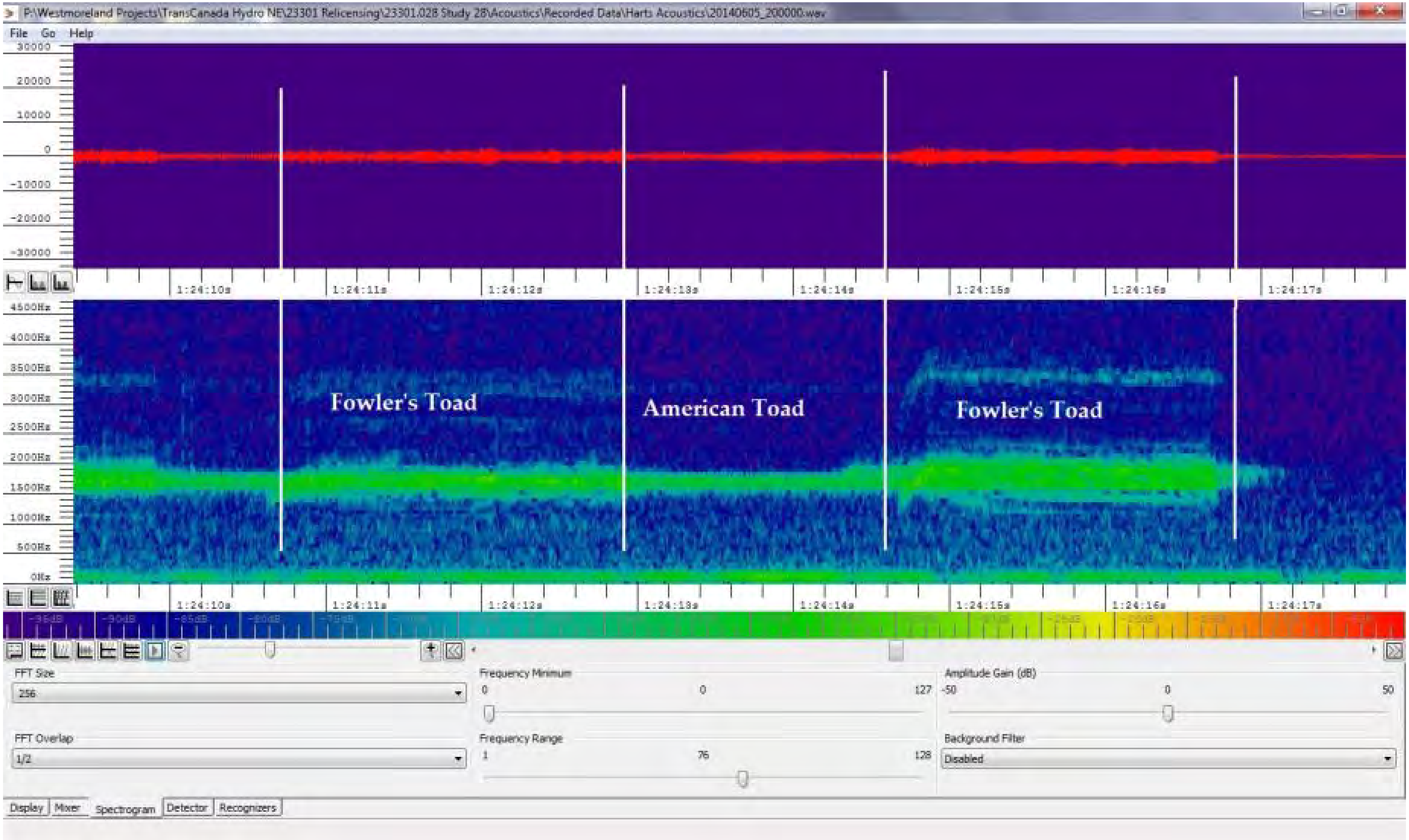
- The 2014 status summary report included potential detection at Hart Island breeding pool which was not a valid record when QA-ed.
- Vermont listed Fowler's toad as a state-endangered species as a Priority 1 "Very Rare" species in 2015.

Study 28 – Fowler’s Toad Survey

Breeding pool Stebbins Island, June 3, 2014

Study 28 – Fowler’s Toad Survey

Example Sonogram
June 5, 2014 from Stebbins Island


P:\Westmoreland Projects\TransCanada Hydro NE\23301 Relicensing\23301.028 Study 28\Acoustics\Recorded Data\Harts Acoustics\20140605_200000.wav

FFT Size: 256

FFT Overlap: 1/2

Frequency Minimum: 0 (0 – 127)

Frequency Range: 76 (1 – 128)

Amplitude Gain (dB): 0 (-50 – 50)

Background Filter: Disabled

Study 28 – Fowler’s Toad Survey

Remaining Activities

- Evaluation of project effects using field observations and Operations modeling
    - Determine weekly and daily water surface elevations during breeding season (May 21 – July 21)
    - Determine habitat suitability for each site based on magnitude of water level fluctuation
    - Identify minimum water level elevation necessary to breach pool at known site

- Issue study report

Study 29

Northeastern Bulrush Survey

Study 29 – Northeastern Bulrush Survey

Study Results

- Developed a typical profile of suitable habitat
- Vegetation habitat maps were reviewed for potential sites
- Field verification was conducted in August and September 2014
  - 8 sites were initially identified
  - 4 sites were eliminated based on field review
  - The remaining 4 sites were more intensively surveyed, including the one site where northeastern bulrush was last observed
- No plants were found

Study 29 – Northeastern Bulrush Survey

Previously recorded northeastern bulrush site

TransCanada

Study 29 – Northeastern Bulrush Survey

Remaining Activities

- Evaluation of project effects using field observations and Operations modeling
  - Identify minimum water level elevation necessary to inundate habitat
  - Determine frequency and timing of river water levels above that minimum

- Issue study report

TransCanada

Study 19

American Eel

Downstream Passage Assessment

Study 19 – American Eel Downstream Passage

Study Summary

- Eel Sourcing
    - Eels were procured from a source in Newfoundland (with concurrence)
    - Eels passed all pathology tests and were approved for import
- Route Selection
    - 170 individuals received radio tags and released upstream of Wilder, Bellows Falls, and Vernon on 5 occasions during a ten day period between October 27 and November 5, 2015
    - Fish were tagged and released in groups of 10 and released in four general areas approximately three miles upstream of each project
- Turbine Survival
    - 313 eels received HI-Z tags and were released (39 control fish) proportionally through different turbine types at all 3 projects.

TransCanada

Study 19 – Route Selection

Radio Telemetry/Route Selection Results

- 50 radio-tagged adult American Silver Eels were released in the Wilder impoundment; 45 subsequently passed the project.

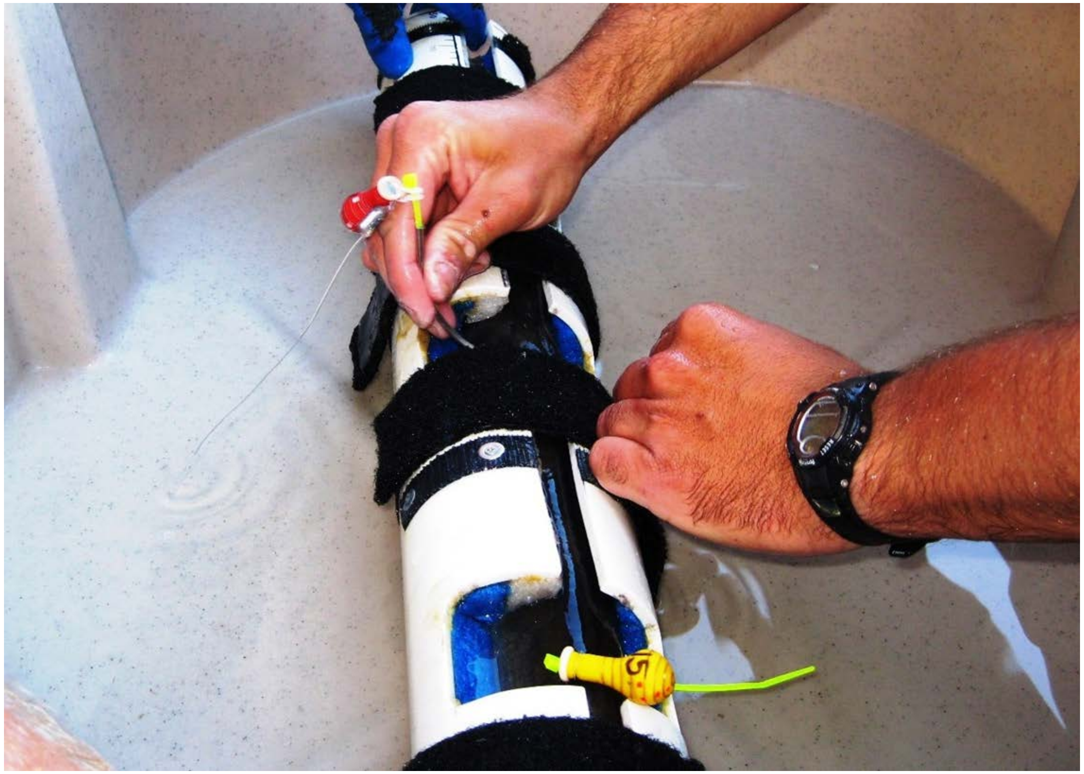
- 50 radio-tagged adult eels were released in the Bellows Falls impoundment, another 20 were released directly into the Bellows Falls Power Canal, and an additional 28 which had passed Wilder were monitored. 93 subsequently passed the project.

- 50 radio-tagged adult eels were released in the Vernon impoundment. Another 24 and 44, released for the Wilder and Bellows studies, respectively, were also monitored. 112 subsequently passed the project.

Study 19 –Turbine Passage Survival

Turbine Surival Methods

- Adult American Eels
- 650-1040 mm
- fitted with 4 to 6 HI-Z tags and radio tag



Study 19 –Turbine Passage Survival

Turbine Survival Methods

- Eels were passed through Vernon Units 4, 8, and 9; Bellows Falls Unit 2; and Wilder Unit 2

Date	Water Temp (°C)	Vernon				Bellows Falls	Wilder		Combined Controls	Actual Treatment Release
		Unit 4 Francis @1000 cfs	Unit 8 Kaplan @ 1000 cfs	Unit 8 Kaplan @ 1700 cfs	Unit 9 Francis @1300 cfs	Unit 2 Francis @ 3200 cfs	Unit 2 Kaplan @ 1700 cfs	Unit 3 Francis		
10/26	8.4		48							50
10/27	8.0				48				10	50
10/28	8.3	48							9	50
10/30	7.7					50			10	53
10/30	7.7							10		10
11/01	7.5						50		10	50
11/03	9.1			50						50
Total		**48**	**48**	**50**	**48**	**50**	**50**	**10**	**39**	**313**

Study 19 –Turbine Passage Survival

Study Variance:

- Turbine testing at Wilder Unit 3 was curtailed after 10 fish were tested when it was determined that most of the discharge was directed into the fishway and the features within the fishway prevented the recapture of seven of the ten eels.
  - It was determined that the egress pattern at Unit 3 would not permit the determination of reliable survival/injury estimates.
  - The aquatics working group was notified of this study plan variance on November 13, 2015.

Study 19 – American Eel Downstream Passage

Remaining Activities:

- Final analysis of radio telemetry
- Final analysis of turbine survival
- Issuance of study report.

Study 20

American Eel

Downstream Migration Timing

Assessment

Study 20 – American Eel Downstream Migration Timing

Study Progress

- Literature reviews completed
- Completion of this study depends in part upon the results of the other American Eel studies (Studies 11, 18 and 19) which are in progress; along with similar FirstLight studies also in progress

Remaining Activities

- Characterize expected outmigration of silver phase eels, based on environmental cues.
- Once data is collected and consolidated from other studies, and analysis complete, the study report will be prepared.

Study 11

American Eel Survey

Study 11 – American Eel Survey

Study Progress

- Site selection conducted in late 2014 with working group
- Revised SSR filed in Volume II of the USR
- 102 mainstem sites and 24 tributary sites (“map units”) selected
- Sampling consisted of a 500-m electrofish transect and a 24-hr baited eel trap set.
- All mainstem and tributary sampling (electrofish and eel trap) completed during targeted time frame of July-August, 2015.
- Study report filed March 1, 2016.

Study 11 – American Eel Survey

Sampling Effort

- 252 samples collected

River Reach	Number Sample Locations		# Samples		
	Mainstem	Major Tributaries	Boat Efish	Pram/ Backpack Efish	Eel Trap
Wilder Impoundment	37	7	38	6	44
Wilder Riverine	15	4	0	19	19
Bellows Falls Impoundment	22	5	24	3	27
Bellows Falls Riverine	5	3	0	8	8
Vernon Impoundment	22	5	22	5	27
Vernon Riverine	1	0	1	0	1
Total	102	24	85	41	126

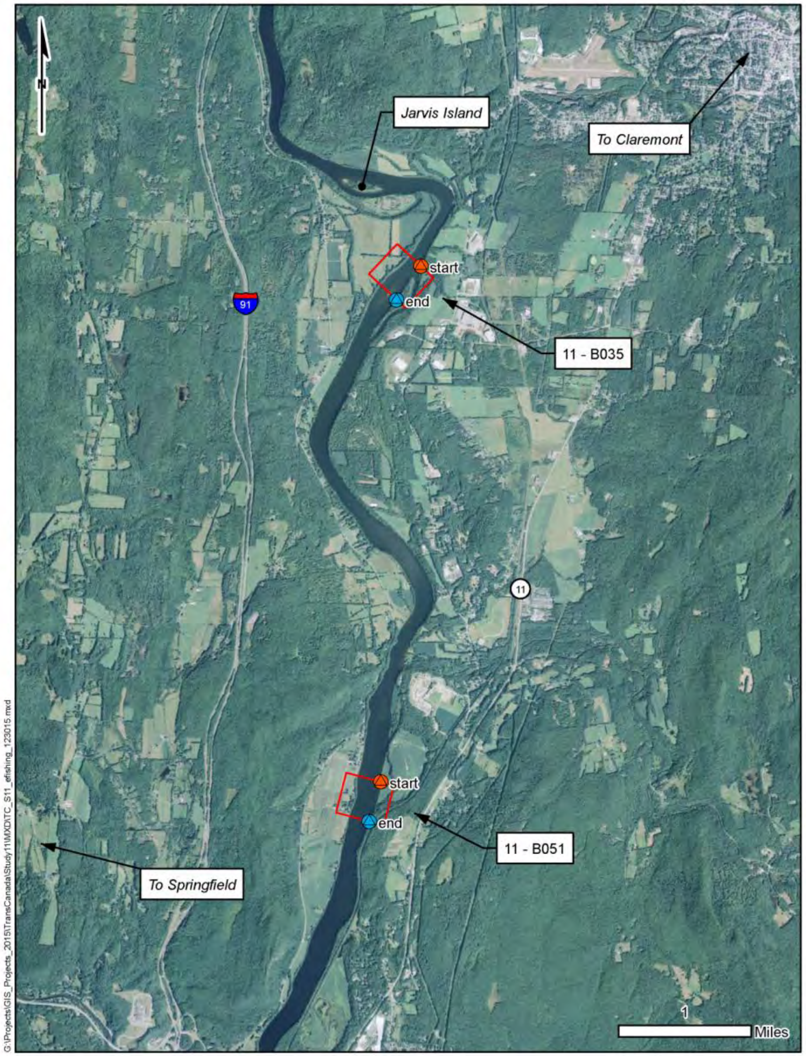
Study 11 – American Eel Survey

Eel Collections

- 3 individuals
- All from Bellows Falls Impoundment
- All collections Aug 19, 2015

Site ID	Horizontal Eye Meas. (mm)	Vertical Eye Meas. (mm)	T. Length (mm)	Index*	Weight (g)
11-B035	6.73	6.1	615	5.3	465
11-B051	11.34	11.42	1156	8.8	3800
11-B051	6.97	6.67	747	4.9	900

- 2 eels classified as “yellow”
- 1 eel classified as “silver”



TransCanada

---

* Eye index as described in: Pankhurst, N. W. 1982. Relation of visual changes to the onset of sexual maturation in the European eel (*Anguilla anguilla*). Journal of Fish Biology 21: 127-140.

Study 11 – American Eel Survey

Study Summary

- Eels known to inhabit CT River as far north as Connecticut Lakes including streams and ponds within the drainage (Scarola 1987; Langdon et al. 2006)
- Overall Study 11 catch rates were very low (3 eels at 2 of 126 locations)
- Low catch similar to previous sampling
  - Yoder et al. (2009) – collected 2 eels in 204 river miles from Lake Francis to Turners Falls
  - Annual electrofish sampling associated with VY (lower Vernon impoundment) observed 27 eels during 24 years of sampling
- Previous and current studies suggest American eel are present in low abundance throughout the study area from the upper extent of Wilder impoundment to downstream of Vernon dam

Study 21

American Shad Telemetry Study

Study 21 – American Shad Telemetry Study

Study Summary

- Field-work began in May 2015 and continued into early July

- 100 adult American Shad were collected from the Holyoke fishlift, tagged and released at Northfield, MA on May 10, 14, and 28, 2015.
  - 52 were tagged with both a radio tag and PIT tag
  - 48 were only PIT tagged.
  - 50 each, male and female
  - Water temperatures at the time of release ranged from 13.4-16.1^{o}C

- 54 additional shad were collected at the Vernon fish ladder, radio-tagged, and released into the Vernon impoundment May 17, 24, and 30 2015.
  - 37 male, 17 female
  - Water temperatures at the time of release ranged from 13.4-16.1^{o}C

Study 21 – American Shad Telemetry Study

Study Summary

- Shad were manually tracked from lower end of Stebbins Island upstream to the Bellows Falls tailrace

- Additional radio and PIT tagged shad released for a concurrent study downstream at the FirstLight projects which entered into the study area were also monitored.

Study 21 – American Shad Telemetry Study

Study Summary - continued

- Four study elements:
  - Migration upstream from below Vernon through the ladder
  - Migration upstream through Vernon impoundment
  - Spawning activity
  - Post-spawning downstream migration

Study 21 – American Shad Telemetry Study

- **Upstream passage analysis includes three metrics:**
  - Fishway Attraction Effectiveness: The proportion of fish that enter a fishway from the number of fish available. For this study, “the number of fish available” is considered the number of radio-tagged American shad detected on the tailrace monitoring arrays. Radio tagged shad only
  - Upstream Fish Passage Efficiency: The proportion of fish that enter a fishway and pass upstream of the viewing window and subsequently pass upstream of the fishway from those available. Radio and PIT Tagged shad
  - Upstream Fish Passage Effectiveness: The proportion of fish that entered the fishway and passed upstream and remained upstream for > 48 hours. Radio tagged shad only

Study 21 – American Shad Telemetry Study

Upstream passage analysis - continued

- Data include all FirstLight tagged fish detected in the study area (to be presented independently.)

- The number of forays into and within the fishway for both passed and non-passed PIT and radio tagged shad will be tabulated and evaluated.

- Additionally Vernon discharge and water temperature at shad entry into the fishway will be evaluated.

Study 21 – American Shad Telemetry Study

Study Results – Tagging/Tracking

- A total 70 radio tagged and 93 PIT tagged shad were detected in the study area, including FirstLight specimens.

- Downstream passage was documented for 44 of the 54 shad located in the Vernon forebay. Of those:
    - 11 passed through the fish pipe
    - 9 passed through turbine units 5-8,
    - 3 passed through turbine units 9-10
    - 7 passed through turbine Units 1-4
    - 5 passed via an unknown route
    - 9 utilized the spillway.
    - Of the remaining 10 shad that were located in the forebay but did not pass: 9 died and became lodged on the trash racks and 1 did not pass.

Study 21 – American Shad Telemetry Study

Tagging and tracking of adult shad

TransCanada

Study 21 – American Shad Telemetry Study

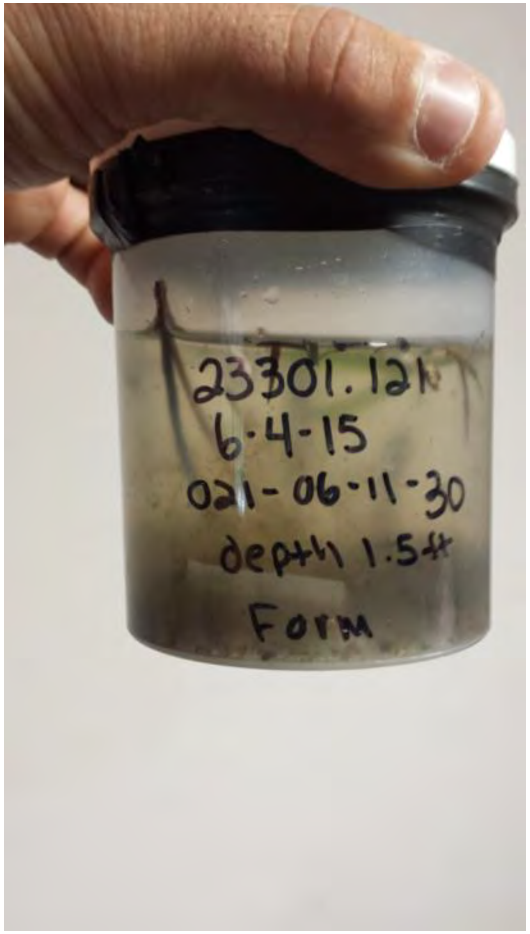
Study Results - Spawning

- Trawls were performed for 2 nights above Vernon, 1 night below Vernon and repeated from May 26 – July 2, 2015 (51 total sampling events)
  - Areas of concentration noted were the Vernon tailrace, and downstream of Bellows Falls
  - Tailraces held significant numbers of shad, especially Bellows Falls to Dunshee Island
  - Higher gradient (tributary gravel/cobble bars) held more shad during spawning and staging
  - Very little splashing occurred on spawning events
  - 120 individual ichthyoplankton net samples (at 60 trawl locations) were collected on 30 nights between 26 May and 2 July, 2015.
  - Shad eggs were successfully collected in all study areas
  - 792 American shad eggs and larvae were collected in 46 samples from below and above Vernon Dam.
    - 774 (98%) were eggs
    - 9 (1%) were yolk sack larvae (YSL)
    - 9 (1%) were post yolk sack larvae (PYSL)

Study 21 – American Shad Telemetry Study

Night trawling

Egg sample collection



Study 21 – American Shad Telemetry Study

Remaining Activities

- Data analysis in progress
- Evaluation of project effects on spawning using output from Hydraulic and Operations models
- Issue study report

Study 22

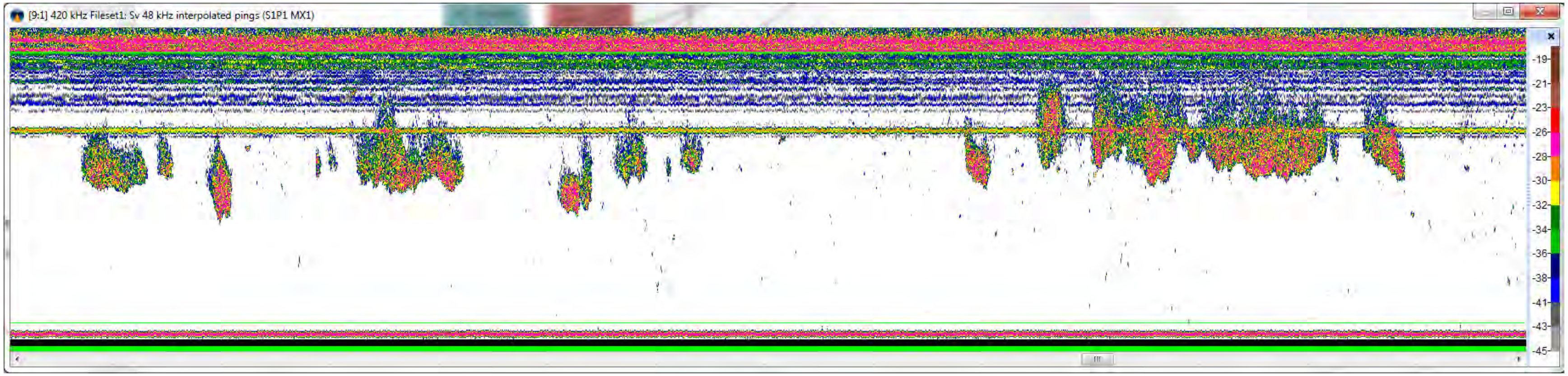
Downstream Migration of Juvenile American Shad - Vernon

Study 22 – Downstream Migration of Juvenile American Shad

Study Summary

- Schools first seen on hydroacoustics on August 23
- Presence of juvenile was confirmed visually on August 26
- Density of schools peaked on October 5-6, 24, and 30
- Wild juvenile shad were collected for both route selection and turbine survival studies
    - E-fishing collections of shad for radio tagging began September 25, with release of 20 fish and continued through mid-November . About 40% of fish collected were tag-able (100 MM or larger).
    - Turbine survival tagging and releases occurred from October 6 - 11
- The last fish schools were seen on hydroacoustics on October 30
- Removal of hydroacoustic equipment began on December 7

Study 22 – Hydroacoustic Evaluation



Run Timing Objectives

- To determine timing of the outmigration of juvenile American Shad in the forebay of Vernon powerhouse
    - Date of onset & departure
    - Number, timing, duration, & relative magnitude of peak abundance
- To describe diel and depth patterns in abundance
- To relate with environmental and operational factors

Study 22 – Hydroacoustic Evaluation

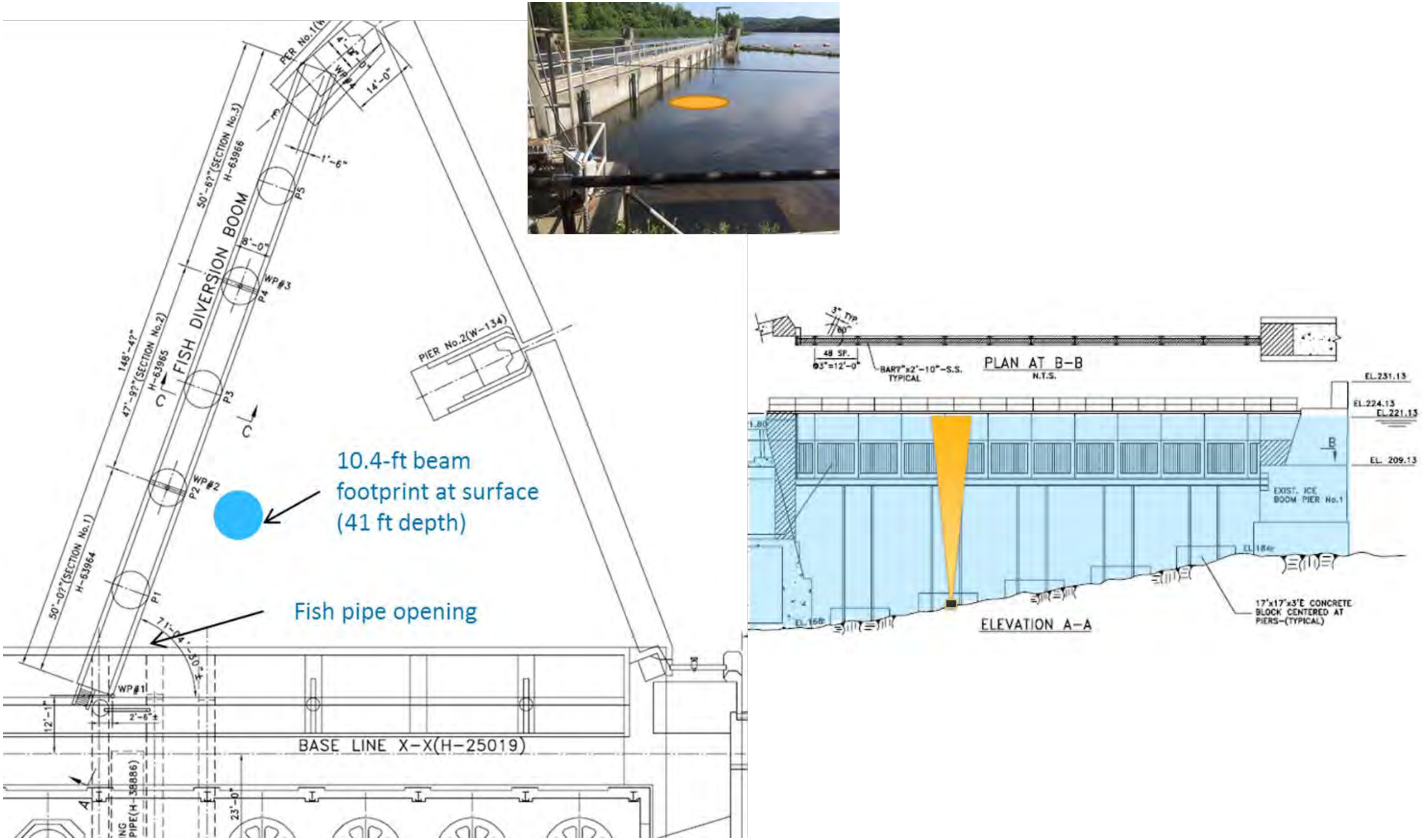
Hydroacoustic Sampling

- 420 kHz HTI Split-beam echosounder
    - (above frequencies known to repel alosines)
- 8-10 pings per second, 5-6 sample echograms/hour
- August 15 through November 15, 2015

Verification Sampling

- Cast Net
- Electrofishing
- Visual Observations
- ARIS imaging sonar (Oct 8)

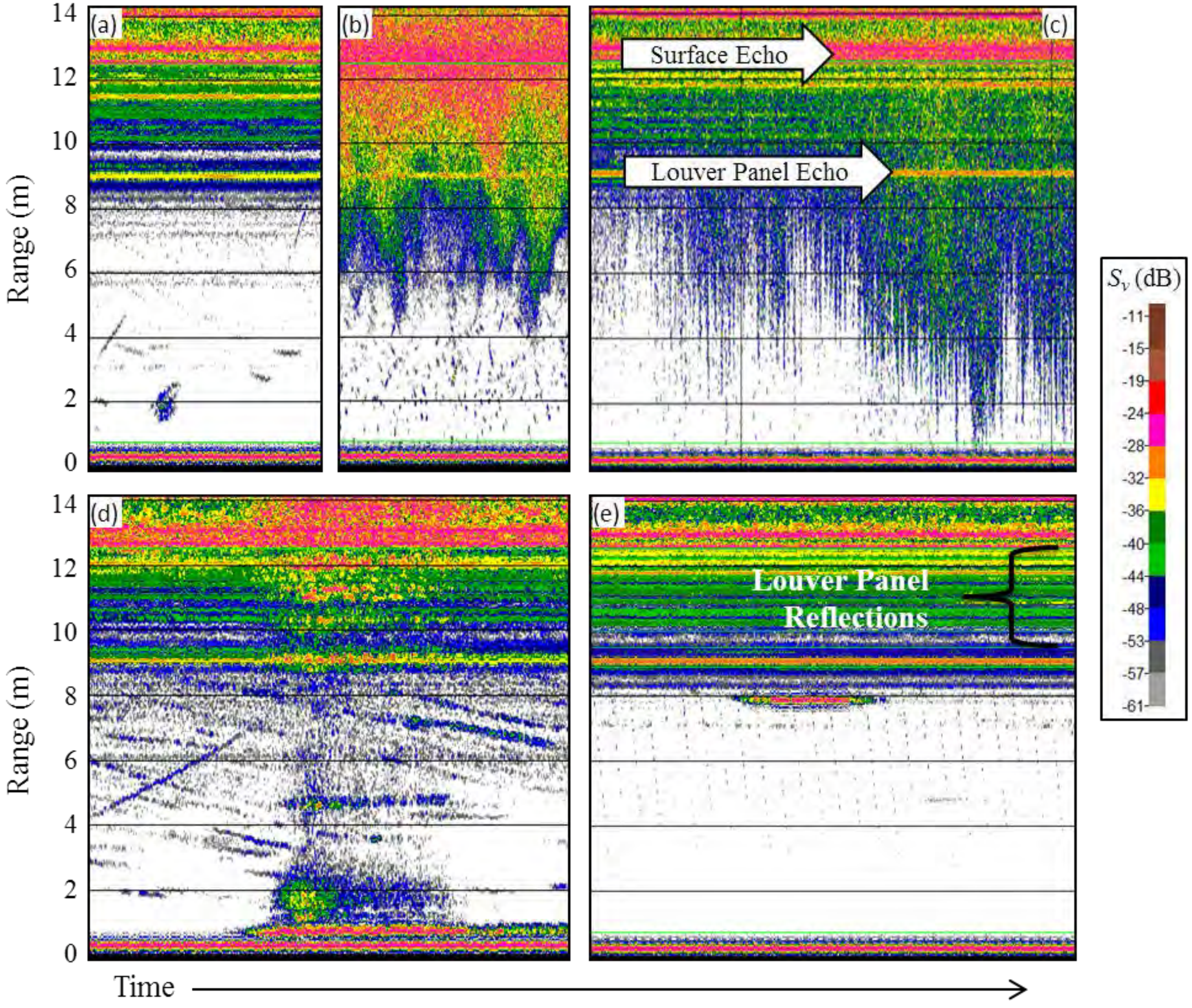
Study 22 – Hydroacoustic Sampling Coverage



10.4-ft beam footprint at surface (41 ft depth)

Fish pipe opening

Study 22 – Echograms of Volume Backscattering Strength



a) No rain, Sep 12, 08:56-08:59

b) Rain, Sep 13, 18:59-19:02

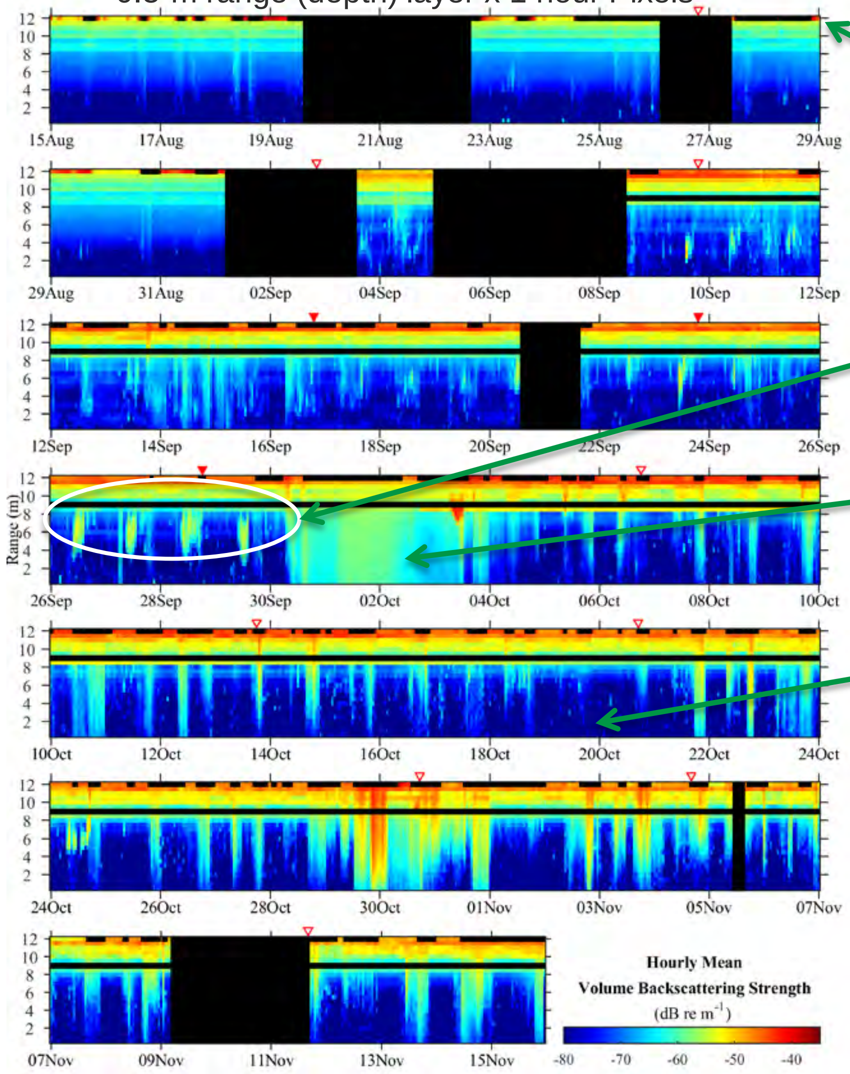
c) Turbine 4 gate opened Oct 27, ~08:00

d) Large target close to transducer Sep 27, 21:38

e) Large fish near louver echo, Oct 28, 03:43

Study 22 – Hourly Mean Volume Backscattering Strength (Sv)

0.5-m range (depth) layer x 1 hour Pixels



Noise near surface

Periods of mid-water echoes (fish)

Periods of noise extending full water column

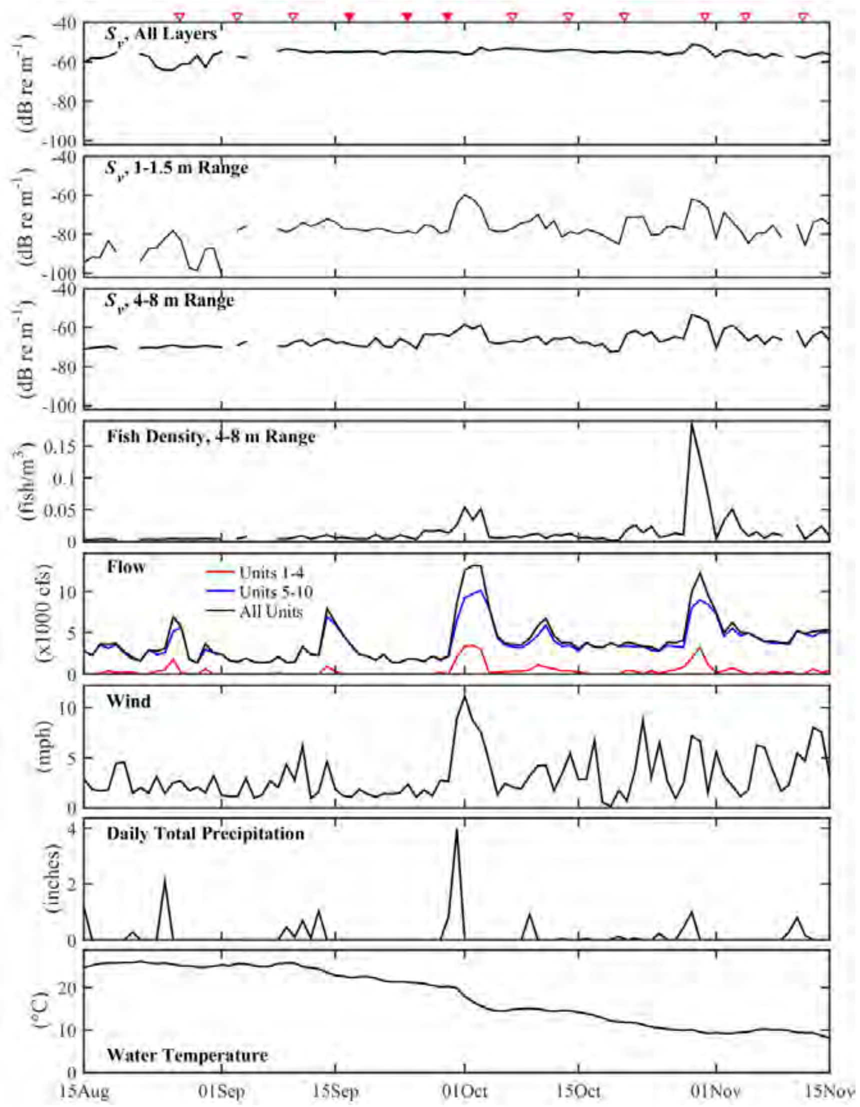
Lowest Sv in bottom layers, except isolated events (weather/operations)

Cast Net Catch

▼ = Shad Caught

▽ = No shad caught

Study 22 – Variability in Volume Backscattering Strength



- Principal driver in S_V time series regardless of depth layer relates to turbine flow, wind, large rainfall events

- Total S_V from automated processing not suitable for determining peaks in fish density

Cast Net Catch

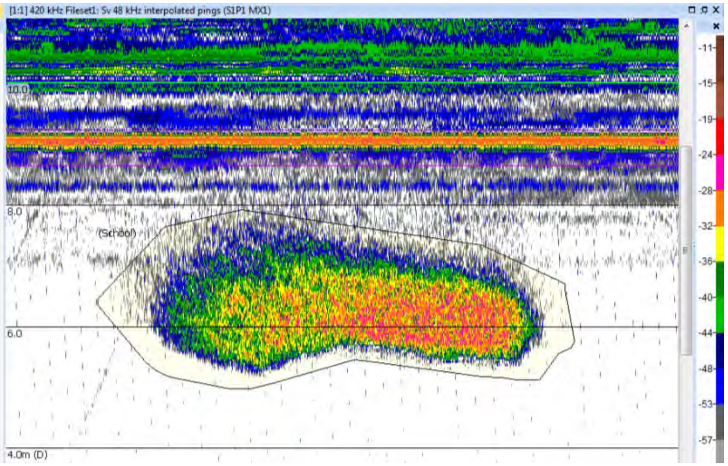
▼ = Shad Caught

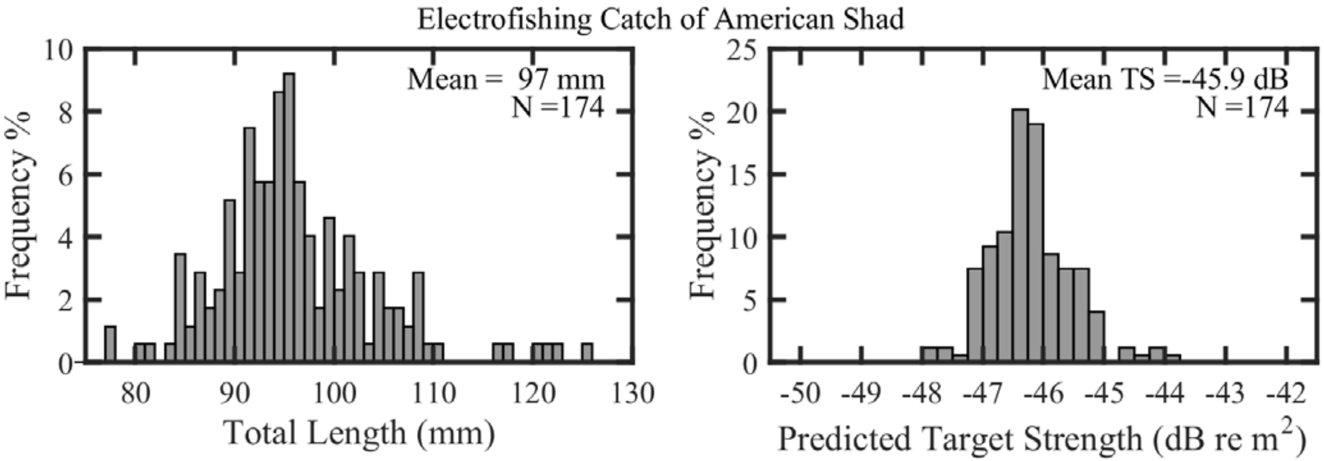
▽ = No shad caught

Study 22 – Relative Index Based on School Classification

- Volume backscatter of manually classified echoes as fish schools
- Divide by acoustic backscattering cross-section of an individual fish

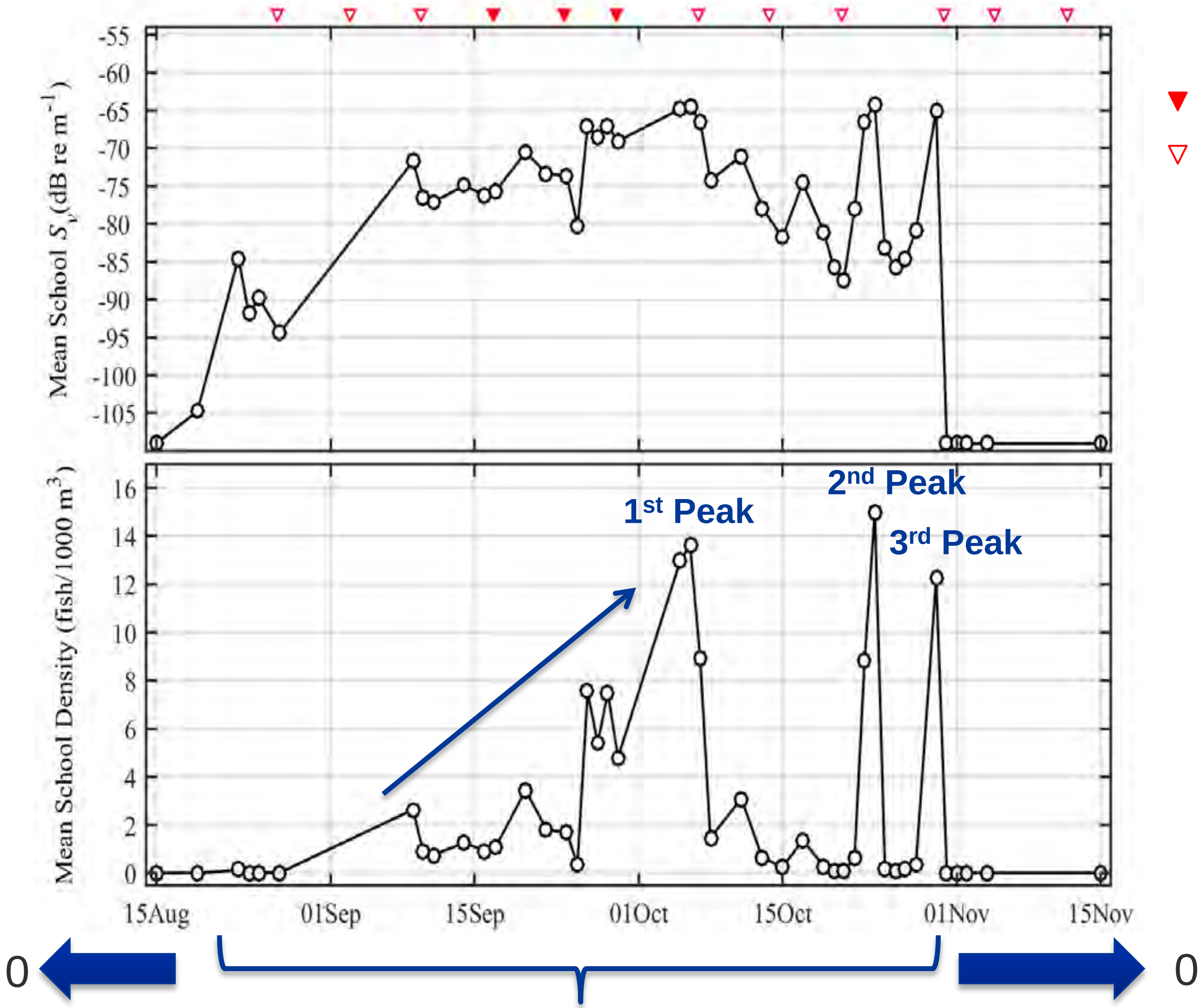
  (Target Strength in decibels)
- Target Strength predicted from mean length of juvenile American Shad caught by electrofishing





TransCanada

Study 22 – Daily Time Series of School Echoes



Cast Net Catch

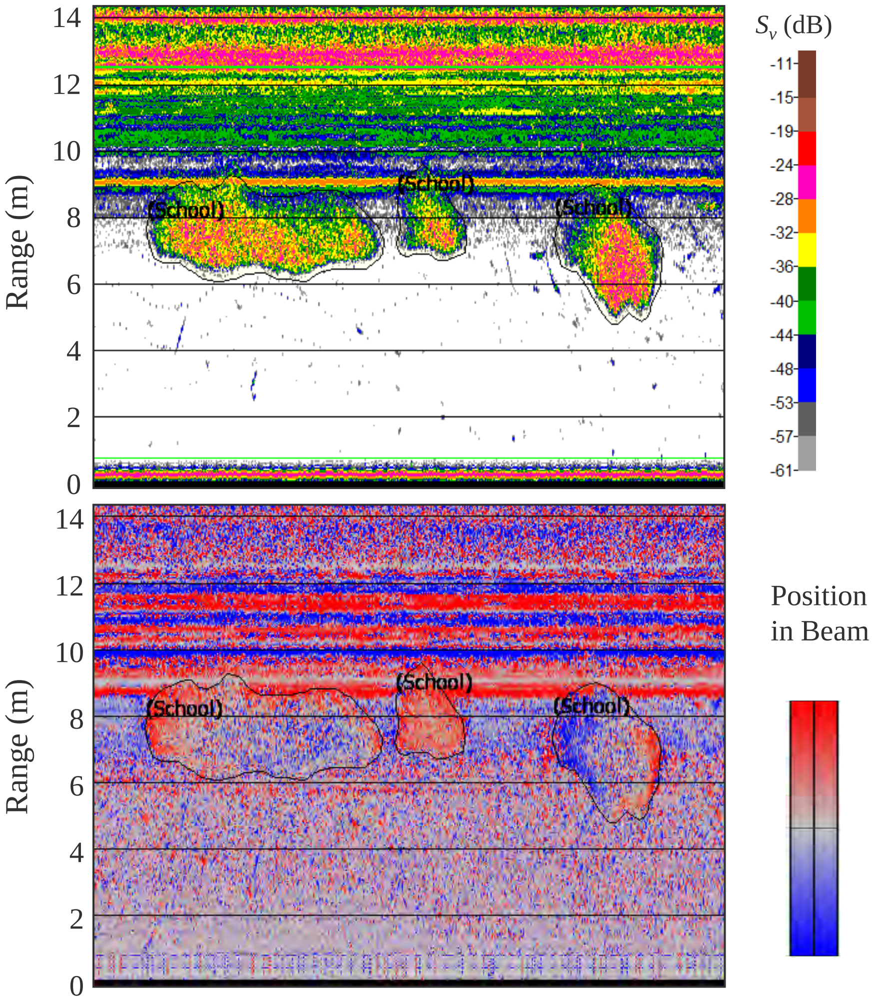
▼ = Shad Caught

▽ = No shad caught

Period of school echoes

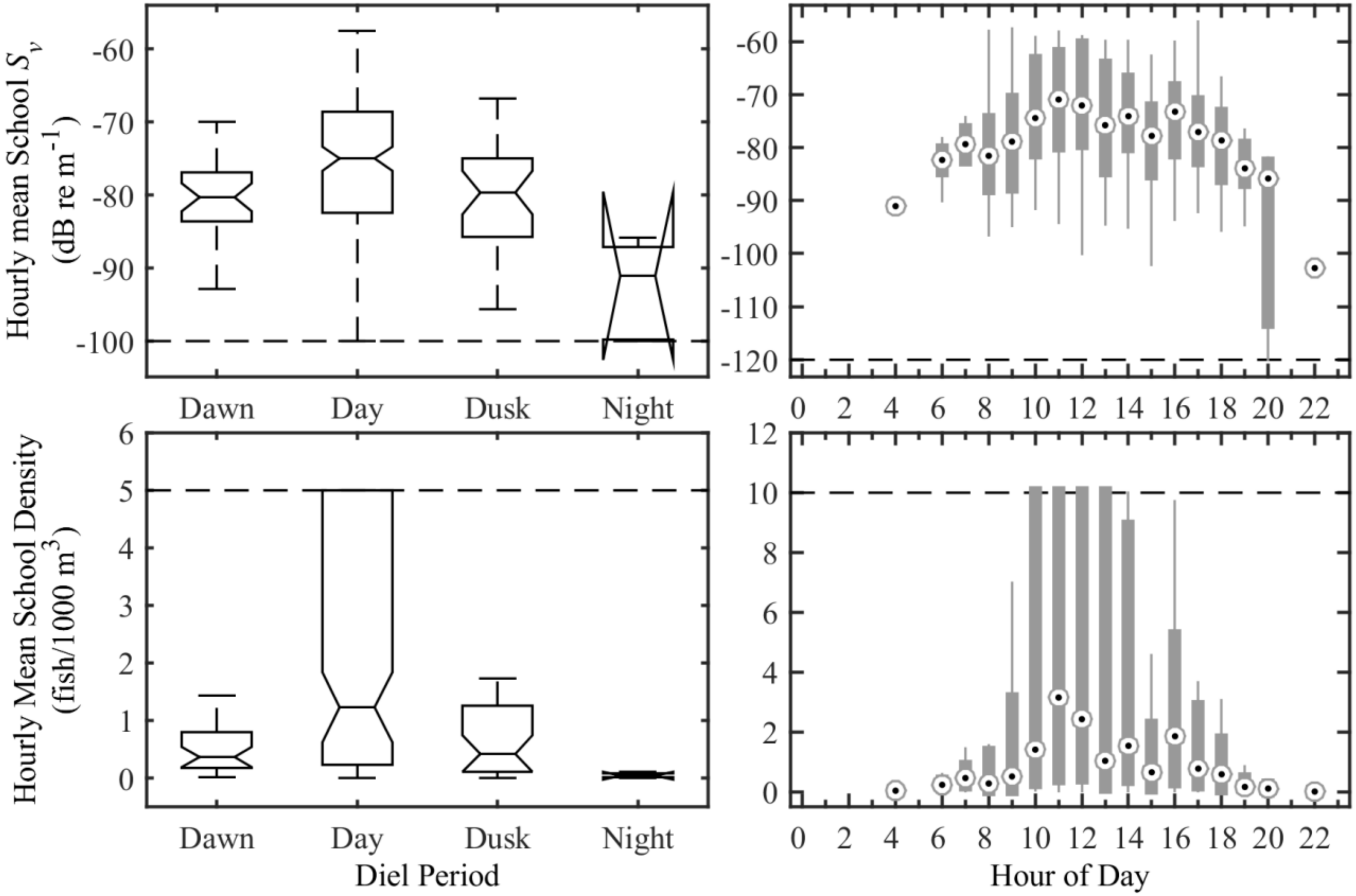
Study 22 – Echogram of School Echoes from 24 October Peak

Oct 24, 2015
16:52-16:57



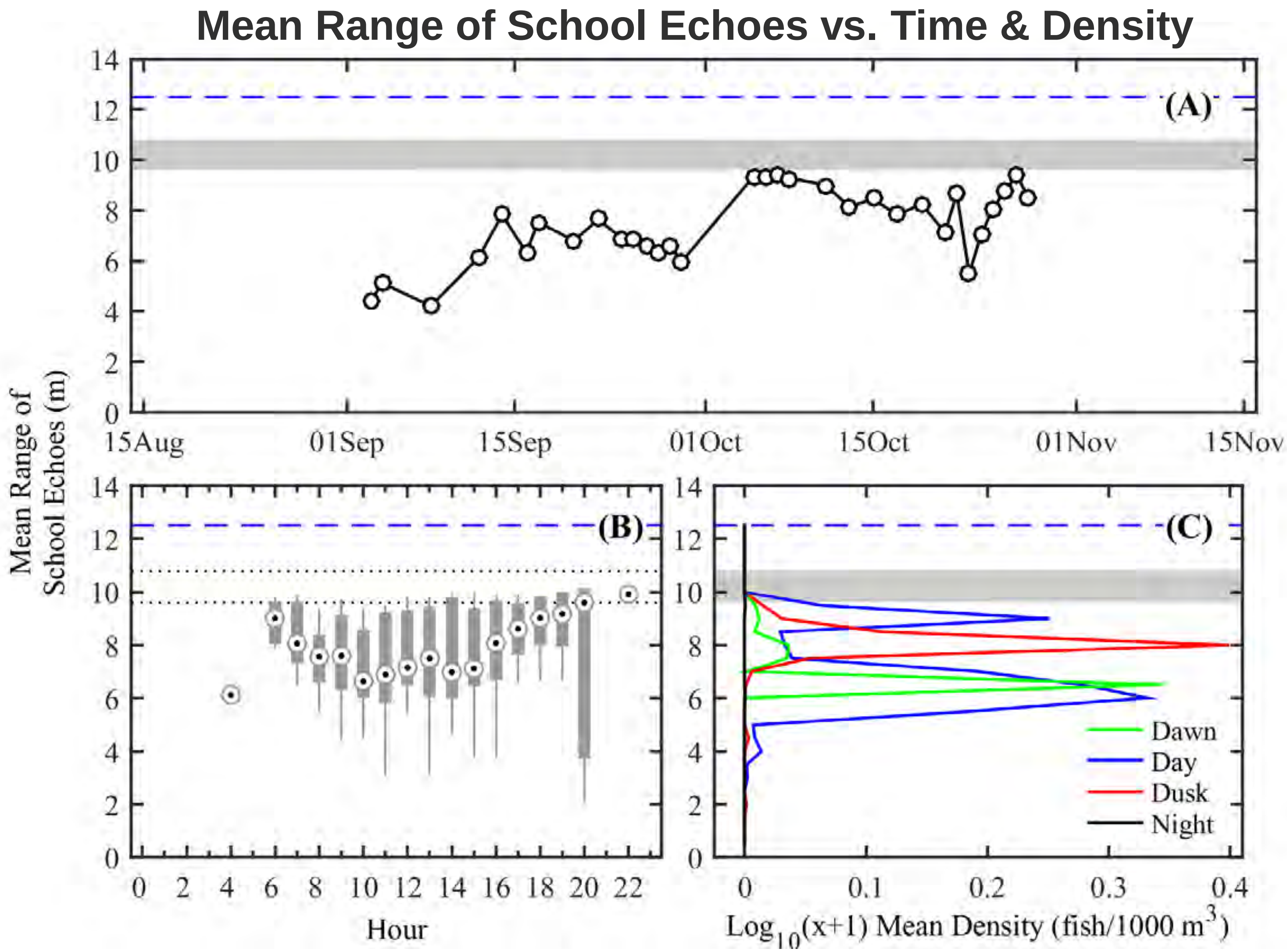
Study 22 – Diel Periodicity of Fish Schools

Hourly Mean Volume Backscattering Strength (S_v) & Fish Density



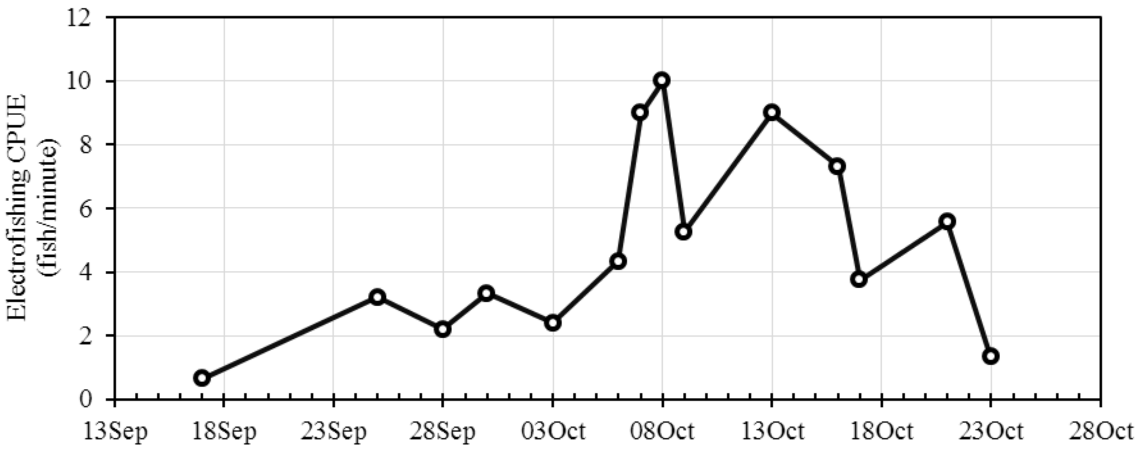
Box plot extent is the 25th and 75th percentiles, whiskers at ±1.5 times the interquartile range, and the symbol or notched line is the median. Non-overlapping notches indicate medians are significantly different at the 95% confidence level (McGill et al. 1978).

Study 22: Vertical Fish School Distribution



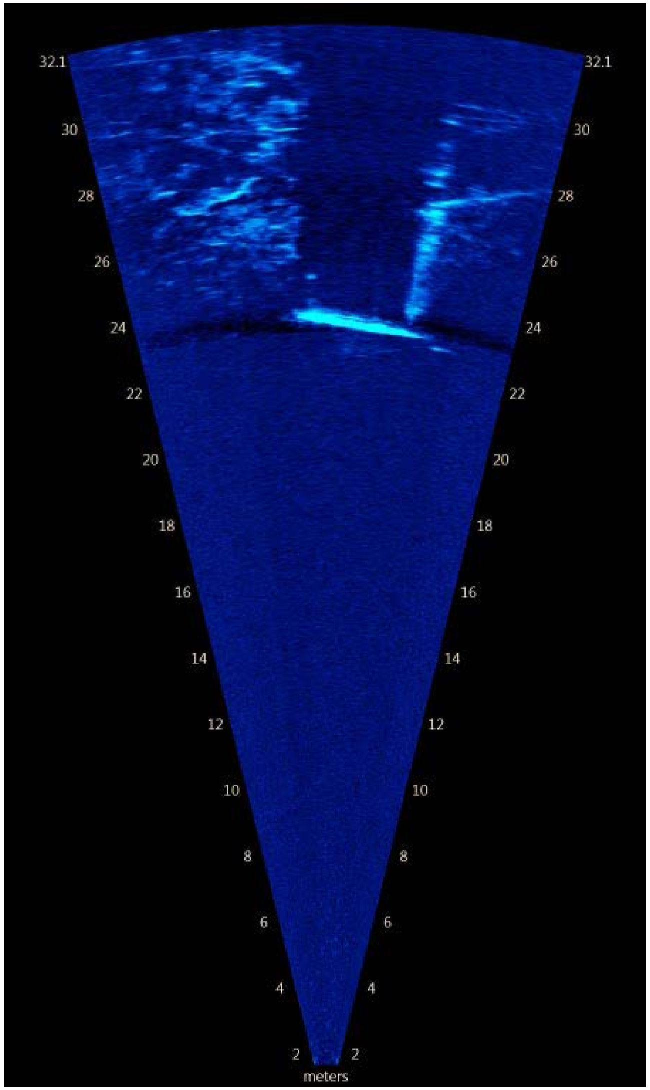
Study 22 – Verification Sampling of Shad

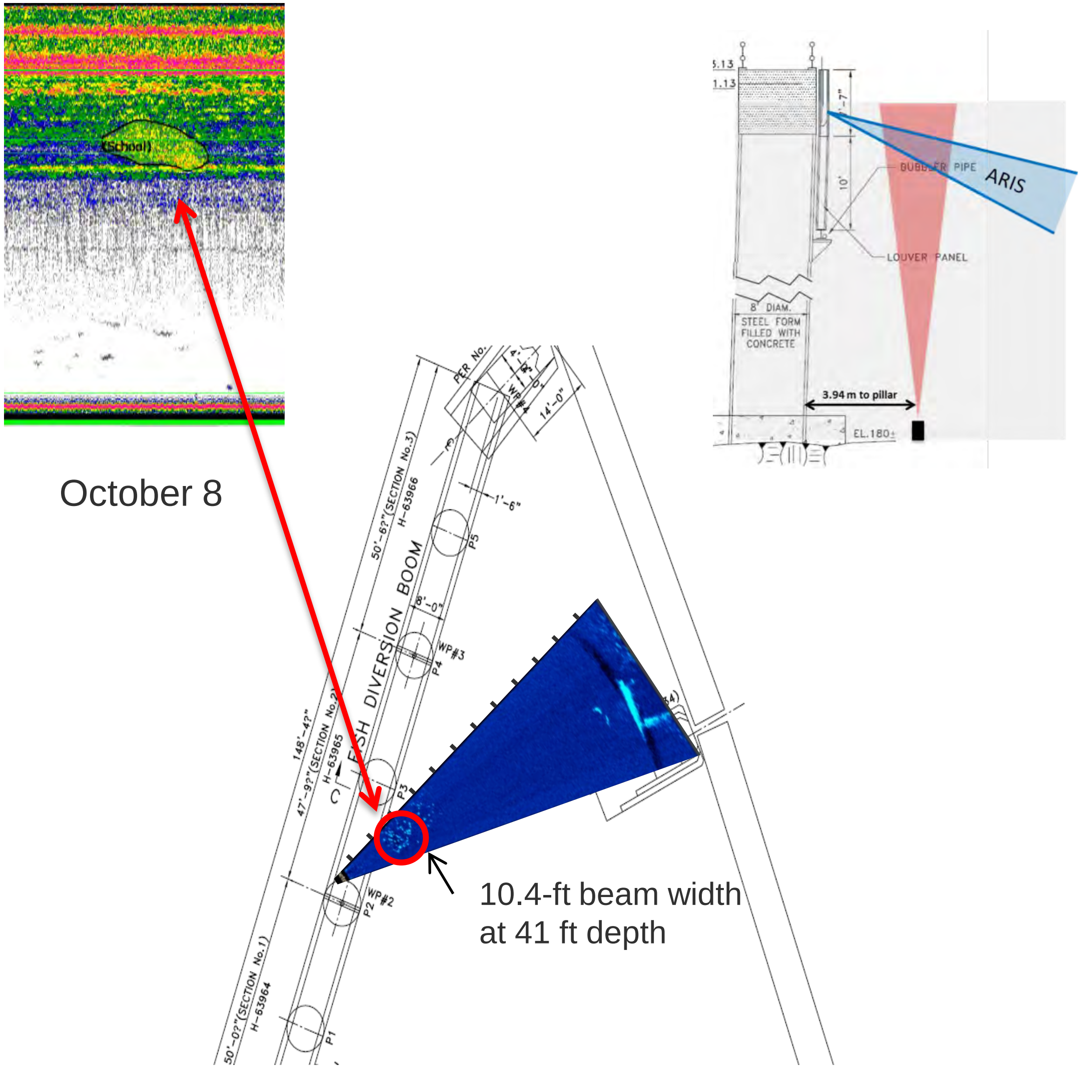
Visual Observations, Cast Nets, Electrofishing, & Imaging Sonar



- Cast nets caught juvenile American Shad in forebay on September 16, 23, & 28 (n=5, 97-117 mm, mean =104 mm)
- Visual observations of juveniles near surface in forebay from 26 August through October 13
- No longer seen at dusk October 20 to November 11
- Electrofishing confirmed presence of juvenile American Shad

Study 22 – ARIS Imaging Sonar Verifies School Echoes





October 8

10.4-ft beam width at 41 ft depth

Study 22 – Summary of Juvenile Shad Outmigration

- Several peaks in density of schooling fish
  - Incremental increases beginning September 9
  - 1st Peak on October 5-6(duration ~16 days)
    - Density peaked initially, remained high for a few days, gradually declined to lower densities ~ October 7
  - 2nd Peak on October 24 (duration ~2 days)
    - Highest daily mean density
  - 3rd Single-day peak on October 30
- Schooling fish absent during November
- Densities of schooling fish highest during the day
- Schools were mostly within 4 meters below fish pipe sill during day, moved up to fish pipe depth layer at dusk – especially in October
- Visual observations, electrofishing, cast netting, and imaging sonar support these echo patterns reflect the timing of out-migrating juvenile American Shad arriving and departing the forebay of Vernon powerhouse.

TransCanada

Study 22 – Route Selection

Radio Telemetry Results

- A total of 310 juvenile shad were equipped with radio tags and released upstream of Vernon dam on 15 occasions during a six week period between September 25 and October 30, 2015.
- In general, the proportion of fish utilizing a given downstream passage route coincided with the average proportion of flow passing through that route - with the exception of those shad utilizing the trash/ice sluice (unable to adequately compare that location as flow data at low flows were not available).

