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August 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 July 15, 2016 Updated Study Results 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 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 August 25, 2016 Updated Study Results Meeting Summary for the three projects, as required by 18 C.F.R. §5.15(c)(3) and the Commission's current Process Plan and Schedule (dated May 5, 2016). The Meeting for the Updated Study Report filed August 1, 2016 was held at the Fairfield Inn in White River Junction, Vermont, with WebEx and call-in capability for participants who could not attend in person.

The attached meeting summary includes meeting notes, points of discussion, the list of meeting attendees, and a copy of the presentation slides used during the meeting. According to the current Process Plan and Schedule, the comment period for these studies and studies filed June 17, 2016 will end on September 30, 2016.

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 L. Ragonese
FERC License Manager

Attachment: August 25, 2016 Updated Study Results 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)

August 25, 2016 Updated Study Results Meeting Summary

August 31, 2016

TRANSCANADA HYDRO NORTHEAST INC.
UPDATED STUDY RESULTS MEETING
AUGUST 25, 2016

The Updated Study Results meeting for study reports filed August 1, 2016 was held on August 25, 2016 at the Fairfield Inn and Suites in White River Junction, VT. Presentation slides follow these notes.

Meeting attendees in person or identified on the telephone:

Name	Affiliation	Name	Affiliation
Bill Connelly	FERC		
Brandon Cherry	FERC	Jeff Crocker	VDEC
John Baummer	FERC	Eric Davis	VDEC
Steve Kartalia	FERC	Lael Will	VFWD
Nick Palso	FERC	Julienne Rosset	FWS
Patrick Crile	FERC	Ken Sprankle	FWS
Michael Watts	FERC	John Warner	FWS
Gregg Comstock	NHDES	Mark Wamser	Gomez & Sullivan
Andrea Donelon	CRWC	Chris Tomichek	Kleinschmidt
Tom Christopher	NE FLOW	Semiu Lawal	Hatch
Amy Chang	FERC	Stu Bridgeman	Hatch
David Deen	CRWC	Ben Ellis	LBG
John Bruno	Landowner	John Ragonese	TransCanada
Jim McClammer	CRJC	Jen Griffin	TransCanada
Adair Mulligan	Hanover Conservancy	Rick Simmons	Normandeau
Richard Walling	CRJC	Steve Leach	Normandeau
John Mudge	Landowner	Doug Royer	Normandeau
David Hewitt	Landowner/ CRJC	Adam Slowik	Normandeau
Jim Kennedy	CRJC	Mark Allen	Normandeau
O. Ross McIntyre		Sarah Allen	Normandeau
Tara Bamford	CRJC	Jen Bryant	Normandeau
Don Pugh		Maryalice Fischer	Normandeau

Study 5 – Operations Modeling Study:
Semiu Lawal and Stu Bridgeman summarized the study and the operations model.

Question (Q): How did the model development process and adjustments to it progress? Were there standard modeling approaches used to reach the point where the model simulated actual operations?
Answer (A): First, we looked at whether the model produced the same amount of energy production as we had. Similarly with hydrologies, we looked at ones over the historic record that represented a range of flows and looked to see how those matched up on an energy basis, water basis, etc. to historical operations, and then we adjusted them for changes that have occurred in the upstream projects and

these projects over those 30 years of historical hydrologies. The model base case is based on what the projects are doing now. We looked at whether the model was over-reacting by trying to maximize energy, and we added some constraints (band widths) to force the model on the storage side (from Second Connecticut Lake on down) not the discharge side, to make sure that the model reflects reality.

Q: The model was calibrated to reflect current operations, so when we apply this model to individual studies, the model results are for current operations?
A: Yes. Different studies used model output differently (range of water fluctuations, modeled water surface elevations, etc. during certain time periods of interest).

Q: How would you define the current operations in a future sense if a new owner chooses to operate differently or the market changes, for instance? The licenses allow broader ranges than TC's normal operations.
A: The reason we do not use the full licensed range is because it does not optimize energy. The licenses reflect conditions at the time of those licenses (e.g., Vernon used to have flashboards where we now have gates, new generating units, etc.) and the conditions necessary for high water management. For alternative scenarios we would apply those alternative constraints and compare output from the base case and the alternative.

Q: Will stakeholders have access to the data that came out of this model that fed directly into the other resource studies?
A: We could give you the actual hourly data, but it is a lot of data. The resource studies included their own analysis of model output based on the needs of each study. That information is included graphically or in tabular format for applicable studies.

Q: Can we ask the model "what if" questions across a range of locations?
A: We want stakeholders to tell us what the proposed operational alternatives are based on a resource concern. Stakeholders should frame the questions in terms of hourly changes in discharge, ramping, water surface elevation, and/or fluctuation. But we cannot change from the 5 hydrologies in the model, we can only constrain the model in different ways. We don't think you want to give us proposed operational alternatives though, until you see the study 9 habitat data.

Q: Was model calibration reported?
A: Yes, in the study plan. Our base case is the current operations and installed equipment not what we had in 1992 for instance.

Study 21 – American Shad Telemetry Study:
Doug Royer summarized the study.

Upstream Passage Discussion

Q: In Table 5.3-3 the travel time values vary a lot, for instance in some cases the average travel time between points is much different from the median value. Does that mean that one fish or a couple might have skewed the average data?
Y: Yes.

Q: Figures 5.3-3 and 5.3-4 include 75 fish and the report talks about 104 fish, what happened to the other 29 fish?
A: The difference is the 29 PIT-tagged fish that were not detected at the fishway entrance due to the lower sensitivity of the dual antenna there. This is discussed in Section 4.3.3 of the report.

Q: I don't understand the definition of forays on p. 26 of the report. Is that forays into the fishway and any detection at the entrance or the first bend? I regard a foray as each detection, not all detections over 4 hours. If a fish enters the fishway and goes up to the first bend three different times, is that one foray or more than one?
A: If it was only detected at the entrance not at the first bend, no matter how many times it was detected there without falling back to the tailrace, it was considered the same foray. *[Post-meeting clarification: The report definition will be expanded or modified for clarity in the revised report. Once in the fishway, the report did not quantify movements between points other than in the travel time tables 5.3-3 and 5.3-4, and to compare those travel times between the lower and upper sections of the fishway; however, we can look more closely at that data in revising the report.]*

Q: What was the detection zone around the fish entrance?
A: The range of detection was in the range of the attraction flow and fish entrance.

Q [comment]: Fish attraction is one issue, the second separate issue is whether fish can get into and stay in the fishway, and the third issue is whether they can pass into the forebay.

Q: When is the start time to measure duration from fishway entrance?
A: From the first detection at that point (fish entrance), for the number of fish detected there.

Q: For fishway efficiency, it may have been in the study plan but what is the value in calculating that statistic? How do you explain that fish get to the counting window and then some do not exit into the forebay? When do fish seem to exit the fishway and what are the operations at that time (flow, head pond, etc.)?
A: We were only trying to evaluate the differences between the lower and upper sections of the fishway, and will look at additional data we have within the fishway along with operations data at the time of exit. Overall, there was not a difference in median passage times through each section.

Q: We do not believe that proportional approach is an appropriate analytical method to evaluate project effects. We don't know what each fish was doing over the time period prior to fishway entrance and passage. You have the telemetry and operations data and we had recommended the time- to-event analysis in prior comments [filed May 2, 2016 on the March 17-18 study meeting].
A: The study was not set up to do the time-to-event type of analysis. Telemetry arrays were set up to have overlapping detection areas. The upstream passage study objectives were to assess near-field attraction, entrance efficiency, and internal efficiency of the fish ladder rather than try to understand behaviors of individual within the tailrace and how fish moved back and forth within that area. The report stated that in general, there do not seem to be operational issues related to fish getting to the fishway entrance based on tailrace residency times but we will look more closely at the data we do have and include that in the revised report.

Q: The study results do not allow us to understand project effects. Only ranges of operations are presented in the report. We need to know when these fish were available and what was happening operationally at that time.
A: We will reevaluate how project effects were assessed and revise the report as needed [see Attachment 1 to these meeting notes describing additional analysis and/or data presentation to be included in the revised report].

Q: The report identified night time forays when the attraction water was not operating. It is important to have information on detections and entrance operational conditions to tease out night time periods.
A: That is one area where we can look more closely at the data for the revised report.

Q: Can you provide the operations data?
A: Yes, we can provide that data over the study period.

Downstream Passage Discussion

Q: It is important to put into context the conditions observed in 2015. Almost half the fish experienced the facility during spill conditions. June was substantially different than normal. Also there was no discussion at all about survival for each fish.
A: Is it your belief that the conditions were not normal for downstream passage? Because we did have periods that were normal operating (non-spill) in 2015 as well.

Q: Yes, there is a limited sample size of fish that passed in non-spill.
A: We can identify whether non-spill conditions were representative of normal, non-spill conditions. However, if you want us to do a hydrological analysis of 2015 then that is a different question. At all projects we have observed more periods of spill lately. With regard to survival of downstream passing fish, the study was not a survival study and the only information available would be based on motion detecting tags. For fish that did not pass, that information is included in the report; however we can look more closely at the potential for passed fish to have been tracked below Vernon as part of the spawning study.

Q: With regard to upstream movement assessment, what happened to the 11 fish that didn't come back down to Vernon?
A: After the spawning surveys were completed we did not do extensive manual tracking in that area, so we don't know, and they may have died either before or after spawning above Vernon.

Spawning Discussion

Q: For the spawning portion, you did not see splashing, but you still assumed the fish was spawning?
A: No, we didn't assume that, we assumed spawning had occurred based on egg/larval collections.

Q: There is very little data presented in the report for spawning. Since you found eggs in enough places, you concluded that spawning occurs throughout the project area, and since you collected eggs at some point in some place under different conditions, that there aren't any project effects? There is no data on what was happening on each of the locations/occasions when you sampled. You don't know if fish actually were spawning. There wasn't any evaluation of what the project effects were.
A: There was very little splashing, so we started looking for spawning locations via radio tracking, habitat type, etc. We were not able to actually see spawning locations so we cannot look specifically at operations at those locations/times. We could only relate operations and flows at the locations/times when we collected eggs. However, we will look more closely at the available data to see if any inferences can be made (see Attachment 1).

Q: The report has descriptive observations of spawning, but the expectation was that analysis would be conducted. Variables like depth, when the river was under operational control or not at the different spawning sampling sites, etc.
A: That data, except for project operations is in Appendix C of the report, with water quality data collected at the trawl sites in Appendix D. Environmental condition data were taken at the start of the trawl. Additional data presentation and/or analyses to be included in the revised report are described in Attachment 1.

Q: Why could you not use the models to look at flows/velocity at the trawl sites?
A: The operations model uses the 5 modeled hydrologies, not 2015 actual flow data. We can clarify in the report that because we didn't see spawning we couldn't do that analysis. We will explain better why we did what we did. All we stated in the report is that we found eggs under lots of different conditions and locations, and as a result, we believe spawning occurred and project operations did not seem to affect that. We will review the collection data, operational data and the report itself in an effort to provide a more robust analysis in the revised report.

Study 27 - Floodplain, Wetland, Riparian and Littoral Vegetative Habitats Study:
Sarah Allen summarized the study and project effects analysis based on model data.

Q: Are the transects shown in the presentation figures from the hydraulic model?
A: Yes.

Q: Did you find any exemplary natural communities that would be affected?
A: The only one we documented in this study (prior 2012 study did that) was a black maple forest, and it is very low quality now due to agricultural disturbance, but we did not find any black maple forests associated with riverine activities. My sense is that the river condition has been stable enough that vegetation communities have adapted and do not seem to be affected by water level fluctuations. However, they have other issues like invasive species disturbance.

Q: Do you sense that changes in the hydrology or operations would change distribution of invasives like Japanese knotweed?
A: Mostly we found Japanese knotweed at the tops of banks, more associated with agriculture, and under the forested canopy. Invasives are prevalent and aggressive by definition, but I do not think it is responding necessarily to the hydrology, but more to land disturbances.

Q: So are you saying that there are not hydrology effects or any way to lessen the impacts?
A: The presence and distribution is due to the hydrology as it exists now. If you were able to significantly change the condition, you might change the vegetation

communities. In the Jesup's milkvetch study conducted in 2012 we also found that species not affected by normal project operations.

Q: This report could be used in two directions. If you looked only at wetlands, you could adjust water levels and look at what the changes might be. The submerged aquatic vegetation may change, but if we change elevations for fish spawning for instance, you could look at what those changes might mean for wetlands.
A: We could get at that in a qualitative sense, and yes if you change water levels some community types will increase and some will decrease at the locations where they currently are found.

Study 32 - Bellows Falls Aesthetic Flow Study:
Ben Ellis summarized the study and the 2016 additional low flow analysis.

Q: The filing indicated the video was filed with FERC, can VANR get a copy of that?
A: Yes. [copy provided at the meeting to VANR staff].

Q: There is talk about rebuilding the Vilas bridge. If that happens it would change the traffic pattern at KOP3. Did you evaluate the scenario of whether there might be alternate viewing locations in the future and whether that would significantly change the aesthetic values?
A: The second study evaluation in 2016 was not part of a focus group, and was only intended to characterize aesthetic changes at lower flows than were part of the focus group evaluation in 2015. It was not part of the study to evaluate different scenarios, other than in the original focus group, in which participants indicated that with additional viewing and accessibility for pedestrians, there might be some additional value. The conclusion we reached was that the leakage flow or a little more provides the aesthetic value based on current viewing opportunities.

Study 14/15 – Resident Fish Spawning Studies:
Mark Allen summarized the final study results related to operations modeling.

No questions.

Study 16 – Sea Lamprey Spawning Assessment:
Steve Leach summarized the final study results related to operations modeling.

Q: Since many of the exposed nest sites were in the riverine reaches, is there discharge data from the models that could be used to see changes in exposure if, say, minimum flows were increased?
A: We do have the hydrographs for modeled years, and the model can output variations based on alternative operating scenarios.

Q: The larger question becomes how many nests do you really need to optimize the abundance of the species in the river?
A: There are management plans or targets for some species but that is an agency issue.

Q: How were sites with suitable habitat treated in this report revision?
A: Those sites were relabeled as “no evidence of spawning in 2015” rather than “no project effect” as they were labeled in the interim study report.

Studies 2 / 3 – Riverbank Transect and Riverbank Erosion Studies:
John Field summarized the consolidated studies and results.

Q: Is notching/overhangs considered not eroding? It would likely continue to erode.
A: Of all the notching we saw, about half was mapped as stable and the other half was otherwise eroding. The process with notching could go either way, either continue to erode or remain stable.

Q: What was the timeframe over which you looked at water fluctuation in the model exceedance curves?
A: We used daily water level fluctuation.

Q: Water-level logger data was in 15-minute intervals, does the notching occur at the monitoring sites where the water levels were fluctuating the most? I would like to see each logger‘s water surface elevation (WSE) data and look at frequency of occurrence.
A: What we show in Appendix A of the report for each monitoring site is the minimum and maximum stage based on the logger data. The notching would be within that range. The median range is shown in the Appendix A site figures within the gray zone. You would see a higher density of logger points within that range than outside of it, so we believe we adequately presented that information.

Q: Is there generally more fluctuation closer to the dam than upstream?
A: No, there is generally greater fluctuation farther upstream in the impoundments. Project operations at the dam affect fluctuation far upstream the least, but overall fluctuation at the upstream end is higher than it is closer to the dam, due to inflow rather than caused by project operations at the dam.

Q: Is the method of using the erosion ratio a standard practice in your field? If not, geotechnical and hydrogeological studies would be needed to evaluate WSE fluctuation.
A: It is a methodology I created and used in the Turners Falls impoundment many years ago. There are multiple causes of erosion at any given site and a single cause cannot be ascribed. The study was looking at the entire study area, not at local factors and causes which likely differ from site to site. To do those types of studies (geotechnical and hydrogeological) over 250 miles of river bank is just not practical.

Q: But you cannot then draw the conclusion that project operations have a minimal or no effect.
A: Project operations are included as a potential cause in the study conclusions, with other causes that are also important and likely.

Q: Can you separate out erosion over the last 10-15 years vs. the last 50 years?
A: The results are based on the available data (1950's and 1970's historical data sets and 2014 field effort for this study). For instance at the Mudge site, there were multiple surveys, so we have those data points but not necessarily at the breakpoints you suggest and not over the entire study area.

Q: I think we have a problem in dealing with this report from the standpoint of the litigation that may come out based on what is happening on River Road in Lyme.
A: We only have the available historical data from there, and in 2014 we mapped it as armored. When we compare 1958 and 1978, we lumped all armoring in the broader stable category for purposes of comparison over time. It obviously had been eroding but we only have the distinct points in time to look at. Can we conclude that everywhere the bank was armored means it was eroding? No, in some places armoring was done preventatively, for instance along the railway.

Q: The public should know from this report that erosion has caused significant problems in some locations like Lyme. The report shows two places mapped as stable in the appendix where the road is undermined.
A: While we understand the problem and the concern in Lyme, that specific site and causal investigation was not part of the study (e.g., to evaluate hazards to infrastructure) and that area is unusual in terms of erosion with likely causes more difficult to identify. *[Post-meeting note: Our transfer of the historical data into digital form was made from paper maps so the precision is not ideal and not at the scale needed to answer this question. Additionally, the historical maps were likely to have called our vegetated-eroding category "stable" as described in the report and at the meeting. Once we know the exact locations of road undermining via GPS, we will look at the 2014 mapping data and relevant photos more closely to determine if there may be a discrepancy.]*

Q: In riverine sections with greater velocity you would expect larger erosion, how do you reconcile that the analysis does not reflect that?
A: When you realize how complex the river is and how it changes (e.g., ledges in some riverine reaches), there are all sorts of possible explanations. It isn't just the forces of water in the impoundment reaches, there is also WSE fluctuation, seepage, groundwater, etc. [*Post-meeting clarification: modeling data will be reviewed further to assess whether impacts of velocity and shear stress can be determined on riverbanks in the study area, and that information included in the revised study report.]*

Q: In the executive summary of report, there is a statement that notching can occur due to various causes "or" due to WSE fluctuation. Shouldn't that be "and WSE" fluctuation?
A: The intent was to distinguish between non-project controlled (e.g., natural) causes and the WSE fluctuations due to normal project operations; it may be more accurate to state the various causes "including" WSE fluctuation.

