Relicensing Study 3.1.2

NORTHFIELD MOUNTAIN/TURNERS FALLS OPERATIONS IMPACT ON EXISITNG EROSION AND POTENTIAL BANK INSTABILITY

Initial Study Report Summary

Northfield Mountain Pumped Storage Project (No. 2485)
and Turners Falls Hydroelectric Project (No. 1889)

Prepared for:

FirstLight GDF SUEZ

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SEPTEMBER 2014

1.1 Study Summary and Consultation Record to Date

Study No. 3.1.2 *Northfield Mountain/Turners Falls Operations Impacts on Existing Erosion and Potential Bank Instability* examines the causes of erosion present throughout the Turners Falls Impoundment (Impoundment), the forces associated with them, and their relative importance at a particular location. Activities conducted to date include: data gathering and literature review, developing a geomorphic understanding of the Connecticut River within the study area, identifying the principal potential causes of erosion in the Impoundment, selection of detailed study sites, and field data collection.

Detailed study sites were selected based on the results of Study No. 3.1.1 *Full River Reconnaissance (FRR).* The results of the FRR were used to identify riverbank features and characteristics found throughout the Impoundment and to ensure the selected detailed study sites were representative of the riverbanks found throughout the study area. The final list of detailed study sites, which was modified after the consultation with the stakeholders described in the consultation record (Appendix A) can be found in the Selection of Detailed Study Sites Report[1] (Appendix B). Field work for this study began in July 2014 and is scheduled to continue through October 2014. As discussed later additional field data collection, specifically photographic documentation of the Impoundment under ice conditions is slated to occur from December 1, 2015 through March 31, 2016.

Consultation that has occurred since FERC issued its September 13, 2013 Study Plan Determination Letter (SPDL) on this study includes the following:

- On May 12, 2014, FirstLight emailed the Massachusetts Department of Environmental Protection (MADEP) a draft version of the Selection of Detailed Study Sites Report. The draft report included the locations where proposed field data collection efforts would occur.

- On June 4, 2014, FirstLight met with MADEP to discuss the Selection of Detailed Study Sites Report and to seek input on the proposed locations for the field data collection efforts.

- On June 6, 2014, FirstLight emailed the Connecticut River Watershed Council (CRWC), Franklin Regional Council of Governments (FRCOG), MADEP and the New Hampshire Department of Environmental Services (NHDES) the Selection of Detailed Study Sites Report, which incorporated MADEP's comments. In that same email, FirstLight invited the same groups to a meeting on June 24, 2014 at the Northfield Mountain Visitors Center.

- On June 24, 2014 as required by FERC in its first SPDL, FirstLight held a meeting attended by the CRWC, FRCOG, the Connecticut River Streambank Erosion Committee (CRSEC), Landowners for Concerned Citizens for License Compliance (LCCLC), FERC, Massachusetts Riverways, National Marine Fisheries Service (NMFS), Franklin Conservation District (FCD), MADEP and Karl Meyer to consult on the Selection of Detailed Study Sites Report.

- On July 3, 2014 CRWC, FRCOG, and MADEP (July 15) submitted via email comment letters (Appendix A) to FirstLight in regard to the Selection of Detailed Study Sites Report and the June 24 meeting. FirstLight submitted via email a response to the Stakeholders on July 23, 2014 (Appendix A). In that same email, FirstLight invited the Stakeholders to a meeting on August 4, 2014 at the Northfield Mountain Visitors Center.

- On August 2, 2014, FRCOG provided comments (Appendix A) on FirstLight's July 23, 2014 response.

- On August 4, 2014 FirstLight held a meeting attended by CRWC, NMFS, FERC, FRCOG, CRSEC, and MADEP to discuss FirstLight's response and finalize the location of the detailed study sites.

On December 13, 2013, FERC issued an Interim Integrated Licensing Process schedule for SPDL. In the letter FERC states:

"In addition to the 19 deferred studies, stakeholders noted that the previously approved study 3.1.2: Project Impacts on Existing Erosion and Potential Bank Instability, did not consider ice process erosional effects within the Turners Falls reservoir. As a result, FirstLight requested that it be provided an opportunity to consider whether any modifications to the approved study are needed. Because any modifications to study 3.1.2 for this purpose could not be implemented in 2014 while Vermont Yankee is operational, we recommend that FirstLight evaluate the need for a study modification in consultation with stakeholders during the 2014 study season. FirstLight should present its findings and any proposed modifications to stakeholders, providing 30-days for stakeholder comment, and consider stakeholder input when determining the need for a modification to study 3.1.2. FirstLight should then present its findings and responses to stakeholder comments in its Initial Study Report (ISR) following the 2014 field season".

- On August 12, 2014, FirstLight emailed the FERC, CRWC, FRCOG, MADEP, NMFS, MADEP, FCD, and LCCLC a proposed addendum to Study 3.1.2 to address ice issues as required by FERC in its December 13, 2013 SPDL. The addendum is attached in Appendix C. Comments on the addendum were received from CRWC on September 11, 2014 (end of Appendix C).

- On August 28, 2014, the CRSEC provided FirstLight a memo (Appendix A) outlining information that would be included in the study report. Also on August 28, 2014, the CRSEC provided FirstLight a second memo (Appendix A) relative to the definition of the upper and lower riverbank.

1.2 Study Progress Summary

Task 1: Data Gathering and Literature Review

Existing data and literature sources were obtained including the following:

- Existing hydrology.

- Water level monitoring data collected in the Turners Falls Impoundment (still on-going).

- Previous FRR's.

- Soil, surficial geology and aerial mapping.

- Various reports regarding the geomorphology of the Impoundment and Connecticut River.

- Boat wave data from 1997 and 2008.

- Groundwater elevation data from 1997-1998.

- Continuous suspended sediment and particle size distribution data collected at the Route 10 Bridge and Northfield Mountain Tailrace (2012-present).

Task 2: Geomorphic Understanding of the Connecticut River

Existing data was reviewed to gain a better understanding of the geomorphology of the Impoundment and Connecticut River within the study area. The final report will contain discussion pertaining to this as outlined in the Revised Study Plan (RSP) and SPDL.

Task 3: Causes of Erosion

The potential causes of erosion and potential primary causes of erosion identified in the RSP were reviewed. No changes are proposed at this time.

Task 4: Field Studies and Data Collection

- Water level loggers were installed at 7 locations throughout the Impoundment in April/May 2014. The water level loggers are collecting data on a 15-minute time step and will remain deployed until late November 2014.

- The 2013 FRR Survey was conducted November-December 2013.

- The final set of detailed study sites were selected in August 2014.

- Bank Stability and Toe Erosion Model (BSTEM) field data collection is ongoing. Data collection efforts started in July 2014 and are expected to continue through October 2014. Field studies at each detailed study site include: determining the effective cohesion, angle or internal friction, pore-water pressure, and bulk weight of the soils; determining the erodibility coefficient; analyses of sediment particle size distribution; and information on vegetation, root structure, and density.

- Boat wave data including amplitude, frequency, and speed was collected in previous years at several locations throughout the Impoundment including the Flagg site, downstream of the Route 10 Bridge, and in the vicinity of the Northfield Mountain tailrace. Additional data will be collected at select detailed study sites during fall 2014 and/or spring, summer 2015.

- Riverbank geometry and channel cross-section surveys were conducted at each detailed study site

Task 5: Data Analyses

Field data review, post processing, QA/QC, and detailed data analyses for all data collected during the 2014 field season is scheduled to occur in 2015. Review and analyses of ice data is proposed to occur in 2016 as discussed in the study addendum (Appendix C).

Task 6: Evaluation of the Causes of Erosion

Preliminary evaluation of the causes of erosion based on data collected in 2014 will occur in 2015. The final evaluation of all causes of erosion (including ice) will occur in 2016 following the completion of all field efforts.

Task 7: Report and Deliverables

The report is expected to be finalized in the 2nd quarter of 2016 after ice photographs are obtained (December 1, 2015 through March 31, 2016) and are incorporated into the evaluation.

1.3 Variances from Study Plan and Schedule

One variance from the RSP pertains to the presence of ice in the Impoundment. The RSP recognized ice as a potentially minor cause of erosion in the study area; however, with the planned shutdown of the Vermont Yankee Nuclear Power Plant in December 2014 the role of ice as it relates to shoreline erosion could have increased significance. In order to determine the effects, if any, that the Vermont Yankee closure may have on potential increases in ice and shoreline erosion processes, FirstLight included an addendum to the RSP (see Appendix C) that addresses ice issues.

Other Information

On page B-8 of its SPDL, FERC states the following under the Applicant's Proposed Study Plan relative to Study No. 3.1.2 *"FirstLight proposes that field transect surveys would be performed four times per year and after significant flood events. FirstLight would collect data based on the geometry at each change/break in grade."* Under the Discussion and Staff Recommendations section of the SPDL for Study No. 3.1.2, FERC states *"Finally our review of FirstLight's study plan indicates that FirstLight did not specifically define the flow value that would trigger a high-flow event survey (section 5.9(b)(6)). Therefore, for the purposes of this study, we recommend that FirstLight define a "high-flow event" as a flow greater than 56,000 cfs at Turners Falls dam."*

FERC's characterization of the Applicant's Proposed Study Plan in the SPDL appears inaccurate. FirstLight's RSP for Study No. 3.1.2 did not include provisions to collect transect data four times per year and after significant flood events. On May 20, 2014 FERC and FirstLight had a conference call to discuss this issue. On May 23, 2014 FirstLight filed a letter with FERC explaining the discrepancy and describing how the BSTEM model will be used, and why collecting the additional data would not inform FirstLight's study. FirstLight also discussed why the cost to conduct the surveys was not economically justified. On September 3, 2014, FERC issued its Clarification on Study 3.1.2.. In its letter, FERC states "*Using 15 years of existing historical stream bank geometry data and 2014 survey data as proposed by FirstLight, along with other field collected data will provide the information necessary to determine the relative causes of erosion, including mass wasting along the Turners Falls reservoir consistent with the approved study objectives and the Commission's study criteria, (section 5.9(b)(6)). Therefore, FirstLight's proposed methodology for collecting stream bank geometry data, as outlined in its revised study plan filed on August 14, 2013, is approved*."

1.4 Remaining Activities

Task 4: Field Studies and Data Collection

Complete field data collection efforts.

Task 5: Data Analyses

Review and post process field collected, QA/QC of all data, detailed data analyses and modeling.

Task 6: Evaluation of the Causes of Erosion

Determine the causes of erosion throughout the Impoundment based on the results of Task 5.

Task 7: Report and Deliverables

Develop final report and deliverables.

Appendix A
Correspondence Log

CONNECTICUT RIVER WATERSHED COUNCIL
The River Connects Us
15 Bank Row, Greenfield, MA 01301 crwc@ctriver.org www.ctriver.org

July 3, 2014

John S. Howard
Director, FERC Hydro Compliance
FirstLight Power Resources/GDF Suez
Northfield Mountain Station
99 Millers Falls Road
Northfield, MA 01360

Re: Stakeholder comments on transects and detailed study sites for Study 3.1.2

Dear John,

I reviewed the "Relicensing Study 3.1.2. Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability: Selection of Detailed Study Sites" dated June 2014 ("Selection of Study Sites Report"), which presents the list of proposed calibration and representative locations for detailed study that will be used for Study No. 3.1.2. I attended the June 24, 2014 meeting with stakeholders to discuss this report. During this meeting, various stakeholders including myself requested additional information. Gomez and Sullivan sent us the requested information after the close of business on June 27, 2014. The purpose of this letter is to give you input on the proposed calibration and representative locations on behalf of the Connecticut River Watershed Council (CRWC). We collaborated with the Franklin Regional Council of Governments (FRCOG) and other members of the Connecticut River Streambank Erosion Committee (CRSEC) on these comments and analyses.

Our analysis indicates that calibration transects and representative locations should either be moved or added to better represent the range of site conditions and influences that exist along the river.

Study Schedule

Stakeholders were asked to provide input before the Fourth of July holiday because field work is due to start immediately the following week. We would like to point out that the Revised Study Plan study schedule stated, "Fixed riverbank transects will be selected during the winter or early spring 2014." We had anticipated being contacted about the transects during the winter or early spring; instead we have been asked to provide comments after having some key information for less than a week. As such, our comments included in this letter are "quick and dirty" given the allotted time. We would appreciate that the FirstLight Team honor stakeholder's good faith efforts to provide thoughtful comments by giving us more time in the future.

Purpose of Comments

FirstLight and its consultants have provided location information on calibration locations, representative locations, and detailed site assessment locations. We will focus our comments on calibration locations and representative locations, but have some comments on detailed site assessments because that information was also given to us.

A calibration location is defined as a detailed study site established at an existing, permanent transect where data collection will occur to calibrate the BSTEM model. The Selection of Study Sites Report proposes 17 calibration locations. Representative locations are defined as detailed study sites established throughout the impoundment at locations that exhibit a representative range of riverbank features, characteristics and erosion conditions. The Selection of Study Sites Report proposes 15 representative locations. Detailed site assessments were part of the Full River Reconnaissance (FRR), already completed but report due in September, and a 2-page description was prepared for each one along with a site sketch. There are 36 locations throughout the impoundment and they were selected based on how representative they were of features or characteristics present in that area (see p. 4-1 of June 2014 report).

Role of restored sites

FirstLight and its predecessors have restored many river segments between 1996 and 2013. Turners Falls Impoundment Restoration Sites Maps 1 through 5 were sent to us on June 27. I compared those sites against the Proposed Representative & Calibration Locations for Detailed Study in Figures 7-2 through 7-6 of the "Selection of Study Sites Report" to make the following table. Note: the Army Corps of Engineers has engaged in bank stabilization efforts using tires and rip-rap that are not noted on the maps.

Representative and transect calibration locations that are located on restored sites

Representative Locations	Transect Calibration Locations
90B: Upstream end of Shearer, Phase 1	9R: Campground Point, Phase 2
119B: Downstream end of Skalski, Phase 2	8B-R: Wallace/Watson, Phase 3
26: Urgiel upstream, Phase 2	6A-L: Skalski, Phase 2
10R: Urgiel upstream, Phase 2	6A-R: Flagg, Phase 1
29: Wickey, Phase 1	10R: Urgiel upstream, Phase 2
21: Kendall, Phase 2	5C-R: Bennett Meadow, Phase 2
2L: Bonnette Farm, preventative maintenance	3R: Kendall, Phase 2
	2L: Bonnette Farm, preventative maintenance

Observations: 7 of 15 representative locations and 8 of 17 calibration locations are located at previously restored sites. Given the purpose of the BSTEM model, it seems odd to have such a high number of altered states used as calibration locations.

Stakeholder Recommendations: See FRCOG comment letter.

Analyses of the information provided

In order to assess whether or not the representative locations and calibration locations are adequately representative of conditions out on the river, we looked at several different characteristics and tried to group the study sites into those categories to see if anything is missing or over-represented.

1. Riverbank features and characteristics.

Table 7-3 in the Selection of Detailed Studies Report shows a matrix of riverbank features and characteristics vs. the proposed representative locations for detailed study. Such a matrix was not completed for calibration locations, and I did not complete one using Table 7-2.

Observations: There is only one representative site with a low upper riverbank height and one that has a medium height. Looking at Table 7-2, it appears that all calibration sites have "heavy" or some "moderate" upper riverbank vegetation, but no sparse vegetation.

Stakeholder Recommendations: Consider changing the sites so that there is a more representative mix of upper riverbank heights and vegetation.

2. Land use

A.
We had asked for transect locations in relation to land use maps. For some reason, we were given a map showing the detailed site assessment locations used in the FRR on the land use maps, even though input is not being requested on those locations. I therefore eyeballed the Proposed Representative & Calibration Locations for Detailed Study in Figures 7-2 through 7-6, plus one change as presented in Powerpoint at the June 26 meeting, against the land use maps given to us. Below is a matrix of locations split by study locations similar in nature to Table 7-2 in the Selection of Study Sites Report.

Land Use	Boat-based represent. location	Land-based represent. location	Existing Transect calibration location	Existing transect calibration & representative location
Agriculture (possible additional category separations shown below, but not provided to us)	87B	29*, 21*	8B-L, 6A-R*, 3R*	8B-L, 7L. 10L, 4L, 2L*

Land Use	**Boat-based represent. location**	**Land-based represent . location**	**Existing Transect calibration location**	**Existing transect calibration & representativ e location**
Agriculture with un-tilled veg buffer Agriculture tilled to the edge Agriculture with a single line of trees along river Agriculture grazing land with veg buffer Agriculture grazing land w/cattle edge	?	?	?	?
Barren	(Not present in the study area)			
Developed				
Forest entire 500 ft swath		26*	9R*	10R*
Forest on an island			11I	6A-I
Forest with some developed land	12B,		6A-L*, 5C-R*, 11L	
Forest with some agriculture land	119B	18	7R, 3L	
Forest is narrow buffer near agriculture				
Forest with some transportation				
Forest with agriculture and transportation	75B			
Non-Forested Wetland	(Very little in study area and none along river's edge)			
Transportation (roads and bridge crossings)				

* Indicates a restored site.

Observations: 10R and 26 seem duplicative. In stakeholder and FirsLight meetings, there has been talk about whether or not the type of agriculture at the top of bank affects erosion (tilling to the edge vs. hayfields or a tree buffer), and FirstLight has only provided information on "agriculture." With more time, I might have been able to take a stab at splitting the agriculture types using MassGIS OLIVER coverages and Google Earth). Counting up the <u>representative locations</u>, there are 13 forested sites and 7agriculture sites. Forest with narrow buffer near agriculture is not well represented, whereas straight forest might be over-represented. Counting up the <u>calibration locations</u>, there are 8 agriculture sites and 9 forested sites.

<u>Stakeholder Recommendations</u>: Break down agriculture into more categories. Make sure that the sites with a narrow vs. wide forested buffers are adequately represented in the calibration sites and the representative sites. Representative locations may have too many forest sites and not enough agriculture sites – confirm, and if so, move a transect.

B.
Since we were sent the "Land Use & Detailed Site Assessments" maps 1-5 on June 27, I categorized the detailed site assessments in a similar way, as shown below.

Land Use	**Detailed Site Assessment Locations**
Agriculture (possible additional category separations shown below, but not provided to us)	6, 7 (restored or just downstream of restored), 25 (restored), 10, 11, 29 (restored), 21 (just downstream of restored), 19, 20
Agriculture with un-tilled vegetated buffer Agriculture tilled to the edge Agriculture with a single line of trees along river Agriculture grazing land with vegetated buffer Agriculture grazing land with cattle to the edge	?
Barren	(Not present in the study area)
Developed	
Forest entire 500 ft swath Forest on an island Forest with some developed land Forest with some agriculture land Forest is narrow buffer near agriculture Forest with some transportation Forest with agriculture and transportation	27, 26 (restored), 34, 2, 4, 3 (restored) 34, 33, 32, 28, 30 35, 24, 9, 14, 1 22 (restored), 12, 13, 36, 15, 16, 17, 18, 31 5 36
Non-Forested Wetland	(Very little in study area and none along river's edge)
Transportation	(Roads and bridge crossings)

Observations: No site assessments on developed land – land is often not developed right at the river's edge, but the section below the French King gorge has several parcels that fit into that category. There is perhaps an overabundance of forest with narrow buffer near agricultural land. Not sure if there is any hayfield agricultural land that was looked at. Forest on an island may be over-represented.

Stakeholder Recommendations: The FRR field work is already completed, but ideally there would have been some analysis of a site with developed land in the buffer, fewer sites on islands, and more agricultural sites that hadn't already been restored.

3. River Morphology

Rivers naturally erode and aggrade and change course over time, and natural erosion or sediment accumulation is one aspect of Study 3.1.2. In this analysis, we looked at sites in relation to river morphology. The 2007 Field report noted that there were areas that experienced erosion not explained by shear velocities. Appendix 4 to the Field Report contained a Hydraulic Analysis conducted by Woodlot in 2007. It would be useful to identify sites that experience erosion in unexpected places, such as point bars or banks subject to relatively low shear stress.

A.
I categorized sites using the Proposed Representative & Calibration Locations for Detailed Study, Figures 7-2 through 7-6 plus one change as presented in Powerpoint at the June 26 meeting.

River segment	Boat-based represent. location	Land-based represent. location	Existing Transect calibration location	Existing transect calibration & representative location
Inside bend			9R*, 11I	7L*, 4L
Outside bend	12B, 75B, 119B*		6A-L*, 11L	7R
Straight	90B*	26*, 29*, 21*, 18	8B-R*, 6A-R*, 10L, 5C-R*, 3R*, 3L	8B-L, 6A-I, 10R*, 2L*

* Indicates a restored site.

Observation: I categorized quickly, and some of the categorization choices may be debatable. Counting up the representative locations, there are 2 inside bends, 4 outside bends, and 9 straight runs. Counting up the calibration locations, there are 4 inside bends, 3 outside bends, and 10 straight runs.

Stakeholder Recommendations: We would like to see more inside bends at representative locations. Move 2 straight run representative locations to inside bend locations. Also, move 2 calibration locations to an inside bend and an outside bend location.

B.
I categorized sites for the detailed site assessment locations based on the "Land Use & Detailed Site Assessments" maps 1-5.

River morphology	Detailed Site Assessment Locations
Inside bend	27, 22, 11, 26 (restored), 12, 13, 21, 18, 31, 33
Outside bend	28, 35, 5, 10, 14, 15, 1, 2, 34, 30, 32
Straight	23, 24, 6, 7, 25, 9, 29 (restored), 36, 16, 17, 20, 19

Observations: Most of the outside bend sites are in that short segment between Vernon Dam and just downstream of Stebbins Island. Otherwise, outside bend sites are somewhat lacking.

Stakeholder Recommendations: The FRR field work is already completed, but ideally we would recommend moving 1-2 sites just below the Vernon Dam to other ouside-bend locations.

4. Hydraulic influences/geographic extent of fluctuation ranges

River fluctuation due to 1) the operation of the Vernon Dam and peaking facilities upstream, 2) the operation of the Turners Falls Dam, and 3) the operation of Northfield Mountain Pumped Storage are also causes of erosion in this section of the Connecticut River. We have not yet seen the results from the water level loggers in the river to truly understand where the river fluctuations vary, but we broke down the river into segments that we hypothesize might have different fluctuation ranges or heights. FirstLight's February 2013 "Hydraulic Modeling Assessment of the TF Impoundment" identified hydraulic break points at the French King Gorge and just below Stebbins Island near the Vernon Dam. The remaining breakpoints are based on stakeholder knowledge of the river and/or intuition.

A.
I categorized sites using the Proposed Representative & Calibration Locations for Detailed Study, Figures 7-2 through 7-6 plus one change as presented in Powerpoint at the June 26 meeting.

River segment	Boat-based represent. location	Land-based represent. location	Existing Transect calibration location	Existing transect calibration & representative location
Barton Cove to FK Gorge/Bridge	12B		9R*	
French King Gorge to Shearer	75B			
Shearer to Route 10 bridge	90B*, 119B*	26*	8B-R*, 6A-R*, 6A-L*, 10L, 5C-R*	8B-L, 7R, 7L, 6A-I, 10R*
Route 10 bridge to state line		29*		4L
State line to just below Stebbins Island		21*, 18	3R*, 3L	2L*
Stebbins Island to Vernon Dam			11I, 11L	

* Indicates a restored site.

Observation: Fluctuation from Northfield Mountain may be greatest near the tailrace, which is the segment between French King Gorge and Shearer. There is only one representative location (thanks to DEP's comments) and no transect calibration locations in this area. Most of the sites are from Shearer to Route 10 Bridge.

<u>Stakeholder Recommendations</u>: Move 5 representative and 5 transect calibration locations to other areas of the river.

B.
I categorized sites for the detailed site assessment locations based on the "Land Use & Detailed Site Assessments" maps 1-5.

River segment	Detailed Site Assessment Locations
Barton Cove to FK Gorge/Bridge	7, 28
French King Gorge to Shearer	22, 35, 5
Shearer to Route 10 bridge	23, 24, 6, 7, 25, 9, 26, 10, 11
Route 10 bridge to state line	12, 13, 29, 36, 14
State line to just below Stebbins Island	15, 21, 16, 17, 18, 19, 20, 1, 31
Stebbins Island to Vernon Dam	2,34, 4, 33, 30, 32, 3

Observations: Too many sites between state line and just below Stebbins Island. Lots of sites for teeny segment from Stebbins Island to Vernon Dam compared to other shorter segments. There are not enough sites in the two lowest segments.

Stakeholder Recommendations: The FRR field work is already completed, but ideally we would have recommended moving 3 sites between the Vernon Dam and the state line to the segments between Barton Cove and Shearer.

Other areas of comment

Section of river downstream of French King Gorge. At the June 24 meeting, we discussed at length the Selection of Detailed Study Sites page 6-4 where it states that the segment between the Turners Falls Dam and French King Gorge "is not of interest to the objectives of the study and therefore will not be investigated in detail." CRWC does not agree with the approach to largely leave this section out of Study 3.1.2.. The Lower Riverbank Sediment maps sent to us on June 27 indicate that the lower riverbank in the section of the Pool below French King Gorge is approximately 50% silt/sand composition rather than bedrock and rip rap. Also, there have been three phase 2 restoration projects in this section, and 6 preventative maintenance locations in this section. An unsolicited phone call to the CRWC came in this week from a person concerned about retreating riverbank in this segment. This section has different fluctuation patterns than the rest of the river and deserves to be included in the study, albeit perhaps with fewer sites and taking into account the higher frequency of bedrock.

Upper and lower riverbank. We have not had time to digest the memorandum sent to us on June 30, 2014 defining the upper and lower riverbank and will send comments under separate cover at a later date.

Thank you for the opportunity to provide input on the field sites used for this study.

Sincerely,

Andrea F. Donlon

Andrea F. Donlon
River Steward

Cc: Kimberly Noake MacPhee, FRCOG
Dave Foulis and Brian Harrington, MassDEP
Ken Hogan, FERC
Bill McDavitt, NOAA NMFS
Russ Cohen, MA Division of Ecological Restoration
CRSEC members: Tom Miner, Michael Bathory, John Bennett

Franklin Regional Council of Governments

MEMORANDUM

To:	John Howard, FirstLight Power Resources
From:	Kimberly Noake MacPhee, P.G. KNM
cc:	Ken Hogan, FERC Brian Harrington, MassDEP David Foulis, MassDEP
Date:	July 3, 2014
Re:	Relicensing Study 3.1.2 Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability: Selection of Detailed Study Sites June 2014

We appreciate the opportunity to provide comments on the above-referenced document. I will note for the record that I was severely constrained by FirstLight's request to receive comments by July 3, 2014, having just met with FirstLight on June 24, 2014 to discuss the report and then receiving the additional requested data from Gomez and Sullivan late in the evening on Friday, June 27, 2014. I received the FirstLight memo on the working definition of upper and lower riverbanks on June 30, 2014. This issue was discussed at the June 24th meeting. After we review and discuss the memo, I and the other stakeholders will provide our comments on FirstLight's working definition of upper and lower riverbanks in a separate letter.

My comments on the selection of detailed study sites focus on data gaps and suggestions for improving the report matrices that characterize riverbank features.

Table 6-1 Turners Falls Impoundment Riverbank Features/Characteristics Matrix

The report states that representative locations are defined as detailed study sites established throughout the impoundment at locations that exhibit a representative range of riverbank features, characteristics and erosion conditions as defined by Table 6-1.

Comment: The Features column of Table 6-1 is missing the following categories that are included in Table 2-1 Riverbank Classification Definitions.

- Sensitive Receptors
- Type(s) of Erosion
- Indicators of Potential Erosion
- Stage of Erosion

These missing categories should be added to Table 6-1.

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Table 7-3 Summary of Riverbank Features and Characteristics – Proposed Representative Locations for Detailed Study

Comment: The omission noted for Table 6-1 carries forward to Table 7-3, with the exception of the category of Stage of Erosion, which is included in Table 7-3. The missing categories and representative sites should be added to Table 7-3 to ensure that the selected locations for detailed study do in fact cover the range of riverbank features, characteristics and erosion conditions found in the impoundment.

Restored Sites

We identified at least 5 restored sites in Table 7-3: Transects 2L, 5CR, 7L, 8BR and 10R.

Comment: Restored sites should be added as a new category to the Features column of Table 7-3. Restored sites should not be used as sites that are representative of the unrestored river conditions. In order to adequately represent all features, characteristics and conditions found in the impoundment, new sites should be selected to replace the restored sites in the revised Table 7-3. We suggest that the age of the restoration and the major technique used in the restoration should be noted. See also comments of the Connecticut River Watershed Council (CRWC). CRWC identified 9 additional representative and calibration site locations that are restored sites.

Lower Riverbank Vegetation

The categories of Sparse, Moderate and Heavy are under-represented in Table 7-3. There is only 1 site in the Sparse category and no sites listed in the Moderate and Heavy categories.

Comment: Sites should be added to these categories. My review of the 38 Land Based Survey Site data sheets indicates 3 sites with Moderate lower river bank vegetation and 4with Sparse bank vegetation. We were not given the 2013 FRR data but there are likely to be more sites in that data set that could be used to fill in the Sparse, Moderate and possibly Heavy lower riverbank vegetation categories. Vegetation on the beach (what FirstLight calls the lower riverbank) stabilizes the toe of slope of the riverbank by dissipating boat wave energy, reducing the erosive effects of pool fluctuations and trapping sediment from high flow events, which encourages the establishment of more vegetation.

Hydraulic Influences and the Geographic Extent of Water Level Fluctuation Ranges

Table 7-3 does not include a category for hydraulic forces acting on the bank:

- shear stress, flow direction, and flow velocity at different flow events and
- water level fluctuations due to the operation of Northfield Mountain Pumped Storage Project

The July 2007 Connecticut River Hydraulic Analysis: Vernon Dam to Turners Falls Dam conducted by Woodlot Alternatives, Inc. for FirstLight predicted surface elevations, flow direction, flow velocity, and shear velocity along the river for 4 different flow recurrence interval events: 1.05, 2, 10, and 100 year events. The hydraulic modeling results were compared with the location of bank erosion mapped in 2004 (NEE, 2005) and interestingly, while erosion does occur where high flow velocities and shear stresses approach near the bank, there were also significant amounts of erosion occurring where flow velocities near the bank are low. Field (2007) recommended that further comparisons of the hydraulic modeling and future erosion mapping might reveal relationships between the intensity of flow along the banks and the type and rate of erosion.

Comment: Table 7-3 should include Hydraulic Forces in the Features column. Existing data and analysis from the 2007 Field study, the July 2007 Woodlot study and FirstLight's Hydraulic Modeling Assessment of the Turners Falls Impoundment (2013) should be compared to the 2013 Land and Boat Based Survey data. Representative and calibration sites should be located in areas where 1) erosion is occurring that is not predicted or is inconsistent with the results of the previous hydraulic modeling and the 2013 field investigations, and 2) where erosion is occurring in areas of high velocity and shear stress as indicated by the hydraulic modeling and the 2013 field investigations. For example, previous studies, including (Field 2007), have documented considerable erosion on the inside of meander bends and other areas of the river where flood flow velocities are low. Erosion has also been observed on both banks simultaneously along straight reaches of the river.

