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OFFICE OF ENERGY PROJECTS

Project No. 1892-030 – New Hampshire/Vermont
Project No. 1855-050 – New Hampshire/Vermont
Project No. 1904-078 – New Hampshire/Vermont
Great River Hydro, LLC

John L. Ragonese
FERC License Manager
Great River Hydro, LLC
One Harbour Place, Suite 330
Portsmouth, NH 03801

Subject: Determination on Requests for Study Modifications and New Studies – Wilder, Bellows Falls, and Vernon Hydroelectric Projects

Dear Mr. Ragonese:

Pursuant to 18 C.F.R. § 5.15 of the Commission's regulations, this letter contains the determination on requests for modifications to the approved study plan for the relicensing of Great River Hydro, LLC's (Great River Hydro) Wilder, Bellows Falls, and Vernon hydroelectric projects. The determination is based on the study criteria set forth in sections 5.9(b), 5.15(d) and (e) of the Commission's regulations, applicable law, Commission policy and practice, and staff's review of the record of information.

Background

The study plan determination on non-aquatic studies for the projects as proposed by Great River Hydro was issued on September 13, 2013.[1] A subsequent study plan determination was issued on February 21, 2014, to address the proposed aquatic studies. Great River Hydro filed study reports for ongoing and finalized studies on September 15, 2014; September 14, 2015; March 1, 2016; May 17, 2016; and June 17 and August 1, 2016. Commission staff issued determinations on requested study modifications and new studies associated with these study reports on January 22, 2015; January 15, 2016; June 29, 2016; September 12, 2016; and November 29, 2016, respectively.

[1] Although the previous licensee, TransCanada Hydro Northeast Inc., filed the study reports discussed herein, for consistency this letter refers to Great River Hydro, the current licensee, as the filing party for all studies and related correspondence. *See TransCanada Hydro Northeast Inc. and TransCanada Hydro Northeast LLC*, 158 FERC ¶ 62,119 (2017); and *TransCanada Hydro Northeast LLC and Great River Hydro, LLC*, 159 FERC ¶ 62,154 (2017).

Following the November 29, 2016 study report determination, Great River Hydro filed a final study report for two studies[2] and revised study reports (including study report addenda) for several studies.[3] As required in section 5.15 of the Commission's regulations, the study reports describe Great River Hydro's progress in implementing the approved study plan, and an explanation of variances from the study plan and schedule. Great River Hydro held a study report meeting on March 30, 2017, and filed a meeting summary on April 14, 2017.

Comments

Comments on the study reports and meeting summary, including requests for study modifications, were filed by: the U.S. Fish and Wildlife Service (FWS), the Vermont Agency of Natural Resources (Vermont ANR), the Vermont Division for Historic Preservation, the New Hampshire Fish and Game Department (New Hampshire FGD), the New Hampshire Department of Environmental Services (New Hampshire DES), the Cowasuck Band of Pennacook-Abenaki People, the Connecticut River Conservancy (CRC), the Connecticut River Joint Commissions (CRJC), John Mudge, Ross McIntyre, and John Bruno. Great River Hydro filed reply comments on June 13 and July 6, 2017.

A number of the comments received do not specifically request additional studies or modifications to the approved studies, and are therefore not addressed herein. For example, some of the comments address the presentation of data; provide additional information; recommend protection, mitigation, and enhancement measures; address ongoing and future consultation; request information that was included in the study report; or request information that Great River Hydro has subsequently provided in its reply comments or agreed to provide in future filings.[4] In addition to the items listed above, this determination does not address requests for study modifications or additional studies that have been addressed in previous Commission letters. This determination only addresses new comments and requests that would require study modifications or additional studies.

[2] The March 22, 2017 study report includes studies 9 and 24.

[3] The November 30, 2016 study report includes studies 10, 14, 15, 17, 18, 23, and 27; the December 1, 2016 study report includes study 33; the December 15, 2016 study report includes studies 6 and 25; the January 17, 2017 study report includes study 22; the February 6, 2017 study report includes studies 2 and 3; and the February 28, 2017 study report includes studies 19 and 21.