Study 22 – Turbine Passage Survival

Turbine Survival Methods

- Wild fish from the Connecticut River
- Tagged with single HI-Z tag and radio tag
- Fish passed through Vernon Units 4 and 8
- Total lengths ranged from 90 to 131 mm, average length 100 mm
- Turbine passage tests conducted October 6-13, 2015

TransCanada

Study 22 – Turbine Passage Survival

Turbine Survival – Wild and Hatchery Fish

Date	Water Temperature (°C)	Unit 4 Wild Fish Used in Analysis	Unit 4 Hatchery fish	Unit 8 Wild Fish Used in Analysis	Unit 8 Hatchery Fish	Control Wild Fish Used in Analysis	Control Hatchery Fish
10-6	15.0		30*				20*
10-7	15.0			20	20*	10	
10-8	14.6			100		48	
10-10	14.5	60		30		50	
10-11	15.0	91				42	
10-12	delayed assesment						
10-13	delayed assesment						
Total		**151**		**150**		**150**	

* Hatchery fish not used in analysis

TransCanada

Study 22 – Downstream Migration of Juvenile American Shad

Remaining Activities

- Data analysis is in progress
- Once completed, study report will be prepared

Study 23

Fish Impingement, Entrainment, and Survival Study

Study 23 – Fish Impingement, Entrainment, and Survival

Study Progress

- Reviewed fish assemblage information (Study 10) and have identified a representative fish community for each Project impoundment
  - Includes all diadromous species
  - Includes resident species comprising greater than 1% of impoundment catch
  - Included additional species as needed to ensure all major families are represented
- Have reviewed available swim-speed literature and summarized for each included fish species
- Have compiled generalized life history characteristics for each represented family for later use in determining entrainment potential
- Have obtained intake and turbine specifications for Project units and are in process of calculating blade strike probabilities (i.e., Franke formula)

Study 23 – Fish Impingement, Entrainment, and Survival

Remaining Activities

- Literature review of entrainment studies conducted at other hydroelectric Projects
- Final ranking of entrainment potential for each representative fish species based on:
  - Habitat and life history relative to Project characteristics
  - Swim speed relative to approach velocities
  - Entrainment data from comparable sites (as available)
- Review passage route studies for American Shad and American Eel to aid in the estimates of total project survival for diadromous fish species

Study 33

Cultural and Historic Resources Study

Study 33 – Historic and Cultural Resources

Study Progress - Archaeological Investigations

Vernon Project 2013 Monitoring Program/Update of Phase 1A Archaeological Reconnaissance Survey Report:

- Study complete: final report submitted to FERC, VTSHPO, NHSHPO, Nolumbeka Project, and Narragansett THPO on December 23, 2014.
- NHSHPO agreed with TransCanada's recommendations for Phase IB survey in New Hampshire on February 23, 2015.
- The VTSHPO did not respond with comments, so TransCanada assumed agreement with recommendations for proposed Phase 1B testing.

Phase IB Archaeological Identification Surveys – Wilder, Bellows Falls, and Vernon Projects:

- Study ongoing.
- Phase IB testing has been completed on all TransCanada-owned lands and private properties where permissions have been granted.
- NHSHPO concurred with PAL's findings and recommendations for Phase II survey by letter on December 16, 2015.
- Vermont Phase 1B report will be submitted by April 1, 2016.

Study 33 – Historic and Cultural Resources

Study Progress - Archaeological Investigations

Phase II Archaeological Evaluation Survey

- Study ongoing.
- Fieldwork for New Hampshire site completed in December 2015; report will be submitted April 2016.
- Fieldwork for Vermont sites scheduled for spring 2016; report will be submitted by August 2016.

Study 33 – Historic and Cultural Resources

Study Progress - Continued

Historic Architectural Resources National Register Evaluation

- Study complete: report was submitted to FERC, NHSHPO, and VTSHPO on May 25, 2015.
- NHSHPO requested the report be provided in its Project Area Form format on June 29, 2015. Separate Project Area Forms for the Wilder, Bellows Falls, and Vernon Projects were submitted to the NHDHR on July 30, 2015.
- By letter dated August 27, 2015 the NHSHPO evaluated the Wilder Dam eligible for the National Register and stated their opinion that the relicensing of the Projects will have no adverse effect on historic architectural resources.
- The VTSHPO did not comment on the report, so TransCanada assumes concurrence with its conclusions that the resources associated with the development and operation of the Wilder, Bellows Falls, and Wilder Projects are eligible for listing in the National Register as part of a potential historic district at each Project.

Study 33 – Historic and Cultural Resources

Study Progress - Continued

Traditional Cultural Properties (TCP) Identification Survey:

- Background archival ethnographic material was gathered including information provided as part of the archaeological and historic properties surveys.
- No meetings or interviews with NITHPO or the Nolumbeka Project were conducted due to a lack of response to TransCanada’s invitations and solicitations to participate in this study.
- A TCP report is currently in draft form that includes categories of historic properties that could be considered TCPs.

March 18, 2016 Agenda – REVISED

Including studies carried over from March 17 meeting:

Study No.	Study Title	Study Lead
16	Sea Lamprey Spawning Assessment (Preliminary report filed 03/01/2016)	Steve Leach
17	Upstream Passage of Riverine Fish Species Assessment (Report not yet filed)	Steve Leach
18	American Eel Upstream Passage Assessment (Report filed 03/01/2016)	Steve Leach
9	Instream Flow Study (Preliminary report filed 03/01/2016)	Steve Eggers
24	Dwarf Wedgemussel and Co-occurring Mussel Study – Delphi Panel and HSCs (Phase I Study report filed 09/15/2014, Phase II report filed 03/02/2015)	Ethan Nedeau, Mark Allen
10	Fish Assemblage Study (Report filed 03/01/2016)	Drew Trested
12	Tessellated Darter Survey (Report filed 03/01/2016)	Drew Trested
13	Tributary and Backwater Fish Access and Habitats Study (Preliminary report filed 09/14/2015)	Drew Trested
14 and 15	Resident Fish Spawning in Impoundments and Riverine Sections Study (Preliminary report filed 03/01/2016)	Mark Allen

Wilder, Bellows Falls, and Vernon Project Relicensing

Updated Study Results Meeting: March 17 – 18, 2016

TransCanada

March 18, 2016 Agenda – REVISED

Including studies carried over from March 17 meeting:

Study No.	Study Title	Study Lead
16	Sea Lamprey Spawning Assessment (Preliminary report filed 03/01/2016)	Steve Leach
17	Upstream Passage of Riverine Fish Species Assessment (Report not yet filed)	Steve Leach
18	American Eel Upstream Passage Assessment (Report filed 03/01/2016)	Steve Leach
9	Instream Flow Study (Preliminary report filed 03/01/2016)	Steve Eggers
24	Dwarf Wedgemussel and Co-occurring Mussel Study – Delphi Panel and HSCs (Phase I Study report filed 09/15/2014, Phase II report filed 03/02/2015)	Ethan Nedeau, Mark Allen
10	Fish Assemblage Study (Report filed 03/01/2016)	Drew Trested
12	Tessellated Darter Survey (Report filed 03/01/2016)	Drew Trested
13	Tributary and Backwater Fish Access and Habitats Study (Preliminary report filed 09/14/2015)	Drew Trested
14 and 15	Resident Fish Spawning in Impoundments and Riverine Sections Study (Preliminary report filed 03/01/2016)	Mark Allen

Study 16

Sea Lamprey Spawning Assessment

Study 16 – Sea Lamprey Spawning Assessment

Study Progress

- 40 Sea Lamprey collected from Vernon ladder, radio tagged and released ~ one mile upstream of the Vernon (N=20) and Bellows Falls (N=20) Projects
- Tracked from Stebbins Island to Wilder Dam and major tributaries, generally to first obstruction
- 23 sites assessed for spawning activity
  - 4 of 23 spawning habitat assessment sites were altered due to tracking and visual observations
- High flows persisted through much of the season, limiting characterization of some sites
  - 17 sites were revisited post-season in low flow conditions (Aug - Sep), nest elevations documented
  - 6 sites not revisited: well documented in season (N=3), little/no habitat available - no indicators of spawning activity (N=3)

Study 16 – Sea Lamprey Spawning Assessment

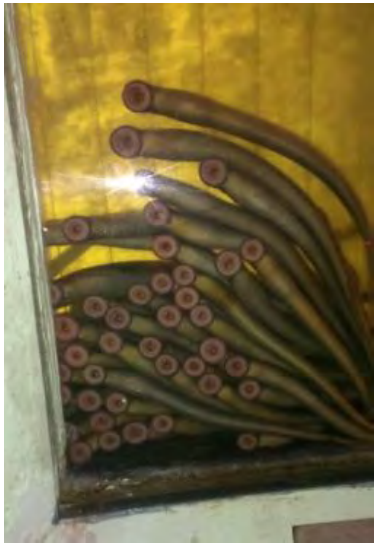
Study Progress (cont.)

- 4 nests at 3 sites where nest building was actively observed were capped
  - Supplemental information: ammocoete collections in other studies (Study 10, 21)
- Spawning sites analyzed with project operations, hydraulic model, and site-specific WSE monitoring.
- Interim report filed March 1, 2016

Study 16 – Sea Lamprey Spawning Assessment

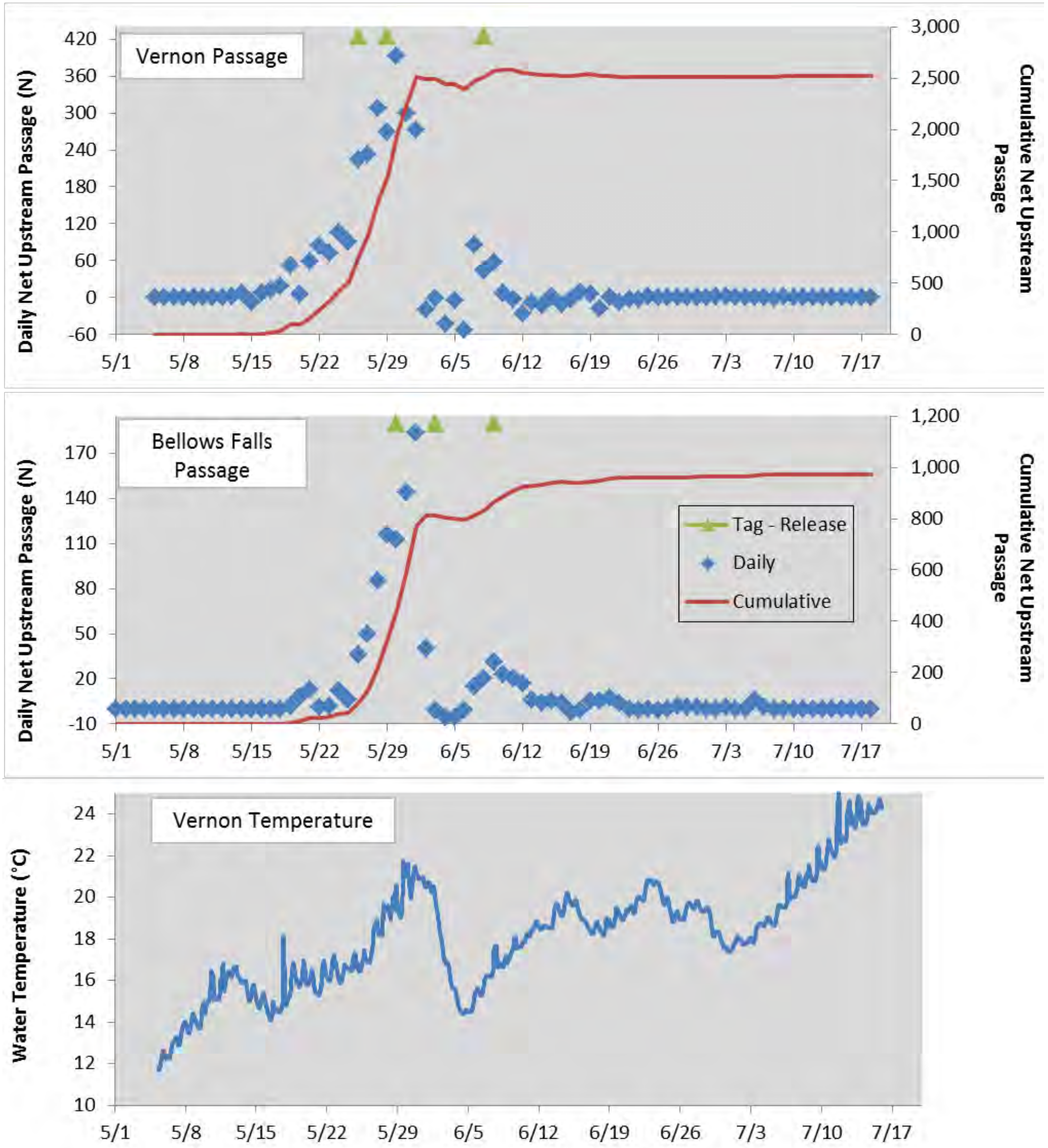
Connecticut River Passage Counts

- Wilder: 2 (0.2%)
- Bellows Falls: 971 (38%)
- Vernon: 2,519 (30%)
- Turners Falls: 8,423 (38%)
- Holyoke; 22,245



Sea Lamprey, Vernon Ladder

TransCanada



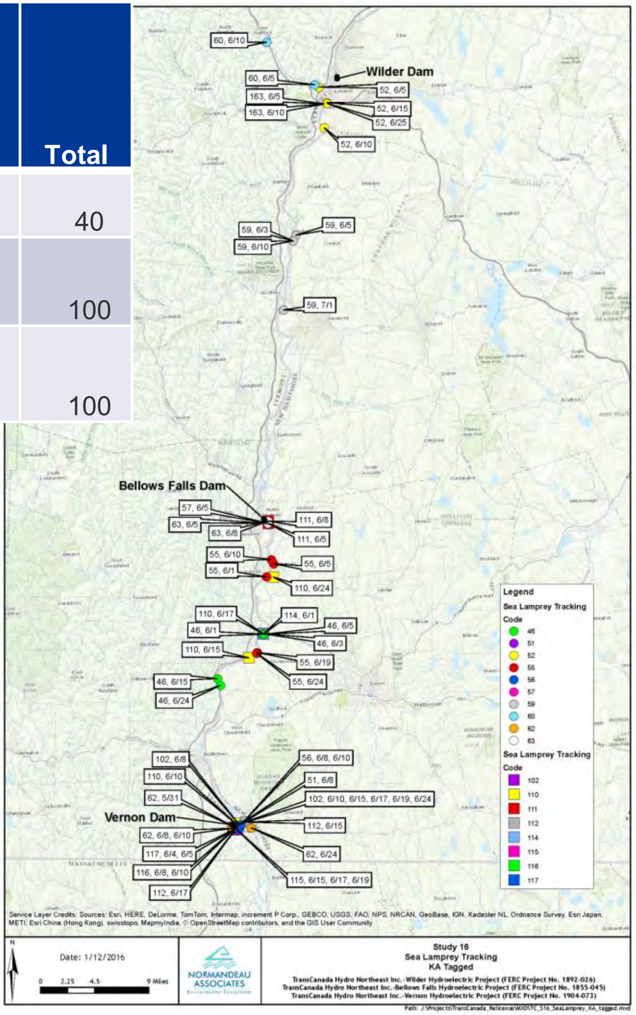
Sea Lamprey Passage, Vernon and Bellows Falls

Study 16 – Sea Lamprey Spawning Assessment

Study Results

- 38 of 40 tagged lamprey (+18 from FirstLight) were relocated.
- 4 of 23 spawning habitat assessment sites were altered due to tracking and visual observations
  - N / reach maintained

	Not Relocated	Upstream-most Reach					Trib.	Total
		Vernon Riverine	Vernon Impound-ment	Bellows Falls Riverine	Bellows Falls Impound-ment	Wilder Riverine		
Total (N)	2	0	7	9	11	9	2	40
% Vernon Releases	5	0	30	40	5	10	10	100
% Bellows Falls Releases	5	0	5	5	50	35	0	100



Service Layer Credits: Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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

Path: J:\Projects\TransCanada_Relicense\MXD\TC_S16_SeaLamprey_KA_tagged.mxd

Study 16 – Sea Lamprey Spawning Assessment

Study Results

- Spawning activity confirmed at 16 (70%) sites
- 1 to 11 nests or nest clusters were identified per site

Sea Lamprey Spawning Site Characterization

TransCanada

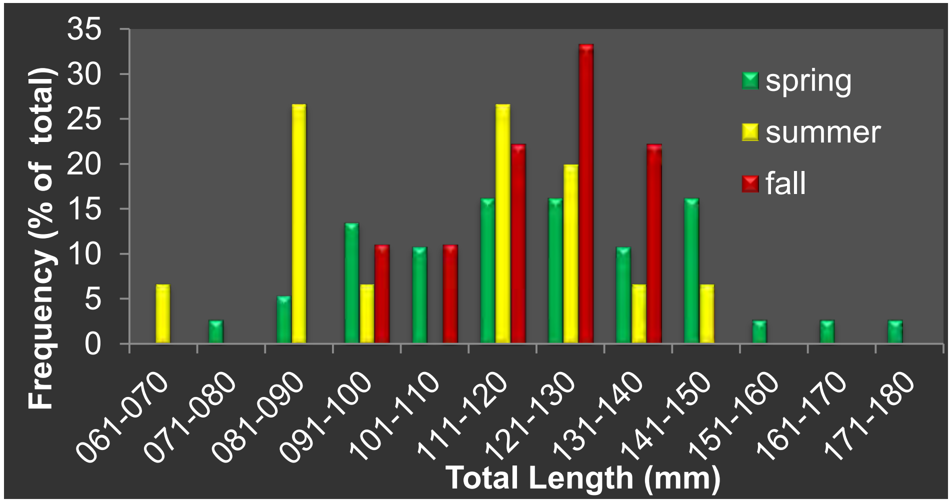
Reach	Site ID	Spawning Activity		
		Telemetry	Visual	Nests
Wilder Riverine Reach				
WL Sub 1	16-WL-001	Y	N	Y
WL Sub 1	**16-WL-002**	N	N	Y
WL Sub 2	**16-WL-003**	Y	N	N
WL Sub 2	**16-WL-004**	Y	N	N
WL Sub 3	**16-WL-005**	N	N	Y
WL Sub 3	**16-WL-006**	Y	N	Y
WL Sub 3	**16-WL-007**	Y	N	Y
Percent of sites		71%	0%	71%
Bellows Falls impoundment				
BT	**16-BT-004**	Y	N	Y
BT	**16-BT-006**	Y	N	N
BT	**16-BT-003**	Y	N	Y
BT	**16-BT-013**	Y	Y	Y
BT	**16-BT-018**	Y	Y	Y
BT	**16-BT-031**	N	N	N
Percent of sites		83%	33%	67%
Bellows Falls Riverine Reach				
BL	**16-BL-001**	N	N	Y
BL	**16-BL-002**	Y	N	Y
BL	**16-BL-003**	Y	Y	Y
Percent of sites		67%	33%	100%
Vernon Impoundment				
VT	**16-VT-014**	Y	N	N
VT	**16-VT-016**	Y	Y	Y
VT	**16-VT-018**	Y	Y	Y
VT	**16-VT-040**	N	N	N
VT	**16-VT-046**	N	N	N
Percent of Sites		60%	40%	40%
Vernon Riverine				
VL	**16-VL-001**	Y	Y	Y
VL	**16-VL-002**	Y	Y	Y
Percent of sites		100%	100%	100%
Overall				
Percent of sites		74%	30%	70%

Study 16 – Sea Lamprey Spawning Assessment

Study Results

- No ammocoetes collected from nest caps
- Nest micro-habitat was altered within caps
- 37 post-emergent ammocoetes were incidentally collected in 6 (5%) of Study 21 ichthyoplankton samples (V and BF riverine, V impoundment)
- 62 ammocoetes / juvenile lamprey were collected in up to 46% (by reach and season) of Study 10 electrofishing sites from all reaches except Wilder impoundment and the Bellows Falls bypassed reach
- Anecdotal observations of juvenile lamprey may be reported as 'eels'

Nest cap, Partridge Brook (16-VT-018)



Length frequency distribution of lamprey collected in Study 10 electrofishing

Study 16 – Sea Lamprey Spawning Assessment

Analysis of Project Effects

Project Operations – Water Level Fluctuations

- 4 sites were determined not to have suitable habitat (4/23 = 17%) and no spawning activity (including nest presence) was identified for 3 sites (3/23 = 13%)
- Remaining sites (N=16, 70%) are being analyzed for water level fluctuation and nest exposure (conservative measure):
  - Freq. and duration of operations where discharge < modeled discharge (hydraulic modeling, Study 4) for submergence WSE of <u>highest nest elevation</u> (lamprey spawning season)
  - Frequency and duration of events (period of record) where observed WSE < nest elevations (10 sites with loggers; 6 with proxy loggers)

    If all nest elevations were continuously submerged for the period of record, then preliminary classification of ‘no project effects’

    If any nest elevation was exposed, then a preliminary classification of ‘moderate project effects’
  - Final classification pending analysis of operations model output for varying water years.
    - 2015 nest elevations may not be representative of different water years

Study 16 – Sea Lamprey Spawning Assessment

Percent of observations of nest elevation exposure
(water level logger period of record, by site)

		Period of Record (5/15 – 7/15)			Nest Elevations[b] (ft)			Percent of time exposed (per nest, 1 – 11, in order of increasing elevation)[c]										
Site[a]	**Logger Site**	**Begin**	**End**	**N obs.**	**Nests (N)**	**Range**	**Mean (SD)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
16-WL-001	15-WR-002	5/15/15 00:00	7/14/15 12:00	5,803	3	324.7-329.1	327.0 (2.2)	0.1%	21.0%	38.4%								
16-WL-002	15-WR-002 (proxy, +0.6 mi)	5/15/15 00:00	7/14/15 12:00	5,803	5	324.4-327.7	326.4 (1.2)	0.0%	15.5%	16.1%	16.7%	25.3%						
16-WL-005	15-WI-005	6/5/15 14:00	7/14/15 13:00	3,741	3	300.3-302.7	301.2 (1.2)	0.0%	0.0%	16.3%								
16-WL-006	15-WI-006	5/27/15 12:15	6/5/15 13:45	871	3	293.1-293.8	293.5 (0.3)	0.0%	0.0%	0.0%								
16-WL-007	15-WI-006 (proxy, +0.7 mi)	5/27/15 12:15	6/5/15 13:45	871	4	291.4-293.7	292.8 (0.9)	0.0%	0.0%	0.0%	0.0%							
16-BT-004	14-BT-002 (proxy, -2.5 mi)	5/26/15 11:00	7/13/15 12:30	4,614	1	291.0	n/a	8.3%										
16-BT-003	14-BT-002	5/26/15 11:00	7/13/15 12:30	4,614	1	290.08	n/a	0.0%										
16-BT-013	14-BT-013	5/28/15 8:15	7/13/15 13:45	4,445	2	286.8-290.0	287.7 (1.4)	0.0%	0.0%									
16-BT-018	16-BT-018	6/15/15 17:30	7/15/15 23:59	2,907	10	289.0-290.5	289.7 (0.4)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
16-BL-001	15-BL-002 (proxy, -1.2 mi)	5/29/15 12:15	7/7/15 10:45	3,739	6	218.1-220.8	n/a	0.0%	0.0%	0.0%	0.0%	0.0%	5.7%					
16-BL-002	15-BL-002	5/29/15 12:15	7/7/15 10:45	3,739	3	219.0-219.2	219.14 (0.9)	0.0%	0.0%	0.0%								
16-BL-003	15-BL-003 (proxy, +1.1 mi)	5/29/15 12:15	7/7/15 10:45	3,739	4	215.7-217.0	219.14 (0.1)	0.0%	0.0%	0.0%	0.0%							
16-VT-016	16-VT-016	6/19/15 17:00	7/15/15 23:29	2,525	4	218.2-219.3	219.0 (0.4)	0.0%	0.0%	0.0%	0.0%							
16-VT-018	16-VT-018	6/15/15 12:45	7/15/15 23:29	2,926	4	220.3-220.8	220.5 (0.2)	0.0%	0.0%	0.0%	0.0%							
16-VL-001	15-VI-002 (proxy, -0.6 mi)	5/27/15 9:45	7/15/15 23:29	4,760	6	177.7-182.7	180.4 (1.8)	0.0%	0.0%	2.5%	6.7%	6.9%	16.9%					
16-VL-002	15-VI-002	5/27/15 9:45	7/15/15 23:29	4,760	11	179.5-181.1	180.2 (0.6)	0.0%	0.0%	0.1%	0.1%	0.9%	1.3%	1.6%	4.4%	4.7%	5.1%	5.5%

TransCanada

Study 16 – Sea Lamprey Spawning Assessment

Summary: preliminary analysis of project operations effects

Nest Exposure

- No project effects: N = 10 (44%, including sites with no suitable habitat or no active spawning)
- No project effects (preliminary): N = 7 (30%)
- Moderate project effects (preliminary): N = 6 (26%)

Water Quality

- DO: all sites met VT instantaneous minimum for Class A waters, 6.0 mg/l, and NH minimum of 5.0 mg/l.
- pH: most met VT standard for Class B waters of 6.5 – 8.5 su. One (tributary) site had a pH record < 6.5; the same site had records above NH 8.0 su standard.
- Turbidity: values >10 NTU occurred at several sites during high flow, most in tributaries
- Variations in temperature were considered naturally occurring.

Study 16 – Sea Lamprey Spawning Assessment

Summary: preliminary analysis of project operations effects

Nest Structure Degradation, Scour, and Flushing

- Evaluated for 13 nests at 5 sites where repeat observations were made (8 nests at 2 tributary sites and 5 nests at 3 mainstem sites)
  - Nest structure degradation in 8 nests (62%), 5 (38%) at tributary sites
    - Nest scour in 5 nests (38%), but 4 (31%) at tributary sites
    - Sediment deposition noted in 7 nests (54%), but 4 (31%) at tributary sites

Remaining Activities

- Analysis of the effect of modeled water surface elevations on spawning habitat
- Issue amended report

TransCanada

Study 17

Upstream Passage of Riverine Fish Species Assessment

Study 17 – Upstream Passage of Riverine Fish Species

Study Progress

- Fishways began operation and video equipment was installed on April 16 at Wilder, April 15 at Bellows Falls, and May 5 at Vernon.
- Video data was continually processed, reviewed and summarized on a weekly basis throughout the study season.
- Wilder ladder was shut down briefly for window cleaning on August 23, 2015, and Bellows Falls and Vernon ladders were shut down for cleaning on December 8, 2015.
- Fishways were closed on January 7, 2016 at Wilder , and on January 6, 2016 at Bellows Falls and Vernon.

NOTE: In variance to the RSP, temperature loggers were inadvertently not installed in fish ladders. Temperature data was obtained from nearby sites used in other studies (primarily Study 6).

Study 17 – Upstream Passage of Riverine Fish Species

Study Results – Wilder

Species	Upstream	Downstream	Net Total
Migratory Species			
Atlantic Salmon	1	0	1
American Shad	0	0	0
Sea Lamprey	4	-2	2
American Eel	204	-152	52
Resident Species			
Bass (Micropterus spp.)	439	-390	49
White Sucker	10	-9	1
Walleye	172	-150	22
Trout	1116	-1052	64
Sunfish (Lepomis spp.)	23	-28	-5
Bullhead	0	0	0
Crappie (Pomoxis spp.)	0	0	0
Pike (Esox spp.)	0	0	0
Yellow Perch	0	0	0
Carp	0	0	0
Other	0	0	0

TransCanada

Study 17 – Upstream Passage of Riverine Fish Species

Study Results – Bellows Falls

Species	Upstream	Downstream	Net Total
Migratory Species			
Atlantic Salmon	1	-1	0
American Shad	90	-46	44
Sea Lamprey	2334	-1363	971
American Eel	245	-185	60
Resident Species			
Bass (Micropterus spp.)	606	-656	-50
White Sucker	48	-42	6
Walleye	27	-31	-4
Trout	144	-136	8
Sunfish (Lepomis spp.)	30	-24	6
Bullhead	0	0	0
Crappie (Pomoxis spp.)	0	0	0
Pike (Esox spp.)	0	0	0
Yellow Perch	0	0	0
Carp	0	0	0
Other	0	0	0

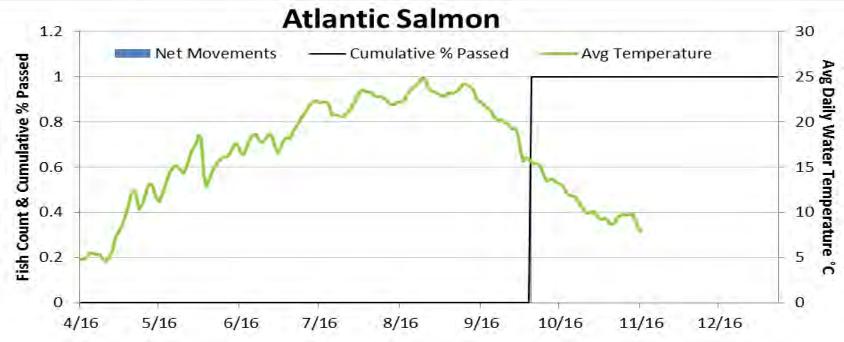
Study 17 – Upstream Passage of Riverine Fish Species

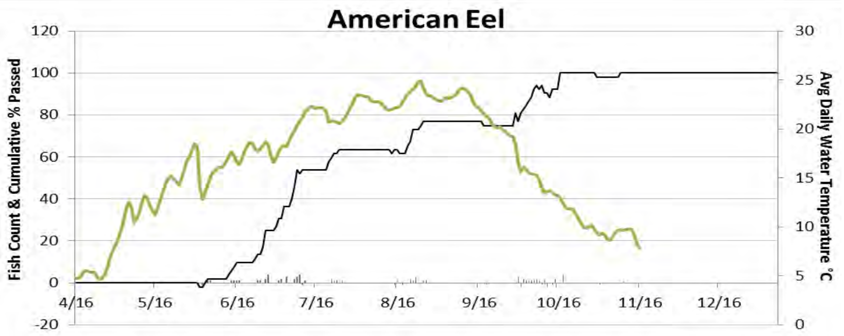
Study Results – Vernon

Species	Upstream	Downstream	Net Total
Migratory Species			
Atlantic Salmon	8	-1	7
American Shad	54890	-16092	38798
Sea Lamprey	7662	-5193	2469
American Eel	4914	-3369	1545
Resident Species			
Bass (Micropterus spp.)	5304	-4538	766
White Sucker	2353	-2010	343
Walleye	132	-73	59
Trout	89	-60	29
Sunfish (Lepomis spp.)	4612	-3422	1190
Bullhead	6	-4	2
Crappie (Pomoxis spp.)	0	0	0
Pike (Esox spp.)	1	-2	-1
Yellow Perch	0	0	0
Carp	102	-95	7
Other	131	-122	9

Study 17 – Upstream Passage of Riverine Fish Species

Daily Net and Cumulative Upstream Passage, and Water Temperature
Wilder

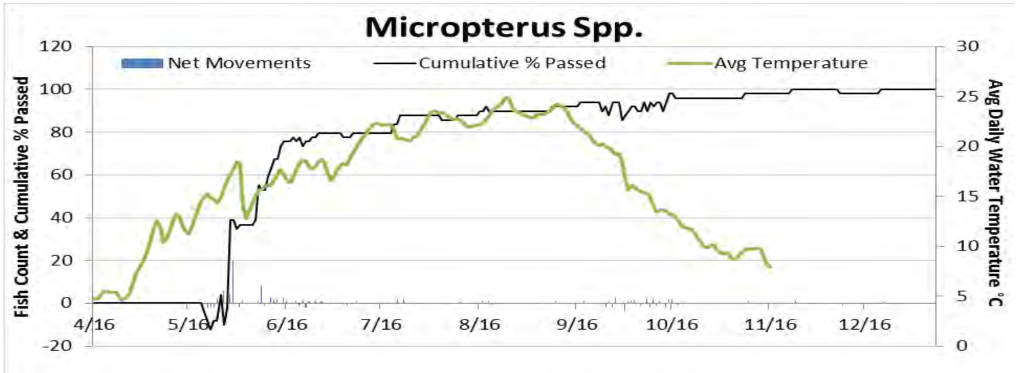


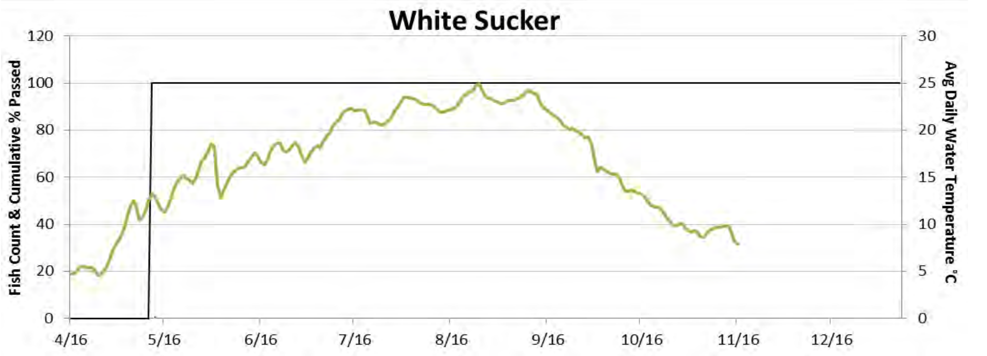


TransCanada

Study 17 – Upstream Passage of Riverine Fish Species

Daily Net and Cumulative Upstream Passage, and Water Temperature - Wilder


Micropterus Spp.

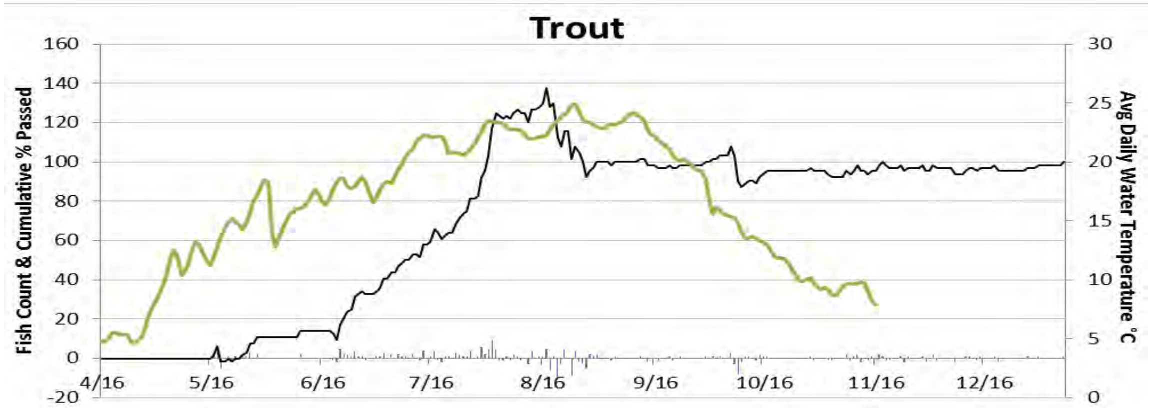

White Sucker

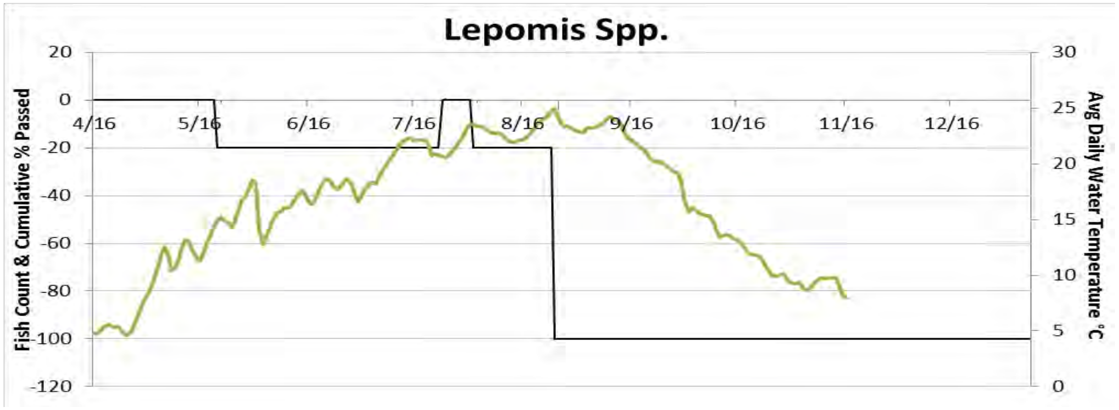

Walleye

TransCanada

Study 17 – Upstream Passage of Riverine Fish Species

Daily Net and Cumulative Upstream Passage, and Water Temperature
Wilder



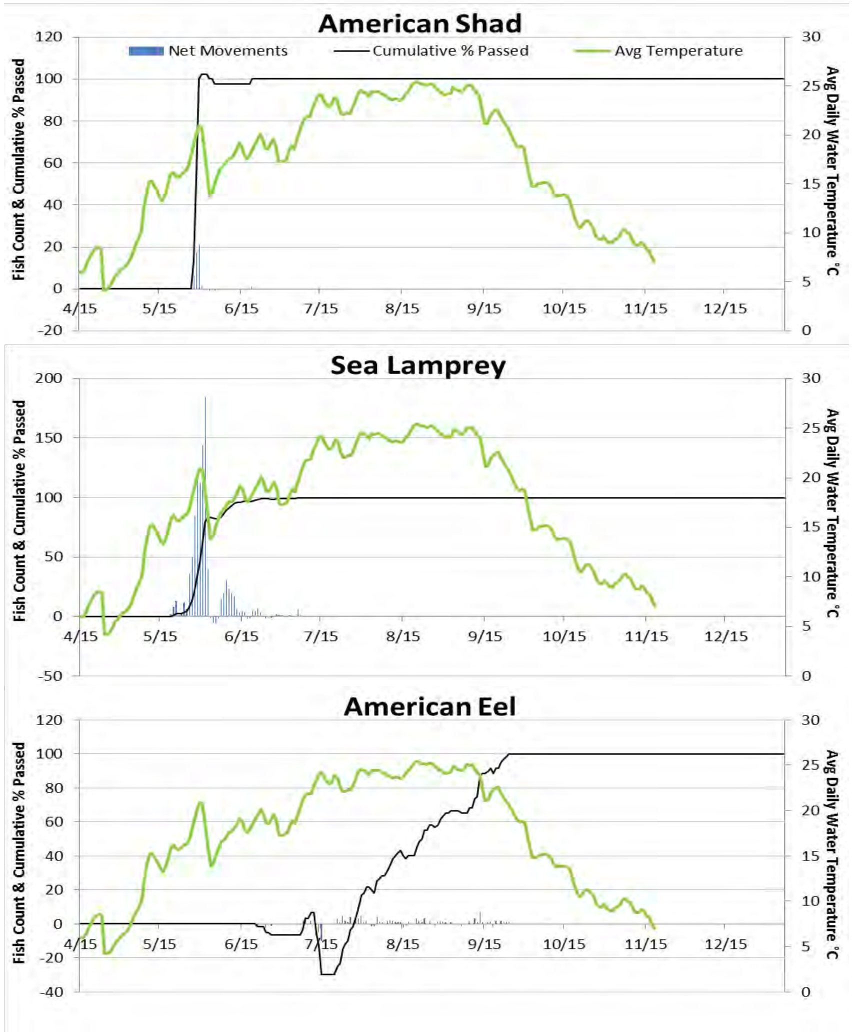


TransCanada

Study 17 – Upstream Passage of Riverine Fish Species

Daily Net and Cumulative Upstream Passage, and Water Temperature

Bellows Falls

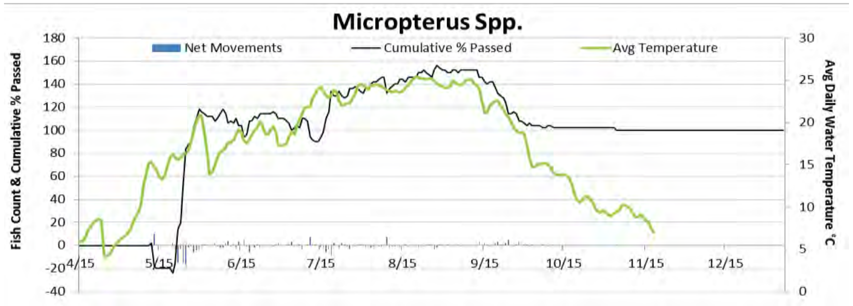


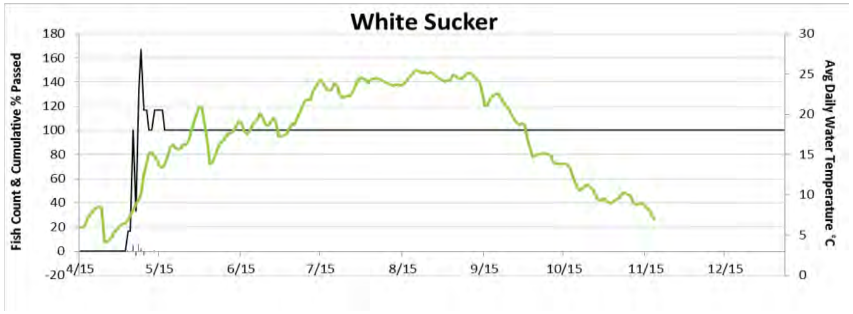
TransCanada

Study 17 – Upstream Passage of Riverine Fish Species

Daily Net and Cumulative Upstream Passage, and Water Temperature

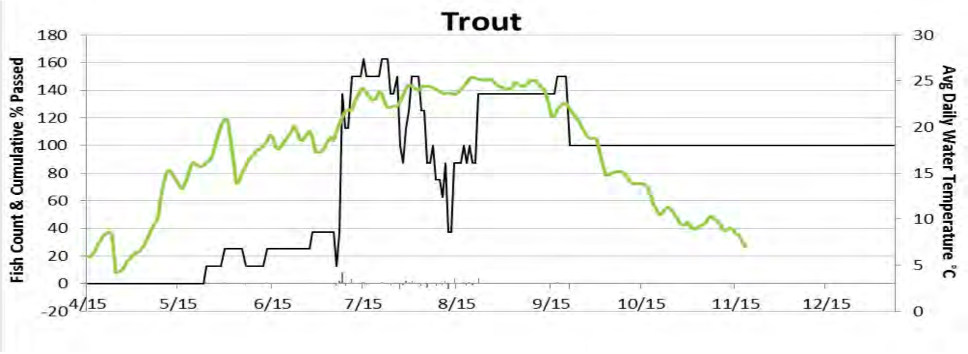
Bellows Falls

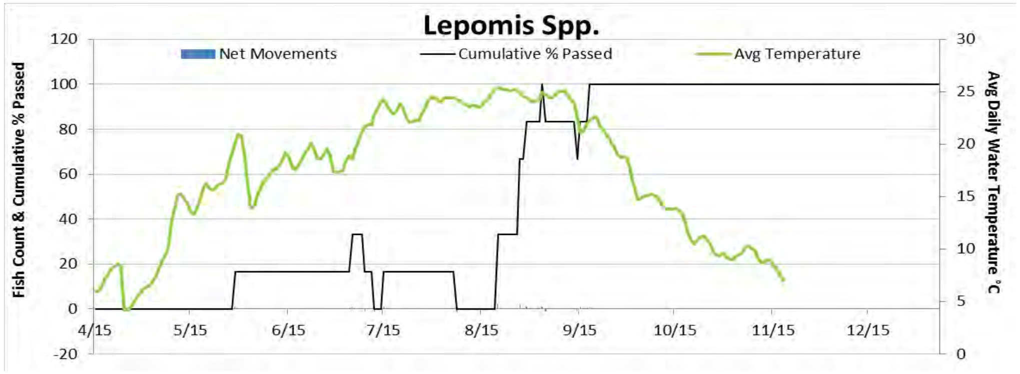




Study 17 – Upstream Passage of Riverine Fish Species

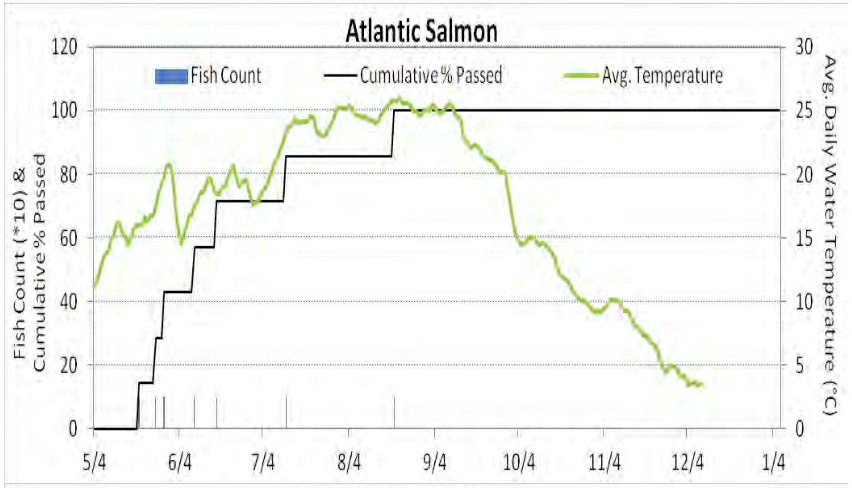
Daily Net and Cumulative Upstream Passage, and Water Temperature
Bellows Falls

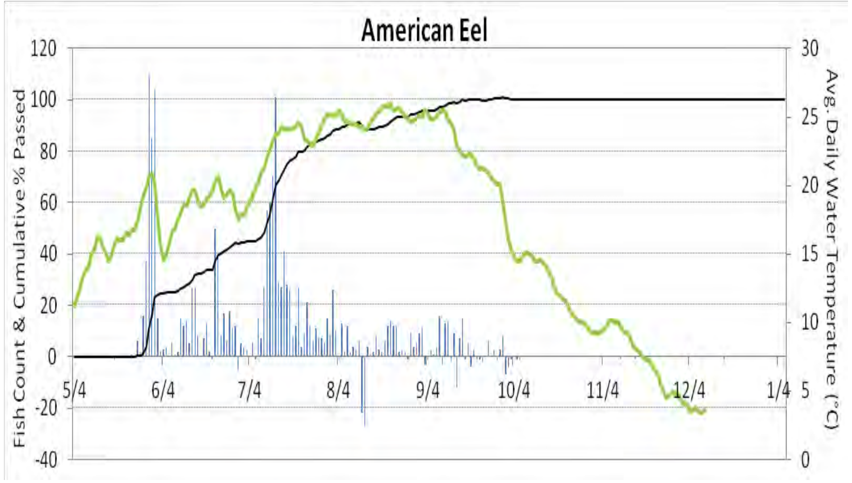




Study 17 – Upstream Passage of Riverine Fish Species

Daily Net and Cumulative Upstream Passage, and Water Temperature
Vernon

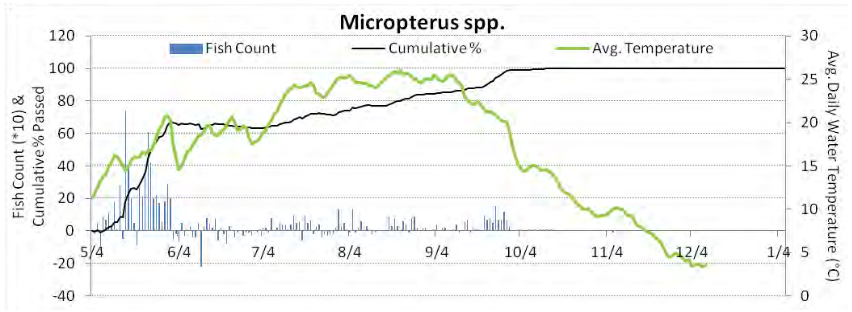


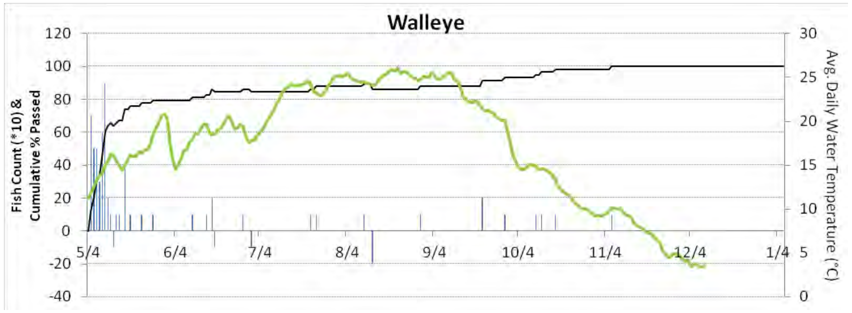


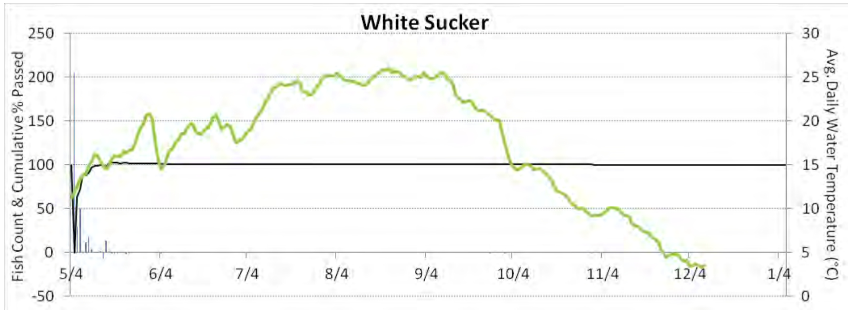
Study 17 – Upstream Passage of Riverine Fish Species

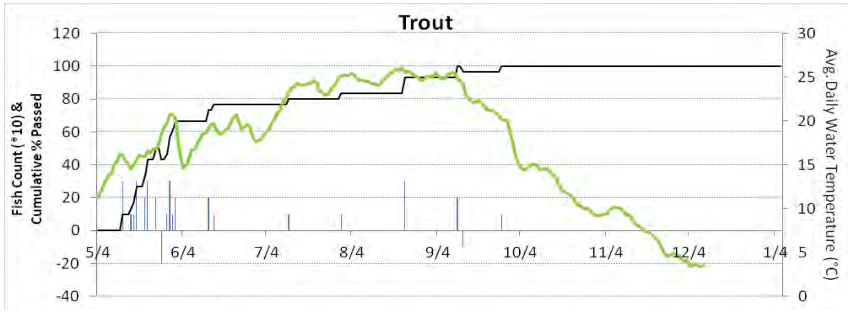
Daily Net and Cumulative Upstream Passage, and Water Temperature

Vernon





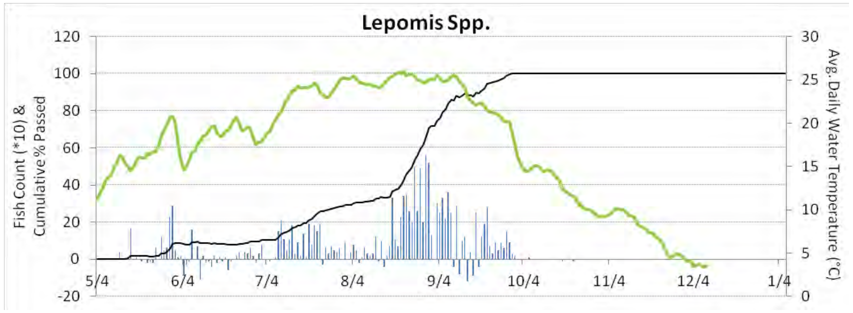


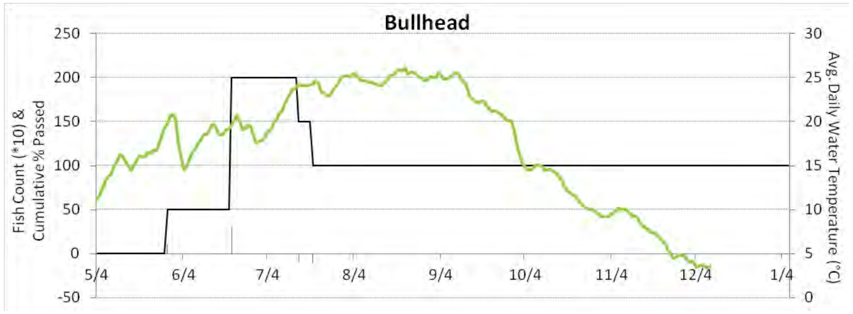


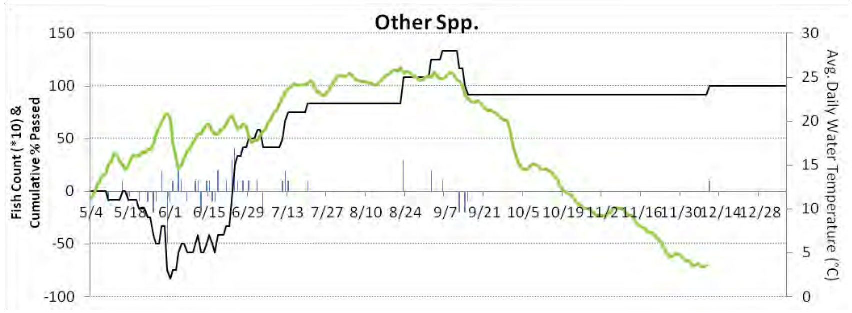
Study 17 – Upstream Passage of Riverine Fish Species

Daily Net and Cumulative Upstream Passage, and Water Temperature

Vernon

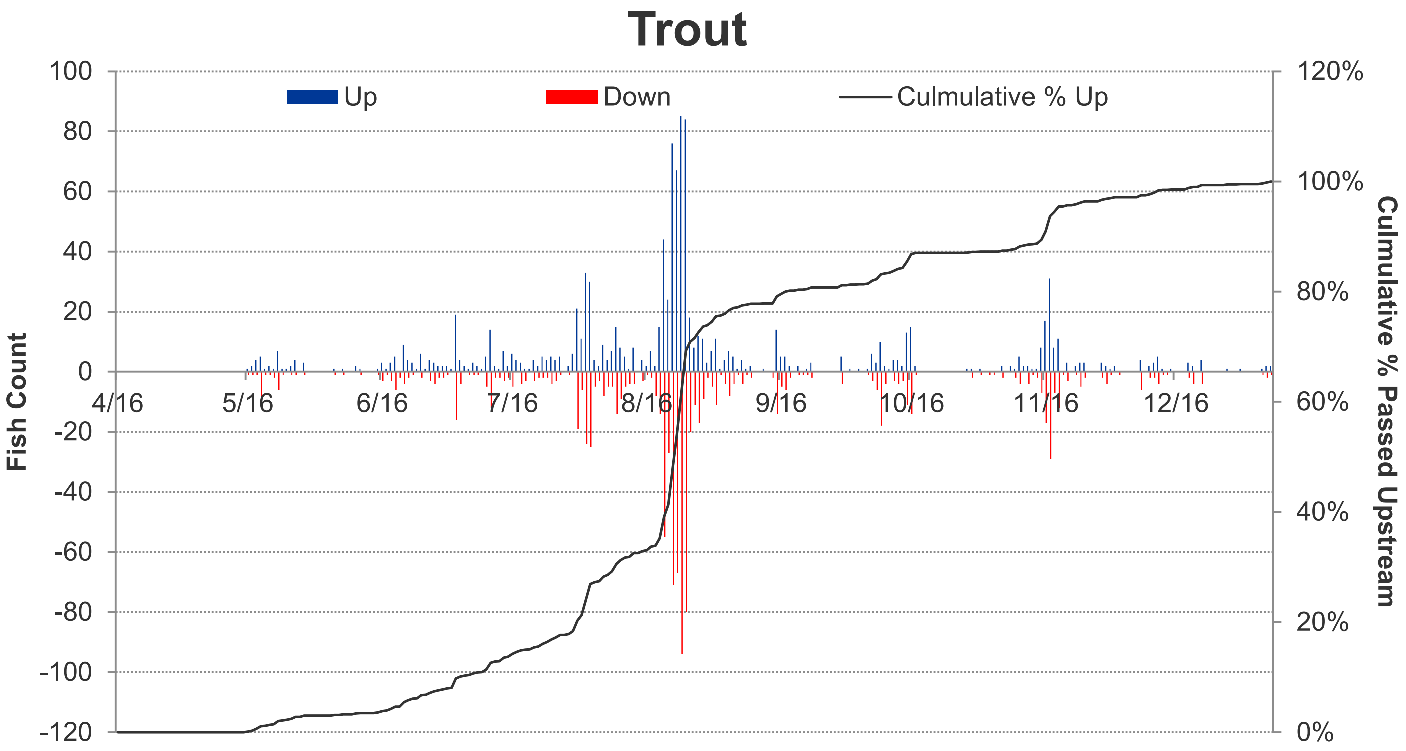






Study 17 – Upstream Passage of Riverine Fish Species

Daily Up and Downstream Counts, Wilder, Trout



Total Up = 1,116; Total Down = -1,052; Net Up = 64

TransCanada

Study 17 – Upstream Passage of Riverine Fish Species

Remaining Activities

- Issuance of study report.

Study 18

American Eel

Upstream Passage Assessment

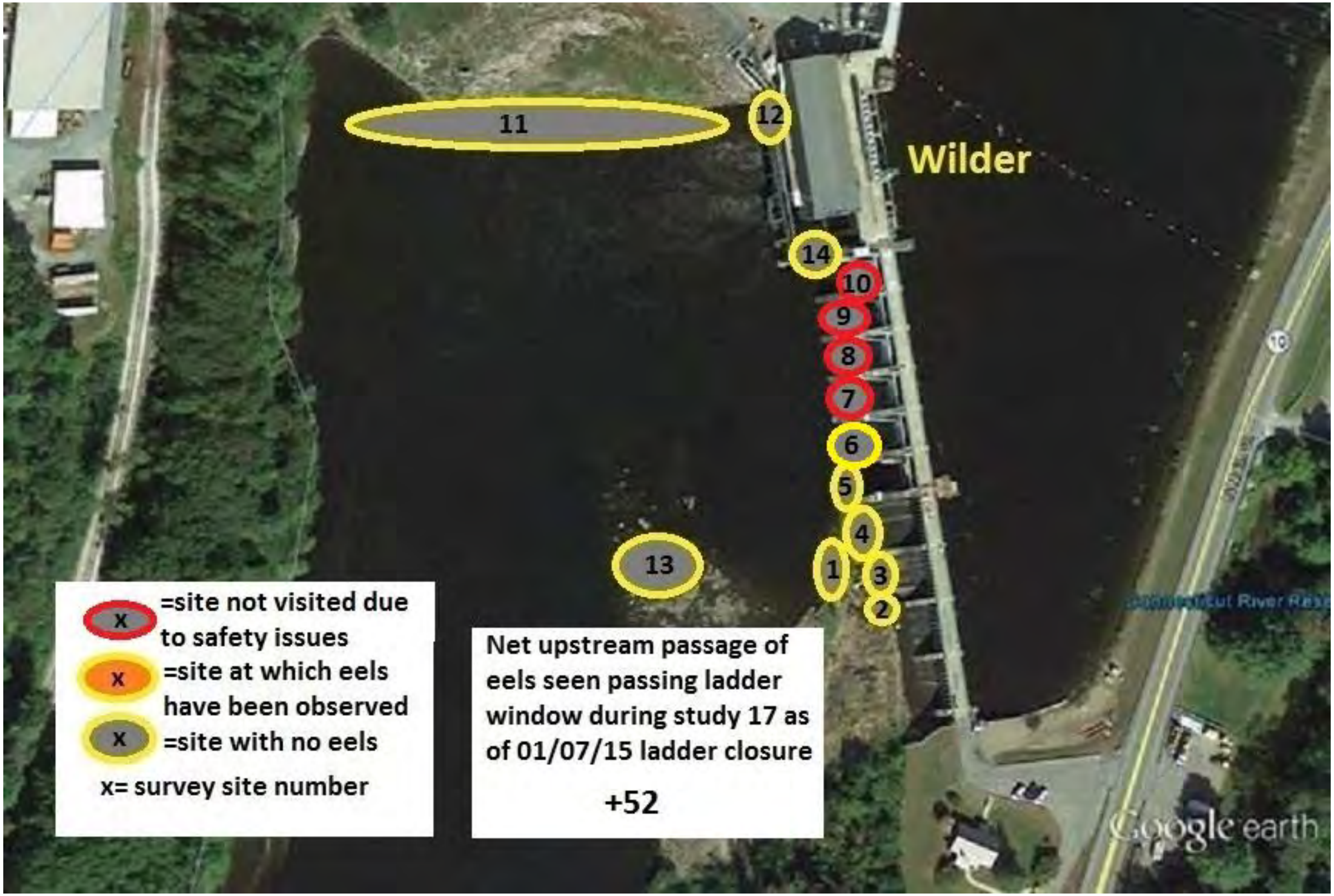
Study 18 – American Eel Upstream Passage

Study Progress

- Systematic surveys of eel presence/abundance at tailrace and spillway locations at all three dams began in May 2015 and continued through October 20, 2015
- Collection of eels using baited eel pots began in May 2015, and ended on August 27, 2015 (with working group concurrence) due to limited success
- No temporary ramp traps were deployed since the only aggregation point was the Vernon fish ladder (operated for Study 17)

- Report was filed on March 1, 2016:
  - NOTE: an error was found in the report, the eel caught in Bellows Falls bypassed reach was at site #7 (northernmost spill gate), not at site #6 (further below the dam). Figure 3.1-3 is correct, Table 4.1-2 and text in Section 4.2 is incorrect.