Table 7 of the Turners Falls Pool Fluvial Geomorphology Study (Field 2007) identified six causes of erosion and listed observations both consistent and inconsistent with the causes of erosion. We have an opportunity to gather data to help evaluate the observations listed in Table 7, which were based on a review of historic data, hydraulic modeling and other field work. Many of the causes of erosion listed in Table 7 are the same ones FirstLight is interested in evaluating as part of Study 3.1.2.

The Hydraulic Forces category should also include sites that represent the geographic extent and magnitude of the water level elevation fluctuations in the river that are due to the operation of the Northfield Mountain Pumped Storage Project. FirstLight has the data on pool elevations.

In a meeting with other stakeholders, we discussed dividing the river into hydraulic segments or areas of influence (see the following table). We do not have historic water level logger data nor have we seen recent data gathered by FirstLight so these segments are our best estimates. FirstLight should identify segments based on their hydraulic modeling data and water level logger data.

River Segments as Identified by Stakeholders	2013 Boat Based Representative Location	2013 Land Based Representative Location	Existing Transect Calibration Location	Existing Transect Calibration & Representative Location
Barton Cove to FK Gorge/Bridge	12B		~~*9R*~~	
French King Gorge to Shearer	75B, 87B	24, 35,5		8A
Shearer to Route 10 bridge	~~*90B, 119B*~~	~~*26*~~, 10, 11	~~*8B-R*~~, ~~*6A-R, 6A-L,*~~ 10L, ~~*5C-R*~~	8B-L, 7R, ~~*7L,*~~ 6A-I, ~~*10R*~~
Route 10 bridge to state line		~~*29*~~		4L
State line to just below Stebbins Island		~~*21,*~~ 18	~~*3R,*~~ 3L	~~*2L*~~
Stebbins Island to Vernon Dam		2, 34, 4, 30, 33	11I, 11L	

Note: This table includes all sites proposed by FirstLight, including the 5 restored sites 2L, 5CR, 7L, 8BR and 10R identified by FRCOG. The Connecticut River Watershed Council (CRWC) identified 9 additional restored sites: 119B, 90B, 9R, 6A-L, 6A-R, 3R, 26, 29 and 21. We have indicated that all 14 of these sites should not be used as representative sites and possibly not as calibration sites by italicizing and crossing out these sites. Please refer to our comments about restored sites and the comment letter prepared by CRWC July 3, 2014.

As shown in the above matrix of river segments, significant gaps exist for representative sites for the river segments in the proposed Hydraulic Forces category. These gaps are highlighted in blue. Additional sites should be selected to fill these gaps and even the distribution of sites among categories. We have suggested sites from the 2013 Land Based Survey data sheets, which are shown in red font. We do not have the 2013 Full River Reconnaissance data so are unable to suggest sites from that data set. We recommend that Boat Based site 87B be included.

River Morphology

As discussed above, there are areas of the river that are eroding that can't be explained by shear velocities and high flow velocities. For example, areas that should be aggrading, like point bars on the inside bend of the river, are eroding.

Comment: The stakeholders compiled a matrix of FirstLight's proposed representative and calibration sites and their locations at an Inside Bend, Outside Bend or Straight Reach. The distribution of these sites should be more even and gaps should be filled. There are plenty of Land-Based Survey locations that could be used to fill these gaps and even the distribution among the morphology types (see last table).

Representative River Morphology Segment	Boat Based Representative Location	Land Based Representative Location	Existing Transect Calibration Location	Existing Transect Calibration & Representative Location
Inside bend			~~*9R*~~, 11I	~~*7L*~~, 4L
Outside bend	12B, 75B, ~~*119B*~~		~~*6A-L*~~, 11L	7R
Straight reach	~~*90B*~~	~~*26, 29, 21*~~, 18	~~*8B-R*~~, ~~*6A-R*~~, 10L, ~~*5C-R*~~, ~~*3R*~~, 3L,	8B-L, 6A-I, ~~*10R*~~, ~~*2L*~~

Note: This table includes all sites proposed by FirstLight, including the 5 restored sites 2L, 5CR, 7L, 8BR and 10R identified by FRCOG. The Connecticut River Watershed Council (CRWC) identified 9 additional restored sites: 119B, 90B, 9R, 6A-L, 6A-R, 3R, 26, 29 and 21. We have indicated that all 14 of these sites should not be used as representative sites and possibly not as calibration sites by italicizing and crossing out these sites. Please refer to our comments about restored sites and the comment letter prepared by CRWC July 3, 2014.

River Morphology Segment	2013 Detailed Land Based Survey Locations
Inside bend	27, 22, 11, 26 (restored), 12, 13, 21, 18, 31, 33
Outside bend	28, 35, 5, 10, 14, 15, 1, 2, 34, 30, 32
Straight	23, 24, 6, 7, 25, 9, 29 (restored), 36, 16, 17, 20, 19

If you have any questions or need further clarification of the comments we've provided, please do not hesitate to contact me at 413.774.3167 x130 or kmacphee@frcog.org.

MassDEP

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Northfield Mountain Station
99 Millers Falls Road
Northfield, MA 01360

July 15, 2014

Re: Stakeholder Comment – Transect & Detailed Study Sites for Study 3.1.2

Dear Mr. Howard:

The Massachusetts Department of Environmental Protection (MassDEP) has reviewed the July 3, 2014 comments of both the Connecticut River Watershed Council (CRWC) and the Franklin Regional Council of Governments (FRCOG). MassDEP attended the June 24, 2014 presentation to stakeholders (including CRWC and FRCOG) and has had subsequent discussions with those stakeholders. In those discussions, MassDEP explained its approach to the studies and review of proposed sites and advised the stakeholders that it would consider the stakeholders comments and where consistent with MassDEP's approach, support those requests.

MassDEP acknowledges that the stakeholders' time to review was limited and MassDEP has likewise made a limited review of those comments in an effort to provide comments as quickly as possible due to the plan to start field work in early July. In an effort to advance the process, MassDEP held of conference call with CRWC, FRCOG and others to explain its approach and encourage the stakeholders to keep the MassDEP's approach in mind as the stakeholders made comments in the hope that those comments would be consistent with the approach in place and result in comments designed to improve the results from the approach in place, which it appears they have done.

Each of First Light, MassDEP and the stakeholders is interested in ensuring that the information being gathered at this time is being gathered at sites that are scientifically representative and designed to gather information that will improve all parties' understanding of the effects of the operation of the pump storage facility. Ultimately this data will be useful in guiding the permitting and operation of the facility as well as any future projects including bank stabilization projects. For MassDEP it is hoped that the information gathered for the FERC Relicensing process will inform the decisions on the anticipated Water Quality Certification and reduce the need gather additional information for that permit.

This letter does not recommend the addition or elimination of any specific site – although the stakeholder letters do make some specific suggestions. This letter does, however, note concerns identified by stakeholders that should be considered by First Light in determining whether the proposed study sites are sufficiently representative and will provide sufficient and scientifically valuable information. While raised as part of the FERC Site Selection Process, the same questions are likely to be raised during the Water Quality Certification Process and First Light's review of the stakeholder comments should be considered in that light as well.

1. Inclusion of stabilized sites.

The inclusion of stabilized sites makes sense as those sites often have additional historic data and further study will allow an analysis of the effectiveness of the various stabilization projects. Further, a sufficient sample of those sites to allow for the variation in stabilization methods, soils, nearby activities and other elements to be analyzed is also appropriate.

Conversely, a sufficient sample of sites that have not been stabilized is also necessary as most of the riverbank has not been stabilized and the sample size should be sufficient to reflect natural bank and the various parameters such as soils, banks, inner/out bends, straight areas, areas with various stages of erosion, lack of erosion, sediment deposition and loss.

First Light should evaluate whether the selected sites are sufficiently representative in light of the concerns raised with respect to the number of stabilized sites, in comparison to non-stabilized sites; including whether it will have an effect on the BSTEM model.

2. Land Use

The CRWC comments ask that more agricultural sites be looked at in place of forested sites and that the analysis include more information on the specific agricultural activities, including narrow vs. wide buffers. The comments note that the calibration sites appear relatively equal in distribution between forested and agricultural areas, while the representative locations have almost twice as many forested sites as agricultural sites.

The Department has focused on the part of the comment specifically concerned with the width of buffers and type of agriculture as important information. The Department believes that the land based site specific work will (and should) provide detailed information on the use at each site, such as; width of buffer, type/intensity of agriculture, soils information, animal presence/grazing information, etc… . What is critical is that the pool of sample sites be sufficiently representative to capture these various differences. First Light should review the selected agricultural sites to ensure that the sample is sufficiently broad to capture the various buffer widths and various agricultural activities along the river. In addition, it should be sure that the land based work includes the information identified by the stakeholders in their comments.

3. River Morphology

The site selection process included both a boat survey of the entire river as well as a land based survey/walk. As explained by First Light in its presentation, where areas of interest were observed in the boat based survey, the site was identified, the boat generally taken to shore for closer examination and the site noted for the land based reconnaissance team.

The stakeholders request that First Light look at areas where there is unexpected activity such as erosion in unexpected places. One example would be the addition of inside bends in areas that are identified as experiencing unanticipated erosion may also provide valuable information. The comments also suggest that areas with bends are likely to provide more useful information than straight sections of the river.

One would expect that some of the sites that the boat based survey identified as areas of interest would be those where the river is acting in ways other than one would normally expect. As such First Light may have already identified some sites that meet these requirements and should consider whether substitution or addition of sites meeting these criteria is appropriate.

4. Hydraulic Influences / Geographic Extent of Fluctuation Ranges

The stakeholder comments reiterate the concern expressed at the recent meeting with First Light that the sites are concentrated in the upper reaches of the impoundment and too few are located in the lower segments of the River. First Lights selection approach intentionally avoids locating transects in areas where bedrock is located because it will not offer substantial information on erosion. While this approach reduces the areas available for study in the lower reaches, it still leaves opportunities to locate study sites in the lower area.

In addition, while the Turners Falls Dam has more control over water levels in this area than First Light, moving detailed study sites downstream to this reach would still be consistent with the approach that the effects of the increase and decrease of the water level are to be studied and can then be extrapolated to other sites upstream with similar features. Given CRWC's comments that the lower river bank is 0% silt/sand based upon First Light's maps, the area should offer some locations at which First Light can gather valuable data.

5. Selection Criteria / Site Characteristics

The CRWC comments identify a lack of sites featuring "low and medium height banks" and "sparse vegetation". The request is that banks offering these features be added, given the greater prevalence of sites with "heavy" or "moderate" vegetation and sites with a "high" upper riverbank height.

This request stays within the characteristics by which First Light has characterized sites. First Light should determine whether there are sites that would provide a broader representation of these characteristics and consider adding or substituting sites as appropriate as it would seem likely to result in additional information that would be beneficial.

Conclusion

Although MassDEP has not identified specific sites for addition, deletion or substitution; the stakeholder comments merit consideration and likely the addition or substitution of some sites; whether calibration sites, representative sites or detailed site assessment locations. It is most appropriate for First Light to review these comments and determine which merit site revisions and then identify and propose the sites that it would add, delete or substitute for Department and stakeholder comment.

I thank you for your consideration of MassDEP's comments and the comments of the stakeholders that have worked diligently to review First Light's plan and to provide timely feedback.

Respectfully,

Brian D. Harrington
Deputy Regional Director
Bureau of Resource Protection

Cc:

Kimberly Noake MacPhee, P.G., FCROG (KMacPhee@frcog.org)
Andrea Donlan, River Steward, CRWC (adonlon@ctriver.org)
Robert Kubit, Dave Foulis and Robert McCollum, MassDEP
Ken Hogan, FERC
Bill McDavitt, NOAA NMFS
Russ Cohen, MA Division of Ecological Restoration (russ.cohen@state.ma.us)

July 23, 2014

VIA EMAIL

Andrea Donlon, CT River Watershed Council
Kimberly Noake MacPhee, Franklin Regional Council of Governments

Re: FirstLight, Relicensing of the Turners Falls Hydroelectric Project (FERC No. 1889) and Northfield Mountain Pumped Storage Project (FERC No. 2485), Study No. 3.1.2- *Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability*

Dear All,

FirstLight Hydro Generating Company (FirstLight) is currently in the process of relicensing its Turners Falls Hydroelectric Project (FERC No. 1889) and Northfield Mountain Pumped Storage Project (FERC No. 2485) with the Federal Energy Regulatory Commission (FERC). As part of the relicensing process FirstLight is required to conduct Study No. 3.1.2 – *Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability* in accordance with the Revised Study Plan (RSP) and Study Plan Determination Letter (SPDL). As part of the SPDL FirstLight is required to consult with Stakeholders regarding the selection of detailed study sites associated with this study.

On June 24, 2014 FirstLight met with Stakeholders to review the proposed detailed study sites as outlined in the Selection of Detailed Study Sites Report distributed June 6, 2014. At the conclusion of this meeting FirstLight requested that Stakeholders file any comments no later than July 3, 2014 due to the impending field schedule. Comment letters were received from the MA Department of Environmental Protection (MADEP), Franklin Regional Council of Governments (FRCOG), and the Connecticut River Watershed Council (CRWC).

FirstLight has reviewed the letters received to date and has developed the enclosed responsiveness table and associated attachments in response to these comments. Stakeholders raised several concerns about the representativeness of the proposed sites. Concerns were specifically raised in regard to a lack of sites in the vicinity of the Northfield Mountain tailrace and in or near Barton Cove. To address these concerns FirstLight is recommending the addition of sites BC-1R and 87B as well as 303B. Site BC-1R is located on the peninsula entering Barton Cove while Site 87B is located just upstream of the Northfield Mountain tailrace. Site 303B is located downstream of the Ashuelot River confluence and satisfies specific riverbank characteristics requested by the Stakeholders. As explained in the attached documents these

John S. Howard
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sites will replace Sites 11I, 6A-I, and 90B. More information on this and other Stakeholder concerns can be found in the enclosed documents.

FirstLight will be hosting a Stakeholder meeting on August 4, 2014 at 9:15 AM in the Northfield Mountain Visitors Center to review the enclosed response and to finalize the location of the detailed study sites. In the meantime upon review of the enclosed documents if you have any questions please feel free to contact me at (413) 659-4489 or john.howard@gdfsuezna.com.

Sincerely,

John Howard

Cc: Ken Hogan, FERC (via email)
Brian Harrington, MADEP
Bob McCollum, MADEP
Bob Kubit, MADEP
David Foulis, MADEP
Tom Miner, CRSEC
Russ Cohen, CRSEC
John Bennett, FCD
Mike Bathory, LCCLC
Bill McDavitt, NMFS
Bob Simons, Simons & Associates
Mark Wamser, Gomez and Sullivan
Tom Sullivan, Gomez and Sullivan
Tim Sullivan, Gomez and Sullivan
Adam Kahn, Foley Hoag
Mike Swiger, Van Ness Feldman
Julia Wood, Van Ness Feldman

Attachment: Responsiveness Table
Attachments A-D

Agency/Stakeholder Comments and FirstLight's Response

LINE	COMMENT	STAKEHOLDER	FIRSTLIGHT RESPONSE
1	Role of Restored Sites: 7 of 15 representative locations and 8 of 17 calibration locations are located at previously restored sites. Given the purpose of the BSTEM model, it seems odd to have such a high number of altered states used as calibration locations.	CRWC	BSTEM can only be calibrated at locations where historic survey data exists. Calibration data will be derived from a subset of the 21 existing, permanent transects located throughout the Impoundment. These locations were established in 1998 and have been surveyed annually over the past 16+ years. The data collected at these sites will be used to calibrate the model at those specific locations. Of the 21 existing transects 11 were selected as 'Calibration' or 'Calibration and Representative' sites (18 detailed study points). The 10 remaining transects were eliminated from consideration for various reasons (see Selection of Detailed Study Sites Report - Appendix C for discussion). Although 7 of the 25 detailed study sites have been altered as of 2013 through implementation of the Erosion Control Plan (ECP) those sites are still useful for BSTEM. Riverbank input parameters used to calibrate BSTEM will utilize 1998 riverbank features and characteristics as observed during the 1998 FRR. Baseline calibration model runs will examine the riverbanks as they were pre-restoration up until they were restored, which occurred at various times during the study period. In the event that a study site was not restored the model will be calibrated at that location from 2000 through 2013. As such, 2013 riverbank features and characteristics (including whether a site has been restored or not), although important, is one small piece of a much larger investigation. The ability to execute multiple model runs using various time periods (e.g., 1998 vs. 2013) and input parameters (e.g., 1998 vs. 2013 riverbank conditions) allows for an investigation of how riverbank geometries have changed over time at a given location. Attachment A contains further discussion pertaining to BSTEM calibration and the role of restored sites.
2	Riverbank features and characteristics: There is only one representative site with a 'Low' Upper Riverbank Height and one that has a 'Medium' height. Looking at Table 7-2, it appears that all calibration sites have "heavy" or some "moderate" Upper Riverbank Vegetation, but no 'sparse' vegetation. Consider changing the sites so that there is a more representative mix of Upper Riverbank Heights and Vegetation's.	CRWC	• Upper riverbanks with a 'Low' height classification are not areas where active erosion is likely to occur or the potential for future erosion is high (as indicated by the yellow highlighted characteristics in Table 7-3). This particular riverbank characteristic is generally less susceptible to erosion because the roots of the vegetation extend through a greater portion of the bank height providing greater stability. As a causation study by its nature investigates the causes of erosion these types of potential study locations are not pertinent. • Site 303B has been added to provide a second site with a 'Medium' upper riverbank height. Based on field observations, the differences in erosion processes at a 'High' vs. 'Medium' upper riverbank are minimal. As such, it does not seem prudent to expend resources adding additional sites at locations with 'Medium' upper riverbank heights. The current distribution of detailed study sites, including the newly added 303B, will adequately satisfy the objectives of this study including investigating any differences between sites with "Medium' and 'High' upper riverbanks. • While 'Sparse' upper riverbank vegetation is rare in the Impoundment today, this particular condition existed at multiple calibration locations in 1998. Given that BSTEM will be executed over various time periods (extending back to 1998 conditions) using various input parameters, 'Sparse' vegetation conditions will be examined during BSTEM model runs.

LINE	COMMENT	STAKEHOLDER	FIRSTLIGHT RESPONSE
3	Land Use: 10R and 26 seem duplicative. In stakeholder and FirstLight meetings, there has been talk about whether or not the type of agriculture at the top of bank affects erosion (tilling to the edge vs. hayfields or a tree buffer), and FirstLight has only provided information on "agriculture." Counting up the representative locations there are 13 forested sites and 7 agriculture sites. Forest with narrow buffer near agriculture is not well represented, whereas straight forest might be over represented. Counting up the calibration locations, there are 8 agriculture sites and 9 forested sites. Break down agriculture into more categories. Make sure that the sites with a narrow vs. wide forested buffers are adequately represented in the calibration sites and the representative sites. Representative locations may have too many forest sites and not enough agriculture sites – confirm, and if so, move a transect.	CRWC	• Land-use field investigations were conducted as part of the 2013 FRR land-based survey. Information including: land-use classification, width of riparian buffer, adjacent agricultural use/practices (e.g., row crops vs. pasture), grazing land, and irrigation practices were collected at that time. Maps depicting this information will be provided in the 2013 FRR report. Correlations between these land-use activities and riverbank erosion processes will be examined using various GIS spatial analyses as part of Study No. 3.1.2. • There are several areas where detailed study sites create a "complex." These complexes provide an opportunity to study the response of riverbanks with a wide variety of features and characteristics under similar hydraulic conditions since they are located in close proximity. Sites 10R, 10L, and 26 are examples of a complex. See Attachment B for further discussion on complexes. • The proposed detailed study sites include a range of land-use types and riparian zone widths. Approximately 50% of the land-use mapped throughout the Impoundment is classified as 'Forested' while 35% is classified as 'Agriculture.' As such, FirstLight believes the current distribution of sites between 'Forested' and 'Agriculture' is appropriate for the purpose of this study.
4	River Morphology: Counting up the representative locations, there are 2 inside bends, 4 outside bends, and 9 straight runs. Counting up the calibration locations, there are 4 inside bends, 3 outside bends, and 10 straight runs. We would like to see more inside bends at representative locations. Move 2 straight run representative locations to inside bend locations. Also, move 2 calibration locations to an inside bend and an outside bend location.	CRWC	• Compared to many other rivers, the Impoundment is fairly straight with a relatively shorter portion consisting of bends. The summary of detailed study sites shows that 60% are in straight reaches, 16% are on an inside bend, and 16% on an outside bend (the remaining 8% are located in unique geomorphic locations (e.g., wide river sections or peninsulas)). This distribution seems to reasonably represent the Impoundment without additional shifting of sites. FirstLight believes the current distribution of detailed study sites between straight reaches, inside bends, and outside bends is appropriate and will adequately examine erosion processes at different geomorphic locations. • In regard to relocating calibration sites, as explained in the response to Line 1, we are relatively limited in our ability to move calibration locations.

LINE	COMMENT	STAKEHOLDER	FIRSTLIGHT RESPONSE
5	<u>Hydraulic Influences/Geographic Extent of Water Level Fluctuations</u>: Fluctuation from Northfield Mountain may be greatest near the tailrace, which is the segment between French King Gorge and Shearer. There is only one representative location and no transect calibration locations in this area. Most of the sites are from Shearer to Route 10 Bridge. Move 5 representative sites and 5 transect calibration locations to other areas of the river.	CRWC	• In order to respond to Stakeholders concerns, while still maintaining a balanced approach that uses as many existing, permanent transects as possible, FirstLight proposes adding two new representative sites and 1 representative/calibration site in lieu of three others that were previously proposed. These sites include: o BC-1R – located on peninsula at entrance to Barton Cove o 87B – located directly upstream of the Northfield Mountain tailrace o 303B – located at the Ashuelot River confluence • The new sites will replace: o 6A-I – located on Kidds Island. Proposed to be deleted because it has a 'Low' upper riverbank height, sites on islands are, in general, of less interest than riverbank sites, and Stakeholders raised concerns about the number of sites proposed in this reach. o 11-I – located on Stebbins Island. Proposed to be deleted because it is located on an island and is in the upstream end of the Impoundment. Stakeholders indicated a desire to utilize resources in the vicinity of the Northfield Mountain tailrace and Barton Cove. o 90B – located just downstream of existing transect 8. Proposed to be deleted because it is duplicative of Site 8B-L. In addition, 90B is one of the sites FRCOG recommended removing. By swapping out these sites FirstLight will be able to accomplish the objectives of the study on schedule and within the budget while accommodating the Stakeholders request for greater coverage in the French King Gorge to Shearer and Barton Cove to French King Gorge reaches. The need to use existing, permanent transects (and the substantial information associated with them) limits the ability to make wholesale changes in transect locations. • For more information on these sites (including updated maps, photos, and riverbank characteristics) refer to Attachment C
6	<u>Downstream French King Gorge</u>: Lower riverbank sediment in this area is approximately 50% silt/sand composition rather than bedrock and rip rap. This section has different fluctuation patterns than the rest of the river and deserves to be included in the study, albeit perhaps with fewer sites and taking into account the higher frequency of bedrock.	CRWC	Site BC-1R has been added to respond to this comment. See comments above (Line 5) and Attachment C.
7	<u>Detailed Site Assessments</u>: Multiple comments were made in regard to the locations of the detailed site assessments.	CRWC	Detailed site assessments were collected during the 2013 FRR land-based survey; they were not required by the FRR or Study 3.1.2 but were conducted to supplement the FRR. These assessments were collected in areas of geomorphic and geotechnical interest as noted by the geotechnical engineer and fluvial geomorphologist based on their field observations. These were not intended to be evenly distributed throughout the Impoundment or representative of all Impoundment conditions. They were based on specific features/locations of interest as observed in the field. None the less, stakeholder recommendations for additional assessments will be reviewed by the fluvial geomorphologist and geotechnical engineer. If it is found that these recommendations add value to Study No. 3.1.1 additional assessments will be conducted during summer 2014 and included in the 2013 FRR report.

LINE	COMMENT	STAKEHOLDER	FIRSTLIGHT RESPONSE
8	Table 6-1: The Features column of Table 6-1 is missing the following categories that are included in Table 2-1 Riverbank Classification Definitions. • Sensitive Receptors • Type(s) of Erosion • Indicators of Potential Erosion • Stage of Erosion These missing categories should be added to Table 6-1	FRCOG	Table 6-1 is RSP Table 3.1.2-2. Even though these categories were not specifically included in Table 6-1 they were evaluated (except for Sensitive Receptors) when determining the representativeness of the proposed sites (as noted in the Selection of Detailed Study Sites report – Table 7-2). Sensitive Receptors were not considered in determining the representativeness of proposed sites. This information was collected as part of the FRR and goes more to the applicability of remediation then to causation.
9	Table 7-3: The omission notes for Table 6-1 carries forward to Table 7-3. The missing categories and representative sites should be added to Table 7-3.	FRCOG	• Type(s) of Erosion and Indicators of Potential Erosion are currently included in Table 7-2. These columns will be added to Table 7-3 for the final draft of the Selection of Detailed Study Sites Report. The final site selection report will be included as an attachment to Study No. 3.1.2's Initial Study Report (ISR) which is due to FERC in September. • Stage of Erosion is already included in Table 7-3 as noted in FRCOG's letter • Sensitive Receptors will not be added to Table 7-3 as they are not relevant to the objectives of Study No. 3.1.2 – see comment above (Line 8).

10	Restored Sites: Restored sites should be added as a new category to the Features column of Table 7-3. Restored sites should not be used as sites that are representative of the unrestored river conditions. In order to adequately represent all features, characteristics, and conditions found in the Impoundment, new sites should be selected to replace the restored sites in the revised Table 7-3. The age of the restoration and the major technique used in the restoration should be noted.	FRCOG	• A table summarizing the status (i.e., if a site has or has not been restored) and age of restoration as well as the major technique used at each detailed study site (if applicable) is included in Attachment D.
			• The use of restored sites is appropriate due to the fact that BSTEM can be run over various time periods (e.g., 1998 vs. 2013) using various input parameters (1998 vs. 2013 features and characteristics). The ability of BSTEM to examine changes in riverbank geometry over time will be used to examine riverbanks pre- and post-restoration if desired. 2013 riverbank conditions (including whether a site has been previously restored or not), although important, are one small piece of a larger investigation. Additional information pertaining to the appropriateness of using restored sites is included in Attachment A.
			• FRCOG and CRWC noted the following detailed study sites as being in areas that have been restored:
			  ○ 9R, 90B, 119B, 26, 8B-R, 6A-R, 6A-L, 5C-R, 7L, 10R, 29, 21, 3R, 2L
			• However, as noted below and in Attachment D:
			  ○ 9R, 8B-R, 6A-R, 6A-L, 10R, 3R, and 2L are sites that have been previously restored
			  ○ 90B, 119B, 26, 5C-R, 7L, 29, and 21 have not been restored but are instead located several hundred feet upstream or downstream of a restored site.

11	Lower Riverbank Vegetation: The categories of Sparse, Moderate, and Heavy are under-represented in Table 7-3. Sites should be added to these categories.	FRCOG	• A detailed study site was added with 'Heavy' lower riverbank vegetation and 'Medium' upper riverbank height (Site 303B) • In addition, there are several locations where significant densities of lower riverbank vegetation are growing that are currently being monitored at restored sites. This level of monitoring will qualitatively add to understanding the effect of lower riverbank vegetation on riverbank stability.

LINE	COMMENT	STAKEHOLDER	FIRSTLIGHT RESPONSE
12	Hydraulic Influences and Geographic Extent of Water Level Fluctuations: Table 7-3 should include Hydraulic Forces in the Features column.	FRCOG	Table 7-3 was developed to evaluate how representative a proposed site's riverbank features and characteristics were. The emphasis being on the physical features and characteristics of the actual riverbank itself and not the forces acting upon the bank. Table 7-3 was never intended to evaluate hydraulic forces or any other forces or potential causes of erosion; it was designed to strictly evaluate features and characteristics. The evaluation of hydraulic influences and the geographic extent of water level fluctuations were conducted in Step 4 of the site selection methodology (as discussed in the Selection of Detailed Study Sites report – Appendix C). As determined in this evaluation, the proposed set of detailed study locations, combined with the newly proposed sites, adequately represents the range of hydraulic influences found throughout the Impoundment.
13	Hydraulic Influences and Geographic Extent of Water Level Fluctuations: Existing data and analysis from the 2007 Field study, the July 2007 Woodlot study, and FirstLight's Hydraulic Modeling Assessment should be compared to the 2013 FRR data. Representative and calibration sites should be located in areas where 1) erosion is occurring that is not predicted or is inconsistent with the results of the previous hydraulic modeling and 2013 field investigations, and 2) where erosion is occurring in areas of high velocity and shear stress.	FRCOG	Hydraulic data analyses and modeling both independent of BSTEM as well as within BSTEM are an important component of understanding the range of forces causing erosion. Once the required field data has been collected various analyses will be conducted/modeled which will examine the forces associated with the hydraulic influences at a given location. By having a set of detailed study sites that are representative of the hydraulic and geomorphic conditions found throughout the study area FirstLight will be able to examine the varying hydraulic forces associated with flowing water, water level fluctuations, boat waves, etc. at each location. FirstLight believes the detailed study sites, combined with the new sites proposed in this table, are balanced and representative of the hydraulic conditions found throughout the Impoundment. The GIS spatial analysis used to determine if sites are balanced (Step 4 of the site selection methodology) is adequate for the purpose of site selection. The data analyses proposed by FRCOG are premature at this point in the study and not necessary for the selection of detailed study sites. This level of analysis will occur once field efforts have been completed using all available data.
14	Hydraulic Influences and Geographic Extent of Water Level Fluctuations: The hydraulic forces category should also include sites that represent the geographic extent and magnitude of the water level elevation fluctuations in the river that are due to the operation of Northfield Mountain.	FRCOG	See comments in Line 12
15	Hydraulic Influences and Geographic Extent of Water Level Fluctuations: The river should be divided into hydraulic segments or areas of influence. FirstLight should identify segments based on their hydraulic modeling data and water level data. Potential segments would include: • Barton Cove to FK Gorge/Bridge • French King Gorge to Shearer • Shearer to Route 10 Bridge • Route 10 Bridge to Stateline • Stateline to below Stebbins Island • Stebbins Island to Vernon Dam	FRCOG	This level of analysis was conducted during Step 4 of the site selection methodology as discussed in the Selection of Detailed Study Sites report. FirstLight believes the geographic distribution of the proposed transects, combined with the new sites proposed in this table, is appropriate and accomplishes the goal of looking at different segments of the Impoundment.