Q: Did you say that if you were willing to spend the time and money you could determine the cause or primary cause of erosion?
A: I think there are multiple causes at every spot, but yes that would be possible at a specific location. But that was not what the study was intended to do. In this study we were trying to tease out if project operations are a primary cause. Notching occurs at the water surface elevation and we did find that some notching occurs within that project operations range and some does not, but notching is only a part of the erosion cycle.

Q: What has not been answered is what the project fluctuation effect is on creating notching which happens 24/7 all year around, as opposed to say boat wakes that only happen in summer and not very much. The report does not say what the effect of WSE fluctuation is on erosion.
A: The report does say that notching is part of the erosion process and notching has multiple causes. The report shows that much of the erosion occurs far upstream in the impoundments where project dam WSE fluctuations have little to no effect. Project operations do not change WSE in those locations as much as it does closer to the dam or just downstream of the dam. But rates of erosion are higher farther upstream. The study does not pinpoint locations, but characterizes project related effects in the data that we could find and develop. We are not saying the projects do not cause <u>any</u> erosion, but that the continuation of the cycle of erosion is dependent on flood flows that remove the base of bank material.

Q [comment]: I just see what I see at my property that the notching continues and is within the normal fluctuation range.

Q: Have you considered the possible correlation with varve layers to infiltration and erosion?

A: We had intended to look at heterogeneity in sediments/substrate that lead to horizontal seepage, but the problem with that in terms of this study was that only three of the 21 sites had bank recession during the 2-year monitoring period. The other issue was that a lot of native bank sediment was covered and we could not get down into it to look closely at the detailed bank make up. I will note that you are talking about precipitation that infiltrates. I will also say that there are some unusual things in Lyme and it might be something related to soils.

Q: Page 110 of the report, you say sink holes happen in the winter but the new one in Hanover happened in the summer.
A: The statement in the report was based on the 21 monitoring sites where three showed bank recession (the term sink holes was not used to describe these instances; see page 61 of the report for sink hole discussion) and all of those occurrences were between November and May.

Q: The last paragraph of report says project operations haven't changed over decades but there is no data or history of operations provided.
A: We can qualify that concept more clearly. All we have done is increase minimum flows from the upstream project (Fifteen Mile Falls) as part of that project relicensing, and we have minimized fluctuation in the impoundments under normal operations, for instance at the Vernon project due to spillway crest control added in the 1980's.

Q: Could you do some correlation between soil types and erosion?
A: We have done that within the context of the bank height and in relation to geomorphic surfaces, which in turn relate to soils. Soil maps are often based only on the upper foot of soils so would not be helpful.

Q: We are asking you to tease out what proportion of erosion is caused by project operations.
A: The USASE 1978 (published in 1979) study did do that. They rank-ordered several causes observed. A concern with ranking is that it leads to defining an area of erosion by a particular cause based on rank, when in reality it is the effect of a combination of the ranked causes. This current study was not intended to attempt to quantify proportional causes of erosion at any given location.

Attachment 1

Study 21 additional data presentation and/or analyses to be included in the revised study report

1. Upstream Passage Assessment

    a. Clarify or modify the definition of "foray". Prepare a table which provides the fish ID, date and time for each unique "foray" observed during the study. The table will include columns for generation at Units 1 through 10, non-unit spill, attraction and bypass flows, temperature, and whether or not that foray was ultimately successful. Provide the same information graphically to potentially identify particular operations that led to more or fewer successful "forays". Review data on forays and present information on day vs. night forays when attraction flow was not operating.

    b. Clarify the term "residency time" in the tailrace and simplify or combine Tables 5.3-3 and 5.3-4 on travel times between points at detection points for both types of tagged fish. Provide a table (as in bullet 1.a above) of residency times for each dual- tagged fish within the study area and, in lieu of a time-to-event analysis which cannot be reasonably conducted for this study, include total project discharge data at the end of residency (e.g., successful foray into fishway) and min/max/mean discharge during residency.

    c. Review detection data within the fish ladder to compare the amount of time fish were in the ladder for fish that exited vs. fish that fell back below the counting window, and evaluate operations data (head pond, flow) at the time of fishway exit.

    d. Provide operations data for the study period as requested.

2. Downstream Passage Assessment

    a. Provide an expanded table for downstream passing fish showing ID, date/time and route of passage along with unit discharges, fish tube and pipe discharge, spill discharge and locations of spill discharges. Plot conditions graphically and at present observed patterns, if they can be discerned.

    b. Include data on PIT-tagged fish detected passing via the fishpipe (as requested via email prior to the study meeting).

c. Expand upon conditions during residency time prior to downstream passage and provide a table as in bullet 2.a above.

d. Expand upon downstream passage survival given the limitations of motion-detecting tags, and review manual tracking data below Vernon to determine which downstream passed fish were tracked.

3. Spawning

a. Since little splashing was observed during spawning surveys, the available data on spawning locations is limited. We will evaluate the usefulness of various approaches to identifying spawning locations, including: reviewing operations and river flows, modeled velocities, and bathymetry data; and/or conducting additional lab analysis of egg stage which may give an indication of egg age at collection to potentially allow inferences of the distance upstream where eggs were spawned. If any of this information proves informative it will be included in the revised report.

Wilder, Bellows Falls, and Vernon Project Relicensing

Updated Study Results Meeting: August 25, 2016

TransCanada

Agenda

Study No.	Study Title	Study Lead
5	Operations Model Study	Semiu Lawal, Stu Bridgeman
21	American Shad Telemetry Study	Doug Royer
14/15	Resident Fish Spawning in Impoundments and Riverine Sections	Mark Allen
Break		
16	Sea Lamprey Spawning Assessment	Steve Leach
32	Bellows Falls Aesthetic Flow Study	Jot Splenda, Ben Ellis
27	Floodplain, Wetland, Riparian, and Littoral Vegetation Habitats Study	Sarah Allen
Lunch		
2/3	Riverbank Transect and Riverbank Erosion Studies	John Field

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Study 5
Operations Modeling

TransCanada

3

Study 5 – Operations Model

Overview:
- Operations model (Vista DSS™) 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 in order to characterize current average annual project effects and make comparisons with effects from alternative operational scenarios at the same locations or for same resources.
- Water level and flow values are available at all model cross sections.
- These data enabled other studies to assess the effects of project operations on aquatic, terrestrial, and geologic resources at locations of interest (econodes).

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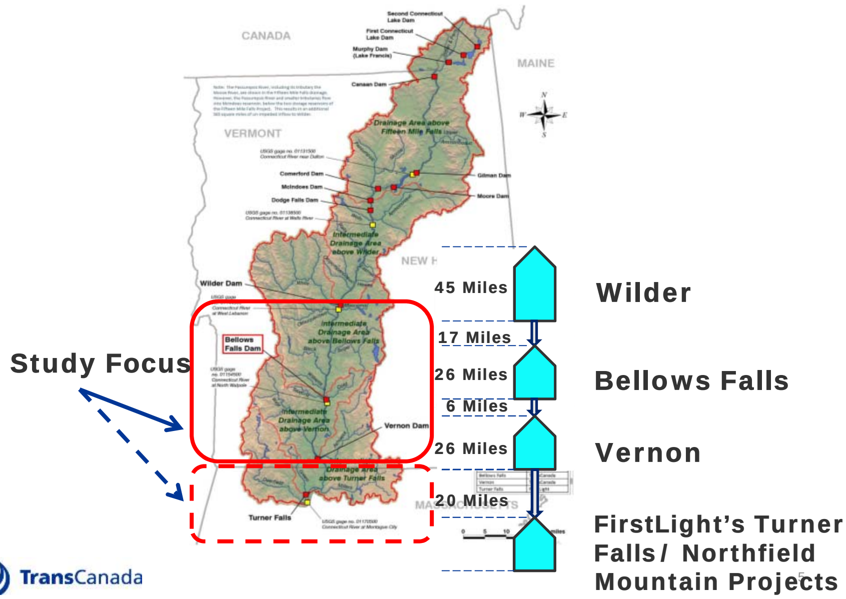
Study 5 - Project Location



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Study 5 – Study Update

- Defined econode habitat indices for additional reaches as provided by resource leads
- Produced Baseline Case results and distributed to various studies.
- Filed study report
- Completed simulation of FirstLight's Turner Falls and Northfield Mountain project operations for the five selected hydrologic years to enable evaluation of habitat indices below Vernon

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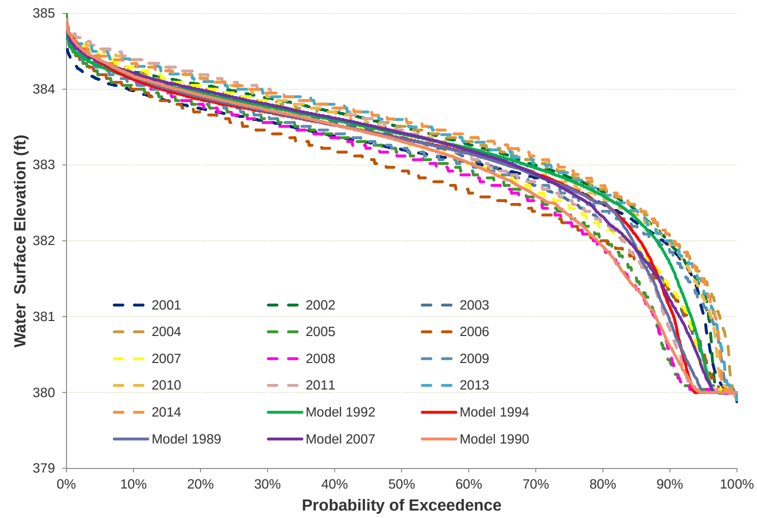
Study 5 – Model Validation: Wilder WSE Duration Curve 1



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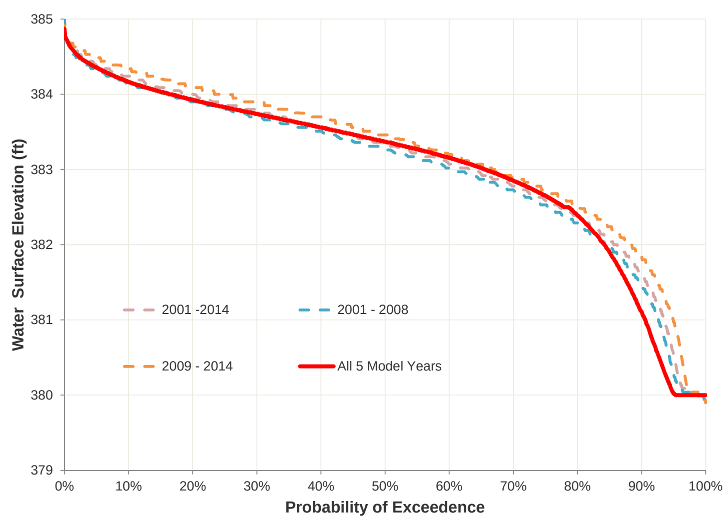
Study 5 – Model Validation: Wilder WSE Duration Curve 2



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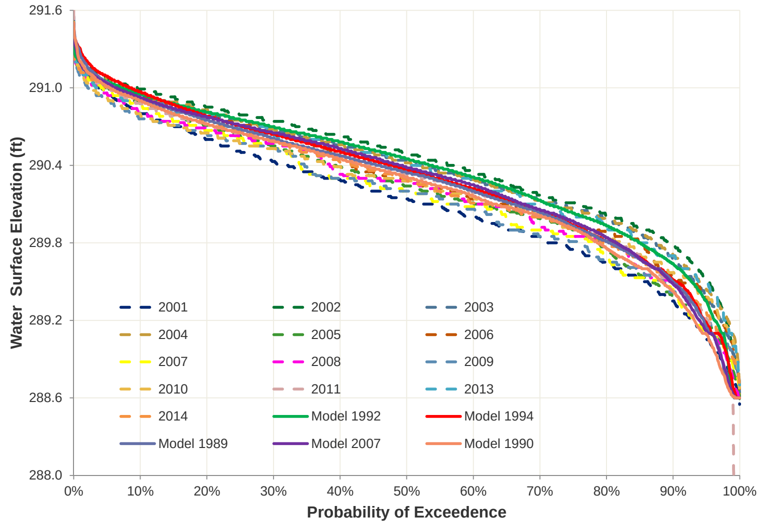
Study 5 – Model Validation: Bellows Falls WSE Duration Curve 1



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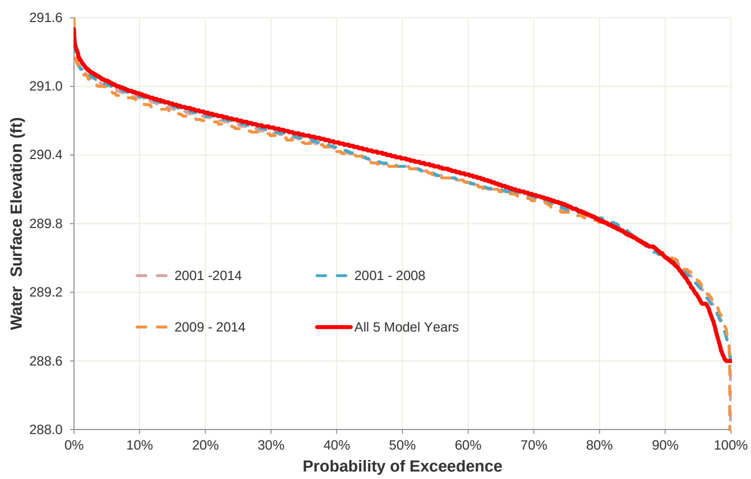
Study 5 – Model Validation: Bellows Falls WSE Duration Curve 2



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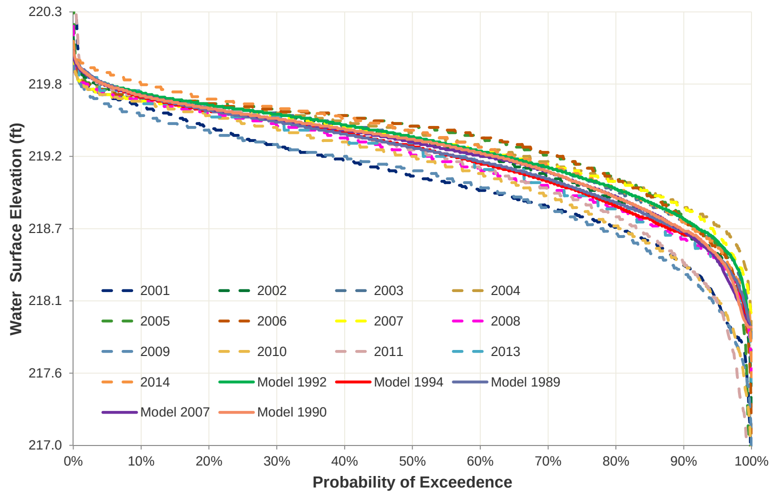
Study 5 – Model Validation: Vernon WSE Duration Curve 1



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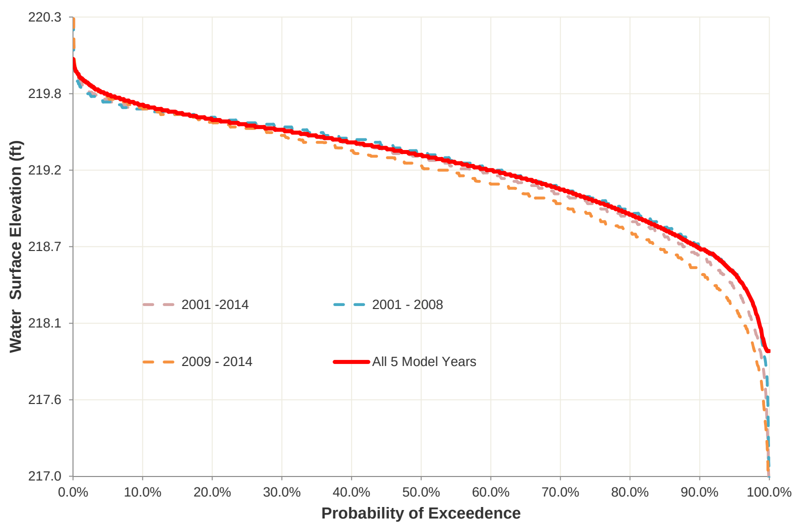
Study 5 – Model Validation: Vernon WSE Duration Curve 2



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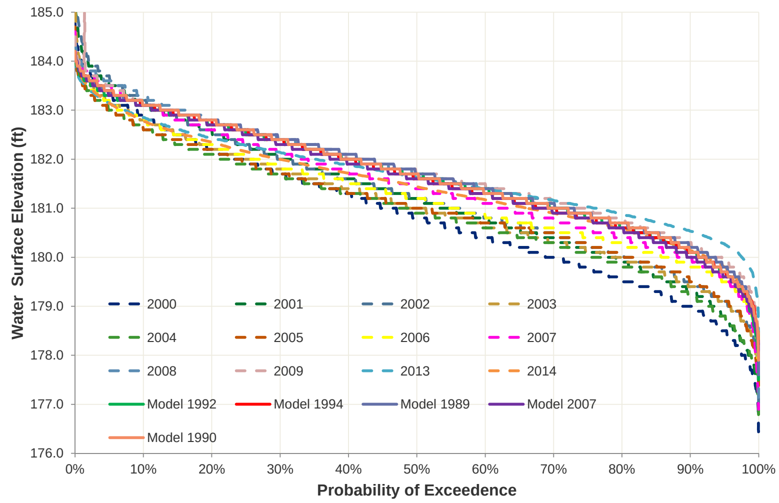
Study 5 – Model Validation: FirstLight WSE Duration Curve 1