[4] In its June 13, 2017 reply comments, Great River Hydro states that it will file report supplements for studies 9, 18, 21, 24, and 25 in the future. Great River Hydro filed the report supplement for study 25 on July 12, 2017.

Study Plan Determination

Pursuant to section 5.15(d) of the Commission's regulations, any proposal to modify a required study must be accompanied by a showing of good cause, and must include a demonstration that: (1) the approved study was not conducted as provided for in the approved study plan, or (2) the study was conducted under anomalous environmental conditions or that environmental conditions have changed in a material way. As specified in section 5.15(e), requests for new information gathering or studies must include a statement explaining: (1) any material change in law or regulations applicable to the information request, (2) why the goals and objectives of the approved study could not be met with the approved study methodology, (3) why the request was not made earlier, (4) significant changes in the project proposal or that significant new information material to the study objectives has become available, and (5) why the new study request satisfies the study criteria in section 5.9(b).

As indicated in Appendix A, the requested modifications to studies 2 (*Riverbank Transect Study*) and 3 (*Riverbank Erosion Study*) are approved in part. The requested modifications to studies 9 (*Instream Flow Study*) and 24 (*Dwarf Wedgemussel and Co-Occurring Mussel Study*) are not approved. The specific modifications to the studies and the bases for modifying or not modifying the study plan are explained in Appendix B. Commission staff considered all study plan criteria in section 5.9 of the Commission's regulations.

Please note that nothing in this determination is intended, in any way, to limit any agency's proper exercise of its independent statutory authority to require additional studies.

If you have any questions, please contact Brandon Cherry at (202) 502-8328, or via e-mail at brandon.cherry@ferc.gov.

Sincerely,

Terry L. Turpin
Director
Office of Energy Projects

Enclosures: Appendix A – Summary of Determinations on Requested Modifications to Approved Studies
Appendix B – Staff's Recommendations on Requested Modifications to Approved Studies

cc: Mailing List, Public Files

APPENDIX A

SUMMARY OF DETERMINATIONS ON REQUESTED MODIFICATIONS TO APPROVED STUDIES

Requested Modifications to Approved Studies (see Appendix B for discussion)

Study	Recommending Entity	Adopted	Adopted in part	Not Adopted
2 – Riverbank Transect Study	Vermont ANR, New Hampshire FGD, New Hampshire DES, CRC, CRJC, John Bruno		X	
3 – Riverbank Erosion Study	Vermont ANR, New Hampshire FGD, New Hampshire DES, CRC, CRJC, John Bruno		X	
9 – Instream Flow Study	FWS, Vermont ANR, New Hampshire FGD			X
24 – Dwarf Wedgemussel and Co-Occurring Mussel Study	Vermont ANR, New Hampshire FGD			X

APPENDIX B

STAFF'S RECOMMENDATIONS ON REQUESTED MODIFICATIONS TO APPROVED STUDIES

Studies 2 and 3 – Riverbank Transect and Riverbank Erosion Studies[5]

Background

The goals of studies 2 (*Riverbank Transect Study*) and 3 (*Riverbank Erosion Study*) were to: (1) monitor riverbank erosion at selected sites in the project impoundments and riverine sections of the Connecticut River that are affected by the projects, (2) determine the location of erosion in areas affected by the projects and compare these locations with previously compiled erosion maps, (3) characterize the processes of erosion, (4) ascertain the likely causes of erosion, and (5) identify the effects of shoreline erosion on other project resources. The approved study plan required Great River Hydro, LLC (Great River Hydro) to use information from study 4 (*Hydraulic Modeling Study*) to analyze the potential effects of streamflow velocity and shear stress[6] on erosion.