LINE	COMMENT	STAKEHOLDER	FIRSTLIGHT RESPONSE
16	<u>Hydraulic Influences and Geographic Extent of Water Level Fluctuations</u>: FRCOG made the following specific site recommendations: • Barton Cove to FK Gorge/Bridge – *Remove site 9R* • French King Gorge to Shearer – *Add sites: 87B, 24, 35, 5* • Shearer to Route 10 Bridge – *Remove 90B, 119B, 26, 8B-R, 6A-R, 6A-L, 5C-R, 7L, 10R and replace with 10, 11* • Route 10 Bridge to Stateline – *Remove 29* • Stateline to below Stebbins Island – *Remove 21, 3R, 2L* • Stebbins Island to Vernon Dam – *Add 2, 34, 4, 30, 33*	FRCOG	• Site 87B has been added to increase coverage in the French King Gorge to Shearer reach as requested by the Stakeholders. • Site BC-1R has been added to increase coverage in the Barton Cove to French King Gorge reach • Site 11I has been removed to focus resources in the vicinity of the Northfield Mountain tailrace and Barton Cove as opposed to near Vernon. • A number of locations cited in the comment letter as having been restored (and therefore being recommended for removal) have not actually been restored (see response in Line 10). These sites include: 90B, 119B, 26, 5C-R, 7L, 29, and 21. Although 7 out of 25 potential locations have experienced some form of restoration these sites are still useful for BSTEM. Due to the fact that BSTEM can be run over various time periods (e.g., 1998 vs. 2013) using various input parameters (1998 vs. 2013 features and characteristics) changes in riverbank geometry can be examined in detail pre- and post-restoration. 2013 riverbank conditions (including whether a site has been previously restored), although important, are one small piece of a larger investigation. Additional information pertaining to the appropriateness of using restored sites is included in Attachment A. • FRCOG raised concerns about the number of sites proposed in the Shearer to Route 10 Bridge reach. 6A-I and 90B are recommended for deletion to provide two less sites in this reach. • FRCOG recommends adding 5 representative sites in the Stebbins Island to Vernon reach. Adding these sites would bring the total number of sites in this area to 6 (assuming 11I is removed). In order to stay within the allotted 25 total detailed study sites (to stay within budget and on schedule) accommodating this request would require swapping out 5 other sites from areas of greater interest. In addition, it would reduce the number of calibration locations found throughout the study area. • Additional information pertaining to the newly proposed sites can be found in Attachment C.
17	<u>Hydraulic Influences and Geographic Extent of Water Level Fluctuations</u>: As shown in FRCOG's matrix significant gaps exist for representative sites for the river segments in the proposed Hydraulic Forces category. Additional sites should be selected to fill these gaps and even the distribution of sites among categories.	FRCOG	Step 4 of the site selection methodology (as discussed in the Selection of Detailed Study Sites report) examined the geographic distribution of detailed study sites throughout the Impoundment using GIS. This assessment included examining how well represented segments of the Impoundment were based on the hydraulic influence found in a given reach (including extent of water level fluctuations). Based on this evaluation, combined with the newly added sites proposed in this table, FirstLight believes the proposed set of detailed study sites provides a balanced, representative, and unbiased set of locations for detailed study. The updated list of proposed sites is proportionately distributed throughout the geographic extent of the Impoundment and includes the various hydraulic influences found throughout the study area.
18	<u>River Morphology</u>: The distribution of sites between inside bend, outside bend, and straight locations should be more evenly distributed and gaps should be filled. FRCOG provides specific site recommendations that could be incorporated.	FRCOG	Compared to many other rivers, the Impoundment is fairly straight with a relatively shorter portion consisting of bends. The summary of detailed study sites shows that 60% are in straight reaches, 16% are on an inside bend, and 16% on an outside bend (the remaining 8% are located in unique geomorphic locations (e.g., wide river sections or peninsulas)). This distribution seems to reasonably represent the Impoundment without additional shifting of sites. FirstLight believes the current distribution of detailed study sites between straight reaches, inside bends, and outside bends is appropriate and will adequately examine erosion processes at different geomorphic locations.

LINE	COMMENT	STAKEHOLDER	FIRSTLIGHT RESPONSE
19	Inclusion of stabilized sites: FirstLight should evaluate whether the selected sites are sufficiently representative in light of concerns raised with respect to the number of stabilized sites, in comparison to non-stabilized sites; including whether it will have an effect on the BSTEM model	MADEP	See comments in Lines 1 and 16 as well as Attachment A in regard to the appropriateness of using restored sites
20	Land-Use: The Department believes that the land based site specific work will (and should) provide detailed information on the use at each site, such as; width of buffer, type/intensity of agriculture, soils information, animal presence/grazing information, etc. The pool of sample sites should be sufficiently representative to capture these various differences. FirstLight should review the selected agricultural sites to ensure that the sample is sufficiently broad to capture the various buffer widths and various agricultural activities along the river. In addition, it should be sure that the land based work includes the information identified by stakeholders in their comments.	MADEP	See comments in Line 3
21	River Morphology: One would expect that some of the sites that the boat based survey identified as areas of interest would be those where the river is acting in ways other than one would normally expect. As such FirstLight may have already identified some sites that meet these requirements and should consider whether substitution or addition of sites meeting these criteria is appropriate.	MADEP	See comments in Line 4
22	Hydraulic Influences: Given CRWC's comments that the lower bank is 50% silt/sand based upon FirstLight's maps, the area should offer some locations at which FirstLight can gather valuable data.	MADEP	Site BC-1R has been added in this area to satisfy CRWC's comment. See comments in Line 5 and Attachment C.
23	Site Characteristics: FirstLight should determine whether there are sites that would provide a broader representation of these characteristics and consider adding or subtracting sites as appropriate as it would seem likely to result in additional information that would be beneficial.	MADEP	See comments in Lines 2 and 11
24	Conclusion: The stakeholder comments merit consideration and likely the addition or substitution of some sites. It is most appropriate for FirstLight to review these comments and determine which merit site revisions and then identify and propose the sites that it would add, delete, or substitute for Department and stakeholder comment.	MADEP	FirstLight appreciates the comments made by Stakeholders and the Department. Updated site recommendations have been provided in Lines 5 and 16. Additional information pertaining to these sites can be found in Attachments A-D. FirstLight will be conducting a workshop with Stakeholders on August 4th. The goal of the workshop will be to discuss Stakeholder comments in light of FirstLight's response and to finalize the list of study sites.

Attachment A – BSTEM Calibration and Role of Restored Sites

BSTEM will examine the changes in riverbank geometry and the influences various forces have on riverbank erosion in both space (throughout the geographic extent of the Impoundment) and time (2000-2013). The model will be calibrated using historic data, validated by comparing the historic data to field collected data, and then run in small increments to examine the specific cause(s) of erosion at a given location with given features and characteristics. Model results will then be extrapolated throughout the Impoundment to determine the cause(s) of erosion at each location. This process is described in greater detail below.

Calibration is a process by which model results are compared with measured data in an attempt to simulate a phenomenon such as erosion. Model parameters are adjusted so that model results reasonably match field collected data. In the case of BSTEM, changes in riverbank geometry over time are compared against surveyed cross-section data from one year to the next over the calibration period (2000-2013). As such, calibration can only occur at locations where data has been collected over time. Without an existing dataset the model cannot be calibrated.

For the purpose of this study, calibration data will be derived from a subset of the 21 permanent transects (transects) that have been established throughout the Turners Falls Impoundment (Impoundment). The existing transects were established in 1998 and have been surveyed annually over the past 16+ years. Survey data collected at these locations provides the fundamental basis and foundation for developing an appropriately calibrated model. Calibration is only possible at these locations.

Historic riverbank survey data was collected at the existing transects starting in 1998 while digital hydrologic (flow) data and water elevation data is available starting in 2000. Based on the available data, the calibration period will start in 2000 and run through 2013. Existing riverbank survey data, data from past FRR's, and digital hydrologic data will be used for various calibration model runs over this period.

Input parameters for the baseline calibration run (2000) will utilize the riverbank features and characteristics as observed at each site during the 1998 FRR (pre-bank restoration). At sites which have been restored since that time the model will be calibrated until restoration occurred at that site. In the event that a site has not been restored, the model will be calibrated from 2000 to present day. Multiple model runs will be executed at each location over various time periods using various riverbank conditions (based on existing data) to ensure an accurate, representative investigation of how each detailed study site has changed over time. Furthermore, riverbank features and characteristics that may have been under represented based on 2013 field conditions can be examined in the model based on past conditions (e.g., 1998 vs. 2013 upper riverbank vegetation).

Given that BSTEM will be run over multiple time periods with multiple input conditions 2013 riverbank features and characteristics (including whether a site has been restored or not), although important, are only one small part of a larger, more comprehensive investigation. As such, the use of restored sites as proposed is appropriate and will not result in biased results.

Proposed representative sites that were identified based on 2013 FRR results do not have a historic dataset and therefore cannot be calibrated. At these locations, the model will be run based on the findings of the 2013 FRR and the data collected during 2014 field efforts. Pertinent lessons learned during the calibration process will be applied to these locations where appropriate. This will provide confidence in applying the model to evaluate causes of erosion to the extent that good model calibration is achieved at the locations where calibration is possible.

Following successful calibration of the model the various causes of erosion will be analyzed and evaluated. The available hydrologic data will be subdivided into small increments that are representative of each particular cause of erosion (e.g., high flow events, low flow events, fluctuating water levels, etc.). BSTEM runs will then be executed at each location for a given time period using that specific hydrologic input. Erosion associated with a particular cause can be quantified to the extent that any particular cause of erosion can be isolated to particular segments of the hydrologic dataset. At locations where calibration is not possible, 2013 riverbank conditions will be examined against the same hydrologic dataset used at the calibrated locations.

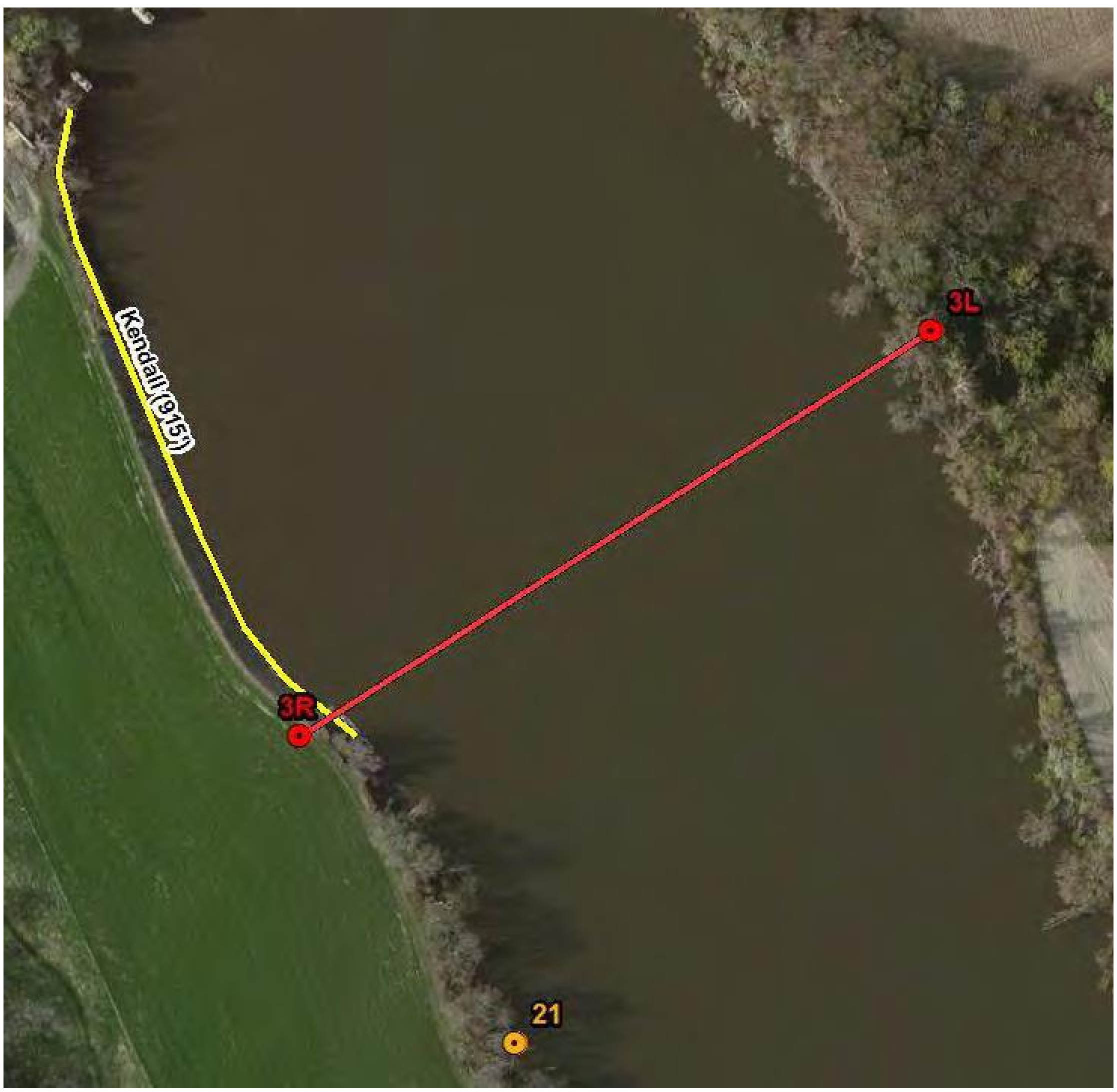
Once the various causes of erosion have been evaluated, the results of the model will be extrapolated to the Impoundment. The extrapolation will be based on the features and characteristics found at a detailed study site which are similar to those found at an unstudied site.

Attachment B – Site Complexes

Several sets of detailed study sites were selected that result in what can be called data "complexes." A data complex is a set of sites that are in close physical proximity to each other such that hydraulic conditions, and likely soil conditions, are similar but riverbank features and characteristics are quite different. Clustering a diverse set of locations in close physical proximity to one another provides an opportunity to analyze the response of these dissimilar riverbanks to similar hydraulic conditions.

An example of one such data complex is shown below. Restoration occurred at Site 3R (Kendall) in 2007. Based on this, approximately 8 years of data before restoration and 6 years of data after can be examined. Site 3L has not been restored and exhibits a different set of riverbank features and characteristics. Nearby, Site 21 provides a location with some degree of erosion and similar riverbank features and characteristics as to what likely existed prior to the Kendall site restoration. Together this data complex, like a few others, provides a good set of sites to analyze and evaluate erosion under a wide variety of riverbank conditions but very similar hydraulics.

Site Complex Example



Attachment C – Site Recommendations

Riverbank features and characteristics – Site 87(B)

Site 87(B) (photo #605)

Site 87(B) Riverbank features and Characteristics

Riverbank Features	Characteristics
Upper Riverbank Slope	Overhanging
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Sparse
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None/Very sparse
Type of Erosion	Rotational slump, Undercut
Potential Erosion Indicators	Exposed roots, Overhanging bank, Creep/Leaning trees
Stage of Erosion	Eroded
Extent of Erosion	Some to Extensive

Riverbank features and characteristics – Site BC-1R

Site BC-1R (photo #377)

Site BC-1R Riverbank features and characteristics

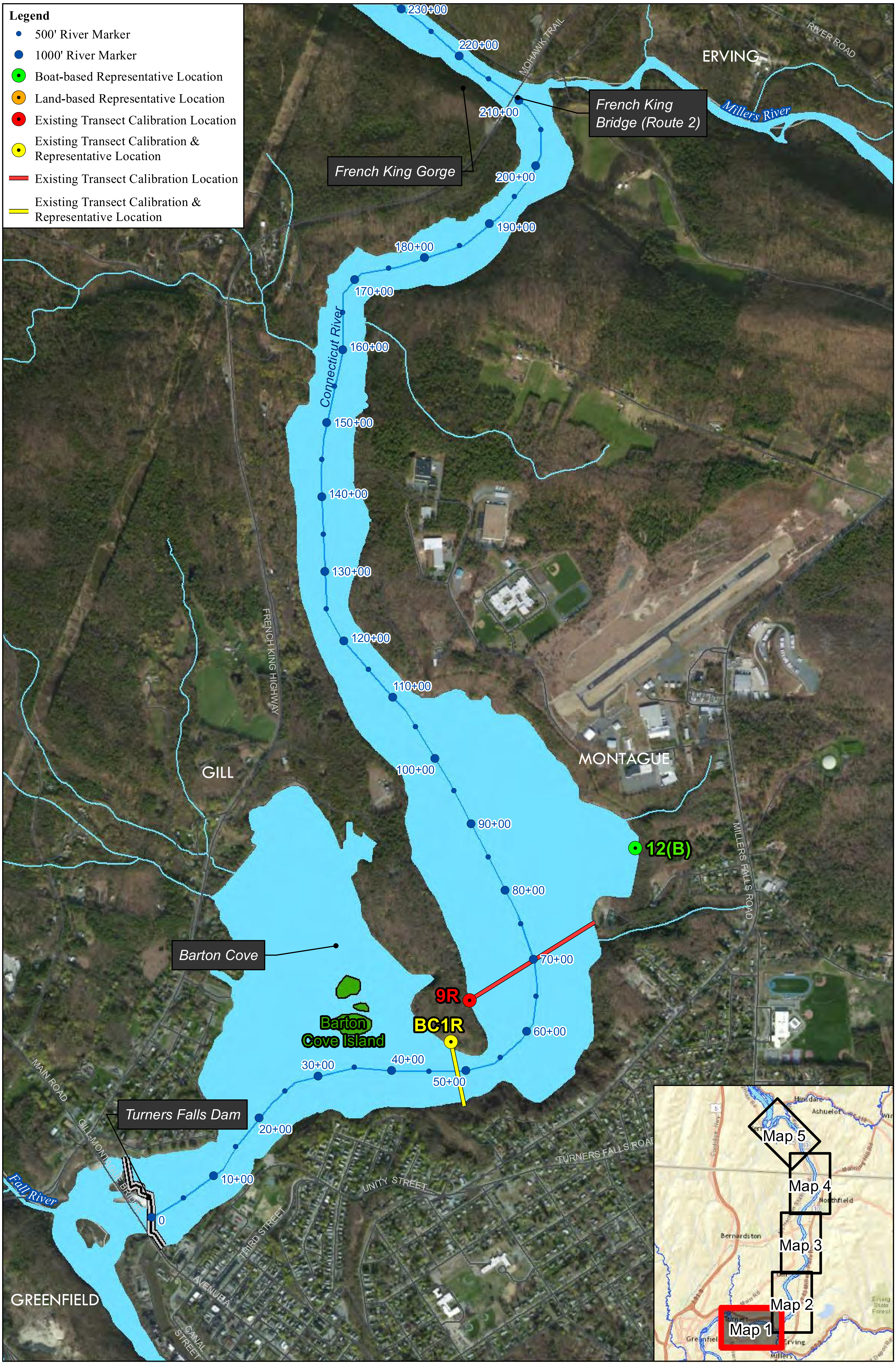
Riverbank Features	Characteristics
Upper Riverbank Slope	Moderate
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None/Very sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Creep/Leaning Trees
Stage of Erosion	Stable
Extent of Erosion	None/little

Riverbank features and characteristics – Site 303(B)

Site 303 (photo #1577)

Site 303(B) Riverbank features and characteristics

Riverbank Features	Characteristics
Upper Riverbank Slope	Moderate
Upper Riverbank Height	Medium
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	Heavy
Type of Erosion	
Potential Erosion Indicators	None
Stage of Erosion	Stable
Extent of Erosion	None/little



FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7-2:
Proposed Representative & Calibration Locations for Detailed Study
Map 1

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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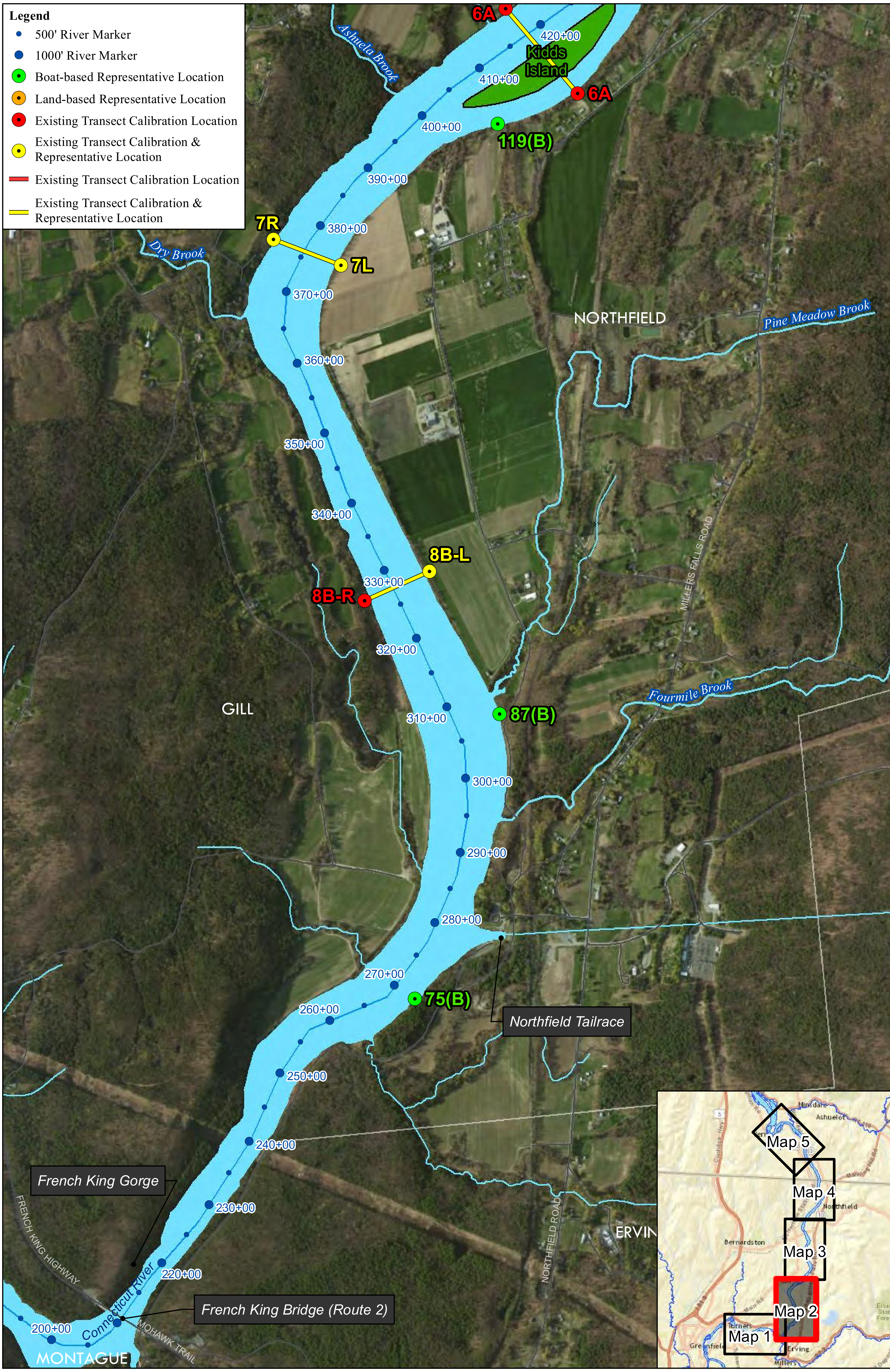

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FIRSTLIGHT POWER RESOURCES

RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7-3:
Proposed Representative & Calibration
Locations for Detailed Study
Map 2

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7-4:
Proposed Representative & Calibration Locations for Detailed Study
Map 3

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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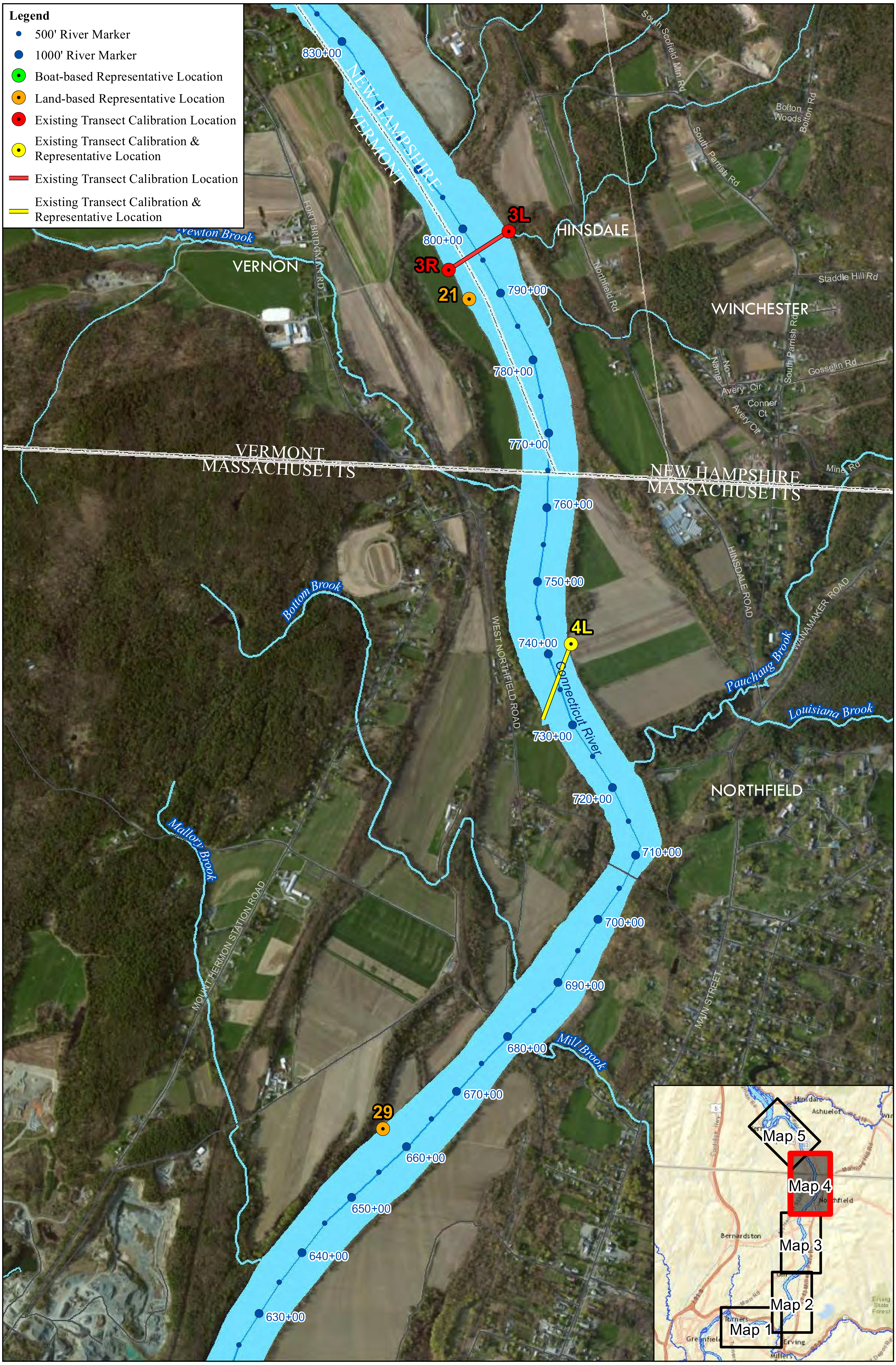

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7-5:
Proposed Representative & Calibration Locations for Detailed Study
Map 4

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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FirstLight GDF SUEZ

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7-6:
Proposed Representative & Calibration Locations for Detailed Study
Map 5

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Attachment D – Summary of Site Information

The following table summarizes the list of detailed study sites based on observations raised by the Stakeholders in their comment letters.

Site #	Cal, Rep, or Both	Restored	Name	Year Stabilized	Comments
11L	C	No	n/a	n/a	Forest, Inside of slight bend
~~11I~~	~~C~~	~~No~~	~~n/a~~	~~n/a~~	~~Island~~
2L	B	Yes	Bonnette Farm	2012	Agriculture, straight, stabilized recently by only planting vegetation – minimal treatment
303(B)	R	No	n/a	n/a	Agriculture, straight
18	R	No	n/a	n/a	Agriculture, straight
3R	C	Yes	Kendall	2007	Agriculture, straight
3L	C	No	n/a	n/a	Forest adjacent to tributary, straight
21	R	No	n/a	n/a	Agriculture, straight, adjacent to restored site providing complementary site in unsterilized area with similar characteristics
4L	B	No	n/a	n/a	Agriculture, inside bend
29	R	No	n/a	n/a	Forested strip between agriculture, straight
5CR	C	No	n/a	n/a	Agriculture, straight
10R	B	Yes	Urgiel	2001-2005	Forest, straight
10L	C	No	n/a	n/a	Agriculture, straight
26	R	No	n/a	n/a	Agriculture, straight, adjacent to restored site providing complementary site in un-stabilized area with similar characteristics
6AL	C	Yes	Flagg	1999-2000	Forest, straight
~~6AI~~	~~B~~	~~No~~	~~n/a~~	~~n/a~~	~~Island~~
6AR	C	Yes	Skalski	2004	Agriculture (grazing, affected by cattle), outside bend
119(B)	R	No	n/a	n/a	Agriculture, inside bend, adjacent to restored site providing complementary site in un-stabilized area
7R	B	No	n/a	n/a	Forest, outside bend

Site #	Cal, Rep, or Both	Restored	Name	Year Stabilized	Comments
7L	B	No	n/a	n/a	Agriculture, inside bend
8BR	C	Yes	Bathory/Gallagher Wallace/Watson	2012 2013	Agriculture/Forest, straight
8BL	B	No	n/a	n/a	Agriculture, straight
~~90(B)~~	~~R~~	~~No~~	~~n/a~~	~~n/a~~	~~Agriculture, straight~~
87(B)	R	No	n/a	n/a	Forested, outside bend
75(B)	R	No	n/a	n/a	Forested, outside bend
12(B)	R	No	n/a	n/a	Forested, wide river section
9R	C	Yes	Campground Point	2008	Forested, wide river section on peninsula
BC-1R	B	No	n/a	n/a	Forested, in Barton Cove on peninsula

** Represents removed site*
** Represents newly added site*

Franklin Regional Council of Governments

MEMORANDUM

To: John Howard, FirstLight Power Resources

From: Kimberly Noake MacPhee, P.G.

cc: Ken Hogan, FERC
Brian Harrington, MassDEP
David Foulis, MassDEP

Date: August 1, 2014

Re: Site selection for Study No. 3.1.2- Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability

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Attached are general comments and responses to FirstLight's responses to FRCOG comments on site selection for Study No. 3.1.2.

/knm
Attachment

12 Olive Street, Suite 2, Greenfield, MA 01301-3318 · 413-774-3167 · www.frcog.org

<u>FRCOG General Comments:</u>

For <u>each of the detailed study sites</u>, document and provide the following information:

1. Detailed cross-section drawings for each of the detailed study sites (like those provided by Kit Choi for the land based survey sites).
2. Full cross-section drawings for sites located at permanent transects – include both banks and prepare at a scale that can be easily read.
3. Locate the Mean Annual Low Water mark on the cross-section and provide the water level elevation (MSL).
4. Locate the Mean Annual High Water mark on the cross-section and provide elevation.
5. Locate the upper and lower project operational range of water level fluctuations (2000-2013) on the cross-sections and provide elevations.
6. Locate the upper and lower project operational range of water level fluctuations allowed by the current license on the cross-sections and provide elevations.
7. Locate the jurisdictional boundaries for the MA Wetlands Protection Act, MassDEP 401 WQC and US Army Corps of Engineers on each detailed cross-section.