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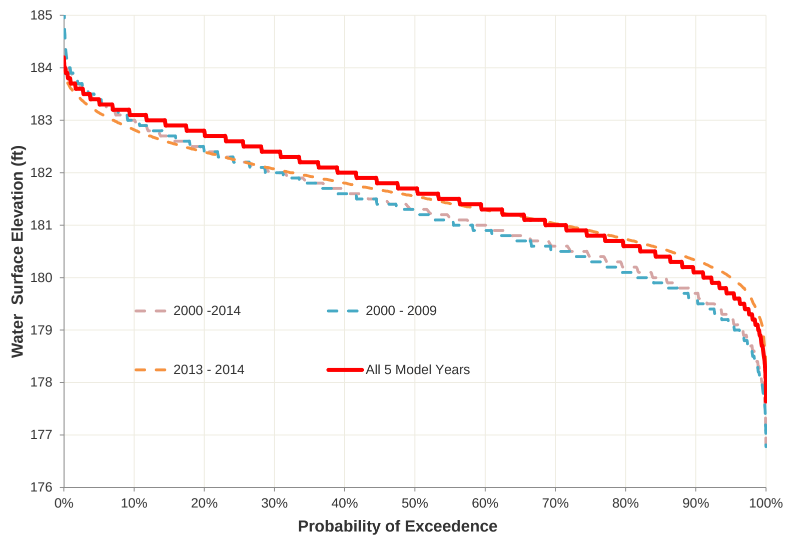
Study 5 – Model Validation: FirstLight WSE Duration Curve 2



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Study 5 – Sample Model Output

Study No.	No. of Econodes	Model Output
2 / 3	1,252	Modal values and duration curves of daily water surface elevation (WSE) variation
9	5	Hourly time series and duration curves of life stages habitat indices for 9 species (total of 25 life stages per location)
13	37	Daily time series of number of hours without access and % time without access
14 / 15	85	Number of days in the time period in which WSEs were lowered in response to imminent storm events
16	34	Hourly time series of WSE
25-26-28-29	48	Maximum, Minimum and Mean statics and plots of Hourly, daily, weekly, monthly and seasonal WSE time series along with reference elevations
27	19	Maximum, Minimum, and Mean statistics of weekly WSE and weekly water level fluctuation time series and plots.

Additional analysis of additional econode habitat indices as requested by resource leads (studies 9, 24)

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Study 21
American Shad Telemetry Study

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Study 21 – American Shad Telemetry Study

Study Summary – Recap

- Four study elements:
  - Migration upstream from below Vernon through the fish ladder
  - Migration upstream through Vernon impoundment to Bellows Falls
  - Spawning activity
  - Post-spawning downstream migration
- 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.
  - 52 were tagged with both a radio tag and PIT tag ("dual-tag")
  - 48 were only PIT tagged.
- 54 additional shad were collected at the Vernon fish ladder, radio-tagged, and released into the Vernon impoundment.

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Study 21 – American Shad Telemetry Study

Study Results – Upstream Passage - Dual Tag Shad

184 dual-tag fish were released into Turners Falls impoundment by TC or FL or were released by FL at Cabot or Holyoke and had passed into the impoundment (N=6).

- 70 (38%) were detected in the study area (Stebbins Island or Vernon tailrace)
- 114 (62%) did not enter the study area. Of those:
  - 46 (40%, or 25% of all 184 impoundment fish) were detected via manual tracking between Stebbins Island and Northfield MA.
  - 68 (60%, or 37% of all 184 impoundment fish) were not detected above Turners Falls dam and may have fallen back after release.

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Study 21 – American Shad Telemetry Study

Study Results – Upstream Passage - Dual Tag Shad

70 dual-tagged fish (TC and FL) were available to assess behavior in the study area, approach to the fishway, passage.

- Average travel time from release to Vernon study area was ~ 8 days, 22 hours. Generally, shad tagged earlier in the season took longer to move than those tagged later in the season.
- Average travel time from release to initial detection in the fishway entrance was ~ 10 days, 11 hours.
- Average time from detection in the tailrace to detection at the attraction flow was ~ 2.5 days, median time was ~ 21 hours.
- Average time from the fishway entrance to exit was ~ 8 hours, median time was 3.5 hours.
- 36 fish were detected at attraction flow, and made a total of 94 forays. 17 made a single foray, 1 made 34 forays.
- 18 fish were detected at least one time at the counting house window monitoring station.

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Study 21 – American Shad Telemetry Study

Study Results – Upstream Passage - PIT Tag Shad

68 PIT-tagged fish (TC and FL) were available to assess movement in the fishway and passage. Only 39 were detected at the fishway entrance due to the lower sensitivity of the PIT receiver there.

- Average travel time from release to fishway entrance was ~ 8 days, 19 hours.
- Average time from fishway entrance (or first bend) to exit was ~ 16.5 hours, median was ~ 5 hours.
- 44 fish made 1 foray, 12 made 2 forays.

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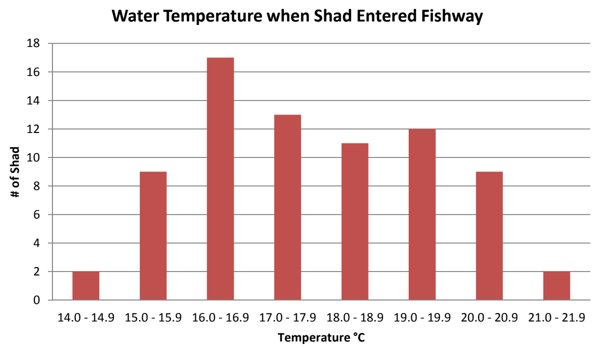
Study 21 – American Shad Telemetry Study

Study Results – Upstream Passage

Both dual-tagged and PIT-tagged shad made successful and unsuccessful forays into the fishway under various water temperatures.



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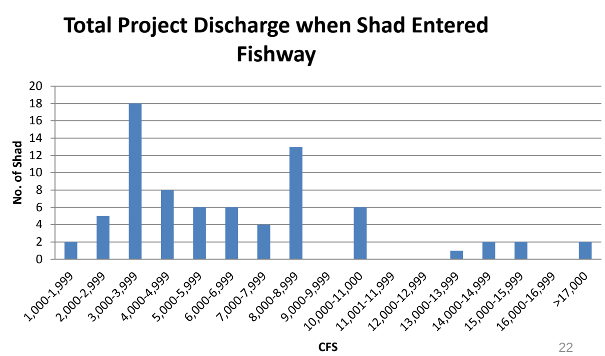
Study 21 – American Shad Telemetry Study

Study Results – Upstream Passage

- Dual tag - no appreciable difference in total station discharges when attraction flow was or was not operating (~9,500 cfs in both cases).
- PIT tag - When attraction flow was not operating, forays occurred when discharge flows ranged from 1,868 cfs to 10,198 cfs (average = 4,074 cfs). When attraction flow was operating, forays occurred at flows ranging from 2,114 cfs to 22,270 cfs (average = 6,650).
- Overall, fish entered at a range of flows.



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Study 21 – American Shad Telemetry Study

Upstream passage analysis:

- Fishway Attraction Effectiveness: The proportion of dual-tag fish that entered the fishway from the number of fish available (# detected in tailrace) = 51.4% (36 of 70).
    - ~ 65% of fish in the study area (tailrace or Stebbins Island) that did not enter the fishway were later detected by manual tracking downstream of Vernon and spawning was documented in that reach.
- Upstream Fish Passage Efficiency: The proportion of dual and PIT tagged fish that were detected upstream of the counting house window from those that entered the fishway = 67.3% (70 of 104).
    - Average travel time > in lower fishway section (~ 11.5 h) than in the upper section (~ 3 hours). Median times were more similar: ~2.5 hours in the lower section vs 1.3 hours in the upper section.
- Upstream Fish Passage Effectiveness: The proportion of dual-tag fish that exited the fishway and remained upstream for > 48 hours from those that entered = 51% (53 of 104).
    - 73% of PIT-tagged shad and 50% of dual-tagged shad passed in a single foray.
    - Differences in effectiveness between tag types (33.3% dual, 60.3% PIT) but similar median travel times entrance to exit (~ 3.5 hours dual, ~ 4 hours PIT).

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Study 21 – American Shad Telemetry Study

Study Results – Upstream Migration

65 radio-tagged shad were monitored upstream of Vernon dam.

- All fish were detected upstream at least once beyond detections in the Vernon forebay.
- 18 (32.1%) migrated to the Bellows Falls tailrace, 14 of those eventually returned and passed downstream of Vernon dam.
- Travel time to Bellows Falls ranged from ~ 20.5 hours to over 23 days; with a median travel time of ~5.7 days.
- 54 (83.1%) shad monitored above Vernon were later re- located in the Vernon forebay.
    - Median time from release in the impoundment or upstream passage at Vernon to the subsequent initial detection in the forebay was 11 days, 22.5 hours, including time spent upstream prior to subsequent downstream migration.

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Study 21 – American Shad Telemetry Study

Study Results – Downstream Passage

Downstream passage was documented for 81.5% (44 of 54) shad located in the Vernon forebay. Of those:

- 11 (25%) passed through the fish pipe
- 9 (20%) passed through turbine units 5-8,
- 3 (7%) passed through turbine units 9-10
- 7 (16%) passed through turbine Units 1-4
- 5 (11%) passed via an unknown route
- 9 (20%) utilized the spillway.
- 10 were located in the forebay but did not pass:
  - 9 were found dead and lodged on the trash racks and 1 with unknown passage route with tag found stationary in tailrace.
  - It is unclear when these fish died – could have died upstream and drifted into the forebay after spawning; and the one that became stationary may have died either before or during passage.

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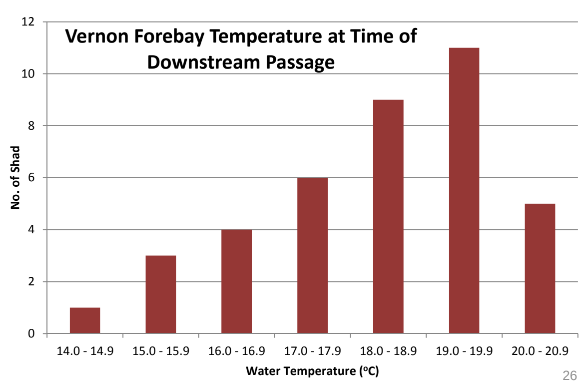
Study 21 – American Shad Telemetry Study

Study Results – Downstream Passage

- Most shad passed downstream from May 19 to June 25, last one passed July 7.
- Comparable numbers passed during the day and at night when attraction flow was off.
- Residency time ranged from < one minute to 21.3 days; median = 9.75 hours.
- Over half of passed fish (51.3%) passed at water temperatures between 18.0°C and 19.9°C.



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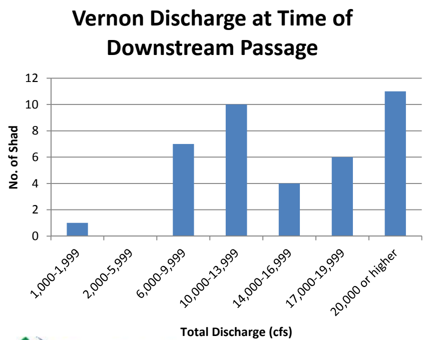
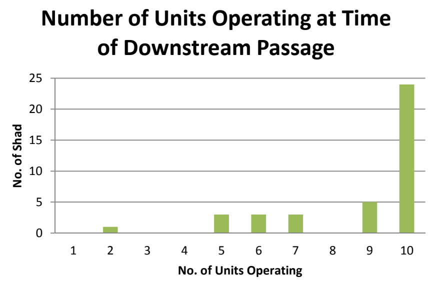
Study 21 – American Shad Telemetry Study

Study Results – Downstream Passage

Fish passed by a variety of routes within each discharge range.

- At flows <14,000 cfs, 67% passed via the turbines, 28% use the fish pipe, 5% used the spillway.
- Between 14,000 - 20,000 cfs, 60% used the fish pipe or spillway, 40% used the turbines.
- At flows > 20,000 cfs, 55% used the spillway, 27% used turbines, 18% used the fish pipe.





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Study 21 – American Shad Telemetry Study

Study Results – Downstream Passage

- The fish pipe provides about 350 cfs or 2.7% of proportional flow (1.4 -2.3% during spill and 2.4 - 5.7% during non-spill), most fish with known passage route (28.2%) used that route indicating its effectiveness for that purpose.
- Units 9 and 10 provided 26.2% of total flow during passage through them, but they were never the only units operating when fish passed via that route.
- Units 5-8 are operated more frequently (after Unit 10 with fish ladder ops) and during passage through them accounted for an average of 43.7% of total flow.
- Units 1-4 operate least and accounted for 16.3% of total flow when fish passed this route.
- The spillway accounted for over 42% of total flow on average when that route was used.

Route	Number Passed	% Passed with Known Route	Average of Proportional Flow at Time of Passage
Fish pipe	11	28.2%	2.7%
Turbine Units 5-8	9	23.1%	43.7%
Turbine Units 1-4	7	17.9%	16.3%
Turbine Units 9-10	3	7.7%	26.2%

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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 (60 total sampling events)

- Spawning occurred throughout the study area with concentrations in the Vernon and Bellows Falls riverine reaches.
- 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 were collected on 30 nights between 26 May and 2 July, 2015.
- 792 shad eggs and larvae were collected in 46 samples.
    - 774 (98%) were eggs
    - 9 (1%) were yolk sack larvae (YSL)
    - 9 (1%) were post yolk sack larvae (PYSL)

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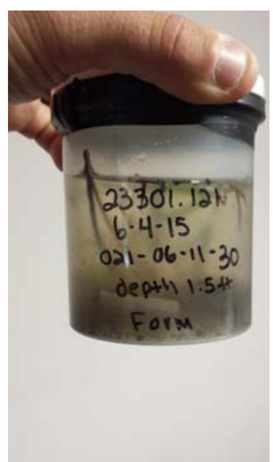
Study 21 – American Shad Telemetry Study

Night trawling

Egg sample collection



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Study 21 – American Shad Telemetry Study

Study Results - Spawning

- The RSP specified that observed effects of project operations on spawning activity would be classified as:
  - no effect –viable eggs were collected;
  - moderate effect –spawning may have been hindered but viable eggs were collected
  - adverse effect –no viable eggs were collected.
- Since:
  - eggs and/or larvae were collected during a wide range of project discharge flows.
  - collections occurred throughout the study area in close proximity spatially and temporally to locations where they were not collected.
  - Therefore, this effects classification could not be conducted as planned using the hydraulic and operations models.
  - And, overall spawning results indicate no adverse project effect.

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Study 21 – American Shad Telemetry Study

Study Summary and Conclusions

- Spawning: Project operations do not appear to have an adverse effect.
- Downstream Passage: Project does not appear to be a significant barrier to safe and timely passage.
  - Median residency = 9.75 hours.
  - 81.5% passed and were confirmed non-stationary based on detections at monitors or through manual tracking.
  - Of the remainder, 9 were found stationary at the trashracks and may have died upstream and drifted into the forebay after spawning or were impinged on the trash rack. One was found stationary in the tailrace and may have died either before or during passage.

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Study 21 – American Shad Telemetry Study

Study Summary and Conclusions – Continued

- Upstream Passage: Fishway seems to adequately pass adult shad.
  - Average time from initial tailrace detection to fishway entry ~ 2.5 days (median ~ 21 h).
  - Average time from the fishway entrance to exit ~ 8 hours (median ~ 3.5 h).
  - 65% of study area fish that didn't enter the fishway were detected downstream and spawning was documented.
  - Fishway Attraction Effectiveness = 51.4%, within the range of attraction effectiveness values (11.0% - 73.0%) observed at other facilities for adult shad.
  - Upstream Fish Passage Efficiency = 67.3%. Average travel time was longer in the upper fishway, but median travel times in lower and upper portions were similar (~2.5 h in the lower section vs 1.3 h in the upper section).
  - Upstream Fish Passage Effectiveness = 51.0%, within the range (40-60%) of the CRASC management plan for shad in the Connecticut River.