The final study report filed by Great River Hydro on August 1, 2016, included two years of erosion monitoring data for 21 sites, an analysis of the types and processes of erosion occurring within the project area, and a discussion of potential project effects on erosion.

In response to stakeholder comments on the final study report and the November 29, 2016 study plan determination, Great River Hydro filed additional information in its February 6, 2017 revised study report related to potential causes of riverbank erosion occurring within the study area, including an analysis of the effects of streamflow velocity and shear stress on erosion.

Riverbank Transect Assessments

In the revised study report, Great River Hydro used multiple logistic regression to analyze the relationship between erosion and potential correlating factors, including shear

[5] The results for studies 2 and 3 were combined into a single report; therefore, they are addressed together in this appendix.

[6] Shear stress is a measure of the force of flowing water on the riverbed and is a common parameter used for predicting soil erosion. Shear stress is a function of water density, depth, and slope.

stress. Given the complications of quantifying critical shear stress,[7] Great River Hydro used average channel shear stress to evaluate the potential effect of project operation on erosion in the study area.

Requested Study Modifications

The New Hampshire Department of Environmental Services (New Hampshire DES) and Connecticut River Conservancy (CRC) indicate that shear stress and velocity were not analyzed at the 21 monitoring sites in accordance with the November 29, 2016 study plan determination. New Hampshire DES and CRC state that using average channel shear stress to evaluate riverbank erosion fails to capture the complexities of the erosion processes occurring at the riverbank and water surface interface. The parties suggest that critical shear stress is a more appropriate measure of the forces acting on the riverbank and suggest that Great River Hydro conduct an analysis of near-bank critical shear stress and velocity to determine the likely causes of erosion occurring at the 21 monitoring sites. The Vermont Agency of Natural Resources (Vermont ANR), New Hampshire Fish and Game Department (New Hampshire FGD), Connecticut River Joint Commissions (CRJC), and John Bruno support this request.

Comments on Requested Study Modifications

Great River Hydro states that it did not analyze critical shear stress because site-specific factors (e.g., bank vegetation, secondary flow circulation, bend geometry, and sediment lithology) complicate efforts to quantify shear stress levels in near-bank areas and lead to widely varying shear stress levels over short lengths of bank. Great River Hydro states that average channel shear stress was modeled for all 21 monitoring sites, and the analysis shows that higher shear stress does not correlate with bank instability.

Discussion and Staff Recommendation

Great River Hydro's analysis of the erosion processes occurring at the 21 monitoring sites, as presented in the revised study report, is incomplete and inconsistent with what was required in the approved study plan. As stated on page 33 of the approved study plan, bank shear stress assessments were to be completed as part of study 2 to compare different sites for their susceptibility to erosion. Great River Hydro indicates that an increase in average channel shear stress does not correlate with a higher likelihood of bank instability based on an analysis of where erosion is occurring in the study area. However, Great River Hydro also states that average channel shear stress does not adequately capture all of the factors controlling the dynamic near-bank flow conditions.

[7] Critical shear stress represents the point where shear forces of a flowing river exceed the frictional forces of the riverbed and sediment can become entrained.

Because critical shear stress and near-bank velocities can play a significant role in the erosion process, staff recommends that Great River Hydro file an addendum to the revised study report by November 15, 2017, that includes an analysis of estimated critical shear stress, near-bank velocity, and the potential correlation of these factors with project operation at the 21 monitoring sites. This discussion should include a table for each monitoring site that lists critical shear stresses and near-bank velocities with respect to water surface elevations corresponding to project operation (e.g., minimum flow, average project operating ranges, maximum hydraulic capacity). For each monitoring site, Great River Hydro should describe the river channel features corresponding to each water surface elevation, including stratigraphy, the presence or absence of vegetation, the presence of any visual erosion indicators (e.g., slumps, falls, notching, undercutting), and other notable bank features (e.g., groundwater seeps).