FRCOG Comment	FirstLight Response	FRCOG Follow-up Comment
<u>Restored Sites</u>: Restored sites should be added as a new category to the Features column of Table 7-3. Restored sites should not be used as sites that are representative of the unrestored river conditions. In order to adequately represent all features, characteristics, and conditions found in the Impoundment, new sites should be selected to replace the restored sites in the revised Table 7-3. The age of the restoration and the major technique used in the restoration should be noted.	A table summarizing the status (i.e., if a site has or has not been restored) and age of restoration as well as the major technique used at each detailed study site (if applicable) is included in Attachment D. The use of restored sites is appropriate due to the fact that BSTEM can be run over various time periods (e.g., 1998 vs. 2013) using various input parameters (1998 vs. 2013 features and characteristics). The ability of BSTEM to examine changes in riverbank geometry over time will be used to examine riverbanks pre- and post-restoration if desired. 2013 riverbank conditions (including whether a site has been previously restored or not), although important, are one small piece of a larger investigation. Additional information pertaining to the appropriateness of using restored sites is included in Attachment A. FRCOG and CRWC noted the following detailed study sites as being in areas that have been restored: 9R, 90B, 119B, 26, 8B-R, 6A-R, 6A-L, 5C-R, 7L, 10R, 29, 21, 3R, 2L	Restoration technique information missing. We agree that there is value in using pre- and post-restoration data for restored sites for BSTEM runs. We note that assessing areas upstream and downstream of and in close proximity to restored sites also is valuable because bank erosion has been noted in these areas, particularly when stone toe protection and riprap were used at the restored sites. However, we do not consider these restored sites as representative of river conditions generally. In other words, these sites are not representative of river conditions in areas where there are no restored sites. Due to the scale of the maps provided to stakeholders, it was difficult to discern whether these detailed study locations were located at or near restored sites.

	However, as noted below and in Attachment D: 9R, 8B-R, 6A-R, 6A-L, 10R, 3R, and 2L are sites that have been previously restored 90B, 119B, 26, 5C-R, 7L, 29, and 21 have not been restored but are instead located several hundred feet upstream or downstream of a restored site.	
<u>Lower Riverbank Vegetation</u>: The categories of Sparse, Moderate, and Heavy are under-represented in Table 7-3. Sites should be added to these categories.	A detailed study site was added with ‘Heavy’ lower riverbank vegetation and ‘Medium’ upper riverbank height (Site 303B). In addition, there are several locations where significant densities of lower riverbank vegetation are growing that are currently being monitored at restored sites. This level of monitoring will qualitatively add to understanding the effect of lower riverbank vegetation on riverbank stability.	We reiterate our concern with the lack of sites that represent Sparse and Moderate vegetation. The data gaps in the matrix (Table 7-3) should be filled. Out of the 38 Land Based Survey Site data sheets there are 3 sites with Moderate lower river bank vegetation and 4 with Sparse bank vegetation. We were not given the 2013 FRR data but there are likely to be more sites in that data set that could be used to fill in the Sparse, Moderate and possibly Heavy lower riverbank vegetation categories. Vegetation on the beach (what FirstLight incorrectly identifies as the lower riverbank) stabilizes the toe of slope of the riverbank by dissipating boat wave energy, reducing the erosive effects of pool fluctuations and trapping sediment from high flow events, which encourages the establishment of more vegetation. While there is value in the data for the restored sites, there is also value in gaining more knowledge about the sites where vegetation on the beach is naturally occurring and flourishing and providing protection to the riverbank toe of slope.
<u>Hydraulic Influences and Geographic Extent of Water Level Fluctuations</u>: Table 7-3 should include Hydraulic Forces in the Features column.	Table 7-3 was developed to evaluate how representative a proposed site’s riverbank features and characteristics were. The emphasis being on the	This is a major data gap and flaw in the transect selection methodology. We reiterate our concern that the hydraulic influences (as currently understood from existing data) should be part of the site selection process.

• shear stress, flow direction, and flow velocity at different flow events and • water level fluctuations due to the operation of Northfield Mountain Pumped Storage Project	physical features and characteristics of the actual riverbank itself and not the forces acting upon the bank. Table 7-3 was never intended to evaluate hydraulic forces or any other forces or potential causes of erosion; it was designed to strictly evaluate features and characteristics. The evaluation of hydraulic influences and the geographic extent of water level fluctuations were conducted in Step 4 of the site selection methodology (as discussed in the Selection of Detailed Study Sites report – Appendix C). As determined in this evaluation, the proposed set of detailed study locations, combined with the newly proposed sites, adequately represents the range of hydraulic influences found throughout the Impoundment.	 FirstLight states that the evaluation of hydraulic influences and the geographic extent of water level fluctuations were conducted in Step 4 of the site selection methodology. This is not supported by the methodology outlined in Appendix C or other vague references to hydrologic and hydraulic conditions in the text of the June 2014 report.
<u>Hydraulic Influences and Geographic Extent of Water Level Fluctuations</u>: Existing data and analysis from the 2007 Field study, the July 2007 Woodlot study, and FirstLight's Hydraulic Modeling Assessment should be compared to the 2013 FRR data. Representative and calibration sites should be located in areas where 1) erosion is occurring that is not predicted or is inconsistent with the results of the previous hydraulic	Hydraulic data analyses and modeling both independent of BSTEM as well as within BSTEM are an important component of understanding the range of forces causing erosion. Once the required field data has been collected various analyses will be conducted/modeled which will examine the forces associated with the hydraulic influences at a given location. By having a set of detailed study sites that are representative of the hydraulic and	The site selection criteria should include a Hydraulic Influences and Geographic Extent of Water Level Fluctuations category in order to identify sites that are representative of the unique hydraulic conditions of the impoundment. Equating simple geographic distribution of sites across the impoundment with hydraulic conditions and anomalies is not valid. There is existing, specific data available to FirstLight to use to select sites that are representative of the hydraulic conditions in the impoundment. We disagree with FirstLight's statement that "[b]y having a set of detailed study sites that are representative of the hydraulic (emphasis added) and

modeling and 2013 field investigations, and 2) where erosion is occurring in areas of high velocity and shear stress. The hydraulic forces category should also include sites that represent the geographic extent and magnitude of the water level elevation fluctuations in the river that are due to the operation of Northfield Mountain.	geomorphic conditions found throughout the study area FirstLight will be able to examine the varying hydraulic forces associated with flowing water, water level fluctuations, boat waves, etc. at each location. FirstLight believes the detailed study sites, combined with the new sites proposed in this table, are balanced and representative of the hydraulic conditions found throughout the Impoundment. The GIS spatial analysis used to determine if sites are balanced (Step 4 of the site selection methodology) is adequate for the purpose of site selection. The data analyses proposed by FRCOG are premature at this point in the study and not necessary for the selection of detailed study sites. This level of analysis will occur once field efforts have been completed using all available data.	geomorphic conditions found throughout the study area FirstLight will be able to examine the varying hydraulic forces associated with flowing water, water level fluctuations, boat waves, etc. at each location [emphasis added].” For the reasons stated above, we disagree with FirstLight’s statements.
<u>Hydraulic Influences and Geographic Extent of Water Level Fluctuations</u>: The river should be divided into hydraulic segments or areas of influence. FirstLight should identify segments based on their hydraulic modeling data and water level data. Potential segments would include: • Barton Cove to FK Gorge/Bridge	This level of analysis was conducted during Step 4 of the site selection methodology as discussed in the Selection of Detailed Study Sites report. FirstLight believes the geographic distribution of the proposed transects, combined with the new sites proposed in this table, is appropriate and accomplishes the goal of looking at different segments of the	See previous related comments.

• French King Gorge to Shearer • Shearer to Route 10 Bridge • Route 10 Bridge to Stateline • Stateline to below Stebbins Island • Stebbins Island to Vernon Dam	Impoundment.	
<u>Hydraulic Influences and Geographic Extent of Water Level Fluctuations</u>: FRCOG made the following specific site recommendations: • Barton Cove to FK Gorge/Bridge – Remove site 9R • French King Gorge to Shearer – Add sites: 87B, 24, 35, 5 • Shearer to Route 10 Bridge – Remove 90B, 119B, 26, 8B-R, 6A-R, 6A-L, 5C-R, 7L, 10R and replace with 10, 11 • Route 10 Bridge to Stateline – Remove 29 • Stateline to below Stebbins Island – Remove 21, 3R, 2L • Stebbins Island to Vernon Dam – Add 2, 34, 4, 30, 33	•Site 87B has been added to increase coverage in the French King Gorge to Shearer reach as requested by the Stakeholders. •Site BC-1R has been added to increase coverage in the Barton Cove to French King Gorge reach •Site 11I has been removed to focus resources in the vicinity of the Northfield Mountain tailrace and Barton Cove as opposed to near Vernon. •A number of locations cited in the comment letter as having been restored (and therefore being recommended for removal) have not actually been restored (see response in Line 10). These sites include: 90B, 119B, 26, 5C-R, 7L, 29, and 21. Although 7 out of 25 potential locations have experienced some form of restoration these sites are still useful for BSTEM. Due to the fact that BSTEM can be run over various time periods (e.g., 1998 vs. 2013) using various input parameters (1998 vs. 2013 features and	If FirstLight is going to stick to a maximum of 25 sites then we need to ensure adequate representation of conditions, particularly hydraulic influences and geographic extent of water level fluctuations, which is currently lacking.

	characteristics) changes in riverbank geometry can be examined in detail pre-and post-restoration. 2013 riverbank conditions (including whether a site has been previously restored), although important, are one small piece of a larger investigation. Additional information pertaining to the appropriateness of using restored sites is included in Attachment A. • FRCOG raised concerns about the number of sites proposed in the Shearer to Route 10 Bridge reach. 6A-I and 90B are recommended for deletion to provide two less sites in this reach. • FRCOG recommends adding 5 representative sites in the Stebbins Island to Vernon reach. Adding these sites would bring the total number of sites in this area to 6 (assuming 11I is removed). In order to stay within the allotted 25 total detailed study sites (to stay within budget and on schedule) accommodating this request would require swapping out 5 other sites from areas of greater interest. In addition, it would reduce the number of calibration locations found throughout the study area. • Additional information pertaining to the newly proposed sites can be found in Attachment C.	Budget and schedule should not determine the number of study sites. FirstLight needs to have sufficient sites to provide a <u>complete</u> picture of bank erosion occurring throughout the project boundary and the causal factors. Adding sites as recommended by the FRCOG and other stakeholders should not be at the expense of eliminating sites that FirstLight has identified as areas of interest.

River Morphology: The distribution of sites between inside bend, outside bend, and straight locations should be more evenly distributed and gaps should be filled. FRCOG provides specific site recommendations that could be incorporated.	Compared to many other rivers, the Impoundment is fairly straight with a relatively shorter portion consisting of bends. The summary of detailed study sites shows that 60% are in straight reaches, 16% are on an inside bend, and 16% on an outside bend (the remaining 8% are located in unique geomorphic locations (e.g., wide river sections or peninsulas). This distribution seems to reasonably represent the Impoundment without additional shifting of sites. FirstLight believes the current distribution of detailed study sites between straight reaches, inside bends, and outside bends is appropriate and will adequately examine erosion processes at different geomorphic locations.	FRCOG reiterates its prior comments. The CT is not a straight river; it meanders across a relatively small floodplain and exhibits recognizable sinuosity[1] (see Relicensing Study 3.1.2, Figure 7-6). FRCOG's sinuosity comment is a specific reference to a bigger gap/flaw in FirstLight's overall approach to site selection. Our first comment memo was very specific about the distribution of the sites and included tables and recommendations for sites that could be added. The process FirstLight used to determine the distribution of sites did not include river morphology and hydraulic/geomorphic conditions, or if it did it doesn't describe them. Instead, stakeholders are asked to accept sites based on data and assessment in the 2013 FRR, which study report is and remains unavailable to us for corroboration. Further, geographic distribution of sites as selected by FirstLight does not, in our opinion, capture the varying hydrologic and hydraulic conditions found throughout the project area. Table 6-1 that FirstLight keeps referencing does not include any column for river morphology or hydraulic conditions.

Kimberly Noake MacPhee, P.G.
FRCOG-FRPB

August 1, 2014

[1] A river's sinuosity is its tendency to move back and forth across its floodplain, in an S-shaped pattern, over time. Reference: http://forest.mtu.edu/faculty/hyslop/gis/sinuosity.html

Franklin Regional Council of Governments

CONNECTICUT RIVER STREAMBANK EROSION COMMITTEE

MEMORANDUM

TO: John Howard

FROM: Connecticut River Streambank Erosion Committee

DATE: August 28, 2014

RE: Relicensing Study No. 3.1.2

At the August 4, 2014 meeting held at Northfield Mountain Visitor Center, we discussed comments on Study No. 3.1.2 submitted in writing by CRSEC on August first. This is a follow-up Memo to confirm a commitment that Tom Sullivan made at the meeting to include the following information in the study report:

1. Detailed cross-section drawings for each of the detailed study sites (like those provided by Kit Choi for the land based survey sites).
2. Full cross-section drawings for sites located at permanent transects – include both banks and presented at a scale that can be easily read.
3. Locate the Mean Annual Low Water mark on the cross-section and provide the water level elevation (MSL).
4. Locate the Mean Annual High Water mark on the cross-section and provide elevation.
5. Locate the upper and lower project operational range of water level fluctuations (2000-2013) on the cross-sections and provide elevations.
6. Locate the upper and lower project operational range of water level fluctuations allowed by the current license on the cross-sections and provide elevations.
7. Locate the jurisdictional boundaries for the MA Wetlands Protection Act, MassDEP 401 WQC and US Army Corps of Engineers on each detailed cross-section.

If there are any disagreements or questions regarding the requested information, please contact Kimberly Noake MacPhee at FRCOG.

cc: Ken Hogan, FERC
Robert McCollum, DEP
David Foulis, DEP
Bob Kubit, DEP
Brian Harrington, DEP
Bill McDavitt, NOAA
Tim Sullivan, Gomez & Sullivan
Mickey Marcus, NEE

Franklin Regional Council of Governments

CONNECTICUT RIVER STREAMBANK EROSION COMMITTEE

MEMORANDUM

TO: John Howard

FROM: Connecticut River Streambank Erosion Committee

DATE: August 28, 2014

RE: Upper vs. lower riverbank working definition

At the August 4, 2014 meeting held at Northfield Mountain Visitor Center, we discussed the set of transects to be used in Study 3.1.2 *Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability*. We told you at that meeting that we would respond more formally to Tim Sullivan's June 27, 2014 Memorandum (sent to us via email on June 30) on the working definition of "upper" vs. "lower riverbank" of the Turners Falls Impoundment. This memorandum documents the Connecticut River Streambank Erosion Committee's response as of this time.

The definition of upper vs. lower riverbank is central to understanding the extent and causation of bank erosion in the impoundment. Our primary desire is that the designation and the definition remain consistent throughout the relicensing process and beyond. We have found the past shifting of methodologies, site names, and definitions from one Full River Reconnaissance (FRR) to the next to be confusing and problematic. We worry when we read in the second paragraph of the 6/27/14 Memorandum that "It is anticipated that these definitions will continue to evolve….".

No scientific basis is given for the current definition and no scientific rationale for having an evolving definition is provided by FirstLight. In fact, we would argue that an evolving and non-cited, not scientifically accepted and replicable definition runs counter to accepted academic, professional and regulatory practices. Stakeholders and regulatory agencies should not be asked to accept a random definition of bank that is unsupported by citations and examples from current literature that clearly document why this definition is valid for the Turners Falls Pool.[1]

The relicensing process is governed by state and federal regulatory agencies. Further, the relicensing studies cross several related disciplines. Any definition of the river bank should be grounded in acceptable science and be consistent with the US Army Corps of Engineers' and MassDEP's definition of bank. The definition of bank, according to the attached references (US Army Corps of Engineers, BSTEM and King County, Washington) is

[1] We note that the riverbank profiles created by Kit Choi for the transect study call the base of the bank "the bank toe" and the beach is outward of that. This confirms our position, which is supported by the attached references, that the toe of the bank should always be taken as the base of the bank.

consistent, understandable and grounded in the scientific literature, unlike the "continuing to evolve" definition of bank proposed by FirstLight. It defies logic that some arbitrary definition of bank is used to describe the conditions in the Turners Falls Impoundment now, and the definition of bank will evolve and likely be different for the 401 Water Quality Certificate and US ACOE jurisdictional review. How is the bank defined in the VT/NH reach of the river? Consistency and validity of a bank definition is a critical component of the relicensing studies.

Previous FRR investigations of the Turners Falls Pool have been plagued by inconsistencies in terminology, to wit:

- Earlier FRRs did not include the mudflat/beach area as part of river bank. This has been changing over time. The most recent available FRR (2008) apparently treated mudflat/beach area as comprising the entirety of what FirstLight now calls the lower bank.
- Turners Falls Impoundment, Lower vs. Upper Riverbank, June 27, 2014, defines lower bank as "frequently below water" (lower than average height of water level fluctuations "high water mark"?) and "mostly barren of vegetation other than some scattered aquatic vegetation" and demonstrates those conditions, especially lack of vegetation, in photos on pp. 3, 4, and 5. The document also defines upper bank as "frequently above water" and "supports various types of terrestrial vegetation."
- RSP Study No. 3.1.2 *Northfield Mtn./Turners Falls Operations Impacts on Existing Erosion and Potential Bank Instability* Selection of Detailed Study Sites – Stakeholder Response**,** August 4, 2014, asserts there is "heavy" lower bank vegetation at Site 303B (pg. 13), but it appears that the area in question is neither frequently under water nor barren of vegetation - and that the vegetation shown is terrestrial, not aquatic.
- Erosion Control Plan - Status and Update of Activities, August 15, 2014, appears to characterize lower bank and beach area as different entities. The section on the Split River Farm site (no location, station or river mile information provided) states "no new lower bank erosion has occurred" and "several inches of sediment have settled on the lower bank and beach area." (Photos # 1 and 2)

It seems evident from the above examples that the definition of various areas of bank and land under water (at least below ordinary high water level fluctuation) need clarification and, most importantly, consistent usage.

We discussed another concern at the August 4th meeting. We asked if previous FRRs counted percentage of eroding riverbank based on the upper riverbank only, and whether the 2013 FRR is going to count percentage of eroding riverbank using lower plus upper riverbank area. Our thought is that the percentage of eroding riverbank could get skewed low if this change from one FRR to the next was made, since lower riverbanks could be disregarded as beach areas. Mickey Marcus of New England Environmental was not present at the August 4th meeting to confirm the methods of previous FRRs, but you assured us that the 2013 FRR would use the upper riverbank only for this calculation. We requested that this be documented in the September 2014 filing of the 2013 FRR, and you agreed to include it. Therefore, we expect to see documentation on how percentage of eroding riverbank is calculated in the forthcoming FRR.

These are our concerns at this time. We may have additional comments and concerns after reviewing the 2013 FRR when it is released in the middle of September.

cc: Ken Hogan, FERC
Robert McCollum, DEP
David Foulis, DEP
Bob Kubit, DEP
Brian Harrington, DEP
Bill McDavitt, NOAA
Tim Sullivan, Gomez & Sullivan
Mickey Marcus, NEE

References:

CHAPTER 3

MODES AND CAUSES OF BANK FAILURES

To effectively control bank erosion, river bank management must be compatible with the nature of the river system and the composition of its banks. Before restorative methods are applied to eroding banks, it is essential to understand the mechanism of erosion. Otherwise, large investments of time and money may potentially be wasted in projects that fail or require frequent maintenance. This chapter discusses various forms and causes of bank failure.

3.1 STREAMBANK ZONES

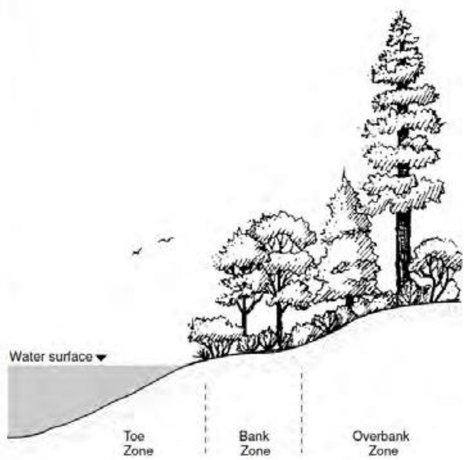
Streambanks can be divided into three general zones: toe, bank, and overbank zones. Although the boundaries between these zones are imprecise because river levels vary seasonally, they are useful in subsequent discussions. These zones are shown in Figure 3.1, and can be described as follows (adapted from Logan 1979):

Toe Zone. The toe zone is that portion of the bank between the ordinary high water (OHW) and low water levels. This is the zone most susceptible to erosion as it is exposed to strong currents, debris movements, and wet-dry cycles. This zone is normally inundated throughout much of the year. In areas where stabilization is necessary, non-vegetative structural protection is normally required in this zone because few woody plants can tolerate year-round inundation.

Bank Zone. The bank zone is that portion of the bank above the OHW mark (OHWM) that is inundated during periods of moderate flows (i.e., up to bankfull flow). Although above OHWM, these sites are still exposed to periodic erosive currents, debris movement, and traffic by animals and humans. The water table in this zone is frequently close to the soil surface because of its proximity to the river.

Overbank Areas. The overbank area is that portion of the bank from the bank zone inland that is subjected to inundation or erosive action only during occasional periods of high water (i.e., greater than bankfull flows). This zone is generally subjected to periodic dry periods in which the soil moisture is primarily dependent on characteristic rainfall of the area. When relatively flat and generally underlain by alluvial deposits, this area is also called a floodplain. When it rises steeply and directly from the streambank, this area is called a bluff.

Figure 3.1 Section of streambank zones in natural channels.



In some situations, toe protection with riprap or other structural means may be the only streambank protection required. Usually, structural protection below OHWM will be combined with vegetative designs above OHWM. Combined systems of this sort provide maximum protection against failure and yield greater benefits for aquatic and terrestrial ecosystems. The design of bank protection measures is discussed in Chapter 7.

http://www.kingcounty.gov/environment/waterandland/flooding/bank-stabilization-projects/guidelines.aspx

Technical Report EL-97-8
April 1997

US Army Corps
of Engineers
Waterways Experiment
Station

Environmental Impact Research Program

Bioengineering for Streambank Erosion Control

Report 1
Guidelines

by Hollis H. Allen, James R. Leech

Bioengineering by Zones

Plants should be positioned in various elevational zones of the bank based on their ability to tolerate certain frequencies and durations of flooding and their attibutes of dissipating current and wave energies. Likewise, bioengineering fixes should be arranged by zone, which will be discussed below. The zone definitions given below correspond to those used by the U.S. Army Engineer District, Omaha, and have been used in preparing guidelines for the use of vegetation in streambank erosion control of the upper Missouri River (Logan et al. 1979). These zones are not precise and distinct since stream levels vary daily and seasonally—they are only relative and may be visualized as somewhat elastic depending on the bank geometry. If one carefully copied nature in the planning process, plant species can be chosen that will adapt to that specific zone or microhabitat. Mallik and Harun (1993) lend credence to this zonal concept in a study on the Neebing-McIntyre Floodway, parts of the Neebing and McIntyre River Complex near the Intercity area of Thunder Bay, Ontario, Canada. They describe four microhabitats: bank slope, scarp face, above-water bench, and underwater depositional shelf. Each one had distinctively dominant plant species that generally correspond to the types of plants adapted for this report. Figure 5 illustrates the location of each bank zone for the upper Missouri River example. A description of each and the types of vegetation and appropriate species examples associated with them is given below. This zonal concept can be expanded to other streams to facilitate prescription of the erosion control treatment and plants to use at relative locations on the streambank.

Toe zone

The toe zone is that portion of the bank between the bed and average normal stage. This zone is a zone of high stress and can often be undercut by currents. Undercutting here will likely result in bank failure unless preventative or corrective measures are taken. This zone is often flooded greater than 6 months of the year.

Figure 6 illustrates the plant species prescribed for each streambank zone on the upper Missouri River except for the toe zone. The toe zone would likely have to be treated by some hard material, such as rock, stone, log revetments, cribs, or a durable material such as a geotextile roll (to be discussed later).

Splash zone

The splash zone is that portion of the bank between normal high-water and normal low-water flow rates. This and the toe zone are the zones of highest stress. The splash zone is exposed frequently to wave wash, erosive river currents, ice and debris movement, wet-dry cycles, and freezing-thawing cycles. This section of the bank would be inundated throughout most of the year (at least 6 months/year), but note that a large part of this inundation may occur in the dormant season of plants. The water depths will fluctuate daily, seasonally, and by location within the splash zone.

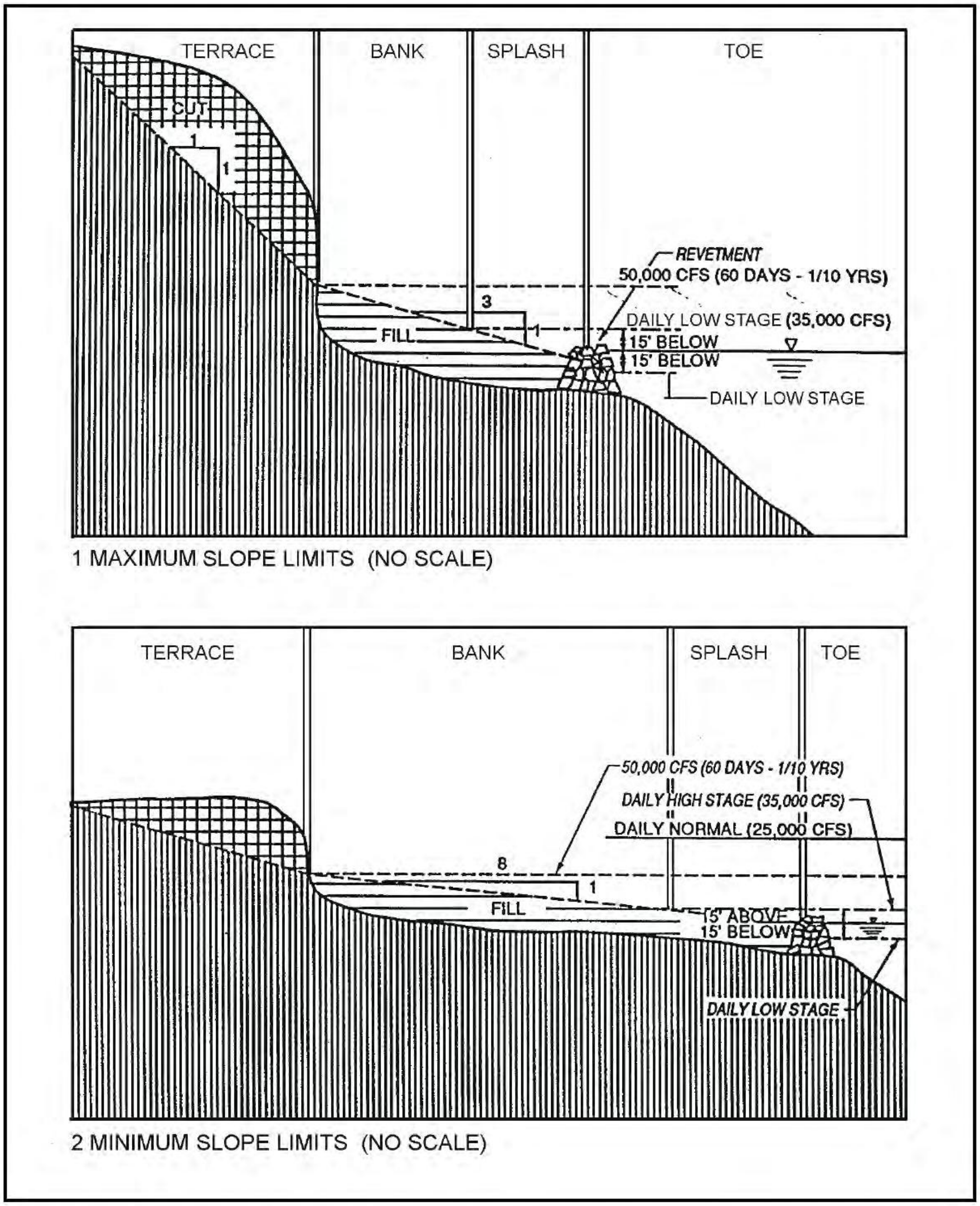


Figure 5. Bank zones defined on constructed slopes

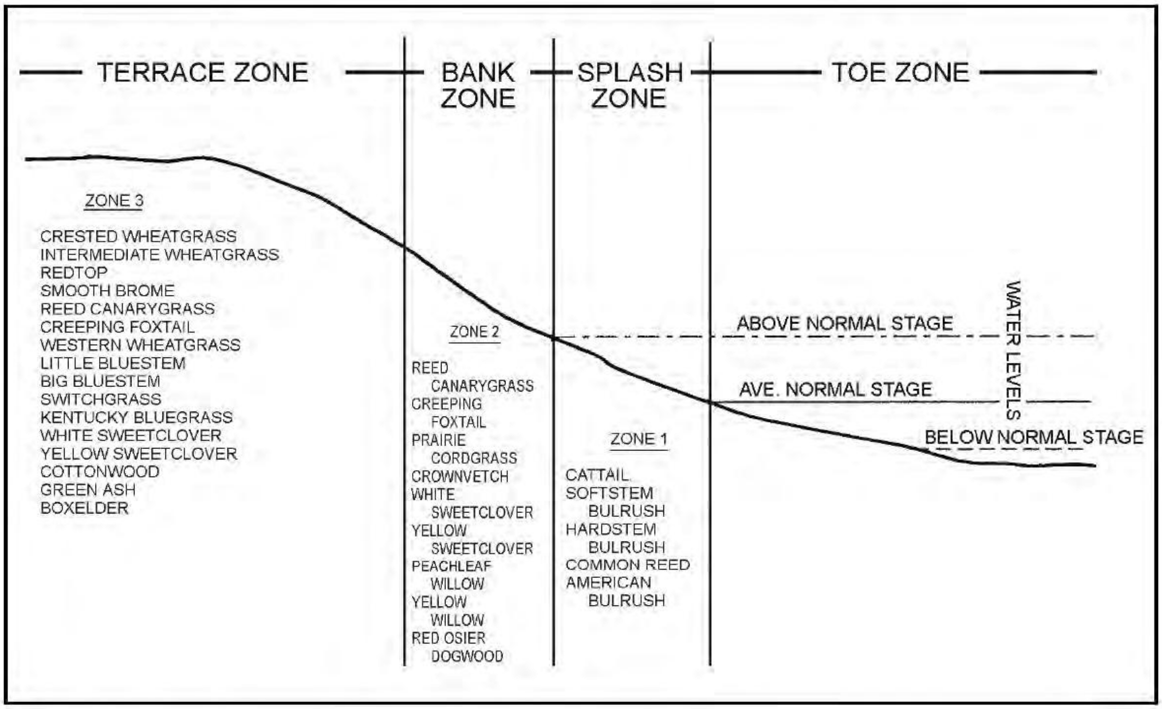


Figure 6. Possible species to plant by zone on Missouri River

Bank zone

The bank zone is that portion of the bank usually above the normal high-water level; yet, this site is exposed periodically to wave wash, erosive river currents, ice and debris movement, and traffic by animals or man. The site is inundated for at least a 60-day duration once every 2 to 3 years. The water table in this zone frequently is close to the soil surface due to its closeness to the normal river level.