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Study 14 & 15 – Resident Fish Spawning

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Study 14 & 15 – Resident Fish Spawning

Final Report Revisions Based on Interim Report Comments

1. Treatment of Yellow Perch incubation assessment
   - Out-of-water egg masses
   - Top vs. middle elevation measurements
   - Direction and duration of incubation periodicity
2. Additional WSE buffer for Fallfish nests
3. Misc. editorial changes
4. Assessment of project effects based on modeling
   - Calculation of min, median, and max egg/nest elevation criteria
   - Estimated # of days the criteria were exceeded according to species periodicity, study site, and 5 modeled water years
   - Effects of "high flow impoundment operations"
5. Conclusions

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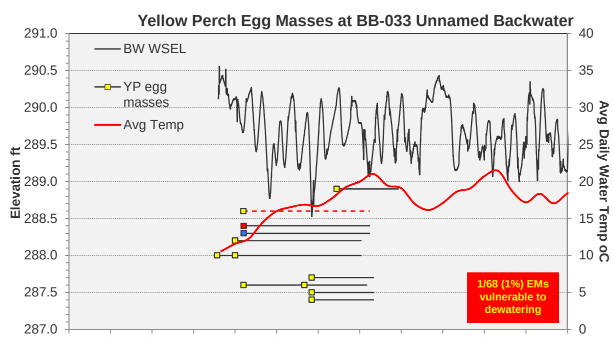
Study 14 & 15 – Resident Fish Spawning

1. Treatment of Yellow Perch incubation assessment

- Assumed any dewatering assumed to result in mortality
- Only highest elevation used for comparison with WSEs
- Full extent of incubation time projected forward only (not centered)



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Study 14 & 15 – Resident Fish Spawning

2. Additional WSE buffer for Fallfish nests

- 0.5 ft buffer added to ensure base of nest remained wetted
  - Buffer estimated to wet 90% of average mound area (mound in photo below was 0.5 ft high)

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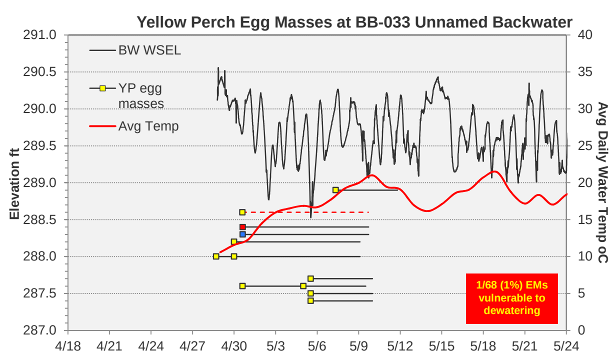
Study 14 & 15 – Resident Fish Spawning

3. Misc. editorial changes

- All figs labeled with # spawning observations; range and mean % added to text; etc.



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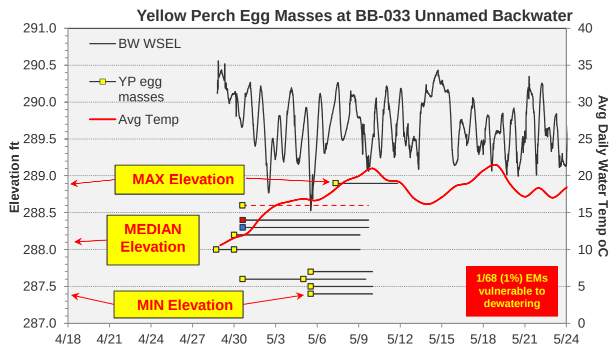
Study 14 & 15 – Resident Fish Spawning

4. Assessment of project effects

- Calculation of minimum, median, and maximum egg/nest elevation criteria



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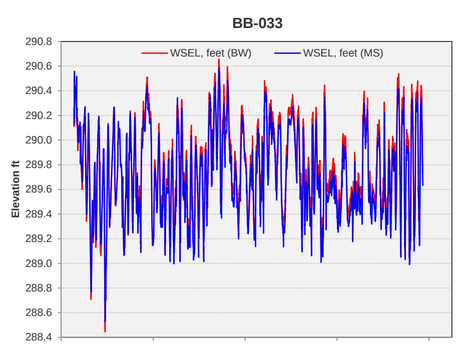
Study 14 & 15 – Resident Fish Spawning

4. Assessment of project effects

- The Hydraulic and Operations Models were used to estimate WSEs at the closest transect for each of the 5 modeled water years



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Study 14 & 15 – Resident Fish Spawning

4. Assessment of project effects

- Calculated the estimated # and % of days the spawning elevation criteria were deceeded at each site and water year within a species spawning periodicity
- Note that actual duration of an individual spawning event may be much shorter than the duration (periodicity) of a spawning season (eg, Sunfish spawn over a 30-40 day period but the duration of egg incubation and fry rearing is only ~5 days)

Spawning Periodicity	Wilder	Bellows	Vernon	# Days Spawn Periodicity	# Days Egg Incub / Fry Rearing
Yellow Perch (YP):	4/20 - 5/15	4/15 - 5/10	4/15 - 5/10	25	5 - 25
Sunfish (SF):	5/20 - 6/30	5/15 - 6/20	5/15 - 6/20	40	5 (10d used in 2015 data)
Fallfish (FF):	5/15 - 6/5	5/10 - 5/30	5/10 - 5/30	20	7-8 (15 d used in 2015 data)
Smallmouth Bass (SB):	5/20 - 6/20	5/20 - 6/20	5/20 - 6/20	30	10-20 (30d used in 2015)

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Study 14 & 15 – Resident Fish Spawning

4. Assessment of project effects

- Estimated % of days the min, median, and max criteria were deceeded for Yellow Perch and Sunfish in Bellows backwater BB-033.
- Comparing 2015 spawning observations with modeled hydrologies.

Site BB-033		1992			1989			1994			2007			1990		
Species	Site ID	%Days < Min	%Days < Med	%Days < Max	%Days < Min	%Days < Med	%Days < Max	%Days < Min	%Days < Med	%Days < Max	%Days < Min	%Days < Med	%Days < Max	%Days < Min	%Days < Med	%Days < Max
YP	14-BB-033	0%	0%	8%	0%	0%	27%	0%	0%	19%	0%	0%	15%	0%	0%	0%
SF	14-BB-033	8%	22%	32%	5%	19%	27%	0%	0%	5%	0%	22%	32%	5%	16%	22%

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Study 14 & 15 – Resident Fish Spawning

4. Assessment of project effects

- Estimated % of days the criteria were deceeded according to species periodicity, study site, and 5 modeled water years

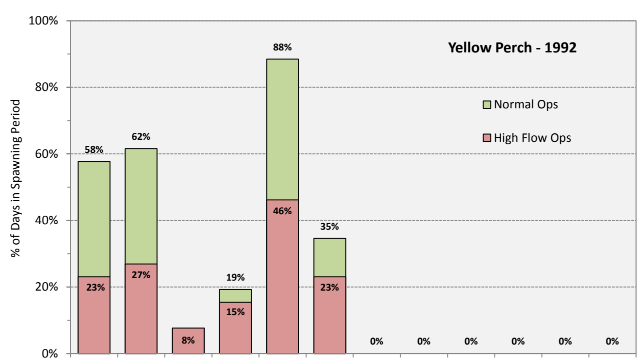
		OPERATIONS UNDER NORMAL CONDITIONS				
		1992	1989	1994	2007	1990
Species	Reach / Habitat Type	Avg % Days Below Median	Avg % Days Below Median	Avg % Days Below Median	Avg % Days Below Median	Avg % Days Below Median
Yellow Perch*	Wilder BWs	45%	33%	53%	42%	62%
	Bellows BWs	0%	4%	5%	3%	0%
	Vernon BWs	0%	0%	5%	0%	1%
Sunfish	Wilder BWs	64%	50%	33%	43%	37%
	Bellows BWs	22%	17%	2%	23%	14%
	Vernon BWs	1%	5%	1%	4%	5%
Fallfish	Bellows Tribs	0%	0%	0%	0%	0%
	Wilder Islands	61%	34%	40%	35%	32%
	Bellows Islands	0%	0%	0%	0%	0%
	Vernon Islands	14%	0%	5%	5%	0%
Smallmouth	Wilder Tribs	41%	22%	11%	20%	19%
Bass	Bellows Tribs	7%	6%	0%	6%	5%
	Vernon Tribs	0%	0%	0%	0%	0%
	Wilder Islands	54%	50%	39%	48%	45%
	Bellows Islands	34%	22%	1%	29%	15%
	Vernon Islands	34%	16%	9%	22%	13%

* Includes high flow impoundment operations

Study 14 & 15 – Resident Fish Spawning

4. Assessment of project effects

- Relative effects of high flow operations on % of days the criteria were deceeded for Yellow Perch (using one year as an example)



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Study 14 & 15 – Resident Fish Spawning

4. Assessment of project effects - Limitations

- Spawning surveys emphasized shallow habitats most vulnerable to project effects due to limitations on water visibility – deeper and less vulnerable eggs/nests and deeper habitat were likely present but not assessed
- It is highly likely that elevations chosen for spawning activities by each species will differ according to the flow conditions present in a given year - which limits confidence in interpreting the 2015 spawning data with modeled WSEs in prior years
- The predicted % of days with WSEs below spawning criteria encompass the full length of each species spawning season, which may be far longer than the period of actual spawning
- These and other factors make this assessment a “worst-case scenario”, and should be interpreted in context with other study results, such as the high abundance of the principal species in the study area (e.g., Yellow Perch, Smallmouth Bass)

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Study 14 & 15 – Resident Fish Spawning

5. Conclusions – Assessment of Project Effects

- Yellow Perch: WSE’s were predicted to drop below median elevations of observed egg masses more often in the Wilder backwater habitats (30-60% of spawning days) than in the Bellows or Vernon backwaters (<5%)
- Roughly 50% of days with below criteria elevations (among modeled water years) in Wilder backwaters occurred during high flow operations

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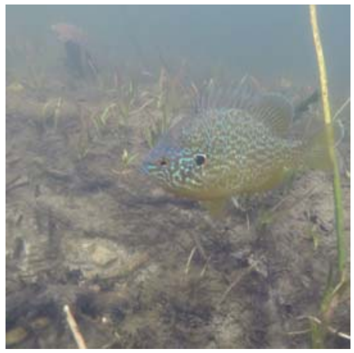
Study 14 & 15 – Resident Fish Spawning

5. Conclusions – Assessment of Project Effects

- Sunfish: WSE's were predicted to drop below elevations of observed egg nests most often in Wilder backwater habitats (30-65% of days), versus 2-20% of days in Bellows backwaters, and only 5% of days (or less) in Vernon backwaters
- *Note that this assumes a 40 day spawning period, not a ~5 day incubation/fry period*



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Study 14 & 15 – Resident Fish Spawning

5. Conclusions – Assessment of Project Effects

- Fallfish: WSE's were predicted to drop below elevations of observed nesting mounds in 30-60% of days in Wilder island/bar habitats, but mostly <5% of days in the Bellows or Vernon riverine reaches
- Smallmouth Bass: Low WSE's were predicted to drop below elevations of observed nesting in 10-40% of days in Wilder tributary habitats and in 40-55% of days in Wilder island/bar habitats;
- WSE's rarely dropped below median elevations in Bellows or Vernon tributaries, but deceeded median elevations in up to 35% of days in Bellows and Vernon riverine reaches

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Study 16
Sea Lamprey Spawning Assessment

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Study 16 – Sea Lamprey Spawning Assessment

Study Summary (Recap)

- 23 sites assessed for spawning activity
  - Wilder riverine reach (N = 7) Bellows Falls impoundment (N = 6), Bellows Falls riverine reach (N = 3), Vernon impoundment (N = 5), Vernon riverine reach (N = 2)
- 38 of 40 tagged lamprey (+18 from FirstLight) were relocated
- 4 site locations were altered due to tracking and visual observations
- 17 sites were revisited post-season in low flow conditions (Aug - Sep), nest elevations documented
  - 6 sites were not revisited: well documented in season (N=3), little/no habitat available - no indicators of spawning activity (N=3)
- 4 nests at 3 sites where nest building was actively observed were capped
  - No ammocoetes collected from nest caps, micro-habitat disruptions observed
  - Supplemental information: ammocoete collections in other studies (Study 10 - 5% of ichthyoplankton samples, Study 21 - in up to 46% of e-fishing sites by reach and season)

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Study 16 – Sea Lamprey Spawning Assessment

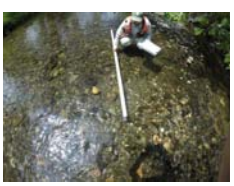
Study Summary (Recap)

- Interim report filed March 1, 2016
- Comments received, response to comments filed May 31, 2016
- Revised report filed August 1, 2016
  - Spawning sites analyzed with project operations model, and site-specific WSE monitoring
  - Range and rate of change of WSE by site
  - Number and duration of exposures by elevation

Study 16 – Sea Lamprey Spawning Assessment

Summary of potential and verified Sea Lamprey spawning activity observed by study site.

Location Type	Potential Activity	Verified Activity[a]	
	Telemetry	Visual	Nests
	Wilder Riverine Reach		
Riverine	Y	N	Y
Riverine	N	N	Y
Riverine/Tributary	Y	N	N
Riverine	Y	N	N
Riverine	N	N	Y
Riverine	Y	N	Y
Riverine	Y	N	Y
% of sites	71%	0%	71%
	Bellows Falls impoundment		
Impoundment	Y	N	Y
Impoundment	Y	N	Y
Impoundment	Y	N	N
Impoundment	Y	Y	Y
Impoundment/Tributary	Y	Y	Y
Impoundment	N	N	N
% of sites	83%	33%	67%
	Bellows Falls Riverine Reach		
Riverine	N	N	Y
Riverine	Y	N	Y
Riverine	Y	Y	Y
% of sites	67%	33%	100%
	Vernon Impoundment		
Impoundment	Y	N	N
Impoundment	Y	Y	Y
Impoundment/Tributary	Y	Y	Y
Impoundment/Tributary	N	N	N
Impoundment Tributary	N	N	N
% of sites	60%	40%	40%
	Vernon Riverine		
Riverine	Y	Y	Y
Riverine	Y	Y	Y
% of sites	100%	100%	100%
	Overall		
% of sites	74%	30%	70%
	By Location Type		
Riverine	75%	25%	83%
Impoundment	73%	36%	55%



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Study 16 – Sea Lamprey Spawning Assessment

Appendix E (example): Level Logger Data, 2015 - Analysis of Water Surface Elevations and Nest Elevation Exposure

Site 16-VL-001							
	Water Surface Elevation						
Observations, all	N (0.25 hr)	4760					
Observations, normal operations	N (0.25 hr)	3247					
WSE (ft.) NAVD88	Min	180.7					
	Max	185.9					
	Mean	184.0					
Up Ramping (ft./0.25 hr)	N	843					
	Min	0.1					
	Max	0.9					
	Mean	0.1					
Down Ramping (ft./0.25 hr)	N	848					
	Min	-0.1					
	Max	-0.8					
	Mean	-0.1					
		Nest Exposure (in order of increasing elevation)					
		1	2	3	4	5	6
Exposed (normal operations)	N	0	0	0	`112	128	627
	% of Observations	0%	0%	0%	3%	4%	19%
Exposure Duration (hr)	N (events)	0	0	0	11	10	18
	Min	.	.	.	0.25	0.25	0.25
	Max	.	.	.	15.25	15.25	58.50
	Mean	.	.	.	6.98	7.58	9.22

Site VL-001, Level Logger 15-VI-002 (proxy, -0.6 mi), period of record 5/27 9:45 - 7/15 23:29 (4,760)

Nest	El.	Lat	Long	HEC-RAS Node Range of Normal Ops (ft, NAVD88)	
1	177.7	42.7688796	-72.514217	180.8	186.8
2	179.0	42.7688462	-72.514246	180.8	186.8
3	180.3	42.7677604	-72.514320	180.8	186.6
4	181.4	42.7677547	-72.514289	180.8	186.6
5	181.4	42.7666749	-72.514266	180.8	186.6
6	182.7	42.7687038	-72.514329	180.8	186.8

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Study 16 – Sea Lamprey Spawning Assessment

Appendix F (example): Operations Model Data - Analysis of Water Surface Elevations and Predicted Nest Elevation Exposure

Site 16-VL-001		MODEL YEAR 1992						MODEL YEAR 1994						MODEL YEAR 1989					
Nest (in order of increasing elevation)		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
WSE (ft. NAVD88)	Min	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8
	Max	186.7	186.7	186.5	186.5	186.5	186.7	186.8	186.8	186.6	186.6	186.6	186.8	186.8	186.8	186.7	186.7	186.7	186.8
	Mean	183.6	183.6	183.5	183.5	183.5	183.6	184.3	184.3	184.1	184.1	184.1	184.3	184.7	184.7	184.7	184.7	184.7	184.7
Up Ramping (ft./hr)	Min	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Max	4.9	4.9	4.8	4.8	4.8	4.9	4.7	4.7	4.5	4.5	4.5	4.7	5	5	4.8	4.8	4.8	5
	Mean	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0.5
Down Ramping (ft./hr)	Min	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
	Max	-4.7	-4.7	-4.5	-4.5	-4.5	-4.7	-4.5	-4.5	-4.4	-4.4	-4.4	-4.5	-4.6	-4.6	-4.4	-4.4	-4.4	-4.6
	Mean	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7
Exposed	N	0	0	0	119	119	480	0	0	0	84	84	316	0	0	0	43	43	188
	% of Observations	0%	0%	0%	9%	9%	36%	0%	0%	0%	6%	6%	24%	0%	0%	0%	4%	4%	16%
Duration (hr)	N (events)	0	0	0	51	51	120	0	0	0	40	40	94	0	0	0	27	27	58
	Min	.	.	.	1	1	1	.	.	.	1	1	1	.	.	.	1	1	1
	Max	.	.	.	12	12	36	.	.	.	8	8	12	.	.	.	10	10	13
	Mean	.	.	.	5.5	5.5	5.3	.	.	.	3.6	3.6	4.0	.	.	.	4.4	4.4	4.7

Continued.