Due to the complicating factors associated with determining critical shear stress, Great River Hydro should provide a best estimate of critical shear stress in the November 15, 2017 addendum to the revised study report. Where appropriate, critical shear stress could be estimated based on grain size/shape (e.g., Shield's diagram)[8] or interpreted using the Hydrologic Engineering Center's River Analysis System (HEC-RAS) model (e.g., comparison to overbank shear stress).[9] Any estimates or assumptions made should be discussed in the November 15, 2017 addendum to the revised study report.

Further analysis of near-bank velocity and stratigraphy are discussed below.

Regression Analysis

Several comments on Great River Hydro's final study report suggested that Great River Hydro's method for analyzing data (i.e., the erosion ratio[10]) was not a generally accepted scientific method, and recommended additional analysis. In response, Great River Hydro proposed to include a statistical analysis of the data using a logistic

[8] Shields, A., 1936, Application of Similarity Principles and Turbulence Research to Bed-Load Movement, translated by W.P. Ott and J.C. Uchelen (Mitt. Preuss. Verschsanst., Berlin, Wasserbau Schiffbau; California Institute of Technology, Pasadena, California, 1936), Report No. 167.

[9] If complex river morphology at some sites prohibits a meaningful estimation of critical shear stress or near-bank velocities, Great River Hydro should reconsider the use of the two-dimensional model, as proposed in the revised study plan.

[10] The erosion ratio is the percentage of unstable banks that exhibit a specified feature (e.g., bank height) divided by the percentage of total banks that exhibit that feature, including stable banks. An erosion ratio greater than 1 suggests erosion may preferentially occur at banks with the specified feature.

regression method in an effort to distinguish the contribution of various causal factors of erosion. In the revised study report, Great River Hydro states that it analyzed bank instability across about 250 miles of riverbank within the project boundary at 1-foot intervals, using the following potential correlating factors: bank height, water surface elevation, average channel shear stress, bend geometry, and the presence of armoring[11] or vegetation as potential erosion predictors. The results of the analysis indicate that none of the potential correlating factors exhibit a strong enough relationship to explain the variability observed in the bank stability data.

Requested Study Modifications

New Hampshire DES and CRC state that Great River Hydro's logistic regression analysis may not have been conducted in an appropriate manner. New Hampshire DES and CRC state that the observations in Great River Hydro's analysis were not independent, which is a violation of the logistic regression methodology.[12] CRC recommends evaluating the regression analysis for spatial auto-correlations and dependencies, and if significant, conducting an alternative statistical test. New Hampshire DES and CRC also state that Great River Hydro's regression analysis of the bank stability mapping dataset – spanning the entire project area – is insufficient. CRC states that Great River Hydro's analysis should be performed specifically on the data collected at the 21 monitoring sites because these data include bank features otherwise not evaluated (e.g., presence of notching/undercutting, vegetation, soil lithology). Vermont ANR, New Hampshire FGD, CRJC, and John Bruno support these requests.

Comments on Requested Study Modifications

Great River Hydro acknowledges the lack of independent observations in its analysis, but states that the analysis can still result in useful empirical estimates for identifying potential causes of erosion. Great River Hydro states that the logistic regression analysis corroborates the results of the erosion ratio analysis, and further analysis using spatial auto-correlation is not needed. Great River Hydro also states that the mapping dataset used for the regression analysis includes the 21 monitoring sites.

[11] Armored banks are banks that have been, or have attempted to be, stabilized using rip-rap or other materials, usually to prevent further erosion.

[12] Great River Hydro analyzed bank instability at 1-foot intervals in the study area. Observations recorded from such small intervals in the same area likely have similar values for bank height, water surface elevation, average channel shear stress, bend geometry, armoring, and vegetation and, therefore, are not independent. Including observations that are not independent in a regression analysis can produce results that are biased or false (i.e., find a statistically significant relationship when no relationship actually exists).

According to Great River Hydro, independent evaluations of the 21 monitoring sites would not provide any meaningful results because only 3 sites showed measurable erosion of the upper bank.