Terrace zone

The terrace zone is that portion of the bank inland from the bank zone; it is usually not subjected to erosive action of the river except during occasional flooding. This zone may include only the level area near the crest of the unaltered "high bank" or may include sharply sloping banks on high hills bordering the stream.

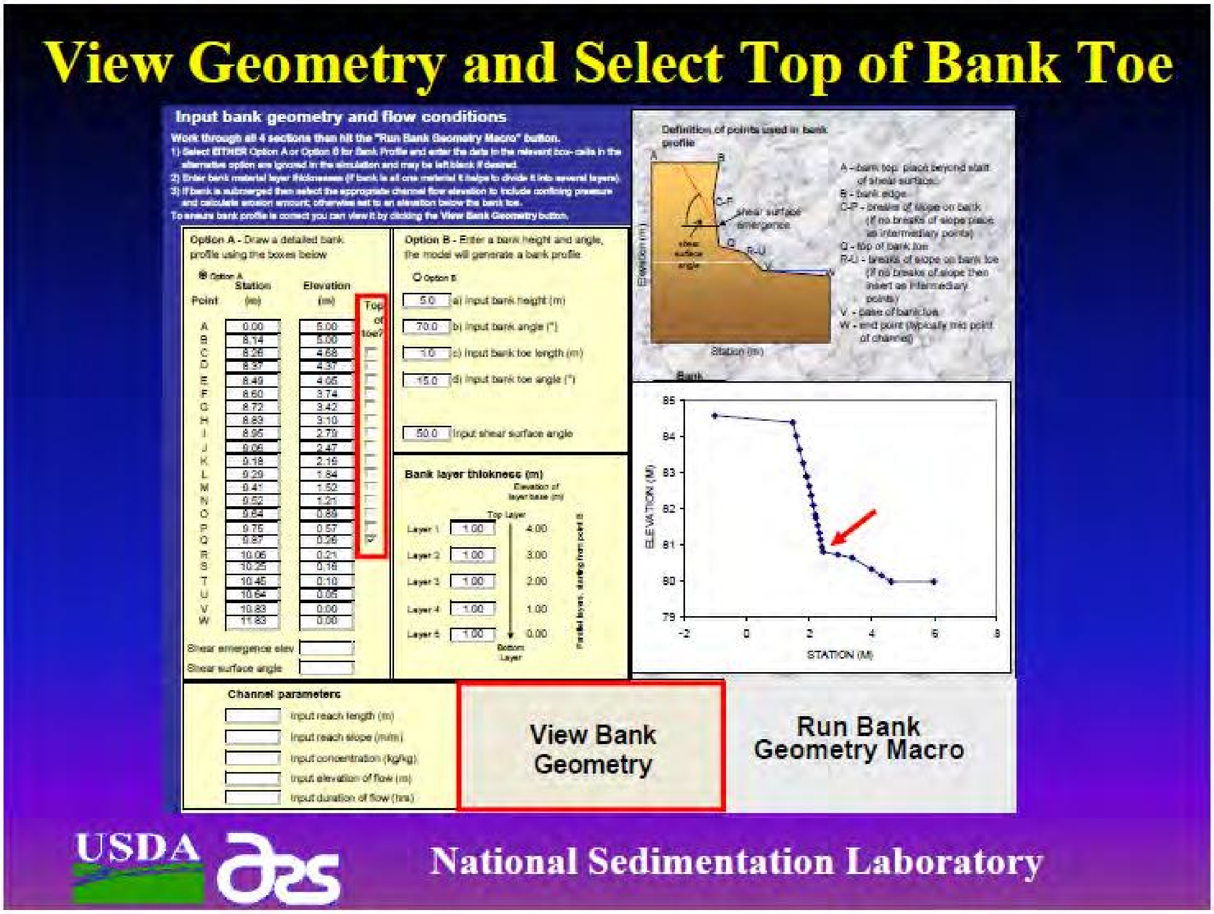
Development of the Bank-Stability and Toe-Erosion Model (BSTEM Version 5.4)

Andrew Simon, Robert Thomas, Andrea Curini and Natasha Bankhead

USDA-ARS National Sedimentation Laboratory, Oxford, MS

andrew.simon@ars.usda.gov

USDA ARS National Sedimentation Laboratory


View Geometry and Select Top of Bank Toe
Input bank geometry and flow conditions
Option A - Draw a detailed bank profile using the boxes below
Option B - Enter a bank height and angle, the model will generate a bank profile
Bank layer thickness (m)
Channel parameters
Definition of points used in bank profile
View Bank Geometry
Run Bank Geometry Macro
ELEVATION (M)
STATION (M)
USDA
National Sedimentation Laboratory

Connecticut River – Turners Falls Impoundment Riverbank Classification for Land Based Survey

Observation Point Number: *18* **Personnel:** *YKC, AS, MM, CM, TS*

Date: *November 15, 2013* **Time:** *10:00 am*

Station Number: *870+00* **Photo Reference Numbers:** *642 - 646*

Left or Right Bank (Looking Downstream): *Left*

Length of Representative Segment, From Station Number *867+00* **To Station Number** *925+00*

Previously Stabilized? *No*

Geologic / Geotechnical Observations:

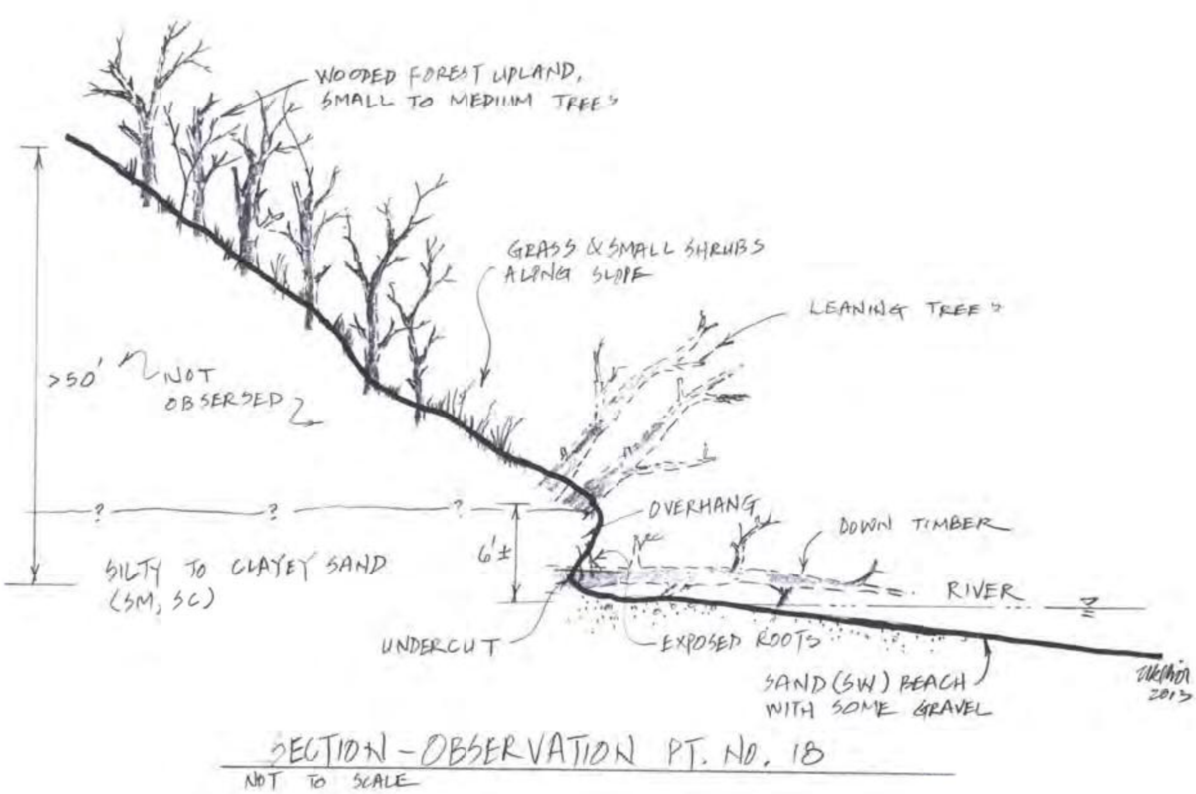
Stratigraphy:
(Refer to Site Sketch below for locations of soil/rock layers
Notations in parentheses are based on Unified Soil Classification System)

SILTY SAND (SM) to CLAYEY SAND (SC) – Mostly fine sand, 20% to 30% low- to medium-plastic fines.

Observed Erosion Features:

- *Overhangs to near-vertical scarps near toe of bank.*
- *Exposed roots of leaning trees near toe of bank at river level, with undercuts behind roots.*
- *Down timber and leaning trees near river level.*

Site Sketch:



DRAFT

Connecticut River – Turners Falls Impoundment Riverbank Classification for Land Based Survey

Observation Point Number: *18* **Date:** *November 15, 2013*

Station Number: *870+00*

Maximum Root Depth:

-

Erosion Classification:

Types of Erosion: mass wasting

Indicators of Potential Erosion: Exposed roots
Overhanging bank
Undercuts

Notes: overhangs to near vertical scarps at the toe of the bank, exposed roots of leaning trees near toe of bank at river level with undercuts behind roots, downed trees and leaning trees near river level

Bank Vegetation:

Top: Heavy (>50%), Broad-leaved deciduous tree
Red oak, black birch, shag bark hickory, green ash, Japanese barberry, Christmas fern*

Face: Heavy (>50%), Broad-leaved deciduous tree
Red oak, black birch, shag bark hickory, green ash, river rye, sedges, solidago*

Toe: None-Very sparse (0-10%) emergent (nonpersistents)
river rye, sedges

NOTE: The dominant plant is noted with an *

Adjacent Land Use:
Agricultural & forested

Sensitive Receptor:
Yes

Notes: *emergent shelf at toe from ~station 930+00 to 920+00*

High bank, low bench

Lots of herbaceous veg at top of bank

Invasive species present (barberry, bittersweet), although sparse

DRAFT

Appendix B
Selection of Detailed Study Sites Report

RELICENING STUDY 3.1.2

NORTHFIELD MOUNTAIN/TURNERS FALLS OPERATIONS IMPACT ON EXISTING EROSION AND POTENTIAL BANK INSTABILITY

SELECTION OF DETAILED STUDY SITES

Northfield Mountain Pumped Storage Project (No. 2485) and Turners Falls Hydroelectric Project (No. 1889)

Prepared by:

Kit Choi, P.E.

SEPTEMBER 2014

EXECUTIVE SUMMARY

FirstLight Hydro Generating Company (FirstLight), a subsidiary of GDF SUEZ North America, Inc., is the current licensee of the Northfield Mountain Pumped Storage Project (FERC No. 2485) and the Turners Falls Hydroelectric Project (FERC No. 1889). FirstLight has initiated with the Federal Energy Regulatory Commission (FERC, the Commission) the process of relicensing the two Projects using FERC's Integrated Licensing Process (ILP). As part of this process FirstLight is required by FERC to conduct various environmental studies during 2014, 2015, and 2016. Descriptions of these studies were included in the Revised Study Plan (RSP) FirstLight filed with FERC on August 14, 2013. The RSP was subsequently approved by the Commission in its Study Plan Determination Letters (SPDL) issued on September 13, 2013 and February 21, 2014 respectively. Included in the RSP and SPDLs were Study No. 3.1.1 *2013 Full River Reconnaissance* and Study No. 3.1.2 *Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability* (FirstLight, 2013).

Study No. 3.1.2 *Northfield Mountain/Turners Falls Operations Impacts on Existing Erosion and Potential Bank Instability* will examine the causes of erosion present throughout the Turners Falls Impoundment (the Impoundment), the forces associated with them, and their relative importance at a particular location (FirstLight, 2013). In order to gain a thorough understanding of these topics, FirstLight has identified and selected a number of calibration and representative locations for detailed study where in-depth investigation and analyses will occur. The final set of calibration and representative locations spans the geographic extent of the Turners Falls Impoundment and is representative of the range of riverbank features, characteristics, and conditions found in this area.

As outlined in the RSP, the selection of the calibration and representative locations for detailed study is based on field observations made during Study No. 3.1.1 *2013 Full River Reconnaissance* (FRR), review and analysis of 2013 FRR data, and examination of the existing, permanent transects that are currently established throughout the Impoundment (FirstLight, 2013).[1] The 2013 FRR was a reconnaissance level riverbank survey which spanned the entire Impoundment from the Vernon Hydroelectric Project in Vernon, VT to the Turners Falls Dam in Montague, MA. Components of the FRR that were relevant to the transect selection associated with Study No. 3.1.2 included: 1) land-use mapping; 2) sensitive receptor mapping; 3) evaluation of past bank stabilization projects; 4) land-based survey; and 5) boat-based survey.

Field work for the 2013 FRR was conducted during the summer-early winter of 2013. Classification of land-uses adjacent to riverbanks was conducted and sensitive receptor locations were mapped during the late summer and fall of 2013. The land- and boat-based surveys, including evaluation of past bank stabilization projects, were conducted on November 11-19 and December 10-12, 2013. In addition, land-use classifications and sensitive receptor locations were validated and updated, if necessary, during the land-based survey.

Permanent, existing transects located throughout the Impoundment were also evaluated as part of the FRR land- and boat-based surveys in order to determine the representativeness of each transect as compared to

[1] For the purpose of this report, Representative Locations are defined as study sites established throughout the Impoundment at locations that exhibit a representative range of riverbank features, characteristics, and erosion conditions. A representative location can be established at an existing, permanent transect or a newly identified site. Calibration Locations are defined as a detailed study site established at an existing, permanent transect where data collection will occur to calibrate the BSTEM model. Riverbank features and characteristics to be studied were defined in the RSP and include a wide range of riverbank geometry, sediment, extent of vegetation, and extent of erosion. While the sites focus on areas with erosion, they also include areas that are stable or have been stabilized in order to better understand the wide range of conditions found along the Impoundment. Bedrock segments or other highly developed segments that have been rip-rapped will not be examined.

riverbank conditions found throughout the Impoundment. These transects, which have been surveyed periodically since the 1990s, provide valuable data on the extent of channel change resulting from the geomorphic processes of erosion and deposition. The data collected at these locations can be used to better understand the role that natural processes, hydropower operations, and other factors may play in regard to bank stability as well as to calibrate the Bank Stability and Toe Erosion Model (BSTEM) that will be utilized in Study No. 3.1.2 (FirstLight, 2013).

The purpose of this Selection of Detailed Study Sites Report is to present the list of final calibration and representative transects and detailed study points (locations where field data collection will occur) that will be used for Study No. 3.1.2. Calibration and representative locations for detailed study were selected based on a four step methodology, including:

1. Evaluate Existing, Permanent Transects and Identify Calibration and/or Representative Locations for Detailed Study;
2. Identify Supplemental Representative Locations for Detailed Study;
3. Evaluate the Range of Riverbank Features and Characteristics of the Representative Locations Selected for Detailed Study; and
4. Evaluate the Geographic Distribution of the Representative Locations Selected for Detailed Study

After completing this four step methodology FirstLight presented a list of proposed representative and calibration study sites to MADEP, the Connecticut River Watershed Council (CRWC), the Franklin Regional Council of Governments (FRCOG), the Connecticut River Streambank Erosion Committee (CRSEC), and the New Hampshire Department of Environmental Services (NHDES) for review and comment as per FERC's SPDL (FERC, 2013). After receiving written comments and meeting with the MADEP and Stakeholders FirstLight updated and finalized the location of detailed study sites based on the feedback received.[2] The detailed study sites discussed in this report represent the final locations which will be investigated in detail as part of Study No. 3.1.2.

Based on the methodology described above combined with MADEP and Stakeholder feedback, FirstLight has selected a total of 25 calibration and/or representative locations where detailed investigation and analyses will occur. Of the 25 sites, FirstLight has identified 16 representative detailed study sites. Seven of the representative sites are located at existing, permanent transects (these locations will also be used in the calibration of the BSTEM model) while the remaining 9 representative locations were selected based on the results of the 2013 FRR land- and boat-based surveys. In addition to the seven representative and calibration sites mentioned above, 9 additional calibration locations were selected at existing, permanent transects (16 total calibration sites). The selected calibration and representative locations for detailed study extend at relatively even spacing from below Vernon Dam to Barton Cove. The selected locations are representative of riverbank features, characteristics, and conditions found throughout the Impoundment with an emphasis locations experiencing erosion.

[2] Meetings were held on June 4, 2014 at MADEP offices in Springfield, MA and June 24, 2014 and August 4, 2014 at the Northfield Mountain Visitors Center.

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LIST OF ABBREVIATIONS

°F	Degrees Fahrenheit
BSTEM	Bank Stability and Toe Erosion Model
cfs	cubic feet per second
CRWC	Connecticut River Watershed Council
ECP	Erosion Control Plan
HEC-RAS	Hydrologic Engineering Center River Analysis System
ft	feet
FERC	Federal Energy Regulatory Commission
FirstLight	FirstLight Hydro Generating Company
FRCOG	Franklin Regional Council of Governments
FRR	Full River Reconnaissance
Gomez and Sullivan	Gomez and Sullivan Engineers, D.P.C.
GIS	Geographic Information Systems
GPS	Global Positioning System
ILP	Integrated Licensing Process
MA	Massachusetts
MADEP	Massachusetts Department of Environmental Protection
MassGIS	Massachusetts Office of Geographic Information
NEE	New England Environmental
NH	New Hampshire
NHDES	New Hampshire Department of Environmental Services
NOI	Notice of Intent
Northfield Mountain	Northfield Mountain Pumped Storage Hydroelectric Project
PAD	Pre-Application Document
PSP	Proposed Study Plan
QAPP	Quality Assurance Project Plan
RSP	Revised Study Plan
S&A	Simons and Associates
SD1	Scoping Document 1
SD2	Scoping Document 2
SPDL	Study Plan Determination Letter
the Commission	Federal Energy Regulatory Commission
the Impoundment	Turners Falls Impoundment
USGS	United States Geological Survey
VCGI	Vermont Center for Geographic Information
VT	Vermont
VY	Vermont Yankee Nuclear Power Plant

1 INTRODUCTION

FirstLight Hydro Generating Company (FirstLight), a subsidiary of GDF SUEZ North America, Inc., is the current licensee of the Northfield Mountain Pumped Storage Project (FERC No. 2485) and the Turners Falls Hydroelectric Project (FERC No. 1889). FirstLight has initiated with the Federal Energy Regulatory Commission (FERC, the Commission) the process of relicensing the two Projects using FERC's Integrated Licensing Process (ILP). The current licenses for the Northfield Mountain and Turners Falls Projects were issued on May 14, 1968 and May 5, 1980, respectively, with both set to expire on April 30, 2018.

As part of the ILP, FERC conducted a public scoping process during which various resource issues were identified. On October 31, 2012, FirstLight filed its Pre-Application Document (PAD) and Notice of Intent (NOI) with FERC. The PAD included FirstLight's preliminary list of proposed studies. On December 21, 2012, FERC issued Scoping Document 1 (SD1) and preliminarily identified resource issues and concerns. On January 30 and 31, 2013, FERC held scoping meetings for the two Projects. FERC issued Scoping Document 2 (SD2) on April 15, 2013.

FirstLight filed its Proposed Study Plan (PSP) on April 15, 2013 and, per the Commission regulations, held a PSP meeting at the Northfield Visitors Center on May 14, 2013. Thereafter, FirstLight held ten resource-specific study plan meetings to allow for more detailed discussions on each PSP and on studies not being proposed.[3] On June 28, 2013, FirstLight filed with the Commission an Updated PSP to reflect further changes to the PSP based on comments received at the meetings. On or before July 15, 2013, stakeholders filed written comments on the Updated PSP. FirstLight filed a Revised Study Plan (RSP) on August 14, 2013 with FERC addressing stakeholder comments. Included in the RSP were Study Nos. 3.1.1 *2013 Full River Reconnaissance* and Study No. 3.1.2 *Northfield Mountain/Turners Falls Operations Impacts on Existing Erosion and Potential Bank Instability*.

On August 27, 2013 Entergy Corp announced that the Vermont Yankee Nuclear Power Plant (VY), located on the downstream end of the Vernon Impoundment on the Connecticut River and upstream of the two Projects, will be closing no later than December 29, 2014. With the closure of VY, certain environmental baseline conditions will change during the relicensing study period. On September 13, 2013, FERC issued its first Study Plan Determination Letter (SPDL) in which many of the studies were approved or approved with FERC modification. However, due to the impending closure of VY, FERC did not act on 19 proposed or requested studies pertaining to aquatic resources. The SPDL for these 19 studies was deferred until after FERC held a technical meeting with stakeholders on November 25, 2013 regarding any necessary adjustments to the proposed and requested study designs and/or schedules due to the impending VY closure. FERC issued its second SPDL on the 19 remaining studies on February 21, 2014, approving the RSP with certain modifications.

Study No. 3.1.2 *Northfield Mountain/Turners Falls Operations Impacts on Existing Erosion and Potential Bank Instability* will examine the causes of erosion present throughout the Turners Falls Impoundment (the Impoundment), the forces associated with them, and their relative importance at a particular location. In order to gain a thorough understanding of these topics, FirstLight identified and selected a number of fixed calibration and representative riverbank transects and detailed study points where detailed investigation and analyses will occur. The final set of transects and detailed study points spans the geographic extent of the Impoundment and are representative of the range of riverbank features, characteristics, and conditions found throughout the Impoundment. In order to be representative of riverbank conditions, the final list of selected representative locations include:

[3] The ten meetings were held on May 14, 15, 21, and 22, June 4, 5, 11, 12, and 14, and August 8, 2013.

- Locations where riverbanks are stable (including at least one site where bank stabilization has occurred as a result of the Northfield Mountain Erosion Control Plan (ECP)(Simons, 1999) and at least one site that is naturally stable with no bank stabilization work present);
- Locations where the potential for future erosion is low;
- Locations where the potential for future erosion is high; and
- Locations where active erosion is occurring

Field efforts associated with Study No. 3.1.2 began in July 2014 and will continue through September 2014. Additional field work is expected in 2015.

As outlined in the RSP, the selection of the calibration and representative locations for detailed study was based on field observations made during Study No. 3.1.1 *2013 Full River Reconnaissance (FRR)*, review and analysis of 2013 FRR data, and examination of the existing, permanent transects that are currently established throughout the Impoundment (FirstLight, 2013).

The methodology and scope for the 2013 FRR were outlined in the RSP and approved by the Commission in its September 12, 2013 SPDL (FirstLight, 2013, FERC, 2013). In addition, FirstLight consulted with, and sought approval from, the Massachusetts Department of Environmental Protection (MADEP) regarding the methodology and personnel conducting this study prior to field efforts commencing. The MADEP approved the 2013 FRR personnel and methodology following a meeting at the Northfield Visitors Center on November 4, 2013.

The 2013 FRR was a reconnaissance level riverbank survey spanning the Impoundment from the Vernon Hydroelectric Project located in Vernon, VT to the Turners Falls Dam in Montague, MA. Components of the FRR that were relevant to the selection of detailed study sites associated with Study No. 3.1.2 included:

- Conducting a land-based investigation of the riverbanks and islands to document indicators of potential erosion and potential bank instability;
- Identification of land-use practices within 200 feet of the riverbank and islands from Turners Falls Dam to Vernon Dam;
- Identification and definition of riverbank features and characteristics such as bank slope, height, sediment composition, and vegetation;
- Identification and definition of the type, stage, indicators, and extent of erosion;
- Identification and mapping of the location(s) of sensitive receptors, including important wildlife habitat, along the riverbanks and islands of the Impoundment;
- Spatially identifying, using a Global Positioning System (GPS), the transition points where riverbank features or characteristics change from one classification to another;
- Creation of geo-referenced video and photographic documentation of all riverbanks classified throughout the Impoundment; and
- Evaluation of past bank stabilization projects

Field work for the 2013 FRR was conducted during the summer-early winter of 2013. Classification of land-uses adjacent to riverbanks was conducted and sensitive receptor locations were mapped during the late summer and fall of 2013. The land- and boat-based surveys, including evaluation of past bank stabilization projects, were conducted on November 11-19 and December 10-12, 2013 during leaf-off. An evaluation of the existing, permanent transects existing throughout the Impoundment was also conducted as part of the land- and boat-based surveys. In addition, land-use classifications and sensitive receptor locations were validated and updated, if necessary, during the land-based survey.

Personnel participating in the 2013 FRR included a fluvial geomorphologist/hydraulic engineer, geotechnical engineer, wildlife biologist, environmental scientist/bank restoration design and permitting specialist, and various support staff. Specific personnel conducting the land- and boat-based surveys included:

- Robert Simons, PE (Simons and Associates (S&A), Project Director, Fluvial Geomorphologist and Hydraulic Engineer),
- Mickey Marcus PWS (New England Environmental (NEE), Project Manager, Senior Scientist),
- Kit Choi, PE (Geotechnical Engineer),
- Andrew Simon (Cardno ENTRIX, Fluvial Geomorphologist, BSTEM),
- Natasha Bankhead (Cardno ENTRIX, Fluvial Geomorphologist, BSTEM),
- Christin McDonough (NEE, Environmental Scientist),
- Gregg Simons (S&A, Hydraulic Engineer), and
- Sean Werle (NEE, Environmental Scientist).

All personnel listed above were approved by the MADEP in advance of field efforts. Chuck Momnie (FirstLight), John Howard (FirstLight), and Tim Sullivan (Gomez and Sullivan) were also present for portions of the field efforts.

Field conditions (leaf-off) were favorable for the study allowing for field work to progress without issue. Weather conditions during the land- and boat-based surveys ranged from temperatures in the teens to 40's (°F) with generally no significant precipitation. The majority of the trees located along the riverbanks had lost their leaves by the time of the survey allowing for good visibility of riverbank conditions. Flow conditions during the survey were generally less than the long-term median flows for these dates.

The results of the 2013 FRR were used to identify the location of representative transects and detailed study points which will be used for investigation and analyses associated with Study No. 3.1.2 (FirstLight, 2013). Riverbank conditions found at these locations are representative of the range of riverbank features, characteristics, and erosion processes found throughout the Impoundment. The final transects and detailed study points were selected to represent a combination of existing, permanent transects as well as newly identified locations. Newly identified locations were selected based on detailed geotechnical and geomorphic assessments conducted during the FRR land-based survey.

After completing the four step selection methodology outlined in Section 6 FirstLight presented a list of proposed representative and calibration study sites to MADEP, the Connecticut River Watershed Council (CRWC), the Franklin Regional Council of Governments (FRCOG), the Connecticut River Streambank Erosion Committee (CRSEC), and the New Hampshire Department of Environmental Services (NHDES) for review and comment as per FERC's SPDL (FERC, 2013). After receiving written comments and meeting with the MADEP and Stakeholders FirstLight updated and finalized the location of detailed study sites based on the feedback received.[4] The detailed study sites discussed in this report represent the final locations which will be investigated in detail as part of Study No. 3.1.2.

[4] Meetings were held on June 4, 2014 at MADEP offices in Springfield, MA and June 24, 2014 and August 4, 2014 at the Northfield Mountain Visitors Center.

2 AVAILABLE/DEVELOPED INFORMATION SUPPORTING FULL RIVER RECONNAISSANCE FIELD WORK

Prior to initiation of 2013 FRR field activities various resources and existing datasets were gathered to support survey efforts. Information gathered included: surficial geology maps, aerial photographs, land-use maps, sensitive receptor maps, riverbank classification reference guides, and detailed land- and boat-based data forms and data dictionaries. Digital and hardcopies of these datasets were present in the field throughout the survey. Descriptions of each support dataset can be found below.

In addition to the support datasets gathered, various field equipment was utilized to satisfy the field objectives of the land- and boat-based surveys. Equipment utilized during these assessments included: a sub-meter GPS, data-logger, laser range-finder, GPS enabled Pentop field computer, Red Hen Geo-referenced Videotaping System, and GPS enabled digital cameras. The combination of the various support datasets and field equipment allowed for accurate and efficient data collection by field personnel.

Surficial Geology Maps

Surficial geology maps were obtained from the State of Vermont and from the USGS for the various quadrangles in New Hampshire and Massachusetts. These maps show a range of categories such as bedrock, glacial till, lake-bottom sediments, moraines, fluvial sands and gravels, recent alluvium, etc. Examples of the surficial geology maps used during the course of this study are provided in Appendix A. Also included in Appendix A is an example of the USGS surficial geology legend (description of map units) using Hinsdale, NH as an example.

Aerial Photographs

Aerial photographs from a variety of sources were obtained and utilized during the FRR field work. These photographs were loaded onto a Pentop computer to assist with the riverbank delineation and identification of attributes captured as part of the land-based survey. In addition, aerial photographs of the study area will be utilized as base layers for the various FRR maps which will be produced as part of the final report.

Land-use Maps

Maps of land-use adjacent to Impoundment riverbanks were developed by NEE during the summer/fall of 2013 (Section 3). Land-use data was loaded onto the Pentop computer as a reference and for validation during the land-based survey. In addition, hard copy land-use maps were kept with field personnel throughout the course of the survey (Figures 3-1-3-5).

Sensitive Receptors

The location of sensitive receptors (i.e. important wildlife habitat located at or near the riverbank) were identified by NEE during the summer/fall of 2013 (Section 3). Maps depicting these locations were created in advance of the land- and boat-based survey. Hard copies of these maps were kept on hand by field personnel throughout the course of this study (Figures 3-6-3-10). Previously identified sensitive receptor locations were validated and updated, if needed, during the fall/winter 2013 field efforts.

Riverbank Classification Reference Guides

Hard copies of riverbank classification matrices, definition tables, and reference guides developed as part of the RSP (FirstLight, 2013) were kept on hand by field personnel throughout the duration of the study. Examples of these are included in this report as Table 2-1 and Figure 2-1. In addition, riverbank classification photos contained in Appendix D of the 2013 Full River Reconnaissance Quality Assurance

Project Plan (QAPP) (Simons, 2013) were referenced to assist in riverbank classification as needed. Data dictionaries based on field data sheets developed in advance of field efforts were also utilized in order to capture riverbank feature and characteristic attributes. Examples of these data sheets can be found in Sections 4 and 5 respectively.

River Marker Stations

River marker stations were developed to determine the general location of cross-sections and other areas of interest throughout the Impoundment. River marker locations were based on distance upstream of the Turners Falls Dam along a mid-channel path. Major stations were established every 1,000 ft while minor stations were established every 500 ft. Stationing follows the convention utilized in the available HEC-RAS hydraulic model where cross-sections were developed at 500 ft intervals throughout the length of the Impoundment.