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Study 16 – Sea Lamprey Spawning Assessment

Appendix F (example): Continued

Site 16-VL-001		MODEL YEAR 1992						MODEL YEAR 1994					
Nest (in order of increasing elevation)		1	2	3	4	5	6	1	2	3	4	5	6
WSE (ft. NAVD88)	Min	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8	180.8
	Max	186.8	186.8	186.6	186.6	186.6	186.6	186.8	186.8	186.6	186.6	186.6	186.8
	Mean	184.1	184.1	184.0	184.0	184.0	184.1	184.5	184.5	184.3	184.3	184.3	184.5
Up Ramping (ft./hr)	Min	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Max	4.7	4.7	4.5	4.5	4.5	4.7	4.8	4.8	4.6	4.6	4.6	4.8
	Mean	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Down Ramping (ft./hr)	Min	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
	Max	-4.5	-4.5	-4.3	-4.3	-4.3	-4.5	-4.6	-4.6	-4.5	-4.5	-4.5	-4.6
	Mean	-0.8	-0.8	-0.8	-0.8	-0.8	-0.8	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
Exposed	N	0	0	0	86	86	326	0	0	0	36	36	228
	% of Observations	0%	0%	0%	7%	7%	26%	0%	0%	0%	3%	3%	19%
Duration (hr)	N (events)	0	0	0	39	39	87	0	0	0	28	28	79
	Min	.	.	.	1	1	1	.	.	.	1	1	1
	Max	.	.	.	11	11	22	.	.	.	8	8	10
	Mean	.	.	.	4.9	4.9	5.0	.	.	.	2.8	2.7	3.4

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Study 16 – Sea Lamprey Spawning Assessment

Analysis summary of project operations effects on Sea Lamprey nest exposure (Operational Control Periods)

Site ID	Habitat Assessment				
	Site Classification	Nests (N)	Elevation (range) NAVD88	Vertical Distribution (ft.)	Conclusion
16-WL-001	active spawning area	3	324.7-329.1	4.4	moderate project effect
16-WL-002	active spawning area	5	324.4-327.7	3.3	moderate project effect
16-WL-003	non-suitable spawning habitat / [limited habitat, but no observed spawning]	0	.	.	Insufficient habitat
16-WL-004	suitable spawning habitat but no observed spawning	0	.	.	No spawning evident in 2015
16-WL-005	active spawning area	3	300.3-302.7	2.4	Project Effect
16-WL-006	active spawning area	3	293.1-293.8	0.7	Moderate Effect
16-WL-007	active spawning area	4	291.4-293.7	2.3	Moderate Effect
16-BT-004	active spawning area	1	291.1	.	Project Effect
16-BT-003	active spawning area	1	290.1	.	Project Effect
16-BT-006	suitable spawning habitat but no observed spawning	0	.	.	No spawning evident in 2015
16-BT-013	active spawning area	2	287.8-290.0	1.2	Moderate Effect
16-BT-018	active spawning area with larval sampling	10	289.0-290.5	0.5	No Effect
16-BT-031	non-suitable spawning habitat / [limited habitat, but no observed spawning]	0	.	.	Insufficient habitat
16-BL-001	active spawning area	6	218.1-220.8	2.7	Moderate Effect
16-BL-002	active spawning area	3	219.1-219.2	0.1	Project Effect
16-BL-003	active spawning area	4	215.7-217.0	1.3	No Effect
16-VT-014	suitable spawning habitat, but no observed spawning	0	.	.	No spawning evident in 2015
16-VT-016	active spawning area with larval sampling	4	218.2-219.3	1.1	Moderate Effect
16-VT-018	active spawning area with larval sampling	4	220.3-220.8	0.5	No Effect
16-VT-040	non-suitable spawning habitat	0	.	.	Insufficient habitat
16-VT-046	non-suitable spawning habitat	0	.	.	Insufficient habitat
16-VL-001	active spawning area	13[a]	177.7-182.7	5.0	Moderate Effect
16-VL-002	active spawning area	28[b]	179.5-181.1	1.6	Moderate Effect

No Effect = all identified nest elevations continuously submerged for period of record / all model years

Moderate Effect = any nest exposed / all submerged for any one model year, but any exposed in any model year

Project Effect = all exposed (for any duration) in all model years

Study 16 – Sea Lamprey Spawning Assessment

Results

- Of 23 sites: 4 sites did not to have sufficient suitable habitat (17%), 3 in impoundment reaches, one in riverine reach
- Of 19 sites:
  - 3 sites: suitable habitat but no verification of spawning activity identified in 2015 (16%)
  - 16 sites: classified as active spawning habitat in 2015 (84%)
    - 10 in riverine reaches (83% of riverine sites)
    - 6 in impoundment reaches (55% of impoundment sites, includes 2 in tributaries)
- Of 16 sites:
  - 3 sites (19%): no effect, 2 impoundment (tributary),1 riverine
  - 9 sites (56%): moderate effect, 2 impoundment, 7 riverine
  - 4 sites (25%): project effect, 2 impoundment, 2 riverine
- Of 10 riverine sites: 1 site (10%) no effect, 7 sites (70%) moderate effect, 2 sites (20%) project effect
- Of 6 impoundment sites: 2 sites (33%), tributary) no effect, 2 sites moderate effect, 2 sites project effect

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Study 16 – Sea Lamprey Spawning Assessment

Conclusions and Limitations

- Spawning surveys emphasized shallow habitats most vulnerable to project effects due to study design and limitations on water visibility.
- Fish were also detected by radio telemetry in water > 8 feet deep during the spawning season, which when surveyed during low water periods, was ~ 2 feet deep or less when nests were identified.
- Sea Lamprey were distributed among all study reaches, and evidence of spawning activity was recorded in all study reaches.
- It is highly likely that elevations chosen for spawning activities will differ according to the flow conditions present in a given year - which limits confidence in interpreting the 2015 observed spawning with modeled WSEs in prior years.
- The predicted # of events and duration of WSEs below spawning elevations recorded in 2015 encompass the full length of the potential spawning season, which may be far longer than the period of actual spawning (e.g., 2 weeks)

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Study 32 Update
Bellows Falls Aesthetic Flow Study

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Study 32 – Objectives and Methods

Study Objectives:

- Collect videography and still photography to document the appearance of the bypassed reach at different flow levels.
- Identify sites and viewsheds potentially affected by the aesthetic conditions in the bypassed reach.
- Determine the interest of nearby residents related to aesthetic conditions in the bypassed reach
- Identify flow ratings and timing preferences, if any.

Initial Study May 30-31, 2015	
Flow Number	Flow Rate
1	~ 125
2	1,580
3	2,370
4	3,300
5	4,370
6	5,560

Additional Study June 29, 2016	
Flow Number	Approximate Flow Rate
1	~ 125
2	500
3	1,000
4	1,600

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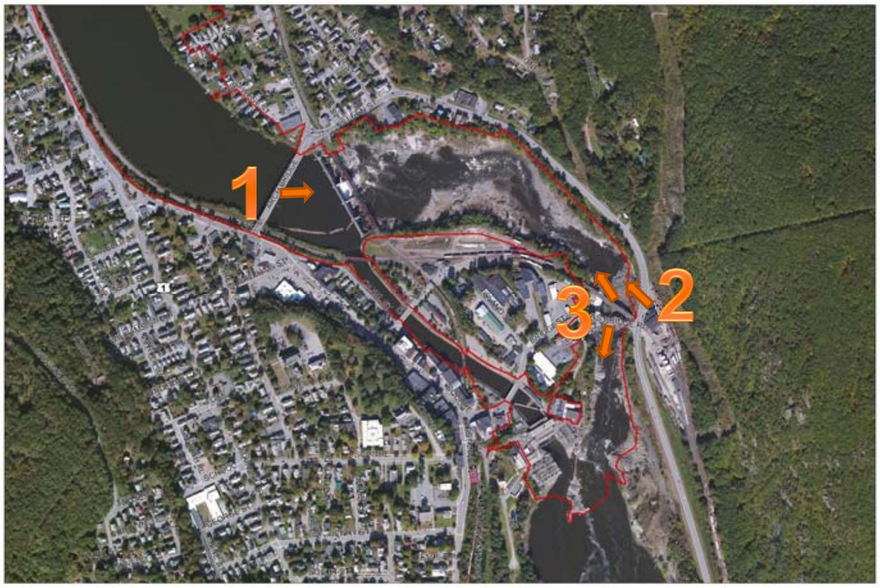
Study 32 – Observation Points



Study 32 – Results

Study Results:

- Focus group on August 20, 2015
  - Only 1 participant indicated that aesthetics were extremely important.
  - Participants reacted more favorably to higher flows; however no clear preferred level was evident.
  - Participants noted there are no publically available viewing areas and questioned the need for specific aesthetic flows give the lack of visibility.

- Findings from June 29, 2016 releases
  - No noteworthy differences among any flows from KOP 1.
  - Minor changes between leakage flows and 500 cfs from KOP 2 and KOP 3
  - Most visible difference between 500 cfs and 1,000 cfs from KOP 2 and KOP 3 when prominent features in the bypassed reach are covered.
  - Rocks and cobble bars are covered between 1,000 cfs and 1,600 cfs.
  - River sounds not heard over background noise from KOP 1 at any flow.
  - River sounds become audible at KOP 2 and KOP 3 starting at 500 cfs.

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Study 32 - KOP 2

Leakage (125 cfs)

500 cfs

1,000 cfs

1,600 cfs

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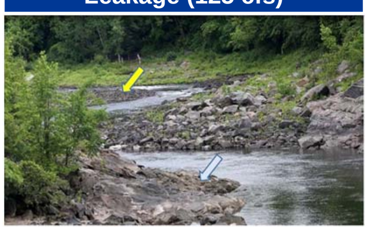
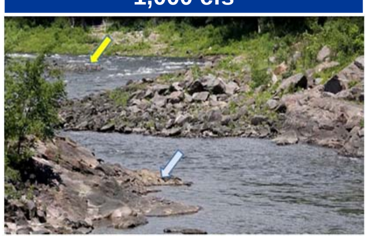
Study 32 - KOP 3

Leakage (125 cfs)

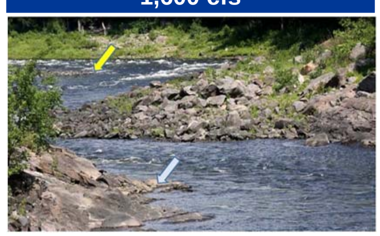


500 cfs

1,000 cfs



1,600 cfs



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

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

Study Results - Recap

- 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
  - Ground verification of vegetation mapping
  - Confirmed an additional 5 floodplain communities and 3 listed species records
  - Confirmed 27 invasive/non-native species (only mapped Phragmites and Japanese knotweed) – 163 acres)
  - and included incidental wildlife observations of 87 species
- Associated data from the field were tabulated and compiled into a database for analysis
- Natural features and land uses mapped covered a total of 9,153 acres, and were composed of upland vegetation cover (62% cover), wetlands and tributary streams (23% cover), developed lands (12% cover), and riverine features (2% cover)

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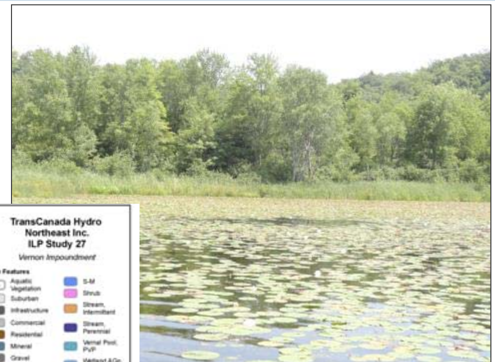
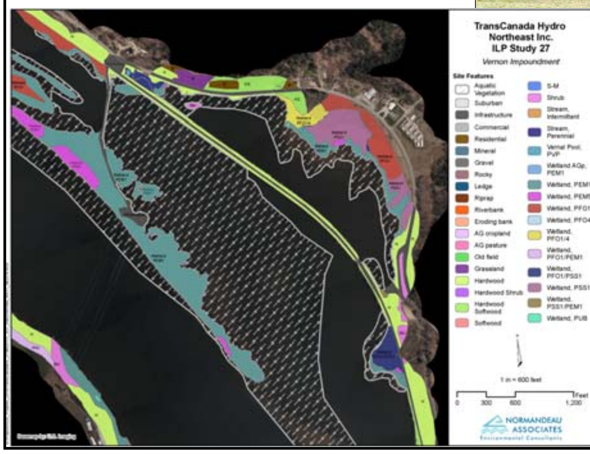
Study 27 – Floodplain, Wetland, Riparian, Littoral Vegetative Habitats

Example
Terrestrial Habitat Map
Hinsdale, NH





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

Acreage of land use by general categories

Cover type	Wilder	Wilder Riverine	Bellows Falls	Bellows Falls Riverine	Vernon	Total	% of Total
Upland Vegetated	2297	778	1140	92	1449	**5756**	**63%**
Wetland and Stream	701	17	737	1	657	**2114**	**23%**
Developed	339	181	242	42	306	**1110**	**12%**
Riverine Features	32	58	31	27	25	**174**	**2%**
Total	**3364**	**1034**	**2151**	**162**	**2437**	**9154**	**100%**

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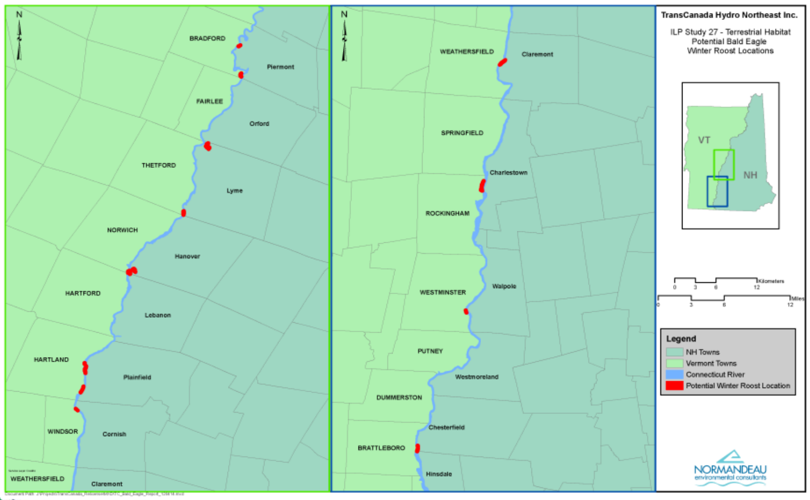
Study 27 – Floodplain, Wetland, Riparian, Littoral Vegetative Habitats

Potential Bald Eagle Winter Roost Sites



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

Assessment of Project Effects

Vegetation bordering the projects is responding to both normal project operations and large/extreme events

- Larger water events cause flooding and scour
  - Influences all vegetation, including higher elevation vegetation (forested wetland, floodplains and other riparian vegetation
  - Exceed generating capacity of the projects and normal project operations
- Smaller daily, lower flows affect lower elevation communities
  - Marshes and scrub-shrub wetlands
  - Typically controlled by normal project operations

Study 27 analysis was based on hydrologic model results, water level data loggers from Study 7, LiDAR-based topography and field observation:

The further upriver from the dam, the more water level fluctuations resembled riverine flows

- Fluctuations in riverine sections were largest
- Fluctuations in upper impoundment sections were larger and clearly influenced by riverine flows
- Fluctuations in lower impoundment sections were relatively small and similar to those observed at dam
- Fluctuations in mid-impoundment sections were intermediate

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

Vegetation Community Adaptations

Submerged aquatic vegetation occurs below lower limit of water level fluctuations

- Susceptible to dessication and scour, thus proliferates in areas not exposed at low flows and protected from strong currents
  - Well developed beds mapped in backwaters and coves – none in riverine
  - Wilder has relatively few large SAV compared to Bellows Falls and Vernon

Emergent and Scrub-shrub wetlands

- Tolerant of short-term inundation but vulnerable to scour by ice and currents
  - Most prevalent in protected coves and backwaters
  - Lower limit of shallow marsh approximated the middle of normal project ops range

Forested Wetlands

- Not tolerant of regular or prolonged flooding
- In study area, small in size and not along riverbank
  - Typically associated with beaver impoundments and backwaters 1-2 feet higher in elevation than normal project operations.

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

Vegetation Community Adaptations

Floodplain Forests

- Most occurred on terraces above the zone of normal project operations
  - Many have been cleared for agriculture
- Silver maple floodplain forests prevalent on low elevation islands and terraces
  - Floodplain island in Vernon was estimated to be about 1.5 feet above normal project operations
  - Others were well above normal project operation but still showed evidence of large (non-project related) events

Upland and Riparian Habitats

- Clearly above normal project operations
- Are not adapted to frequent inundation and scour but can tolerate periodic flood events

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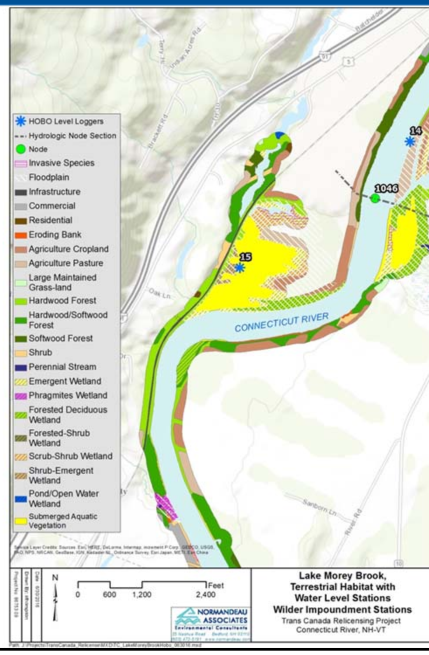
Study 27 – Floodplain, Wetland, Riparian, Littoral Vegetative Habitats

Wilder
mid-impoundment



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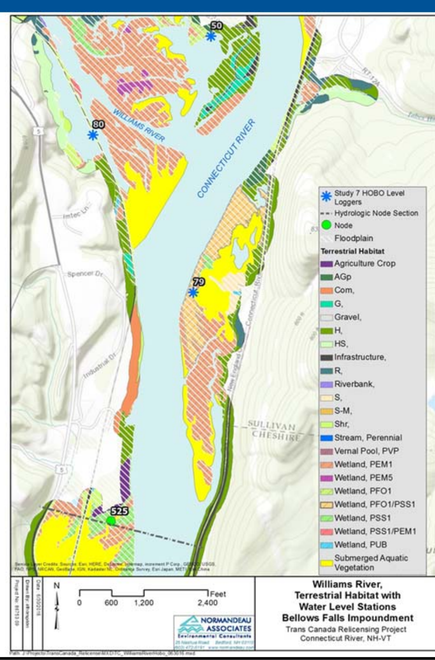
Study 27 – Floodplain, Wetland, Riparian, Littoral Vegetative Habitats

Bellows Falls
Lower Impoundment



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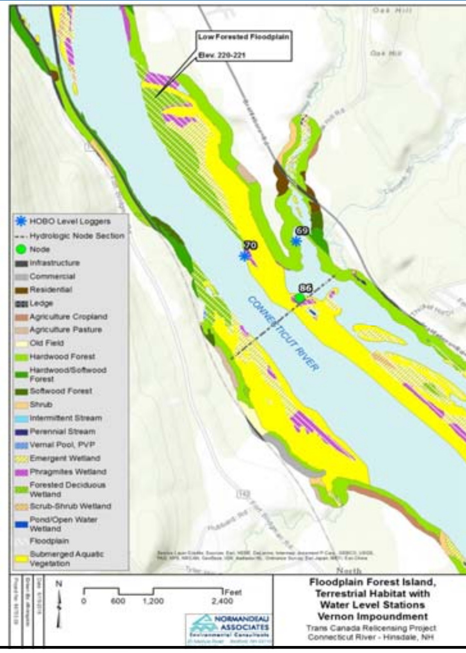
Study 27 – Floodplain, Wetland, Riparian, Littoral Vegetative Habitats

Vernon
Lower Impoundment



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Studies 2 and 3

Riverbank Transect Study
Riverbank Erosion Study

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Studies 2 and 3

How does erosion occur?
Where and how much erosion is occurring?
What is the rate of erosion?
How has erosion changed through time?
What are the causes of erosion?