Study 18 – American Eel Upstream Passage



x =site not visited due to safety issues

x =site at which eels have been observed

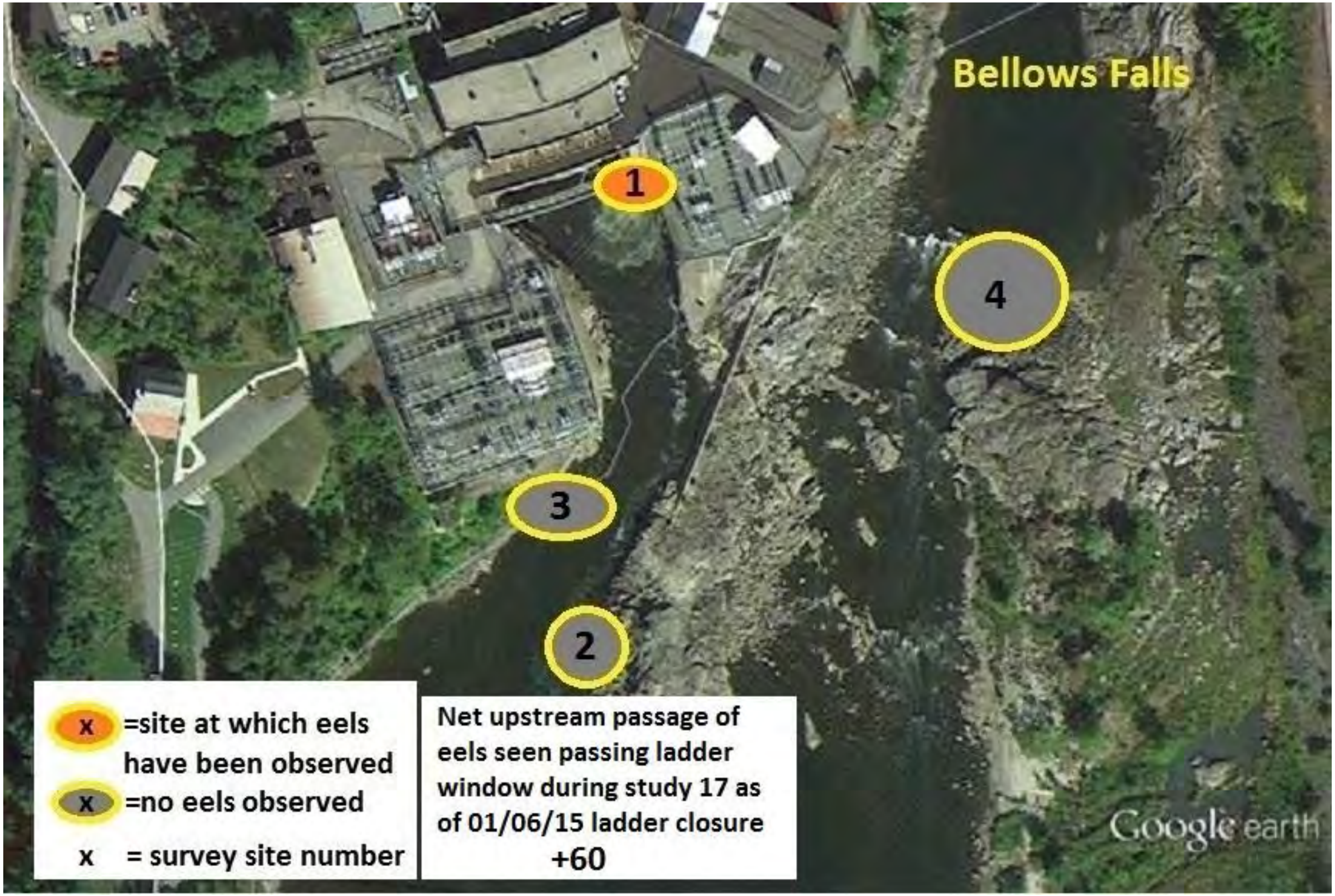
x =site with no eels

x= survey site number

Net upstream passage of eels seen passing ladder window during study 17 as of 01/07/15 ladder closure

+52

Study 18 – American Eel Upstream Passage



x =site at which eels have been observed

x =no eels observed

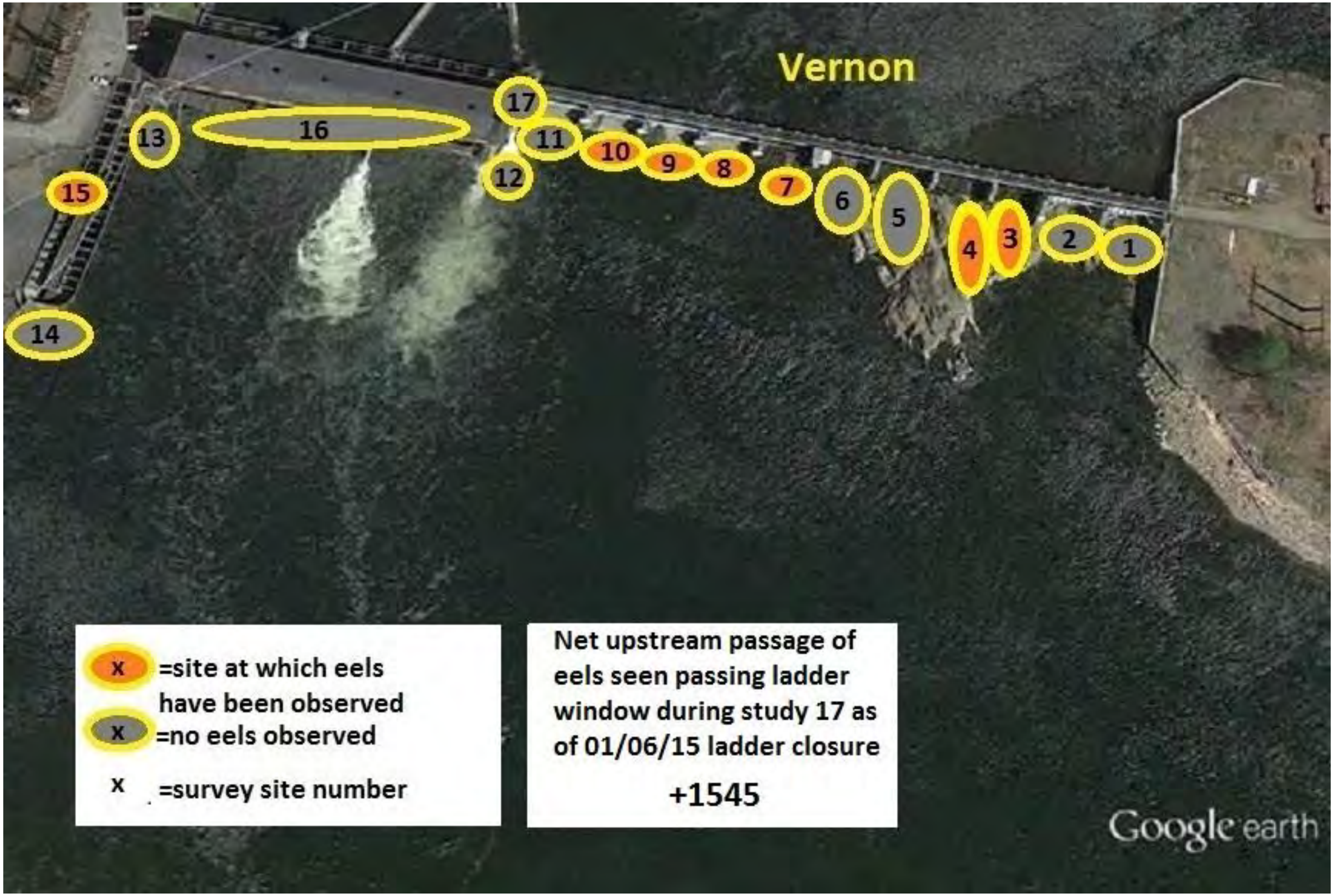
x = survey site number

Net upstream passage of eels seen passing ladder window during study 17 as of 01/06/15 ladder closure

+60

Study 18 – American Eel Upstream Passage

Study 18 – American Eel Upstream Passage



🟠 x =site at which eels have been observed

⚪ x =no eels observed

x =survey site number

Net upstream passage of eels seen passing ladder window during study 17 as of 01/06/15 ladder closure

+1545

Study 18 – American Eel Upstream Passage

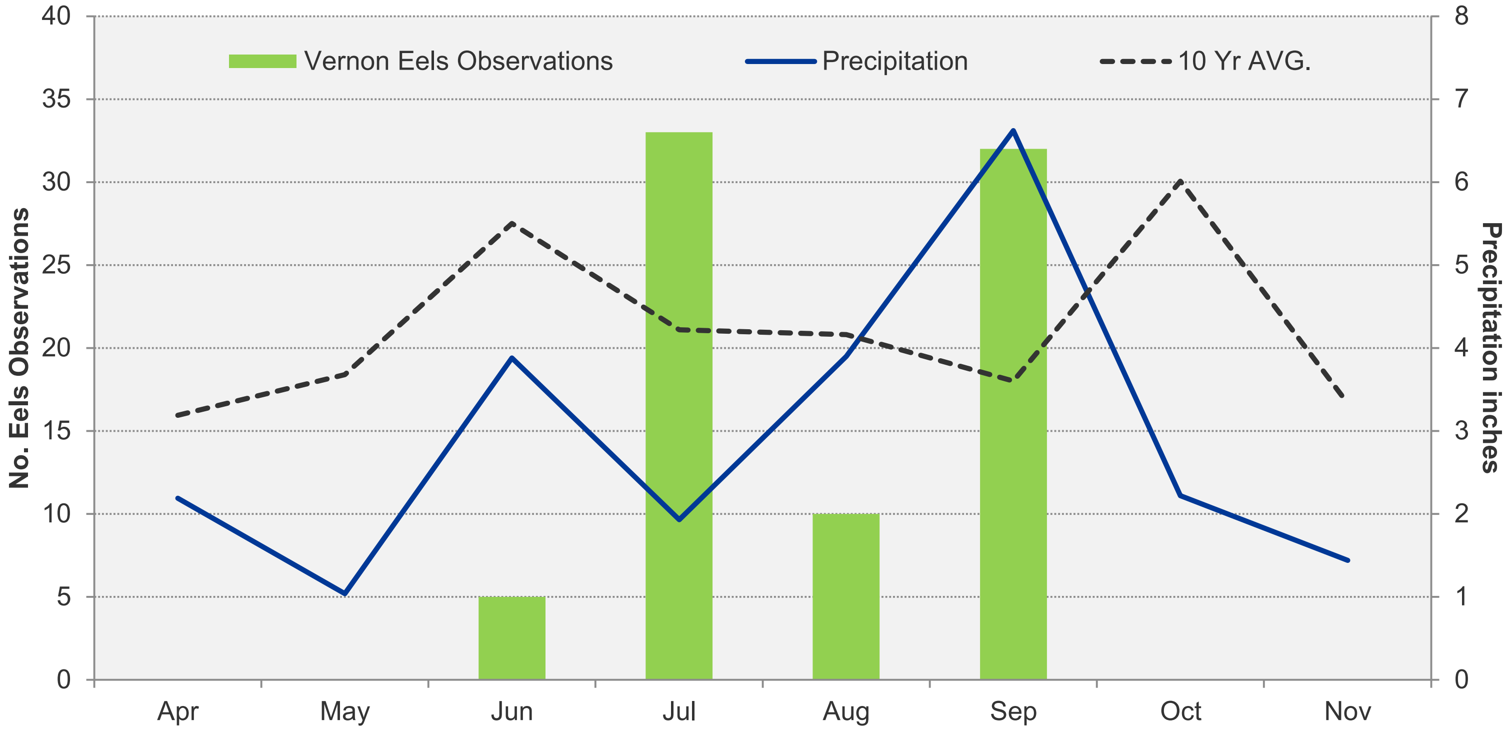
Number and location of eels collected at Vernon *

Date	Site Number																	Total by Date
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
5/7/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0
5/13/2015	0		0	0	0	0	0	0	0	0	0	0	0	0				0
5/20/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0
5/27/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0				0
6/3/2015				0	0	0	0	0	0	0	0	0	0	0				0
6/11/2015					0	0	0	0	0	0	0		0	0				0
6/17/2015				0	0	0	0	0	0	0	0	0	0	0	1			1
6/24/2015													0	0	4			4
7/1/2015				0	0	0	0	0	0	0	0	0	0	0	5			5
7/9/2015	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0			2
7/15/2015	0	0	0	0	0	0	3	3	4	4	0	0	0	0	7			21
7/22/2015				0	0	0	0	0	0	0	0	0	0	0	2			2
7/29/2015	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1			3
8/5/2015	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0		1
8/12/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		1
8/19/2015	0	0	0	0	0	0	1	2	1	0	0	0	0	0	2	0		6
8/26/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0		2
9/2/2015	0	0	0	0	0	0	0	4	0	0	0	0	0	0	6	0	0	10
9/9/2015	0	0	0	2	0	0	1	4	0	0	0	0	0	0	3	0	0	10
9/16/2015	0	0	1	0	0	0	0	1	0	0	0	0	0	0	3	0	0	5
9/23/2015	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2	0	0	4
9/28/2015	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	3
10/6/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/13/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/20/2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total by Site	**0**	**0**	**1**	**4**	**0**	**0**	**5**	**21**	**5**	**5**	**0**	**0**	**0**	**0**	**39**	**0**	**0**	**80**

* Blanks indicate not sampled due to safety

Study 18 – American Eel Upstream Passage

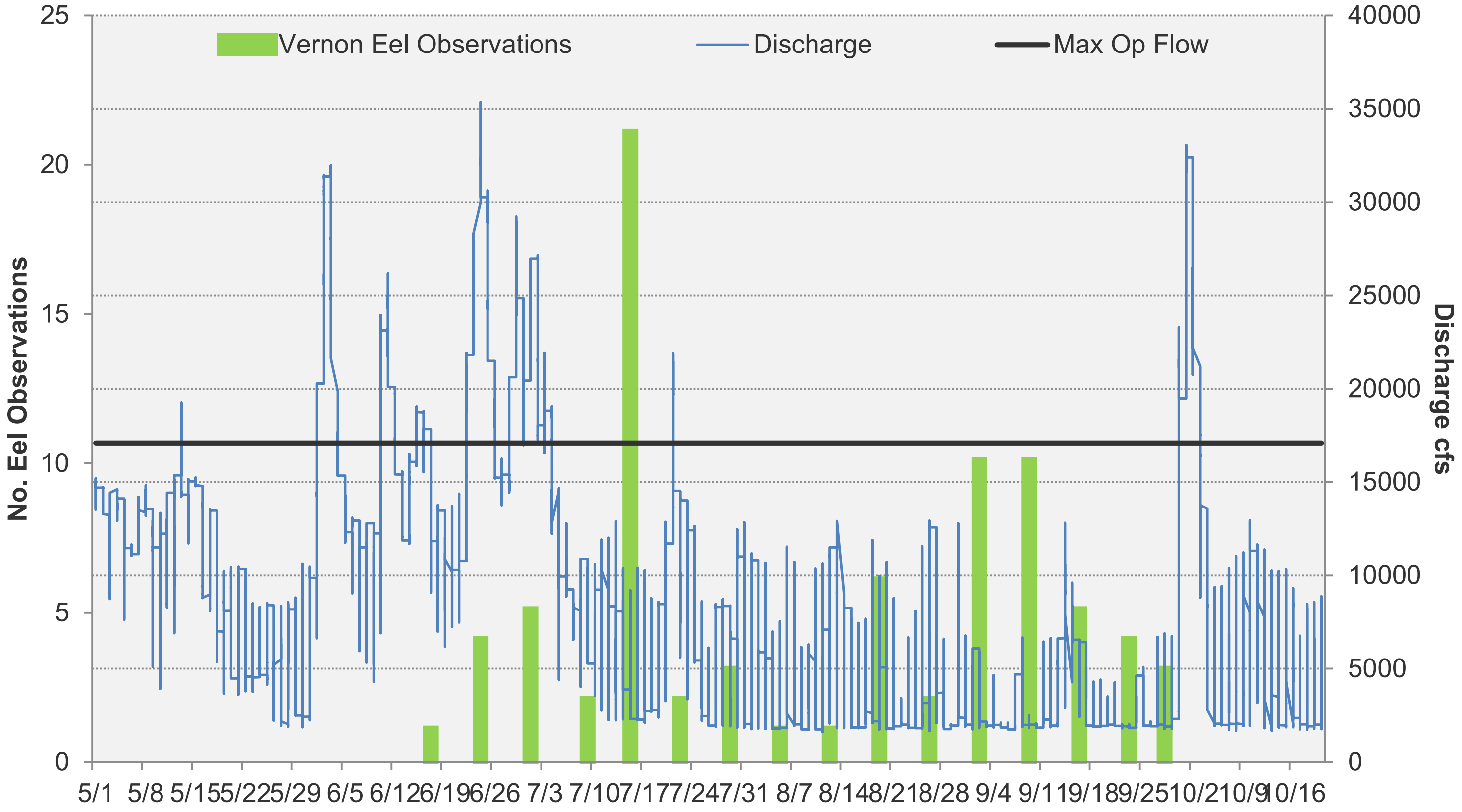
Vernon Eel Observations vs. Precipitation



Study 18 – American Eel Upstream Passage

Vernon Eel Observations vs. Project Discharge

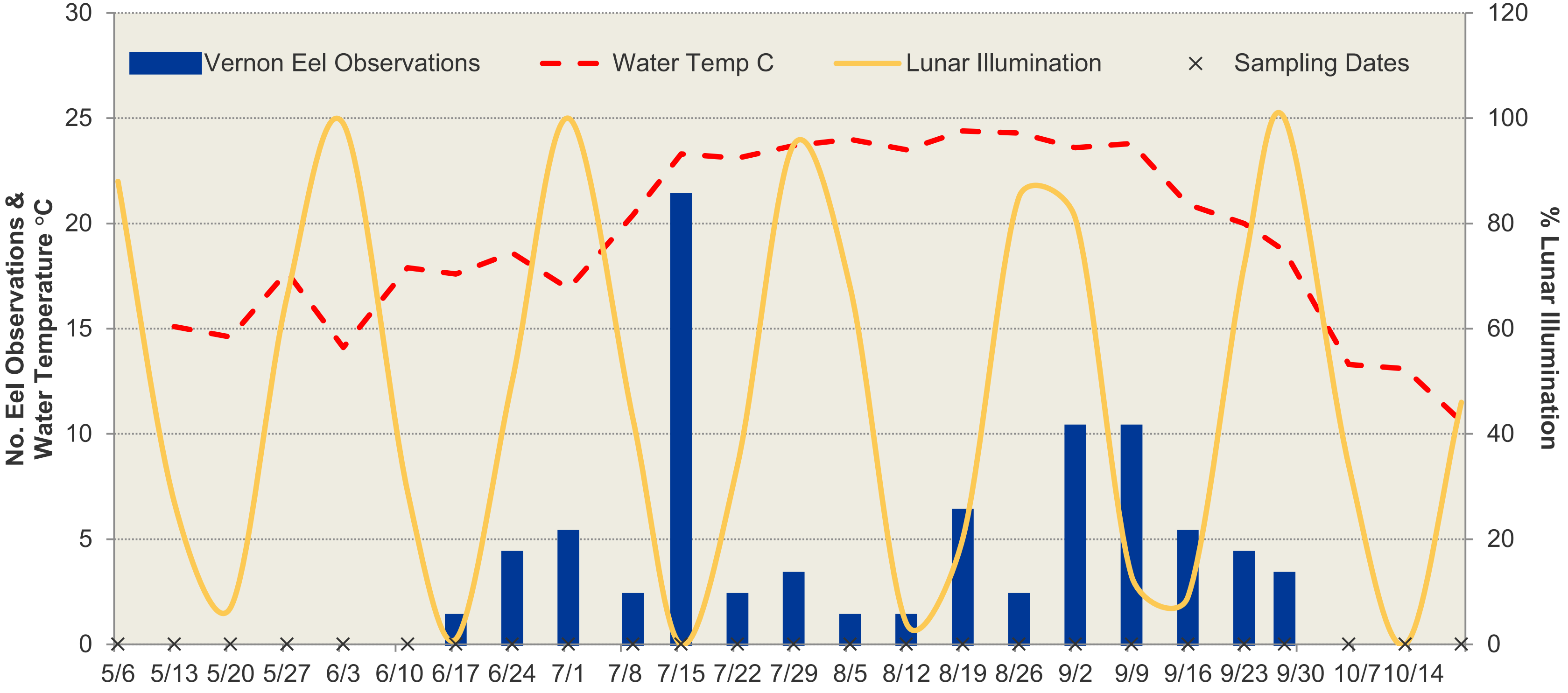
(surveys did not occur at some higher flows due to safety)



TransCanada

Study 18 – American Eel Upstream Passage

Vernon Eel Observations vs. Water Temp and Lunar Illumination



TransCanada

Study 18 – American Eel Upstream Passage

Study Results:

- A single eel was observed at Wilder in the fish ladder when dewatered
- 3 observed at Bellows Falls (2 in eel pots, one below the dam)
- 80 observed at Vernon, none in eel pots
- At Vernon 49% of eels were observed at the fish ladder, and 45% below the dam in the area of submerged flood gates
- 67% of eels were in the 12-18” size class including all 3 at Bellows Falls, 29% in the 6-12” class, 4% > 18”

Study 9

Instream Flow Study

Study 9 – Instream Flow Study

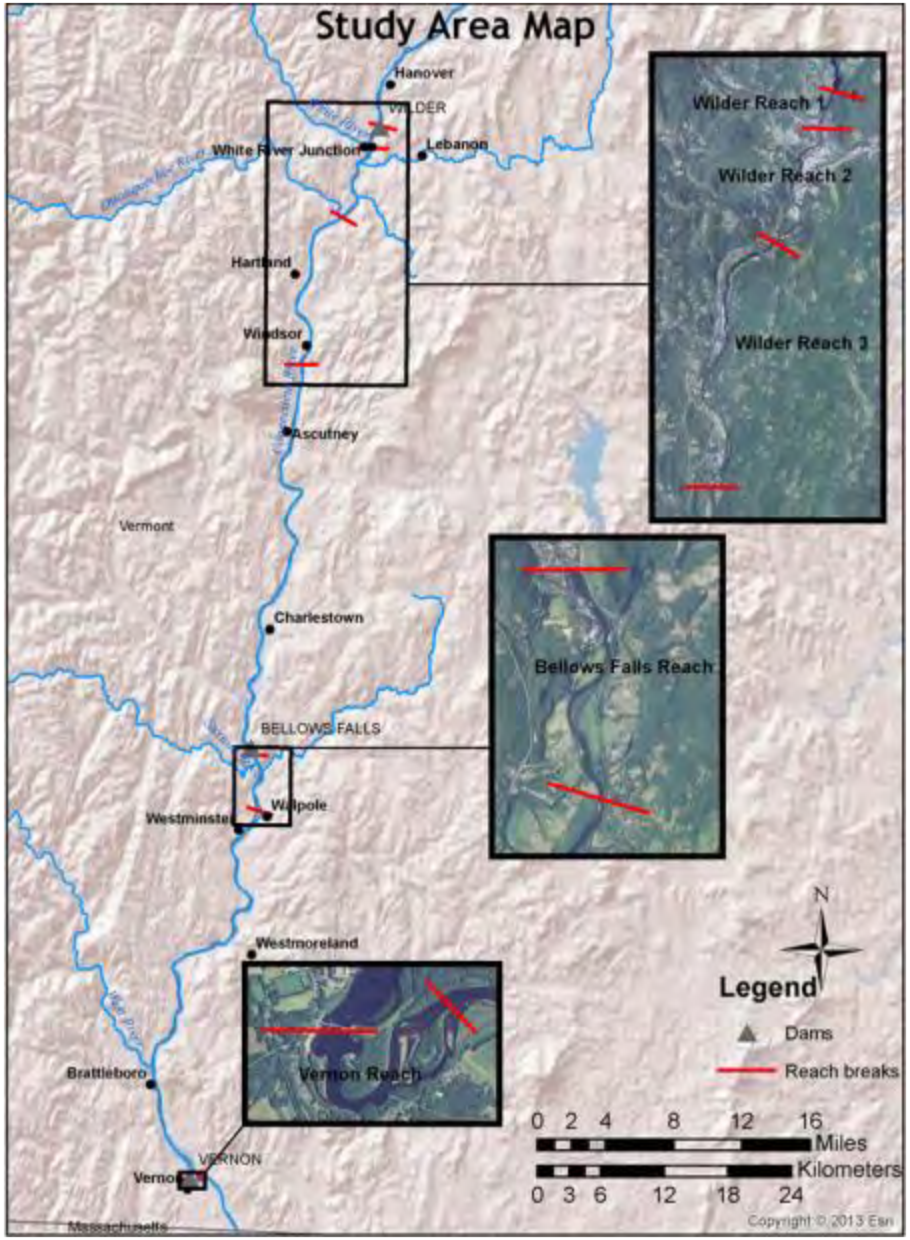
Interim Study Report Filed March 1, 2016

- Study Area – 1D transect and 2D study site locations
- 1D transect model calibration (not covered here)
- 2D Johnston Island model calibration (not covered here)
  - 2D model for Chase Island calibrated but was not ready to include in report
- Final HSC (see report appendix)
- Habitat Index (AWS) graphs for 1D reaches and 2D site at Johnston Island
  - Habitat index results by habitat type or groups of similar habitat types
- Bellows Falls bypassed reach AWS
- Sumner Falls Demonstration Flow (DFA)

TransCanada

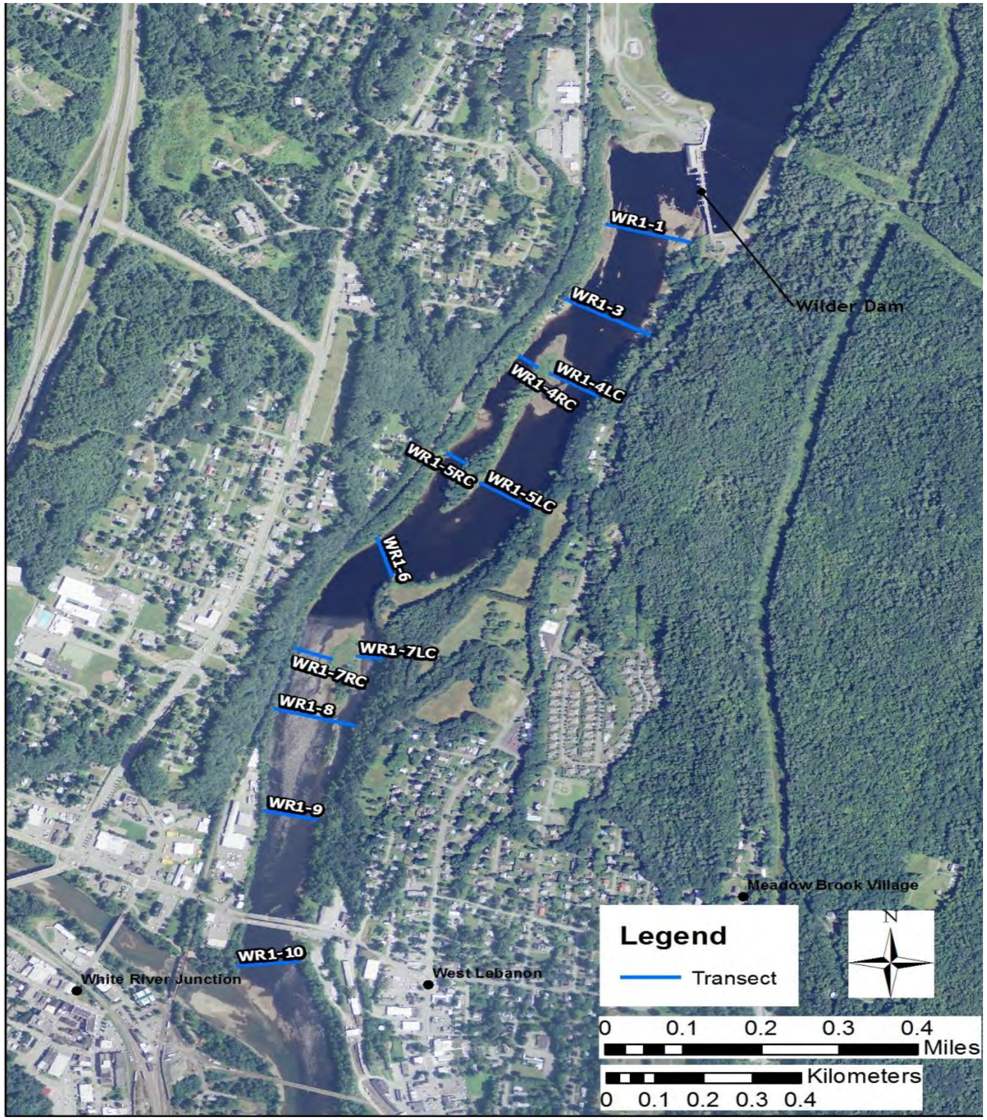
Study 9 – Instream Flow Study – Study Area

- Wilder Reach 1 – 12 transects (includes three split channel)
- Wilder Reach 2 – 15 transects and a 2D site
- Wilder Reach 3 – 13 transects (plus three side channel) and a 2D site
- Bellows Falls Reach – 19 transects
- Bellows Falls bypassed reach – 7 transects
- Vernon Reach – 16 transects (includes split channel and side channel)



TransCanada

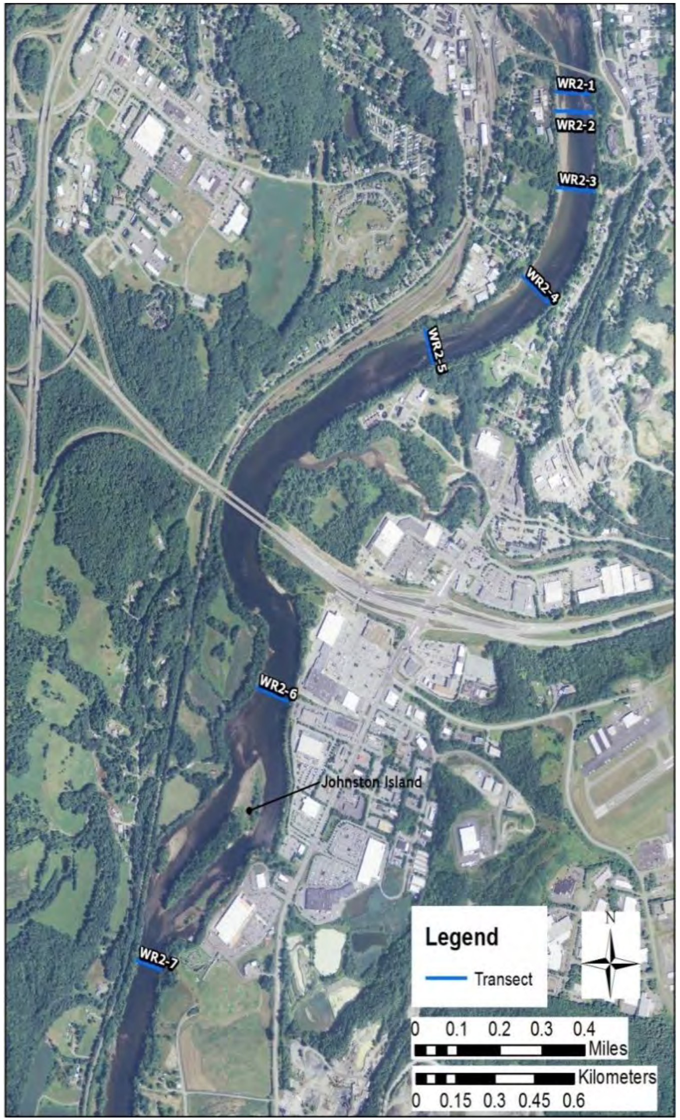
Study 9 – Instream Flow Study – Wilder Reach 1

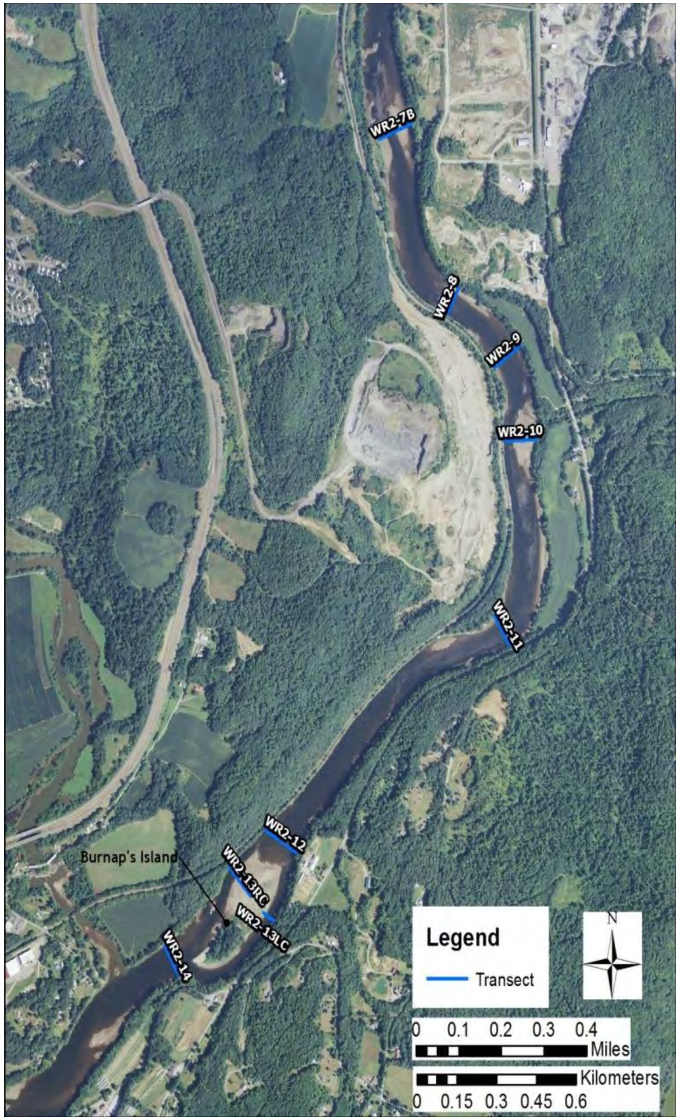


Transect ID	Habitat Type
WR1-1	Deep Pool
WR1-3	Deep Pool
WR1-4 LC	Run
WR1-4 RC	Run
WR1-5 LC	Glide
WR1-5 RC	Run
WR1-6	Deep Pool
WR1-7 LC	Run
WR1-7 RC	Run
WR1-8	Run
WR1-9	Deep Pool
WR1-10	Glide

TransCanada

Study 9 – Instream Flow Study – Wilder Reach 2 (+2D Site)

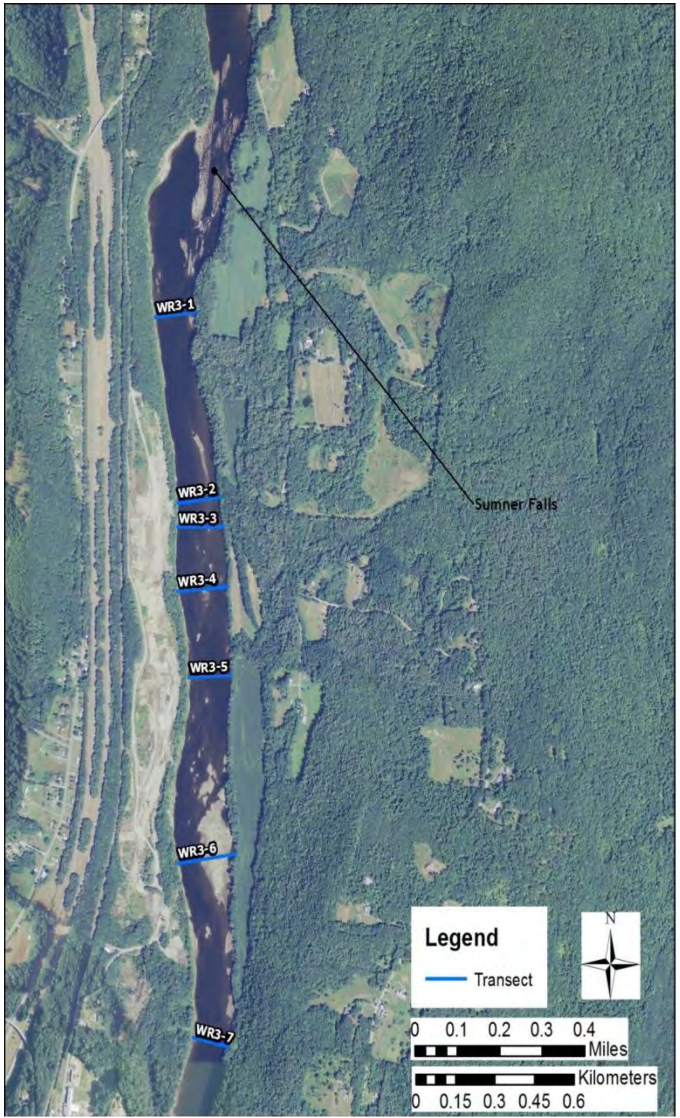


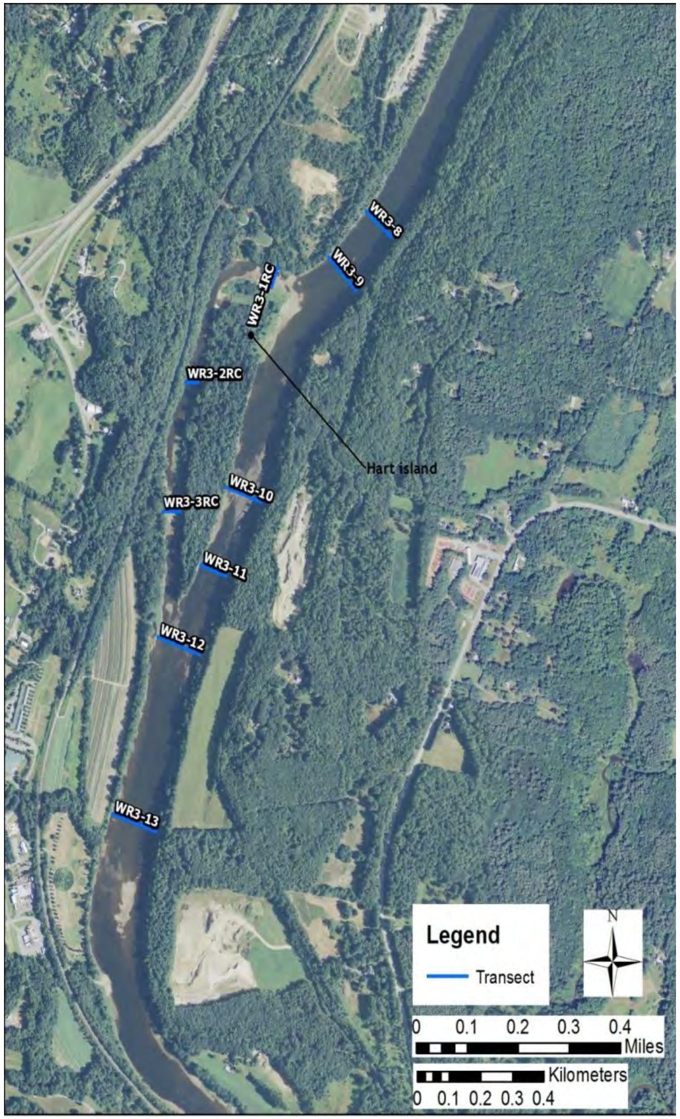


Transect ID	Habitat Type
WR2-1	Run
WR2-2	Riffle
WR2-3	Run
WR2-4	Glide
WR2-5	Pool
WR2-6	Glide
WR2-7	Deep Pool

Transect ID	Habitat Type
WR2-7b	Run
WR2-8	Run
WR2-9	Pool
WR2-10	Run
WR2-11	Deep Pool
WR2-12	Glide
WR2-13 LC/RC	Run
WR2-14	Deep Pool

Study 9 – Instream Flow Study – Wilder Reach 3

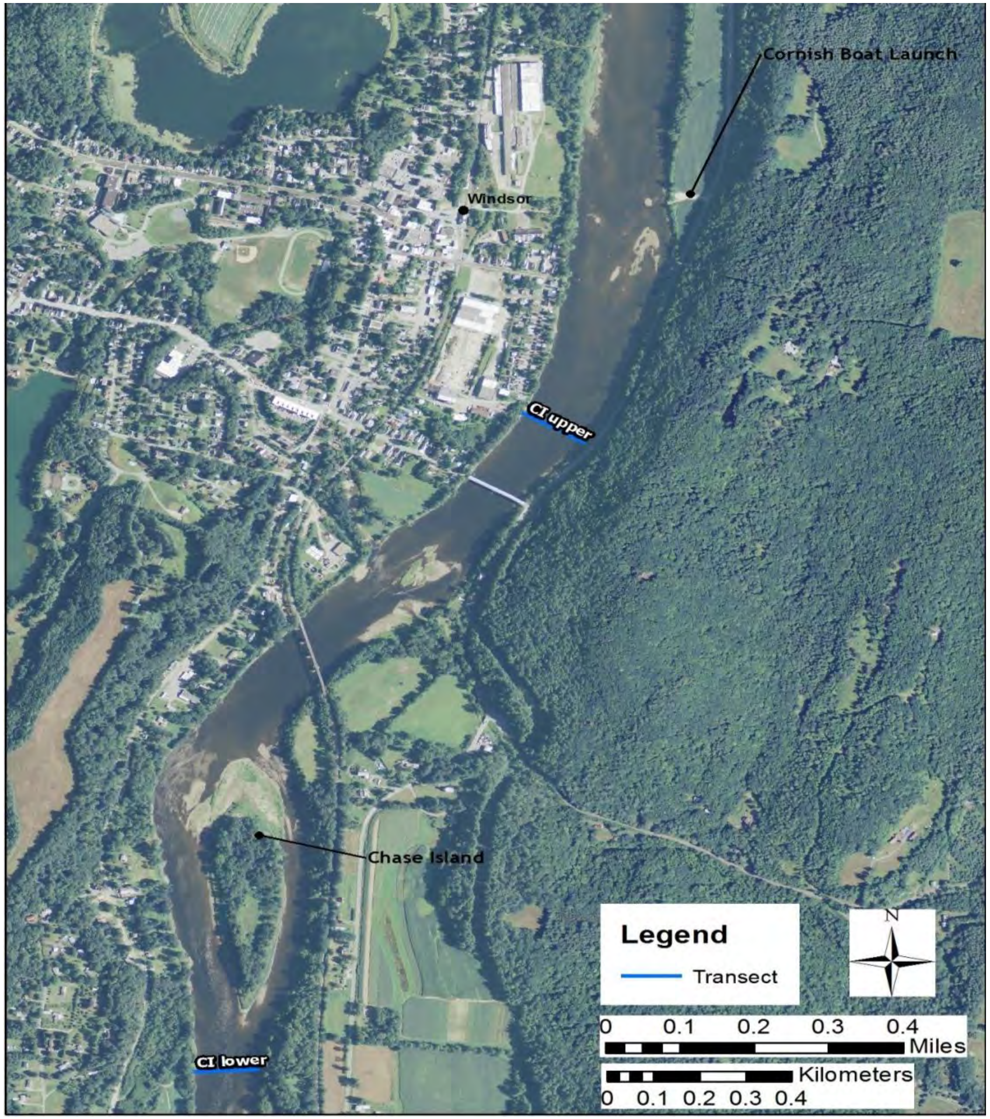




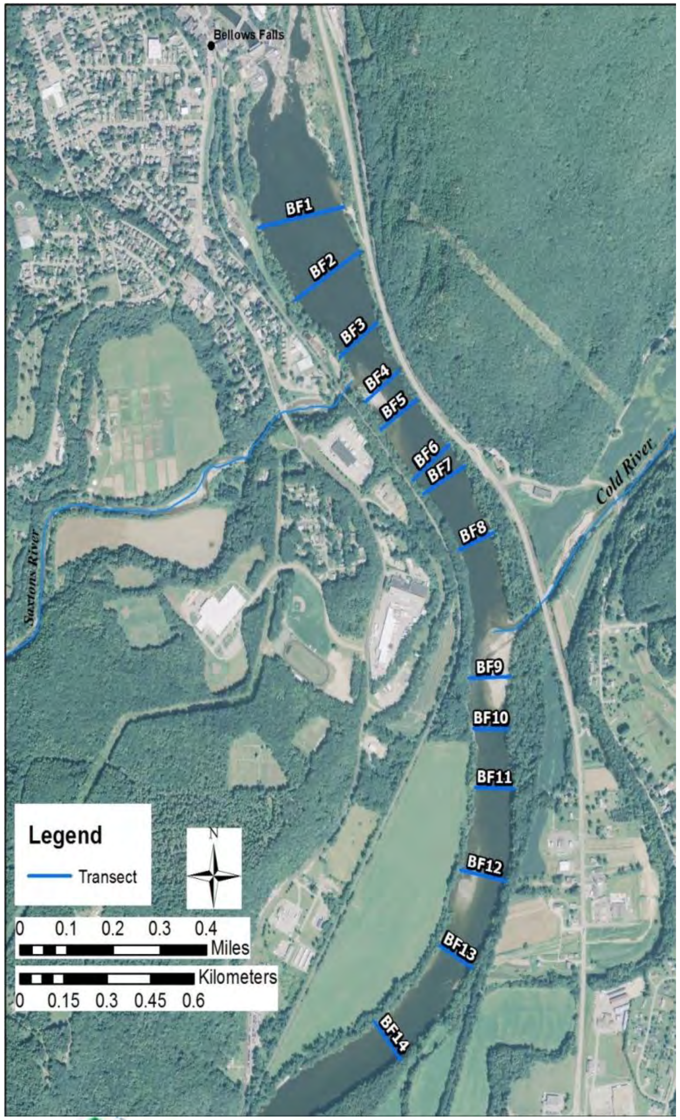
Transect ID	Habitat Type
WR3-1	Glide
WR3-2	Pool
WR3-3	Glide
WR3-4	Riffle
WR3-5	Run
WR3-6	Run
WR3-7	Glide

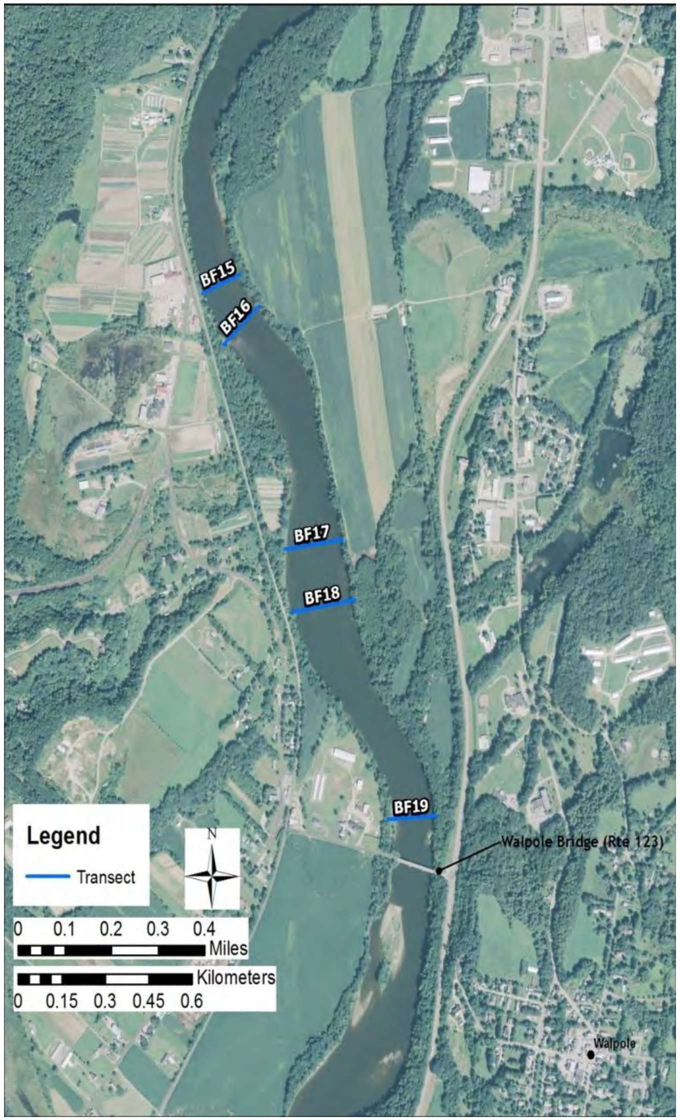
Transect ID	Habitat Type
WR3-8	Pool
WR3-9	Glide
WR3-10	Riffle
WR3-11	Pool
WR3-12	Riffle
WR3-13	Glide
WR3-1 RC	Riffle
WR3-2 RC	Pool
WR3-3 RC	Riffle

Study 9 – Instream Flow Study – Chase Island 2D Site



Study 9 – Instream Flow Study – Bellows Falls Reach



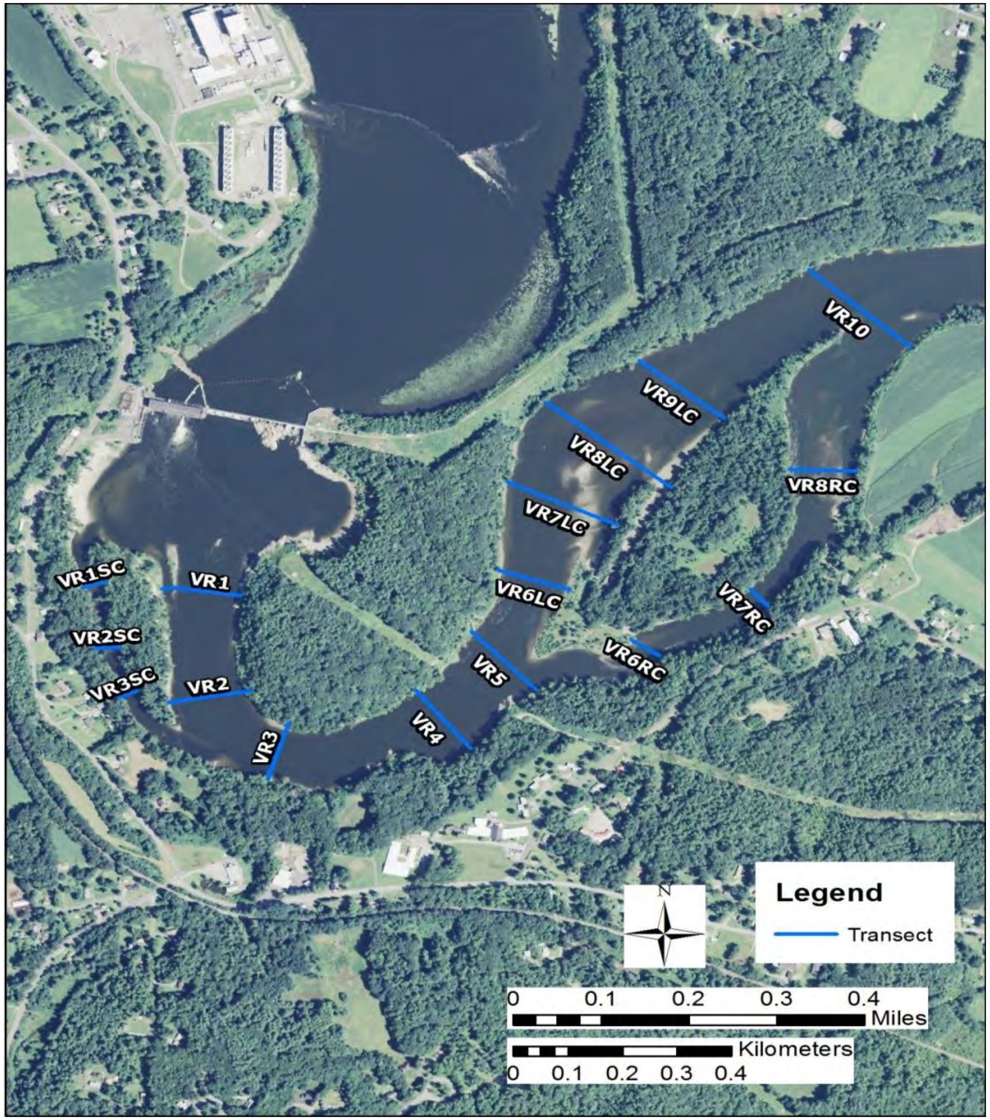


Transect ID	Habitat Type
BF1	Deep Pool
BF2	Glide
BF3	Glide
BF4	Run
BF5	Glide
BF6	Riffle
BF7	Riffle
BF8	Run
BF9	Run
BF10	Pool
BF11	Glide
BF12	Run
BF13	Pool
BF14	Glide

Transect ID	Habitat Type
BF15	Pool
BF16	Glide
BF17	Pool
BF18	Glide
BF19	Deep Pool

TransCanada

Study 9 – Instream Flow Study – Vernon Reach



Transect ID	Habitat Type
VR1	Run
VR2	Run
VR3	Deep Pool
VR4	Deep Pool
VR5	Glide
VR6 LC	Run
VR7 LC	Glide
VR8 LC	Run
VR9 LC	Glide
VR6 RC	Run
VR7 RC	Pool
VR8 RC	Run
VR10	Pool
VR1 SC	Run
VR2 SC	Riffle
VR3 SC	Pool

Study 9 – Instream Flow Study

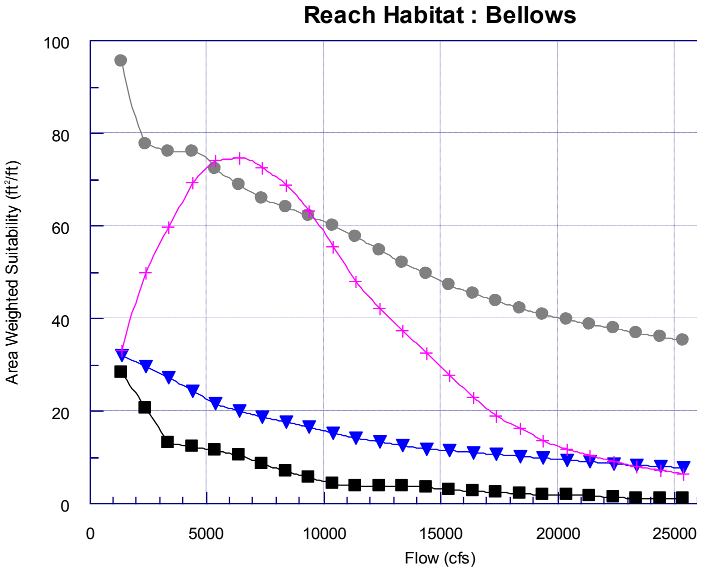
- Final transect locations
- 1D transect model calibration (not covered here)
- 2D Johnston Island model calibration (not covered here)
    - 2D model for Chase Island calibrated but was not ready to include in report
- Final HSC (see report appendix)
- **Habitat Index (AWS) graphs 1D reaches and 2D site at Johnston Island**
    - Habitat index results by habitat type or groups of similar habitat types
- Bellows Falls bypassed reach (calibration and AWS)
- Sumner Falls Demonstration Flow results

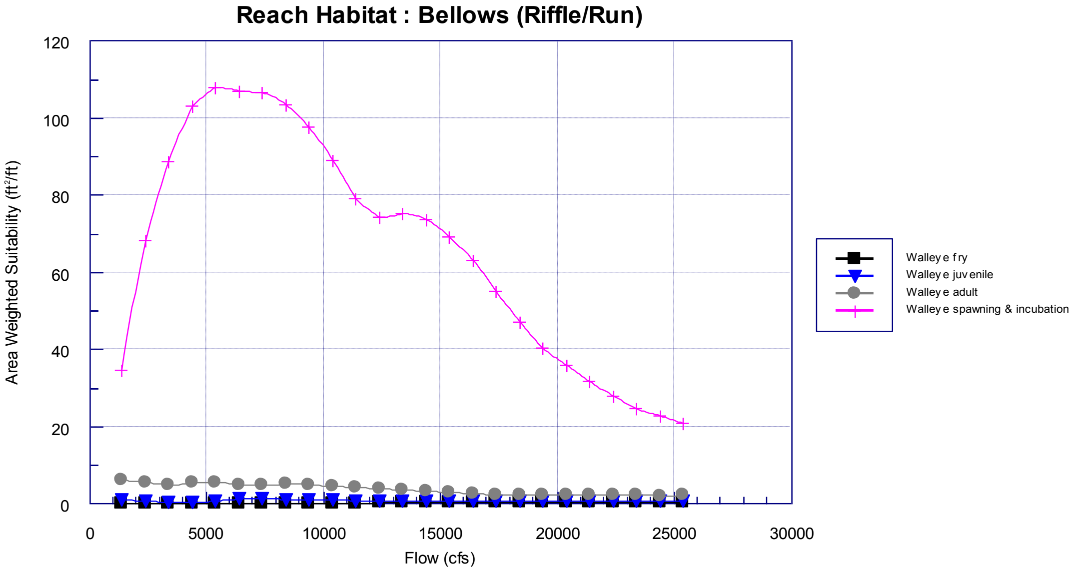
Study 9 – Instream Flow Study – Habitat Index (AWS)

Bellows Reach Habitat Types and Weights

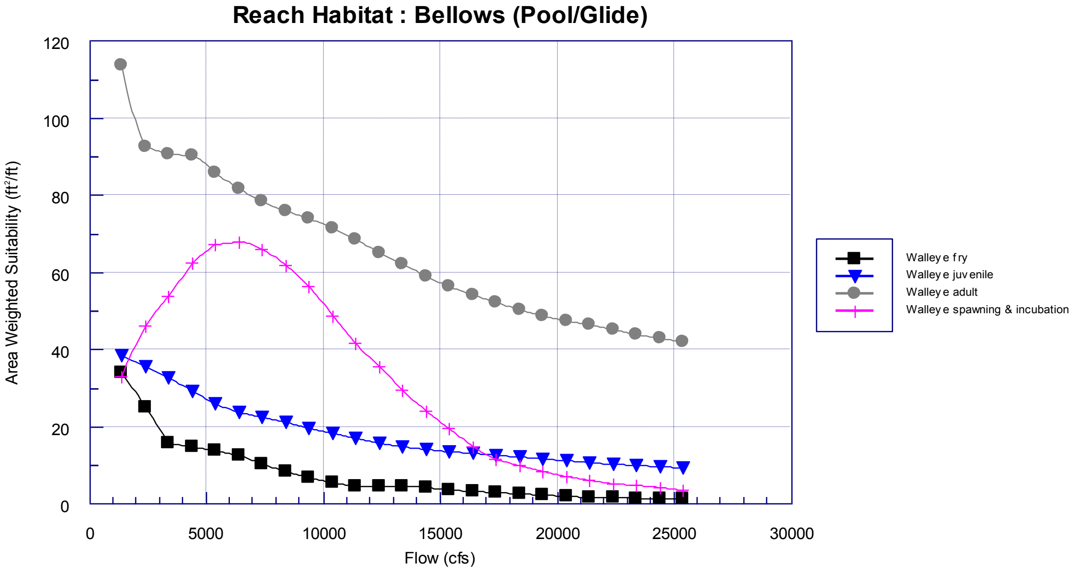
Transect ID	Habitat Type	% Transect Weighting
BF1	Pool (deep)	11.2
BF2	Glide	3.5
BF3	Glide	3.5
BF4	Run	3.8
BF5	Glide	3.5
BF6	Riffle	0.9
BF7	Riffle	0.9
BF8	Run	3.8
BF9	Run	3.8
BF10	Pool	9.1
BF11	Glide	3.5
BF12	Run	3.8
BF13	Pool	9.1
BF14	Glide	3.5
BF15	Pool	9.1
BF16	Glide	3.5
BF17	Pool	9.1
BF18	Glide	3.5
BF19	Pool (deep)	11.2

Study 9 – Instream Flow Study – Habitat Index (AWS)





Walleye
Bellows Reach

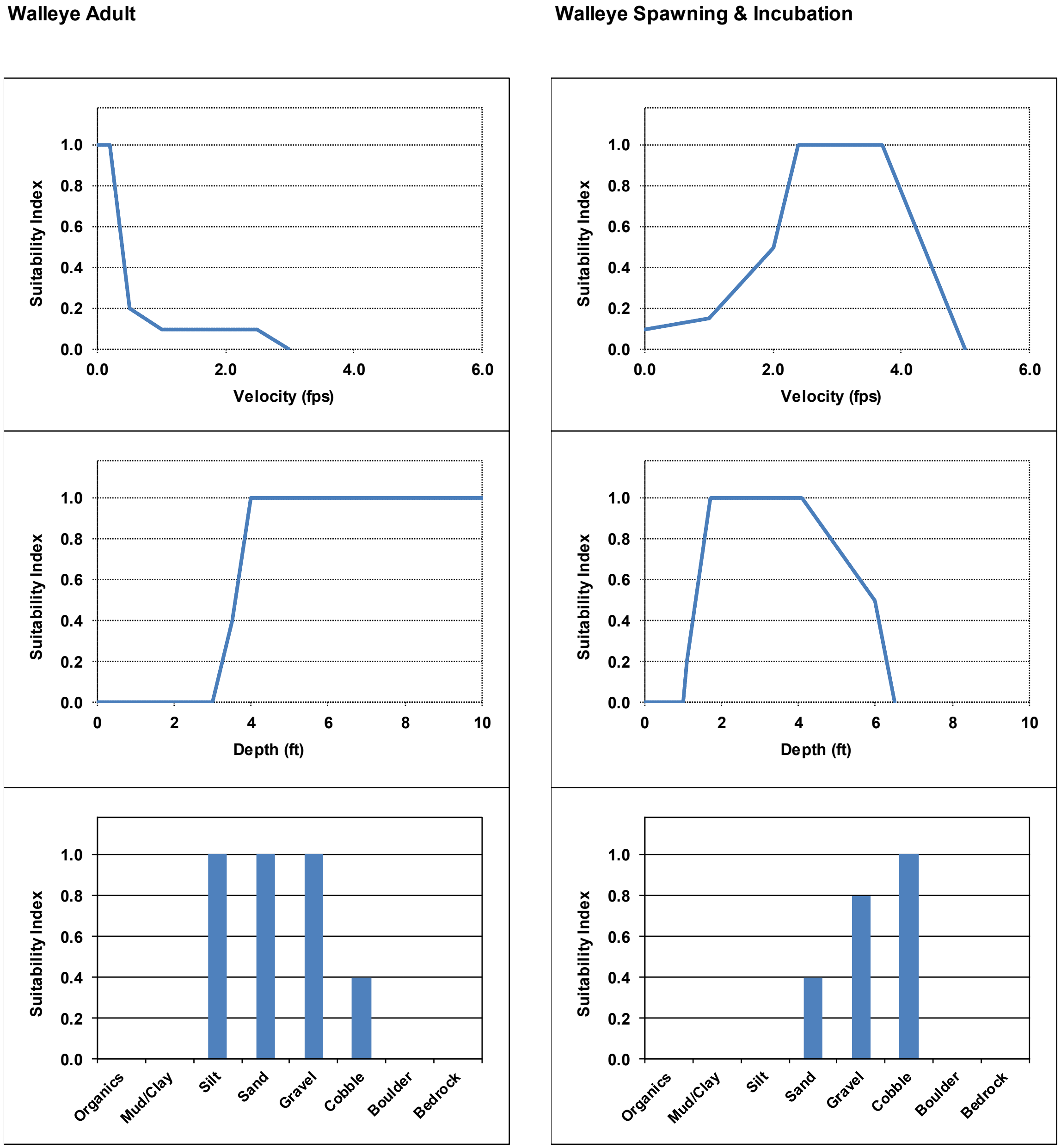


TransCanada

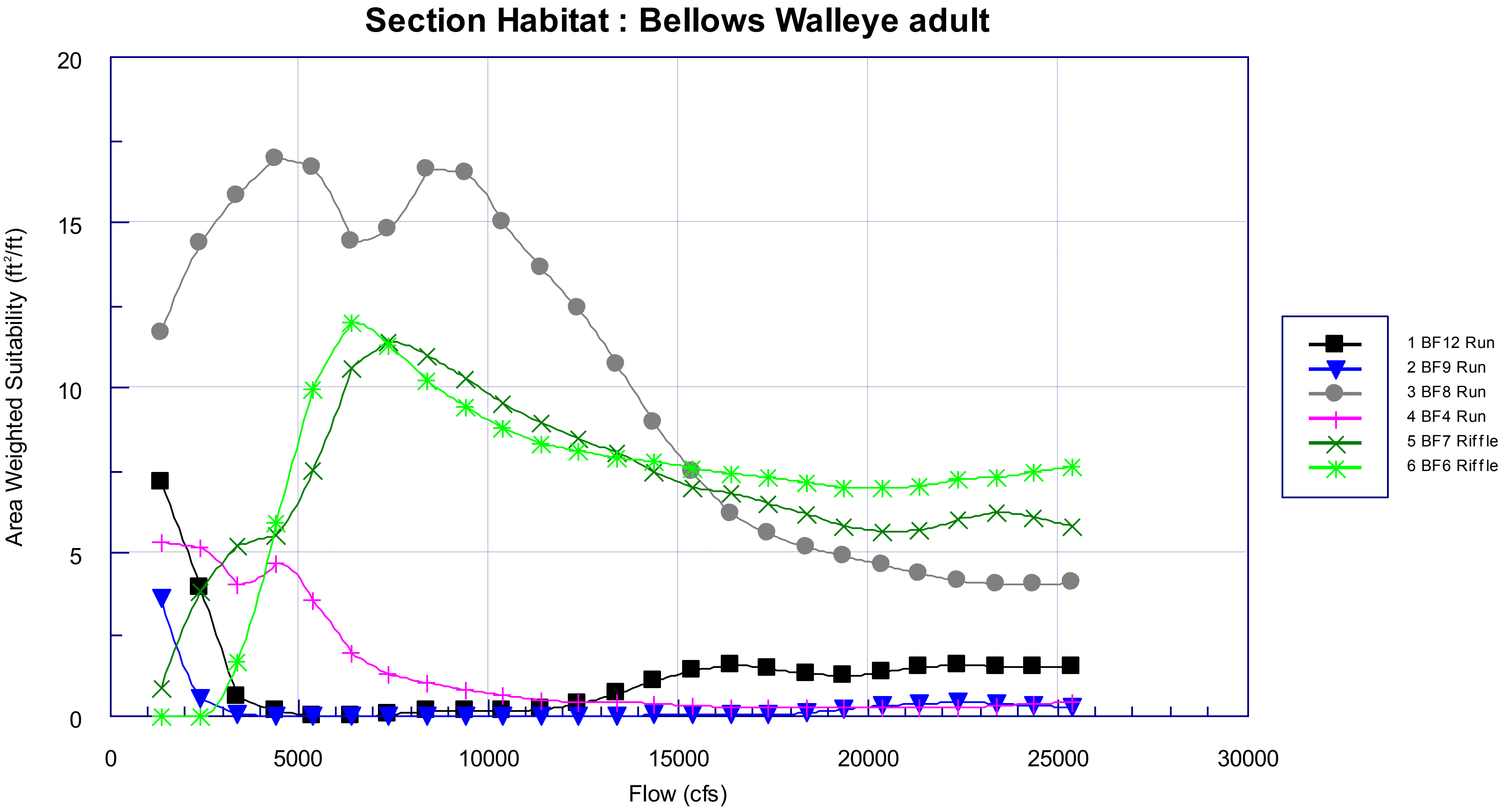
Study 9 – Instream Flow Study – Habitat Index (AWS)

Walleye Adult – Slow and Deep

Walleye Spawning – Fast and Shallow

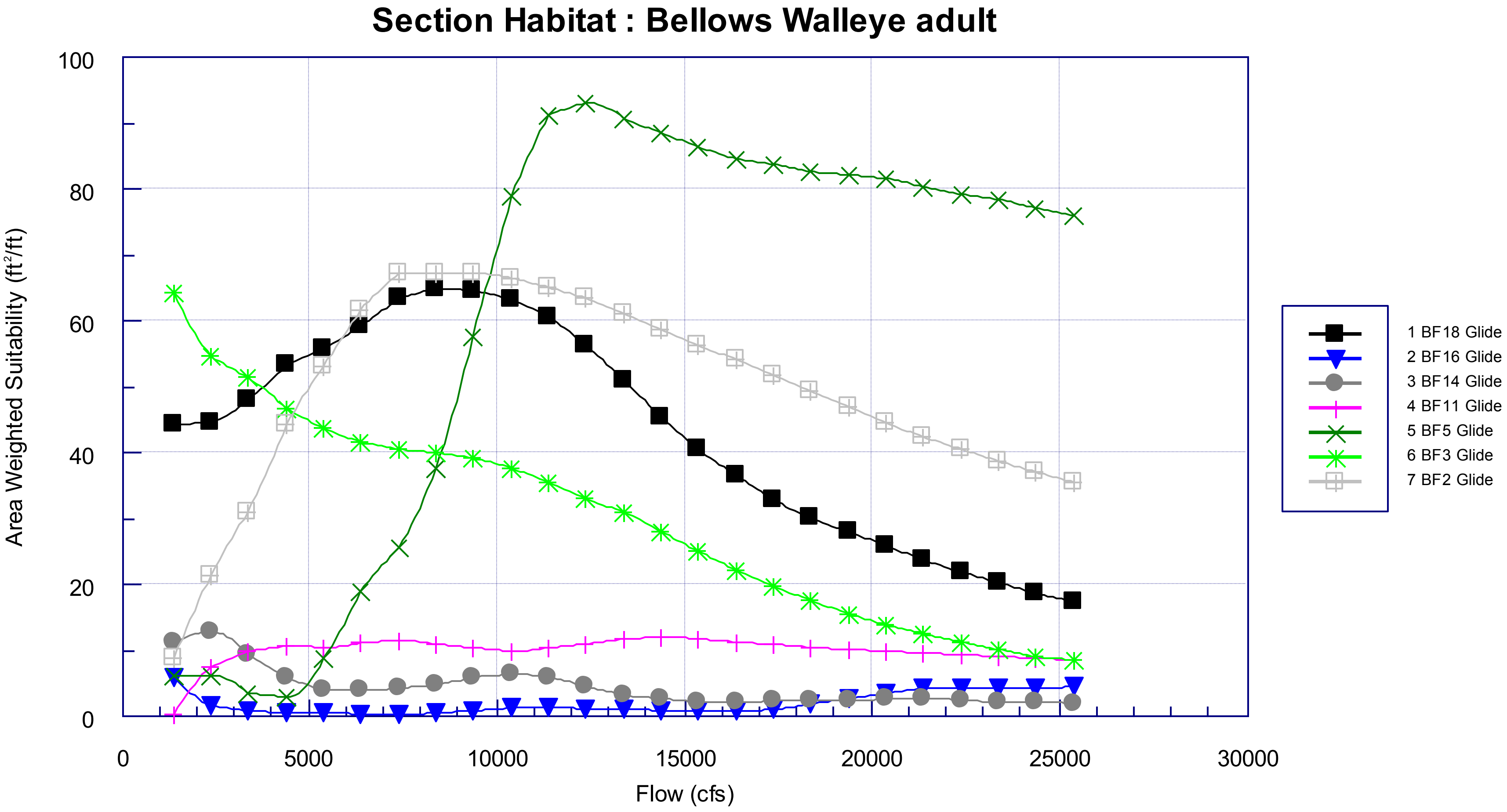


Study 9 – Instream Flow Study – Habitat Index (AWS)



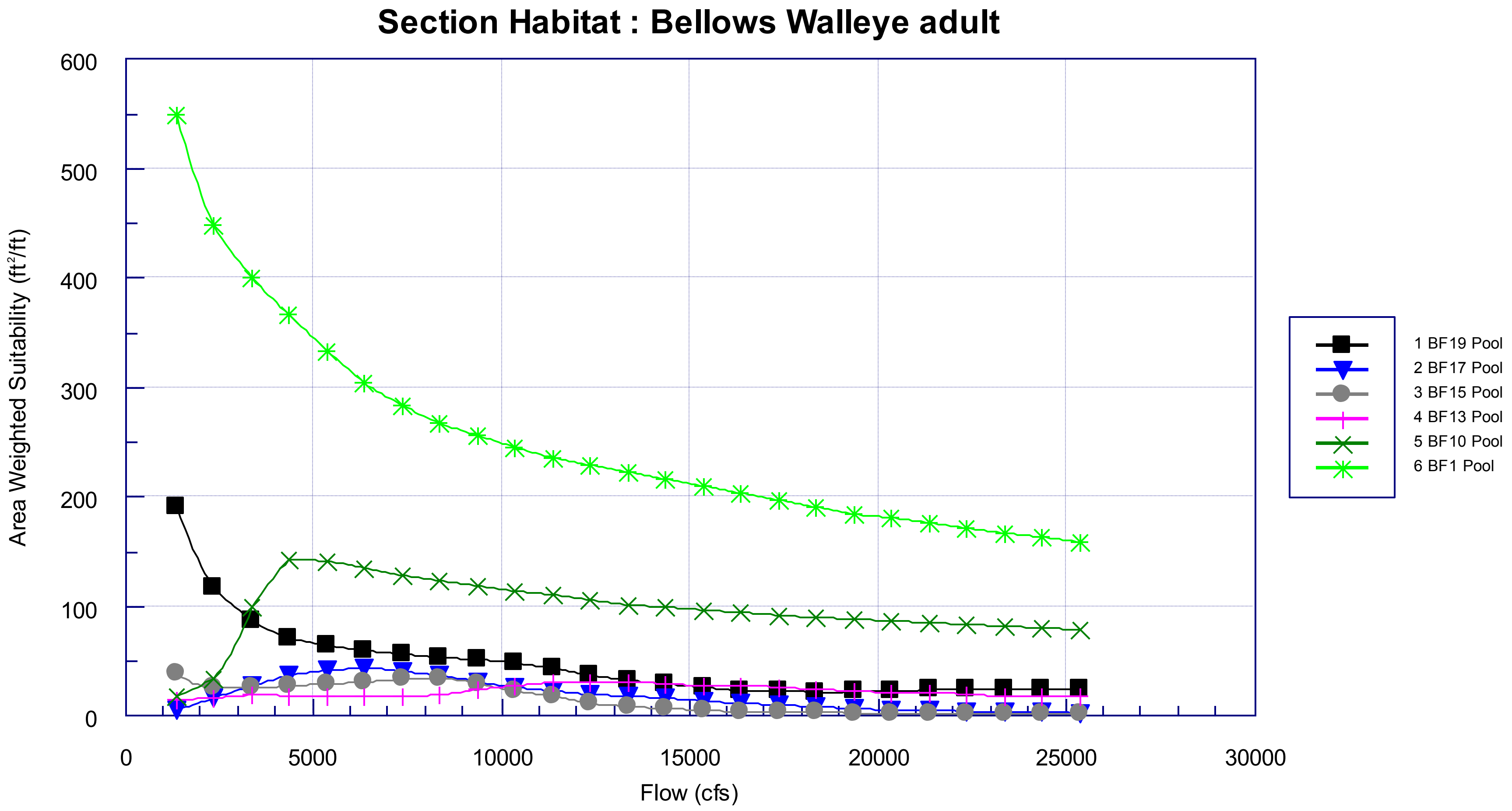
TransCanada

Study 9 – Instream Flow Study – Habitat Index (AWS)