Table 2-1 Riverbank Classification Definitions[5]

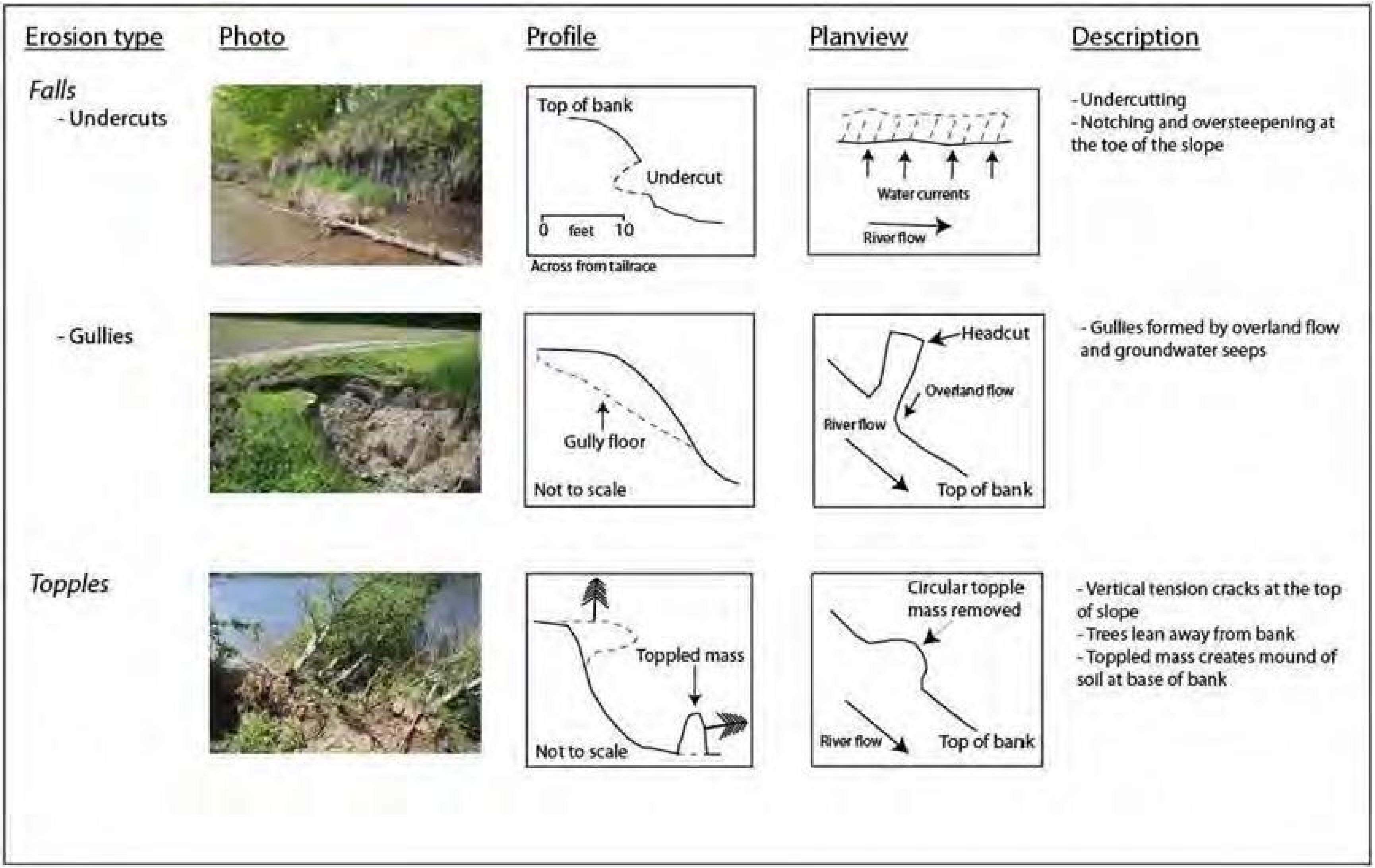
RIVERBANK CHARACTERISTICS *(Upper and Lower)*[6]	
Riverbank Slope	**Overhanging** – any slope greater than 90º
	Vertical – slopes that are approximately 90º
	Steep – exhibiting a slope ratio greater than 2 to 1
	Moderate – ranging between a slope ratio of 4 to 1 and 2 to 1
	Flat – exhibiting a slope ratio less than 4 to 1[7]
Riverbank Height	**Low –** height less than 8 ft above normal river level[8]
	Medium – height between 8 and 12 ft above normal river level
	High – height greater than 12 ft above normal river level
Riverbank Sediment	**Clay –** any sediment with a diameter between .001 mm and .062 mm
	Silt / Sand – any sediment with a diameter between .062 mm and 2 mm
	Gravel – any sediment with a diameter between 2 mm and 64 mm
	Cobbles – any sediment with a diameter between 64 mm and 256 mm
	Boulders – any sediment with a diameter between 256 mm and 2048 mm
	Bedrock – unbroken, solid rock
Riverbank Vegetation	**None to Very Sparse –** less than 10% of the total riverbank segment is composed of vegetative cover
	Sparse – 10-25% of the total riverbank segment is composed of vegetative cover
	Moderate – 25-50% of the total riverbank segment is composed of vegetative cover
	Heavy – 50 % or greater of the total riverbank segment is composed of vegetative cover
Sensitive Receptors	Descriptions of important wildlife habitat use on or near the riverbank such as bank swallow colonies, kingfisher nests, eagle nests, prime odonate and mussel habitat, etc.
EROSION CLASSIFICATIONS	
Type(s) of Erosion[9]	**Falls –** Material mass detached from a steep slope and descends through the air to the base of the slope. Includes erosion resulting from transport of individual particles by water.
	Topples – Large blocks of the slope undergo a forward rotation about a pivot point due to the force of gravity. Large trees undermined at the base enhance formation.
	Slides – Sediments move downslope under the force of gravity along one or several discrete surfaces. Can include planar slips or rotational slumps.
	Flows – Sediment/water mixtures that are continuously deforming without distinct slip surfaces.
Indicators of Potential Erosion	**Tension Cracks –** a crack formed at the top edge of a bank potentially leading to topples or slides (Field, 2007)
	Exposed Roots – trees located on riverbanks with root structures exposed, overhanging.
	Creep – defined as an extremely slow flow process (inches per year or less) indicated by the presence of tree trunks curved downslope near their base (Field, 2007)
	Overhanging Bank – any slope greater than 90º
	Notching – similar to an undercut, defined as an area which leaves a vertical stepped face presumably after small undercut areas have failed.
	Other – Indicators of potential erosion that do not fit into one of the four categories listed above will be noted by the field crew.

[5] RSP Table 3.1.1-3 (FirstLight, 2013)
[6] All quantitative classification criteria (e.g. slope, height, vegetation, extent, etc.) were based on estimates made during field observations of riverbanks. The FRR is a reconnaissance level survey that does not include quantitative analysis.
[7] Beaches are defined as a lower riverbank segment with a flat slope
[8] For the purpose of this study, Normal Water Level will be defined as water levels within typical pool fluctuation levels, but below Ordinary High Water (186' NGVD29, as measured at Turners Falls Dam).
[9] Field, 2007

Stage(s) of Erosion	**Potential Future Erosion –** riverbank segment exhibits multiple or extensive indicators of potential erosion
	Active Erosion – riverbank segment exhibits one or more types of erosion as well as evidence of recent erosion activity
	Eroded – riverbank segment exhibits indicators that erosion has occurred (e.g. lack of vegetation, etc.), however, recent erosion activity is not observed. A segment classified as Eroded would typically be between Active Erosion and Stable on the temporal scale of erosion.
	Stable – riverbank segment does not exhibit types or indicators of erosion
Extent of Current Erosion	**None/Little**[10] **–** generally stable bank where the total surface area of the bank segment has approximately less than 10% active erosion present.
	Some – riverbank segment where the total surface area of the bank segment has approximately 10-40% active erosion present
	Some to Extensive – riverbank segment where the total surface area of the bank segment has approximately 40-70% active erosion present
	Extensive – riverbank segment where the total surface area of the bank segment has approximately more than 70% active erosion present

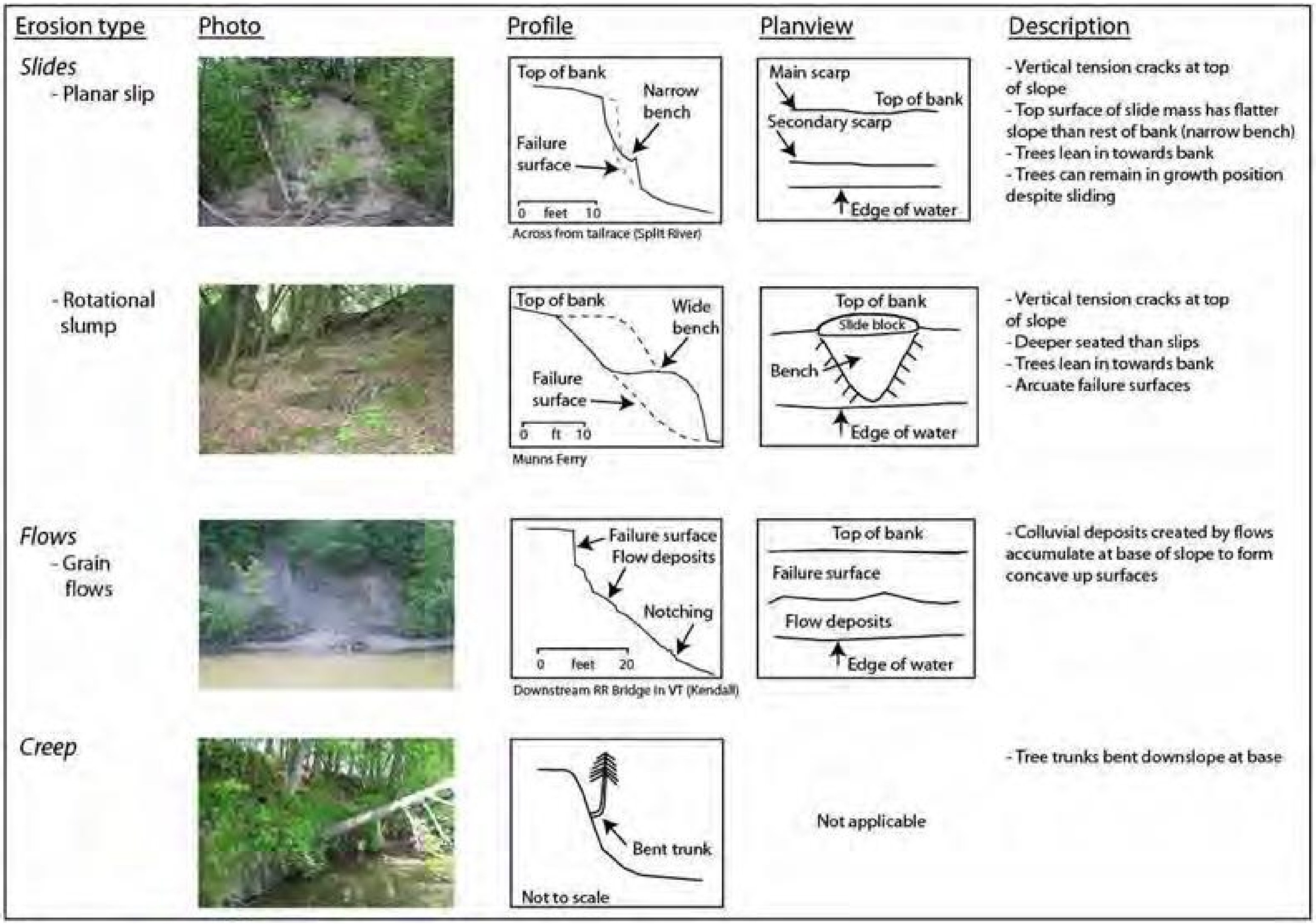
[10] Riverbanks consist of an irregular surface and include a range of natural materials (silt/sand, gravel, cobbles, boulders, rock, and clay), above ground vegetation (from grasses to trees), and below ground roots of different densities and sizes. Due to these characteristics, there are small areas of disturbance which often occur at interfaces between materials, particularly in the vicinity of the water surface. These small disturbed areas can be considered as erosion, or sometimes can result from deposition or even eroded deposition. No natural riverbank exists which does not have at least some relatively small degree of disturbance or erosion associated with the natural combination of sediment types/sizes and vegetation. As such, the extent of erosion for generally stable riverbanks that include these relatively small disturbed areas is characterized as little/none.

Figure 2-1 Types of Erosion Occurring in the Turners Falls Impoundment and their Characteristics[11]



[11] RSP Table 3.1.1-4 (FirstLight, 2013)

Figure 2-1 Types of Erosion Occurring in the Turners Falls Impoundment and their Characteristics (continued)[12]



[12] RSP Table 3.1.1-4 (FirstLight, 2013)

3 FULL RIVER RECONNAISSANCE - LAND-USE AND SENSITIVE RECEPTOR MAPPING[13]

Throughout the late summer and early fall of 2013 NEE developed a preliminary dataset containing land-use classifications of all properties adjacent to riverbanks and sensitive receptor locations throughout the Impoundment.

In order to develop a comprehensive land-use dataset, preliminary analysis of aerial photographs was conducted in order to: 1) determine the width of riparian buffers; 2) develop a list of predetermined land-use categories that would be used during field classification; and 3) identify other pertinent land-use information that would be useful during the field survey. Land-use layers from the State of Massachusetts Geographic Information Systems Center (MassGIS) were also referenced to complement the preliminary analysis.

Following completion of preliminary analysis and data gathering, land-uses adjacent to Impoundment riverbanks were identified for an area of approximately 200 feet horizontally from the top of the slope. Land-use categories identified during this process included:

- Agriculture – 27.8%
- Barren – 0.1%
- Developed – 8.2%
- Forest – 60.3%
- Non-forested wetland – 0.4%
- Open water – <0.1%
- Restored – 1.1%
- Transportation – 2.1%

The land-use dataset was then loaded onto the Pentop field computer and hard copy field maps were developed for field personnel to reference throughout the FRR land-based survey. Land-use classifications were validated and updated, if needed, as part of the FRR land-based survey and the final land-use dataset was developed. Figures 3-1-3-5 provide examples of the Impoundment land-use maps developed as part of this effort. Land-use classifications and their potential contribution to bank instability and erosion will be investigated in greater detail in Study No. 3.1.2.

In addition to the development of a comprehensive land-use dataset, NEE identified and mapped sensitive receptor locations found along or near the riverbanks of the Impoundment. The primary goal of this survey was to identify, quantify and/or rank potentially sensitive features that may be affected by changes in the environment (including bank restoration efforts). The sensitive receptor field survey focused on documenting actual habitat and classified each site by function (e.g., nesting, mating, breeding, etc.).

Sensitive receptor mapping was conducted over 15 non-consecutive days by NEE staff from August to December 2013. Three wildlife biologists conducted bank surveys from a motor boat by visually scanning banks for sensitive receptor sites using 10x42 strength binoculars and a Canon EF 70-200mm f/2.8 L lens. To maximize observation success, the survey was conducted by boat traveling at a slow speed close to the shore of each bank. The coordinates of sensitive receptor locations were recorded with a Trimble GeoExplorer 6000 series XT with sub-meter accuracy GPS. Points were collected from the toe or the top of the slope, even in cases where a receptor site was located mid-bank. Occasionally several

[13] Report sections discussing the 2013 FRR provide a preliminary, high level overview of the field efforts conducted during the 2013 FRR survey. For the most up to date, detailed information regarding the 2013 FRR refer to FirstLight's 2013 Full River Reconnaissance Survey report filed with FERC on September 15, 2014.

bank nests were located communally and only 1 point was collected. Spatial attribute data gathered included the number of cavities and the number of unique species in such cases as well as field notes, x and y coordinates, and endangered status. Overall, 31 sensitive receptor locations were identified. Figures 3-6-3-10 present sensitive receptor maps based on the field work conducted in 2013.[14]

[14] Due to the fact that the sensitive receptor survey will be completed in 2014, the locations presented in Figures 3-6-3-10 should be considered preliminary. As such all sensitive receptor maps are labeled as “Draft.”

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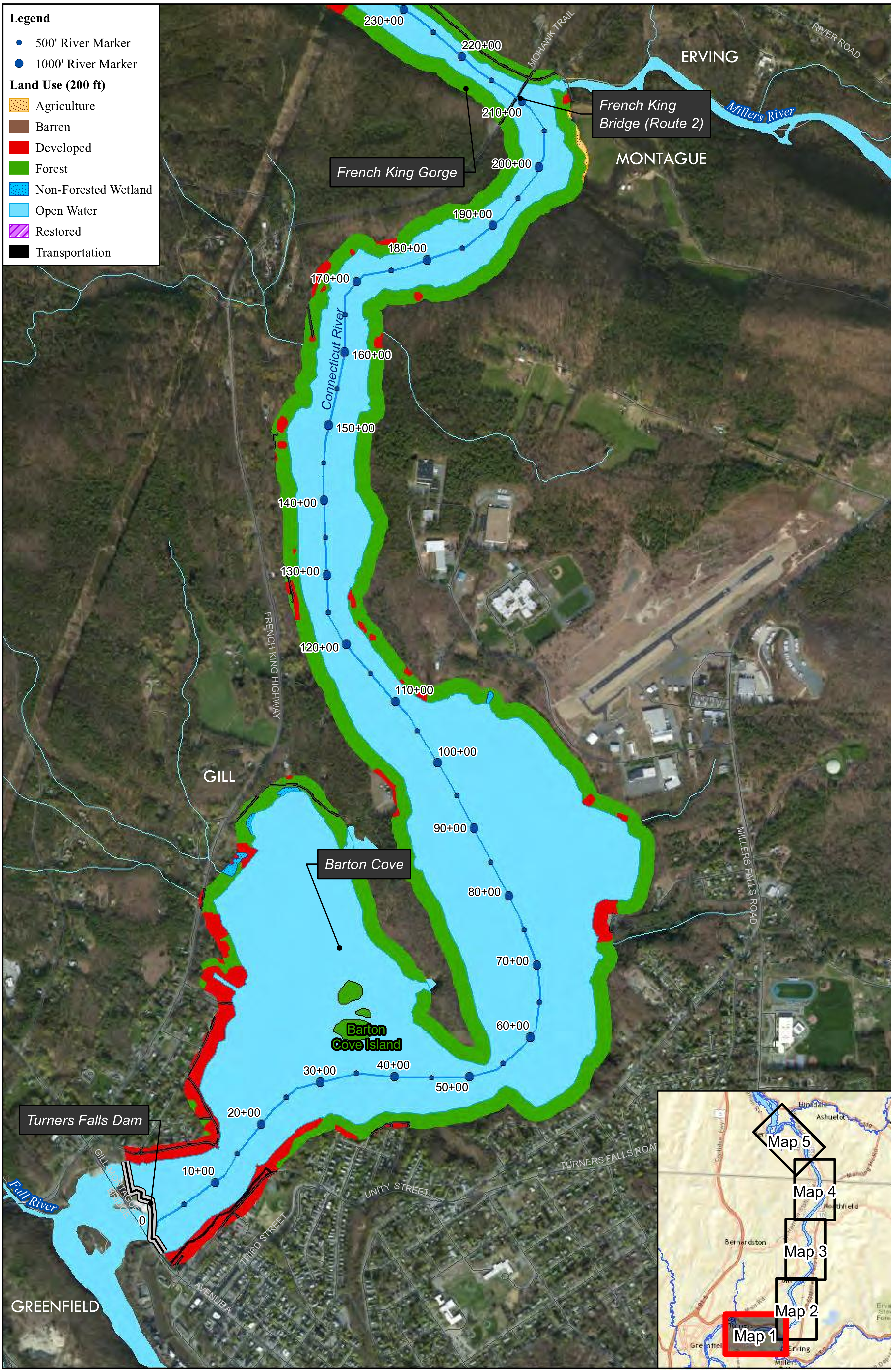

FirstLight GDF SUEZ

FIRSTLIGHT POWER RESOURCES

RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 3-1:
Land Use Classifications
within 200 ft of Connecticut River
Map 1

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan,

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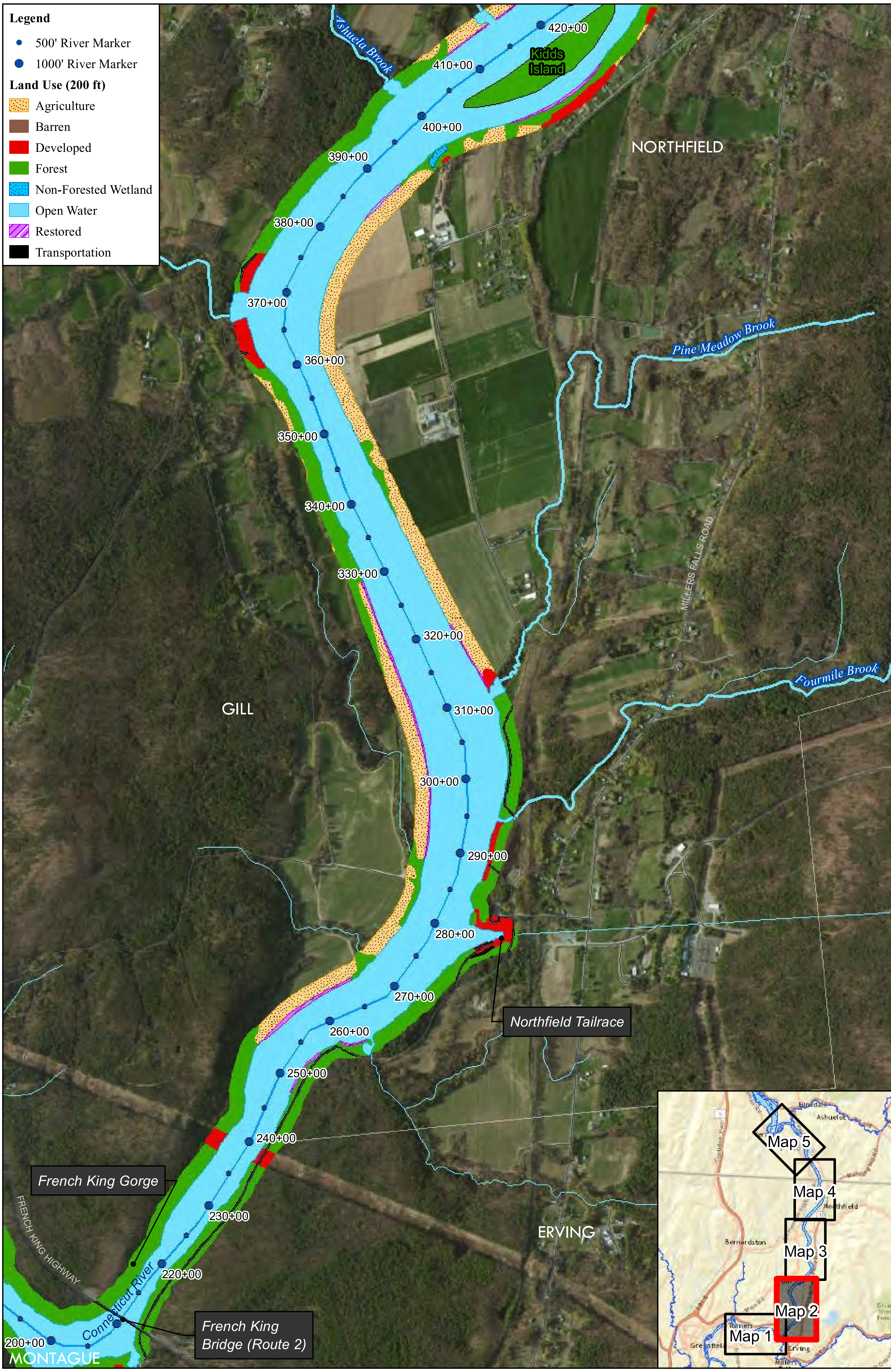

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

N

Figure 3-2:
Land Use Classifications
within 200 ft of Connecticut River
Map 2

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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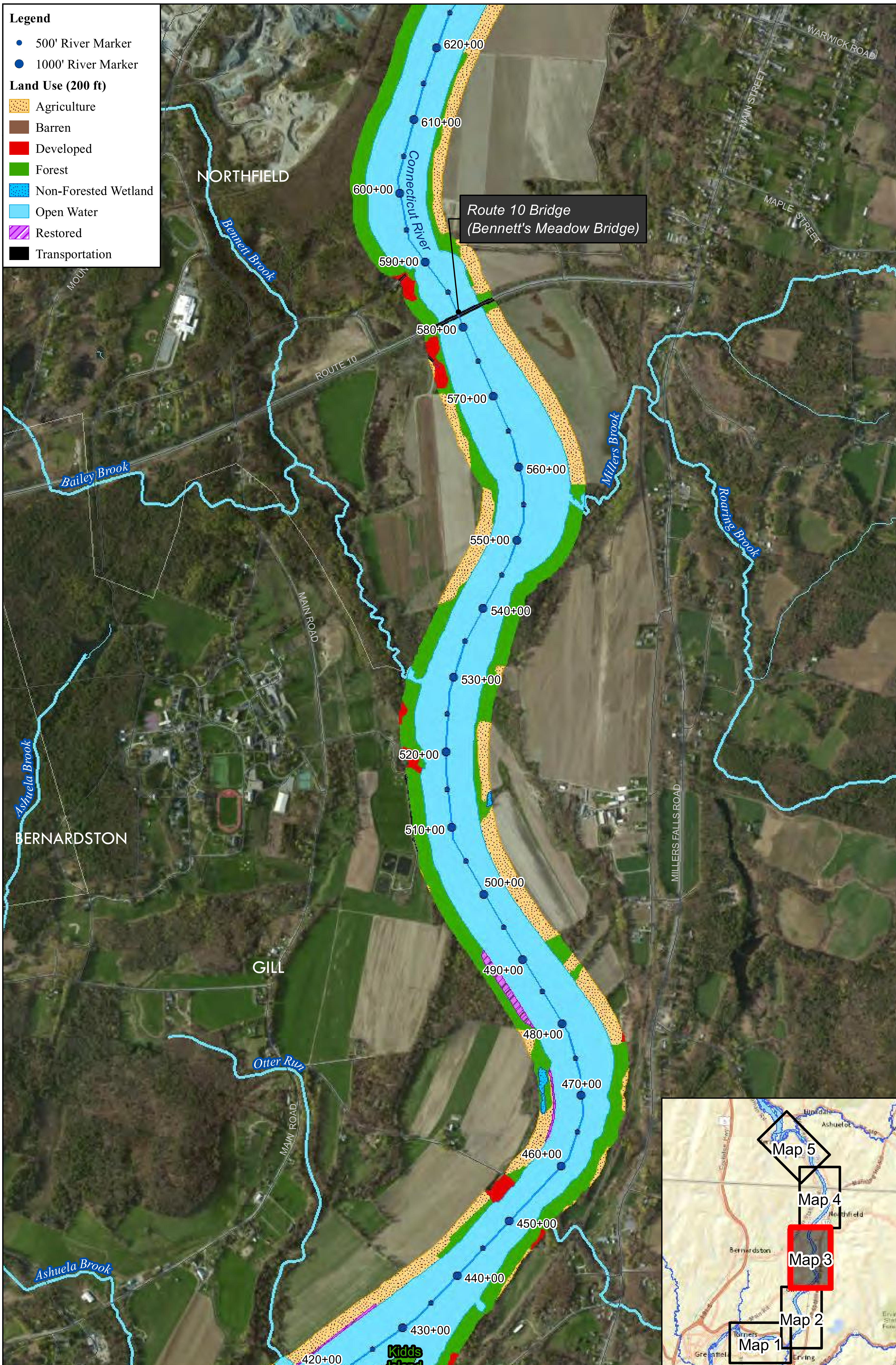

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

N

0 625 1,250 2,500 Feet

Figure 3-3:
Land Use Classifications
within 200 ft of Connecticut River
Map 3

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan,

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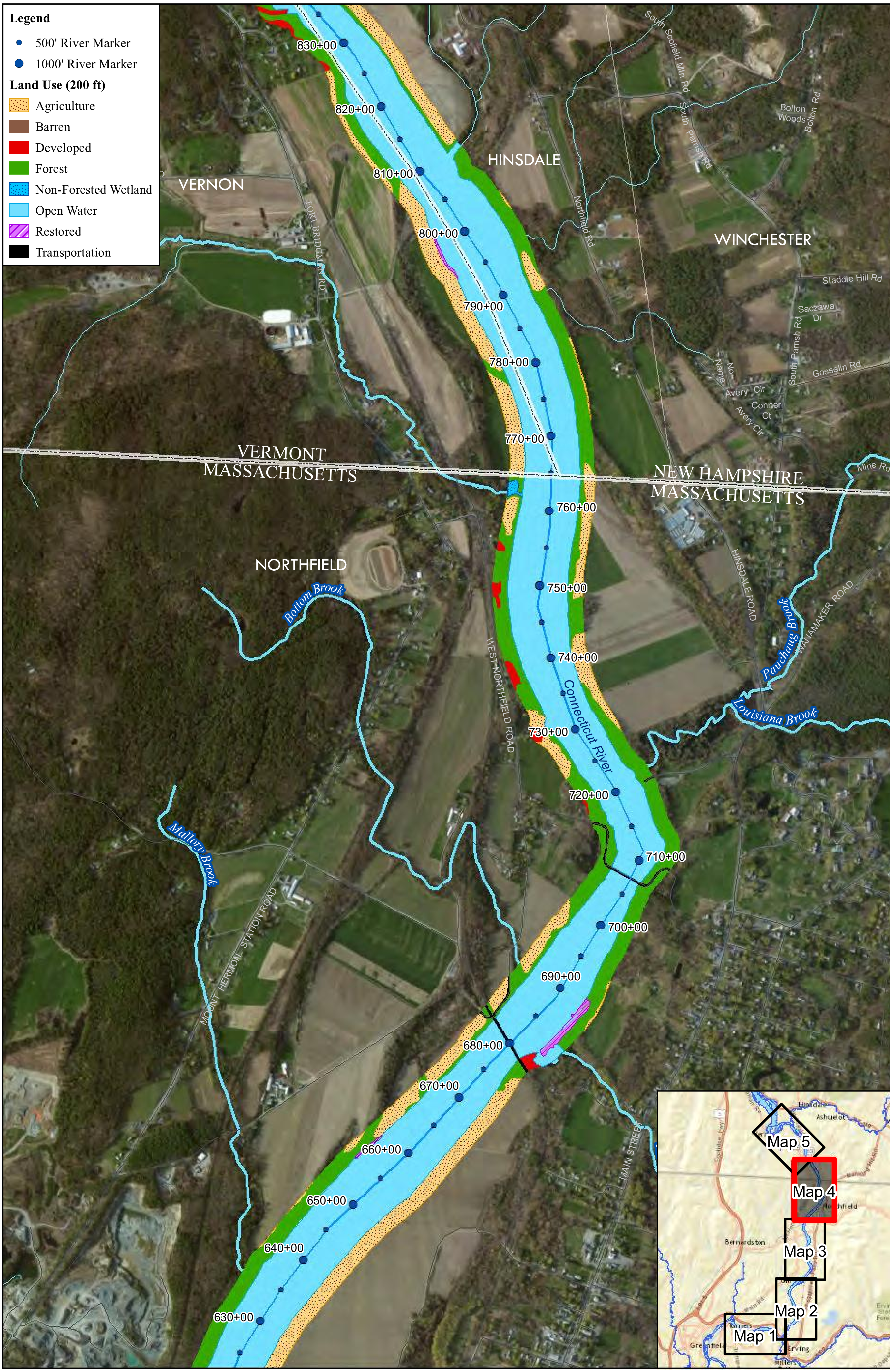