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Studies 2 and 3

How does erosion occur?

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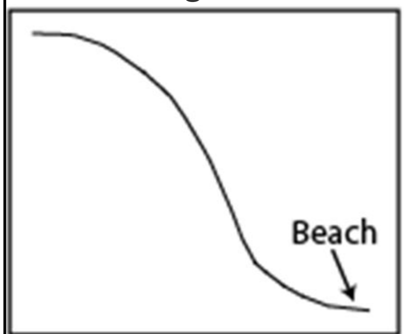
Study 3 – Riverbank Erosion Study

Erosion is a multi-stage cyclic process

Stage 1



Stable bank

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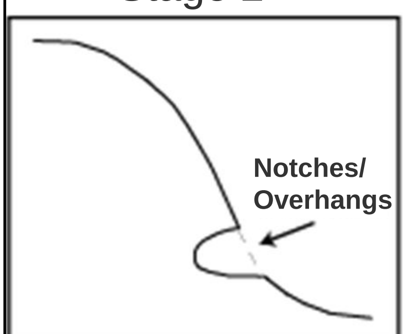
Study 3 – Riverbank Erosion Study

Stage 2



Notches/Overhangs

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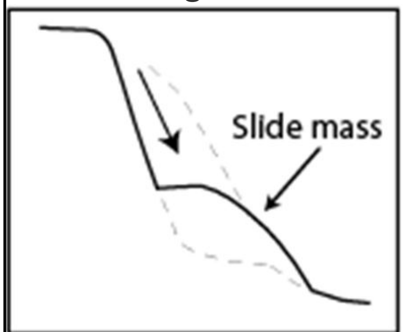
Study 3 – Riverbank Erosion Study

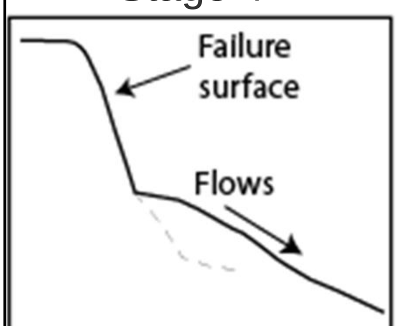
Stage 3



Sliding/Toppling

Study 3 – Riverbank Erosion Study

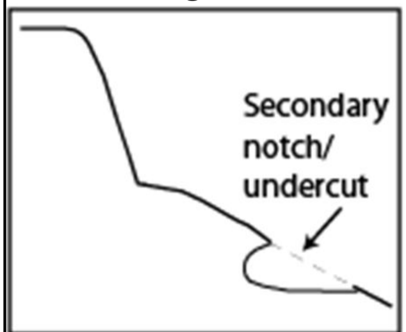
Stage 4



Flows

Study 3 – Riverbank Erosion Study

Stage 5



Secondary notching/
Material removal

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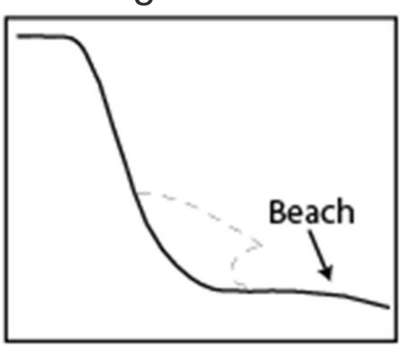
Study 3 –Riverbank Erosion Study

JR9

Stage 6



Restabilization/Reset

unless material is removed from the base of the bank by flood flows

TransCanada

84

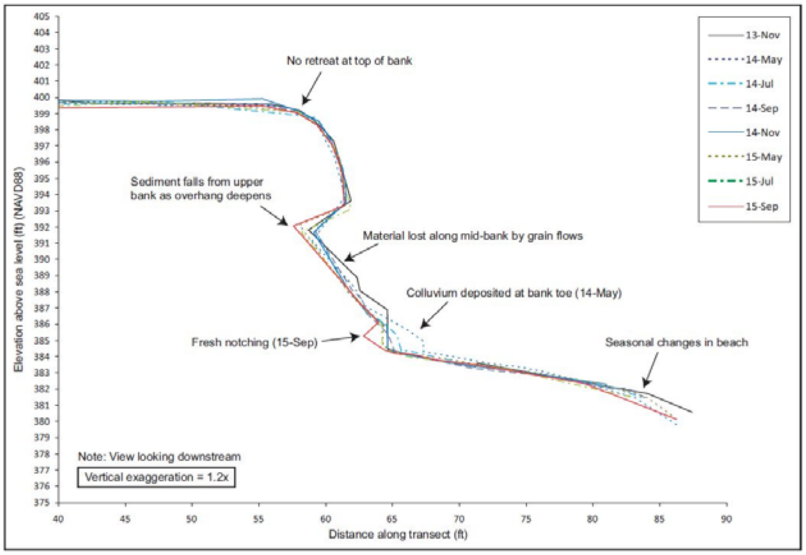
Slide 84

JR9 I would state this differently than in his notes. In other words I would say,
" In many cases formation of a bench results in a stable bank; i.e. Further erosion in stages 1-5 starting with notching is alleviated by the bench.

However, due to high flows, NOT WSE fluctuation the bench is eroded away downstream and thus restarts the cycle."

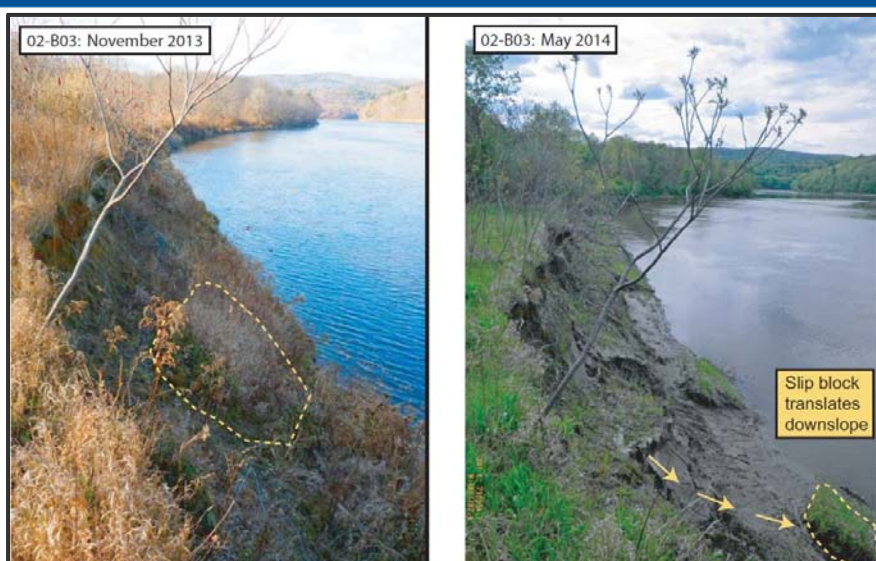
John Ragonese, 8/23/2016

Study 2 –Riverbank Transect Study



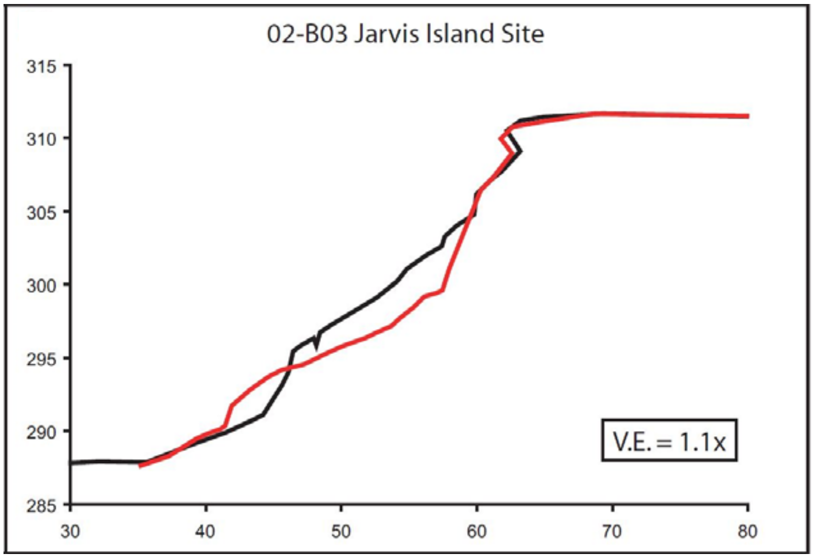
TransCanada **Monitoring Results Site 02-W09 Lyme, NH (Mudge Site)** 85

Study 2 –Riverbank Transect Study



TransCanada 86

Study 2 –Riverbank Transect Study



TransCanada

87

Example of material sliding and accumulation at base of bank

Studies 2 and 3

Where and how much erosion is occurring?

TransCanada

88

Study 3 – Riverbank Erosion Study

TransCanada **Bare eroding bank with soil draped over top of bank** 89

Study 3 – Riverbank Erosion Study

TransCanada **Vegetated bank with hidden erosion** 90

Study 3 – Riverbank Erosion Study

TransCanada

Vegetated bank with hidden erosion – planar slips visible

91

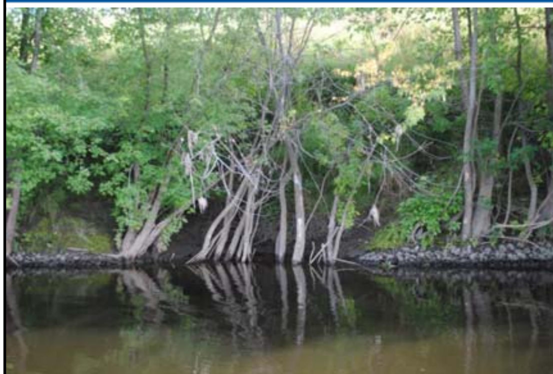
Study 3 – Riverbank Erosion Study

TransCanada

Bank armoring may also hide erosion

92

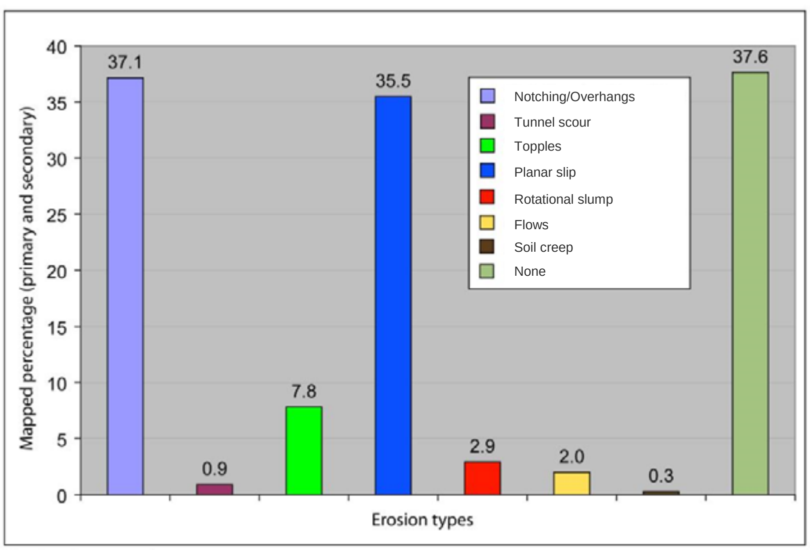
Study 3 – Riverbank Erosion Study



Examples of failed armor

TransCanada

Study 3 – Riverbank Erosion Study



Erosion types mapped – all types other than notching are "eroding"

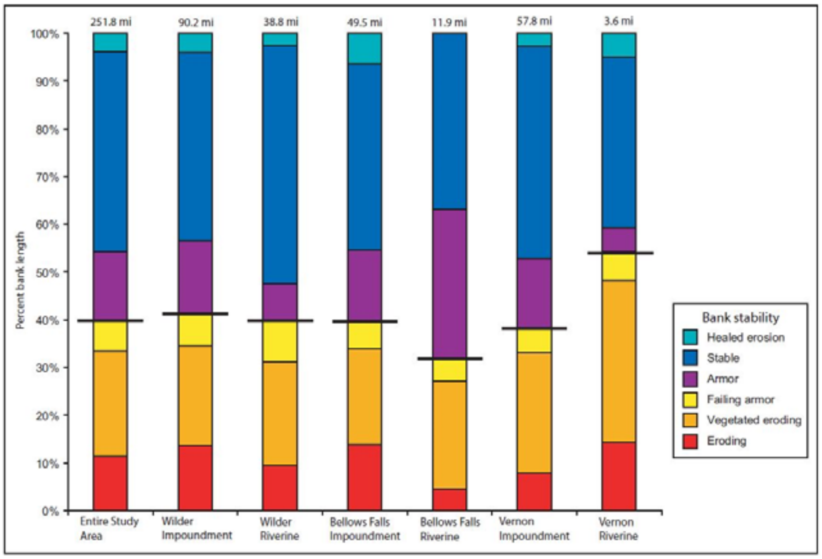
Study 3 – Riverbank Erosion Study

TransCanada **Vegetation does not = stable if erosion is present** 95

Study 3 – Riverbank Erosion Study

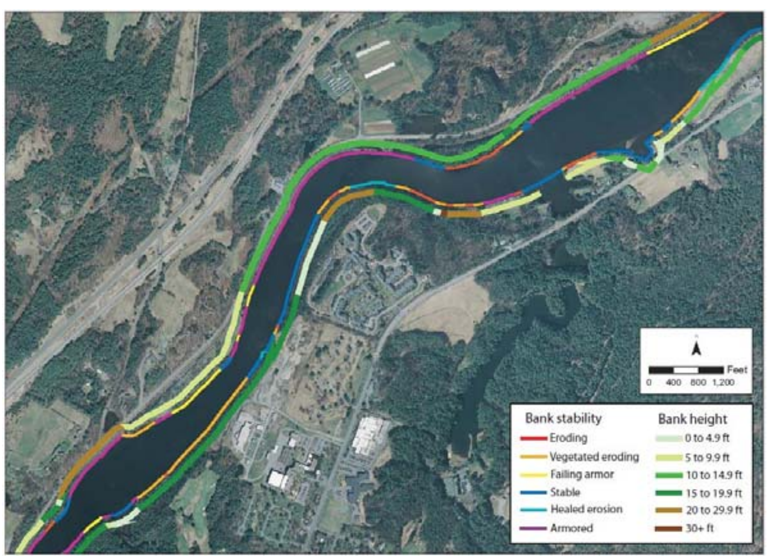
TransCanada **Vegetation (leaning trees) indicates erosion is present** 96

Study 3 – Riverbank Erosion Study



TransCanada **Levels of unstable banks similar among study reaches and also elsewhere on the CT River with limited dam control**

Study 3 – Riverbank Erosion Study



TransCanada **Erosion locations can be compared to other conditions like bank height**

98

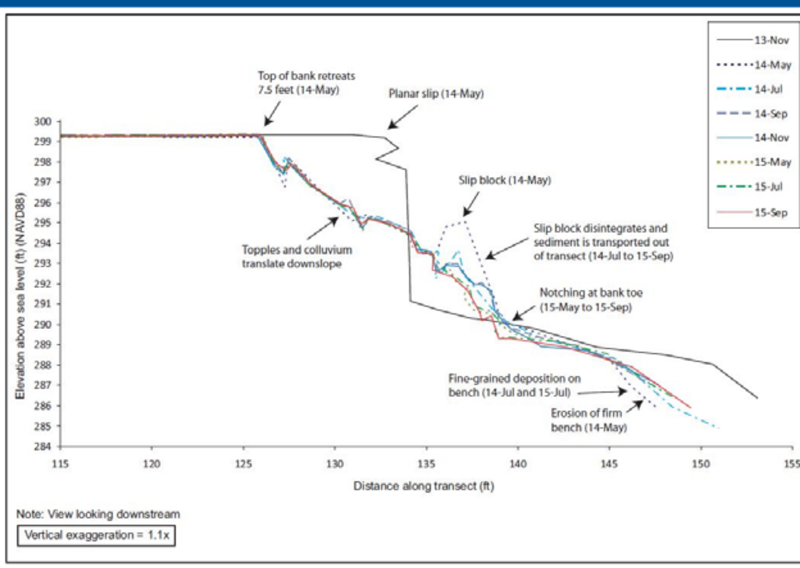
Studies 2 and 3

What is the rate of erosion?