Discussion and Staff Recommendation

The results of the logistic regression presented in the revised study report corroborate the results of the erosion ratio in the final study report, which suggests that the erosion ratio is an adequate method for identifying single predictors of erosion (e.g., bank height, geometry). While spatially auto-correlating the dataset, conducting an additional statistical analysis (e.g., multi-variable approach), and performing regression analyses at each of the monitoring sites may increase the measure of confidence in determining predictors of erosion within the project area, the discussion presented in the revised report, as supplemented by the addendum recommended above, should be sufficient for distinguishing the potential causal factors of erosion in the study area. Therefore, we do not recommend that Great River Hydro perform additional statistical analyses at this time.

Stratigraphy Analysis

In response to Vermont ANR's comments on the final study report, Great River Hydro proposed to analyze: (1) the extent of notching within normal project operating ranges at the 21 monitoring sites, and (2) the corresponding riverbank sediment layers, to the extent possible, to provide further understanding of the erosion occurring within the project area.

Requested Study Modifications

No comments were submitted on the revised study report.

Comments on Requested Study Modifications

Great River Hydro did not file any comments regarding its proposed stratigraphy analysis.

Discussion and Staff Recommendation

In the revised study report, Great River Hydro provides information on the extent of notching within normal project operating ranges and stratigraphy profiles for each of the 21 monitoring sites. However, the revised study report does not include a stratigraphy analysis or detailed discussion of the observed soil profiles, including the potential role of soil composition in erosion susceptibility. As stated in the approved study plan, streambank erosion may be more likely to occur with certain soil types or

interfaces when subjected to project-related water surface elevation fluctuations. Therefore, staff recommends that Great River Hydro include in the November 15, 2017 addendum, an analysis of the stratigraphy at the 21 monitoring sites, including, at a minimum, a discussion of any potential correlation between erosive features (e.g., notches, undercutting) and soils present within normal project operating ranges.

Streamflow Velocity Analysis

As part of its evaluation of contributing factors of erosion within the project area, Great River Hydro used cross-channel velocity measurements collected at six monitoring sites (i.e., Bellavance, Mudge, Charlestown, Hartford, Malnati, and Stebbins Island monitoring sites) using acoustic Doppler current profilers (ADCPs) to calculate an average velocity for those six sites. Great River Hydro also analyzed average velocities generated by the HEC-RAS model, using ADCP-calculated average velocities for validation. Great River Hydro then analyzed whether the average velocities at various operating levels and flood flows exceed the minimum streamflow velocity needed to transport sediment in the project areas (i.e., the "threshold velocity"). Based on estimated threshold velocities,[13] the character of sediment in the study area, and vegetative growth on the banks, Great River Hydro estimates that sediment entrainment along the Connecticut River occurs at a minimum threshold velocity of 2 feet/second (ft/s), and a range of 2 to 3 ft/s. Great River Hydro's analysis showed that velocities at the impoundment sites were below the 2-ft/s minimum threshold for sediment entrainment under normal project operation.

Requested Study Modifications

New Hampshire DES requests that Great River Hydro discuss the relationship between average velocity and near-bank velocity at each of the 21 monitoring sites. New Hampshire DES additionally requests that Great River Hydro identify the areas along the approximately 250 miles of riverbank where average velocities exceeded the 2-ft/s threshold. Vermont ANR, New Hampshire FGD, and CRJC support New Hampshire DES's request.

Comments on Requested Study Modifications

Great River Hydro indicates that its calculation of average velocity at the six monitoring sites with ADCPs was based on actual measurements across the channel, including near-bank sections. Great River Hydro states that cross-channel velocity data were not collected at the other 15 monitoring sites because it was beyond the scope of the

[13] Great River Hydro analyzed minimum threshold velocity values published by the U.S. Department of Agriculture Natural Resources Conservation Service and U.S. Army Corps of Engineers. See pages 126-132 of the revised study report.

approved study plan. Great River Hydro adds that identifying locations along the approximately 250 miles of riverbank where flow velocity exceeds 2 ft/s would be misleading, as velocity is also a function of inflow and local channel characteristics. Great River Hydro, therefore, believes that additional analysis of streamflow velocity is not needed.