FirstLight GDF SUEZ

N

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 3-4:
Land Use Classifications
within 200 ft of Connecticut River
Map 4

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan,

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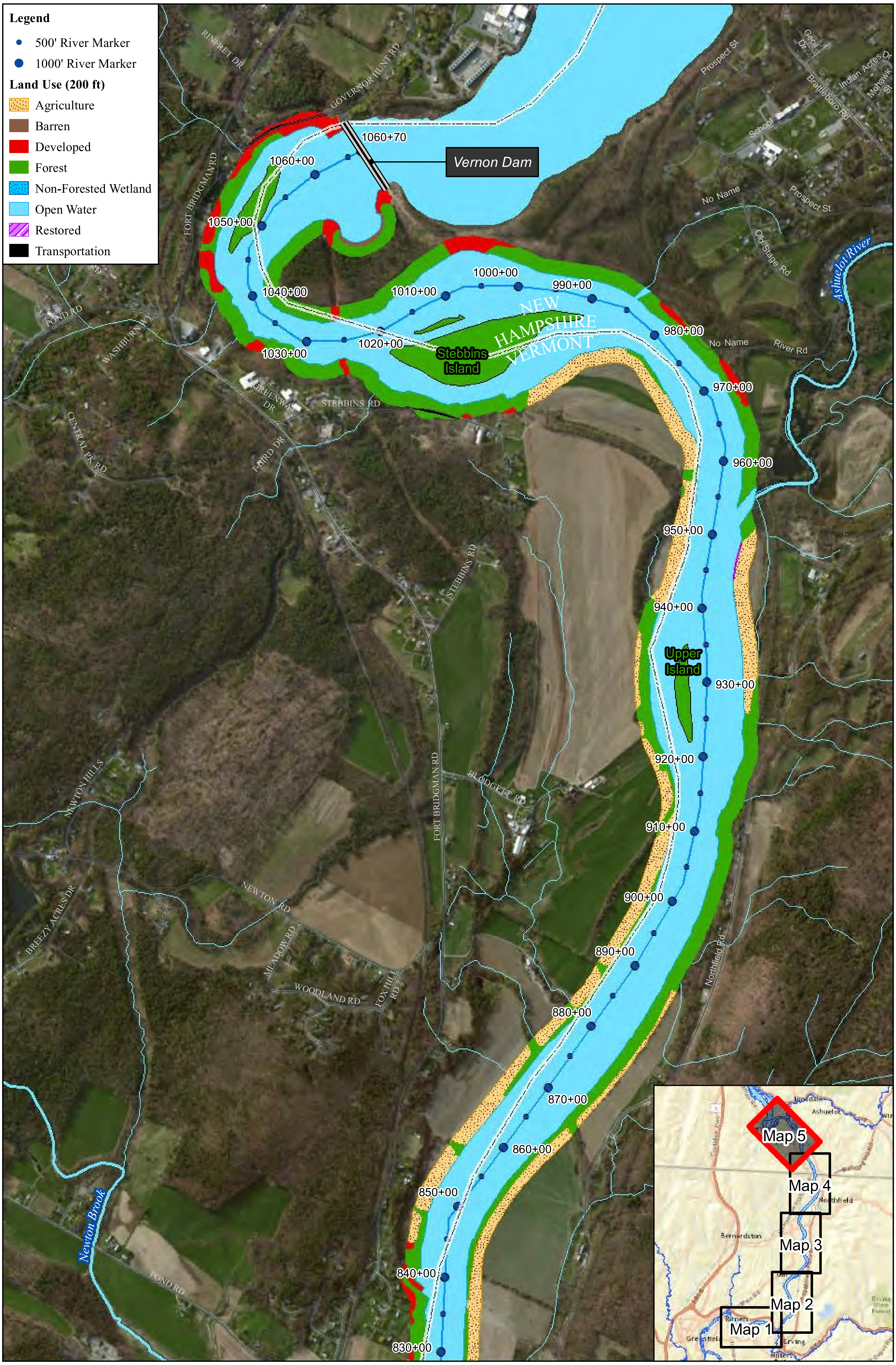

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 3-5:
Land Use Classifications
within 200 ft of Connecticut River
Map 5

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan,

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FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 3.6:
Sensitive Receptors
Map 1

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors,

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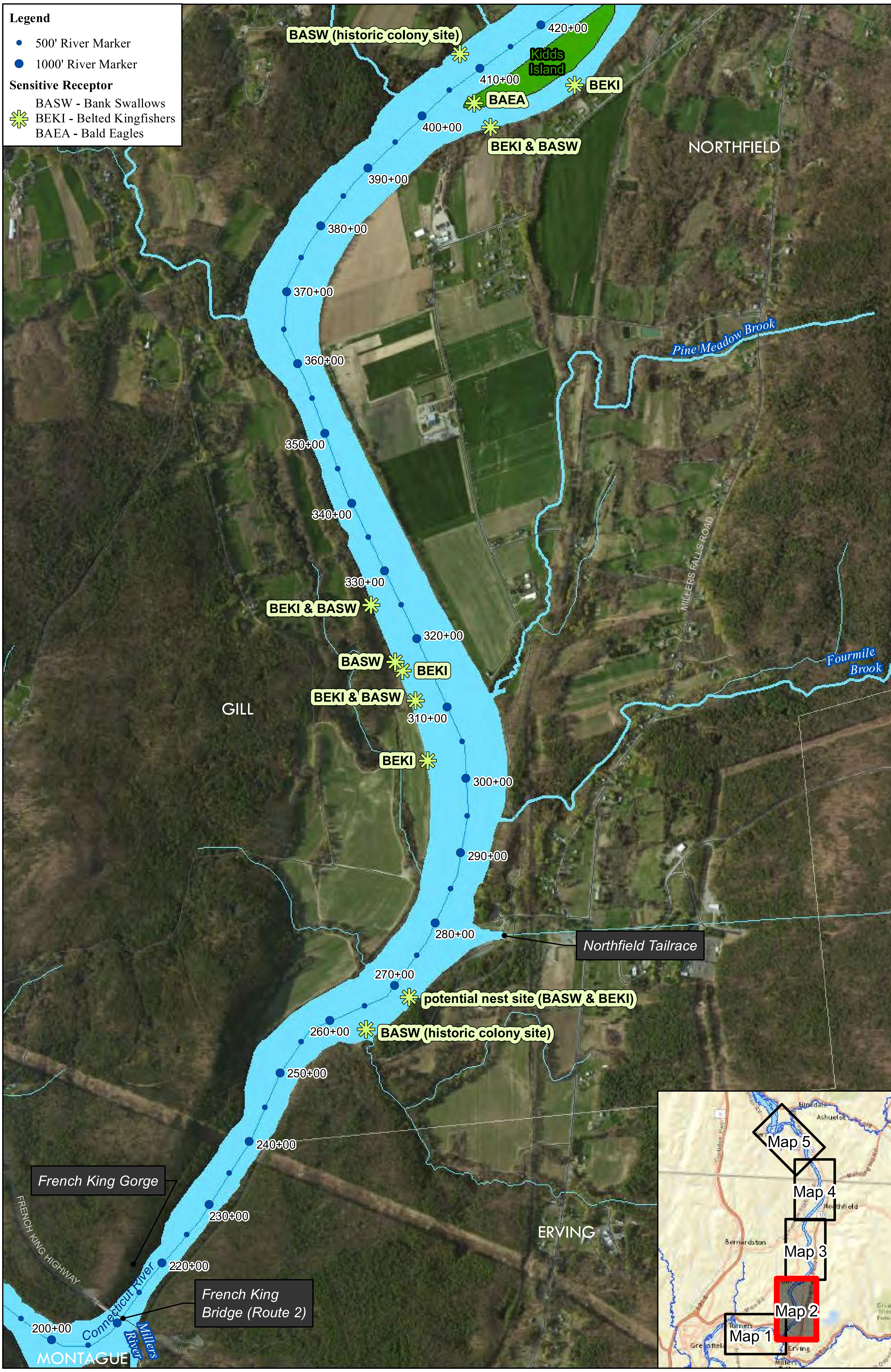

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FIRSTLIGHT POWER RESOURCES

RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 3.7:
Sensitive Receptors
Map 2

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors,

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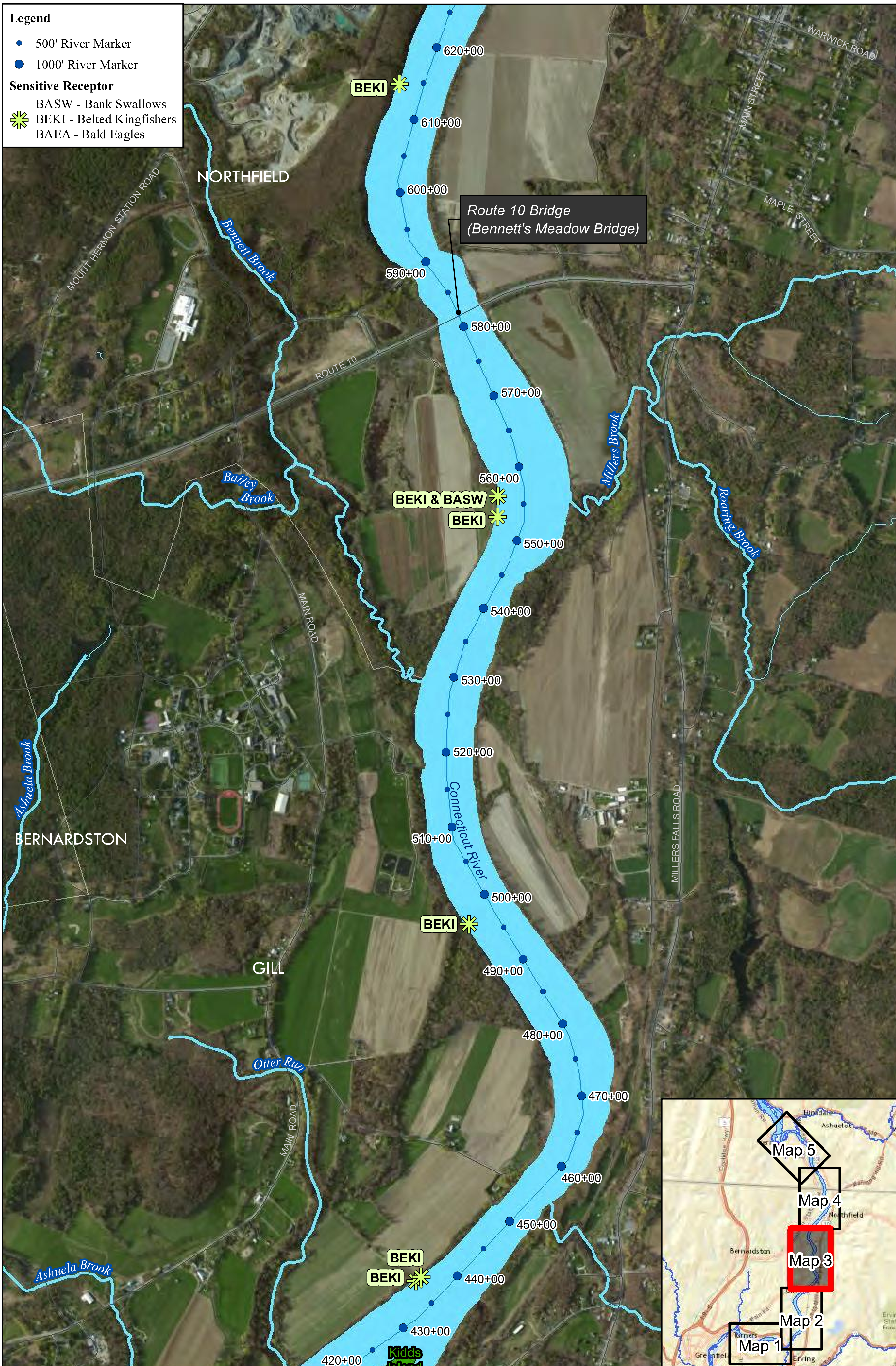

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

N

Figure 3.8:
Sensitive Receptors
Map 3

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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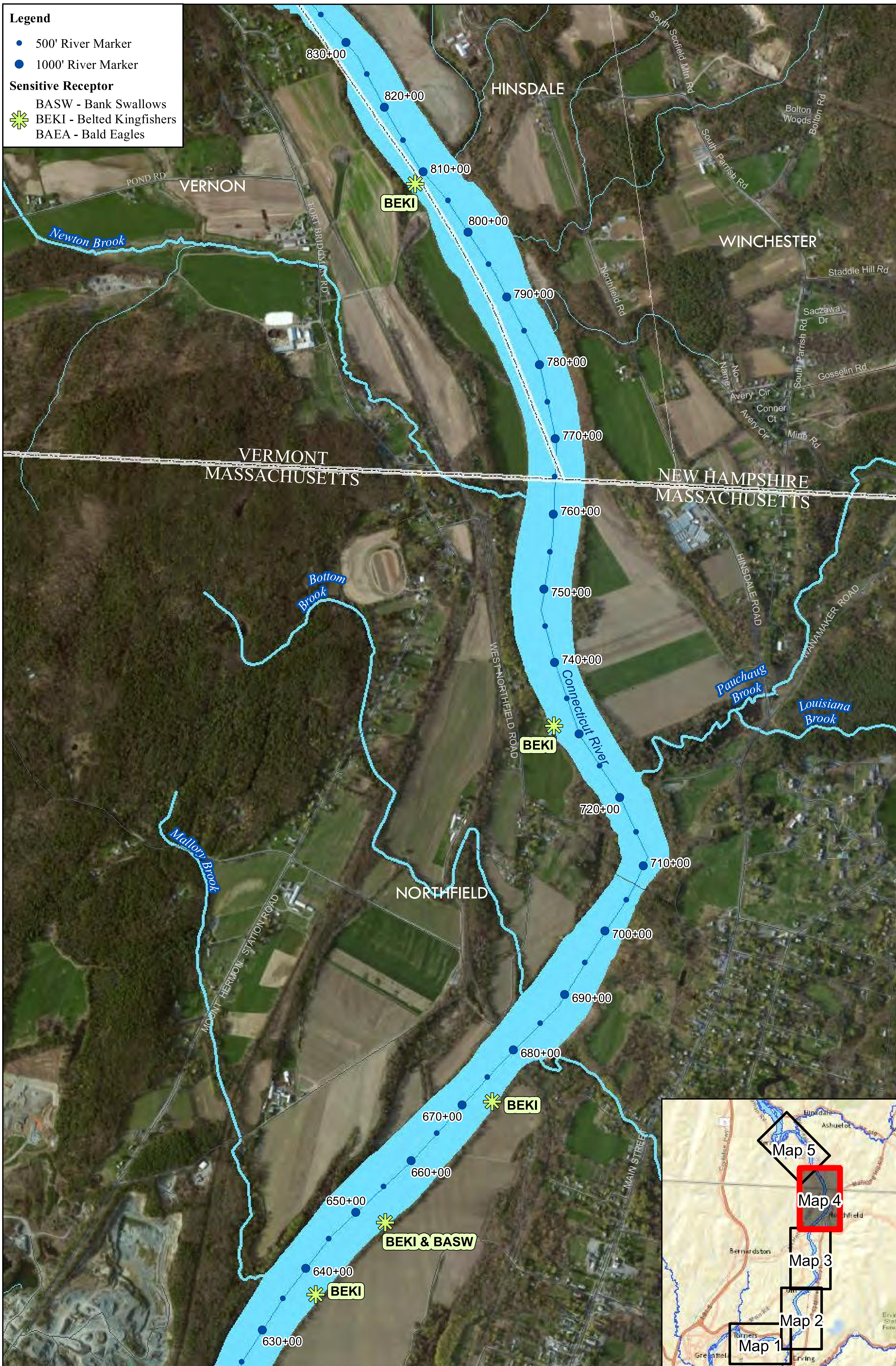

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 3.9:
Sensitive Receptors
Map 4

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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FIRSTLIGHT POWER RESOURCES

RELICENSING STUDY 3.1.2

NORTHFIELD MOUNTAIN/TURNERS FALLS

OPERATIONS IMPACT ON

EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 3.10:
Sensitive Receptors
Map 5

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors,

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4 FULL RIVER RECONNAISSANCE - LAND-BASED SURVEY[15]

As part of the 2013 FRR, a land-based survey was conducted from November 11-19 and December 10-13, 2013 to identify and define indicators of potential erosion and bank instability as well as erosion features that may not have been readily visible during the boat-based survey (Section 5). In addition, land-use classifications and sensitive receptor locations previously identified were validated and updated as needed. The land-based survey consisted of walking along the top of the riverbanks on both sides of the river throughout the extent of the Impoundment, including islands, except in areas where: 1) access was not possible or the area was deemed impassible; 2) access was unsafe; or 3) bank conditions did not warrant assessment (e.g. bedrock areas).

Figures 4-1-4-5 denote the areas walked during the land-based survey. The light green lines depicted in the figures highlight the longitudinal extent of the riverbanks which were walked by field personnel. Upon review of these figures it will be observed that a few short segments of riverbank were not walked. These areas were not surveyed due to the reasons discussed above. In addition, three islands were not assessed at the time of the survey due to lack of boat access as hard winter weather prevailed starting in mid to late December. These islands were revisited in the early summer 2014 once weather conditions improved, flow conditions receded, and accessibility was no longer an issue.

Field efforts associated with the FRR land-based survey consisted of four tasks: 1) delineation of riverbank segments based on common features and characteristics; 2) identification of pertinent attributes such as indicators of potential erosion and various geomorphic and geotechnical observations; 3) detailed geotechnical and geomorphic assessments areas of interest; and 4) validation of previously identified land-use classifications and sensitive receptor locations. Data was collected in a variety of ways including: hard copy datasheets, GPS enabled digital photographs, dataloggers, and a Pentop computer equipped with GPS and ArcGIS.

Riverbank segments were delineated based on common features and characteristics as observed by field personnel while traversing the riverbanks. The GPS enabled Pentop computer was preloaded with an ArcGIS application which was used to delineate segments and capture pertinent attributes. The ArcGIS application contained aerial photography of the study area, data layers and data dictionaries which could be edited directly in the field, and various support datasets (i.e. land-use, sensitive receptors, surficial geology, etc.). Table 4-1 provides an example of the attributes captured using this application. In addition to delineating riverbanks, the ArcGIS application was also used to capture the location and attributes of pertinent geomorphic or geotechnical features. GPS enabled photographs were captured for all segments and features while pertinent photo information was stored in the ArcGIS application.

Detailed geotechnical and geomorphic assessments were conducted at 38 locations throughout the Impoundment (shown as a green dot and numbered on Figures 4-1-4-5). Detailed assessment sites were selected by the geotechnical engineer or fluvial geomorphologist at locations where features of particular geomorphic or geotechnical interest existed or, in some cases, where features and characteristics were representative of a given area.[16] Sites selected for detailed assessment exhibited a wide range of riverbank conditions from low, well vegetated or stabilized areas to areas of riverbank erosion or

[15] Report sections discussing the 2013 FRR provide a preliminary, high level overview of the field efforts conducted during the 2013 FRR survey. For the most up to date, detailed information regarding the 2013 FRR refer to FirstLight's 2013 Full River Reconnaissance Survey report filed with FERC on September 15, 2014.

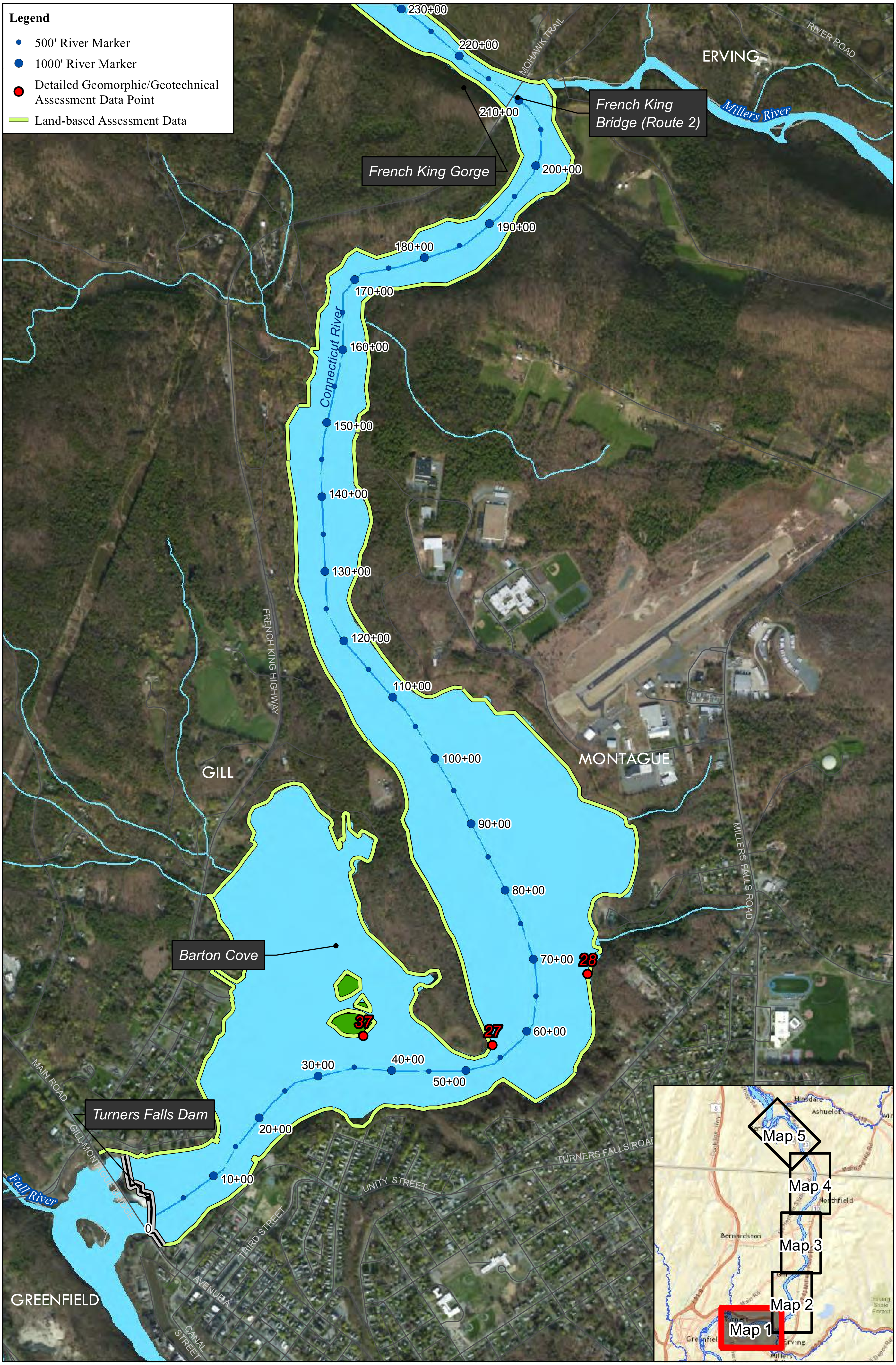
[16] Detailed site assessments were not conducted at every land-based segment but instead only at areas of interest as noted by the geotechnical engineer and/or fluvial geomorphologist. In the event that a detailed assessment was not conducted at a given land-based segment, the combination of the land and boat-based surveys ensured comprehensive coverage of all riverbanks throughout the Impoundment.

instability where vegetation was not as prevalent. Observed sites also included areas where recent stabilization occurred which employed newer techniques such as large woody debris and vegetation only. The detailed geotechnical and geomorphic assessments were conducted in addition to the land-based methodology required by the RSP. The assessments were used to complement observations made while traversing the riverbanks.

Once a site was selected for assessment, both the top and bottom of the bank was investigated in detail. Field datasheets were completed (including site sketches) and GPS enabled digital photographs were captured at the 36 locations. An example of a completed datasheet used for these assessments can be found in Figure 4-6. The results of the detailed site assessments were used to help inform selection of the transects and detailed study points discussed in Section 7.

Table 4-1 Land-based Survey ArcGIS Application Attributes

Attribute Field	Description
ID	Riverbank segment ID number
Station Number	River marker station number
Photo Numbers	Description of all photos taken at segment including photo numbers
Riverbank	Drop-down list – Options: Right or Left
Personnel	Field personnel present for classification
Date	Date of classification
Previously Stabilized	Drop-down list – Options: Yes or No
Geotechnical Observations	Text field for geotechnical observations
Field Observations	Text field for general field observations
Erosion Type	Major and minor erosion types present along segment. Drop-down list – Options: Planar Slip / Flow / Falls – Undercut / Falls – Gullies / Topples / Slide or Flow / Rotational Slump
Indicators of Potential Erosion	Major and minor indicators of potential erosion present along segment. Drop-down list – Options: Tension Cracks / Exposed Roots / Creep or Leaning Trees / Overhanging Bank / Notching / Other
% Vegetative Cover – Top / Face / Toe	% of vegetative cover at the top, face, and toe of segment. Drop-down list – Options: None to Very Sparse (<10%) / Sparse (10-25%) / Moderate (25-50%) / Heavy (>50%)
Max Root Depth – Top / Face / Toe	Approximation of max root depth at the top, face, and toe of segment
Vegetative Type – Top / Face / Toe	Description of vegetative type present at the top, face, and toe of segment
Stratigraphy Material(s)	Description of the stratigraphy material present
Stratigraphy Color(s)	Description of the stratigraphy color
Stratigraphy Thickness	Approximation of the stratigraphy thickness
Stratigraphy Notes	General notes on stratigraphy present
Adjacent Land-Use	Description of adjacent land-use
Sensitive Receptors	Description of any sensitive receptors present
Notes	General notes
Segment Length	Length of riverbank segment in feet



FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 4-1:
Land Based Survey
Map 1

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

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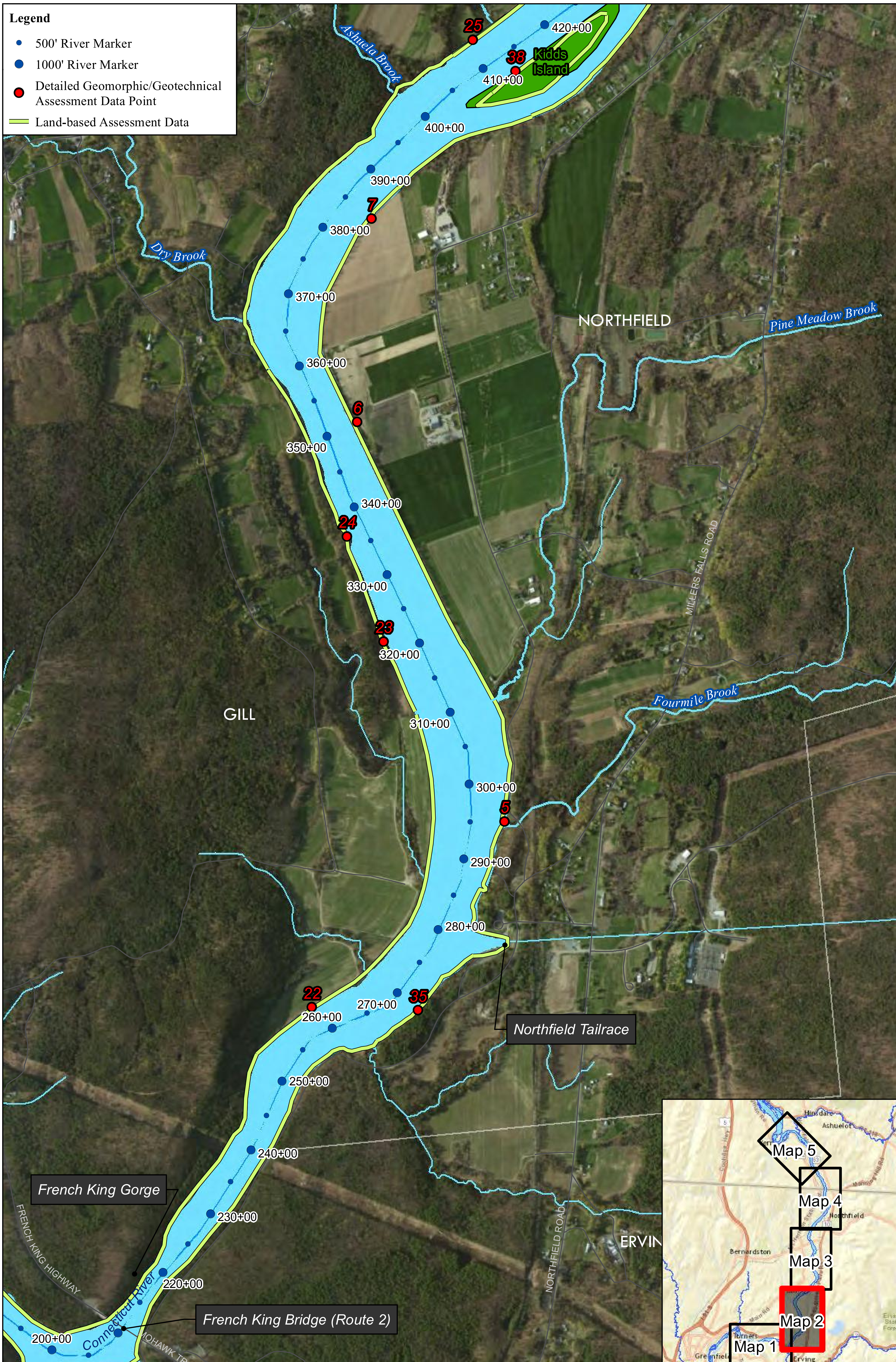

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OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 4-2:
Land Based Survey
Map 2

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

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NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 4-3:
Land Based Survey
Map 3