TransCanada

99

Study 2 –Riverbank Transect Study

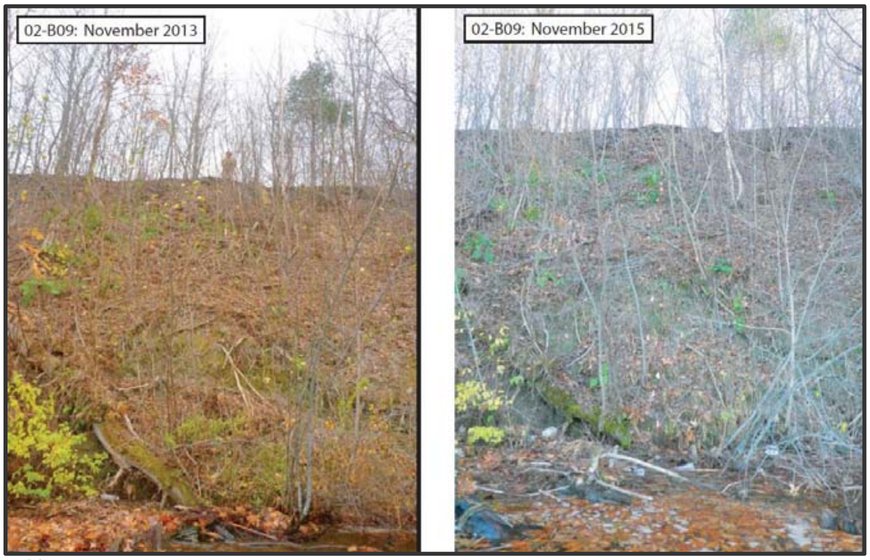


TransCanada

Rate of erosion during study period
Site 02-B07 Charlestown, NH (Charlestown Site)

100

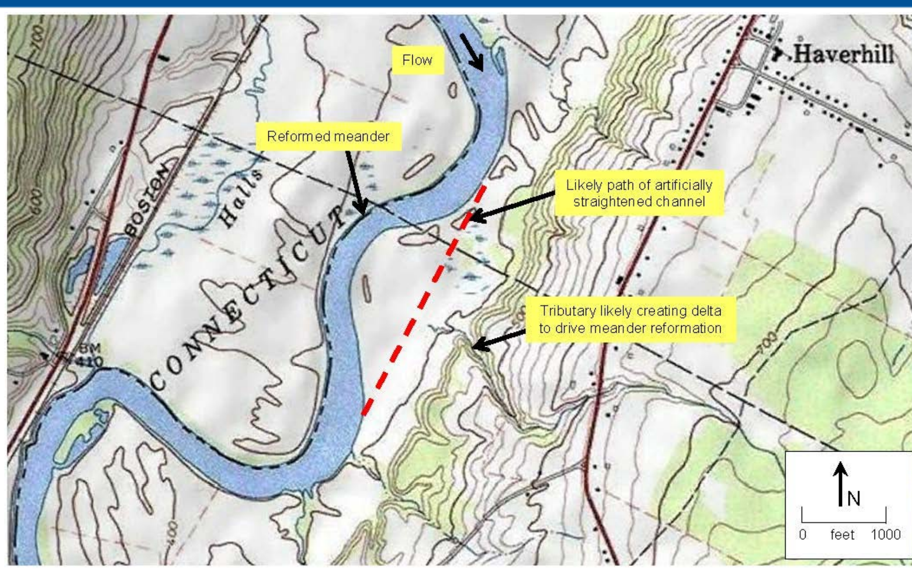
Study 2 –Riverbank Transect Study



TransCanada **No erosion evidence during the study period at Site 02-B09 North Walpole site**

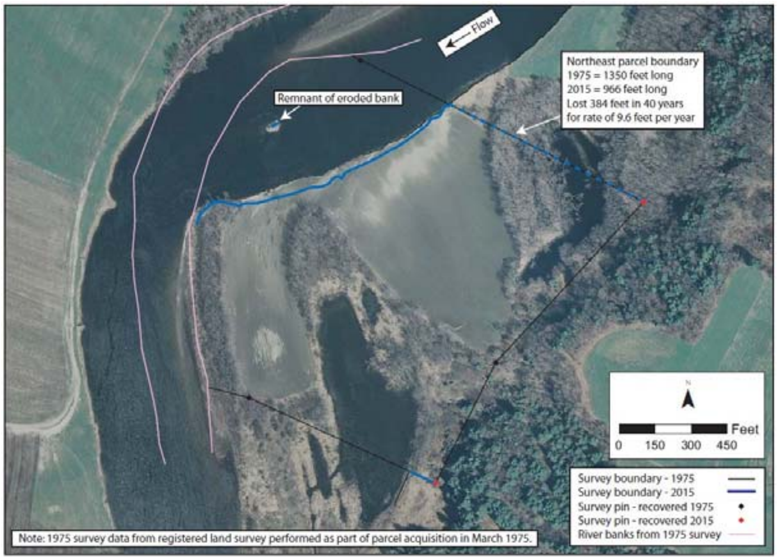
101

Study 3 – Riverbank Erosion Study



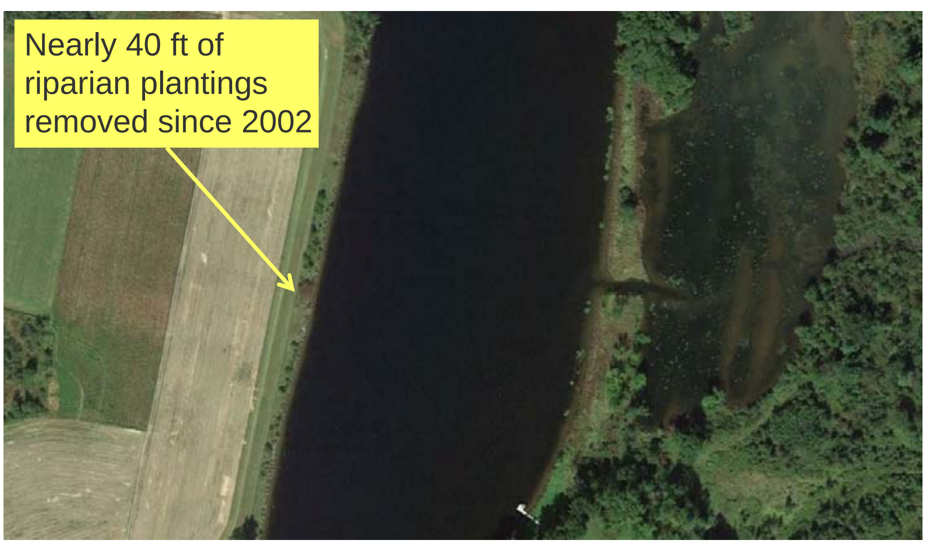
TransCanada **Meander formed prior to 1930 in upper Wilder impoundment implying erosion rate of 12 ft/yr or > prior, with little change since**

Study 3 – Riverbank Erosion Study



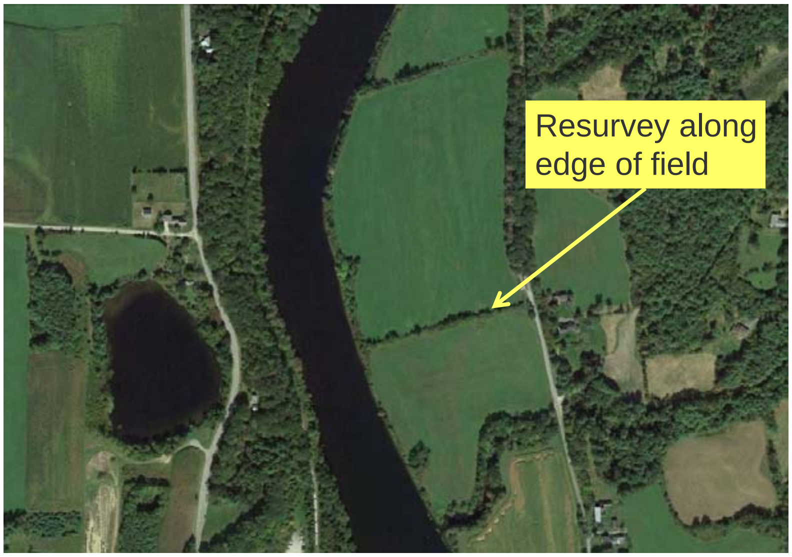
TransCanada **Just upstream of that meander, study monitoring indicates erosion rate of 9.6 ft/yr between 1975 and 2015 (Lewis site)**

Study 3 – Riverbank Erosion Study



TransCanada **Erosion rate = 3 ft/yr, Fairlee VT** 104

Study 3 – Riverbank Erosion Study



TransCanada

Erosion rate was 0.9 ft/yr from 1961-1989, and only 0.3 ft/yr since, at Site 02-W09 Lyme, NH (Mudge Site)

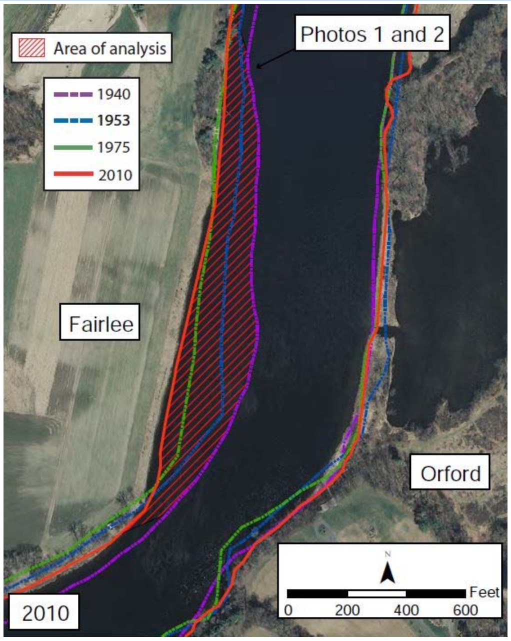
Studies 2 and 3

How has erosion changed through time?

TransCanada

106

Study 1 – Historical Riverbank Position and Erosion Study

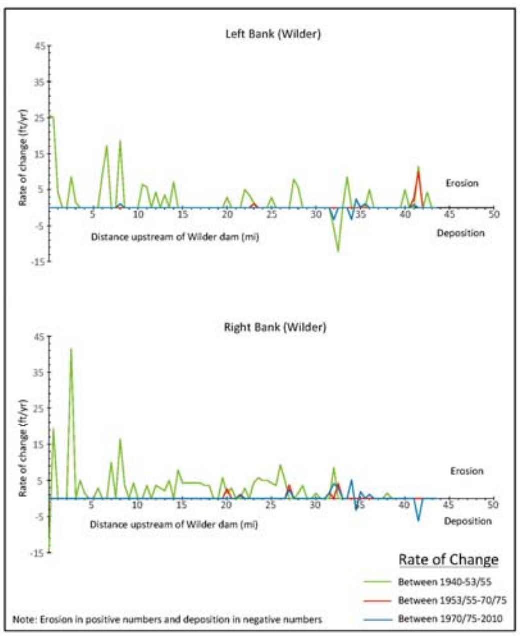


TransCanada

107

Study 1 – Historical Riverbank Position and Erosion Study

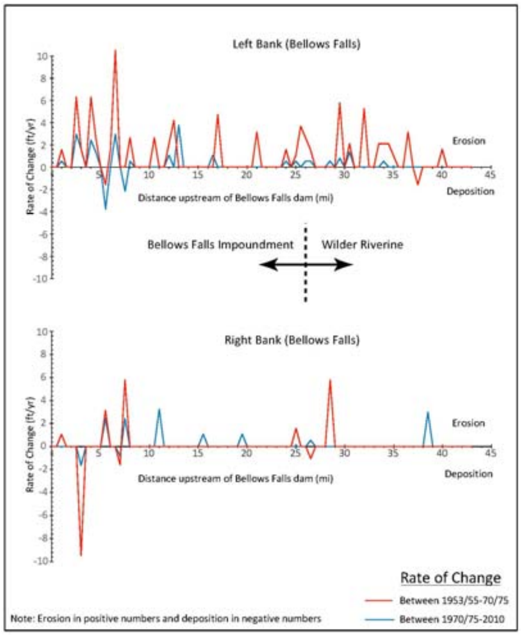
Changes in erosion over time with distance upstream from Wilder dam



TransCanada

Study 1 – Historical Riverbank Position and Erosion Study

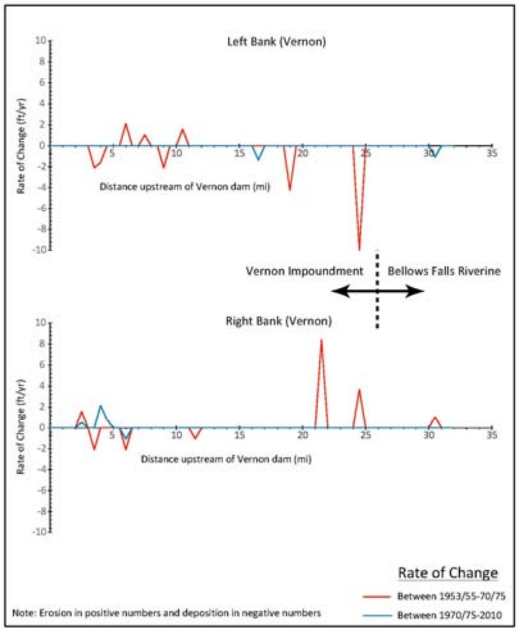
Changes in erosion over time with distance upstream from Bellows Falls dam



TransCanada

Study 1 – Historical Riverbank Position and Erosion Study

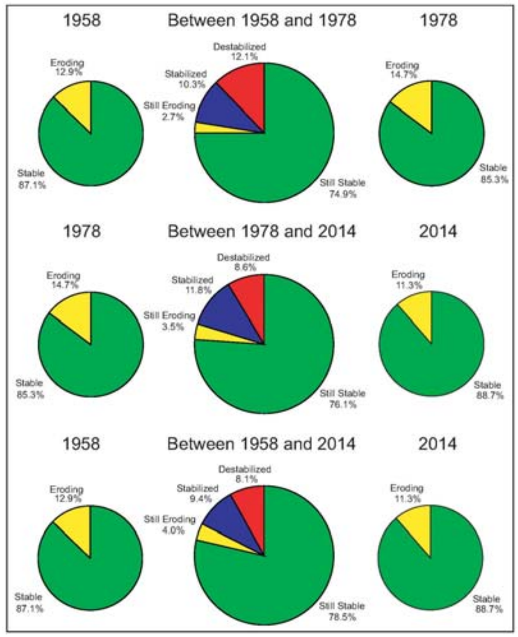
Changes in erosion over time with distance upstream from Vernon dam



TransCanada

Study 1 – Historical Riverbank Position and Erosion Study

Although the total amount of erosion has stayed roughly the same across the study area, locations of erosion have changed.



TransCanada

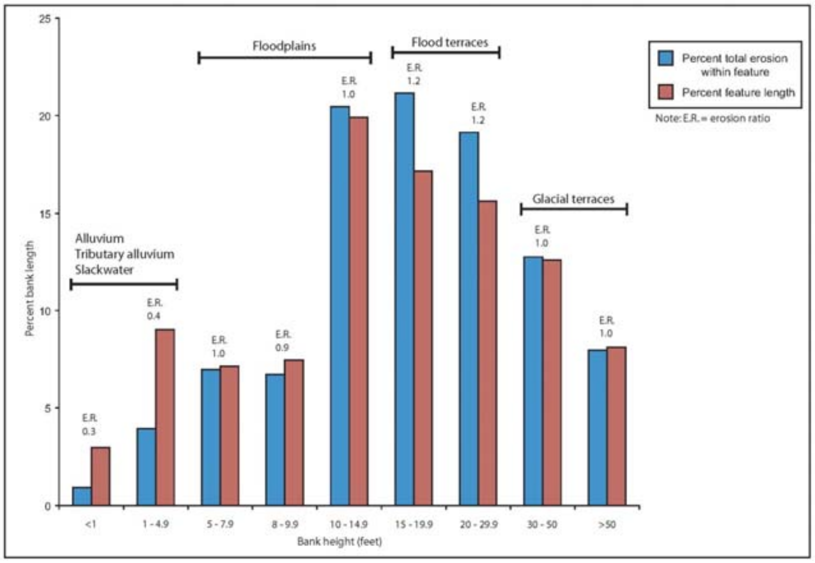
Studies 2 and 3

What are the causes of erosion?