Discussion and Staff Recommendation

Studies 2 and 3 were conducted to identify the potential contributing factors of riverbank erosion in the project areas. Accurate velocity assessments are necessary to determine the conditions under which sediment is transported from bank areas. To the extent near-bank streamflow velocities differ from average channel velocities within a given section of the Connecticut River, the analysis of project effects on sediment entrainment may be inaccurate. Therefore, Commission staff recommends that Great River Hydro include, in the November 15, 2017 addendum, near-bank velocities associated with multiple water surface elevations (e.g., minimum flow, average project operating range, maximum project hydraulic capacity), as measured at the six sites with ADCPs. For the remaining 15 sites, staff recommends that Great River Hydro include the average velocity associated with multiple water surface elevations as calculated by the HEC-RAS model. If possible, Great River Hydro should include a discussion or estimate of the near-bank velocity for these 15 sites based on available data. Additionally, where available, this analysis should be supplemented with literature-based, soil-specific estimates of threshold velocities for each of the 21 monitoring sites, in order to determine the potential for project operation to effect riverbank erosion.

We do not recommend that Great River Hydro identify the areas along the approximately 250 miles of riverbank where velocity exceeds 2 ft/s. Mapping these areas is beyond the scope of the approved study plan, and the additional analysis on near-bank velocity at the 21 monitoring sites should provide the necessary information for our analysis of the relationship between streamflow velocity and sediment transport.

Hydraulic Gradient between Impoundment Water Surface Elevations and Groundwater

Requested Study Modifications

CRC states that the revised study report does not describe the relationship between streambank erosion and the hydraulic gradient between impoundment water surface elevations and groundwater, as required by the November 29, 2016 study determination. CRC recommends that Great River Hydro collect groundwater elevation data and describe observations of groundwater seeps at the 21 monitoring sites to analyze the resulting potential for riverbank erosion, if any. New Hampshire FGD, CRJC, and John Bruno support CRC's request.

Comments on Requested Study Modifications

Great River Hydro indicates that further analysis of the hydraulic gradient between water surface elevations and groundwater is beyond the scope of the approved study plan.

Discussion and Staff Recommendation

In the revised study report, Great River Hydro suggests that the hydraulic gradients between groundwater levels in the bank and water surface elevations are likely small because project operation only results in fluctuations of less than a median of 2 feet for most of the study area. As a result, Great River Hydro suggests that the hydraulic gradients would not result in strong seepage forces. Great River Hydro recognizes that small fluctuations can still contribute to bank instability; however, data in Figure 5.6.5-4 of the revised study report show that greater levels of bank instability do not occur in the project areas where water surface elevation fluctuations are the greatest and seepage forces are the highest.

While collecting groundwater elevation data may provide additional information on the hydraulic gradient between water surface elevations and groundwater, the data and analysis presented in the revised report, as supplemented by the addendum recommended herein, should be sufficient for staff to analyze the potential for project operation to influence erosion and the potential causal factors of erosion. Therefore, we do not recommend that Great River Hydro collect additional groundwater data at this time. However, as discussed above, Commission staff recommends that Great River Hydro discuss any observations of groundwater seeps (either naturally occurring or project-related) at the 21 monitoring sites in the November 15, 2017 addendum.

HEC-RAS Data

Requested Study Modifications

New Hampshire DES and CRC recommend that Great River Hydro provide the HEC-RAS input and output data to stakeholders for further analysis. Vermont ANR, New Hampshire FGD, CRJC, and John Bruno support this request.

Comments on Requested Study Modifications

Great River Hydro states that it described the HEC-RAS model data in the report for study 4 (*Hydraulic Modeling Study*), and suggests that providing such massive datasets would result in the data being misinterpreted and potentially misapplied.