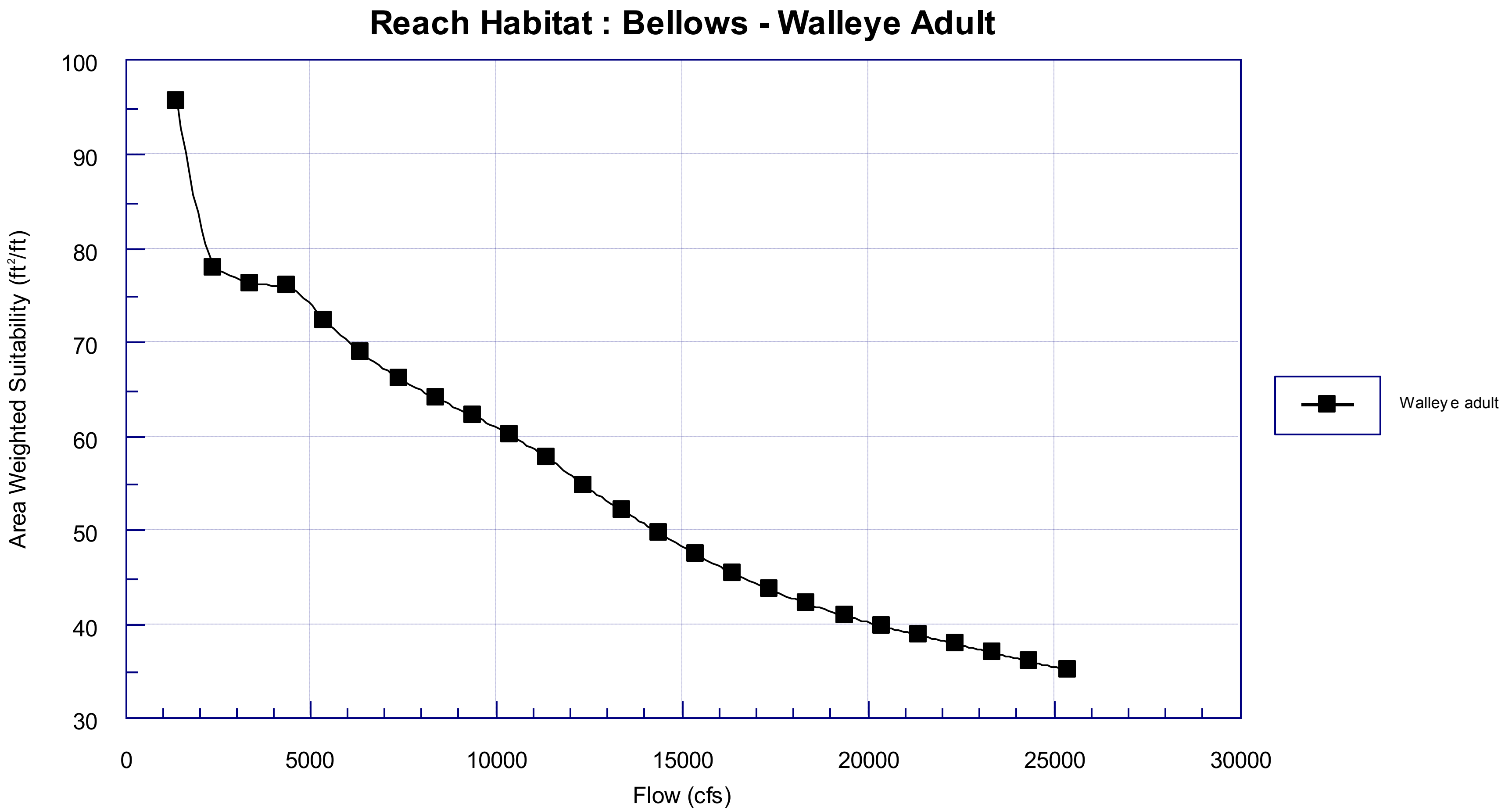


TransCanada

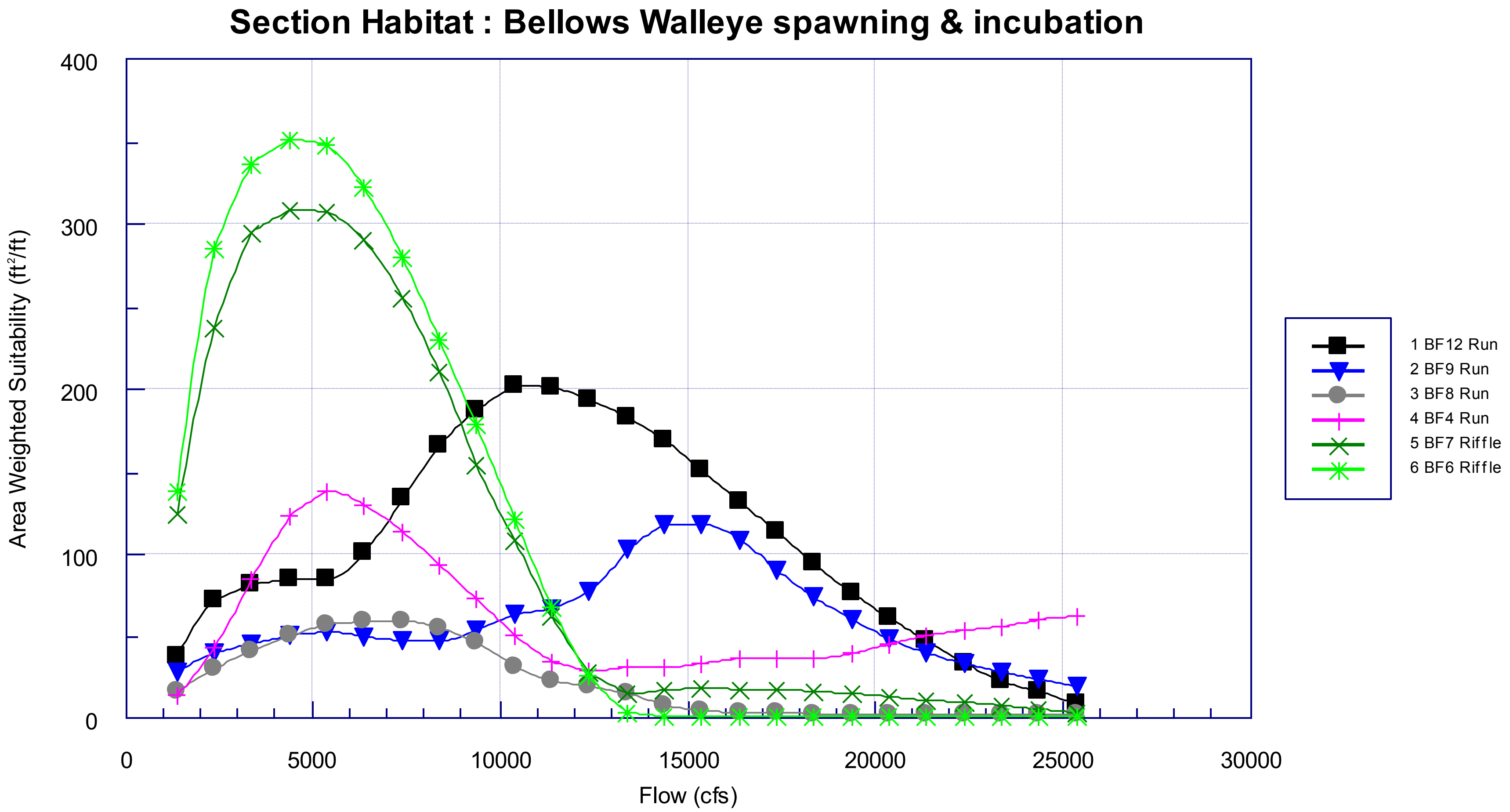
Study 9 – Instream Flow Study – Habitat Index (AWS)



Study 9 – Instream Flow Study – Habitat Index (AWS)

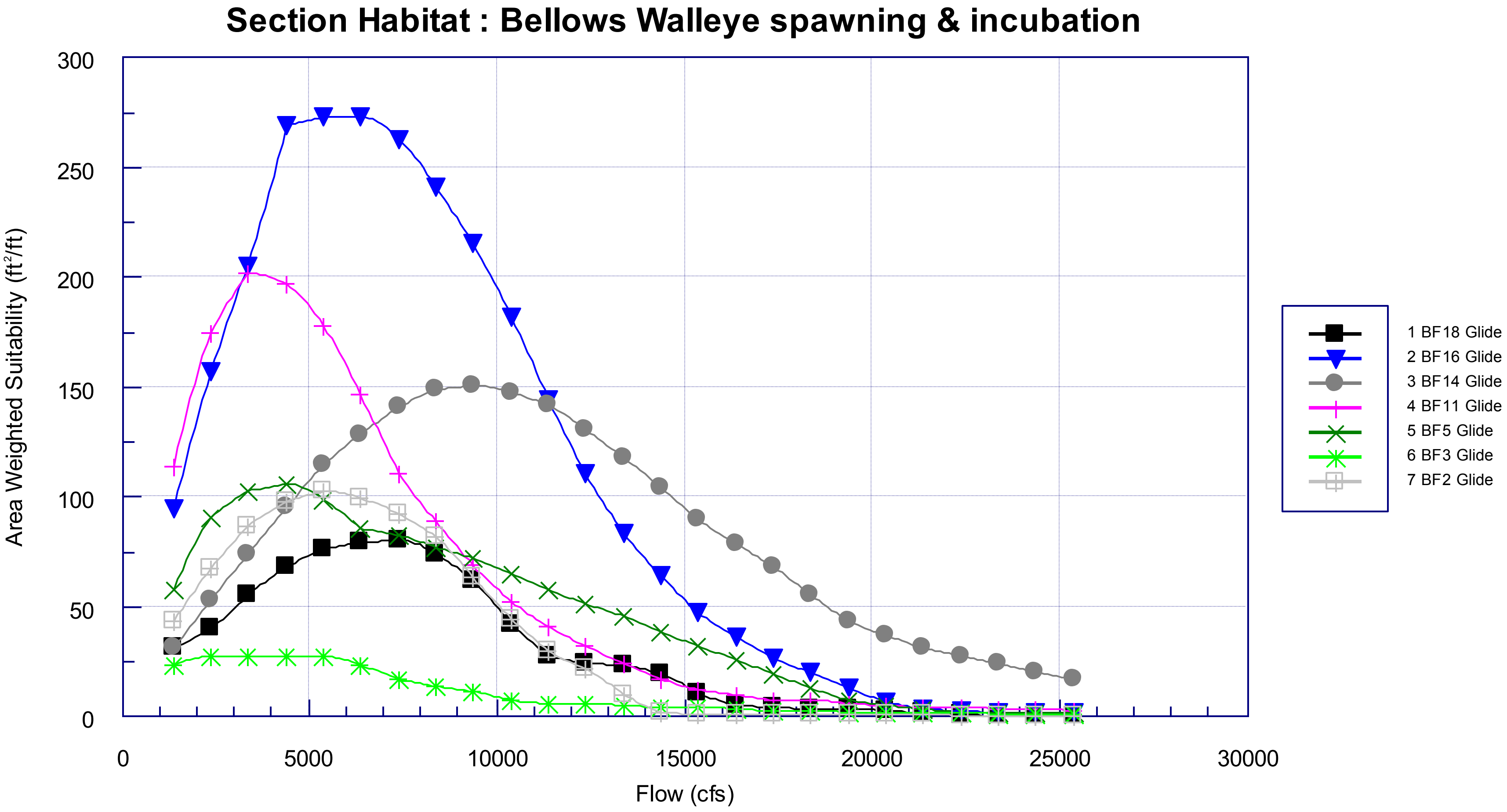


Study 9 – Instream Flow Study – Habitat Index (AWS)



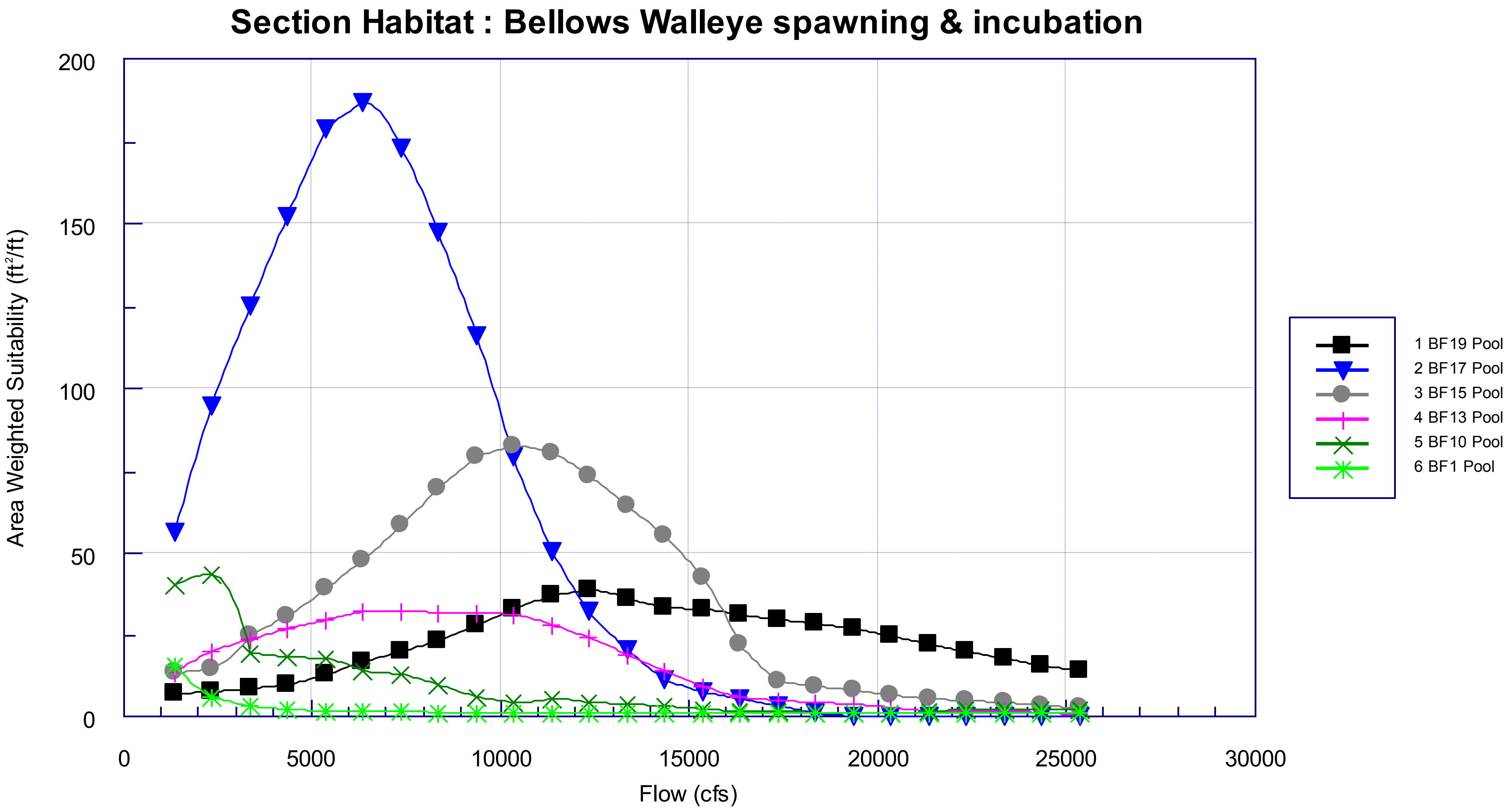
TransCanada

Study 9 – Instream Flow Study – Habitat Index (AWS)

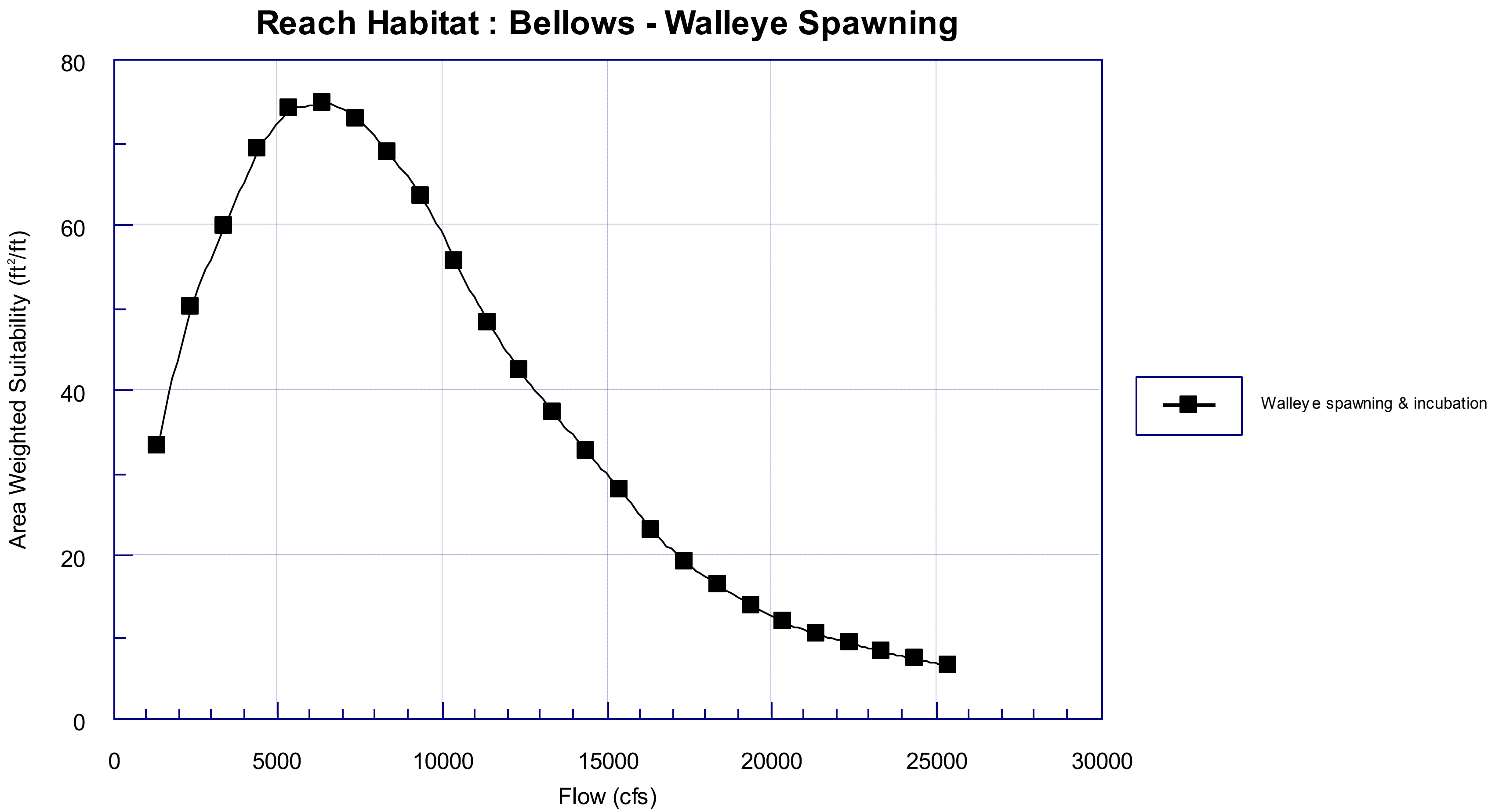


TransCanada

Study 9 – Instream Flow Study – Habitat Index (AWS)

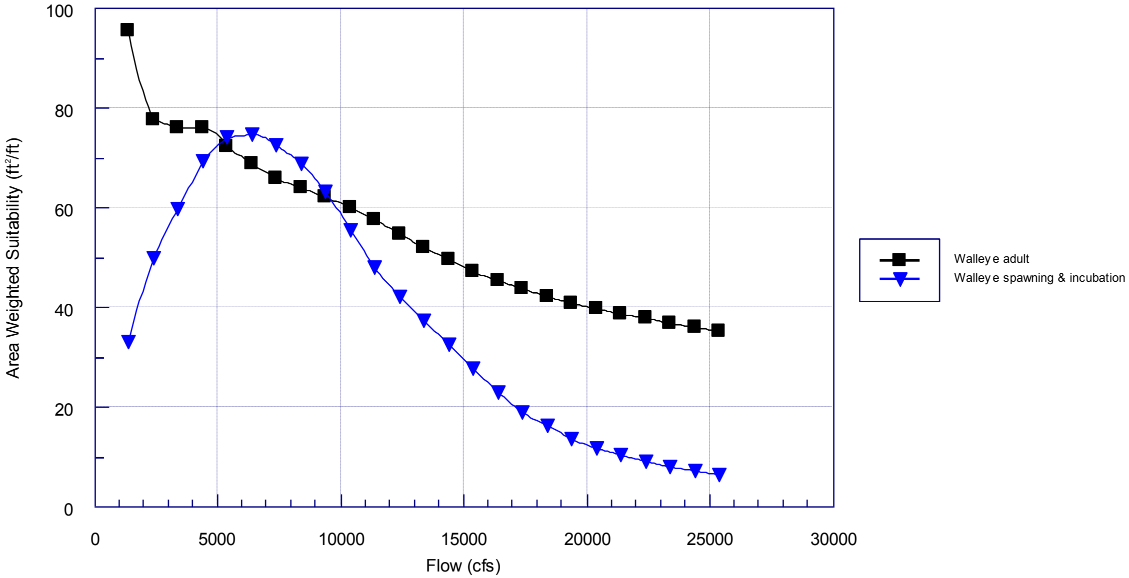


Study 9 – Instream Flow Study – Habitat Index (AWS)

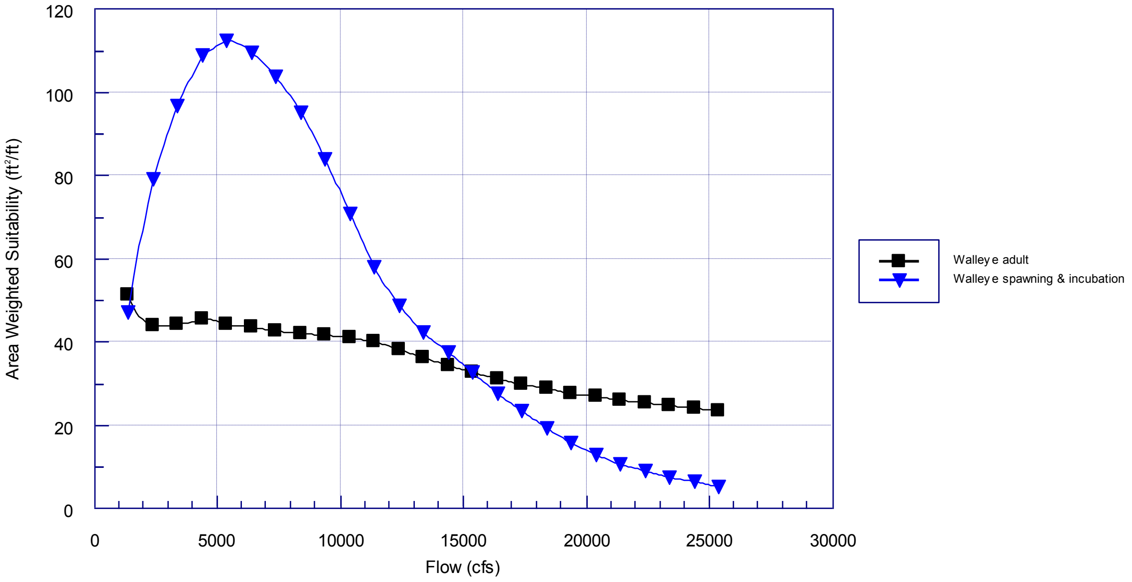


TransCanada

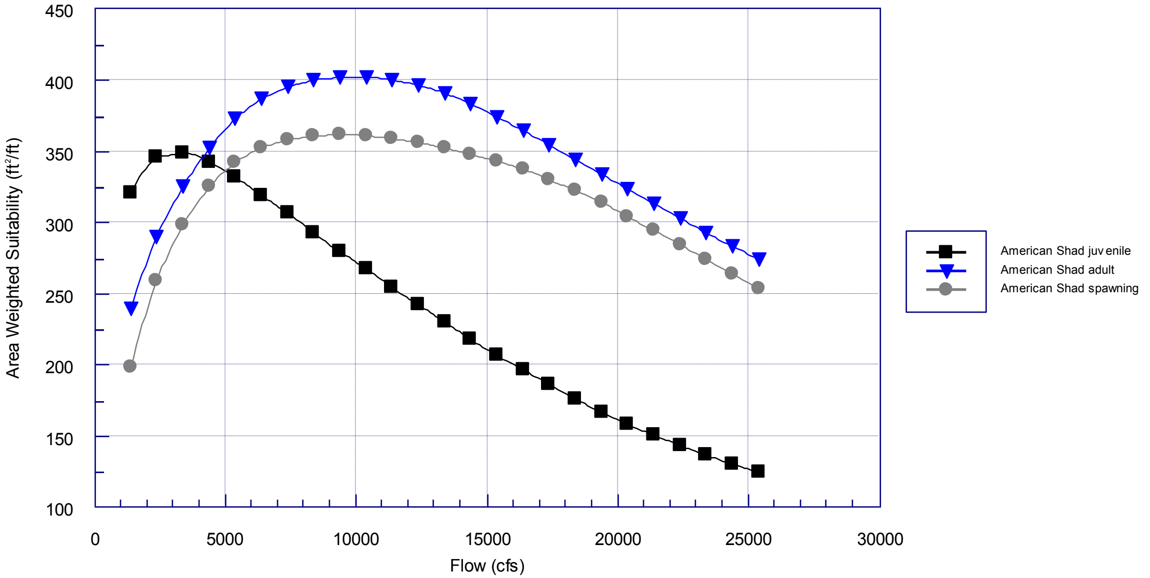
Study 9 – Instream Flow Study – Habitat Index (AWS)


Reach Habitat : Bellows - Habitat Weighted

Walleye :
Adult
Spawning


Reach Habitat : Bellows - Habitat Equally Weighted

Study 9 – Instream Flow Study – Habitat Index (AWS)

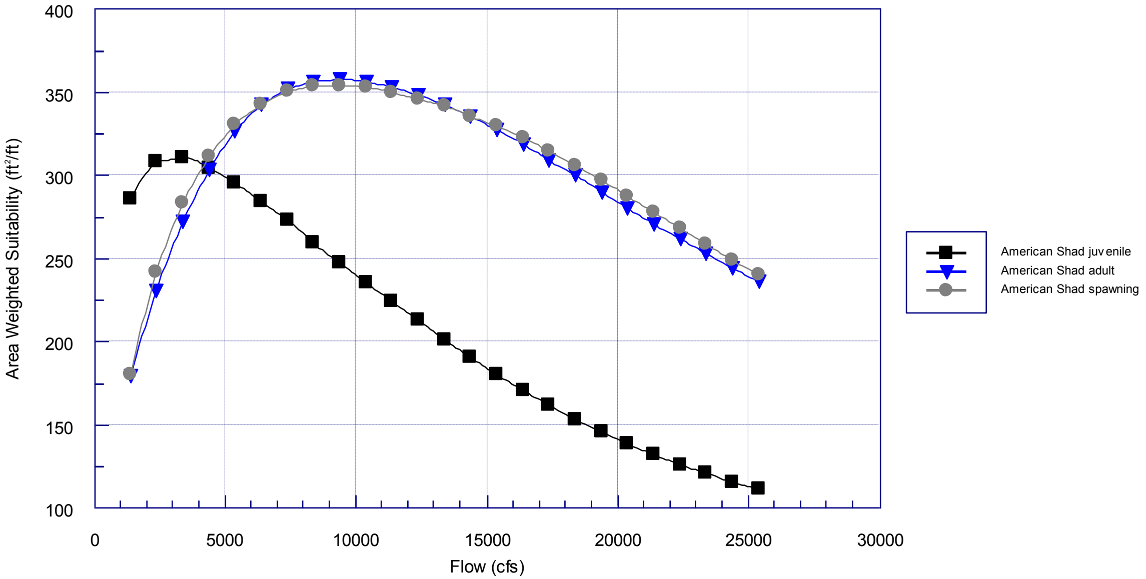

Reach Habitat : Bellows - Habitat Weighted

American Shad:

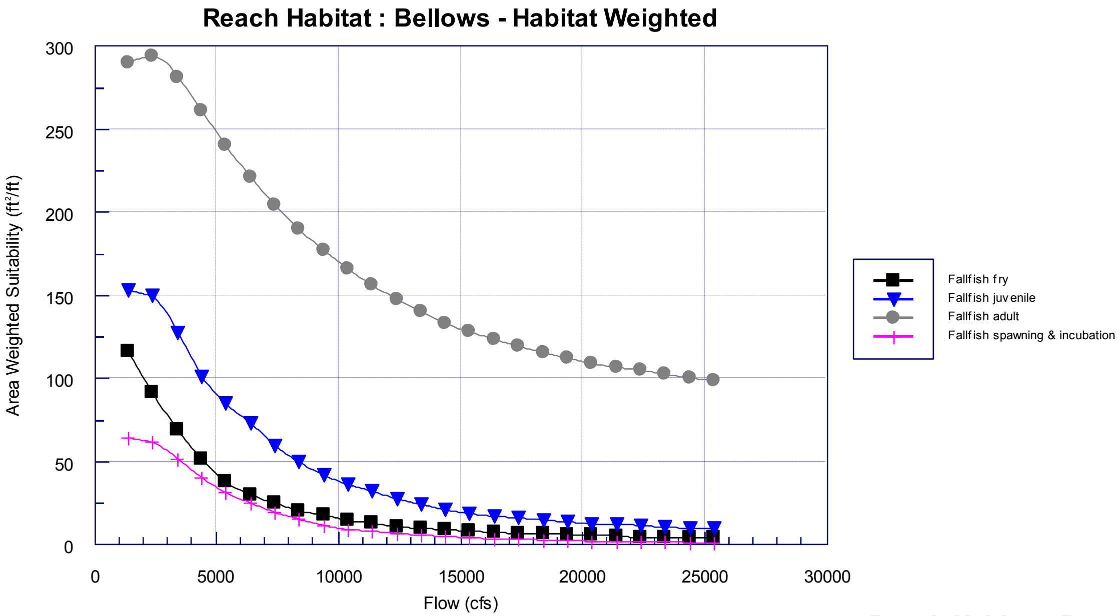
Juvenile

Adult

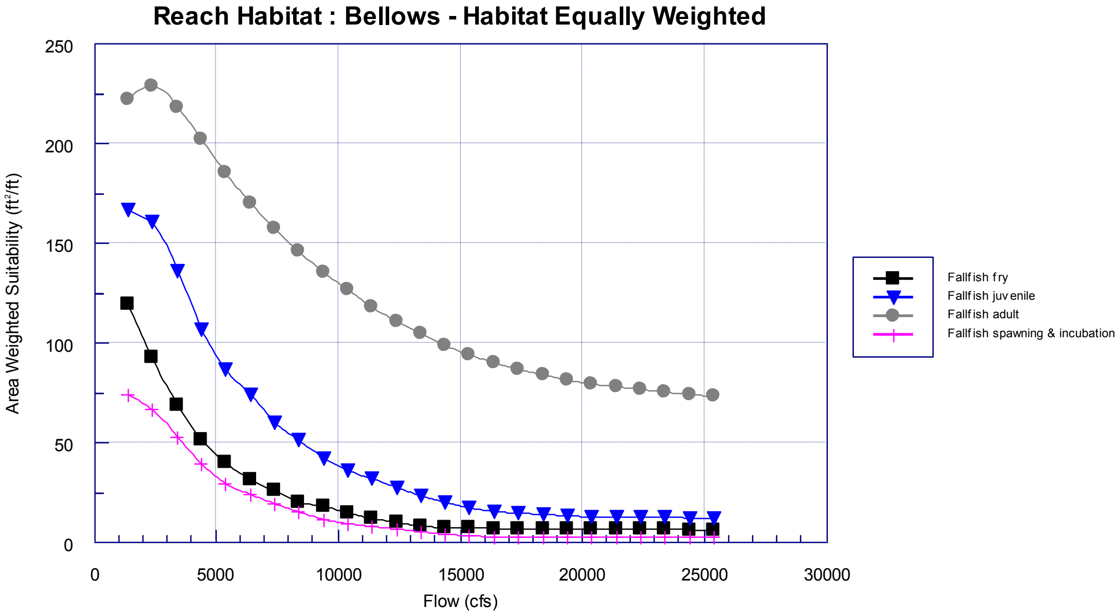
Spawning


Reach Habitat : Bellows - Habitat Equally Weighted

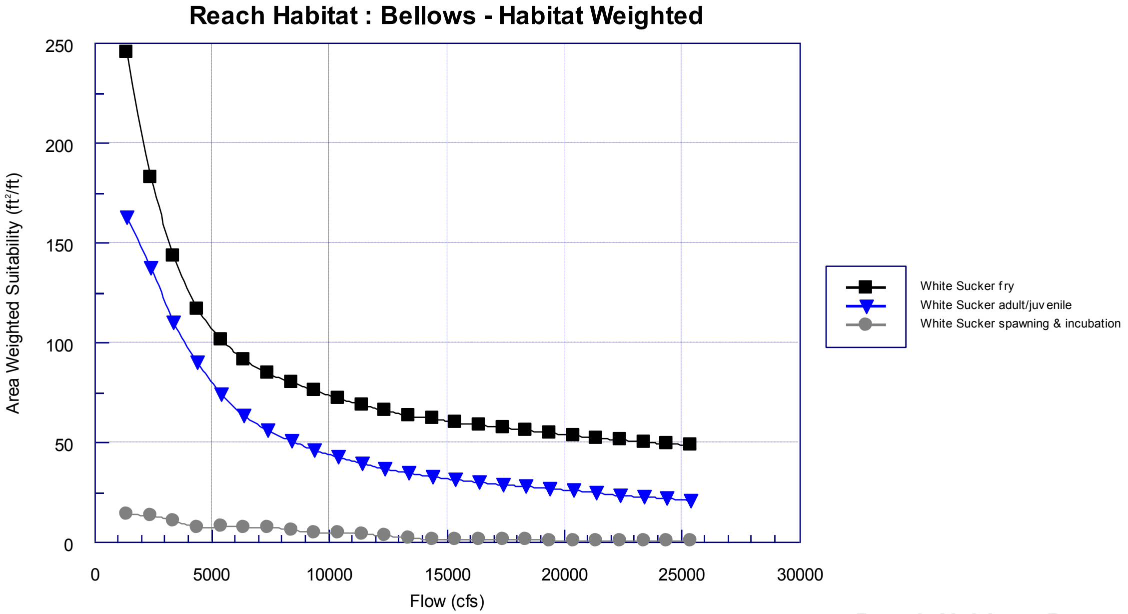
Study 9 – Instream Flow Study – Habitat Index (AWS)



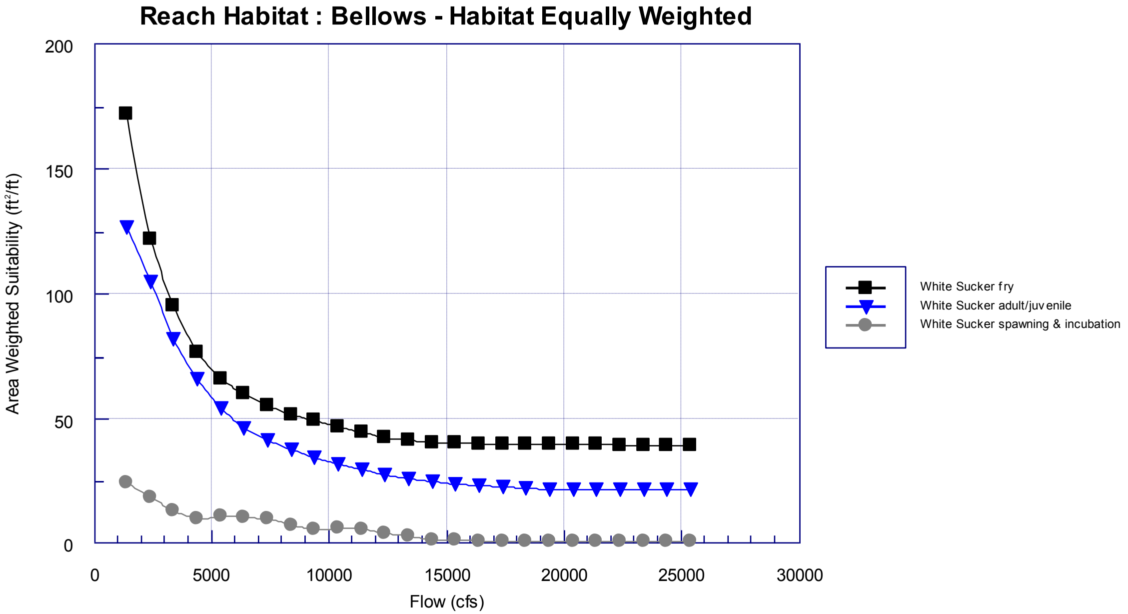
Fallfish:
Fry
Juvenile
Adult
Spawning



Study 9 – Instream Flow Study – Habitat Index (AWS)

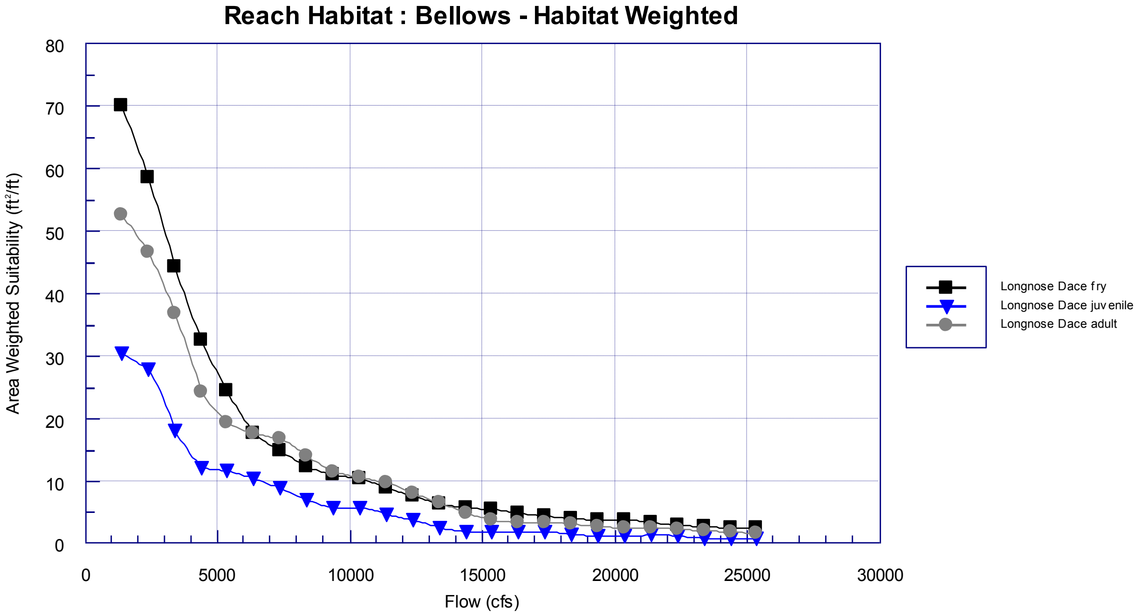


White Sucker :
Fry
Juvenile / Adult
Spawning



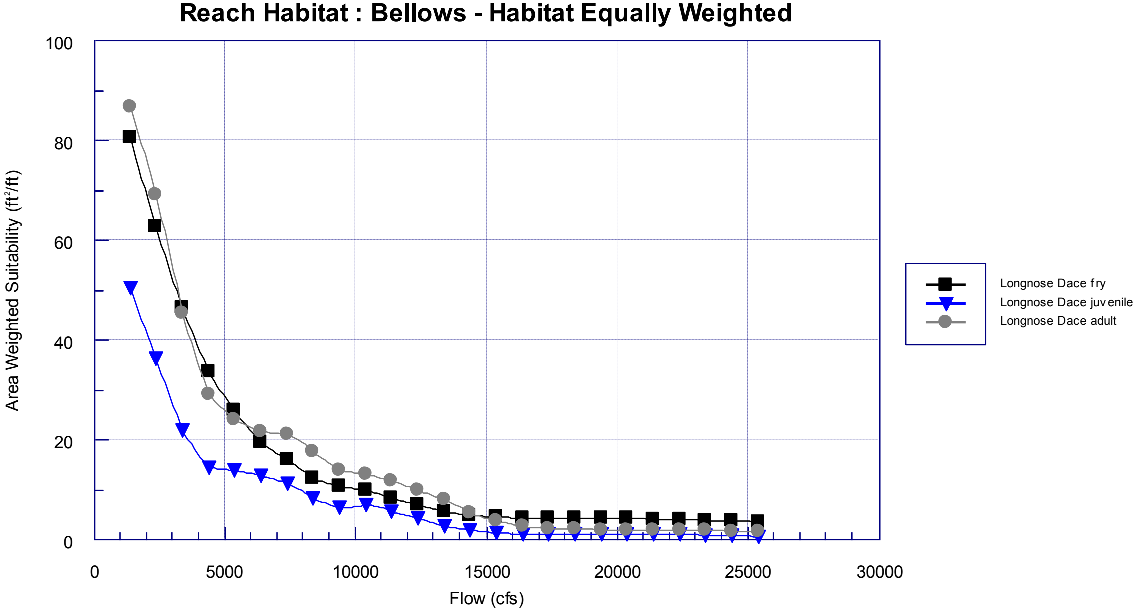
TransCanada

Study 9 – Instream Flow Study – Habitat Index (AWS)



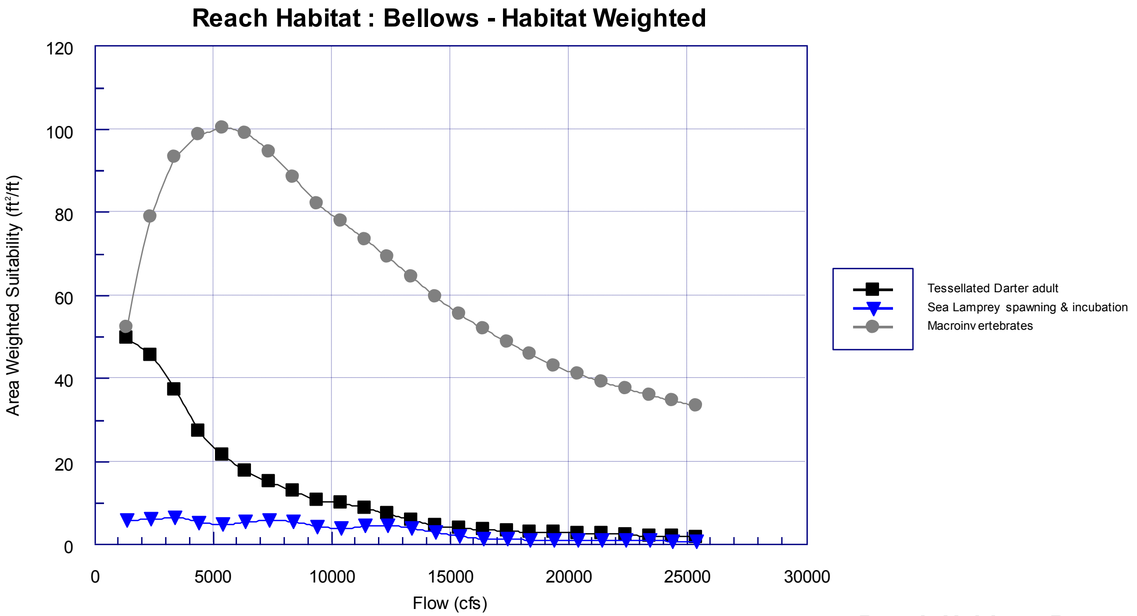
Reach Habitat : Bellows - Habitat Weighted

Longnose Dace :
Fry
Juvenile
Adult

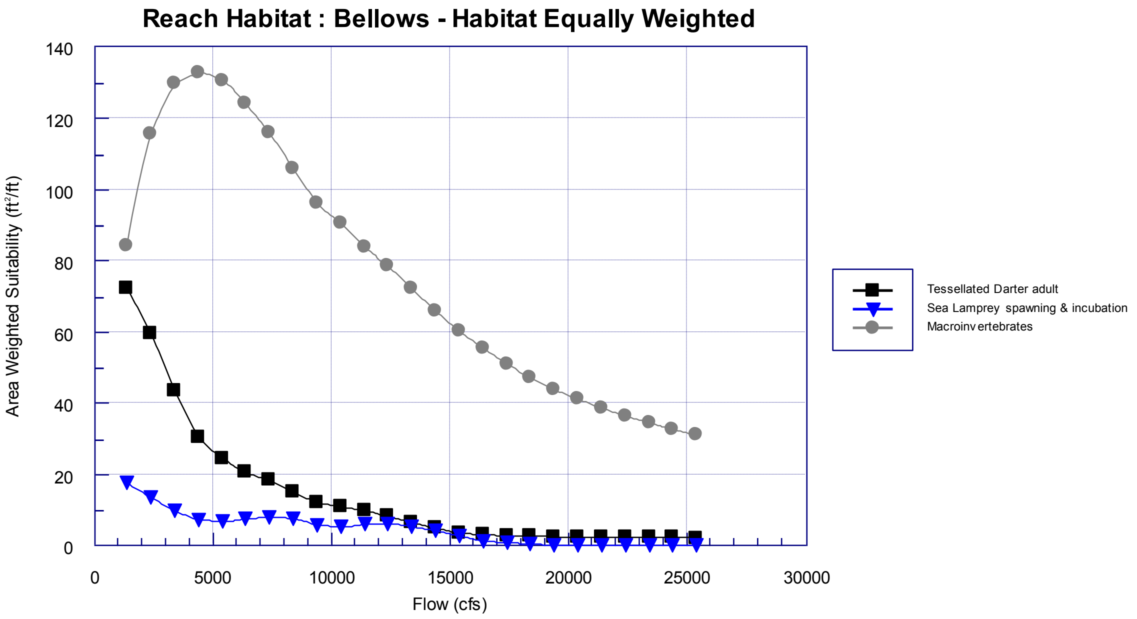


Reach Habitat : Bellows - Habitat Equally Weighted

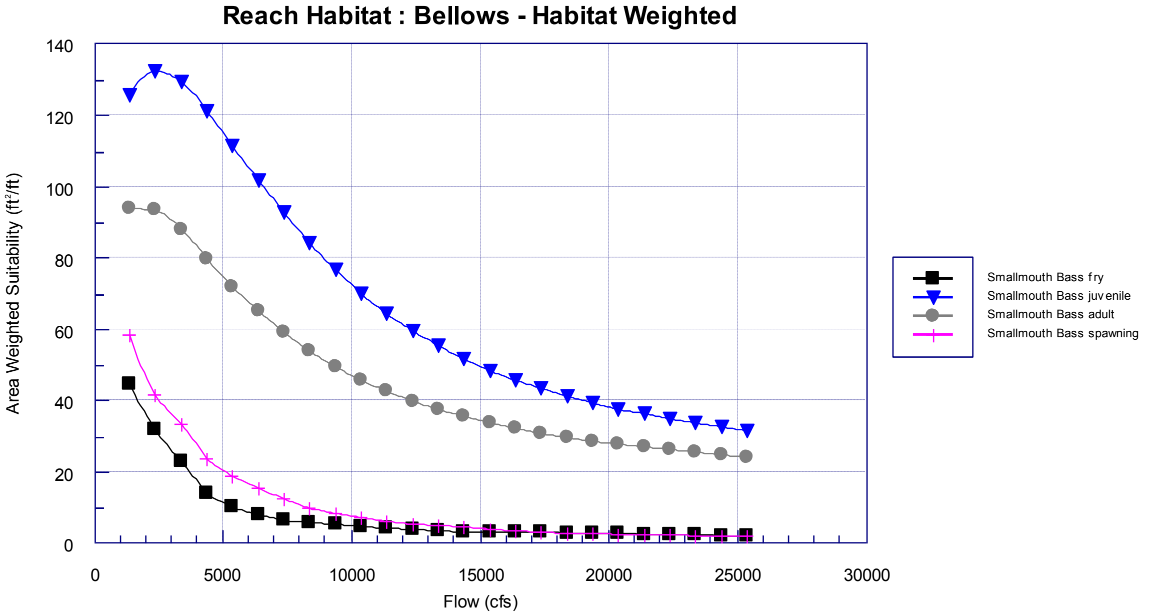
Study 9 – Instream Flow Study – Habitat Index (AWS)



Tessellated Darter
Sea Lamprey Spawning
Macroinvertebrates



Study 9 – Instream Flow Study – Habitat Index (AWS)



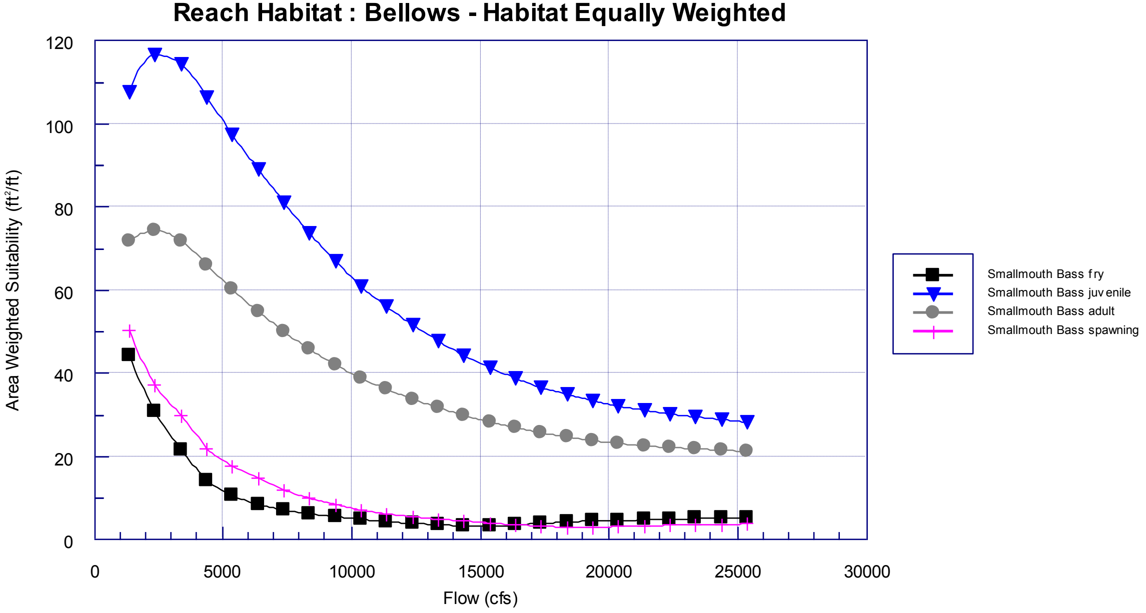
Smallmouth Bass:

Fry

Juvenile

Adult

Spawning



TransCanada

Study 9 – Instream Flow Study – Habitat Index

Comparison of 1D and 2D Model Results

Habitat Index results for 1D transects and reaches reported as
Area Weighted Suitability (AWS) – ft^2

Habitat Index results for 2D sites reported as
Weighted Usable Area (WUA) – ft^2

Both calculate point or cell suitability the same way:

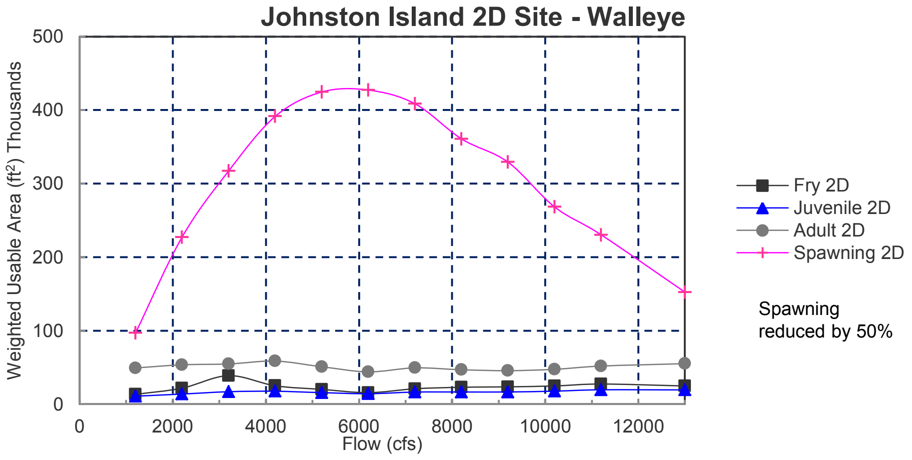
Combined Suitability Index (CSI) value =

Velocity (SI) * Depth(SI) * Substrate(SI)

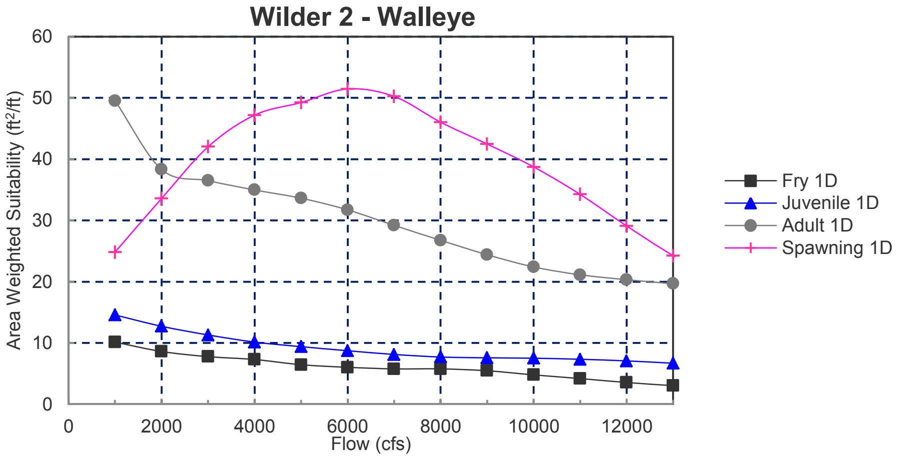
The difference in scale is:

- Area in AWS is based on transect widths weighted by percent
- Area in WUA is based on the weighted suitable portion of the total area of the 2D site

Study 9 – Instream Flow Study – Habitat Index (AWS)

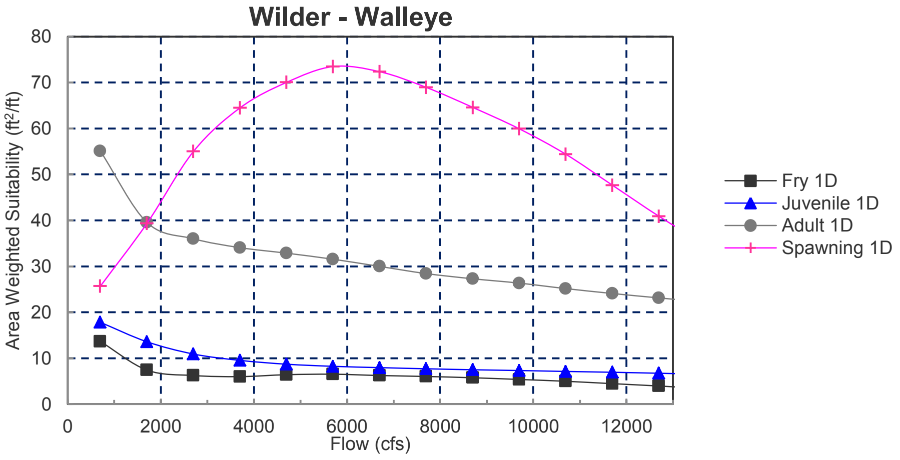


Spawning reduced by 50%



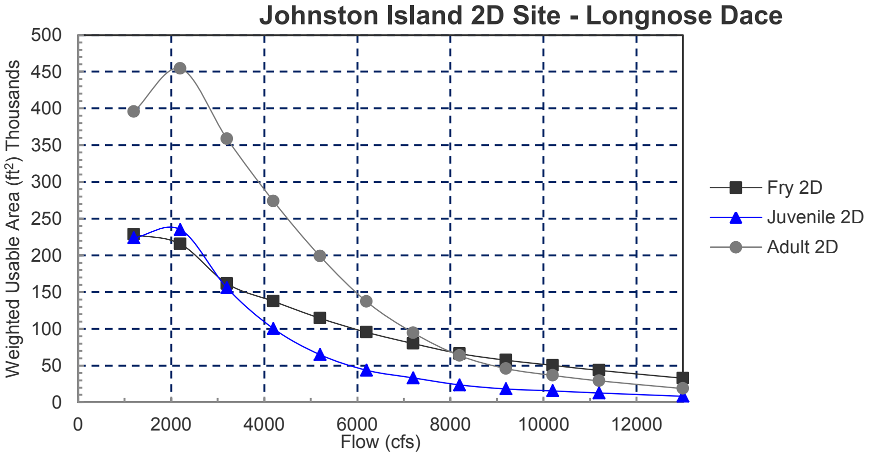
Comparison of results for Walleye:

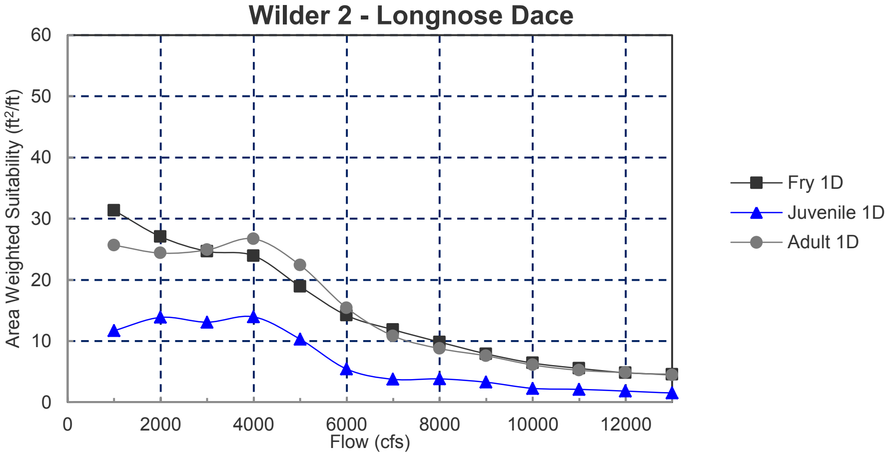
- **Johnston Island 2D site (Wilder reach 2)**
- **1D transects Wilder reach 2**
- **1D transects Wilder reaches combined**



TransCanada

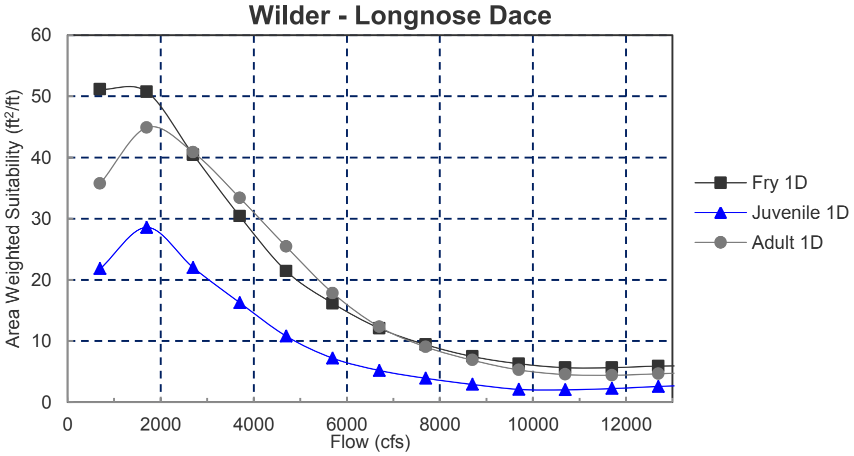
Study 9 – Instream Flow Study – Habitat Index (AWS)



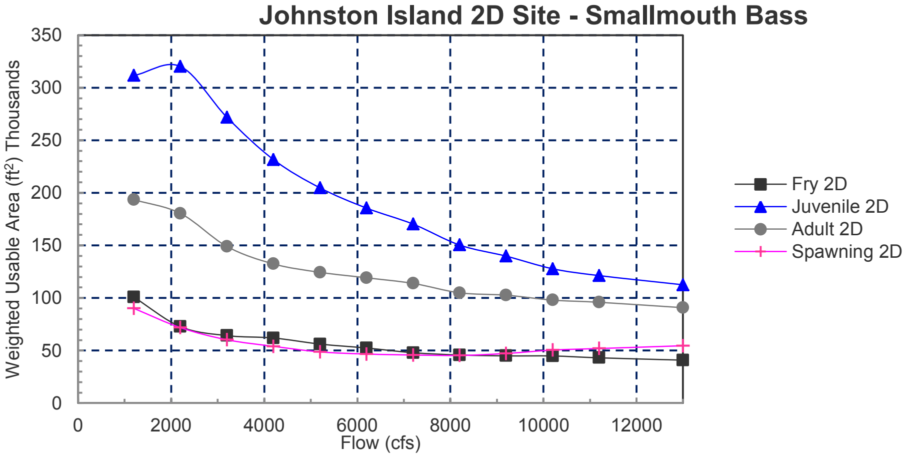


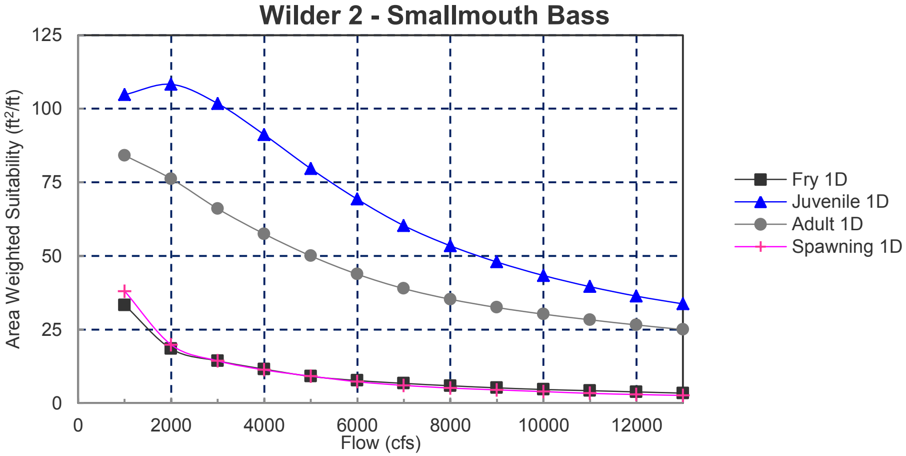
Comparison of results for Longnose Dace:

- **Johnston Island 2D site (Wilder reach 2)**
- **1D transects Wilder reach 2**
- **1D transects Wilder reaches combined**



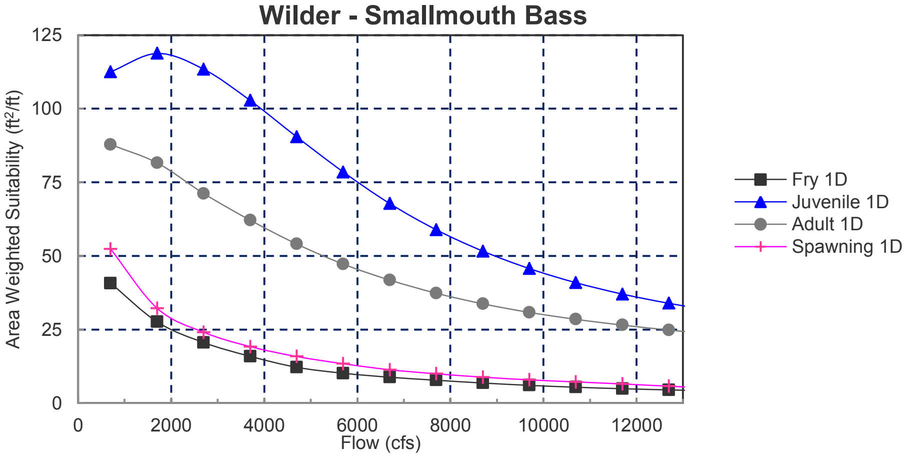
Study 9 – Instream Flow Study – Habitat Index (AWS)





Comparison of results for Smallmouth:

- **Johnston Island 2D site (Wilder reach 2)**
- **1D transects Wilder reach 2**
- **1D transects Wilder reaches combined**



TransCanada

Study 9 – Instream Flow Study – Vernon Reach

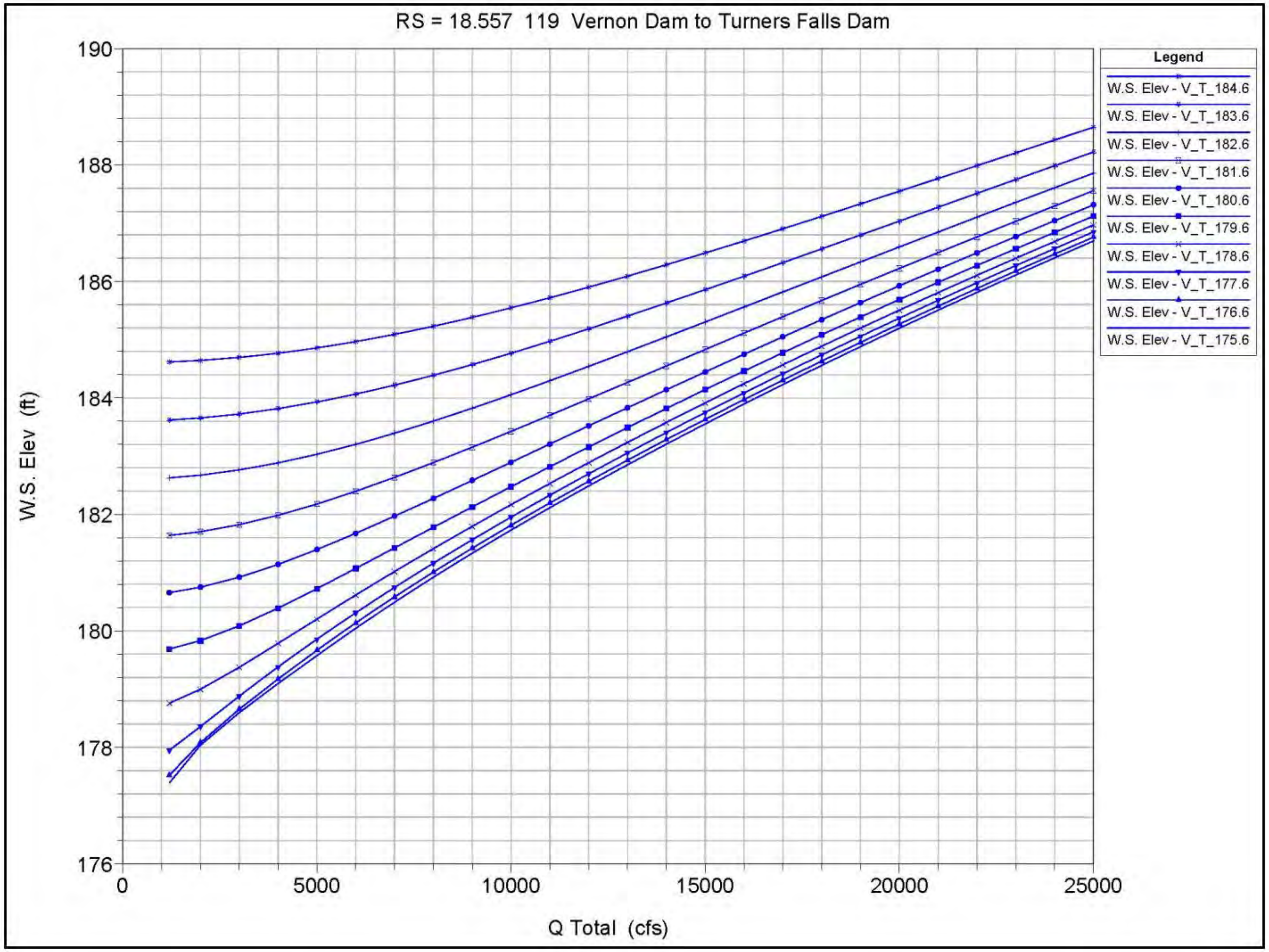
HEC-RAS Rating Curves – Transect VR-10

Turners Falls Reservoir:			176.6	177.6	178.6	179.6	180.6	181.6	182.6	183.6	184.6	elevation (ft NAVD88)
River Station	Node	Flow (cfs)	WSEL (ft)	WSEL (ft)	WSEL (ft)	WSEL (ft)	WSEL (ft)	WSEL (ft)	WSEL (ft)	WSEL (ft)	WSEL (ft)	
18.557 VR	119 VR	1200	177.5	177.9	178.8	179.7	180.6	181.6	182.6	183.6	184.6	
18.557 VR	119 VR	2000	178.1	178.4	179.0	179.8	180.7	181.7	182.7	183.7	184.6	
18.557 VR	119 VR	3000	178.7	178.9	179.4	180.1	180.9	181.8	182.8	183.7	184.7	
18.557 VR	119 VR	4000	179.2	179.4	179.8	180.4	181.1	182.0	182.9	183.8	184.8	
18.557 VR	119 VR	5000	179.7	179.9	180.2	180.7	181.4	182.2	183.0	183.9	184.9	
18.557 VR	119 VR	6000	180.1	180.3	180.6	181.1	181.7	182.4	183.2	184.1	185.0	
18.557 VR	119 VR	7000	180.6	180.7	181.0	181.4	182.0	182.6	183.4	184.2	185.1	
18.557 VR	119 VR	8000	181.0	181.2	181.4	181.8	182.3	182.9	183.6	184.4	185.2	
18.557 VR	119 VR	9000	181.4	181.6	181.8	182.1	182.6	183.2	183.8	184.6	185.4	
18.557 VR	119 VR	10000	181.8	182.0	182.2	182.5	182.9	183.4	184.1	184.8	185.5	
18.557 VR	119 VR	11000	182.2	182.3	182.5	182.8	183.2	183.7	184.3	185.0	185.7	
18.557 VR	119 VR	12000	182.6	182.7	182.9	183.2	183.5	184.0	184.5	185.2	185.9	
18.557 VR	119 VR	13000	182.9	183.1	183.2	183.5	183.8	184.3	184.8	185.4	186.1	
18.557 VR	119 VR	14000	183.3	183.4	183.6	183.8	184.1	184.5	185.0	185.6	186.3	
18.557 VR	119 VR	15000	183.6	183.7	183.9	184.1	184.4	184.8	185.3	185.9	186.5	
18.557 VR	119 VR	16000	184.0	184.1	184.2	184.5	184.7	185.1	185.6	186.1	186.7	
18.557 VR	119 VR	17000	184.3	184.4	184.6	184.8	185.0	185.4	185.8	186.3	186.9	
18.557 VR	119 VR	18000	184.6	184.7	184.9	185.1	185.3	185.7	186.1	186.6	187.1	
18.557 VR	119 VR	19000	185.0	185.1	185.2	185.4	185.6	185.9	186.3	186.8	187.3	
18.557 VR	119 VR	20000	185.3	185.4	185.5	185.7	185.9	186.2	186.6	187.0	187.5	
18.557 VR	119 VR	21000	185.6	185.7	185.8	186.0	186.2	186.5	186.8	187.3	187.8	
18.557 VR	119 VR	22000	185.9	186.0	186.1	186.3	186.5	186.8	187.1	187.5	188.0	
18.557 VR	119 VR	23000	186.2	186.3	186.4	186.6	186.8	187.0	187.4	187.7	188.2	
18.557 VR	119 VR	24000	186.5	186.6	186.7	186.8	187.0	187.3	187.6	188.0	188.4	
18.557 VR	119 VR	25000	186.8	186.9	187.0	187.1	187.3	187.6	187.9	188.2	188.6	