TransCanada

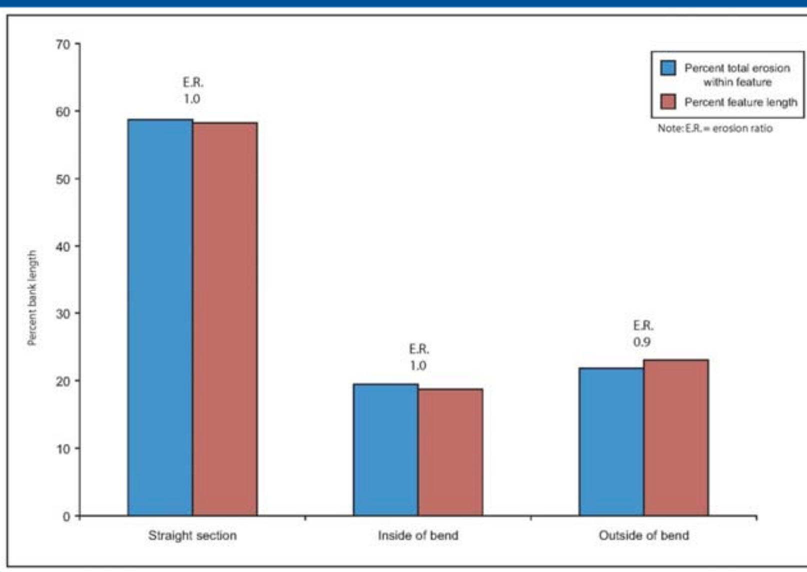
112

Study 3 – Riverbank Erosion Study



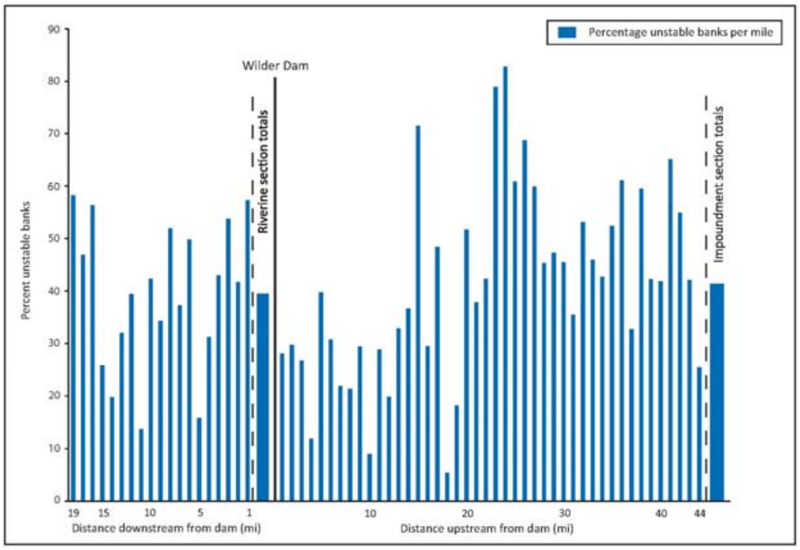
TransCanada **Erosion ratios by bank height**

Study 3 – Riverbank Erosion Study



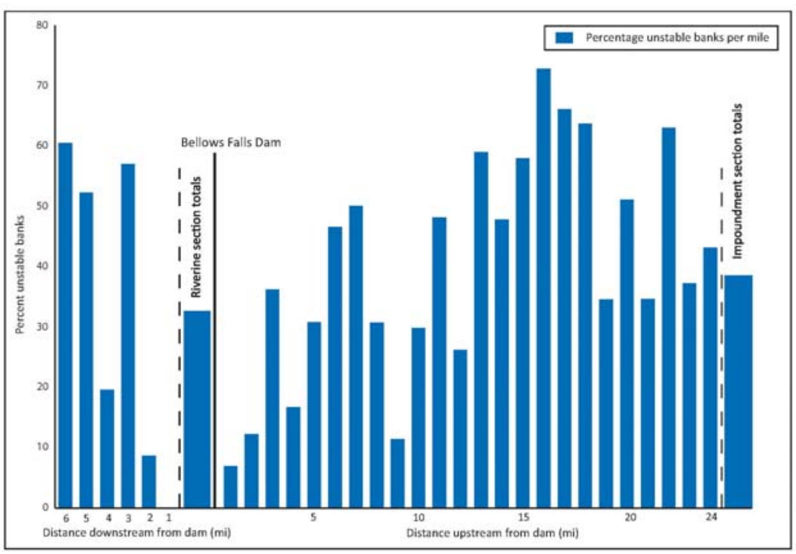
TransCanada **Erosion ratio by river bend position**

Study 3 – Riverbank Erosion Study



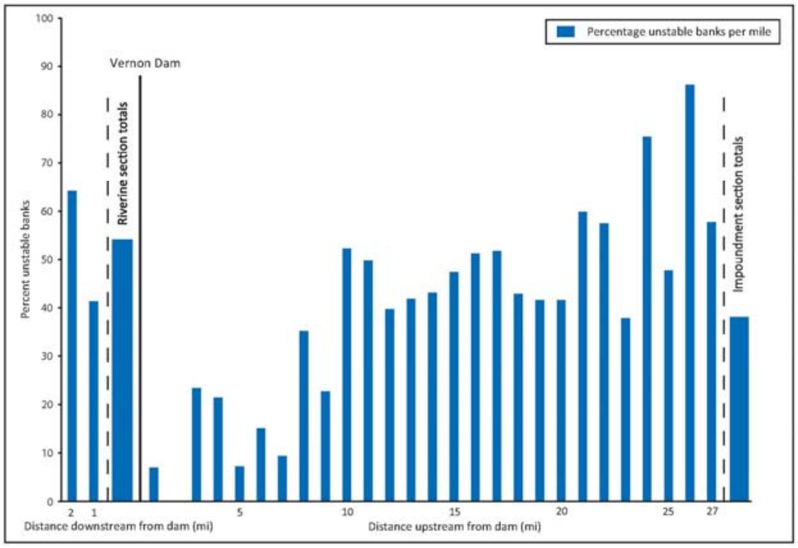
TransCanada **% unstable bank by distance from Wilder dam** 115

Study 3 – Riverbank Erosion Study



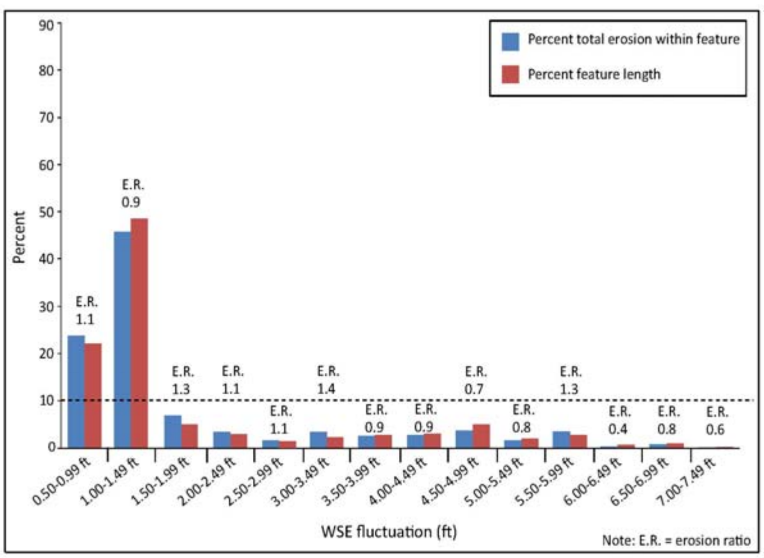
TransCanada **% unstable bank by distance from Bellows Falls dam**

Study 3 – Riverbank Erosion Study



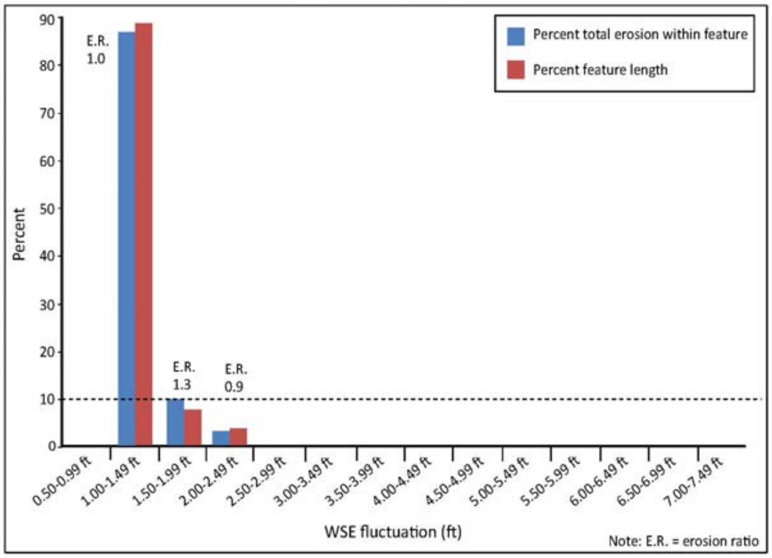
TransCanada **% unstable bank by distance from Vernon dam** 117

Study 3 – Riverbank Erosion Study



TransCanada **% erosion and erosion ratio by water level fluctuation across the entire study area**

Study 3 – Riverbank Erosion Study

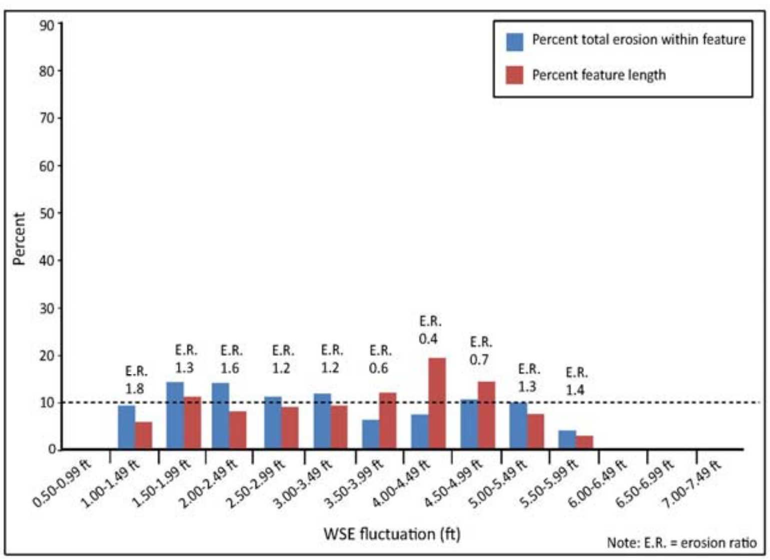


TransCanada

% erosion and erosion ratio by WSE fluctuation
Wilder impoundment, in non-spill conditions

119

Study 3 – Riverbank Erosion Study

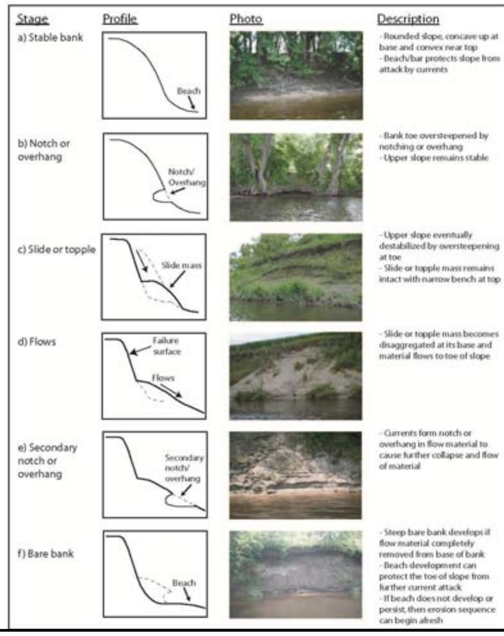


TransCanada

% erosion and erosion ratio by WSE fluctuation
Bellows Falls riverine reach in non-spill conditions

120

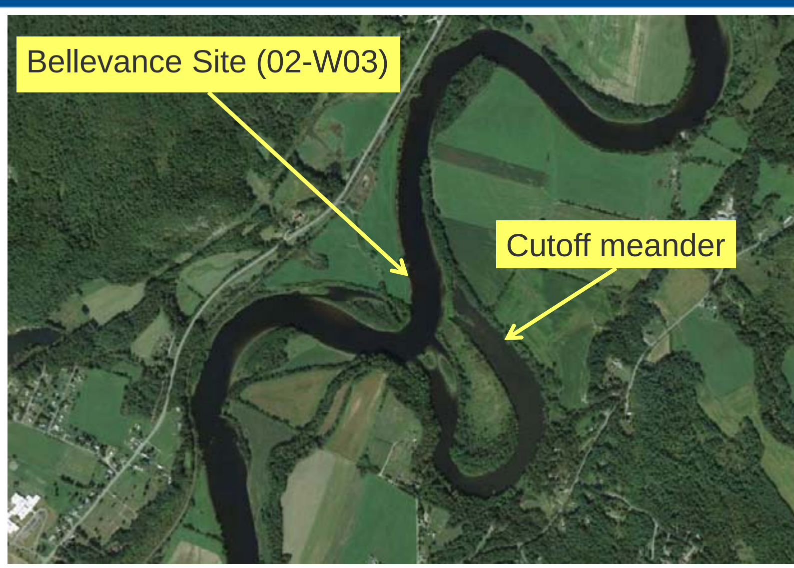
Study 2 –Riverbank Transect Study



TransCanada

121

Study 2 –Riverbank Transect Study

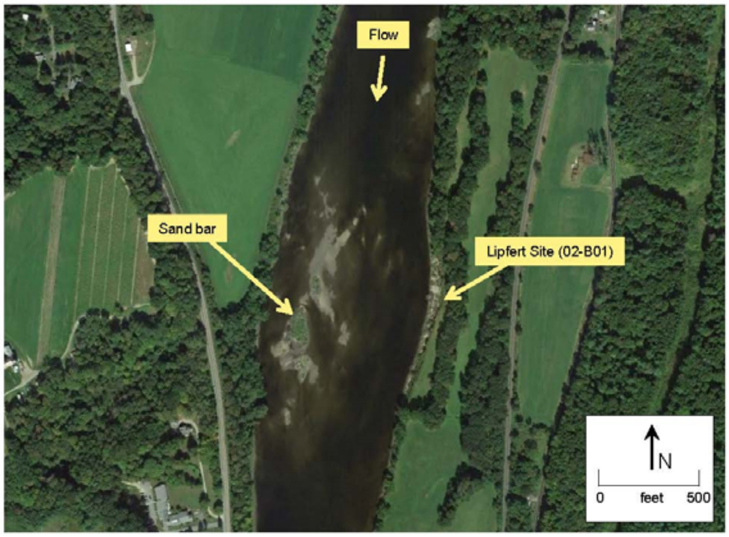


TransCanada

Recent meander cutoff adjacent to Bellevance Site (02-W03) may be a cause of erosion

122

Study 2 –Riverbank Transect Study



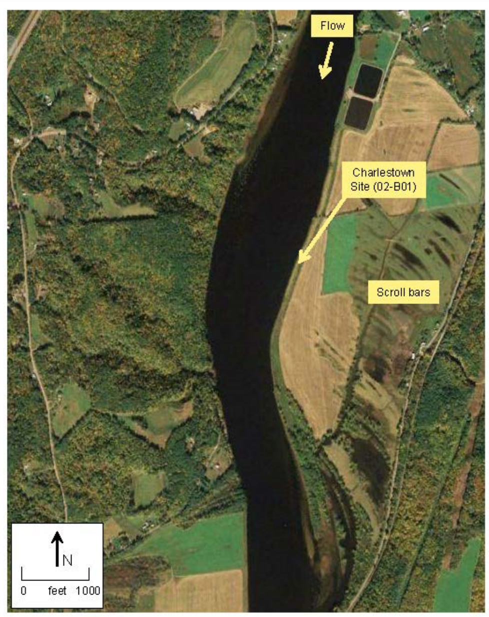
TransCanada

Flow deflection around sandbar toward bank at Lipfert Site (02-B01) may be a cause of erosion

123

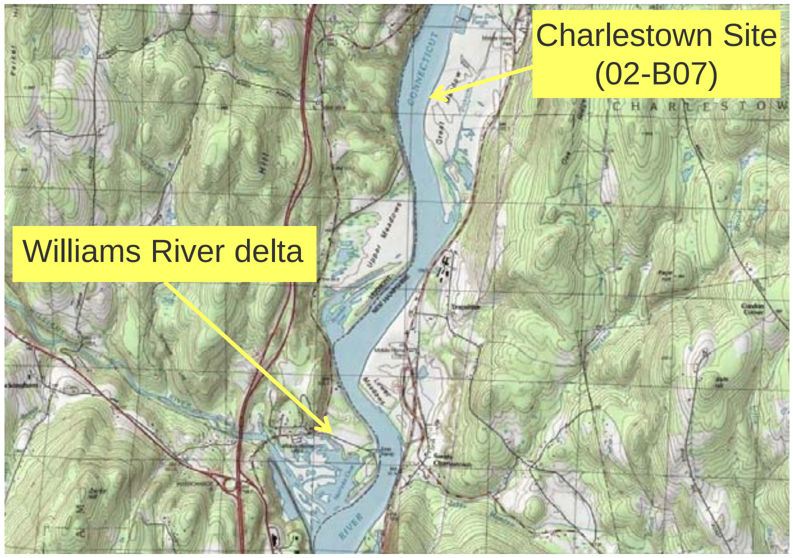
Study 2 –Riverbank Transect Study

Scroll bars at Charlestown Site (02-B07) suggest significant channel migration over decades may be the result of…



TransCanada

Study 2 –Riverbank Transect Study



TransCanada

…backwatering upstream of Williams River delta

125

Studies 2 and 3 - Riverbank Transect and Riverbank Erosion Studies

- **Study Conclusions**
- Erosion levels are largely the same throughout the study area despite variations in WSE fluctuations.
- Rate and locations of erosion have changed through time without significant changes in project operations.
- Levels of erosion are similar to other portions of the Connecticut River without dams.
- Erosion in the study area is the result of multiple causal mechanisms working in concert to sustain the cycle of erosion.
    - Variations in natural bank characteristics.
    - Bank heights and related geomorphic surfaces and bank compositions .
    - Tractive forces generated by flood flows are the only mechanism capable of removing the sediment from the base of the bank and sustain the cycle of erosion.
    - While other processes such as waves or seepage forces created by project-related WSE fluctuations may exert some control on the cycle of erosion, they cannot be considered as resulting in excessive erosion.

TransCanada

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