Discussion and Staff Recommendation

Commission staff recommends that Great River Hydro make the requested HEC-RAS data available to stakeholders upon their request to allow for their supplemental analysis. Any data analyses filed by stakeholders in the proceeding will be independently reviewed by Commission staff.

Evaluation of Alternative Project-Operating Regimes

Requested Study Modifications

New Hampshire DES recommends that Great River Hydro evaluate how operating the projects in a run-of-river mode would reduce the frequency/magnitude of daily and sub-daily water surface elevation fluctuations, and potentially reduce bank seepage forces that contribute to riverbank erosion. Vermont ANR, New Hampshire FGD, and CRJC support New Hampshire DES's request.

Comments on Requested Study Modifications

Great River Hydro indicates that operating the projects in a run-of-river mode would not necessarily result in decreased water surface elevation fluctuations. Great River Hydro suggests that run-of-river mode could potentially increase the magnitude and duration of water surface elevation fluctuations, as the impoundment levels would fluctuate with changes in inflow.

Discussion and Staff Recommendation

An evaluation of alternative modes of operation is beyond the scope of the approved study plan. Therefore, we do not recommend that Great River Hydro evaluate the potential effects of operating the projects in a run-of-river mode. However, Commission staff will analyze recommended alternatives as part of our analysis.

Effects on other Project Resources

Requested Study Modifications

CRC recommends that Great River Hydro provide additional maps depicting erosion and further assessment of the potential impacts of ongoing riverbank erosion and the release of fine sediment on other project resources, including: cobblestone tiger beetle habitat, water quality for fish, aquatic habitat and substrate, spawning of riverine fishes, and freshwater mussels. New Hampshire FGD, CRJC, and John Bruno support CRC's request.

Comments on Requested Study Modifications

Great River Hydro states that a qualitative assessment of the potential impacts of erosion on other project resources was completed in accordance with the approved study plan and no further assessment is needed.

Discussion and Staff Recommendation

The information proved in the revised study report, in conjunction with other project resource study reports filed by Great River Hydro, is sufficient for staff's analysis of the potential effect of erosion on other environmental resources in the project areas. Therefore, we do not recommend that Great River Hydro further assess the potential effects of riverbank erosion on other project resources at this time.

Study 9 – Instream Flow Study

Background

The goal of study 9 was to assess the effect of current project operation on downstream aquatic resources and habitats. The specific objectives of the study were to: (1) determine the relationship between habitat suitability and streamflow for key aquatic species in the study area; and (2) develop habitat duration curves that present habitat suitability across specific time periods (e.g., critical life stages) and over a range of flows. Great River Hydro also used a dual-flow analysis[14] to evaluate the effects of different flow regimes on aquatic habitat.

Requested Study Modifications

The U.S. Fish and Wildlife Service (FWS) recommends that Great River Hydro conduct supplemental dual-flow analyses using baseline flows of 8,000 cubic feet per second (cfs), 10,000 cfs, and 12,000 cfs for the following species/life stages: co-occurring mussels, spawning American shad, and spawning sea lamprey. FWS indicates that Great River Hydro's maximum base flows for the analyses (e.g., 5,000 cfs) are inadequate because habitat suitability continues to increase above these base flows.

FWS states that Great River Hydro's dual-flow results do not accurately represent the loss in habitat associated with certain flow regimes. FWS recommends that Great River Hydro present the change in persistent habitat[15] in the analysis as a percentage of

[14] A dual-flow analysis is a comparison of habitat availability at specific lower and higher flows. Great River Hydro's analysis compared minimum-generation flows to flows released during normal project operation.

[15] Persistent habitat is the suitable habitat available at both the lower and higher flows in a dual-flow analysis

the maximum habitat suitability index. Vermont ANR and New Hampshire FGD support FWS's request.