TransCanada

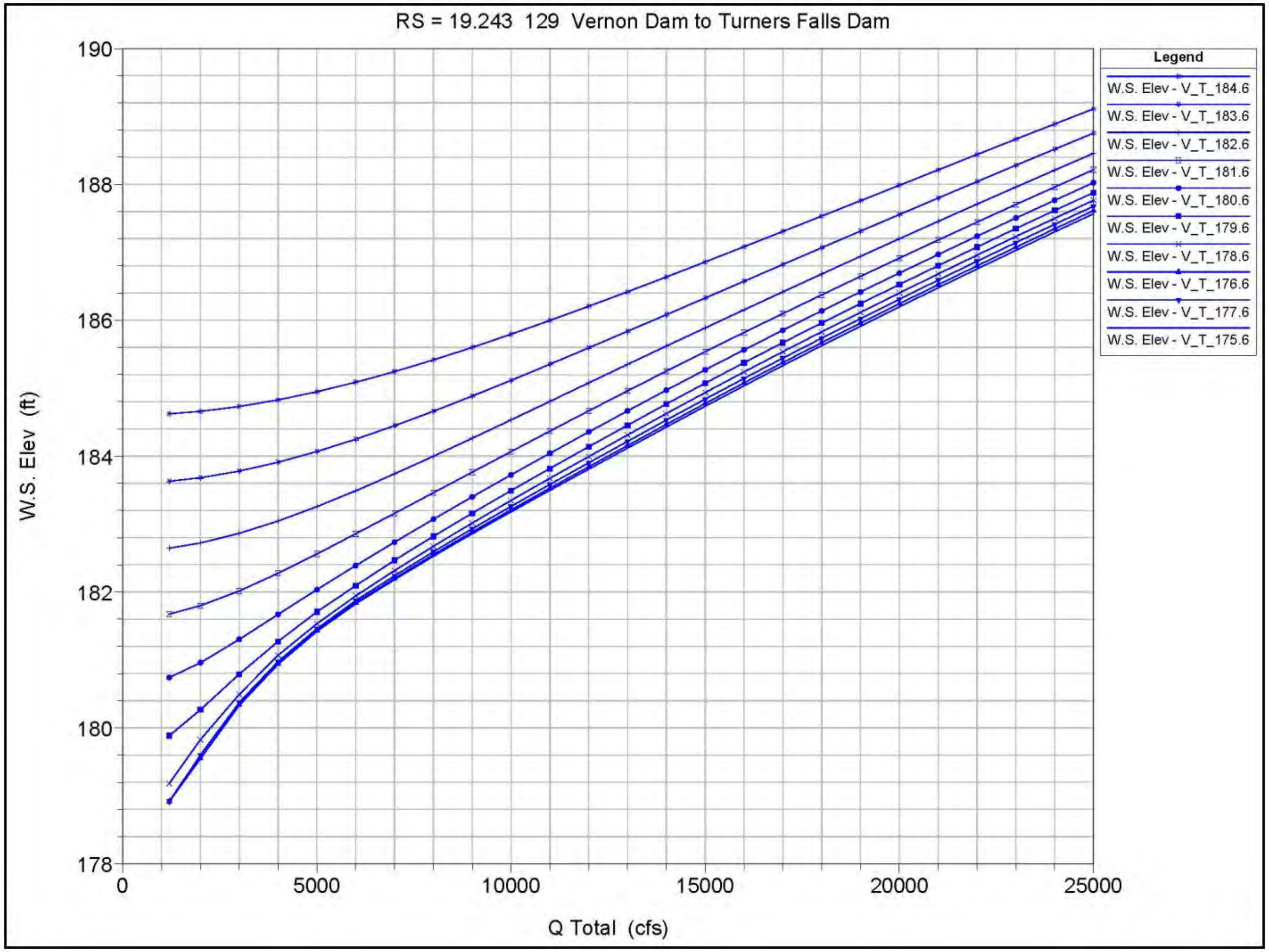
Study 9 – Instream Flow Study – Vernon Reach

HEC-RAS Rating Curves – Transect VR-10

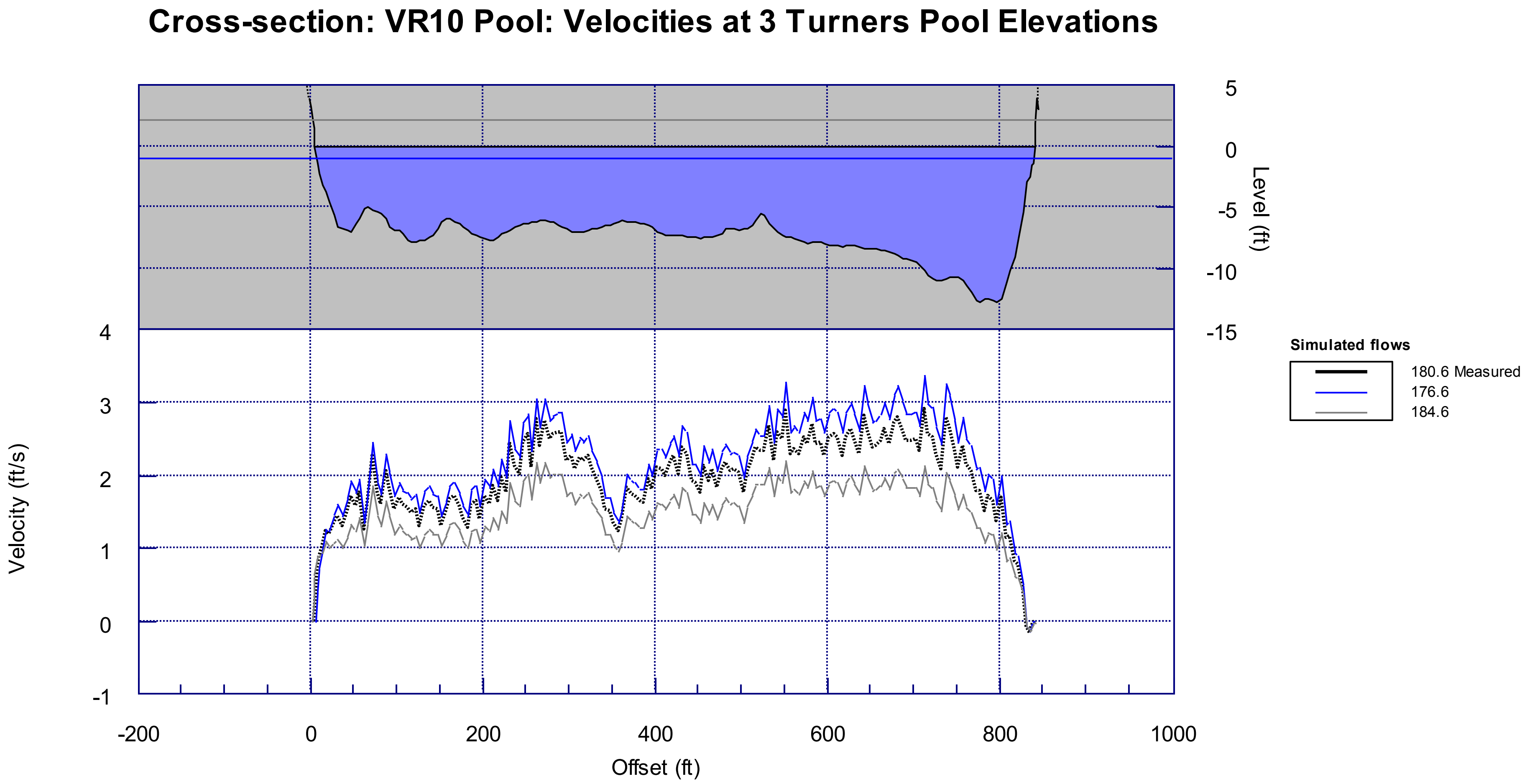


Study 9 – Instream Flow Study – Vernon Reach

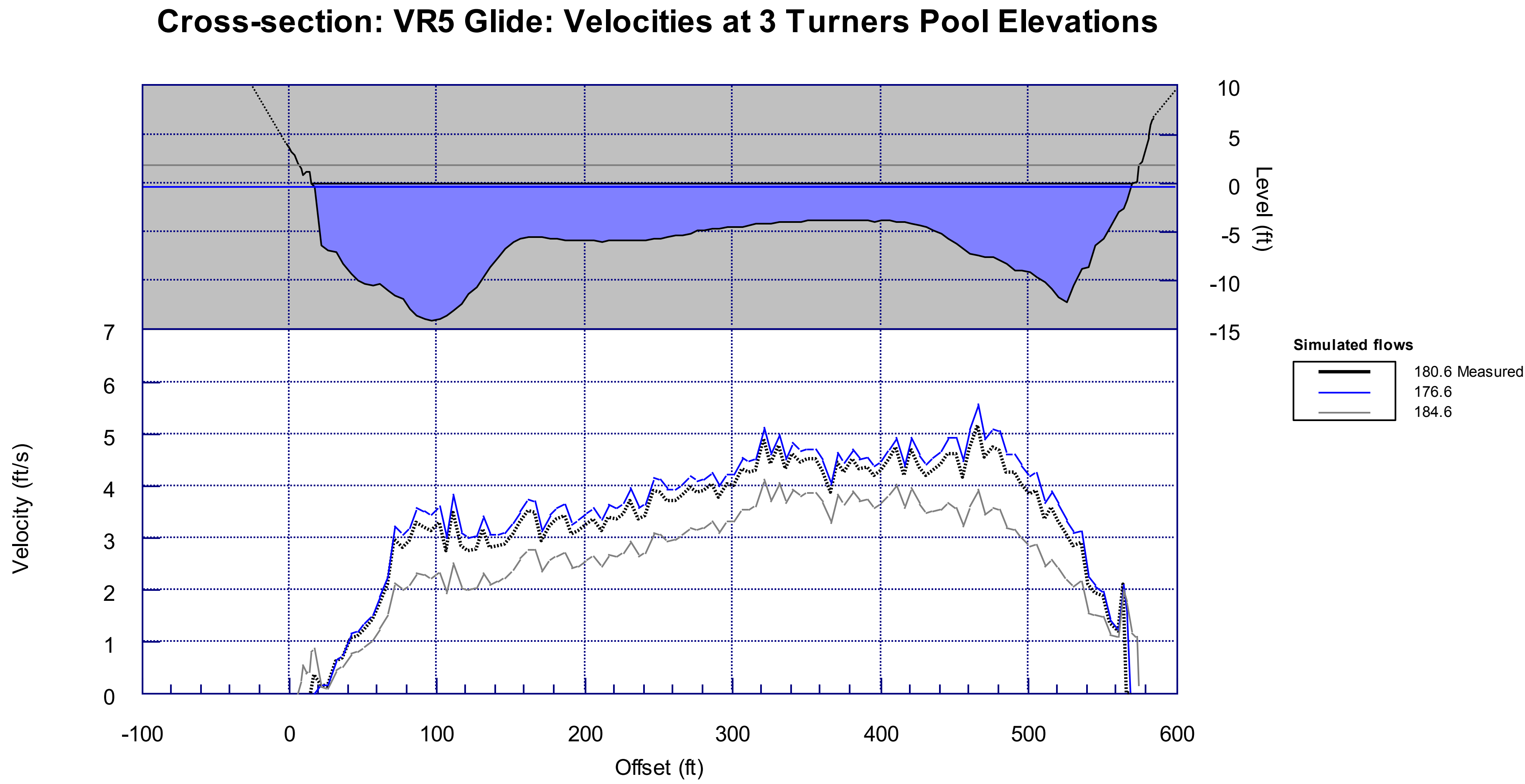
HEC-RAS Rating Curves – Transect VR-5



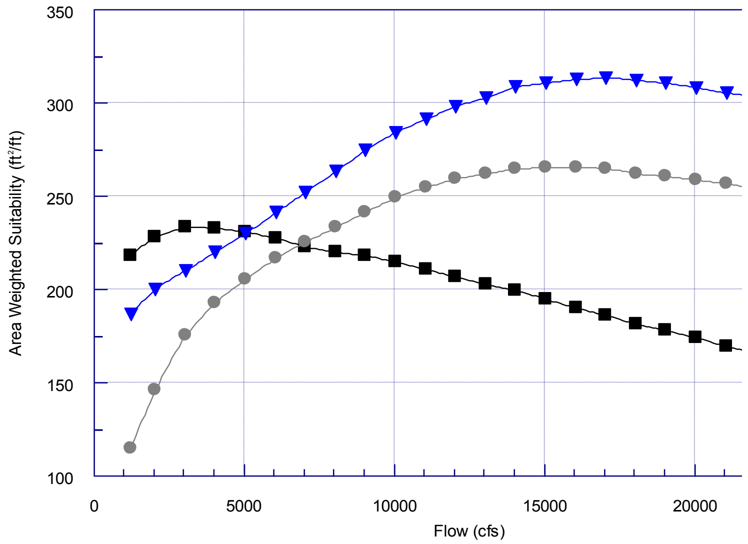
Study 9 – Instream Flow Study – Vernon Reach

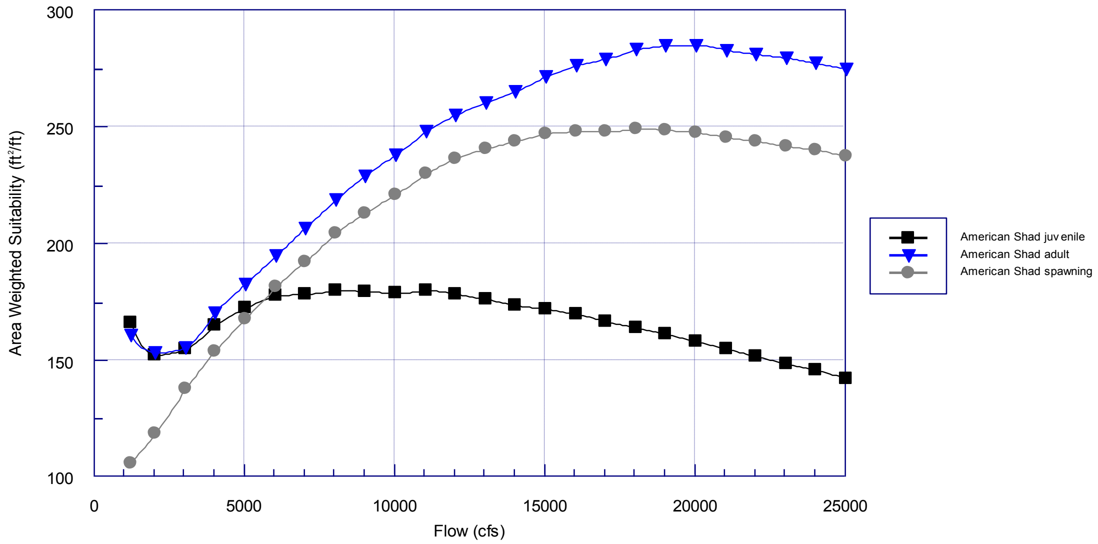


Study 9 – Instream Flow Study – Vernon Reach



Study 9 – Instream Flow Study – Vernon Reach Habitat


Reach Habitat : Vernon (180-6)

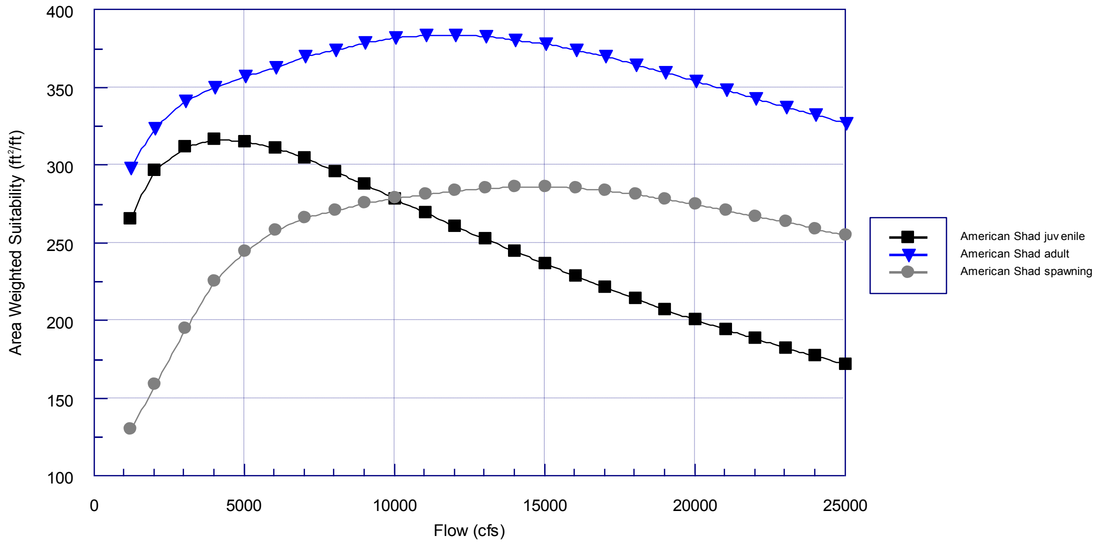

Reach Habitat : Vernon (176-6)

Habitat results at 3 Turners pool elevations:

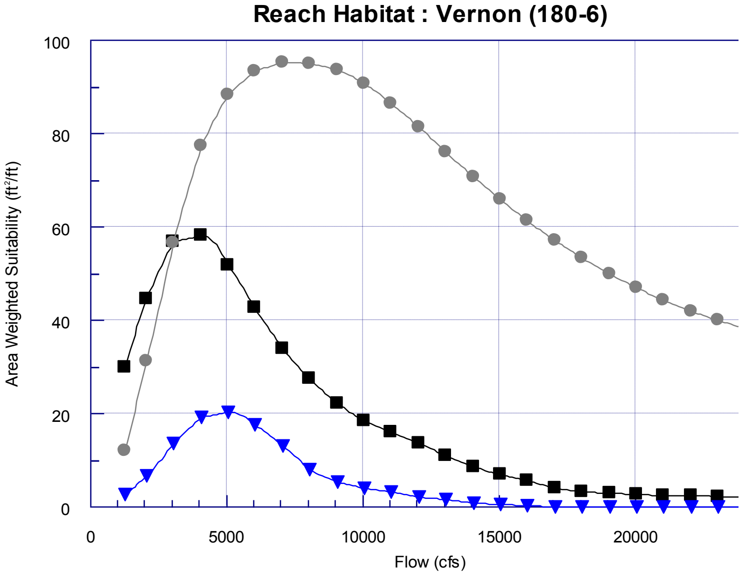
American Shad :

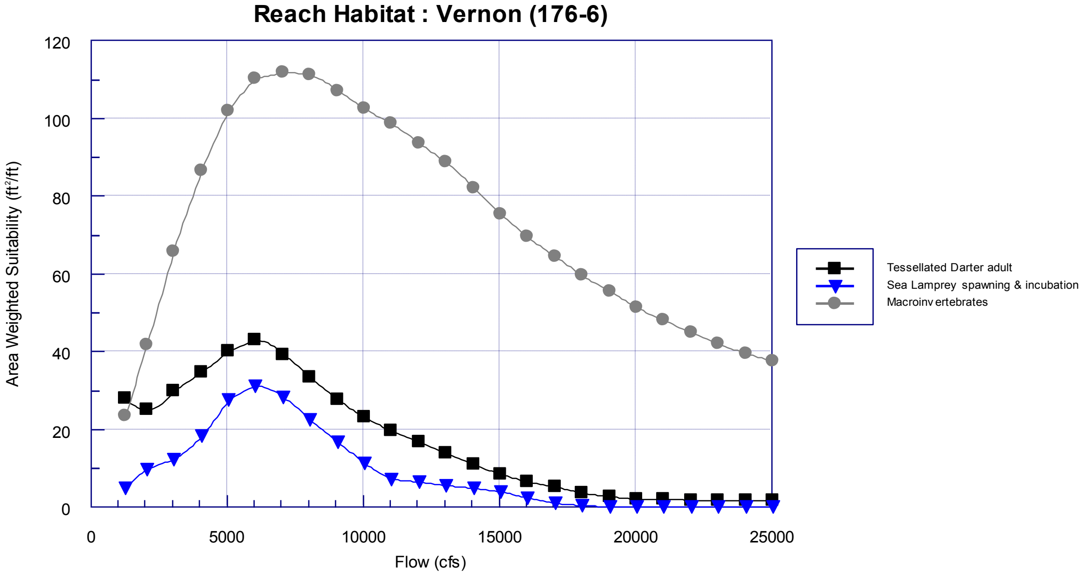
Juvenile
Adult
Spawning

TransCanada


Reach Habitat : Vernon (184-6)

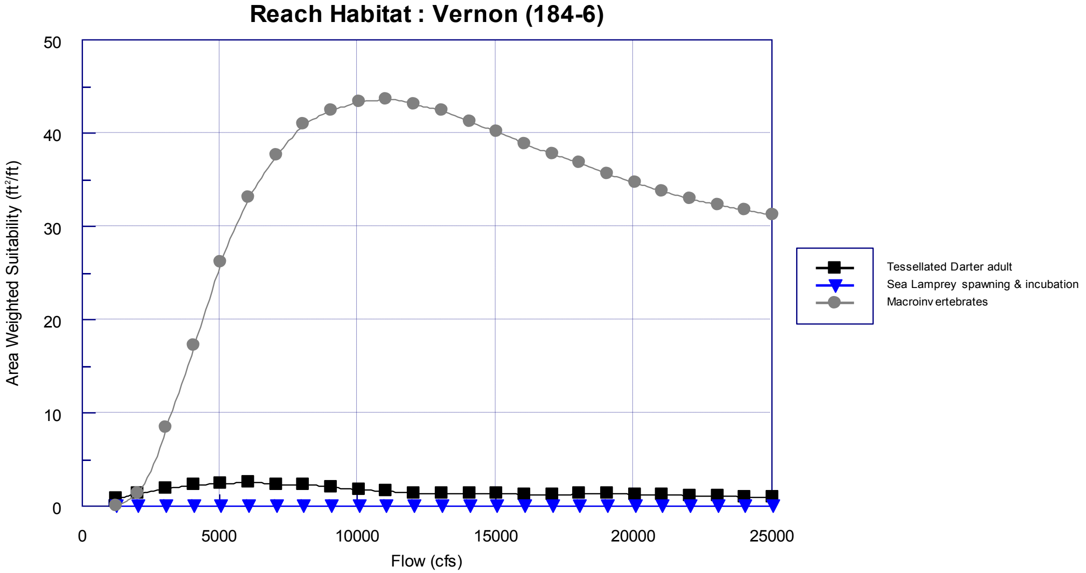
Study 9 – Instream Flow Study – Vernon Reach Habitat


Reach Habitat : Vernon (180-6)


Reach Habitat : Vernon (176-6)

Habitat results at 3 Turners pool elevations:

Tessellated Darter
Sea Lamprey Spawning
Macroinvertebrates

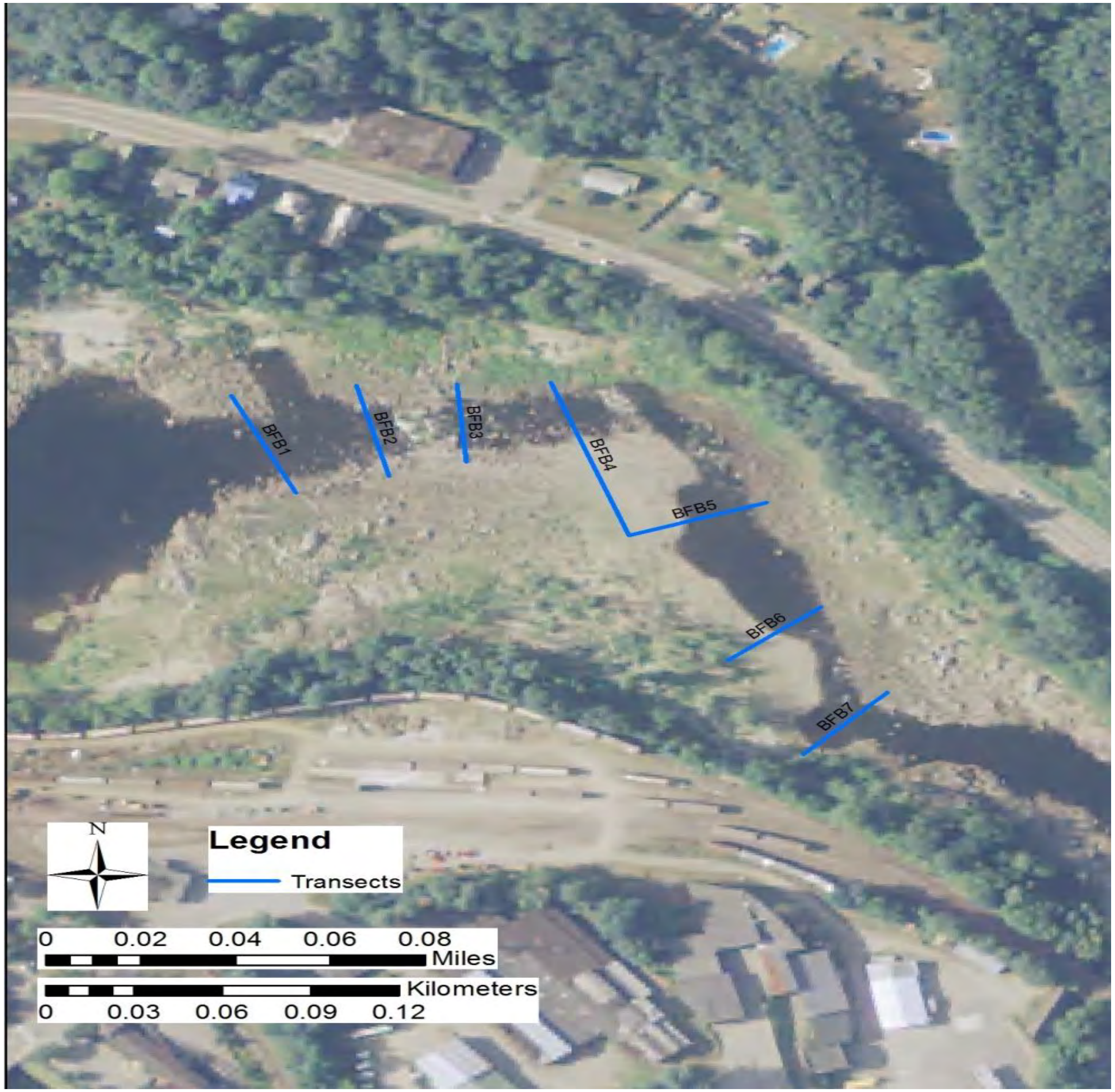

Reach Habitat : Vernon (184-6)

TransCanada

Study 9 – Instream Flow Study

- Final transect locations
- 1D transect model calibration (not covered here)
- 2D Johnston Island model calibration (not covered here)
    - 2D model for Chase Island calibrated but was not ready to include in report
- Final HSC (see report appendix)
- Habitat Index (AWS) graphs 1D reaches and 2D site at Johnston Island
    - Habitat index results by habitat type or groups of similar habitat types
- **Bellows Falls bypassed reach AWS**
- Sumner Falls Demonstration Flow results

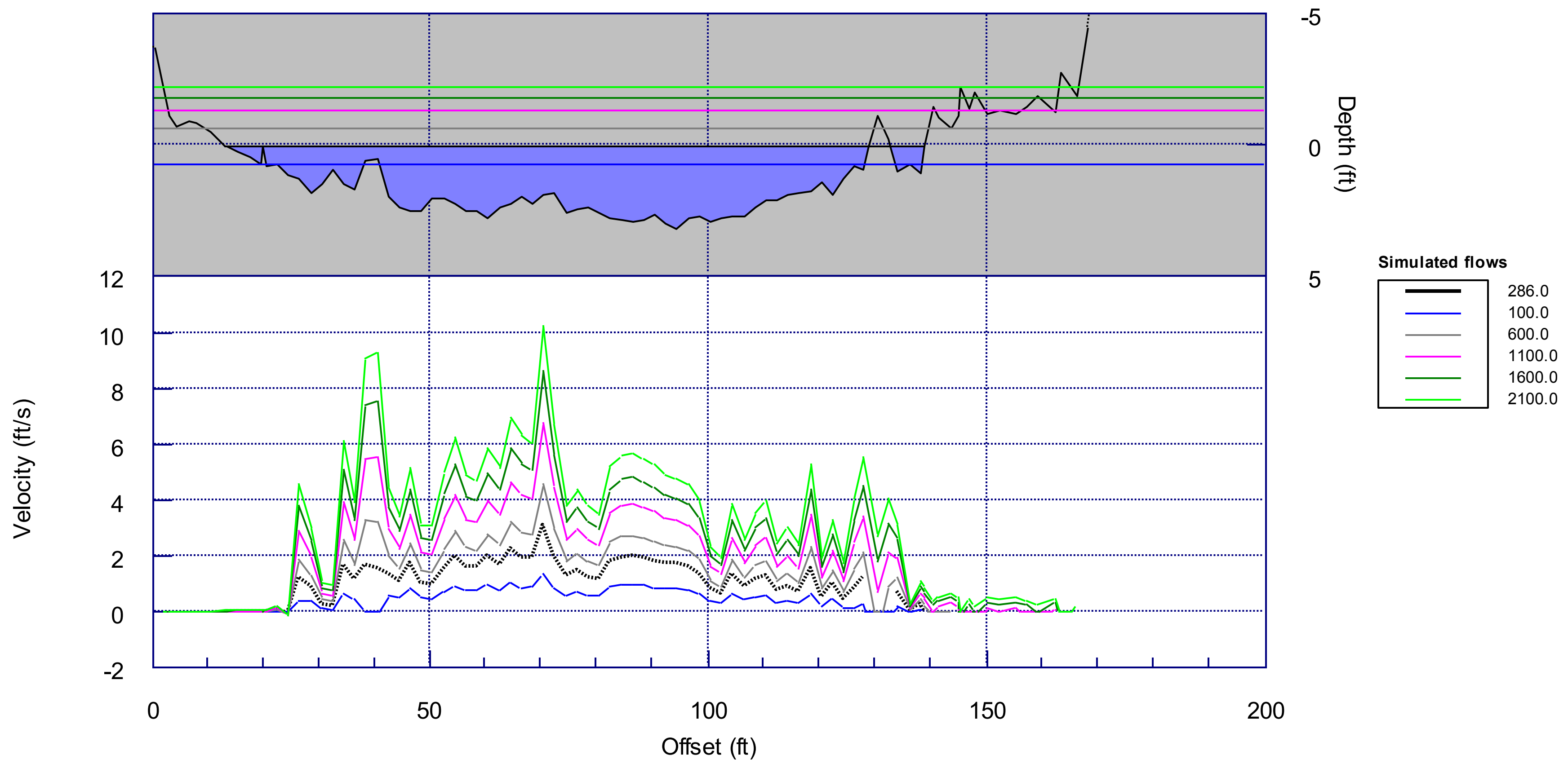
Study 9 – Instream Flow Study – Bellows Falls Bypass Reach



Study 9 – Instream Flow Study – 1D Model Calibration

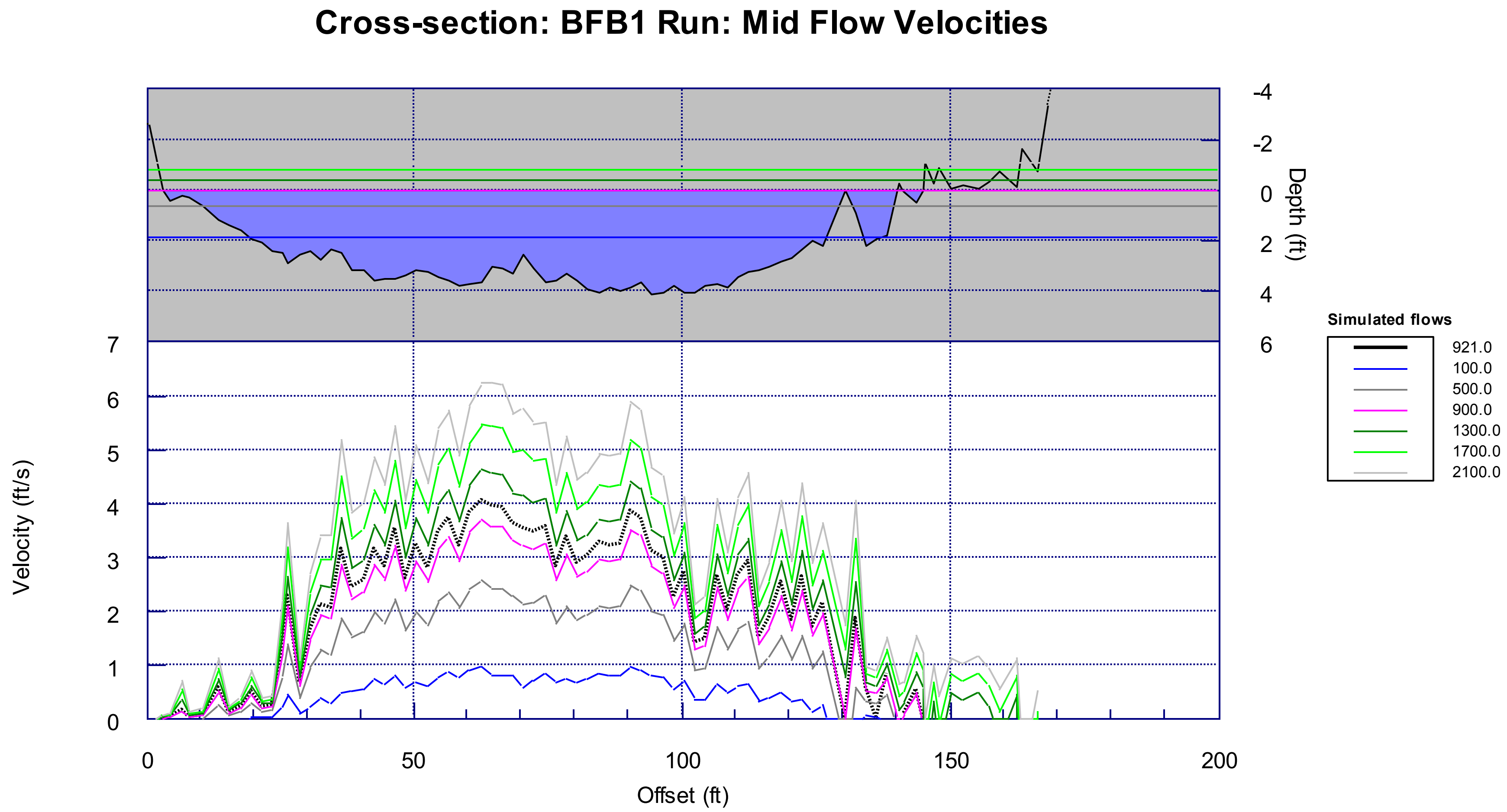
Bellows Falls bypassed reach

Cross-section: BFB1 Run: Low Flow Velocities



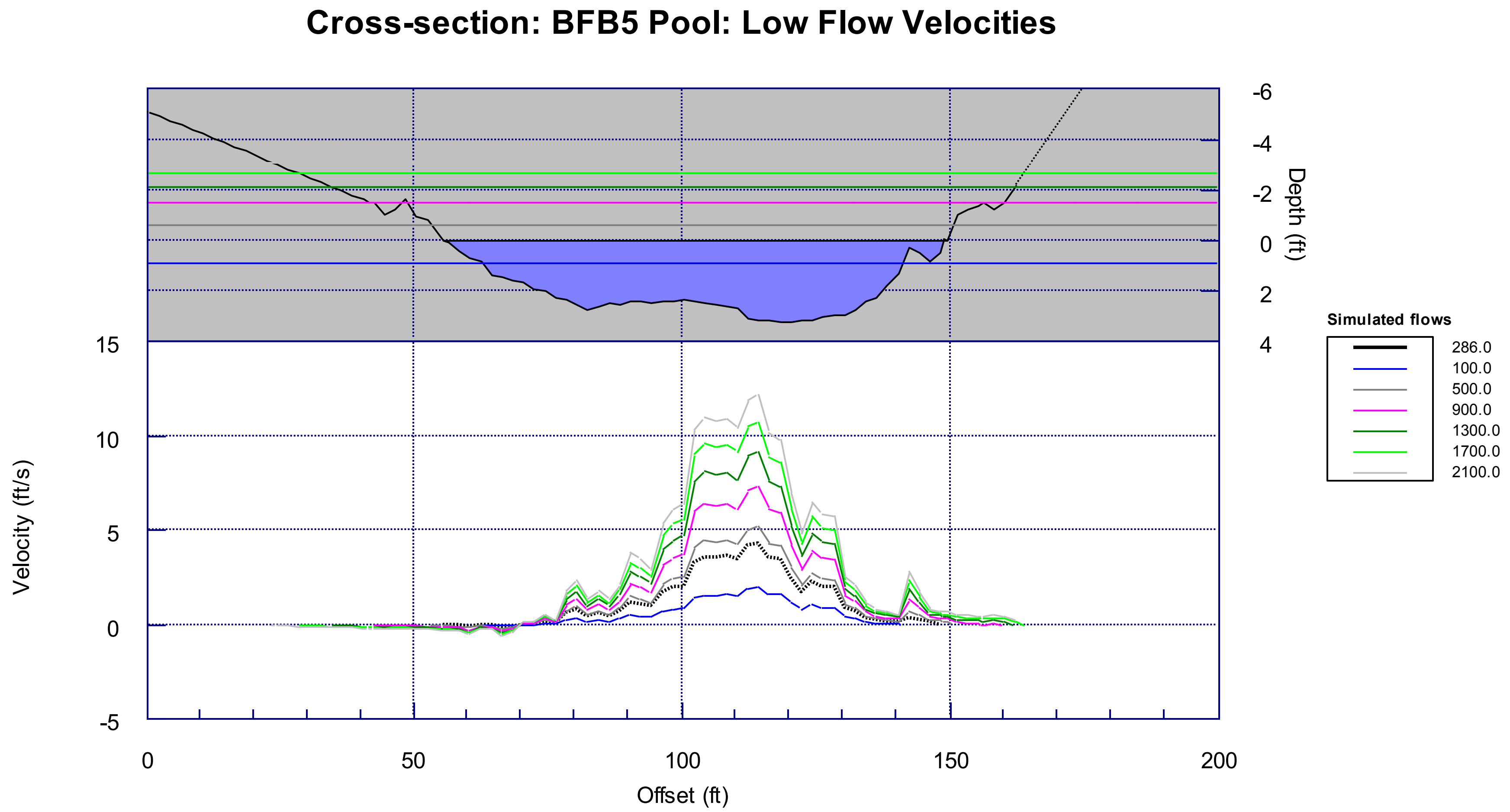
Study 9 – Instream Flow Study – 1D Model Calibration

Bellows Falls bypassed reach



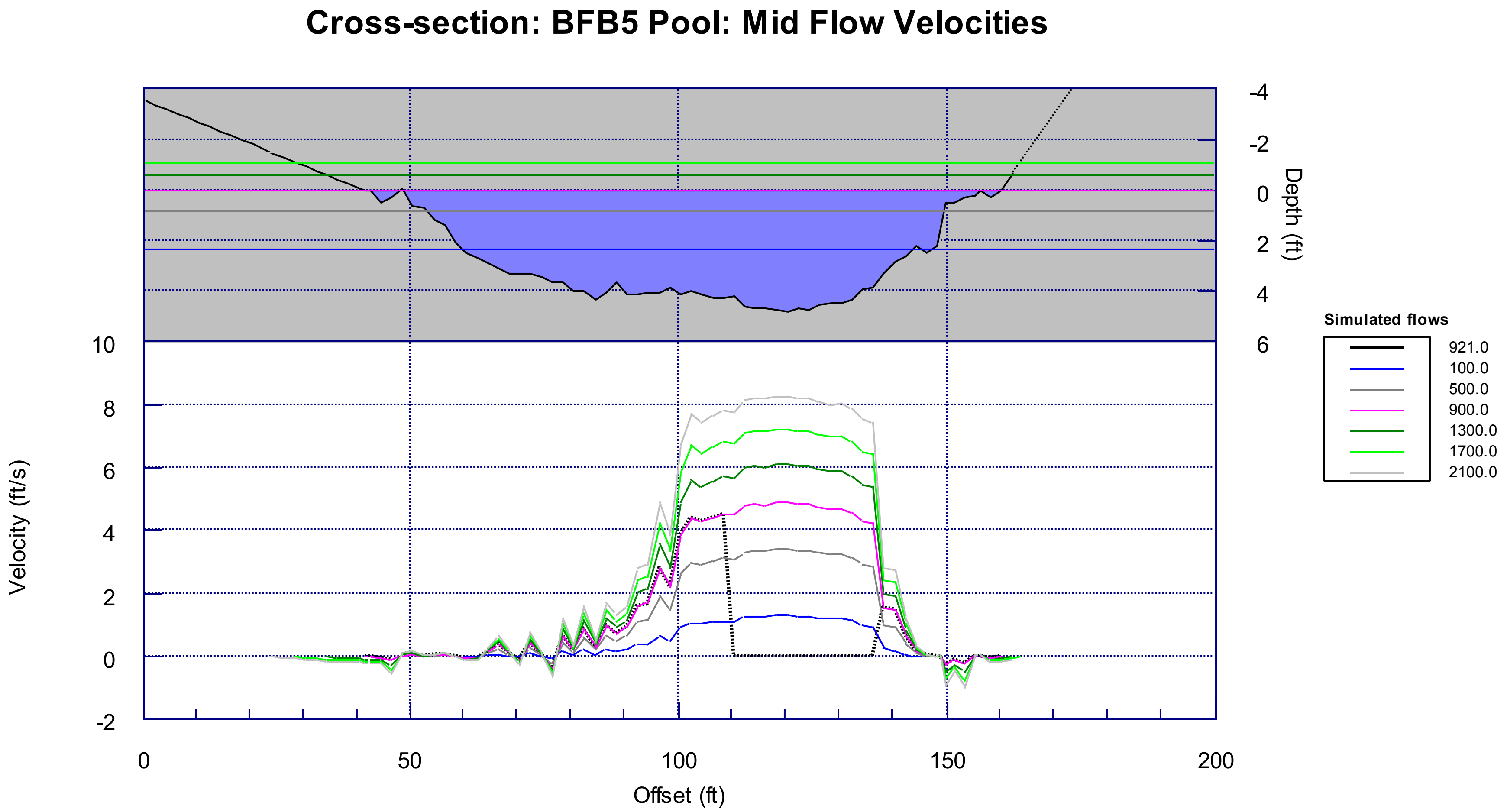
Study 9 – Instream Flow Study – 1D Model Calibration

Bellows Falls bypassed reach

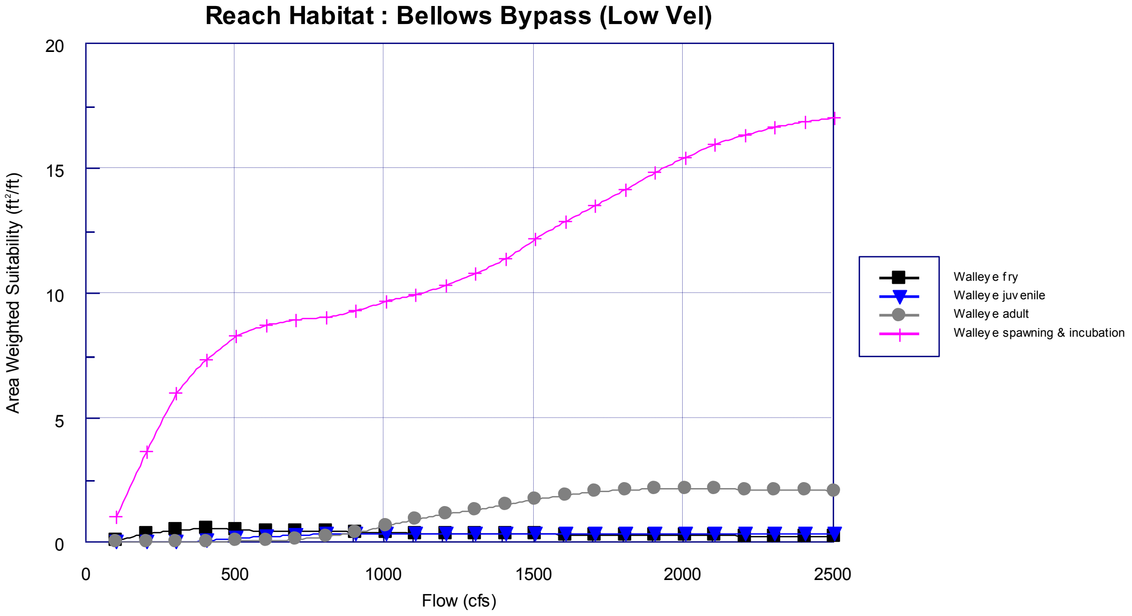


Study 9 – Instream Flow Study – 1D Model Calibration

Bellows Falls bypassed reach



Study 9 – Instream Flow Study – Habitat Index (AWS)



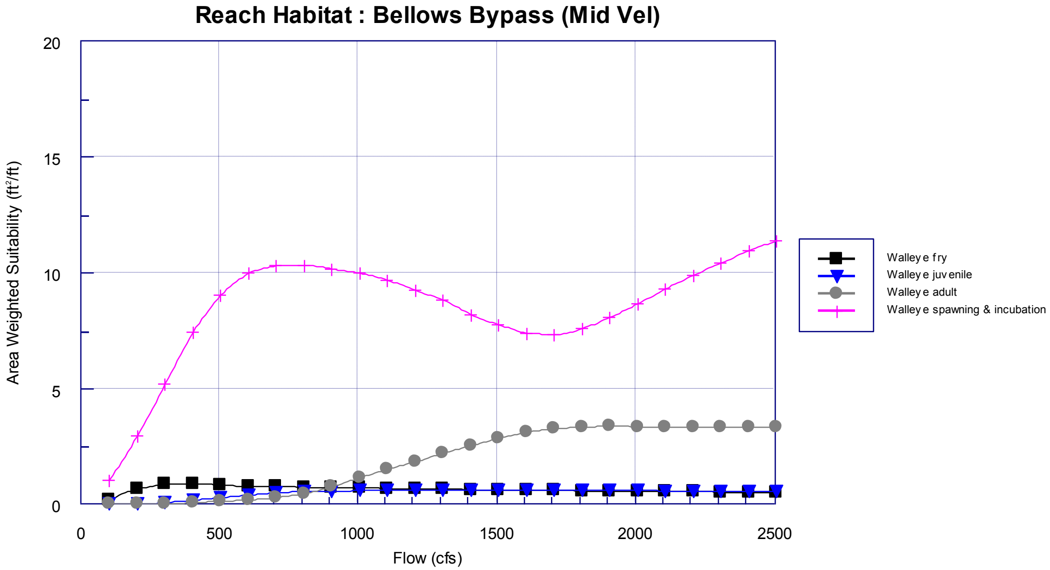
Walleye :

Fry

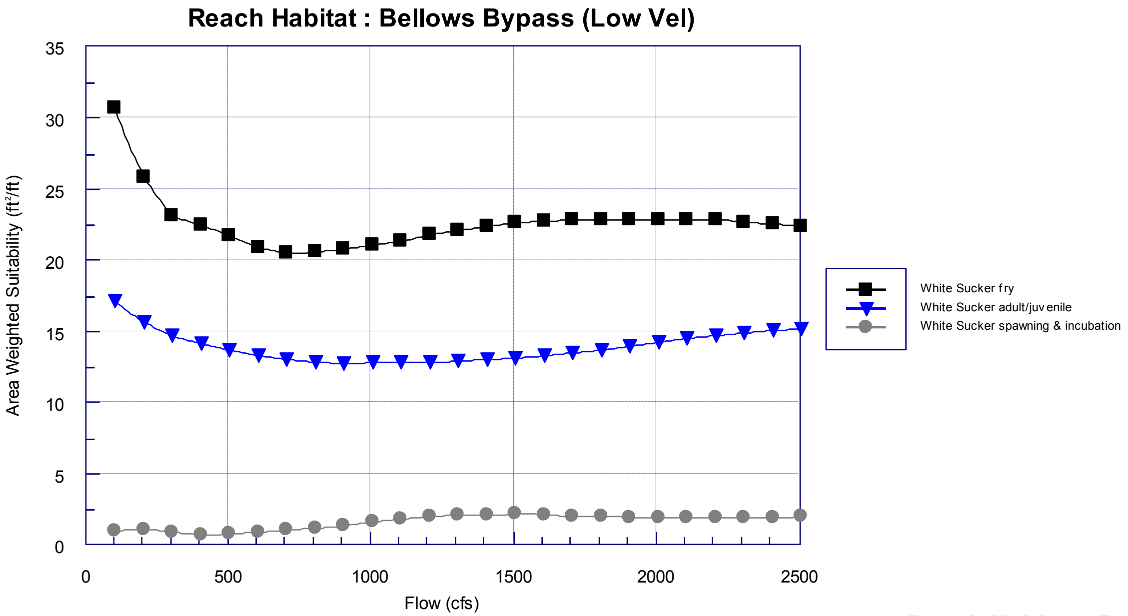
Juvenile

Adult

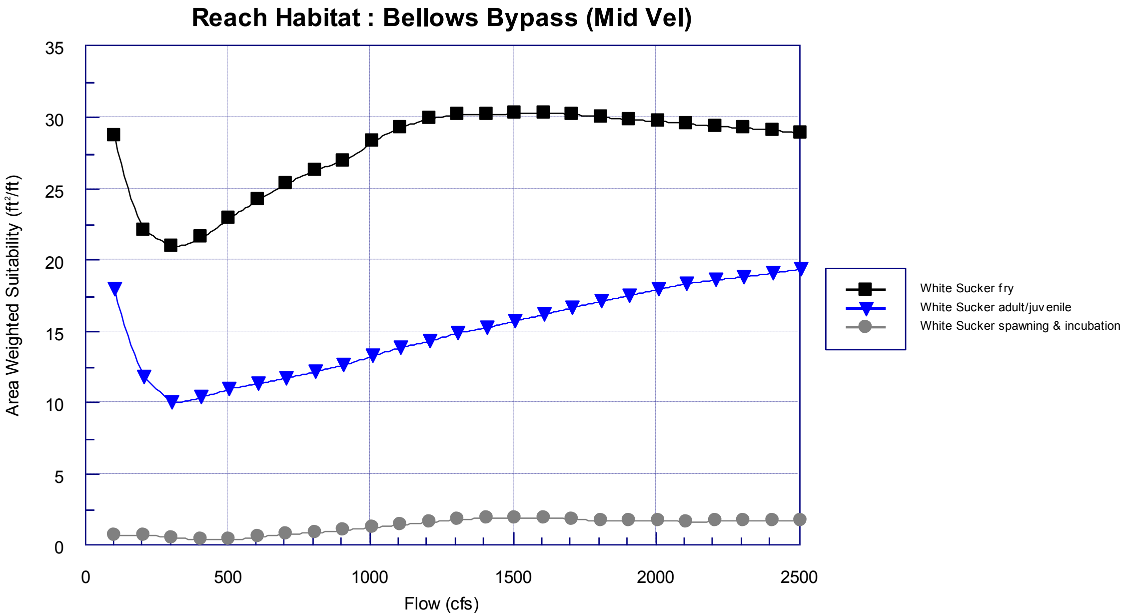
Spawning



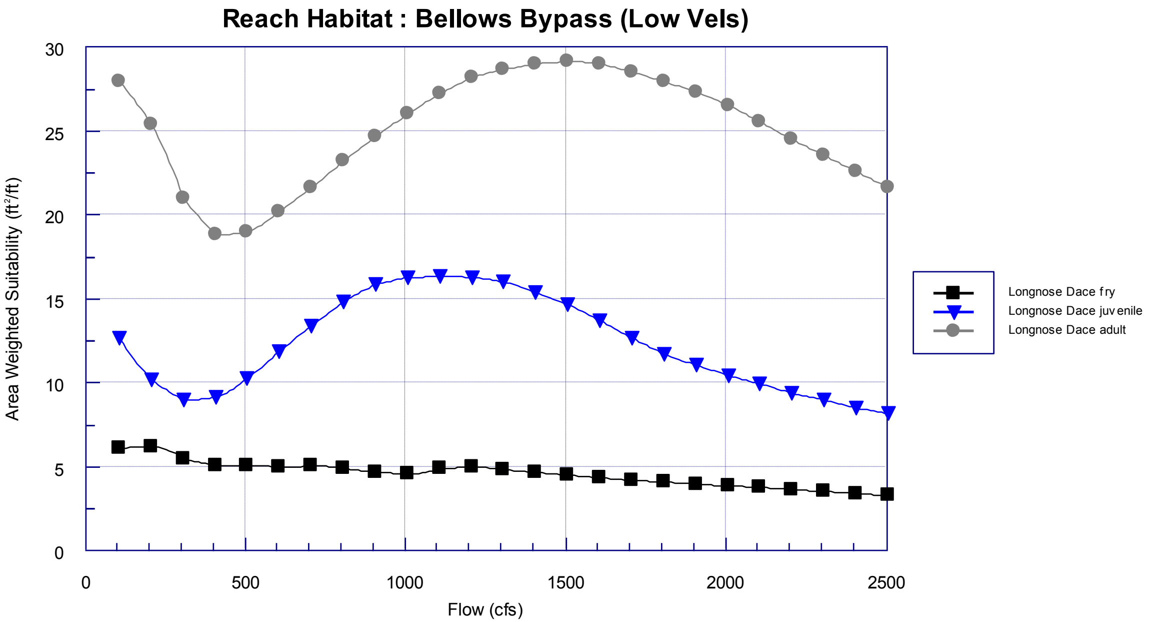
Study 9 – Instream Flow Study – Habitat Index (AWS)



White Sucker :
Fry
Juvenile / Adult
Spawning



Study 9 – Instream Flow Study – Habitat Index (AWS)



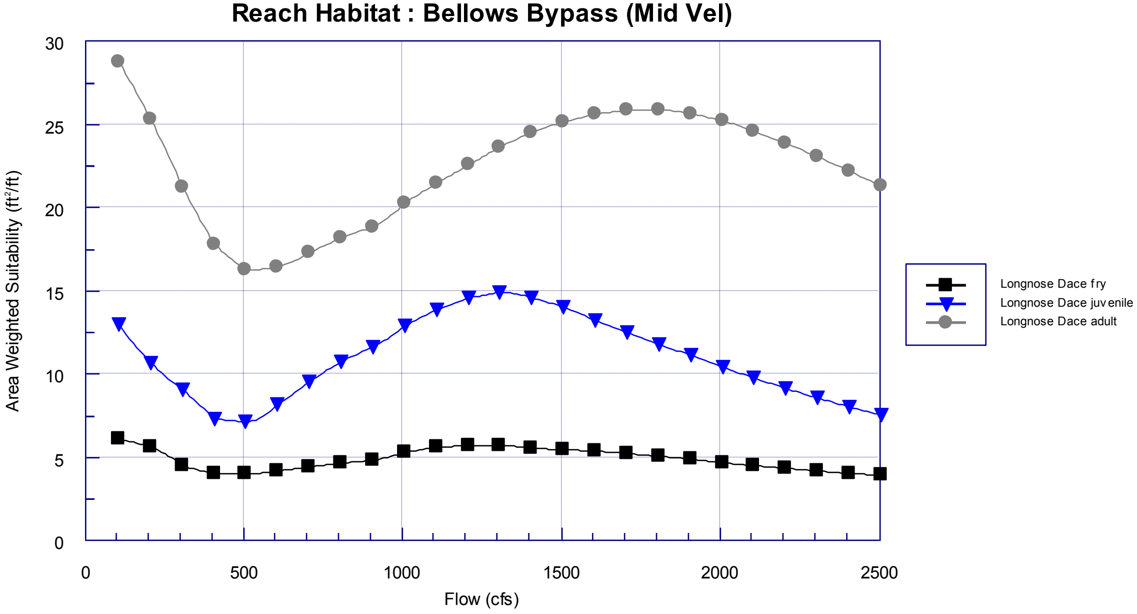
Reach Habitat : Bellows Bypass (Low Vels)

Longnose Dace :

Fry

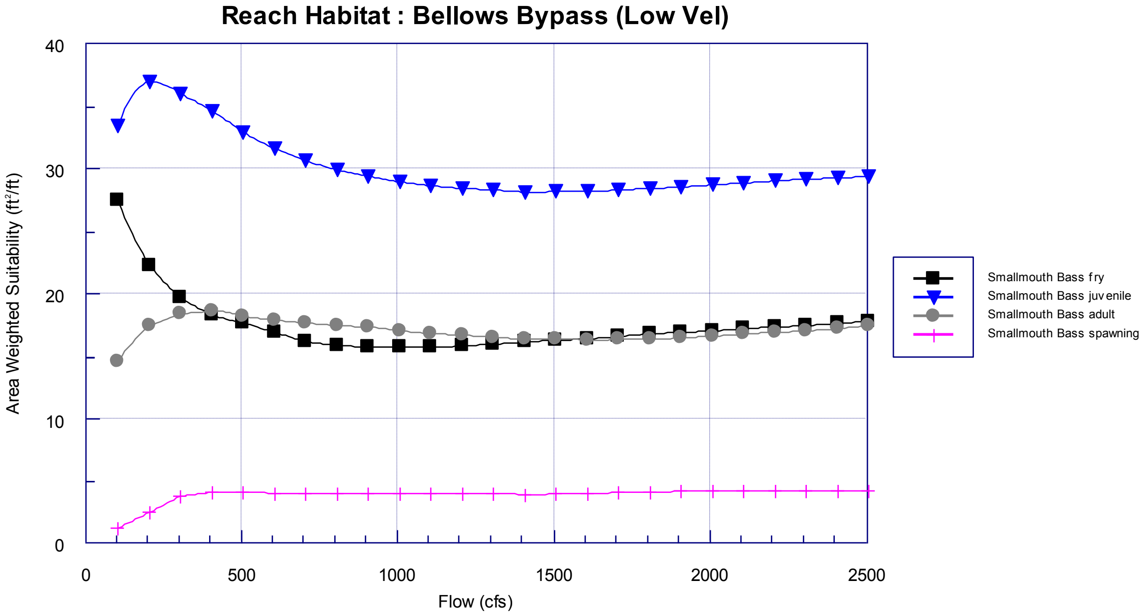
Juvenile

Adult

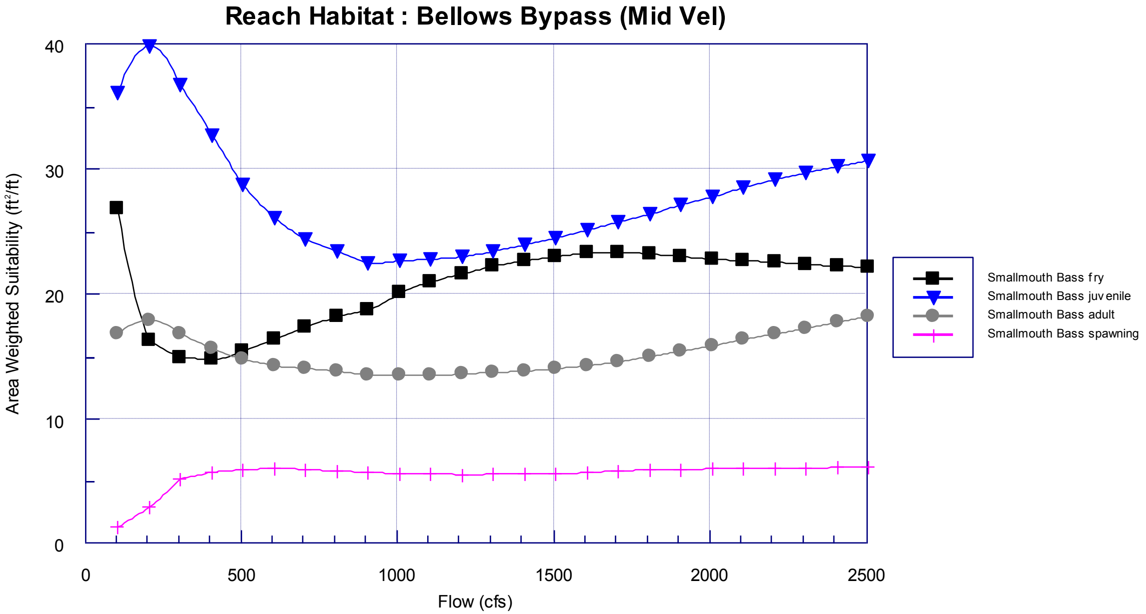


Reach Habitat : Bellows Bypass (Mid Vel)

Study 9 – Instream Flow Study – Habitat Index (AWS)



Smallmouth Bass:
Fry
Juvenile
Adult
Spawning



TransCanada

Study 9 – Instream Flow Study

- Final transect locations
- 1D transect model calibration (not covered here)
- 2D Johnston Island model calibration (not covered here)
  - 2D model for Chase Island calibrated but was not ready to include in report
- Final HSC (see report appendix)
- Habitat Index (AWS) graphs 1D reaches and 2D site at Johnston Island
  - Habitat index results by habitat type or groups of similar habitat types
- Bellows Falls bypassed reach (calibration and AWS)
- **Sumner Falls Demonstration Flow (DFA)**

Study 9 – Instream Flow Study

Sumner Falls Demonstration Flow (DFA)

- 5 transects established in the upper portion of Sumner Falls
- Bottom profiles surveyed
- 4 flow levels observed
- Discharge measured at the site using ADCP
- Changes in water surface elevation noted at each flow level by reading gages strategically placed across each transect
- Depth and wetted width calculated from WSE and bottom profile points (~150 to 230 points per transect)
- Aerial photos taken at each flow level

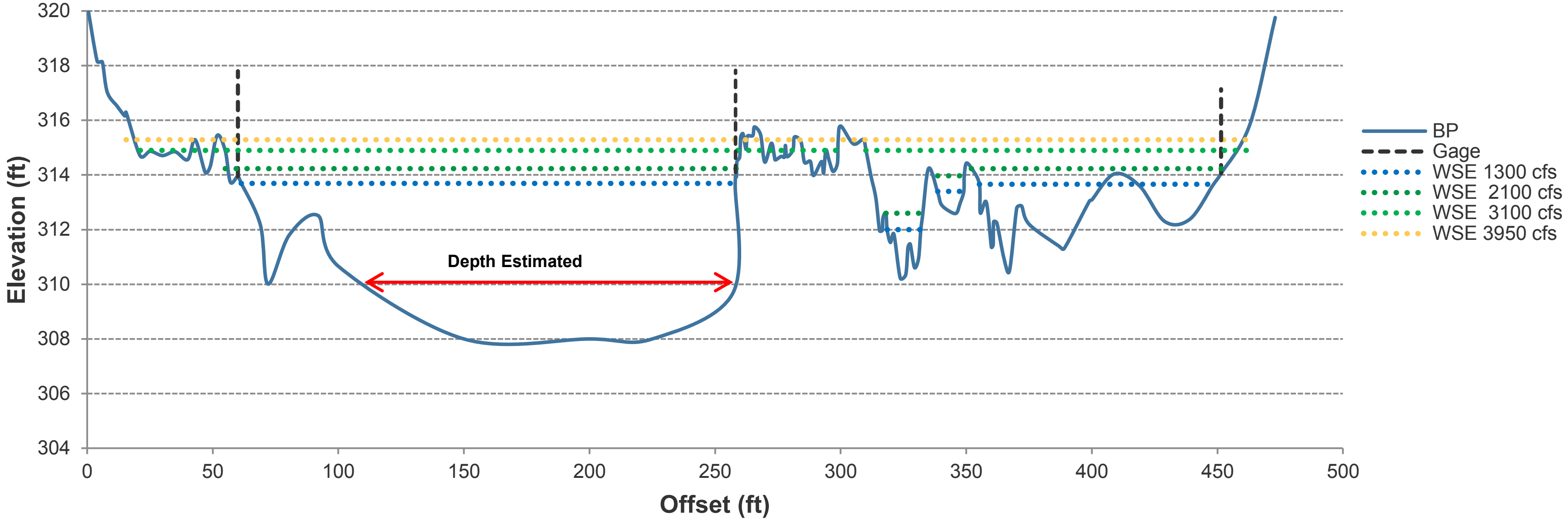
Study 9 – Instream Flow Study – Sumner Falls DFA

Study 9 – Instream Flow Study – Sumner Falls DFA

Study Area and Transect Locations – Flow 2,100 cfs

Study 9 – Instream Flow Study – Sumner Falls DFA

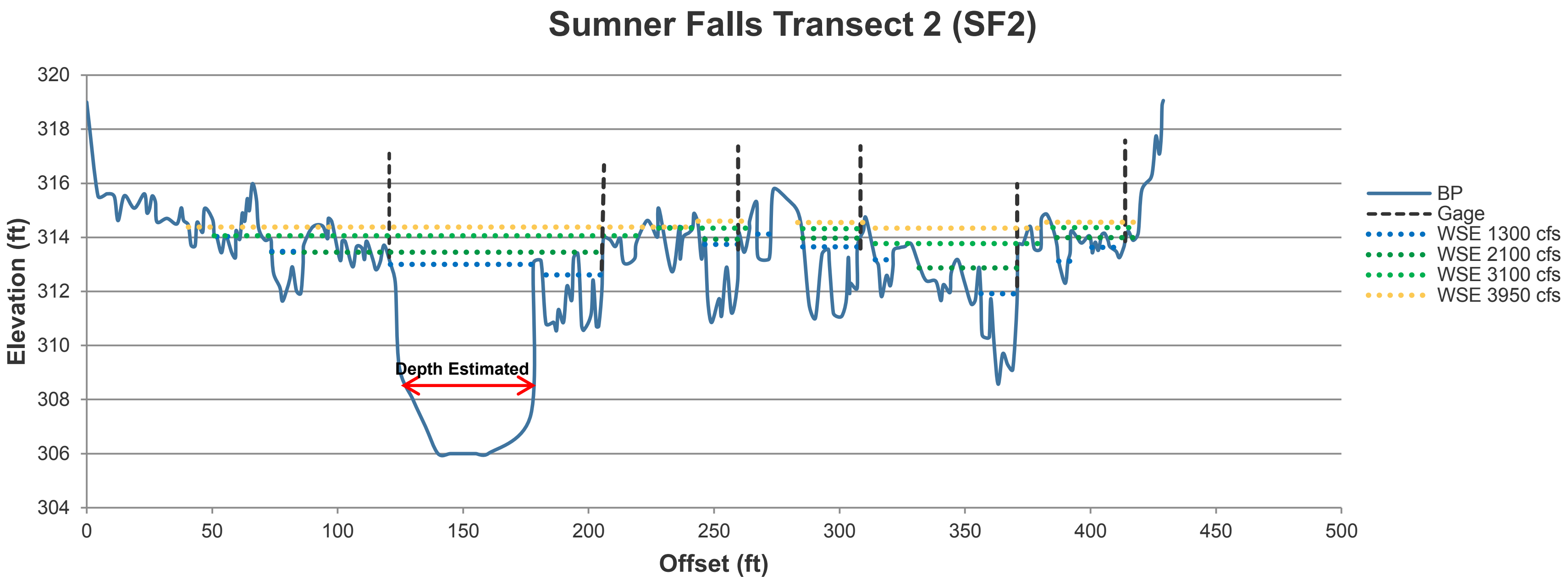
Bottom Profile and WSE at 4 flow levels


Sumner Falls Transect 1 (SF1)

SF1	Wetted Width by Depth Range (ft)					Percent Wetted Width by Depth				
Depth (ft)	<0.5	≥0.5<0.7	≥0.7<1.0	> 1.0	Total	<0.5	≥0.5	≥0.7	> 1.0	Total
1300 cfs	28.1	14.9	10.1	250.4	303.4	6%	58%	55%	53%	64%
2100 cfs	24.1	28.2	1.9	280.4	334.6	5%	66%	60%	59%	71%
3100 cfs	45.2	8.0	27.6	322.0	402.8	10%	76%	74%	68%	85%
3950 cfs	26.6	15.5	20.1	355.2	417.3	6%	83%	79%	75%	88%
Total Width					473					

Study 9 – Instream Flow Study – Sumner Falls DFA

Bottom Profile and WSE at 4 flow levels



Sumner Falls Transect 2 (SF2)

SF2	Wetted Width by Depth Range (ft)					Percent Wetted Width by Depth				
Depth (ft)	<0.5	≥0.5<0.7	≥0.7<1.0	> 1.0	Total	<0.5	≥0.5	≥0.7	> 1.0	Total
1300 cfs	22.5	9.9	15.5	122.2	170.1	5%	34%	32%	28%	40%
2100 cfs	41.0	19.8	11.3	138.4	210.4	10%	39%	35%	32%	49%
3100 cfs	67.9	17.7	33.5	179.9	299.0	16%	54%	50%	42%	70%
3950 cfs	39.2	29.5	29.4	213.5	311.5	9%	63%	57%	50%	73%
Total Width					429					

TransCanada

Study 9 – Instream Flow Study – Sumner Falls DFA

Results of all transects combined

Total	Wetted Width by Depth Range (ft)					Percent Wetted Width by Depth				
Depth (ft)	<0.5	≥0.5<0.7	≥0.7<1.0	> 1.0	Total	<0.5	≥0.5	≥0.7	> 1.0	Total
1300 cfs	135.4	56.1	71.3	964.4	1227.1	6%	48%	46%	42%	54%
2100 cfs	190.5	82.7	87.4	1082.2	1442.7	8%	55%	52%	48%	64%
3100 cfs	227.4	76.8	140.5	1323.4	1768.1	10%	68%	64%	58%	78%
3950 cfs	147.2	88.1	121.4	1510.5	1867.1	6%	76%	72%	67%	82%
Total Width					2270					

Study 9 – Instream Flow Study

Outstanding Items/Requests:

- Determine coding for RBT adult HSC for velocity refuges
- Examine the production of habitat “maps” showing steady state and persistent habitat for 1D transects

Study 9 – Instream Flow Study – RBT HSC

Rainbow Trout Adult HSC

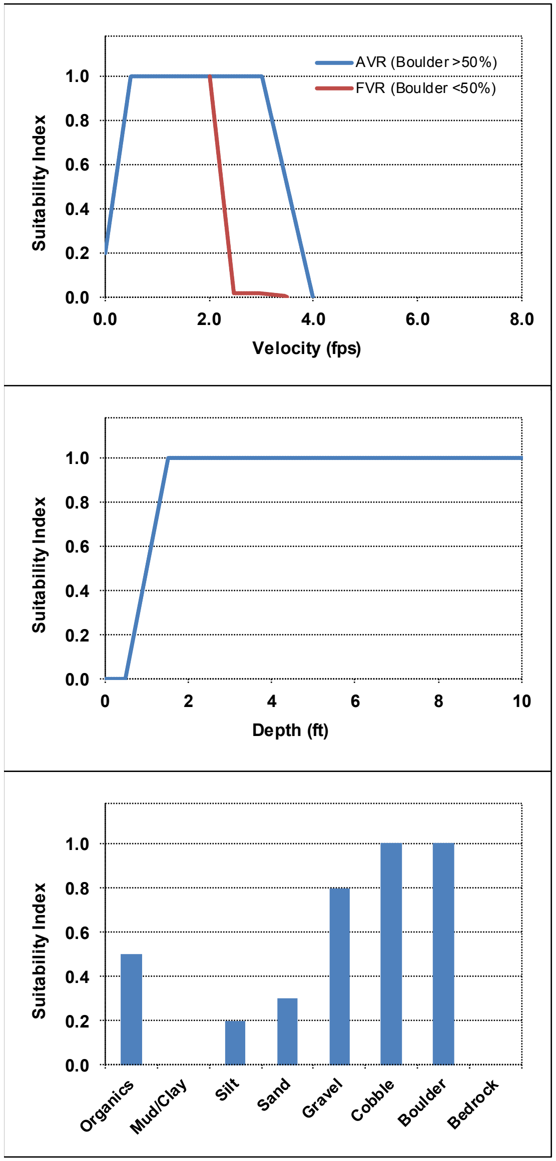
2 Sets of velocity criteria:

- **Abundant Refuges (Boulder >= 50%)**
- **Few Refuges (Boulder < 50% or any other substrate)**

Rainbow Trout

Velocity based Abundant (AVR) or Few (FVR) refuges

USFWS "Bluebook", modified for Clyde River study (1991)



Source:

Gomez and Sullivan, 2000

AVR (Boulder >50%)

Velocity (ft/s)	SI
0.00	0.20
0.50	1.00
3.00	1.00
4.00	0.00

FVR (Boulder <50%)

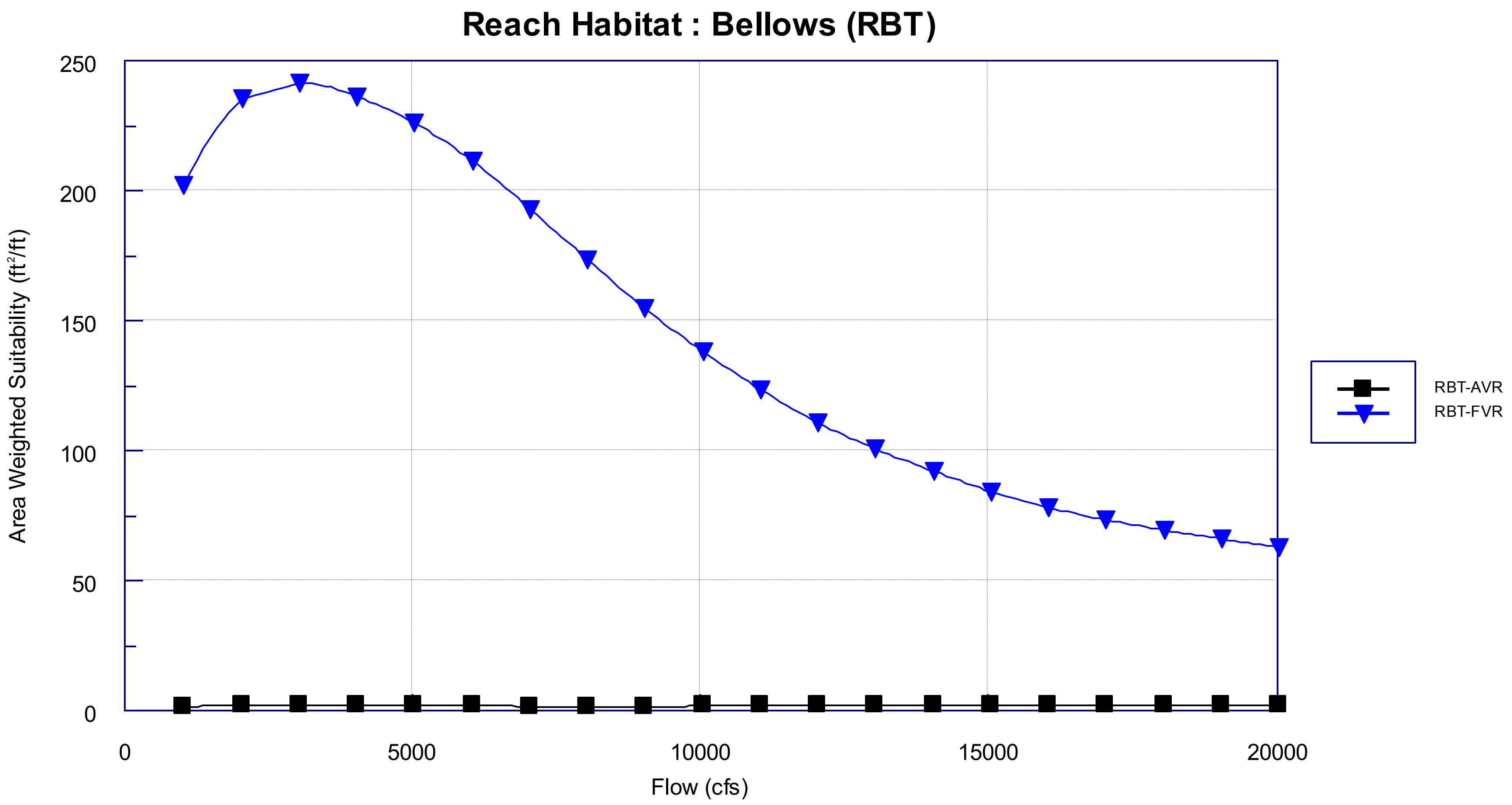
Velocity (ft/s)	SI
0.00	0.20
0.50	1.00
2.00	1.00
2.46	0.02
2.95	0.02
3.44	0.01
3.50	0.00

Depth (ft)	SI
0.00	0.00
0.50	0.00
1.50	1.00
100.00	1.00

Substrate	SI
Organics	0.50
Mud/Clay	0.00
Silt	0.20
Sand	0.30
Gravel	0.80
Cobble	1.00
Boulder	1.00
Bedrock	0.00

Study 9 – Instream Flow Study – RBT Habitat

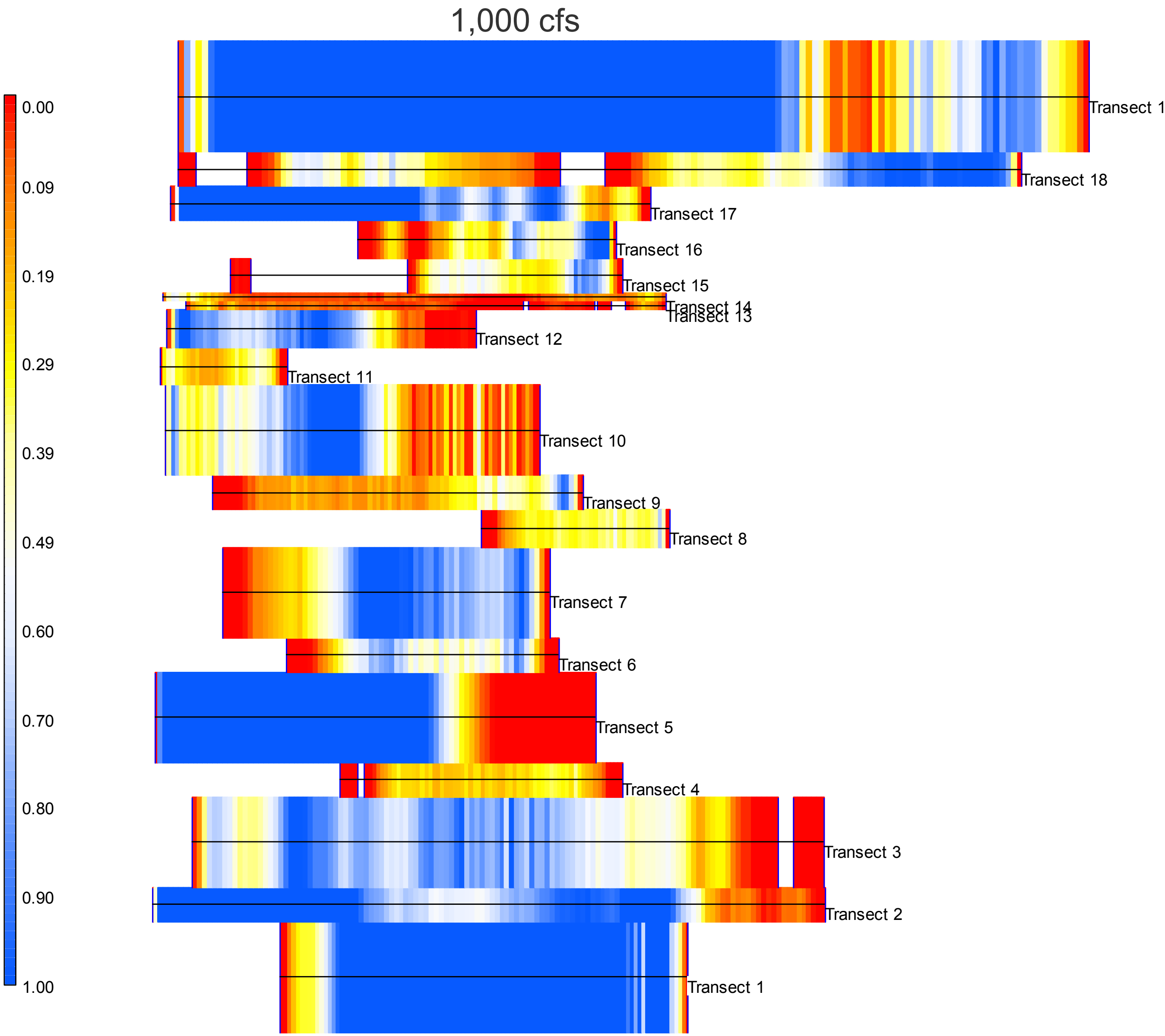
AVR – Abundant velocity refuges; FVR – Few velocity refuges



Study 9 – Instream Flow Study – Plan View Habitat

Bellows Reach

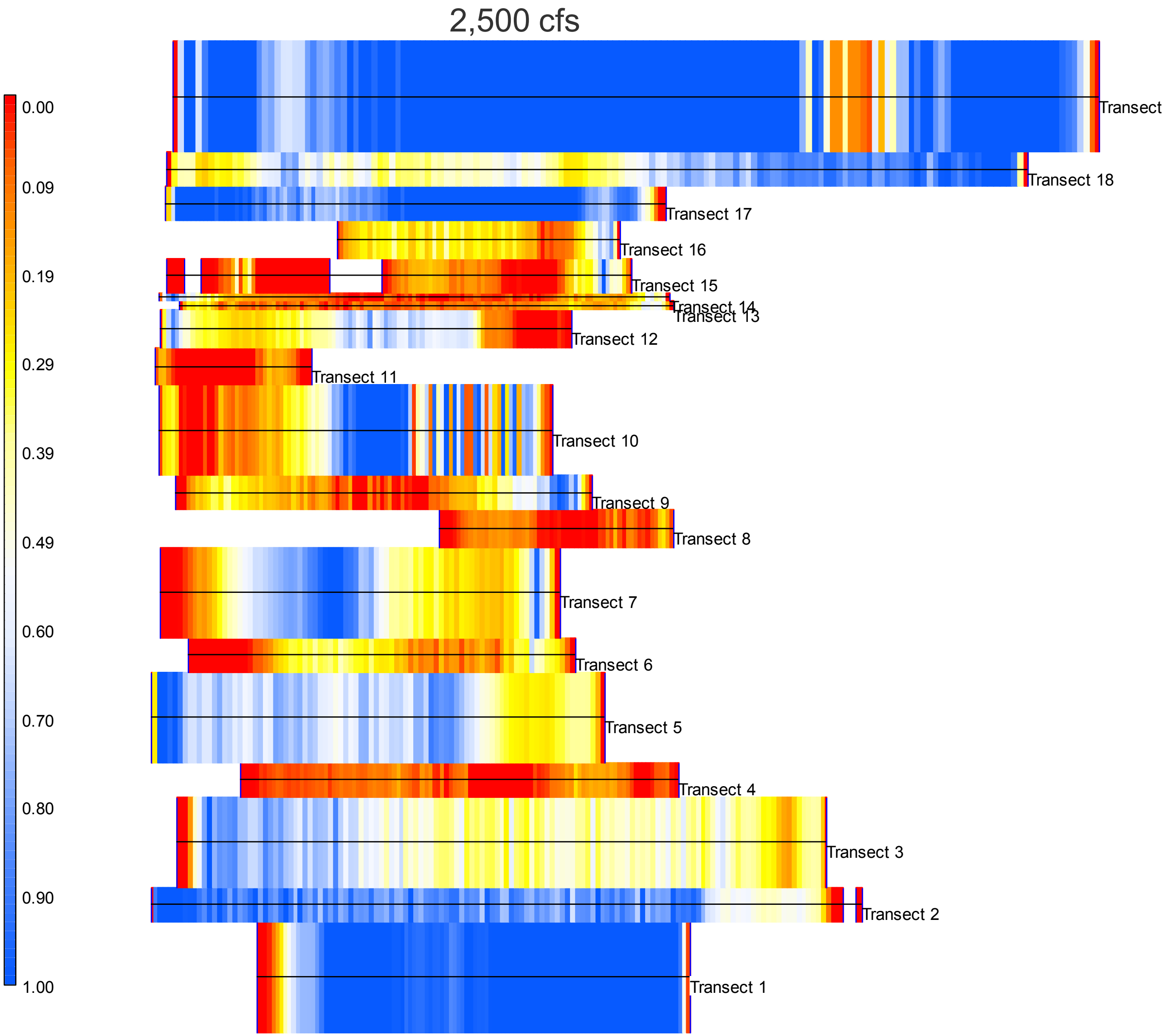
Fallfish Adult CSI



Study 9 – Instream Flow Study

Bellows Reach

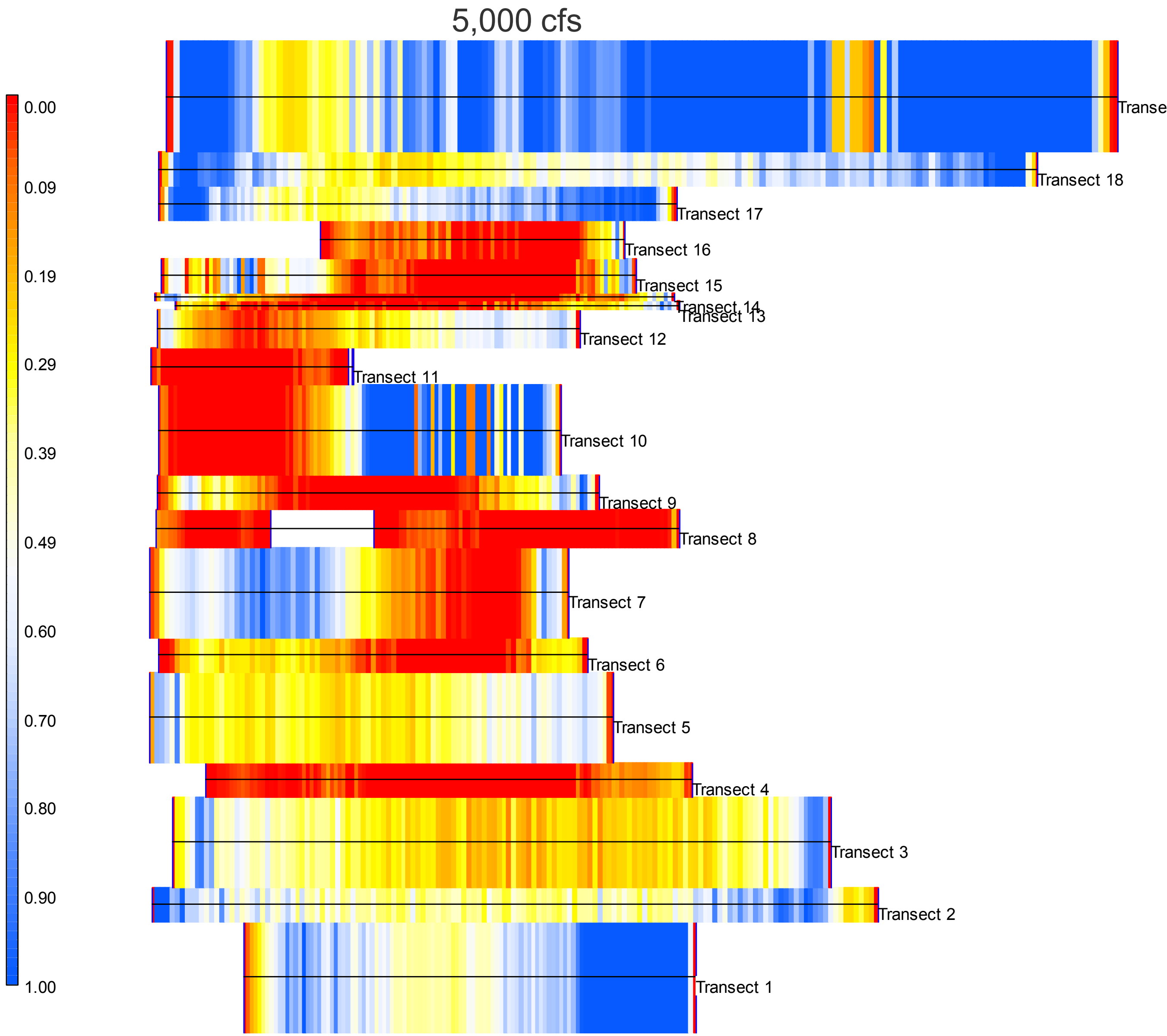
Fallfish Adult CSI



Study 9 – Instream Flow Study

Bellows Reach

Fallfish Adult CSI

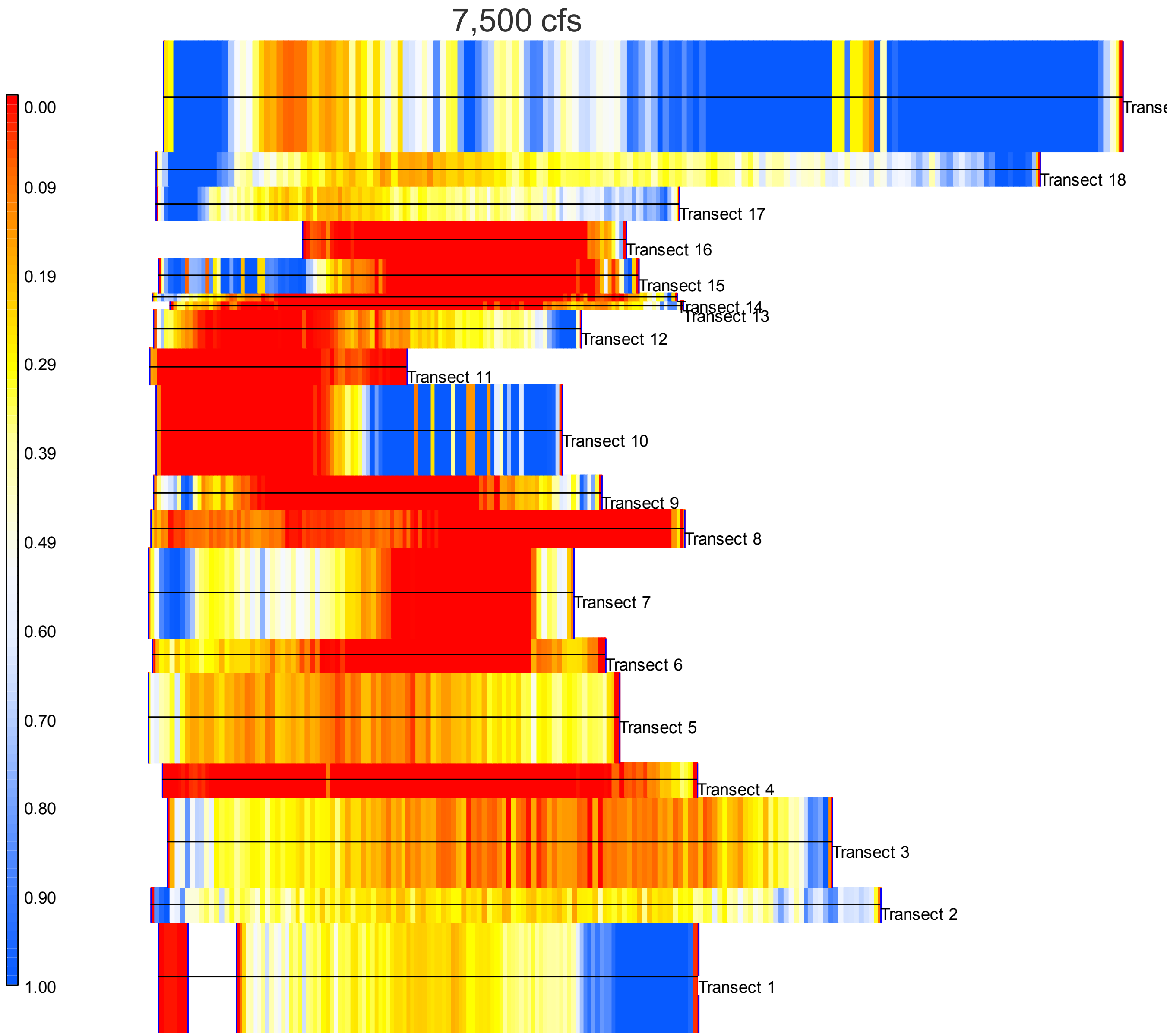


TransCanada

Study 9 – Instream Flow Study

Bellows Reach

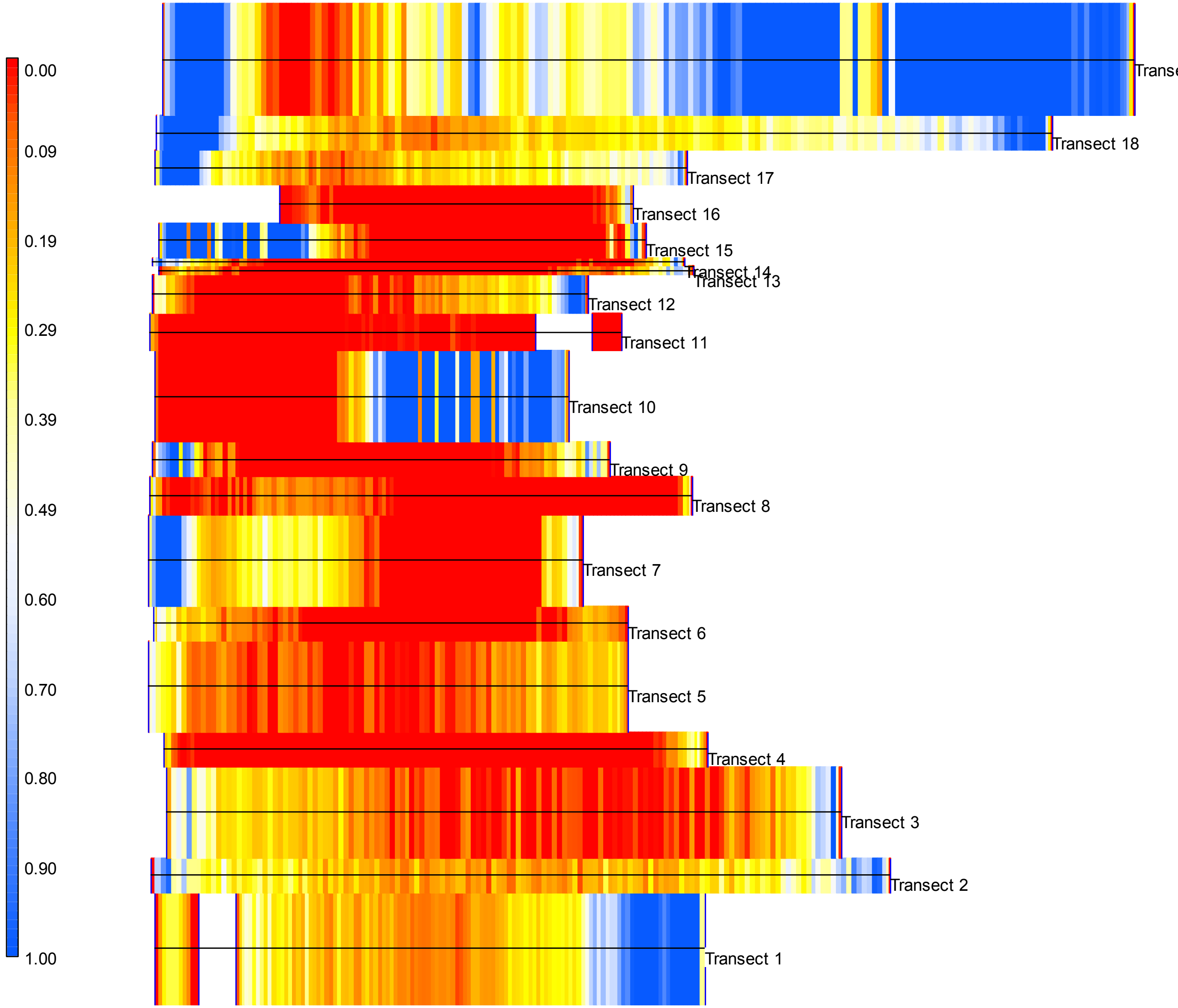
Fallfish Adult CSI



Study 9 – Instream Flow Study

Bellows Reach

Fallfish Adult CSI



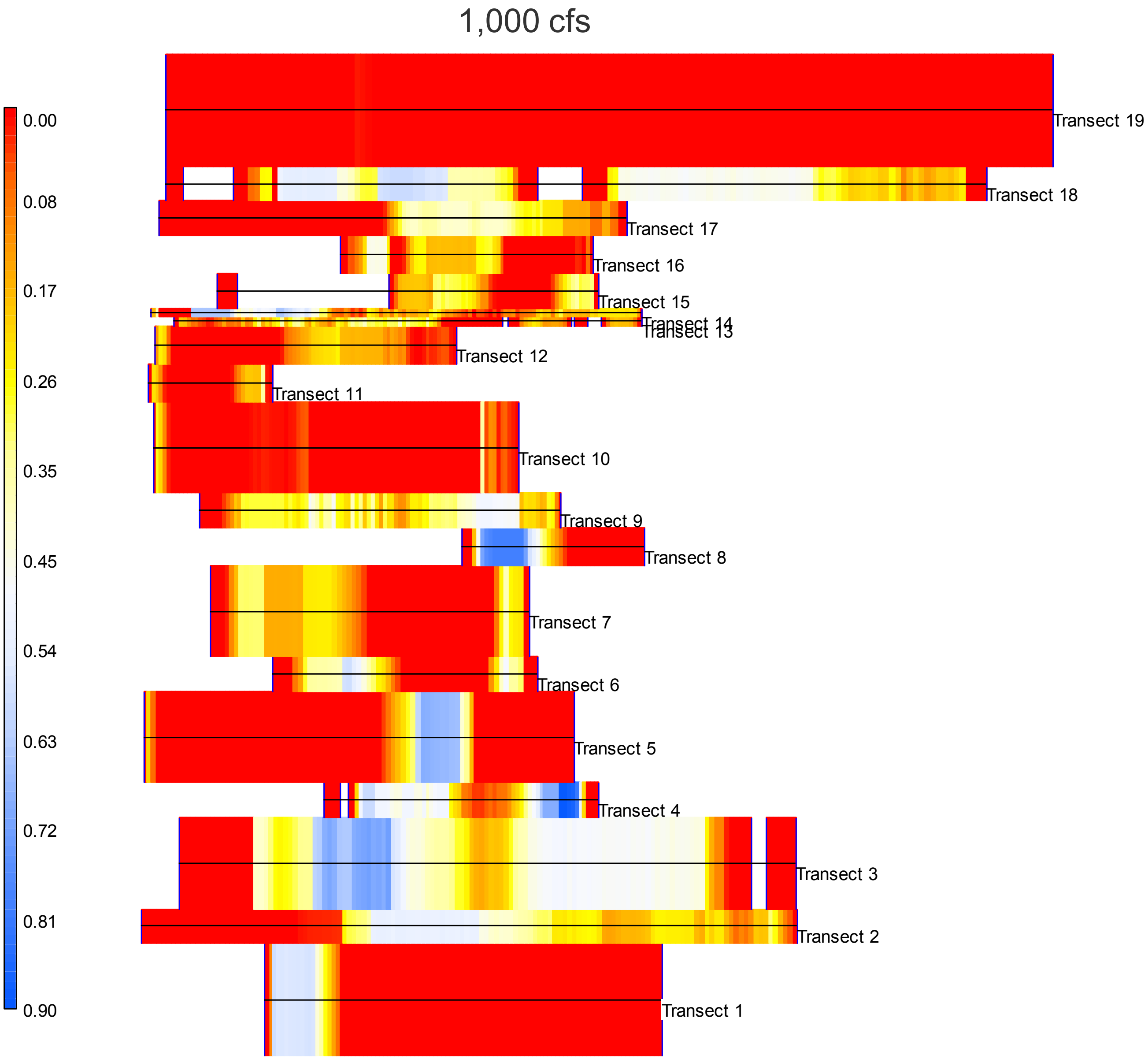
10,000 cfs

TransCanada

Study 9 – Instream Flow Study

Bellows Reach

Fallfish Spawning CSI

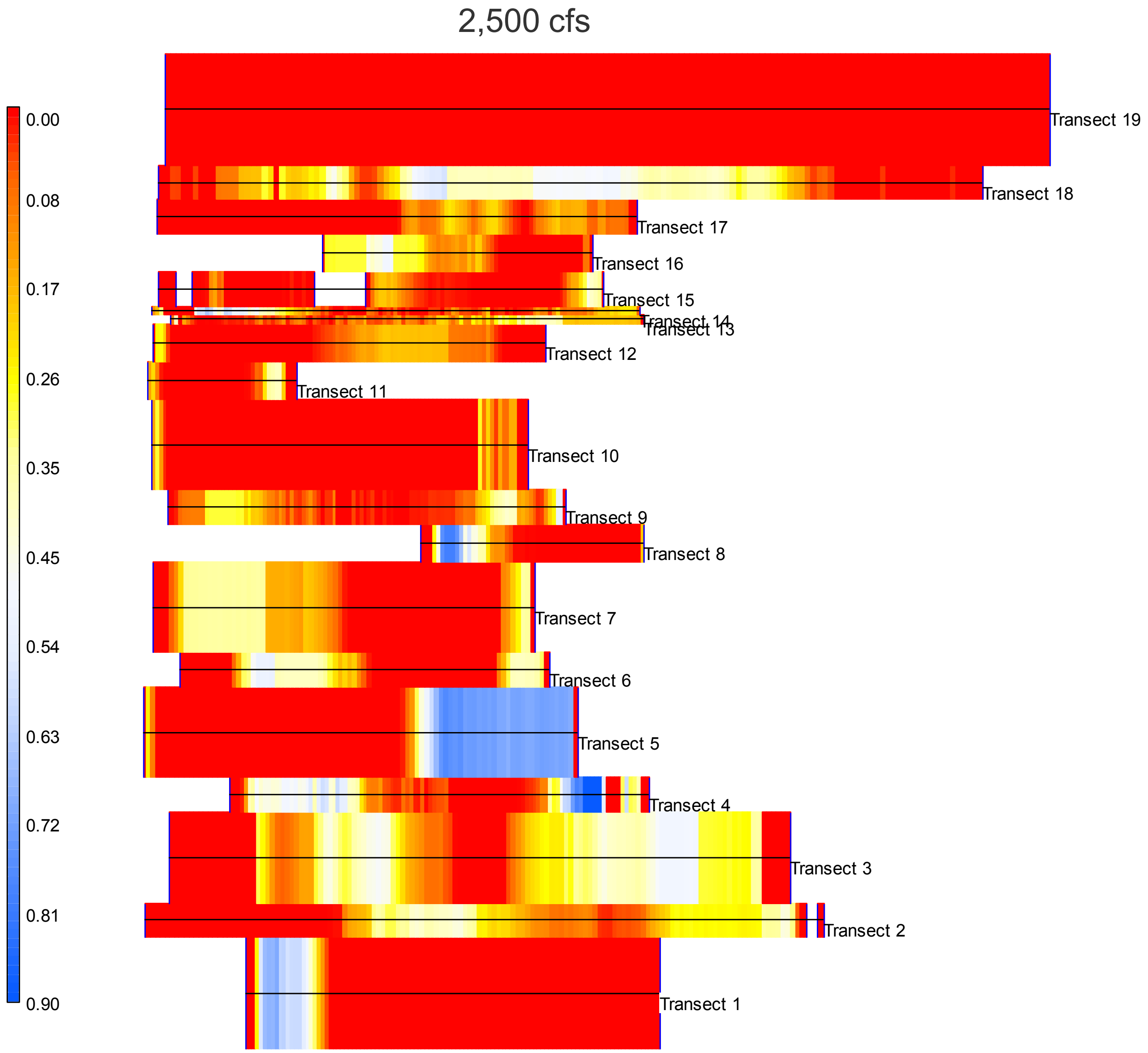


TransCanada

Study 9 – Instream Flow Study

Bellows Reach

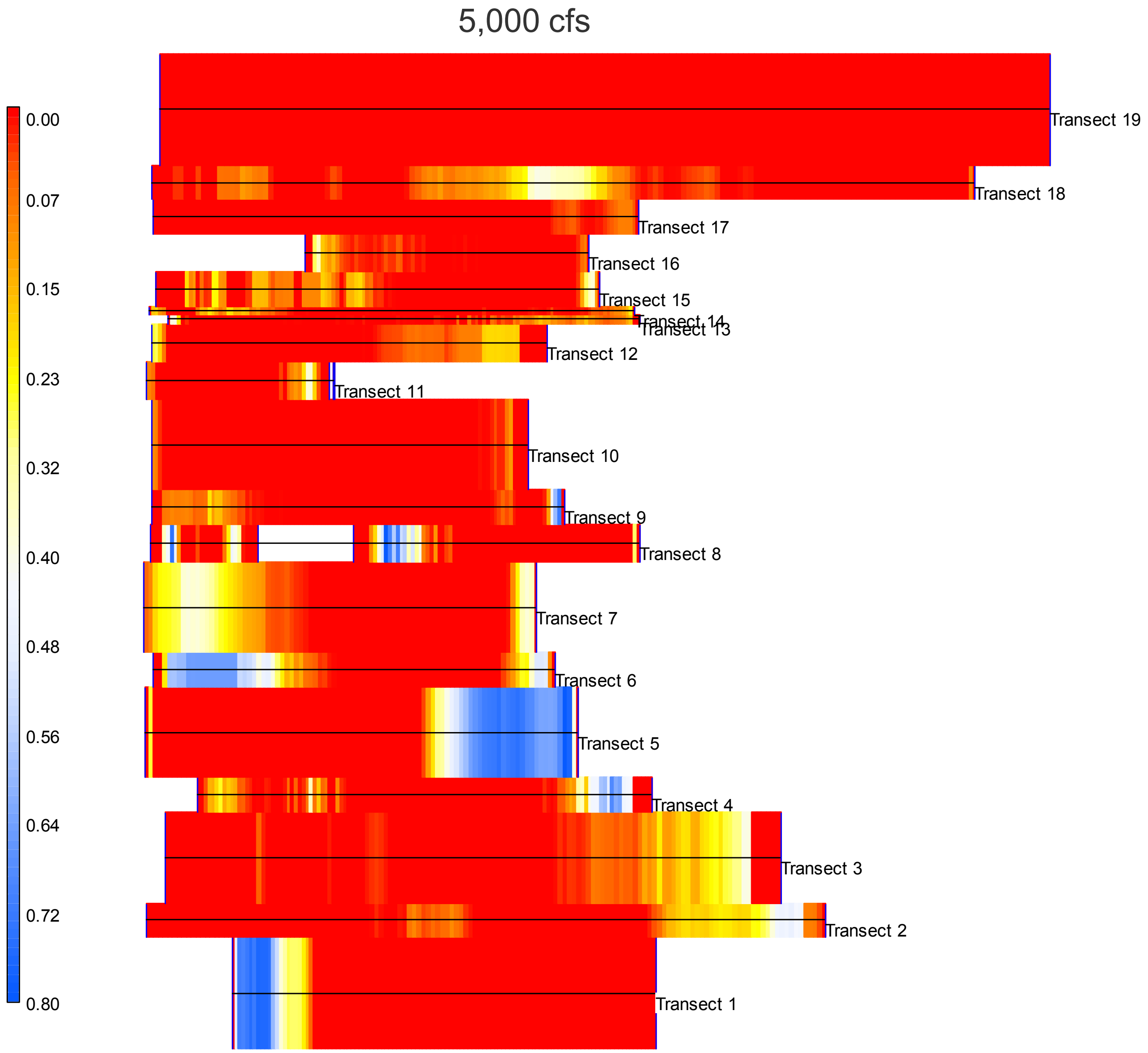
Fallfish Spawning CSI



Study 9 – Instream Flow Study

Bellows Reach

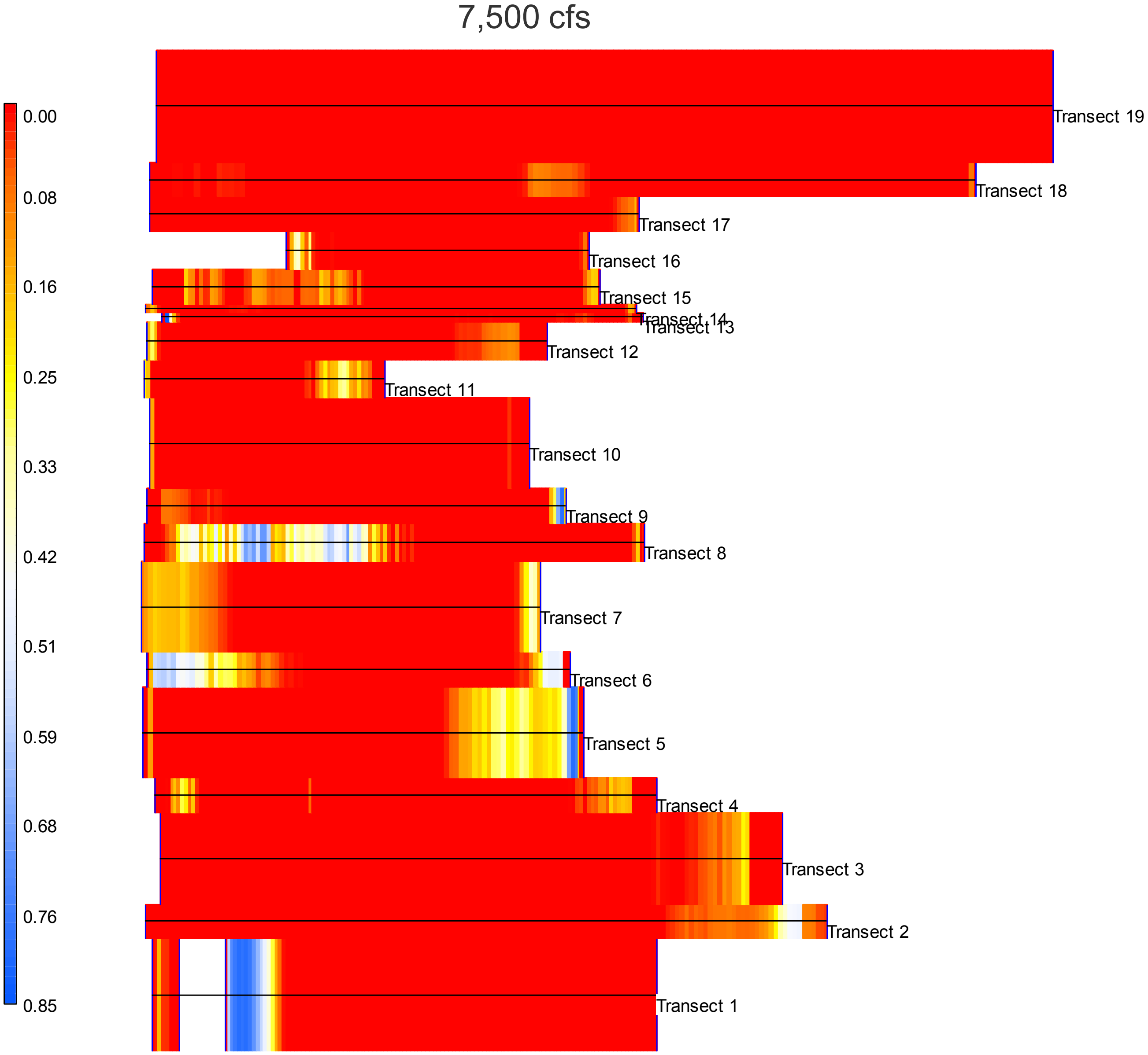
Fallfish Spawning CSI



Study 9 – Instream Flow Study

Bellows Reach

Fallfish Spawning CSI

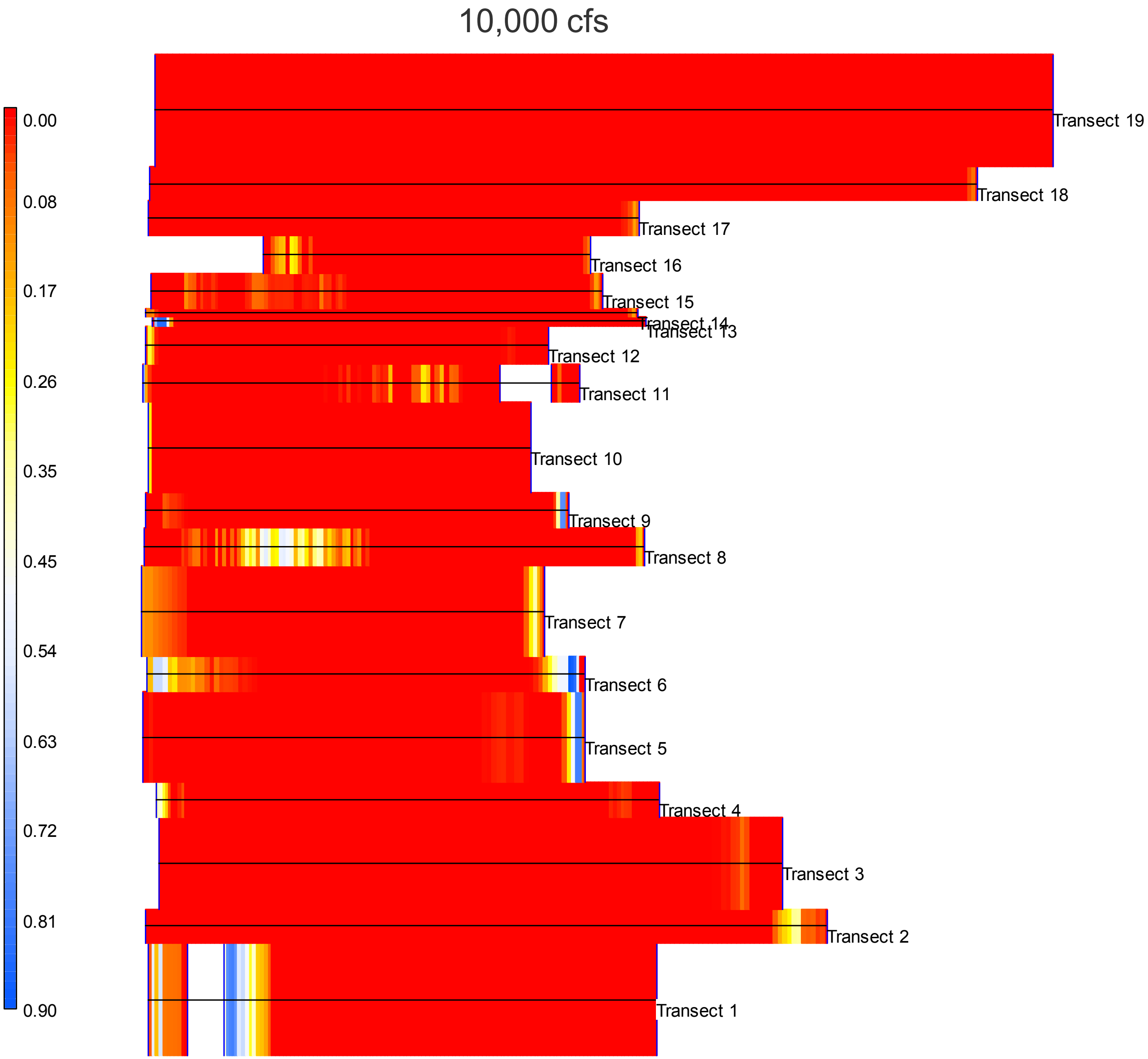


TransCanada

Study 9 – Instream Flow Study

Bellows Reach

Fallfish Spawning CSI



TransCanada

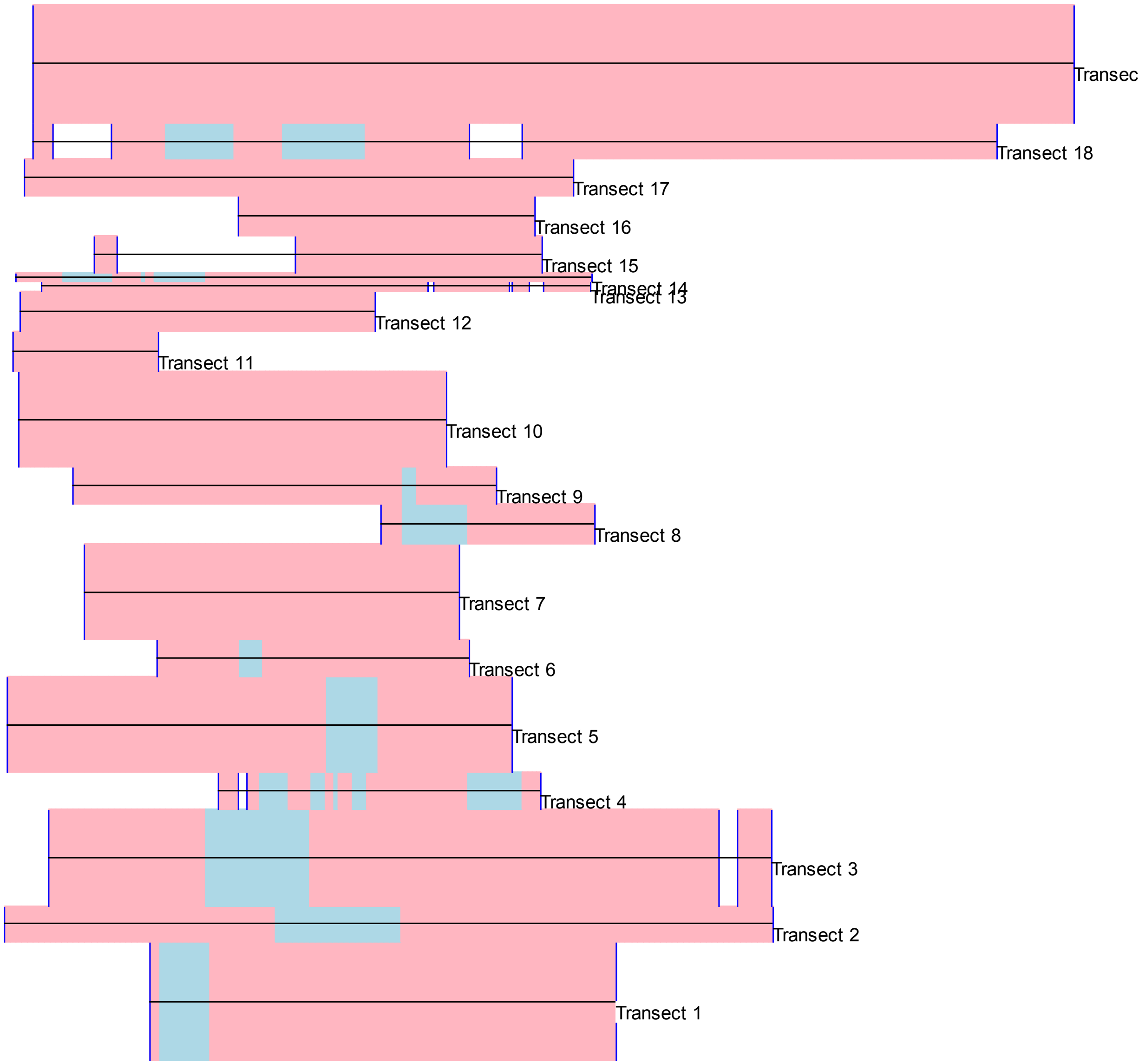
Study 9 – Instream Flow Study

Bellows Reach

Fallfish Spawning

Threshold CSI >= 0.5 (light blue)

1,000 cfs

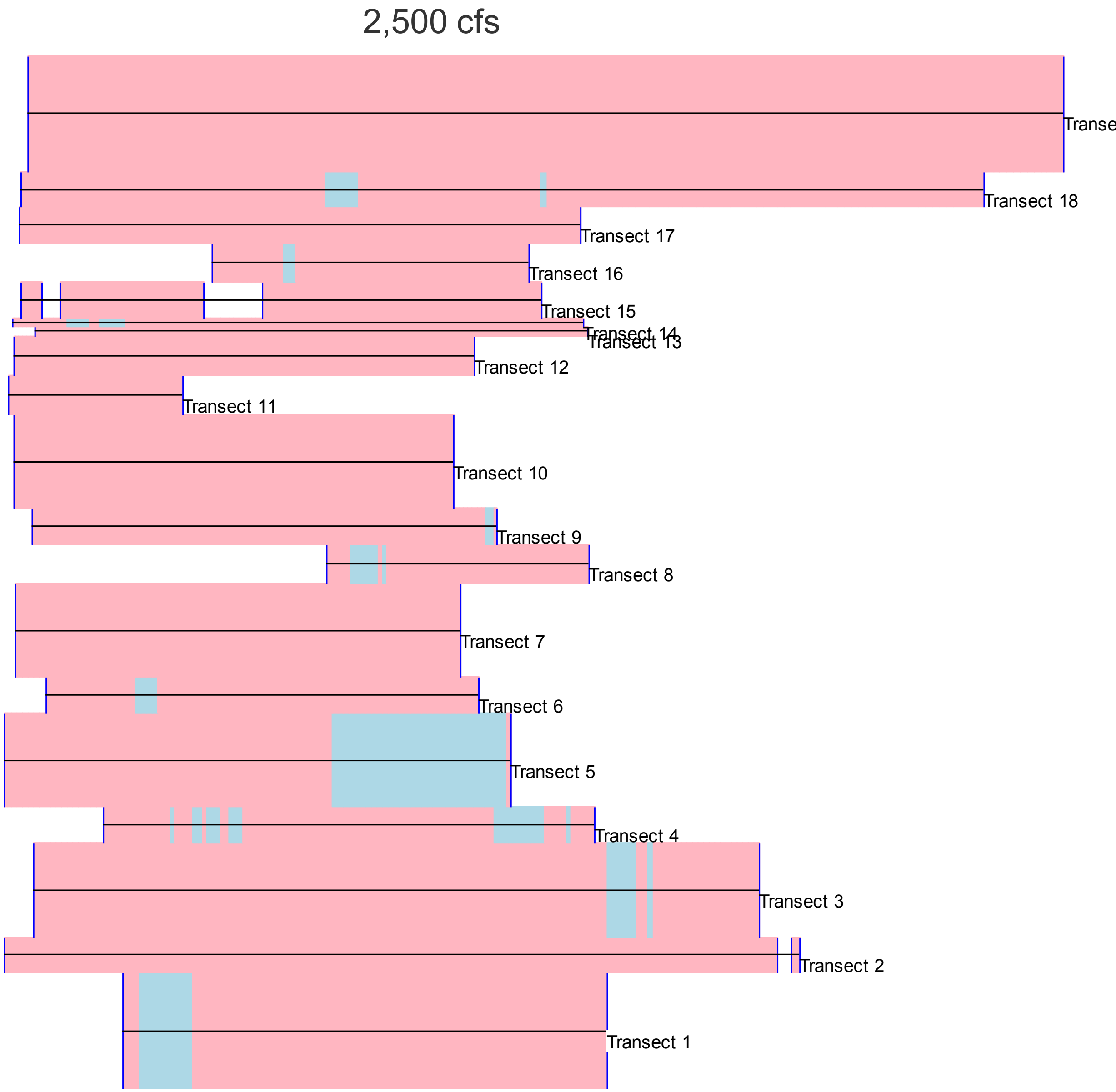


Study 9 – Instream Flow Study

Bellows Reach

Fallfish Spawning

Threshold CSI >= 0.5 (light blue)



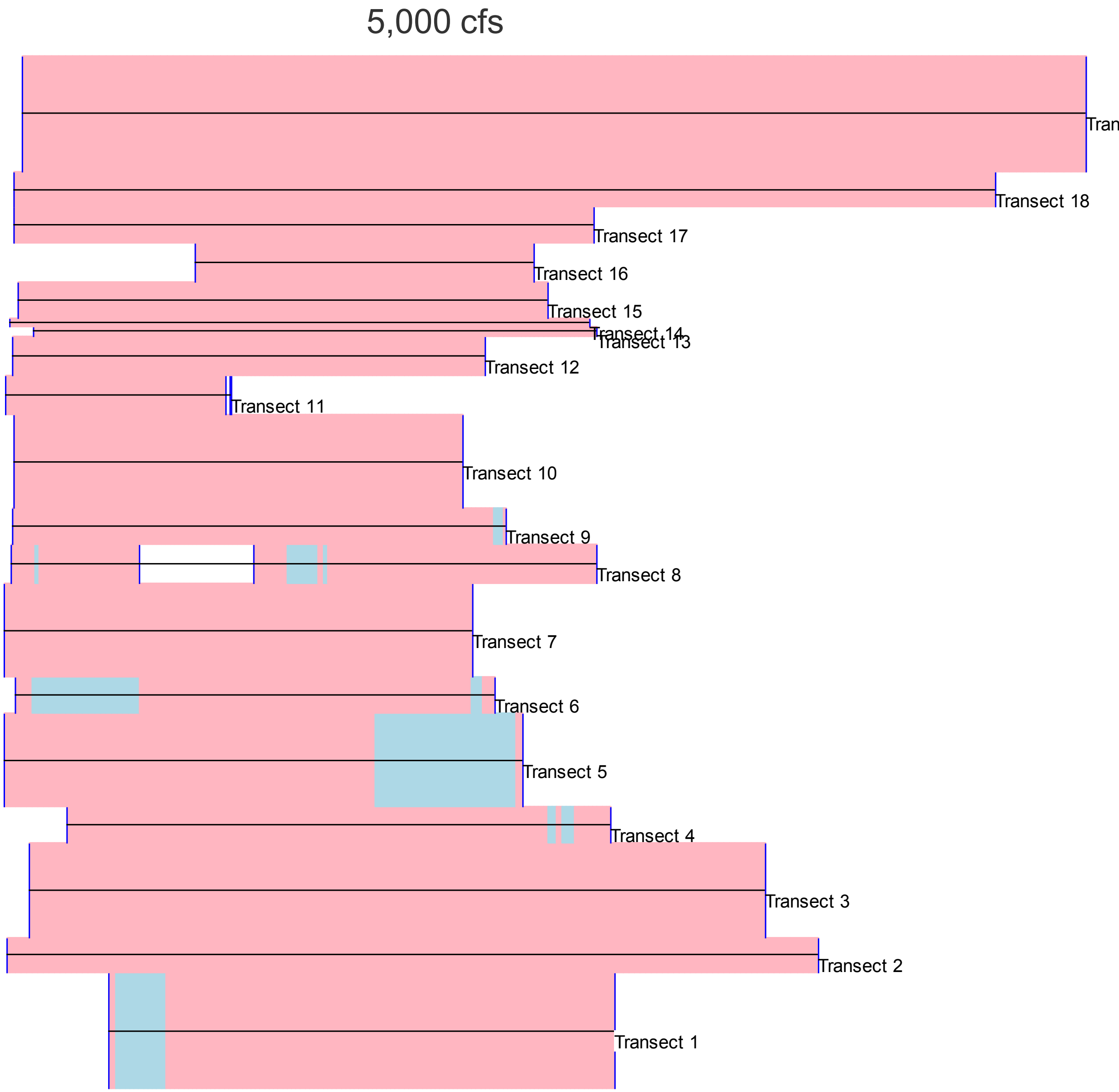
TransCanada

Study 9 – Instream Flow Study

Bellows Reach

Fallfish Spawning

Threshold CSI >= 0.5 (light blue)



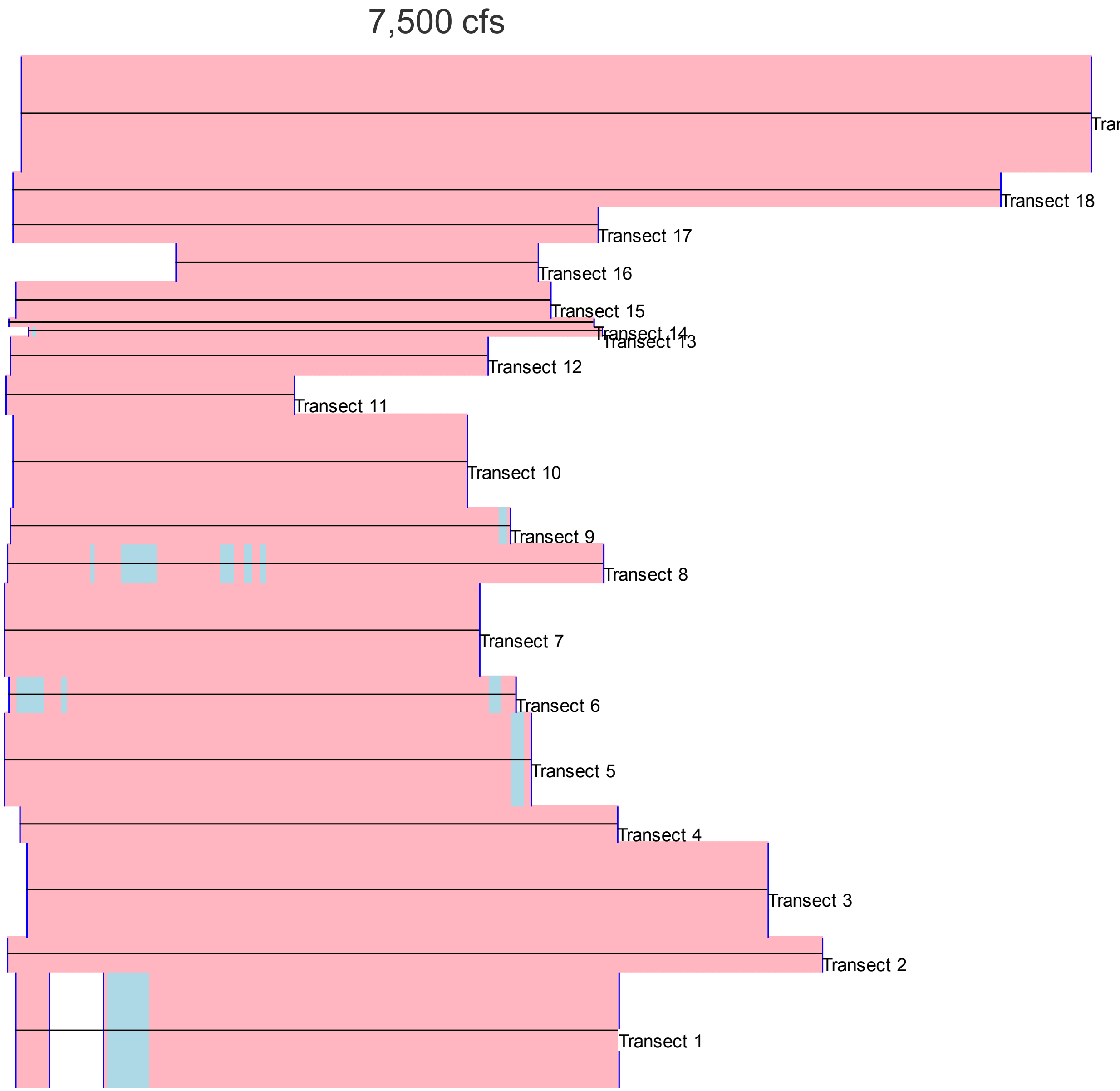
TransCanada

Study 9 – Instream Flow Study

Bellows Reach

Fallfish Spawning

Threshold CSI >= 0.5 (light blue)

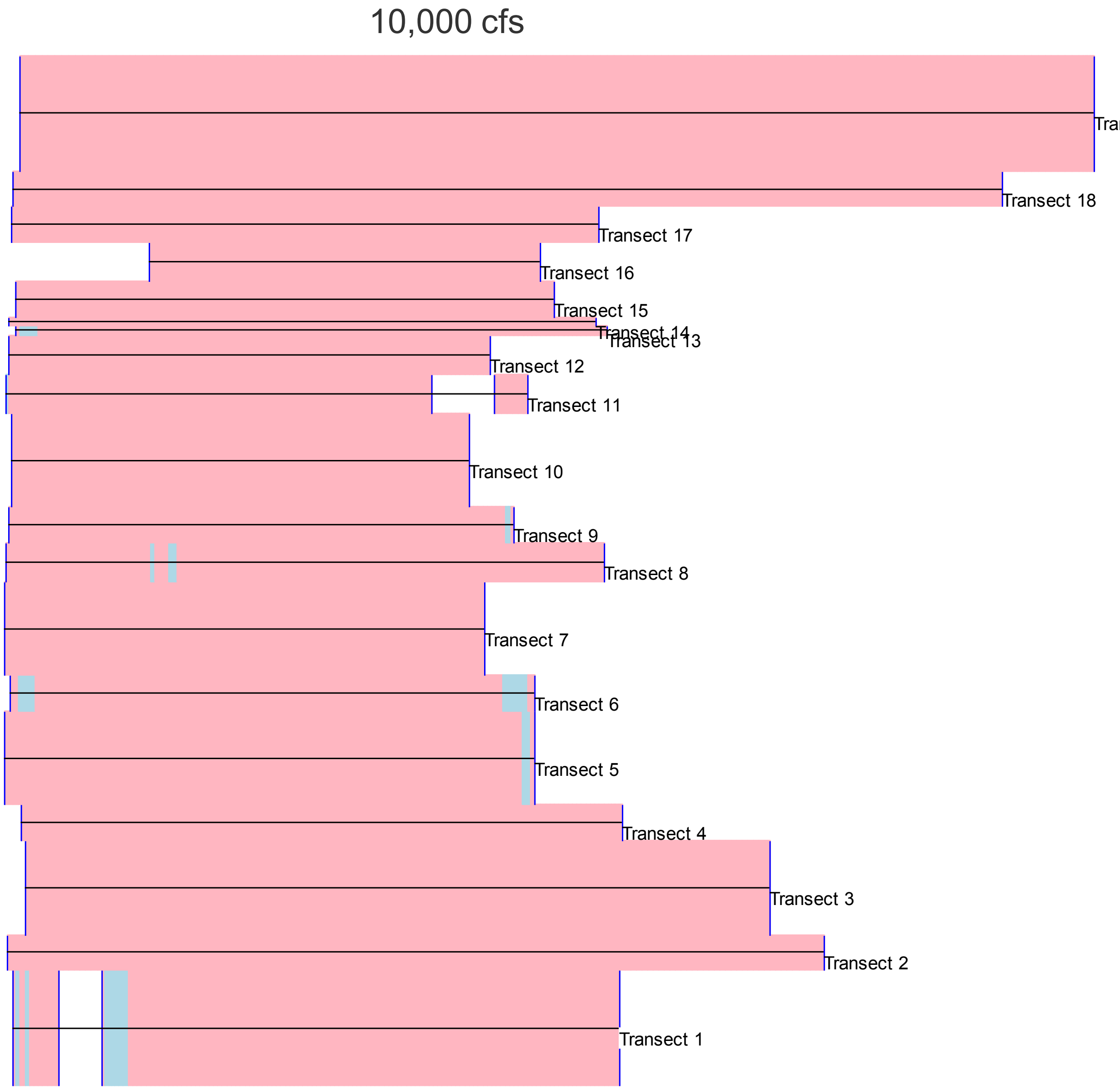


Study 9 – Instream Flow Study

Bellows Reach

Fallfish Spawning

Threshold CSI >= 0.5 (light blue)



TransCanada

Study 9 – Instream Flow Study

Remaining Activities:

- Habitat times series
    - Selection of species and life stages to analyze
    - 5 operational models

- Dual-Flow analysis
    - Selection of species and life stages to analyze
    - Determine flow combinations (e.g. base-peak)

QUESTIONS/COMMENTS

"Look, we've got to improve our habitat-modeling algorithms if we want to make more accurate wild-ass guesses."