Comments on Requested Study Modifications

Great River Hydro states that the appropriate baseline for analyzing project effects is the current minimum flow, and that the higher baseline flows proposed by FWS could not be sustained absent continuous inflows at those same levels.

In addition, Great River Hydro states that the purpose of the dual-flow analysis is to evaluate the change in persistent habitat between the existing minimum flow and higher flows (e.g., peaking flows), rather than to compare the persistent habitat to the maximum habitat suitability index, as proposed by FWS.

Discussion and Staff Recommendation

The highest baseline flows used in Great River Hydro's dual-flow analysis were higher than the existing minimum flows for the projects, but lower than the baseline flows recommended by FWS. However, the study report includes tables and graphs showing the habitat suitability index for flows ranging from the existing minimum flows up to the maximum hydraulic capacities of the projects. These data are adequate for staff's analysis of flow-related effects on habitat for key aquatic species in the study area and to develop any necessary license requirements. In addition, the study report provides the underlying persistent flows for each of the dual-flow analyses, and a modified presentation of the results is not necessary to understand the relationship between habitat and flow. Accordingly, we do not recommend FWS's proposal to supplement the dual-flow analysis and modify the presentation of persistent habitat in the dual-flow analysis.

Study 24 – Dwarf Wedgemussel and Co-Occurring Mussel Study

Background

As approved in the study plan, one goal of study 24 was to assess the influence of flow regime, including water-level fluctuations, on dwarf wedgemussels, co-occurring mussel species, and mussel habitat. As part of study 24, Great River Hydro used the Delphi technique[16] to determine habitat suitability criteria (HSC) for dwarf wedgemussel and a co-occurring mussel, eastern elliptio.[17] The HSC included water depth, benthic

[16] The Delphi technique is a method in which a panel of experts generate habitat suitability criteria for a target species.

[17] HSC describe suitable and unsuitable habitat conditions for aquatic organisms under a range of microhabitat variables.

water velocity, mean column velocity, substrate composition, bed shear stress, and relative shear stress. The HSC were used in one- and two-dimensional hydraulic models to generate habitat suitability index estimates for various flows and water surface elevations in study 9 (*Instream Flow Study*).

Requested Study Modifications

Vermont ANR states that Great River Hydro's analysis does not provide adequate information to determine the appropriate flow regime to protect mussels because the analysis depends on HSC for adult mussels, a life stage that is not sensitive to changes in flow. Therefore, Vermont ANR states that Great River Hydro should analyze habitat suitability for host fish species near mussel beds at the time when female mussels are releasing glochidia.[18] New Hampshire FGD supports Vermont ANR's request.

Comments on Requested Study Modifications

In its reply comments, Great River Hydro states that all life stages of mussels are sensitive to flow and that the study focused on adult and juvenile mussels for which HSC and modeling tools are most effective. Great River Hydro also states that analyzing host fish habitat suitability near mussel beds at the time when female mussels release glochidia would be challenging because: (1) several mussel species occur in the study area, (2) some mussel species are sparse and do not occur within beds, (3) most fish species in the study area likely serve as suitable hosts for one or more mussel species, and (4) the timing of glochidial release varies among mussel species and is likely influenced by several environmental factors.

Discussion and Staff Recommendation

Great River Hydro presents its analysis of mussel habitat suitability in relation to changes in flow in the final report for study 9. The analysis demonstrates that the HSC developed in the study are sensitive to changes in flow, i.e., that habitat suitability changes with different flow scenarios. Great River Hydro's study focused on life stages known to be observable in the field, and the study methods and HSC are consistent with previous mussel studies and are generally accepted in the scientific community. In addition, study 9 provides adequate information to describe potential flow-related effects on host fish. Therefore, the HSC developed in study 24 and the subsequent analyses conducted in study 9 are adequate for staff's analysis, and we do not recommend additional analyses of habitat suitability for host fish habitat near mussel beds.

[18] A glochidium is the parasitic life stage of a mussel that attaches to a fish host.

Document Content(s)

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