TransCanada

Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

TransCanada

Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

Study Progress

- **2013** - Phase 1 field work completed, report filed in Vols IV, V of the ISR
- **2014**
  - Phase 2 study plan, consultation and plan revision (Vol VI of the ISR)
  - Field work in 2014 based on revised plan
- **2015**
  - FERC determination issued January 22, 2015
  - Phase 2 study report filed March 2, 2015
  - Additional consultation March 5, 2015

Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

Study Results to Date

Phase 1 Qualitative Sampling

- No live or dead dwarf wedgemussels were found at the 39 survey sites in the Wilder riverine reach. Co-occurring riverine mussel species were also rare.
- Few dwarf wedgemussels were found in the upper Wilder and Bellows Falls impoundments.
- Co-occurring riverine mussel species were also rare in both impoundments, except for eastern elliptio and eastern lampmussel.
- Dwarf wedgemussel populations were not considered large enough to permit <u>certain types</u> of quantitative sampling, monitoring, or analysis.

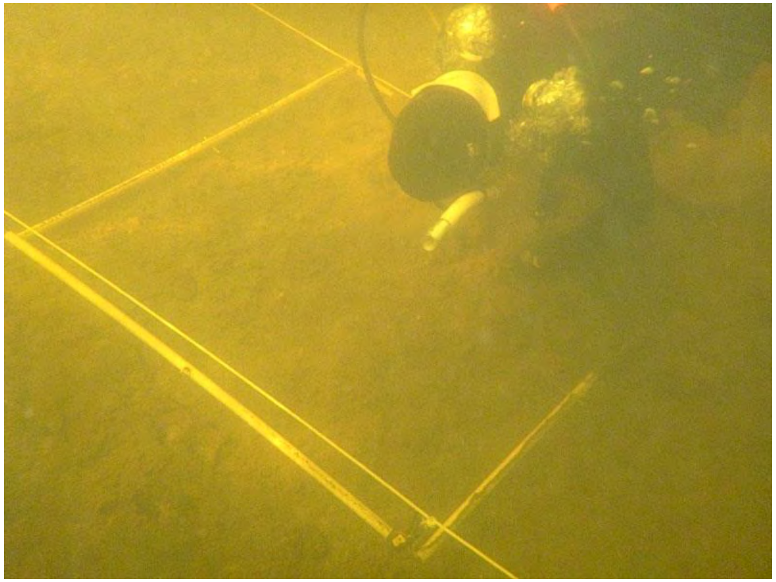
TransCanada

Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

Phase 2 Quantitative Sampling

Phase 2 Transects

- Live dwarf wedgemussels were found in 5 transects and shells were found in 2 additional transects.
- Brief qualitative surveys near transects documented an additional 9 live dwarf wedgemussels. Four transects had no live or dead dwarf wedgemussels.
- Location, habitat, and biological parameters were recorded for each transect.



Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

Phase 2 Quantitative Sampling

Phase 2 Quadrats

- Used 405 1.5x1.5 meter quadrats
- Low mussel densities throughout most of the 2,400-meter reach, with generally higher mussel densities near shorelines, in depositional areas, and hydraulic refugia.
- Only 251 mussels found, including 222 eastern elliptio, 28 eastern lampmussel, and only one dwarf wedgemussel and one triangle floater.
- Live dwarf wedgemussels not found in any of the historic monitoring sites that were within this sampling reach.
- Location, habitat, and biological parameters were recorded for each quadrat.

TransCanada

Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

2015-2016 “Phase 2A”

No additional field work in 2015

Develop Habitat Suitability Criteria (HSC)

- Draft HSC criteria framework for key parameters, with written rationale
- Identify regional experts willing to be part of the Delphi panel and provide background information
- Draft questionnaire to solicit opinion of the Delphi panel
- Fine-tune, eliminate, or add HSC variables based on responses from experts.
- Revise HSC based on comments and resubmit proposed HSC to panelists
- Repeat process 3 or 4 times until resolution and agreement is reached

Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

Phase 2A: Delphi Panel Progress

- Four Delphi panelists (only 3 participated)
- Round 1 questionnaire developed with proposed HSC variables: water depth, mean column velocity, benthic velocity, and substrate
- Based on Round 1 response, three HSC variable added: shear velocity, bed shear stress, relative shear stress.
- Currently (after three rounds) have complete consensus on two HSC curves, and majority consensus on the five remaining curves.

Study 24 – Dwarf Wedgemussel and Co-occurring Mussels

Remaining Activities

- Finalize HSC
- Data analysis and collaboration with other studies
- Final HSC will be used to model habitat in project-affected reaches using 1D and 2D modeling (Study 9), and the results will be used for interpretation and inclusion in the final study report
- Draft and final study report in 2016

Study 10

Fish Assemblage Study

Study 10 – Fish Assemblage Study

Study Progress

- Site selection conducted in late 2014 with working group
- Revised SSR filed in Volume II of the USR
- 69 sites (“map units”) selected for each of spring, summer, and fall sampling events
- Sampling gear types preselected based on anticipated site conditions (boat electrofish, two-hour experimental gill net set, pram or backpack electrofish, beach seine)
- Spring (May-June), Summer (July-August) and Fall (September-October) sampling completed.
- Study report filed March 1, 2016.

TransCanada

Study 10 – Fish Assemblage Study

Summary Statistics

Listed in the RSP

- Calculated on a seasonal basis
- Examined by river reach and habitat type
- Species richness (simple tabulation of number of species)
    - By river reach (sampling gears and seasons combined)
    - By season and river reach (sampling gears combined)
    - By season, river reach and sampling gear
    - By season, river reach and map-unit habitat type
- Diversity (indices to combine info on number of species and their relative abundance)
    - Shannon Diversity Index (H')
    - Evenness based on Shannon Diversity (E_H)
    - By season and river reach (sampling gears combined)
    - By season, river reach and sampling gear
    - By season, river reach and map-unit habitat type
- Relative Abundance (# fish captured with known sampling effort and indexed as CPUE)
    - Calculated for each species on a gear-specific basis
    - Calculated in units appropriate to each gear (e.g., #/hr for efish or gill net, #/haul for beach seine)

Study 10 – Fish Assemblage Study

Summary Statistics (continued)

- CPUA (Catch per unit of area)
- Study incorporated multiple sampling gears – all with inherent biases
- Sought a meaningful way to convert relative abundance data representing max number of gears and fish catch to a common scale to evaluate trends
- Converted “active” gear types to CPUA (i.e., #/100 m^2)
- “Passive” gears were excluded
    - Resulted in exclusion of 0.9% of total Study 10 catch
    - Approach modeled after USGS fish assemblage study on Missouri and Lower Yellowstone Rivers*
- CPUA values were calculated for each fish species by season, river reach, sampling gear and habitat type

---

* Wildhaber, M.L., D.W. Gladish, and A. Arab. 2012. Distribution and habitat use of the Missouri River and Lower Yellowstone River benthic fishes from 1996-1998: A baseline for fish community recovery. River Research and Applications 28: 1780-1803.

Study 10 – Fish Assemblage Study

Sampling Effort

- **Utilized five gear types**
- **Sampled during 3 seasons (spring: May-Jun, summer: Jul-Aug, fall: Sep-Oct)**
- **Total of 429 individual samples across seasons and river reaches**
- **Only season-reach combo not sampled was spring Bellows Falls bypassed reach – due to high flows**

River Reach	# Collected Samples SPRING					# Collected Samples SUMMER					# Collected Samples FALL					# Collected Samples TOTAL				
	BEF	PEF	GN	TN	BS	BEF	PEF	GN	TN	BS	BEF	PEF	GN	TN	BS	BEF	PEF	GN	TN	BS
WI	15	1	15	0	0	15	1	15	0	0	15	2	15	1	0	45	4	45	1	0
WR	0	14	0	0	9	0	14	0	0	12	0	13	0	0	12	0	41	0	0	33
BFI	12	1	11	0	1	12	1	12	1	0	12	2	11	0	1	36	4	34	1	2
BFB	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	6	0	0	0
BFR	0	15	0	0	12	0	14	0	0	11	0	13	0	0	12	0	42	0	0	35
VI	12	1	12	0	0	13	2	12	0	0	13	1	12	0	0	38	4	36	0	0
VR	3	2	2	0	1	3	1	2	0	1	3	1	2	0	1	9	4	6	0	3
Total	**42**	**34**	**40**	**0**	**23**	**43**	**36**	**41**	**1**	**24**	**43**	**35**	**40**	**1**	**26**	**128**	**105**	**121**	**2**	**73**

Study 10 – Fish Assemblage Study

Spring Sampling

- **11 families; 35 species; 3,936 individuals**
- **Overall abundance: Spottail Shiner (31%), Rock Bass (10%), Tessellated Darter (9%)**
- **Within reach: WI = Yellow Perch, WR = Rosyface Shiner, BFI, BFR, VI = Spottail Shiner, VR = Smallmouth Bass**

Family / Common Name	**ALL**	
	N	**%**
Anguillidae		
American Eel	0	0
Catostomidae		
Longnose Sucker	26	0.7
White Sucker	98	2.5
Centrarchidae		
Black Crappie	4	0.1
Bluegill	44	1.1
Largemouth Bass	24	0.6
Pumpkinseed	26	0.7
Rock Bass	385	9.8
Smallmouth Bass	238	6
Clupeidae		
American Shad	3	0.1
Cottidae		
Slimy Sculpin	81	2.1
Cyprinidae		
Blacknose Dace	44	1.1
Blacknose Shiner	0	0
Bluntnose Minnow	1	0
Bridle Shiner	1	0
Common Carp	0	0
Common Shiner	133	3.4
Creek Chub	34	0.9
Cutlips Minnow	0	0
Eastern Silvery Minnow	3	0.1
Fallfish	335	8.5
Fathead Minnow	0	0
Finescale Dace	0	0

Family / Common Name	**ALL**	
	N	**%**
Cyprinidae		
Golden Shiner	10	0.3
Lake Chub	4	0.1
Longnose Dace	28	0.7
Mimic Shiner	4	0.1
Rosyface Shiner	339	8.6
Spottail Shiner	1204	30.6
Esocidae		
Chain Pickerel	2	0.1
Northern Pike	21	0.5
Fundulidae		
Banded Killifish	6	0.2
Gadidae		
Burbot	0	0
Ictaluridae		
Brown bullhead	3	0.1
Channel Catfish	1	0
Yellow Bullhead	1	0
Moronidae		
White Perch	0	0
Percidae		
Tessellated Darter	346	8.8
Walleye	59	1.5
Yellow Perch	371	9.4
Petromyzontidae		
Sea Lamprey	38	1
Salmonidae		
Brook Trout	17	0.4
Brown Trout	2	0.1

Study 10 – Fish Assemblage Study

Spring Sampling

River Reach	Richness	Diversity	Evenness
Wilder impoundment	15	2.07	0.76
Wilder riverine	21	2.21	0.73
Bellows Falls impoundment	20	1.39	0.46
Bellows Falls bypassed reach	n/a	n/a	n/a
Bellows Falls riverine	23	2.44	0.78
Vernon impoundment	19	1.75	0.6
Vernon riverine	16	2.13	0.77
All Reaches	35	2.41	0.68

- **Richness – ranged from 23 (BFR) to 16 (VR)**
- **Diversity – ranged from 2.44 (BFR) to 1.39 (BFI)**
- **Evenness* – ranged from 0.78 (BFR) to 0.46 (BFI)**
- **BFI values likely influenced by high contribution of Spottail Shiner to catch in that reach**

---

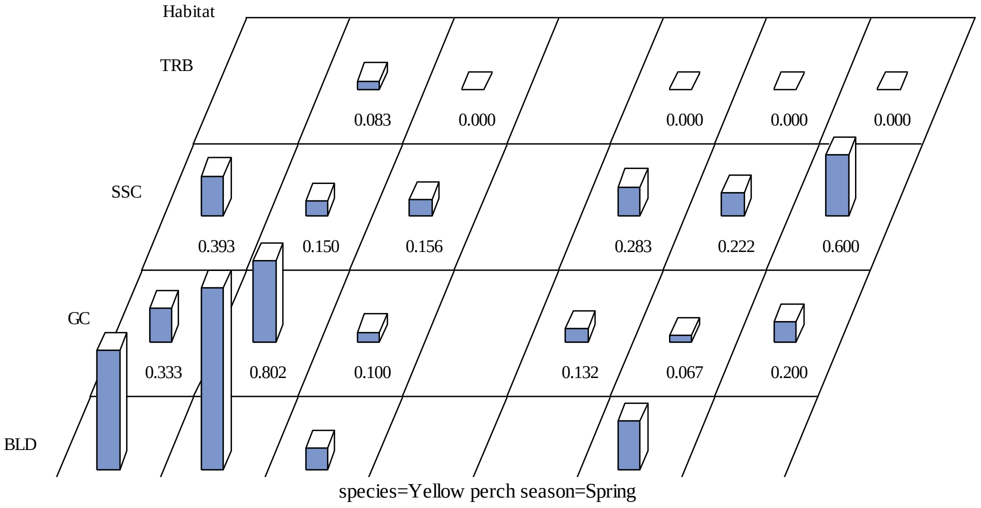
* Evenness runs on a scale of 0 to 1. Values closer to 1 indicate more even distribution among species whereas values closer to 0 indicate dominance by one or more species

Study 10 – Fish Assembla

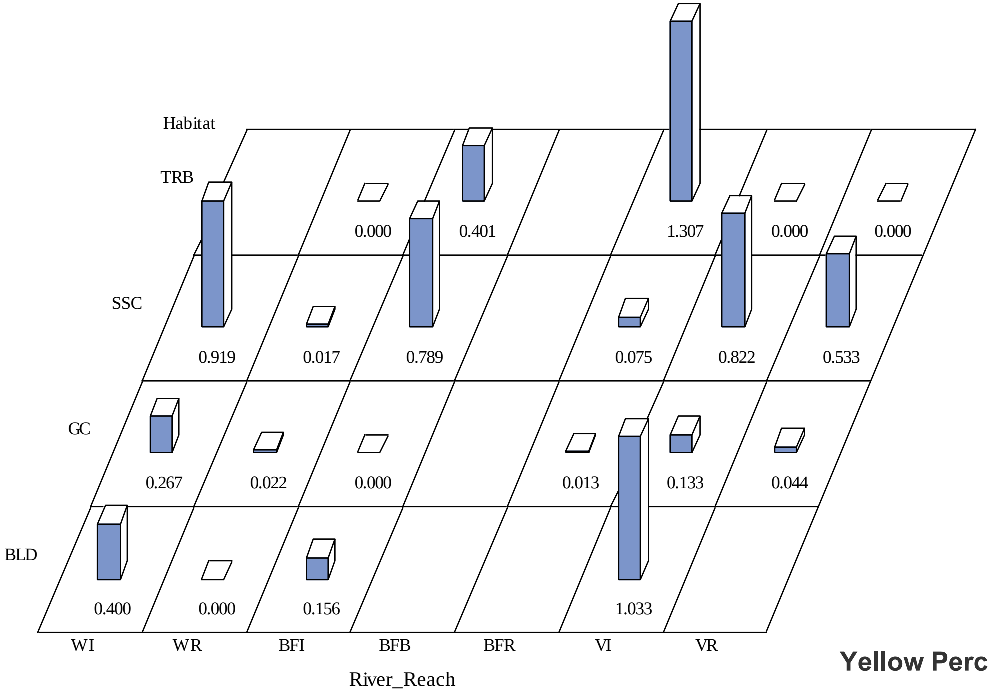
Spring Sampling

- CPUE values for all 35 species by river reach, sampling gear and habitat type (Appendix)
- Report details spatial distribution of CPUA values by river reach and habitat type for fish species representing ~85% of spring catch
    - Spottail Shiner
    - Rock Bass
    - Yellow Perch
    - Tessellated Darter
    - Rosyface Shiner
    - Fallfish
    - Smallmouth Bass
    - Common Shiner
- CPUA values for all species presented in Appendices

TransCanada



Rock Bass



Yellow Perch

Study 10 – Fish Assemblage Study

Summer Sampling

- **13 families; 36 species; 3,776 individuals**
- **Overall abundance: Spottail Shiner (19%), Fallfish (16%), Smallmouth Bass (13%)**
- **Within reach: WI, WR = Fallfish, BFI = Yellow Perch, BFB = Longnose Dace, BFR & VR = Smallmouth Bass, VI = Spottail Shiner**

Family / Common Name	ALL	
	N	%
Anguillidae		
American Eel	0	0
Catostomidae		
Longnose Sucker	0	0
White Sucker	230	6.1
Centrarchidae		
Black Crappie	12	0.3
Bluegill	152	4
Largemouth Bass	87	2.3
Pumpkinseed	34	0.9
Rock Bass	209	5.5
Smallmouth Bass	480	12.7
Clupeidae		
American Shad	33	0.9
Cottidae		
Slimy Sculpin	24	0.6
Cyprinidae		
Blacknose Dace	9	0.2
Blacknose Shiner	0	0
Bluntnose Minnow	3	0.1
Bridle Shiner	7	0.2
Common Carp	2	0.1
Common Shiner	18	0.5
Creek Chub	29	0.8
Cutlips Minnow	0	0
Eastern Silvery Minnow	4	0.1
Fallfish	620	16.4
Fathead Minnow	2	0.1
Finescale Dace	2	0.1
Cyprinidae		
Golden Shiner	67	1.8
Lake Chub	0	0
Longnose Dace	89	2.4
Mimic Shiner	0	0
Rosyface Shiner	5	0.1
Spottail Shiner	746	19.8
Esocidae		
Chain Pickerel	6	0.2
Northern Pike	16	0.4
Fundulidae		
Banded Killifish	3	0.1
Gadidae		
Burbot	3	0.1
Ictaluridae		
Brown Bullhead	9	0.2
Channel Catfish	7	0.2
Yellow Bullhead	0	0
Moronidae		
White Perch	4	0.1
Percidae		
Tessellated Darter	401	10.6
Walleye	14	0.4
Yellow Perch	433	11.5
Petromyzontidae		
Sea Lamprey	15	0.4
Salmonidae		
Brook Trout	0	0
Brown Trout	1	0

Study 10 – Fish Assemblage Study

Summer Sampling

- **Richness – ranged from 21 (WI & VI) to 9 (BFB)**
- **Diversity – ranged from 2.19 (WI) to 1.09 (BFB)**
- **Evenness* – ranged from 0.76 (BFI) to 0.50 (BFB)**
- **BFB values likely influenced by high contribution of Longnose Dace to catch in that reach**

River Reach	Richness	Diversity	Evenness
Wilder impoundment	21	2.19	0.72
Wilder riverine	19	1.87	0.63
Bellows Falls impoundment	17	2.15	0.76
Bellows Falls bypassed reach	9	1.09	0.5
Bellows Falls riverine	18	2.02	0.7
Vernon impoundment	21	2.11	0.69
Vernon riverine	16	2.09	0.75
All Reaches	36	2.49	0.69

---

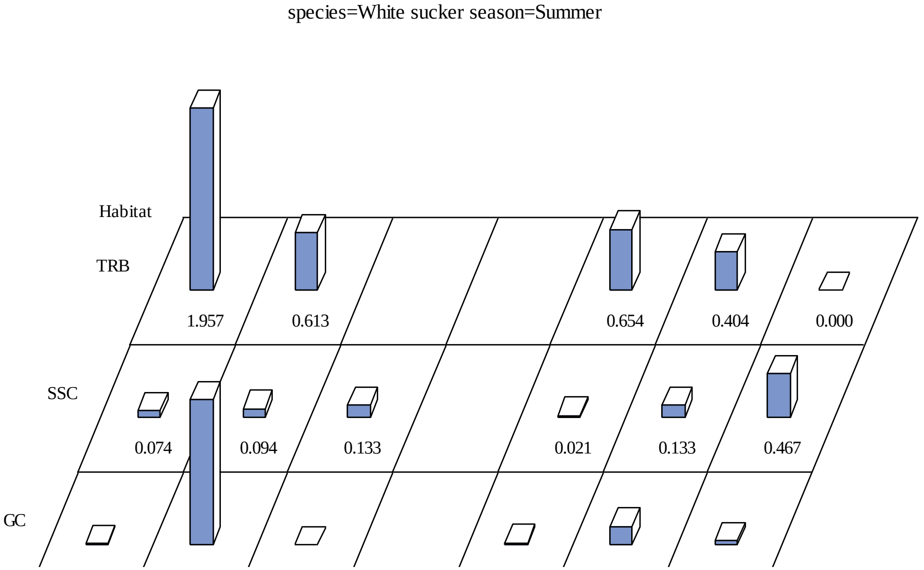
* Evenness runs on a scale of 0 to 1. Values closer to 1 indicate more even distribution among species whereas values closer to 0 indicate dominance by one or more species

Study 10 – Fish Assemblage Study

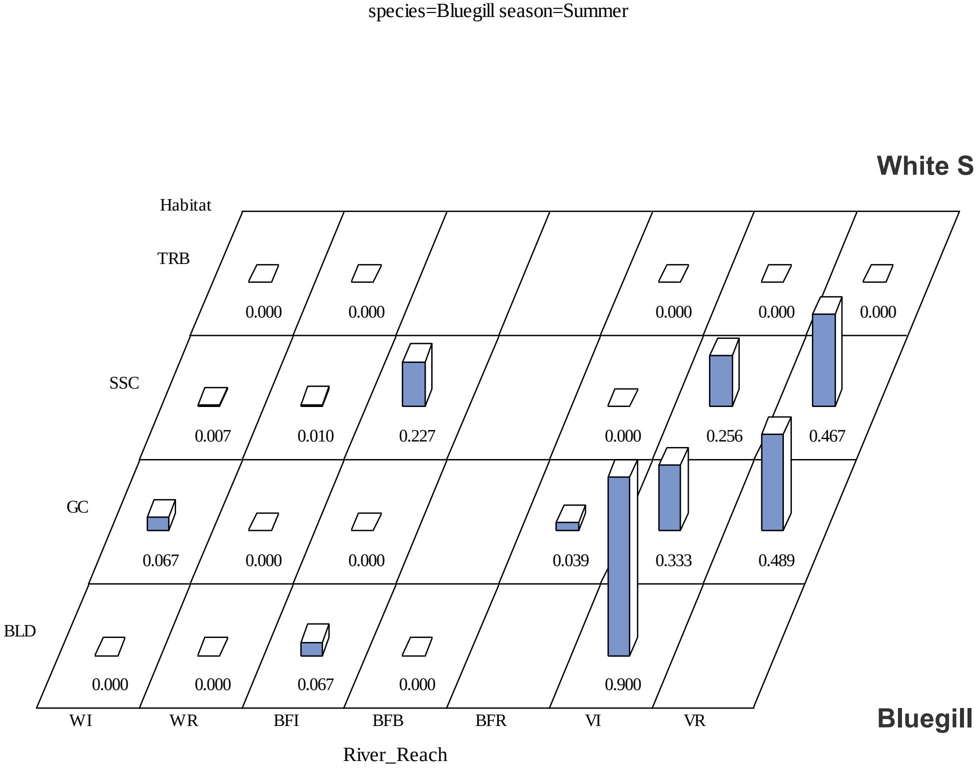
Summer Sampling

- CPUE values for all 36 species by river reach, sampling gear and habitat type (Appendix)
- Report details spatial distribution of CPUA values by river reach and habitat type for fish species representing ~85% of summer catch
  - Spottail Shiner
  - Fallfish
  - Smallmouth Bass
  - Yellow Perch
  - Tessellated Darter
  - White Sucker
  - Rock Bass
  - Bluegill
- CPUA values for all species presented in Appendices

TransCanada



White Sucker



Bluegill

Study 10 – Fish Assemblage Study

Fall Sampling

- **13 families; 36 species; 3,839 individuals**
- **Overall abundance: Spottail Shiner (18%), Smallmouth Bass (17%), Fallfish (13%)**
- **Within reach: WI, BFI = Spottail Shiner, WR, VR = Smallmouth Bass, BFB = Longnose Dace, BFR = Fallfish, VI = Golden Shiner**

Family / Common Name	ALL	
	N	%
Anguillidae		
American Eel	3	0.1
Catostomidae		
Longnose Sucker	0	0
White Sucker	150	3.9
Centrarchidae		
Black Crappie	23	0.6
Bluegill	76	2
Largemouth Bass	92	2.4
Pumpkinseed	32	0.8
Rock Bass	215	5.6
Smallmouth Bass	668	17.4
Clupeidae		
American Shad	43	1.1
Cottidae		
Slimy Sculpin	8	0.2
Cyprinidae		
Blacknose Dace	125	3.3
Blacknose Shiner	50	1.3
Bluntnose Minnow	9	0.2
Bridle Shiner	5	0.1
Common Carp	4	0.1
Common Shiner	121	3.2
Creek Chub	46	1.2
Cutlips Minnow	2	0.1
Eastern Silvery Minnow	56	1.5
Fallfish	438	11.4
Fathead Minnow	0	0
Finescale Dace	0	0

Family / Common Name	ALL	
	N	%
Cyprinidae		
Golden Shiner	241	6.3
Lake Chub	0	0
Longnose Dace	90	2.3
Mimic Shiner	0	0
Rosyface Shiner	25	0.7
Spottail Shiner	682	17.8
Esocidae		
Chain Pickerel	5	0.1
Northern Pike	19	0.5
Fundulidae		
Banded Killifish	10	0.3
Gadidae		
Burbot	0	0
Ictaluridae		
Brown Bullhead	7	0.2
Channel Catfish	6	0.2
Yellow Bullhead	6	0.2
Moronidae		
White Perch	3	0.1
Percidae		
Tessellated Darter	344	9
Walleye	12	0.3
Yellow Perch	213	5.5
Petromyzontidae		
Sea Lamprey	9	0.2
Salmonidae		
Brook Trout	0	0
Brown Trout	1	0

Study 10 – Fish Assemblage Study

Fall Sampling

- **Richness – ranged from 21 (WI & VI) to 9 (BFB)**
- **Diversity – ranged from 2.56 (WI) to 1.25 (BFB)**
- **Evenness* – ranged from 0.84 (WI) to 0.50 (WR)**
- **WR values likely influenced by high contribution of Smallmouth Bass and Tessellated Darter to catch in that reach**

River Reach	Richness	Diversity	Evenness
Wilder impoundment	21	2.56	0.84
Wilder riverine	19	1.48	0.5
Bellows Falls impoundment	17	2.13	0.75
Bellows Falls bypassed reach	9	1.25	0.57
Bellows Falls riverine	18	2.19	0.76
Vernon impoundment	21	2.52	0.83
Vernon riverine	16	2.27	0.82
All Reaches	36	2.68	0.75

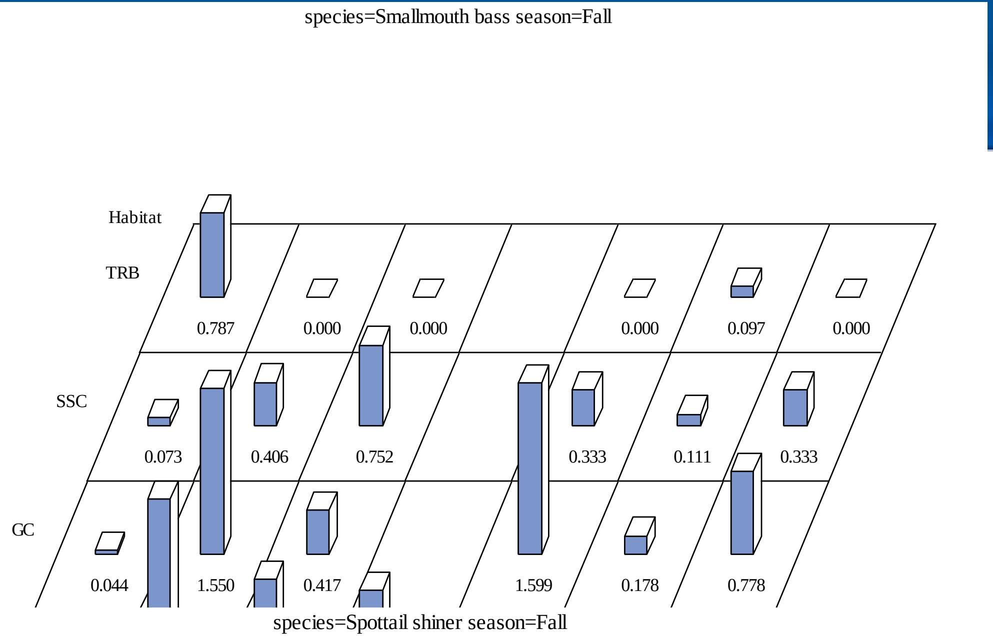
---

* Evenness runs on a scale of 0 to 1. Values closer to 1 indicate more even distribution among species whereas values closer to 0 indicate dominance by one or more species

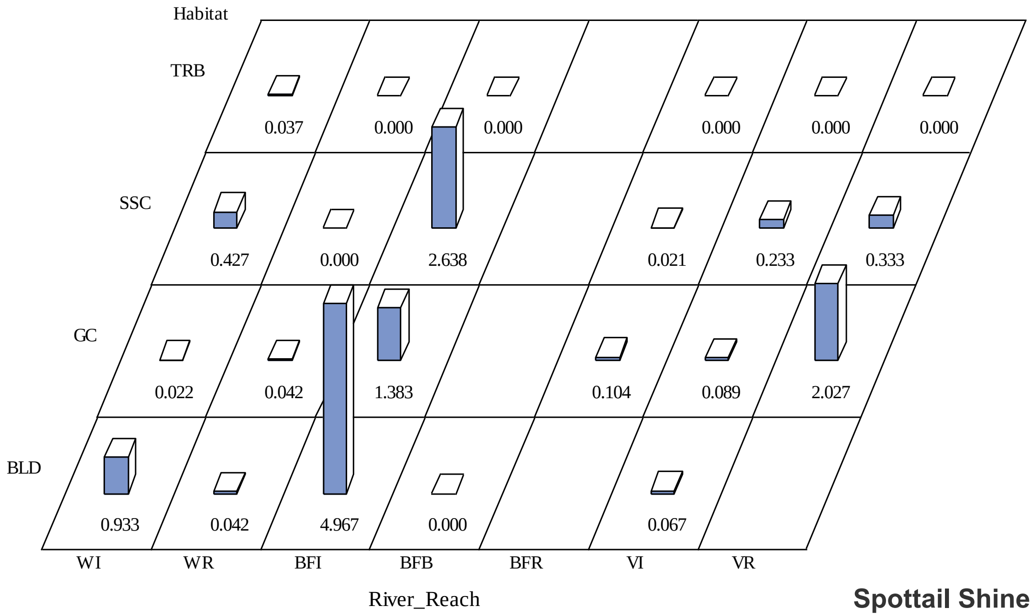
Study 10 – Fish Assembla

Fall Sampling

- CPUE values for all 36 species by river reach, sampling gear and habitat type (Appendix)
- Report details spatial distribution of CPUA values by river reach and habitat type for fish species representing ~80% of fall catch
    - Spottail Shiner
    - Smallmouth Bass
    - Fallfish
    - Tessellated Darter
    - Golden Shiner
    - Rock Bass
    - Yellow Perch
    - White Sucker
    - Blacknose Dace
- CPUA values for all species presented in Appendices



Smallmouth Bass



Spottail Shiner

TransCanada

Study 10 – Fish Assemblage Study

Study Summary

- 429 samples collected May 22 – October 14, 2015
- 14 families, 43 species, 11,551 individuals

- Study report reviews available fish data
    - Vermont Yankee (1991-2014)
    - Yoder et al. (2008)
- Seasonal sampling design and suite of sampling gears associated with Study 10 has produced a robust and up to date data set with which to describe the occurrence, distribution and relative abundance of fish in the Project area

	Impoundment		
	Wilder	**Bellows Falls**	**Vernon**
# Fish	2146	2658	2081
# Families	9	9	12
# Species	26	28	28
#1 Abundance	Yellow Perch	Spottail Shiner	Spottail Shiner
#2 Abundance	Fallfish	Yellow Perch	Yellow Perch
#3 Abundance	Spottail Shiner	Smallmouth Bass	Fallfish
#4 Abundance	Rock Bass	Fallfish	Bluegill
#5 Abundance	Tessellated Darter	Rock Bass	Tessellated Darter

	Riverine Reach		
	Wilder	**Bellows Falls**	**Vernon**
# Fish	2373	1731	357
# Families	8	12	12
# Species	26	31	23
#1 Abundance	Tessellated Darter	Smallmouth Bass	Smallmouth Bass
#2 Abundance	Smallmouth Bass	Tessellated Darter	Bluegill
#3 Abundance	Fallfish	Fallfish	White Sucker
#4 Abundance	Rosyface Shiner	Spottail Shiner	Yellow Perch
#5 Abundance	Rock Bass	Common Shiner	Rock Bass

Study 12

Tessellated Darter Survey

Study 12 – Tessellated Darter Survey

Study Progress

- Site selection conducted in late 2014 with working group
- Revised SSR filed in Volume II of the USR
- Field work completed during targeted time frame of September, 2015.
- Study report filed March 1, 2016.

Study 12 – Tessellated Darter Survey

Sampling Effort

- Sampling locations established in WI, WR, BFI, BFR, VI, and VR reaches
- 45 sites with 3 cross-river transects each selected
- Each transect contained 5 fixed-radius count locations spaced evenly across the channel (3-m diameter)
- Total of 675 count locations across study area

River Reach	Total Number of 500-m Map-units	Selected Number of 500-m Map-units	Number of 3-m Radius Count Circles per Map-unit	Total Number of Visual Survey Areas
Wilder Impoundment	156	14	15	210
Wilder Riverine	60	8	15	120
Bellows Falls Impoundment	93	8	15	120
Bellows Falls Riverine	20	4	15	60
Vernon Impoundment	93	8	15	120
Vernon Riverine	5	3	15	45
Total	**427**	**45**	**-**	**675**

TransCanada

Study 12 – Tessellated Darter Survey

Sampling Protocol

- 3-m radius count circle deployed at each of the 5 locations along transect
- Upon descent, diver counted darters in circle
- Estimated proportion adult : juvenile (based visually on size)
- Classify substrate
- Estimate % aquatic vegetation
- Estimate % woody debris
- Estimate available cover
- Recorded water quality parameters
- Recorded mean water column velocity (ft/s)
- Quantified freshwater mussels from a randomly placed quadrat within count circle

TransCanada

Study 12 – Tessellated Darter Survey

Darter Observations

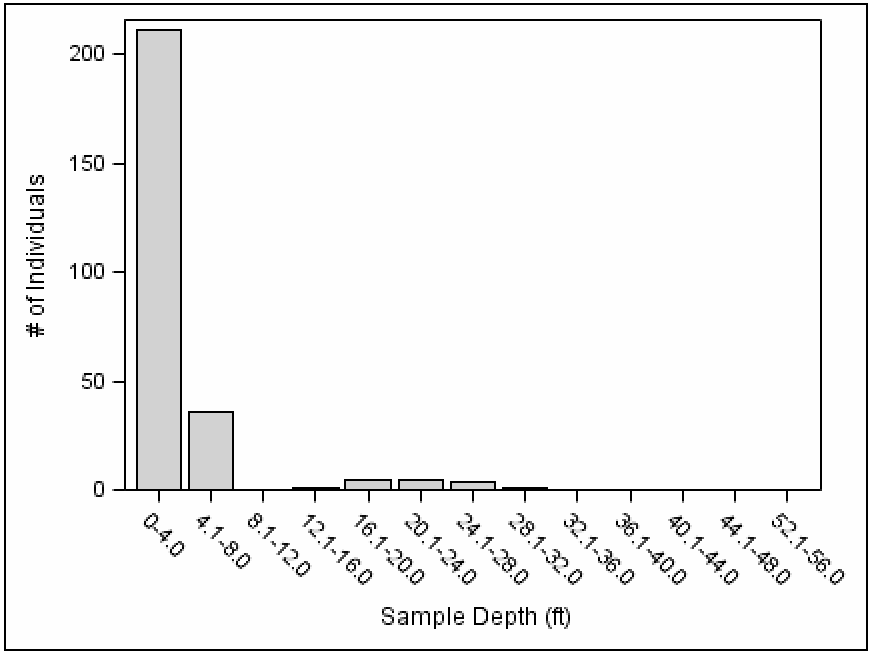
- Observed 263 Tessellated Darters
- Estimated 80% juvenile
- Majority observed in Wilder impoundment with decreasing numbers downstream
- 87% of individuals detected in count circles placed along east or west banks

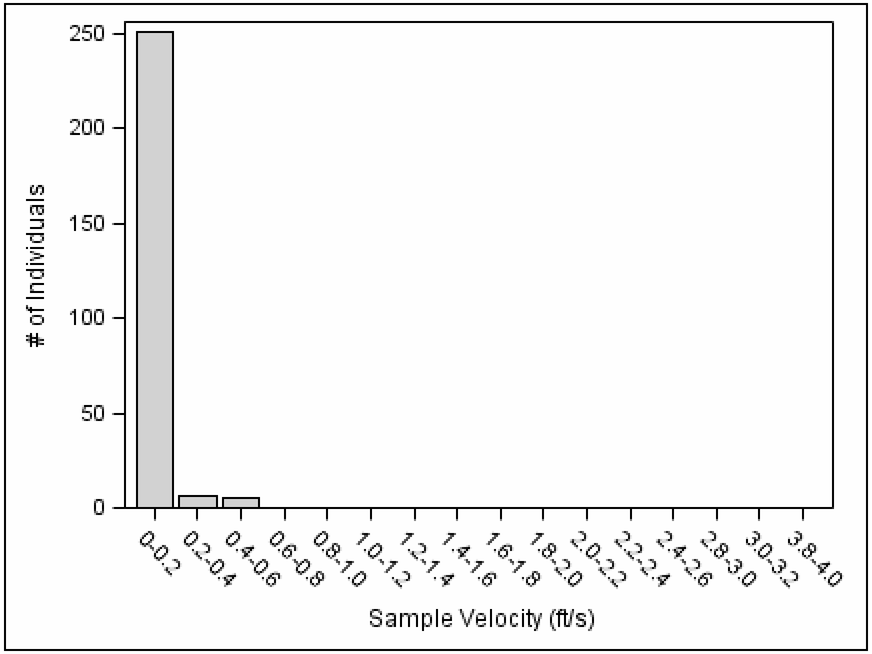
Description	**Total Count of Darters**	**Subtotal: west bank**	**Subtotal: 1/3 channel**	**Subtotal: 1/2 channel**	**Subtotal: 2/3 channel**	**Subtotal: east bank**
Wilder Impoundment	208	111	4	8	5	80
Wilder Riverine	9	4	1	1	1	2
Bellows Falls Impoundment	37	6	14	0	0	17
Bellows Falls Riverine	6	4	0	0	0	2
Vernon Impoundment	2	0	0	0	0	2
Vernon Riverine	1	1	0	0	0	0
Total	**263**	**126**	**19**	**9**	**6**	**103**

Study 12 – Tessellated Darter Survey

Darter Observations

- Majority of observation in water depth <8 ft, no deeper than 32 ft
- All observations in count circles with mean water column velocity of 0.6 ft/s or slower



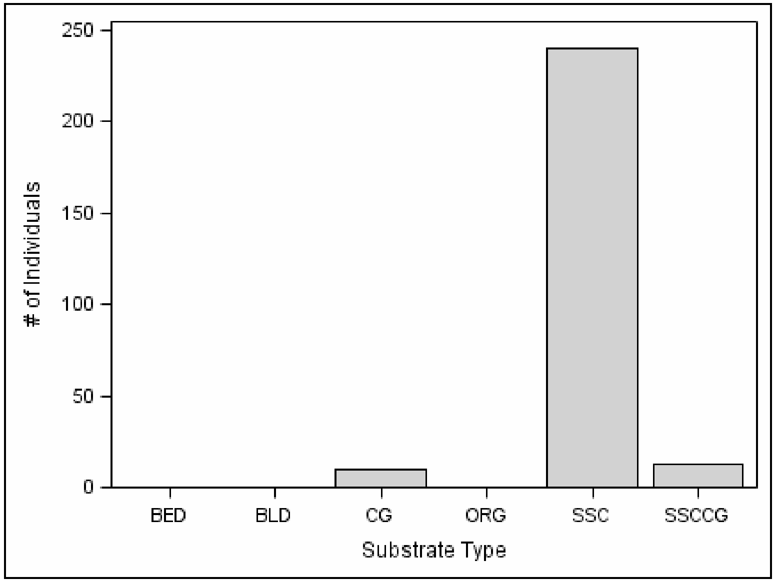


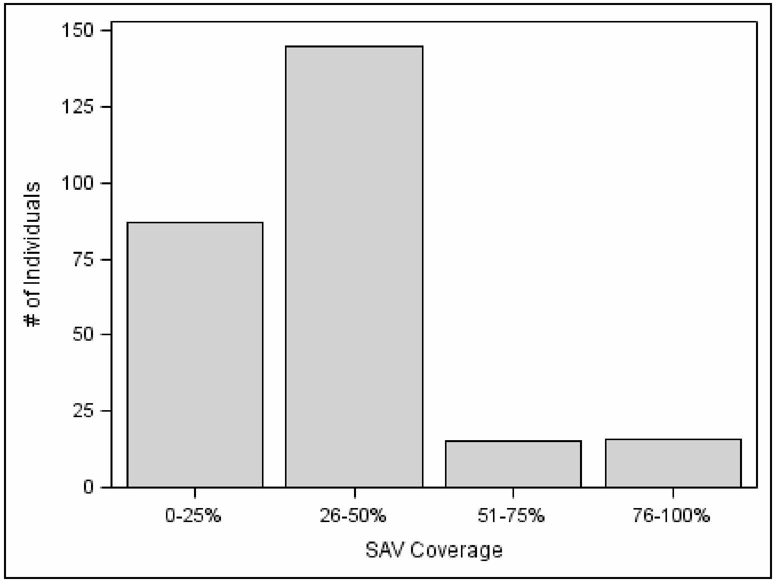
TransCanada

Study 12 – Tessellated Darter Survey

Darter Observations

- Compared observed substrate use to expected distribution among surveyed count circles – showed preference for Silt/Sand/Clay
- Compared observed submerged aquatic vegetation (SAV) coverage to expected distribution among surveyed count circles – showed greater presence in circles with 26-50% coverage

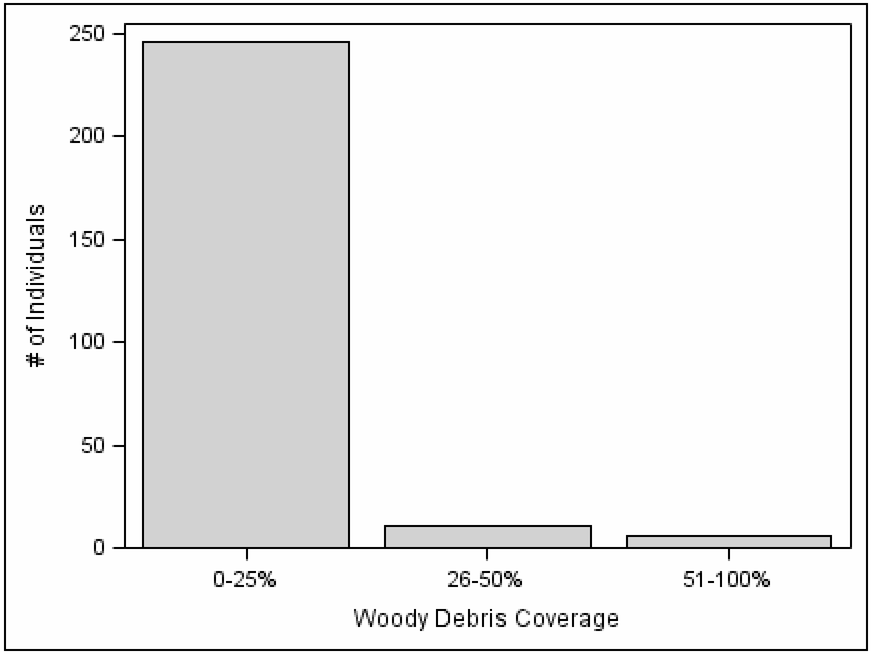




Study 12 – Tessellated Darter Survey

Darter Observations

- Majority of count circles (98%) had less than 25% coverage by woody debris
- Majority of darters were recorded at those locations



Study 12 – Tessellated Darter Survey

Freshwater Mussel Observations

- Four or five species detected*
- Species present and reach distributions in agreement with previous detailed studies of freshwater mussel species

Description	Number of Count Circles	Percentage of Count Circles with Mussels Present			
		ElCo	LaRa	AnIm and/or PyCa	AlUn
Wilder Impoundment	210	49.5%	21.4%	0.0%	0.0%
Wilder Riverine	120	19.2%	9.2%	0.0%	0.0%
Bellows Falls Impoundment	120	69.2%	50.8%	0.0%	0.0%
Bellows Falls Riverine	60	61.7%	50.0%	5.0%	1.7%
Vernon Impoundment	120	85.0%	34.2%	9.2%	0.0%
Vernon Riverine	45	95.6%	8.9%	2.2%	2.2%
Total	**675**	58.1%	28.4%	2.2%	0.3%
Number of Individuals Counted		**392**	**192**	**15**	**2**

Species Abbreviations:
ElCo = *Elliptio complanata* (Eastern Elliptio)
LaRa = *Lampsilis radiata* (Eastern Lampmussel)
AnIm = Anodonta Implicata (Alewife Floater)
PyCa = *Pyganodon cataracta* (Eastern Floater)
AlUn = *Alasmidonta undulata* (Triangle Floater)

*Alewife and Eastern Floaters difficult to distinguish without sacrificing individual – not intent of this study to do so

Study 12 – Tessellated Darter Survey

Study Summary

- Objective was to characterize distribution and relative abundance of Tessellated Darters within project-affected areas
- Mean CPUA was greater in WI than observed in WR, BFR, VI and VR but did not differ significantly from that observed in BI
- In general, observed counts decreased with downstream distance
- Observations were primarily from river bank locations with fewer individuals towards center of channel
- Frequent in depths less than 8 ft and in locations with water velocities less than 0.6 ft/sec
- Observations during Study 12 are consistent with biological accounts reported in the literature for the species
- The species appears to be distributed throughout the three project impoundments and their respective downstream riverine reaches

Study 13

Tributary and Backwater Fish Access and Habitats Study

Study 13 – Tributary and Backwater Fish Access and Habitats

- Site selection conducted in early 2014 with working group
- 37 study locations (tributaries and backwaters) selected for evaluation
- Field measurements conducted July-November 2014
- Consisted of bed elevation measurements, WSE monitoring, photo documentation, water quality

- Study report filed September 14, 2015
- Discussed at October 1, 2015 Study Meeting
  - Interest from working group in the evaluation of access at each study location during the spring months

Study 13 – Tributary and Backwater Fish Access and Habitats

- To evaluate access during the spring (April 1 – June 30), Operations Model output was used
- Ops model relied on a representative subset of 5 historical years of data (as ranked by annual and spring inflow at Vernon and system annual energy production)

Model Year	Annual Inflow Volume at Vernon Rank	Spring Inflow Volume at Vernon Rank	Annual Energy Production Rank
1992	5	6	3
1994	9	16	8
1989	14	12	15
2007	20	21	22
1990	25	22	28

- Model output included daily cumulative hour totals where the predicted mainstem WSE at a study site confluence was lower than the WSE determined during field evaluation to provide at least 0.5 ft of water depth
- Study report included WSE needed for 0.5 ft depth and detailed bed elevation information at each confluence which identified the thalweg location and its elevation value (Appendix A)

Study 13 – Tributary and Backwater Fish Access and Habitats

- Primary need: identification of a repeatable process to classify fish access at each of the 37 locations

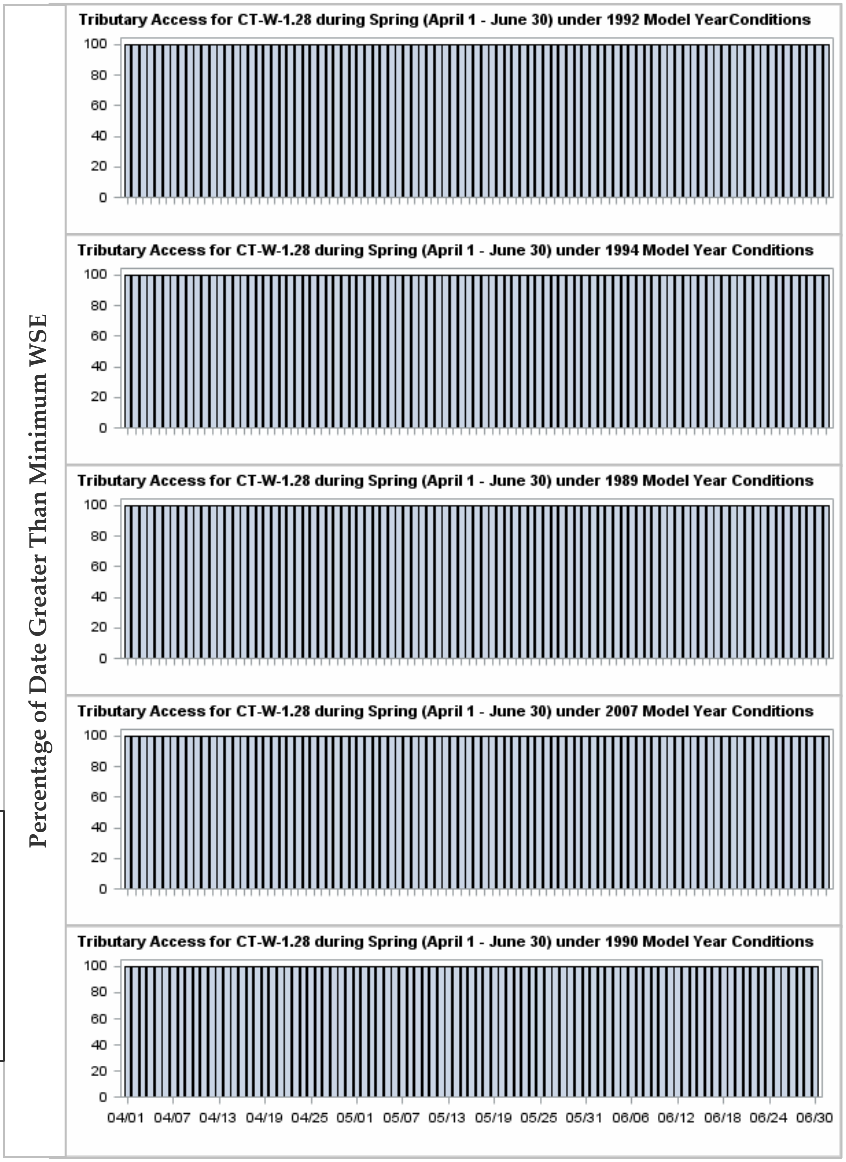
- Proposed use of model output approach:
  - For each location, flag all spring dates where less than 0.5 ft of water present for 12 or more hours (ensures access is available at least half of the day)
  - Determine proportion of dates at each site where access is restricted more than 12 hours
  - Flag model years where that proportion is greater than or equal to 10% of all spring dates (NOTE: 10% of spring dates represents less than one day per week)
  - Categorize access restrictions using these two criteria as follows:

Level of Access Restriction	% of Days (April – June) with 12+ Hours of < 0.5 ft of Access	During this Number of Model Years
None	0	All 5 years
Negligible	<10%	1, 2 or 3
Infrequent	< 10%	4 or 5
Occasional	≥10%	1, 2, or 3
Frequent	≥10%	4 or 5

Study 13 – Tributary and Backwater Fish Access and Habitats

Site CT-W-1.28 (backwater)
New Hampshire side
Wilder Impoundment above Fairlee/Orford
Required Confluence WSE: 376.5 ft

- **Modeled spring restriction 0% of time = “NONE”**
- **Summer/fall measured restriction = 0% of time**
- **Summer/fall confluence depth = 5.6 – 7.2 ft**
- **Summer/fall backwater depth = 1.7 – 4.9 ft**


Tributary Access for CT-W-1.28 during Spring (April 1 - June 30) under 1992 Model YearConditions

Tributary Access for CT-W-1.28 during Spring (April 1 - June 30) under 1994 Model Year Conditions

Tributary Access for CT-W-1.28 during Spring (April 1 - June 30) under 1989 Model Year Conditions

Tributary Access for CT-W-1.28 during Spring (April 1 - June 30) under 2007 Model Year Conditions

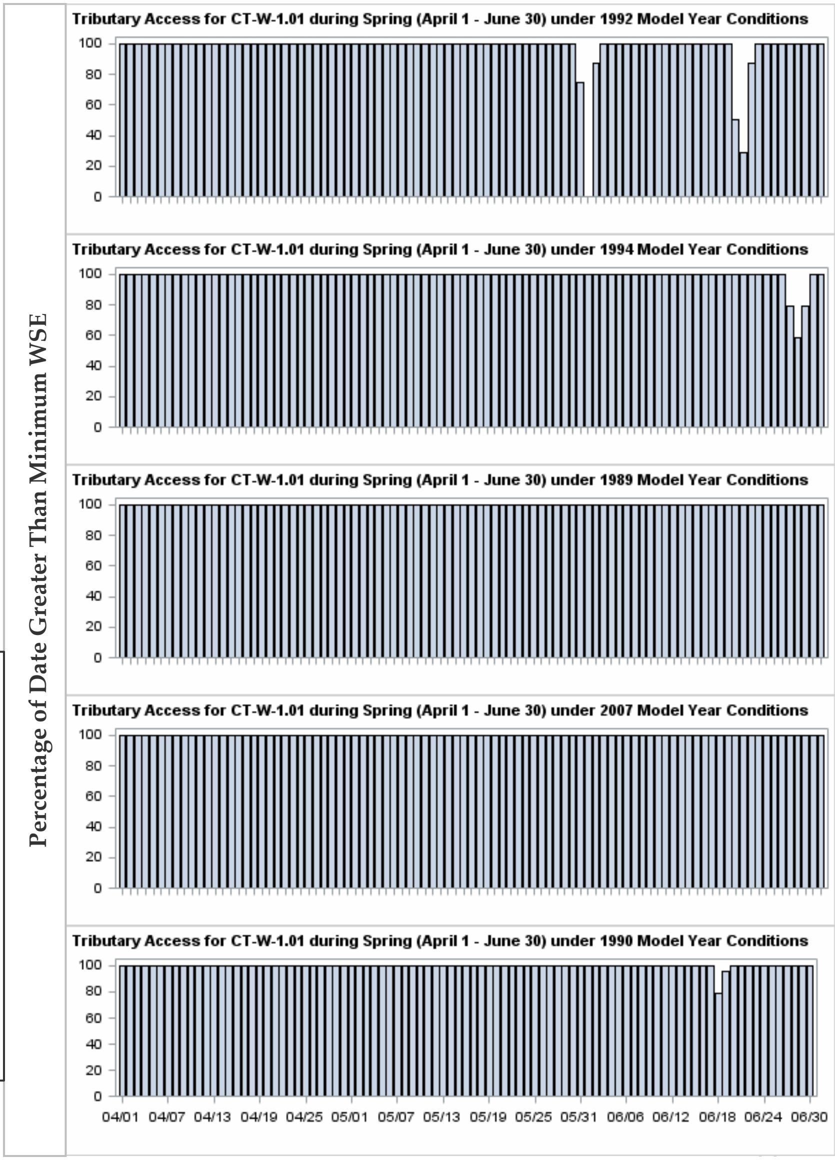
Tributary Access for CT-W-1.28 during Spring (April 1 - June 30) under 1990 Model Year Conditions

TransCanada

Study 13 – Tributary and Backwater Fish Access and Habitats

Site CT-W-1.01 (Harriman Brook – S.O. 2)
Vermont side
Upper Wilder Impoundment above Newbury
Required Confluence WSE: 383.3 ft

- **Modeled spring restriction:**
  - **1 yr with dates containing 12+ hours < 0.5 ft**
  - **1 yr with access restrictions < 10% of all dates, no yrs > 10%**
  - **Overall modeled restriction = “NEGLIGIBLE”**
- **Summer/fall measured = 0% of time < 0.5 ft**
- **Summer/fall confluence depth = 0.8 – 1.4 ft**
- **Summer/fall tributary depth = 0.2 – 4.7 ft**



Study 13 – Tributary and Backwater Fish Access and Habitats

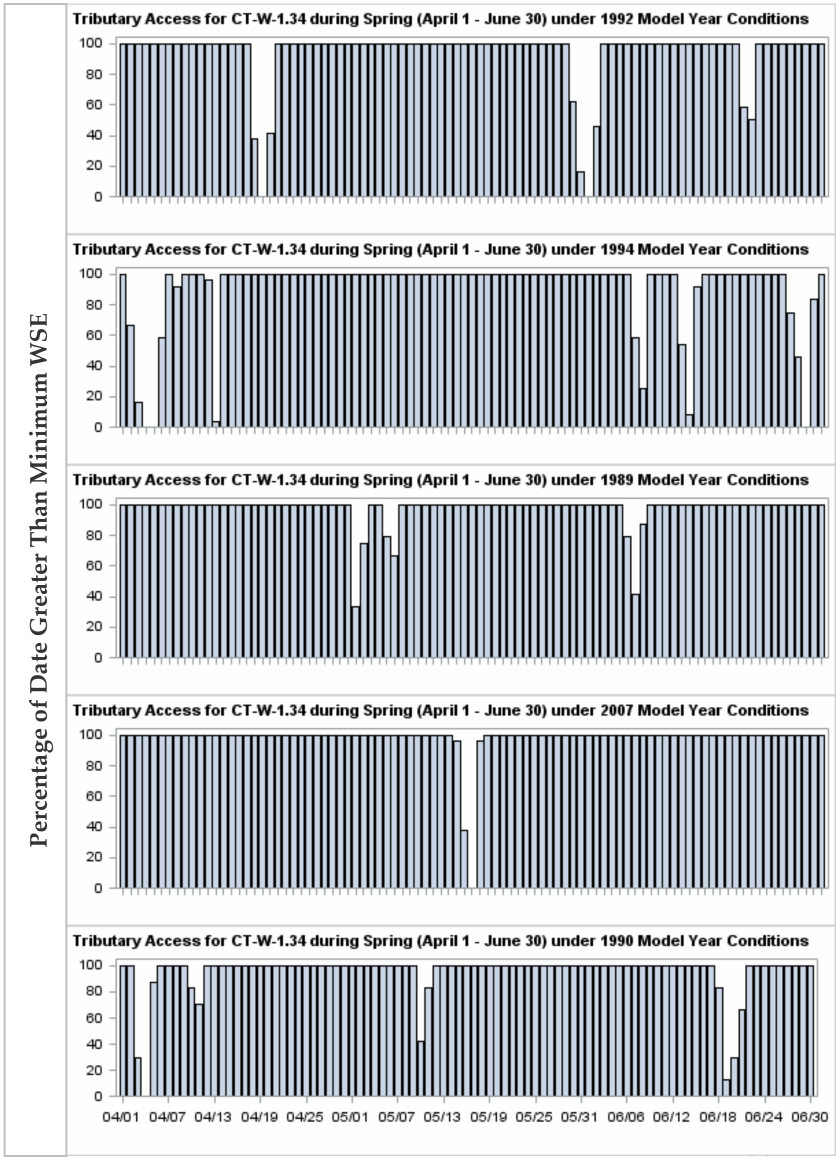
Site CT-W-1.34 (unnamed S.O. 2)

Vermont side

Wilder Impoundment below Fairlee/Orford
Required Confluence WSE: 381.7 ft

- **Modeled spring restriction:**
    - **5 yrs with dates containing 12+ hours of < 0.5 ft**
    - **5 yrs with access restrictions < 10% of all dates, no yrs > 10%**
    - **Overall modeled restriction = "INFREQUENT"**
- **Summer/fall measured = 0.4% of time < 0.5 ft**
- **Summer/fall confluence depth = 0.5 – 1.9 ft**
- **Summer/fall tributary depth = 0.3 – 2.3 ft**

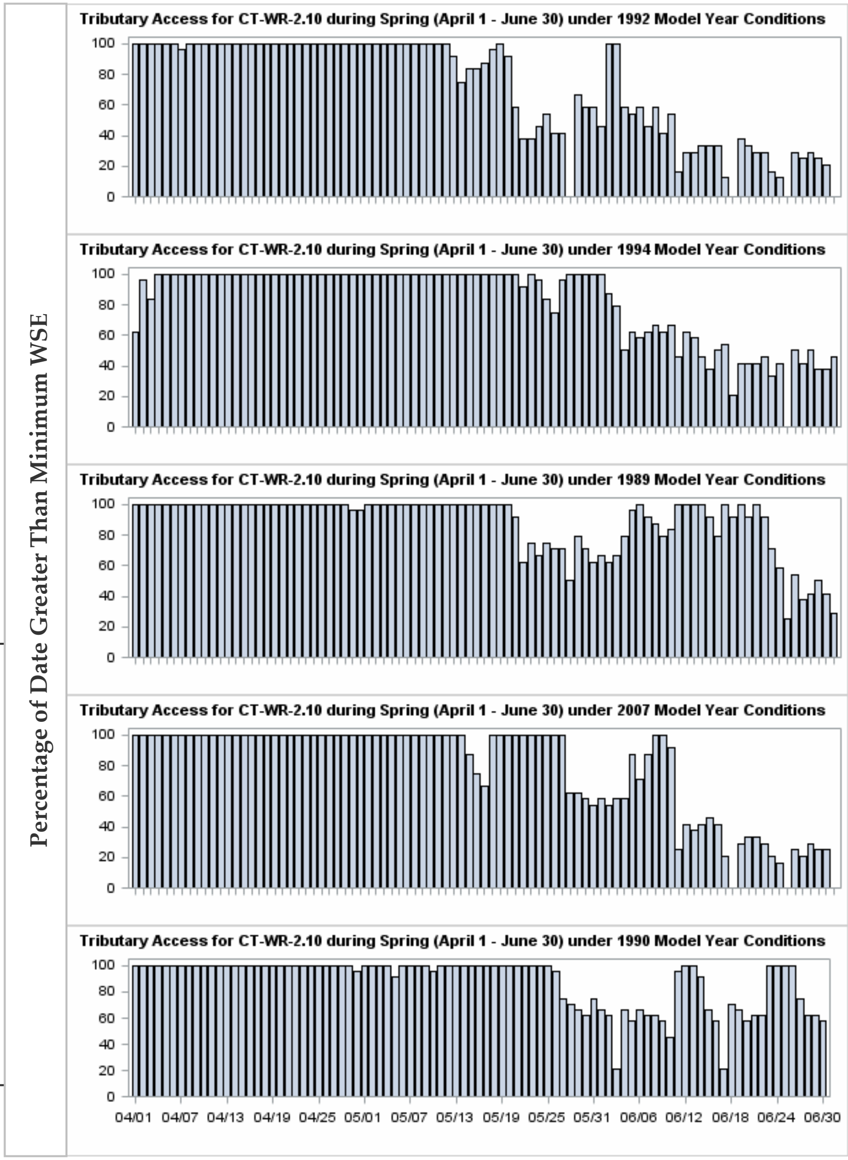
TransCanada



Study 13 – Tributary and Backwater Fish Access and Habitats

Site CT-WR-2.10 (McArthur Brook S.O. 2)
Vermont side
Wilder Riverine, Hartland VT
Required Confluence WSE: 302.7 ft

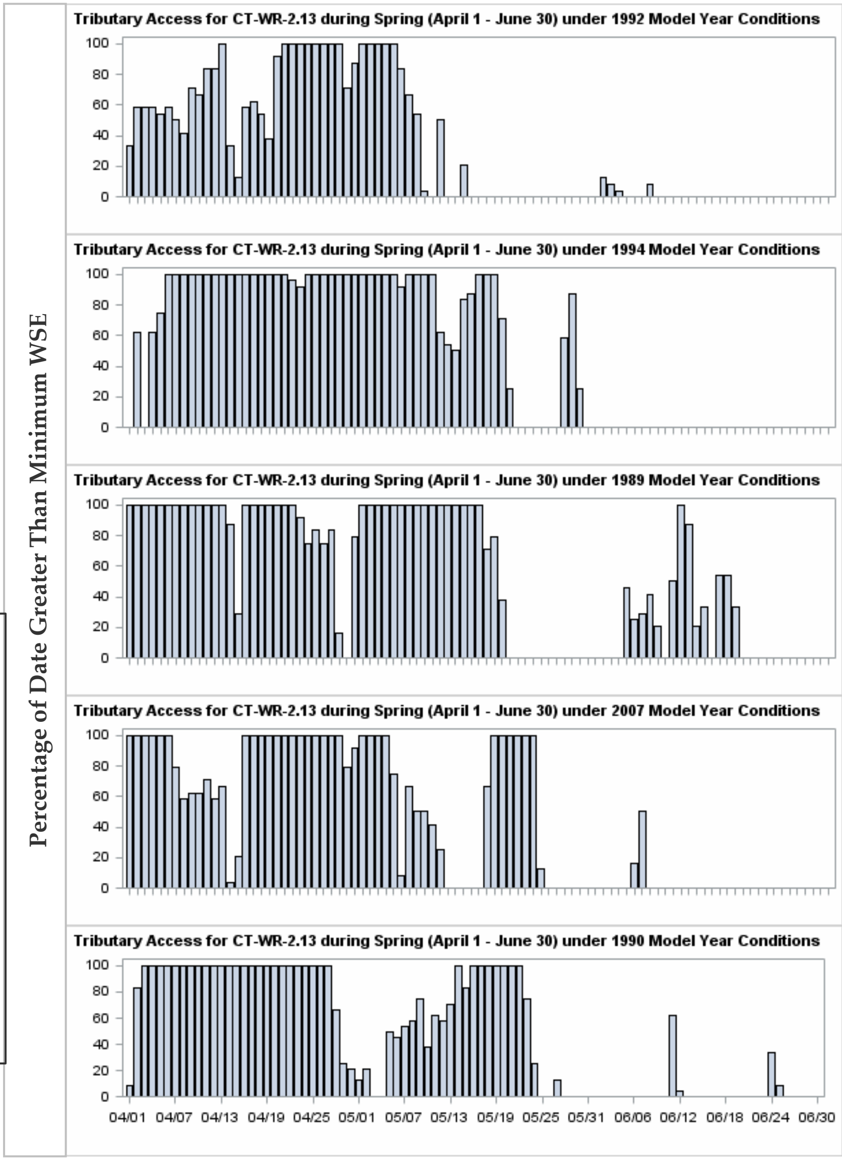
- **Modeled spring restriction:**
  - **5 yrs with dates containing 12+ hours of < 0.5 ft**
  - **2 yrs with access restrictions < 10% of all dates, 3 yrs > 10% of all dates**
  - **Overall modeled restriction = “OCCASIONAL”**
- **Summer/fall measured = 58.2% of time < 0.5 ft**
- **Summer/fall confluence depth = 0.0 – 2.0 ft**
- **Summer/fall tributary depth = 0.4 – 4.7 ft**



TransCanada

Study 13 – Tributary and Backwater Fish Access and Habitats

Site CT-WR-2.13
(Bashan Brook S.O. 1)
Vermont side
Wilder Riverine
below Hartland VT
Required Confluence
WSE: 304.0 ft



- **Modeled spring restriction:**
  - **5 yrs with dates containing 12+ hours of < 0.5 ft**
  - **0 yrs with access restrictions < 10% of all dates**
  - **5 yrs with access restrictions > 10% of all dates**
  - **Overall modeled restriction = "FREQUENT"**
- **Summer/fall measured = 100% of time < 0.5 ft**
- **Summer/fall confluence depth = 0.1 – 0.4 ft**
- **Summer/fall tributary depth = 0.0 – 0.9 ft**

Study 13 – Tributary and Backwater Fish Access and Habitats

- Applied criteria to each of the 37 study sites:

River Reach	Access Classification				
	None	Negligible	Infrequent	Occasional	Frequent
Wilder Impoundment	4	3	2	4	1
Wilder Riverine				2	3
Bellows Falls Impoundment	4	2			
Bellows Falls Riverine		2		1	
Vernon Impoundment	4	2		1	
Total (excluding Vernon Riverine)	**12**	**9**	**2**	**8**	**4**

- The 2 tributaries downstream of Vernon were evaluated under high and low Turners Falls dam elevations
  - No access restrictions at either location under high TF dam elevation
  - “Occasional” and “Frequent” access restrictions under low TF dam elevation

Study 13 – Tributary and Backwater Fish Access and Habitats

#1: Frequent Spring Access Restrictions

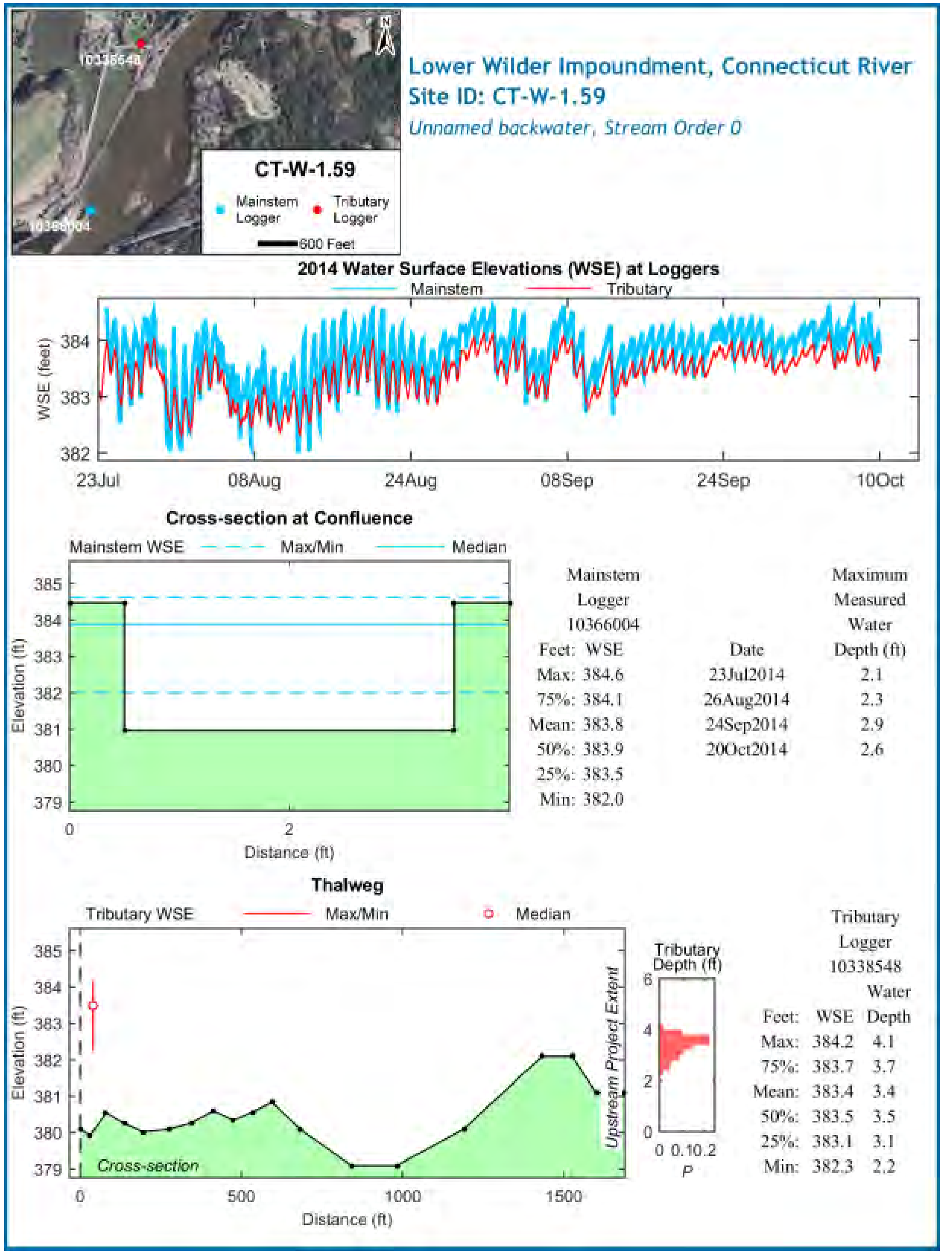
Site CT-W-1.59 (backwater),

Vermont side, lower Wilder impoundment
Required Confluence = WSE 381.5 ft

Summer/Fall 0% of time restricted

Site has a culvert not part of modeled data

TransCanada



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

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

Tributary Logger 10338548

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

Study 13 – Tributary and Backwater Fish Access and Habitats

Site CT-W-1.59 (backwater),

Lower Wilder Impoundment, Connecticut River

Site ID: CT-W-1.59

Unnamed backwater, Stream Order 0

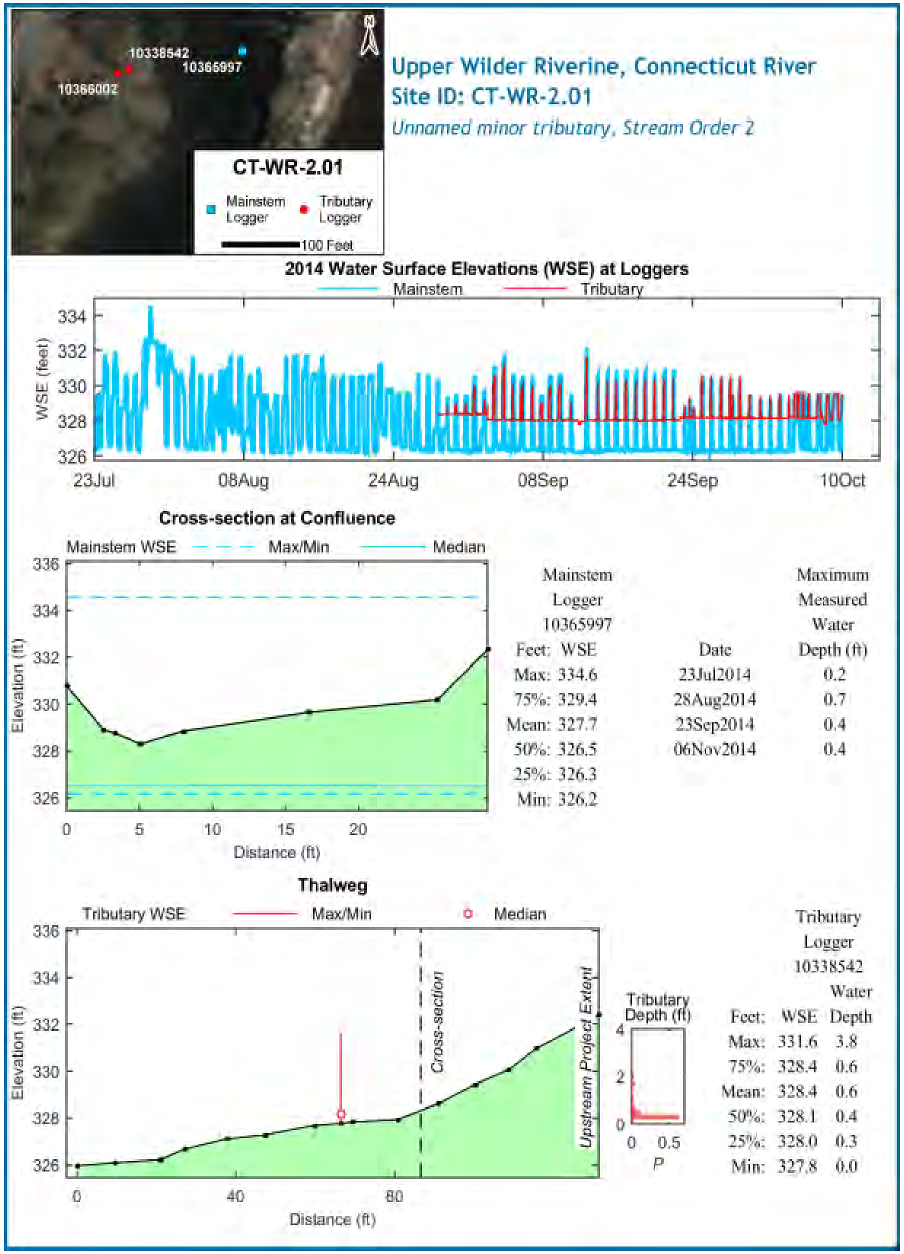
Study 13 – Tributary and Backwater Fish Access and Habitats

#2: Site Frequent Spring Access Restrictions

Site CT-WR-2.01 (S.O. 2),
Vermont side, Wilder Riverine
just below Wilder dam
Required Confluence = WSE: 328.8 ft
Short project-influenced reach

Summer/Fall 70.2% of time restricted
Site has a perched pipe culvert

TransCanada



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

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

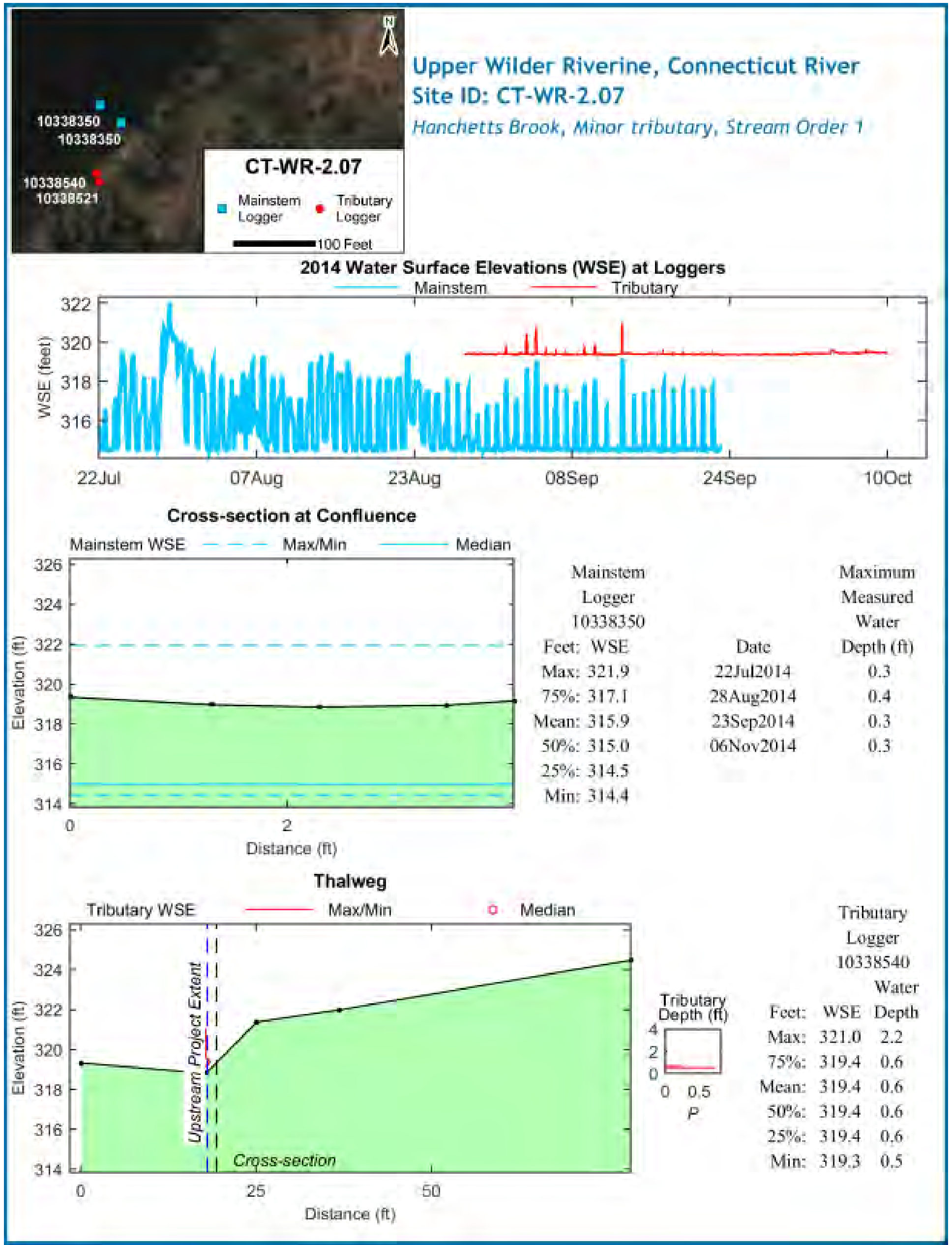
Study 13 – Tributary and Backwater Fish Access and Habitats

#3: Frequent Spring Access Restrictions

Site CT-WR-2.07 Hanchett's Brook (S.O. 1),
New Hampshire side, Wilder Riverine
just above Burnaps Island
Required Confluence WSE= 319.3 ft
Very short project-influenced reach ~ 34 ft

Summer/Fall 95.8% of time restricted

TransCanada



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

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

Tributary Logger 10338540

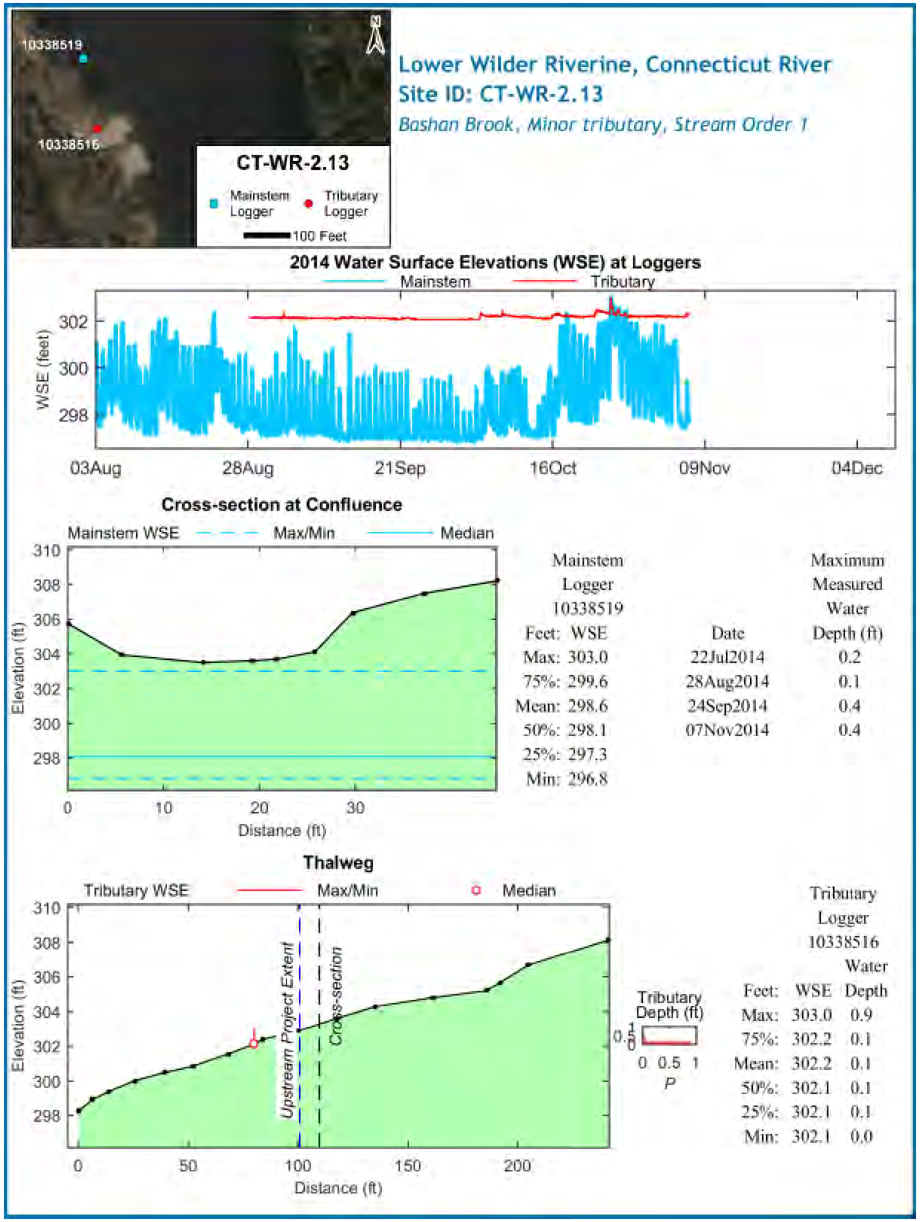
Feet:	WSE	Water Depth
Max:	321.0	2.2
75%:	319.4	0.6
Mean:	319.4	0.6
50%:	319.4	0.6
25%:	319.4	0.6
Min:	319.3	0.5

Study 13 – Tributary and Backwater Fish Access and Habitats

#4: Frequent Spring Access Restrictions

Site CT-WR-2.13
Bashan Brook (S.O. 1),
Vermont side, Wilder Riverine
below Hartland VT
Required Confluence
WSE: 304.0 ft

Short project-influenced reach ~ 100ft
Summer/Fall 100% of time restricted
Manmade blockages observed



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

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

Tributary Logger 10338516 Feet:	WSE	Water Depth
Max:	303.0	0.9
75%:	302.2	0.1
Mean:	302.2	0.1
50%:	302.1	0.1
25%:	302.1	0.1
Min:	302.1	0.0

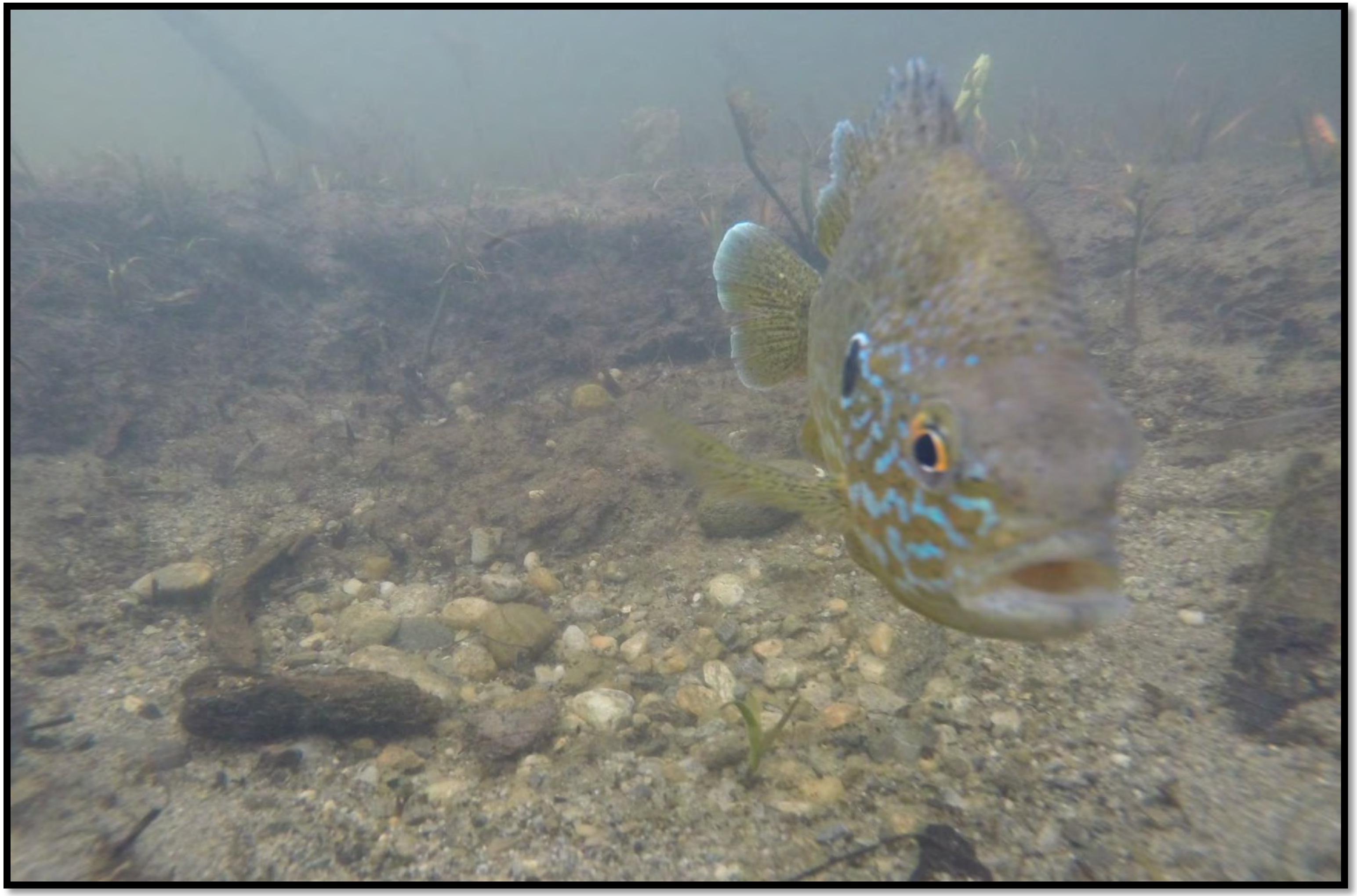
Study 13 – Tributary and Backwater Fish Access and Habitats

Remaining Activities:

- Consider comments on the spring time model approach to analysis
- Complete analysis:
  - in relation to 2014 field measurements of tributary and mainstem WSE's
  - 2014 field observations of site-specific characteristics other than project-related WSE that affect access
- Issue revised study report

TransCanada

Study 14 & 15 – Resident Fish Spawning

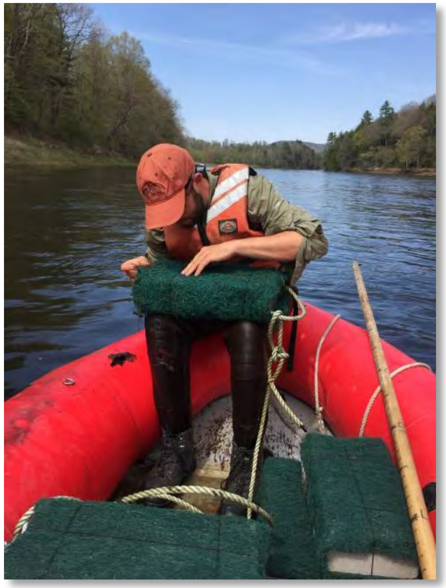


Study 14 & 15 – Resident Fish Spawning

2015 Egg Block Sampling – Effort

(Walleyes & White Suckers)

- Riverine Riffle Sampling: April 16 to June 5
  - 89 egg blocks deployed at 12 sites & fished for 1,919 block-days
- Impoundment Tributary Sampling: April 21 to May 27
  - 153 egg blocks deployed at 16 sites & fished for 2,250 block-days



TransCanada

Study 14 & 15 – Resident Fish Spawning

2015 Egg Block Sampling – Results (White Suckers)

- Sucker eggs were collected in lower Oliverian Brook and lower Hewes Brook in early-May at water temperatures of 10-15^{o}C
    - 52 eggs were collected from 7 blocks in Oliverian Brook on May 6, 8, and 11
    - 10 eggs were collected from 3 blocks in Hewes Brook on May 8 and 11
    - None of the blocks with eggs appeared to be dewatered
    - Neither egg location showed daily changes in WSE's (i.e., these blocks were above project influence) – all lower blocks were devoid of eggs
    - Most blocks had <5 eggs thus spawning likely occurred some distance upstream.
    - Schools of suckers were seen staging at 2 trib mouths (Oliverian Brook and Cold River) in early-May

Study 14 & 15 – Resident Fish Spawning

Egg block maps for Oliverian Brook (left) and Hewes Brook (right):

No eggs on lower blocks

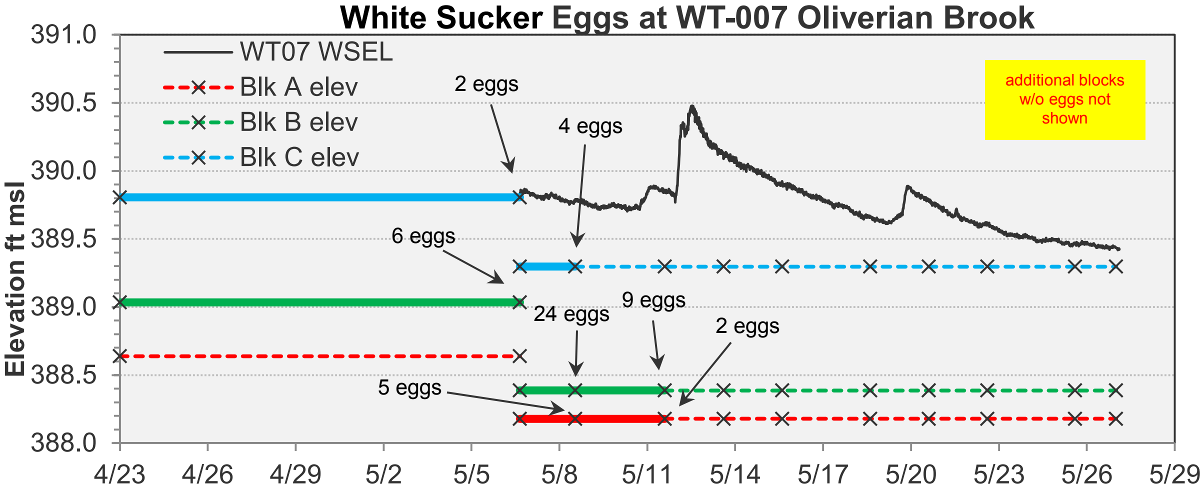
All eggs on upper blocks

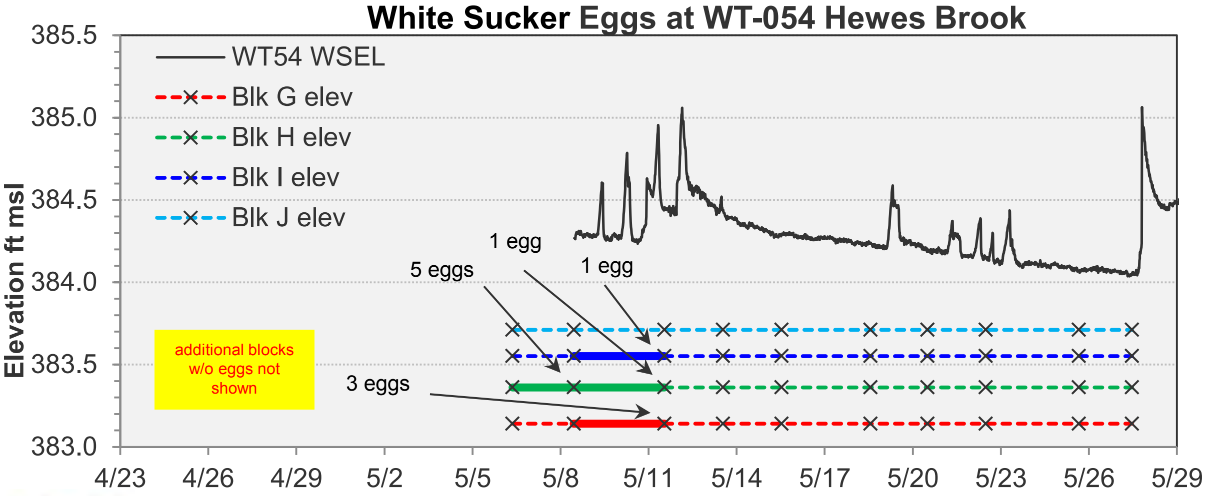
No eggs on lower blocks

All eggs on upper blocks

Study 14 & 15 – Resident Fish Spawning

Egg block elevation plots for White Suckers (only blocks with eggs are shown):

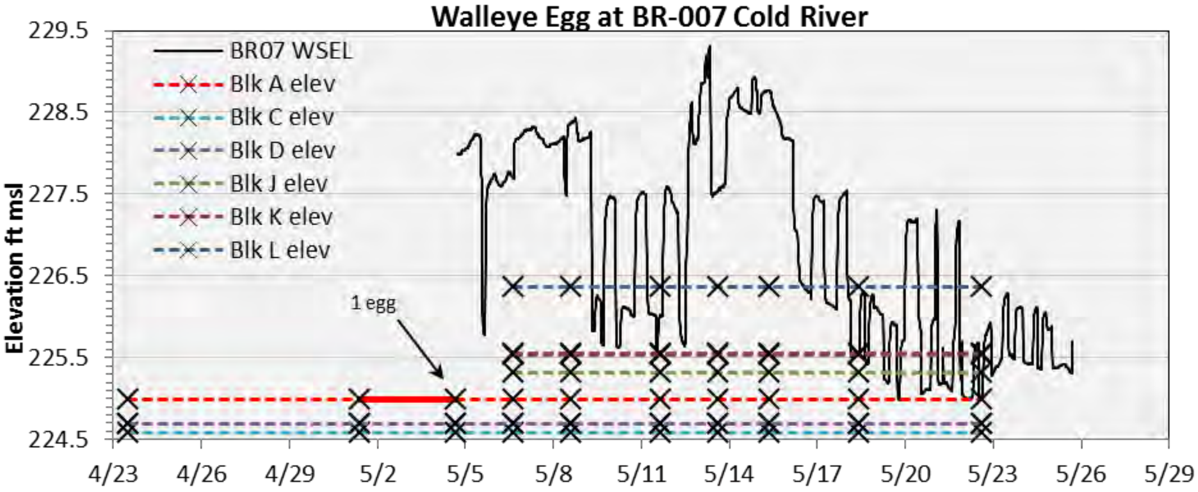




Study 14 & 15 – Resident Fish Spawning

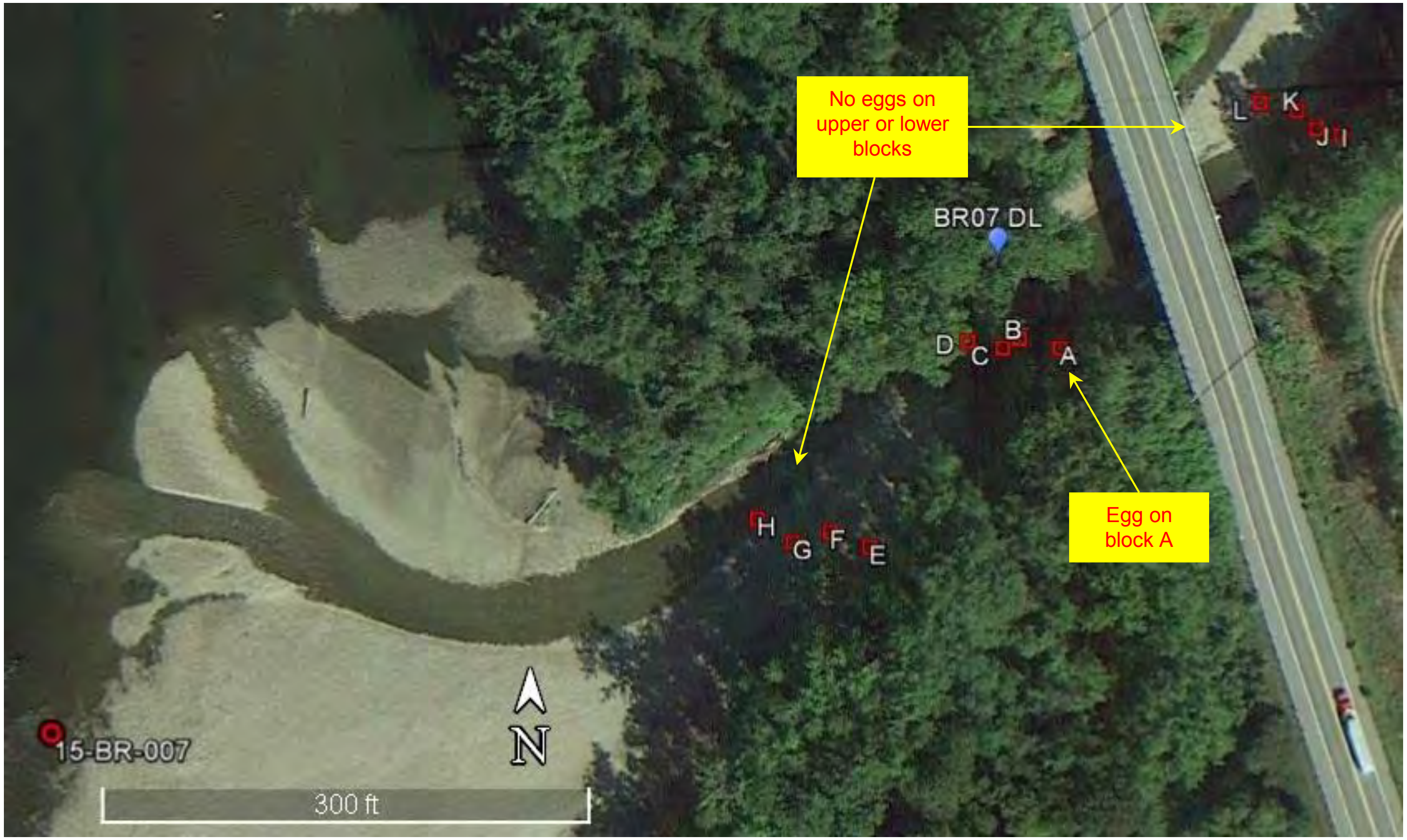
2015 Egg Block Sampling – Results (Walleye)

- One Walleye egg was collected in the lower Cold River on May 4 at a mean daily water temperature of ~14^{o}C
  - The block with an egg did not appear to be dewatered
  - The middle set of blocks did show daily fluctuations in WSE indicative of project operations



Study 14 & 15 – Resident Fish Spawning

Egg block map for the Cold River:



Study 14 & 15 – Resident Fish Spawning

2015 Backwater Sampling – Effort

(Early Spring: Yellow Perch, Northern Pike, Chain Pickerel)

(Late Spring: Largemouth Bass, Bluegill, Pumpkinseed, Black Crappie, Golden Shiner, Spottail Shiner)

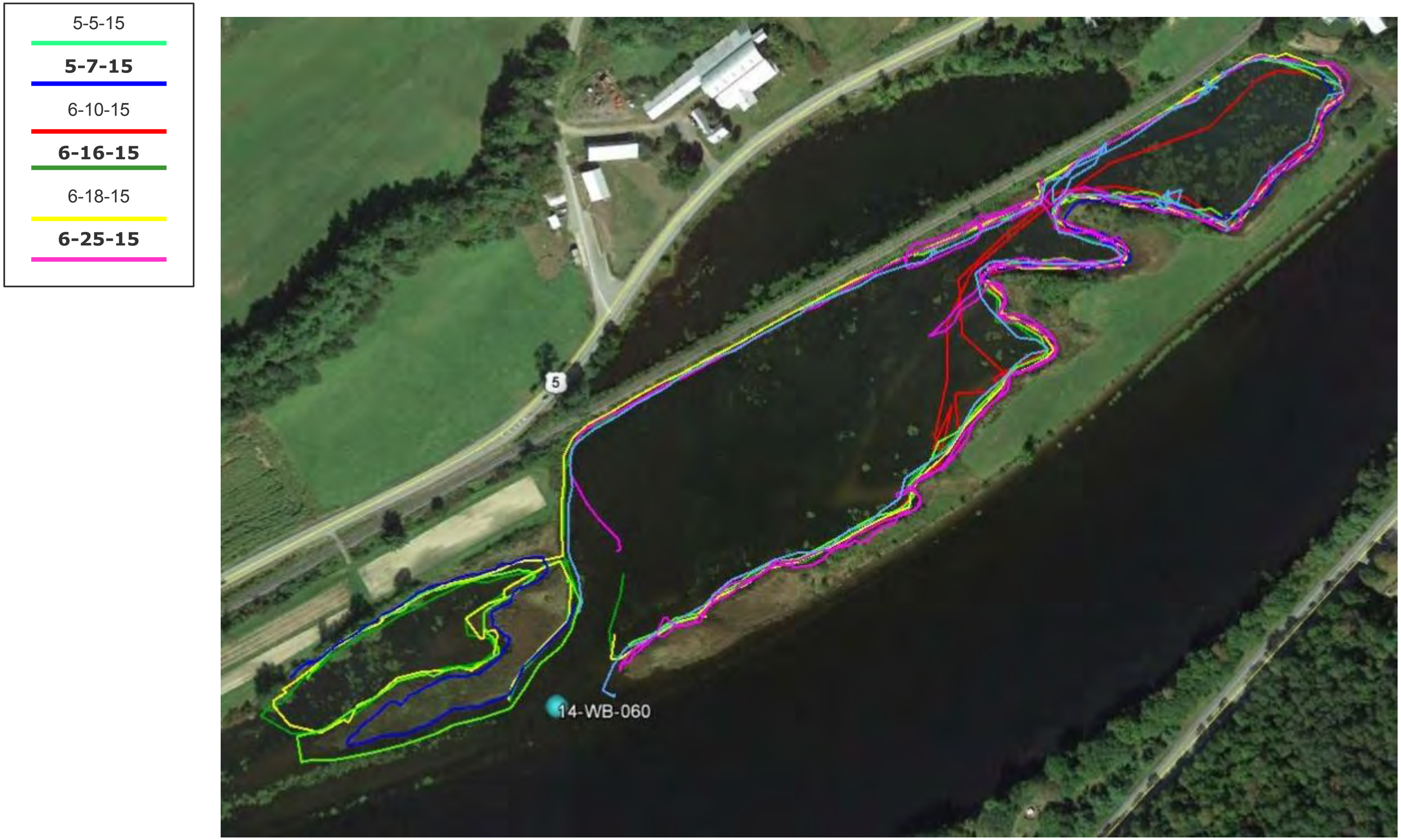
- Impoundment Backwater Sampling: April 28 to July 2
  - 183 surveys within 12 backwater sites, most surveys >1 mile in length
  - Slow motoring or poling in boats, or wading used to survey margin habitats
  - Water clarity limited observations to shallow areas, mostly <3-4 ft (less during high flow events)
  - Angling also employed to assess ripeness of adults, and larval trawls to verify spawning success

Study 14 & 15 – Resident Fish Spawning

Example of Backwater Surveys

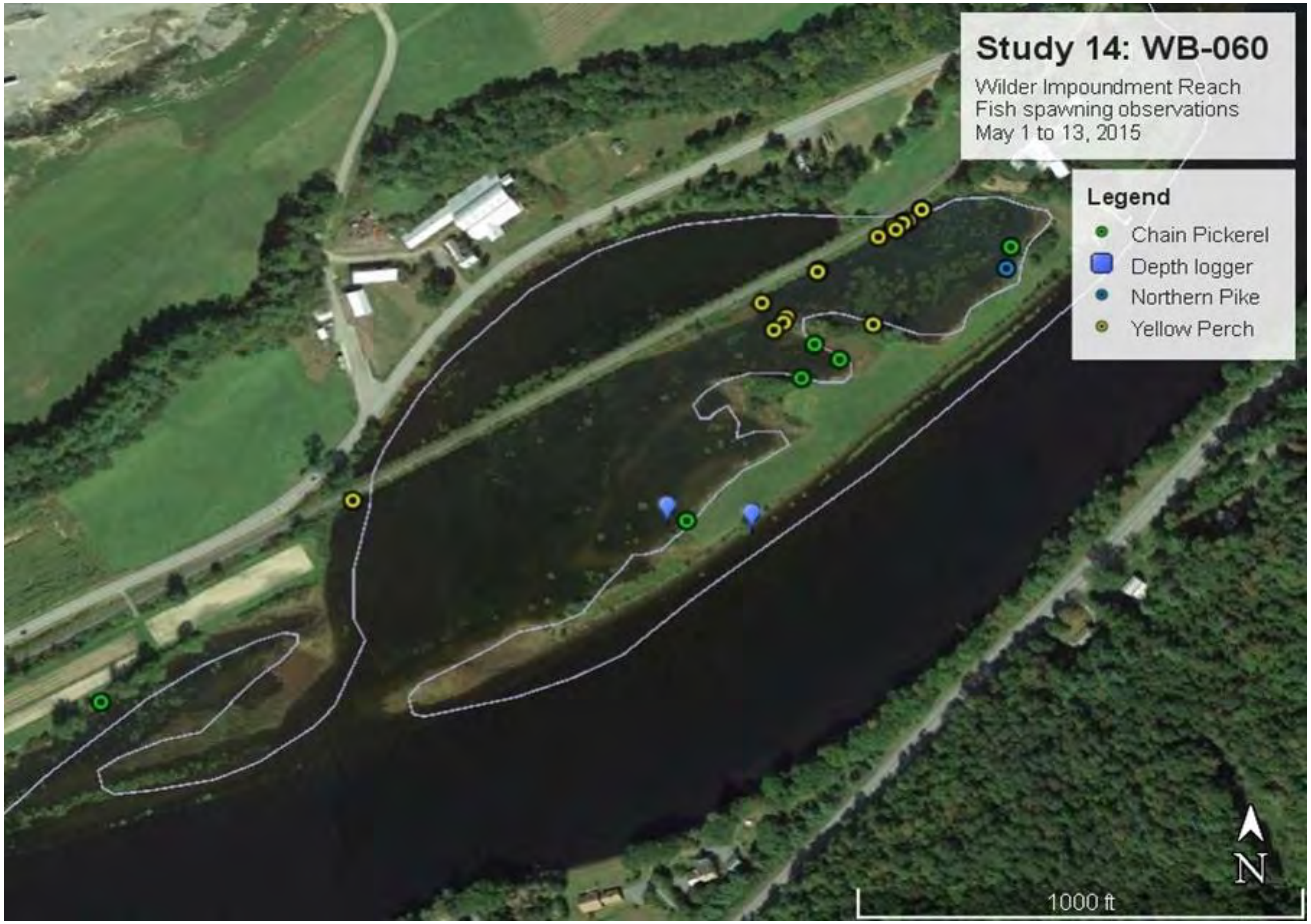
Study 14 & 15 – Resident Fish Spawning

Example of Backwater Showing Tracks from 6 Surveys



Study 14 & 15 – Resident Fish Spawning

Location of spawning observations:



Study 14 & 15 – Resident Fish Spawning

2015 Backwater Sampling – Results

- Early Spring:
  - No spawning activity observed for Northern Pike or Chain Pickerel
    - 55 adult pike and pickerel observed holding in shallow vegetated habitats (but not in spawning aggregations)
    - Net sweeps at pike/pickerel locations were empty
    - 33 adult pike and pickerel captured by angling
      - 1 ripe adult Chain Pickerel caught angling on May 7
    - 1 Chain Pickerel larvae captured in trawl on May 19
  - 838 Yellow Perch egg masses assessed
    - Egg masses were present on initial surveys on April 28^{t}at water temps of 8-11^{o}C, few new egg masses observed after May 6 at 16^{o}C
    - Some egg masses observed on initial surveys were suspended in branches above the WSE (likely deposited during previous high flow event)

TransCanada

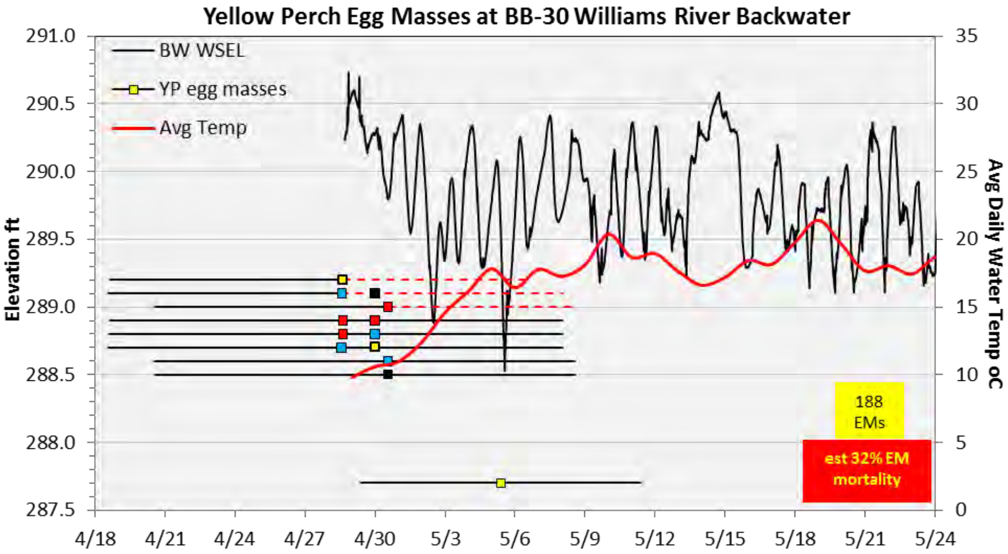
Study 14 & 15 – Resident Fish Spawning

Yellow perch egg masses

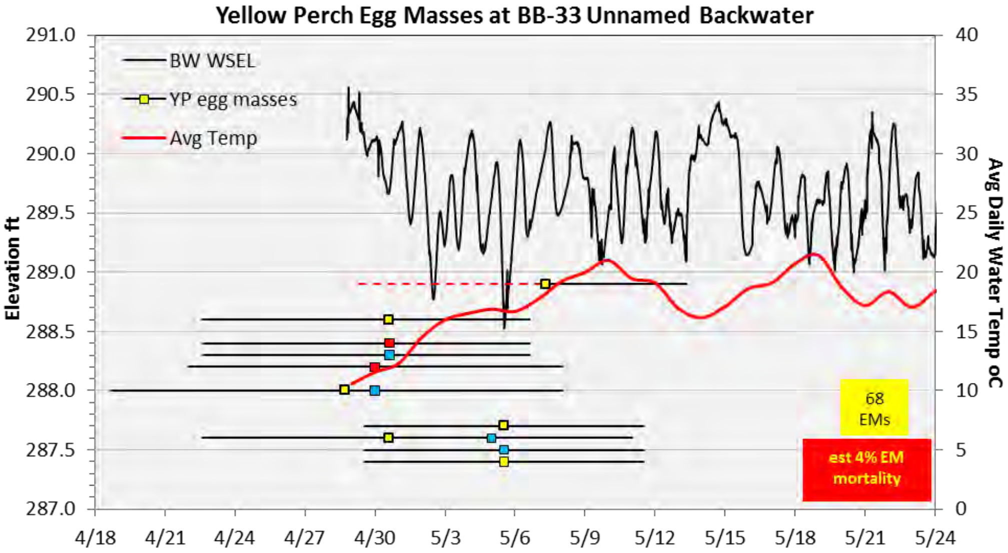
left image shows masses partly out of water, right image is all under water

Study 14 & 15 – Resident Fish Spawning

- Changes in backwater WSE’s (incl uncontrolled) were expected to dewater an average of <25% of the egg masses


Yellow Perch Egg Masses at BB-30 Williams River Backwater

- Larval trawls captured >400 perch larvae in 10 of the 12 backwaters from mid-May to mid-June


Yellow Perch Egg Masses at BB-33 Unnamed Backwater

TransCanada

Study 14 & 15 – Resident Fish Spawning

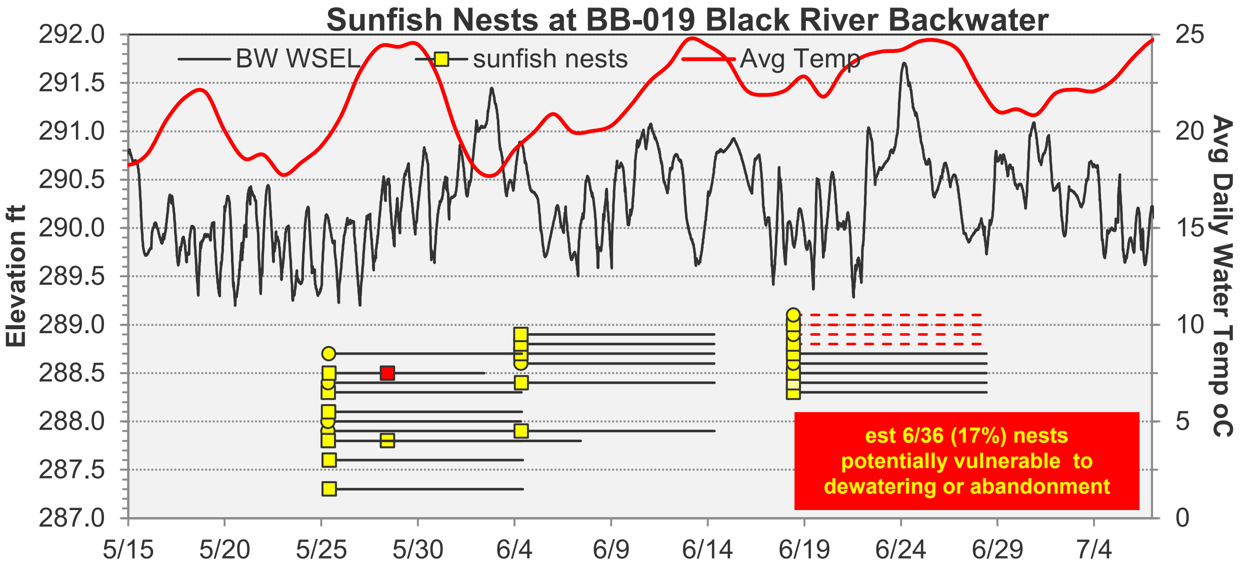
2015 Backwater Sampling – Results

- Late Spring:
  - No spawning locations were identified for crappie or shiners
    - Spottail shiners were the most abundant species captured in the Fish Assemblage Study (Study 10) and cyprinid larvae were common in trawl samples
    - Gravid Spottail Shiners were captured (but not observed spawning) on June 22 at mean daily temps of 18-20^{o}C
    - Gravid Golden Shiners were captured in minnow traps on June 18th and June 24 at mean temps of 17-20^{o}C
  - 5 Largemouth Bass nests were observed – all with eggs or fry (but too few nests to evaluate potential impacts)
  - 123 active sunfish nests were assessed (27 bluegill, 51 pumpkinseed, and 45 unknown sunfish)
    - Active nesting occurred from late-May to mid-June at mean temps of 17-25^{o}C
    - Relatively few eggs or fry were observed, presumably due to short incubation and fry residence times

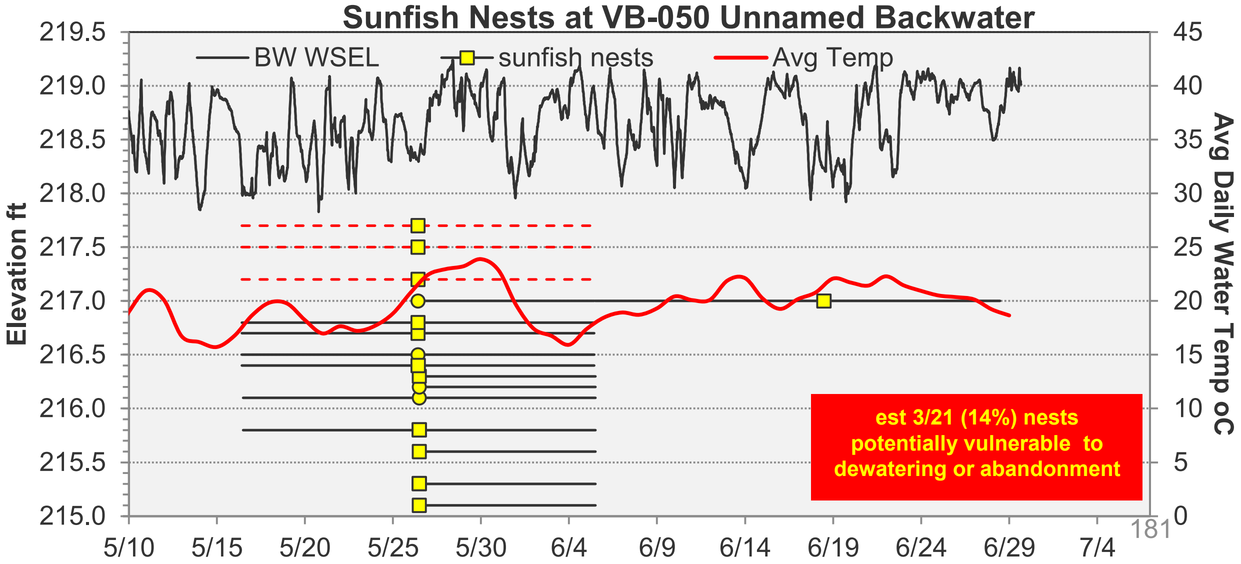
Study 14 & 15 – Resident Fish Spawning

- Changes in backwater WSE’s were expected to dewater nests or displace sunfish adults at an average of 23% of nests

- Only 5 of the 28 vulnerable nests appeared to be actually dewatered; 23 nests had min depths of <0.5’



est 6/36 (17%) nests potentially vulnerable to dewatering or abandonment



est 3/21 (14%) nests potentially vulnerable to dewatering or abandonment

TransCanada

Study 14 & 15 – Resident Fish Spawning

2015 Riverine Spawners Sampling – Effort

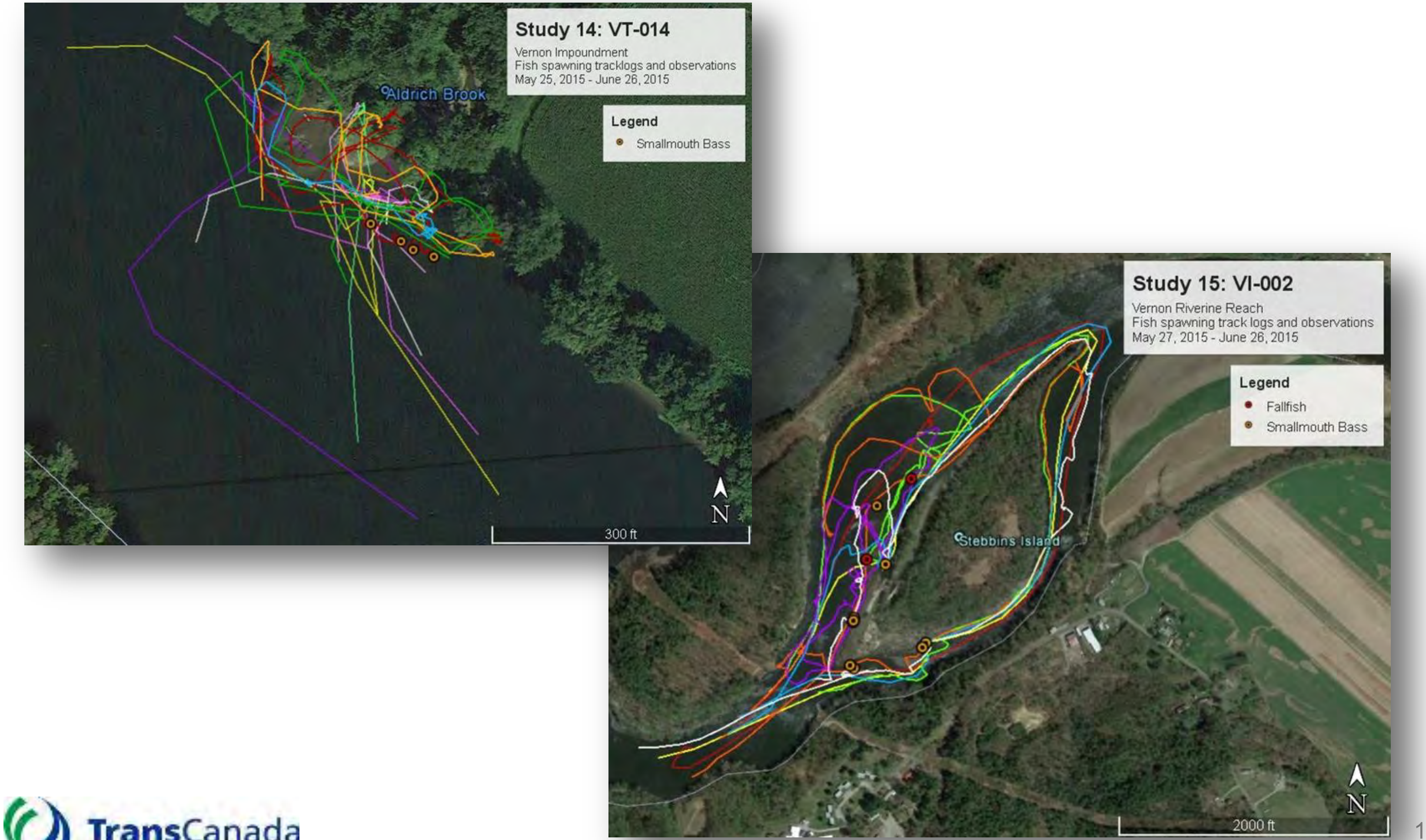
Late Spring: Smallmouth Bass, Fallfish, Spottail Shiner

- Impoundment Tributary Mouth Sampling: May 22 to July 2
  - 135 surveys were conducted at 17 tributary sites
  - Surveys encompassed the lower 1-2 miles of large tributaries and the trib deltas of small tributaries

- Riverine Island / Bar Sampling: May 20 to June 26
  - 51 surveys were conducted at 12 sites (8 islands and 4 bars)
  - Water clarity limited observations to shallow areas in both habitat types (mostly <3-4 ft, less during high flow events)

Study 14 & 15 – Resident Fish Spawning

Examples of Tributary Mouth (left) and Island (right)
Survey Tracks with spawning observations



TransCanada

Study 14 & 15 – Resident Fish Spawning

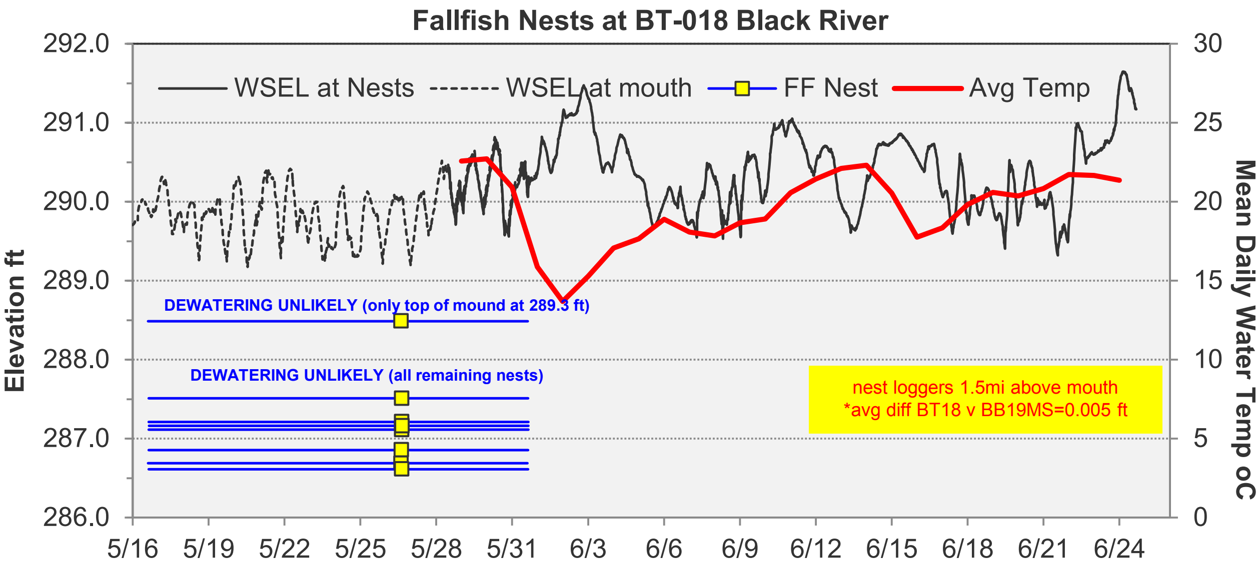
2015 Riverine Spawners Sampling – Results

- Spottail Shiners:
    - No spawning locations were identified for Spottail Shiners (only one location for Rosyface Shiners over a Fallfish nest)
- Fallfish:
    - 26 Fallfish nests were assessed at 7 study sites (12 nests at tribs, 14 at island/bars)
- Smallmouth Bass:
    - 79 active Smallmouth Bass nests were assessed at 8 study sites (35 at tribs, 44 at island/bars)

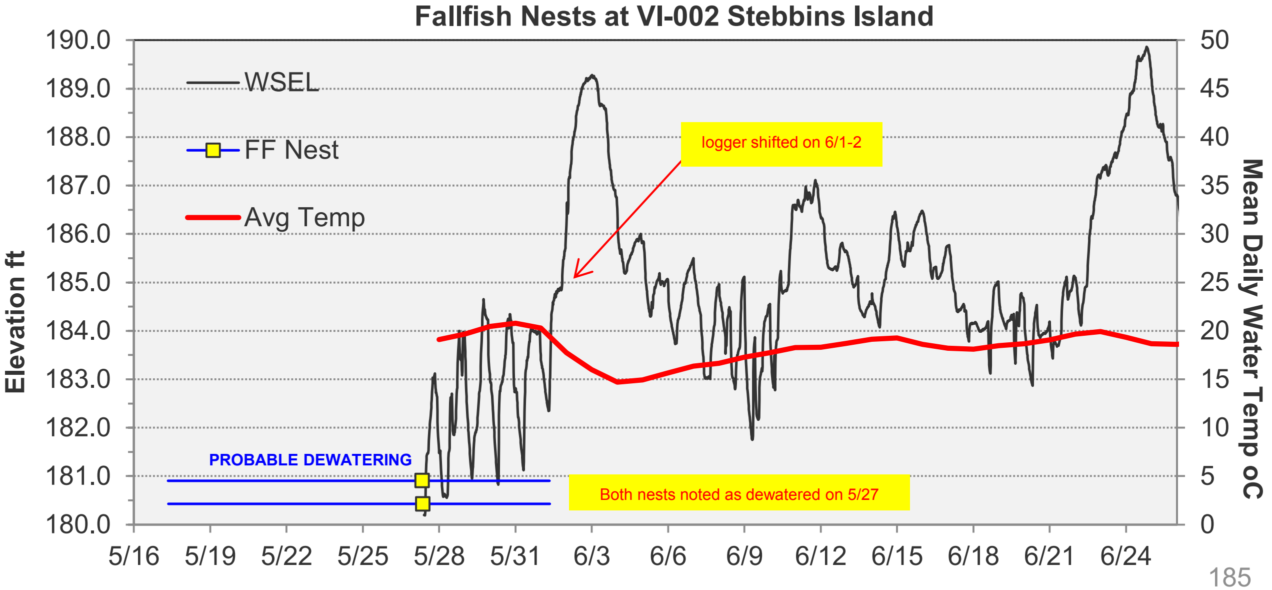
Study 14 & 15 – Resident Fish Spawning

- Minimal changes in trib WSE's did not result in de-watering of any (0%) of the 12 Fallfish nests

- Greater fluctuations in riverine WSE's (especially near dams) resulted in dewatering of 5 of 14 (36%) Fallfish nests



nest loggers 1.5mi above mouth
*avg diff BT18 v BB19MS=0.005 ft

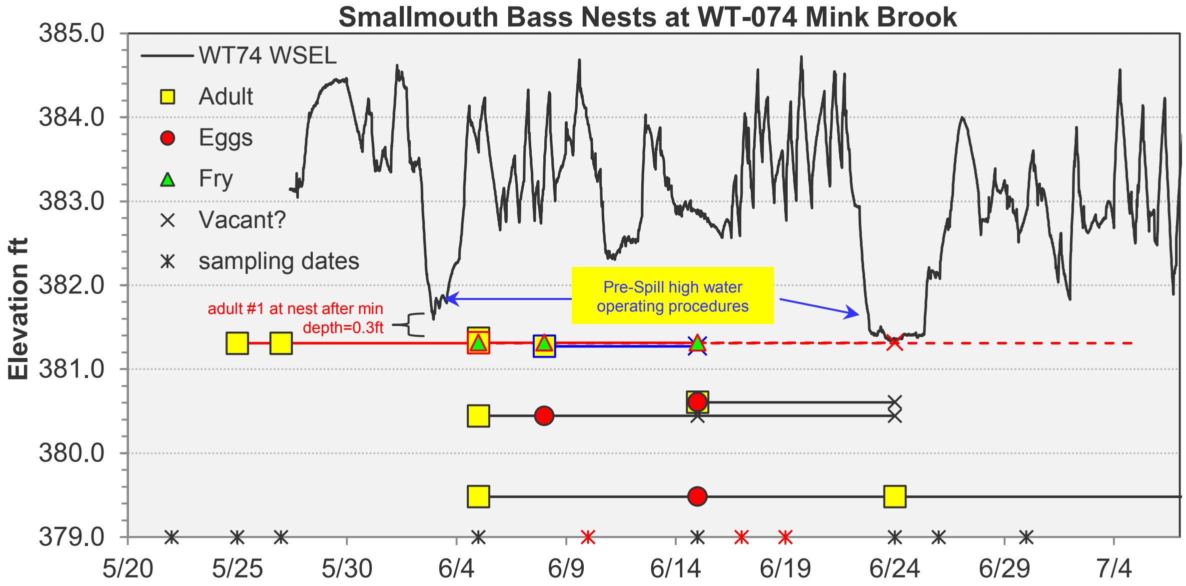


logger shifted on 6/1-2

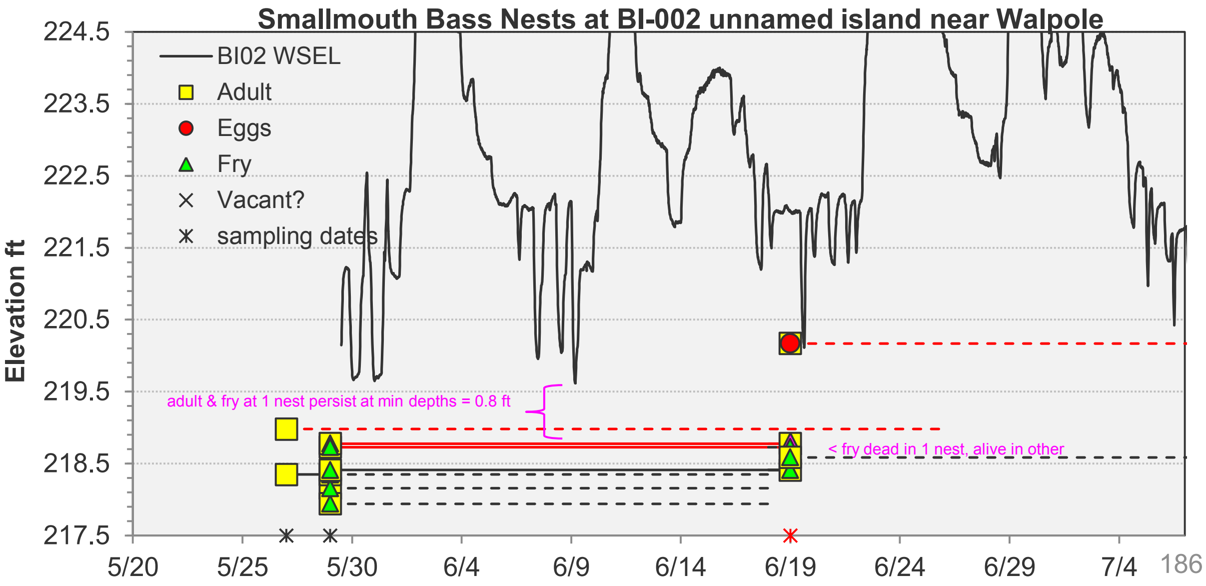
Both nests noted as dewatered on 5/27

Study 14 & 15 – Resident Fish Spawning

- Only 3 of 35 (9%) bass nests at tributaries were vulnerable to dewatering or abandonment (the 3rd nest at Williams River (BT-031) successfully raised fry)



- Greater fluctuations in riverine WSE's (especially near dams) resulted in 15 of 44 (34%) bass nests vulnerable to dewatering or abandonment



TransCanada

Study 14 & 15 – Resident Fish Spawning

Conclusions (Impoundment Reaches)

- Limited collections of White Sucker eggs suggested that tributary spawning may be largely restricted to reaches upstream of project influence
- Minor WSE fluctuations (1-2 ft) in impoundment habitats generally limited dewatering of eggs or abandonment of nests
- An average of 25% of egg masses deposited by perch were vulnerable to dewatering, although many dewatered eggs were deposited at high elevations during early-spring high flow events beyond project control
- Adult pike and pickerel were not observed exhibiting spawning behavior
- Among the late-spring spawners, nests constructed by sunfish in shallow margins were most vulnerable to daily changes in WSE's (23% of nests)
- Lower tributary and tributary mouth spawning by Smallmouth Bass and Fallfish appeared relatively unaffected by daily changes in WSE's

Study 14 & 15 – Resident Fish Spawning

Conclusions (Riverine Reaches)

- A single Walleye egg collected in the lower Cold River suggested that tributary spawning occurred upstream of project influence
- Aggregations of fishermen also suggest Walleye spawning immediately below dams, where shorelines are steep and rocky but hazardous to sample during high flows
- Larger WSE fluctuations in riverine reaches (3+ ft) resulted in a greater percentage of nest dewatering or abandonment among Smallmouth Bass (34%) and Fallfish (36%)
- Project effects on nest spawners were higher at upstream sites closer to the dams, but were relatively minimal at sites >4 miles downstream of the dams due to flow attenuation and tributary inflow

Study 14 & 15 – Resident Fish Spawning

Remaining Activities

- Evaluation of project effects using modeling (ongoing)
    - Observed elevations of eggs or nests at each site were used to estimate a minimum WSE that would be protective of spawning sites (excluding a few outliers)
    - Spawning periodicity for each species was determined from the observation data
    - Ops modeling was used to estimate the number of days the WSEs dropped below these minimum elevations for each site and species, according to spawning periodicity and water–year type
    - This analysis is based on spawning locations (and elevations) observed under 2015 flow conditions and does not account for potential behavioral changes in spawning site selection under years of higher or lower flows