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

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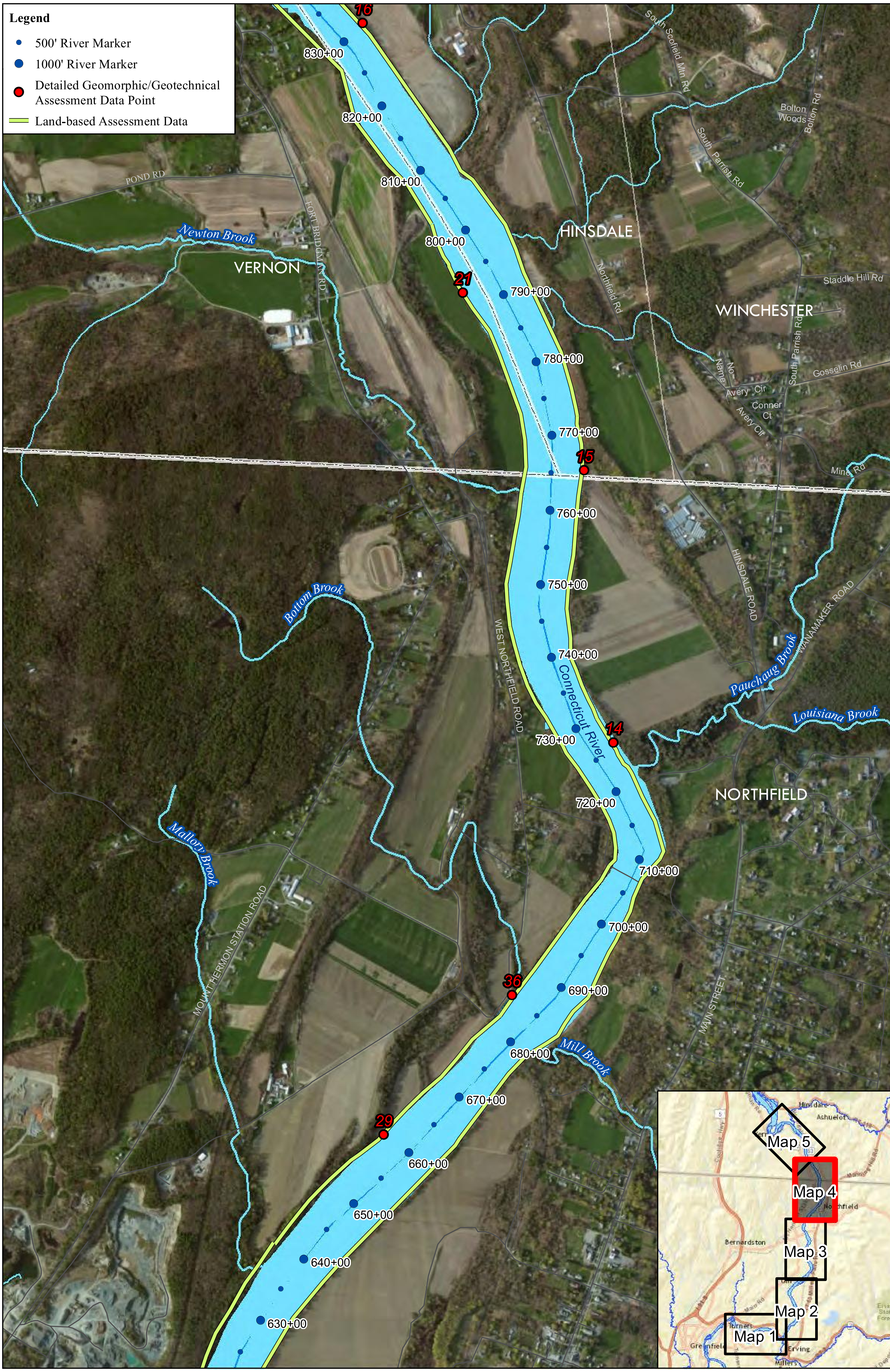

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FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500
Feet

Figure 4-4:
Land Based Survey
Map 4

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

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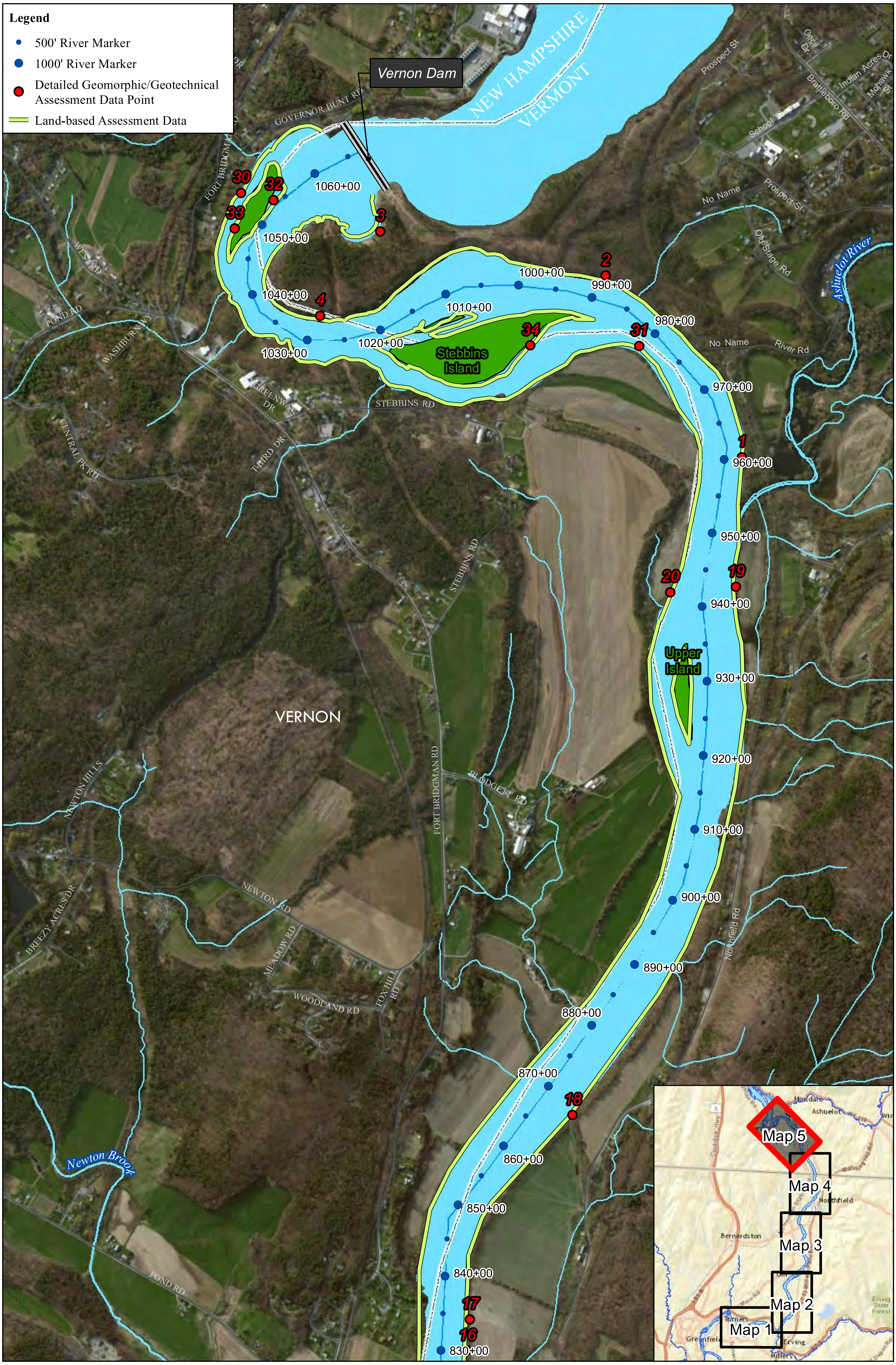

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RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 4-5:
Land Based Survey
Map 5

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

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Figure 4-6 Detailed Land-Based Geotechnical/Geomorphic Assessment Datasheet Example

Connecticut River – Turners Falls Impoundment Riverbank Classification for Land-Based Survey

Observation Point Number: *29* **Personnel:** *YKC, MM, CM*

Date: *November 19, 2013* **Time:** *9:30 am*

Station Number:*659+00 (Note 1)* **Photo Reference Numbers:** *740 – 744*
Note 1 – Observed area is just upstream of Wickey Site. River was high, and beach area was submerged.

Left or Right Bank (Looking Downstream): *Right*

Length of Representative Segment, From Station Number *640+00* **To Station Number** *680+00*

Previously Stabilized? *No*

Geologic / Geotechnical Observations:

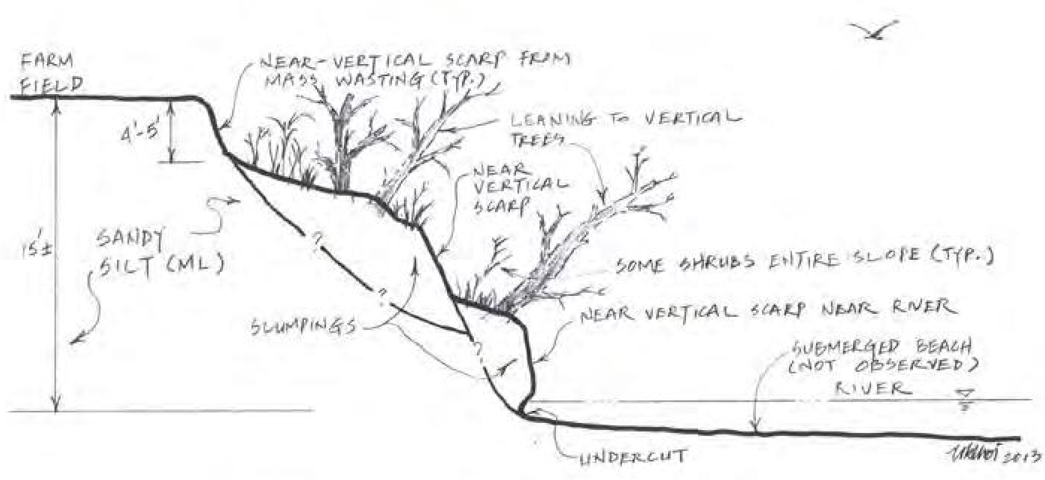
Stratigraphy:
(Refer to Site Sketch below for locations of soil/rock layers
Notations in parentheses are based on Unified Soil Classification System)

SANDY SILT (ML) – Nonplastic, 10% - 20% fine sand, gray.

Observed Erosion Features:

- *Mass-wasting along entire slope, with near-vertical slide scarps exposed.*
- *Slumpings of materials, with some leaning trees.*
- *Undercuts at river level below near-vertical scarps.*

Site Sketch:



SECTION – OBSERVATION PT. No. 29
NOT TO SCALE

5 FULL RIVER RECONNAISSANCE - BOAT-BASED SURVEY[17]

A boat-based survey was conducted simultaneously with the FRR land-based survey in accordance with feedback received from the MADEP. The boat-based survey was conducted from November 11-19, 2013 to identify riverbank features and characteristics as well as the type(s), stage(s), and extent of erosion found throughout the Impoundment. Riverbank segments were identified and delineated based on common features and characteristics using the methodology and classification criteria outlined in the RSP (FirstLight, 2013) and QAPP (Simons, 2013). All riverbanks throughout the Impoundment, including islands, were assessed during the survey with the exception of the right-channel of the island just downstream of Vernon Dam. This location was not surveyed as it was inaccessible due to low flows; however, it was assessed during the FRR land-based survey.

All field work associated with this component of the FRR was conducted from a slow moving boat located a relatively short distance from shore. Specific tasks completed during the boat-based survey included: 1) spatially defining riverbank transition points; 2) classification of riverbank features and characteristics; 3) identification of the type(s), stage(s), indicators, and extent of erosion; and 4) collection of geo-referenced video and photographic documentation. All classification of riverbank characteristics and erosion features conducted during the boat-based survey were based on the criteria found in Table 5-1 as well as the methodology contained in the RSP (FirstLight, 2013) and QAPP (Simons, 2013).

Transition points where riverbank features and characteristics changed from one classification to another were identified and their locations were shot using a sub-meter GPS and laser rangefinder. Once the location of the transition point was shot with the laser rangefinder collection of a GPS point, corresponding offset distance, and angle were triggered on the boat. The combination of these measurements was used to automatically calculate the coordinates of the transition point. These coordinates were then automatically recorded on a datalogger. Once the location of each transition point was captured, observations of riverbank features and characteristics as well as pertinent erosion features for each segment were entered into the datalogger. This procedure was repeated along the entire length of the Impoundment during the field data collection period.

The boat-based survey identified a total of 596 individual riverbank segments covering both banks of the Impoundment. The sum of the segment lengths for both banks totals 228,009 ft (43.2 miles). Riverbank segment lengths range from a minimum of 13 ft to a maximum of 3,330 ft, with an average segment length of 383 ft. Another 40 segments were identified along islands in the Impoundment totaling 20,952 ft (3.97 miles) in length with segment lengths ranging from 62 to 2247 feet, averaging 465 feet long.

In addition to the erosion classification discussed above, two virtually complete set of images (geo-referenced digital photographs and videos) were collected during the FRR boat-based survey to document riverbank conditions along the Impoundment as they existed in November and December 2013. These photographs will be part of the 2013 FRR Report.

[17] Report sections discussing the 2013 FRR provide a preliminary, high level overview of the field efforts conducted during the 2013 FRR survey. For the most up to date, detailed information regarding the 2013 FRR refer to FirstLight's 2013 Full River Reconnaissance Survey report filed with FERC on September 15, 2014.

Table 5-1 Connecticut River – Turners Falls Impoundment Riverbank Classifications for Boat-based Survey[18]

UPPER RIVERBANK CHARACTERISTICS[19]						
Upper Riverbank Slope	Overhanging *>90°*	Vertical *90°*	Steep *(>2:1)*	Moderate *(4:1-2:1)*	Flat *(<4:1)*	
Upper Riverbank Height *(total height above normal river level)*	Low *(<8 ft.)*	Medium *(8-12 ft.)*	High *(>12 ft.)*			
Upper Riverbank Sediment	Clay *(.001-.062mm)*	Silt/Sand *(.062-2 mm)*	Gravel *(2-64mm)*	Cobbles *(64-256mm)*	Boulders *(256-2048mm)*	Bedrock
Upper Riverbank Vegetation	None to Very Sparse *(<10%)*	Sparse *(10%-25%)*	Moderate *(25%-50%)*	Heavy *(>50%)*		
Sensitive Receptors	*Descriptions of important wildlife habitat use on or near the riverbanks such as bank swallow colonies, kingfisher nests, eagle nests, prime odonate and mussel habitat, etc.*					
LOWER RIVERBANK CHARACTERISTICS						
Lower Riverbank Slope	Vertical *90°*	Steep *(>2:1)*	Moderate *(4:1-2:1)*	Flat / Beaches *(<4:1)*		
Lower Riverbank Sediment	Clay *(.001-.062mm)*	Silt/Sand *(.062-2 mm)*	Gravel *(2-64mm)*	Cobbles *(64-256mm)*	Boulders *(256-2048mm)*	Bedrock
Lower Riverbank Vegetation	None to Very Sparse *(<10%)*	Sparse *(10%-25%)*	Moderate *(25%-50%)*	Heavy *(>50%)*		
Sensitive Receptors	*Descriptions of important wildlife habitat use on or near the riverbanks such as bank swallow colonies, kingfisher nests, eagle nests, prime odonate and mussel habitat, etc.*					
EROSION CLASSIFICATION						
Type(s) of Erosion	Falls – Undercut	Falls – Gullies	Topples	Slide or Flow	*Planar Slip* *Rotational Slump* *Flow*	
Indicators of Potential Erosion	Tension Cracks	Exposed Roots	Creep/ Leaning Trees	Overhanging bank	Notching	Other
Stage(s) of Erosion	Potential Future Erosion	Active Erosion	Eroded	Stable		
Extent of Current Erosion	None/Little *(<10%)*	Some *(10%-40%)*	Some to Extensive *(40%-70%)*	Extensive *(>70%)*		

[18] RSP Table 3.1.1-2 (FirstLight, 2013)
[19] All quantitative classification criteria (e.g. slope, height, vegetation, extent, etc.) were based on estimates made during field observations of riverbanks. The FRR is a reconnaissance level survey that did not include quantitative field measurements of characteristics.

6 SELECTION METHODOLOGY FOR CALIBRATION AND REPRESENTATIVE LOCATIONS FOR DETAILED STUDY

To gain a thorough understanding of the causes of erosion, the forces associated with them, and their relative importance at a particular location FirstLight has developed a methodology to identify and select a number of calibration and representative locations where investigation and analyses will occur as part of Study No. 3.1.2. For the purpose of this report a calibration location is defined as a detailed study site established at an existing, permanent transect where data collection will occur to calibrate the BSTEM model. Representative locations are defined as detailed study sites established throughout the Impoundment at locations that exhibit a representative range of riverbank features, characteristics and erosion conditions (as defined by Table 6-1). A representative location can be established at an existing, permanent transect or a newly identified detailed study site. The final set of representative locations is a combination of existing, permanent transects and newly identified detailed study points that span the geographic extent and range of riverbank features observed in the Impoundment.

An existing, permanent transect is a permanently established cross-section that has been surveyed from one bank, across the river, to the other bank. Typically a benchmark with a known vertical and horizontal datum is placed on the endpoints such that future surveys can be compared. Due to varying hydraulic and geomorphic conditions found along a river, riverbank features, characteristics, and erosion conditions can vary from one bank to the other at a given transect. As such, each transect represents two potential detailed study points (right and/or left bank). A detailed study point is defined as the specific location (right or left bank) where detailed investigation, field data collection, and analyses will occur. As a result of these varying riverbank conditions it may not be relevant to the study objectives to conduct detailed investigation at both banks of a given transect. Furthermore, newly identified supplemental representative detailed study sites are selected at only one bank. In the event that only one riverbank has been selected to be investigated in detail, a complete cross-section survey from one river bank, across the channel bed, and up the other river bank will still be conducted at each detailed study site so that hydraulic and erosion analyses can occur. Permanent markers will be placed on both banks denoting the start/end points of the cross-section survey (if they do not already exist).

Field data collection at detailed study sites will occur at several points on the bank to define soil characteristics such as soil layering and thicknesses, particle size distribution, friction angle, cohesion, saturated unit weight, ϕb (angle representing the relation between the shear strength and matric suction), critical shear, and erodibility coefficient. These data will be utilized in modeling and analyzing the processes of erosion and stability at each site and to develop input parameters for the BSTEM model. These parameters combined with changes in channel geometry based on existing, permanent transect surveys over time and concurrent hydrologic/hydraulic data (flow and water levels) will be used to calibrate the BSTEM model. Additional analysis and field data collection related to ice, adjacent land-use, and hydrodynamic forces due to boat waves will also be investigated at each detailed study site.

Once the BSTEM model is adequately calibrated using the historic survey data and 2014 field collected data, model runs will be executed at the representative detailed study points. Model parameters regarding erosion and geotechnical properties at representative sites will be adjusted by applying information learned from the calibration process at calibration locations that are similar to the representative sites based on comparing soil and erosion characteristics between calibration and representative sites. In other words, adjustments to parameters made at calibration sites through the calibration process will be applied to parameters at similar representative sites based on soil and erosion characteristics. The results of the erosion and stability analyses at the representative locations will then be extrapolated to the entire Impoundment based on common riverbank features and characteristics.

The selection of calibration and representative locations for detailed study was based on field observations made during the 2013 FRR, analysis of 2013 FRR data, and field examination of the existing, permanent transects currently established throughout the Impoundment (Figures 7.1-1-7.1-6). The final list of calibration and representative locations that will be used during Study No. 3.1.2 are presented in Section 7.

The first potential set of calibration or representative locations could be selected from the existing, permanent transects located throughout the Impoundment. Existing, permanent transects were established in areas where erosion had been known to occur dating back to the 1990's. Channel geometry survey data of these transects will be very useful in examining the extent of riverbank changes over time and for calibration of the BSTEM model. To determine if some or all of the existing, permanent transects are representative of the riverbank features, characteristics, and conditions found throughout the Impoundment, comparisons were made between the results of the 2013 FRR and the results of the existing, permanent transect assessments.

To be representative of riverbank conditions found in the Impoundment, the final list of representative detailed study locations selected for investigation and analyses include:

- Locations where riverbanks are stable (including at least one site where bank stabilization has occurred as a result of the ECP (Simons, 1999) and at least one site that is naturally stable with no bank stabilization work present);
- Locations where the potential for future erosion is low;
- Locations where the potential for future erosion is high; and
- Locations where active erosion is occurring (FirstLight, 2013)

Due to the nature of this study, the majority of the representative locations selected for detailed study are located in areas where erosion has the potential to occur, is actively occurring, or has occurred.

In addition to being representative of riverbank erosion conditions, the final list of representative detailed study locations is representative of the various riverbank features and characteristics present throughout the Impoundment. Based on review of historic geomorphic data combined with the results of the 2013 FRR a matrix was developed identifying the riverbank features and characteristics found throughout the Impoundment (Table 6-1). Categories highlighted in yellow represent characteristics that are indicative of areas where active erosion is most likely to occur or the potential for future erosion could be high. Special attention was paid to those categories which are highlighted in yellow when selecting the final list of representative detailed study locations as they are most pertinent to the objectives of this study.

Given that riverbank segments identified during the 2013 FRR have characteristics from multiple categories at a given location (e.g. vegetation, sediment, slope, etc.) the final set of representative locations for detailed study is based on representative combinations of the features and characteristics contained in Table 6-1.

Based on the comparison of the 2013 FRR results and the existing, permanent transect assessments FirstLight evaluated if: 1) the existing, permanent transects are adequate for this study; 2) the existing, permanent transects do not provide a representative dataset; or 3) the existing, permanent transects are duplicative and consist of several sites that have very similar features, characteristics, and/or conditions. If it was found that the existing, permanent transects did not provide a representative range of sites, a list of supplemental detailed study points was identified based on the results of the 2013 FRR land- and boat-based surveys. Conversely, if it was found that any of the existing, permanent transects were duplicative, those sites were removed from consideration to avoid duplicating efforts. As such, the final list of representative locations for detailed study are a combination of existing, permanent transect locations and supplemental detailed study sites identified during the 2013 FRR.

The specific methodology used for selecting the calibration and representative locations for detailed study consisted of four main steps; these steps included:

1. Evaluate Existing, Permanent Transects and Identify Calibration and/or Representative Locations for Detailed Study;

2. Identify Supplemental Representative Locations for Detailed Study;

3. Evaluate the Range of Riverbank Features and Characteristics of the Representative Locations Selected for Detailed Study; and

4. Evaluate the Geographic Distribution of the Representative Locations Selected for Detailed Study

Detailed descriptions of each step are found below.

Step 1: Evaluate Existing, Permanent Transects and Identify Calibration and/or Representative Locations for Detailed Study

Based on the existing, permanent transect assessment conducted during the 2013 FRR, transect locations were classified as: 1) calibration only sites; 2) both calibration and representative locations; or 3) eliminated from consideration. Riverbank features, characteristics, and erosion conditions found at the existing, permanent transects were analyzed and compared to the results of the 2013 FRR. Transects containing the riverbank features, characteristics, and erosion conditions of most interest (as defined in Table 6-1, highlighted categories) were selected for preliminary consideration as calibration and/or representative locations. All other existing, permanent transects were eliminated from consideration. A table was developed summarizing the features and characteristics of the proposed locations. Duplicative transects were removed from consideration as representative locations and instead identified as calibration only locations. Significant riverbank characteristic categories (those highlighted in yellow) that are not present at the representative existing, permanent transect locations were identified and supplemental detailed study points were selected (Step 2).

Step 2: Identify Supplemental Representative Locations for Detailed Study

Riverbank features and characteristics that were not present at the representative existing, permanent transect locations were supplemented with additional representative detailed study points. Supplemental representative detailed study points were proposed based on the results of the detailed geomorphic and geotechnical assessments conducted during the FRR land-based survey as well as the results of the FRR boat-based survey. The combination of representative existing, permanent transects and supplemental representative detailed study points resulted in a comprehensive set of locations which are representative of the significant features and characteristics found throughout the Impoundment (as defined in Table 6-1).

Step 3: Evaluate the Range of Riverbank Features and Characteristics of the Representative Locations Selected for Detailed Study

Once the preliminary list of representative locations selected for detailed study was selected the range of riverbank features and characteristics of these locations were evaluated to ensure they were representative of conditions found throughout the Impoundment (as defined in Table 6-1). The preliminary list was then revised as needed with any remaining gaps filled based on the results of the 2013 FRR. Conversely, duplicative locations were eliminated.

Step 4: Evaluate the Geographic Distribution of the Representative Locations Selected for Detailed Study

Using ArcGIS software and georeferenced photos and videos captured during the 2013 FRR, the geographic distribution of the representative locations selected for detailed study were evaluated to ensure they are distributed appropriately throughout the Impoundment. If necessary, the list of proposed representative locations was revised. Given the varying hydrologic and hydraulic conditions found throughout the Impoundment it was vital that the final list of selected transects be adequately distributed throughout the geographic extent of the Impoundment.

After completing this four step methodology FirstLight presented a list of proposed representative and calibration study sites to MADEP, CRSEC, CRWC, and FRCOG for review and comment. The proposed set of study sites was then updated and finalized based on feedback provided by MADEP and Stakeholders. The final set of detailed study sites, which reflect Stakeholder feedback and comments, are presented in Section 7.

Table 6-1 Turners Falls Impoundment Riverbank Features/Characteristics Matrix[20]

FEATURES	CHARACTERISTICS[21]					
Upper Riverbank Slope	Overhanging *>90°*	Vertical *90°*	Steep *(>2:1)*	Moderate *(4:1-2:1)*	Flat *(<2:1)*	
Lower Riverbank Slope[22]	Vertical *90°*	Steep *(>2:1)*	Moderate *(4:1-2:1)*	Flat / Beaches *(<2:1)*		
Upper Riverbank Sediment[23]	Clay *(.001-.062mm)*	Silt/Sand *(.062-2 mm)*	Gravel *(2-64mm)*	Cobbles *(64-256mm)*	Boulders *(256-2048mm)*	Bedrock
Lower Riverbank Sediment	Clay *(.001-.062mm)*	Silt/Sand *(.062-2 mm)*	Gravel *(2-64mm)*	Cobbles *(64-256mm)*	Boulders *(256-2048mm)*	Bedrock
Upper Riverbank Height	Low *(<8 ft.)*	Medium *(8-12 ft.)*	High *(>12 ft.)*			
Degree Upper Riverbank Vegetation	None to Very Sparse *(<10%)*	Sparse *(10%-25%)*	Moderate *(25%-50%)*	Heavy *(>50%)*		
Lower Riverbank Vegetation	None to Very Sparse *(<10%)*	Sparse *(10%-25%)*	Moderate *(25%-50%)*	Heavy *(>50%)*		
Extent of Current Erosion	None/Little *(<10%)*	Some *(10%-40%)*	Some to Extensive *(40%-70%)*	Extensive *(>70%)*		

[20] RSP Table 3.1.2-2 (FirstLight, 2013)
[21] Categories that are highlighted in yellow were identified as characteristics that are indicative of areas where active erosion is most likely to occur or the potential for future erosion is high. The highlighted categories also include a wide range of characteristics that are representative of riverbank conditions found in the Turners Falls Impoundment. Highlighted categories were identified based on review of historic geomorphic data and the results of the 2013 FRR. Transects and detailed study points that will be used for investigation and analyses associated with Study No. 3.1.2 were based on the highlighted categories.
[22] Vertical and Steep lower riverbank slopes are typically indicative or areas where active erosion is occurring or the potential for future erosion is high and therefore would normally be highlighted in yellow. These categories are not highlighted, however, as these specific riverbank conditions do not exist in the Impoundment.
[23] While clay, gravel, cobble, boulder, and bedrock upper riverbank sediments may exist in some locations throughout the Impoundment, these locations are rare and therefore are not representative of riverbank features and characteristics found in the study area. As such, these characteristics are not of interest to the objectives of this study.

7 REPRESENTATIVE AND CALIBRATION SITES FOR DETAILED STUDY

To satisfy the objectives of Study No. 3.1.2 FirstLight has identified 25 calibration and/or representative locations where detailed investigation and analyses will occur. The selected locations were identified based on the results of the 2013 FRR land- and boat-based surveys as well as evaluation of the existing, permanent transects. For the purpose of this report a calibration location is defined as a detailed study site established at an existing, permanent transect where data collection will occur to calibrate the BSTEM model. Representative locations are defined as study sites established throughout the Impoundment at locations that exhibit a representative range of riverbank features, characteristics and erosion conditions (as defined by Table 6-1). A representative location can be established at an existing, permanent transect or a newly identified site.

Utilizing the methodology discussed in Section 6 combined with MADEP and Stakeholder feedback FirstLight identified 16 representative locations for detailed investigation and analyses. The 16 representative sites are evenly distributed throughout the geographic extent of the Impoundment from Vernon Dam to Barton Cove with emphasis placed on areas of interest (e.g., upstream and downstream of the Northfield Mountain tailrace). In addition, these sites are representative of the significant features and characteristics of importance to the objectives of this study (as defined by Table 6-1). Of the 16 representative locations, 7 are established at existing, permanent transects while 9 additional locations were selected at sites identified during the 2013 FRR land- and boat-based surveys. The 7 representative locations which are established at existing, permanent transects will also serve as calibration locations.

In addition to the 7 locations which will serve as both representative and calibration sites, 9 supplemental calibration sites were identified. In order to take advantage of historical survey data dating back to the 1990's, the supplemental calibration sites are located exclusively at existing, permanent transects. Due to the fact that existing, permanent transects may be identified as either a calibration location or a representative and calibration location, overlap exists between the two datasets. As such, the 9 existing, permanent transects which are categorized as calibration only are not considered representative as they are duplicative of riverbank features and characteristics found at other locations.

Table 7-1 provides a summary of the final representative and calibration locations while Table 7-2 details the riverbank features and characteristics found at each site. The geographic distribution of the calibration and representative locations throughout the Impoundment is found in Figures 7-1-7-6.

It is important to note that although study sites have been selected at existing, permanent transects, detailed investigation and analyses may only occur at one riverbank (i.e. right or left). Due to the fact that riverbank conditions vary from one side of the river to the other it may not be relevant to the study objectives to conduct detailed investigation at both banks of a given transect (e.g. the right bank at a transect may be stable with no active erosion while the left bank could be actively eroding). Table 7-1 provides a detailed list noting specifically which bank or banks at an existing, permanent transect will be investigated in detail. Sites selected based on the results of the 2013 FRR land- and boat-based surveys will only be investigated in detail on one side of the river (as noted in Table 7-1). In the event that only one riverbank is investigated in detail, a complete cross-section survey from one bank, across the channel bed, and up the other bank will still be surveyed for the entire cross-section. Permanent markers will be placed on both banks denoting the start/end points of the cross-section survey (if they do not already exist).

The 16 representative locations consist of a range of riverbank features and characteristics including:

- Locations where riverbanks are stable (including at least one site where bank stabilization has occurred as a result of the ECP (Simons, 1999) and at least one site that is naturally stable with no bank stabilization work present);
- Locations where the potential for future erosion is low;
- Locations where the potential for future erosion is high; and
- Locations where active erosion is occurring

As illustrated in Table 7-3, the selected representative sites have a balanced distribution over the various Stages of Erosion and Extents of Current Erosion found throughout the Impoundment. Of the 16 representative sites, 2 are located where Potential Future Erosion exists, 5 at Actively Eroding sites, 4 at Eroded sites, and 5 at Stable sites.[24] Similarly, 6 representative sites are located where None/Little Erosion exists, 5 where Some Erosion exists, 3 where Some to Extensive Erosion exists, and 2 where Extensive Erosion exists. In addition, a broad range of significant upper and lower riverbank features including vegetation, slope, sediment, and bank height are well represented.

Geographically, the selected representative and calibration sites extend at relatively even spacing from just downstream of Vernon Dam to Barton Cove (Figures 7-1-7-6). The geographic extent of the selected sites cover the range of hydrologic and hydraulic conditions found throughout the Impoundment, including:

- Natural features such as the constriction at the French King Gorge;
- Tributary inflows including the Ashuelot and Millers Rivers (and several smaller tributary inflows to the Impoundment); and
- Operation of various hydropower projects including the Vernon Project at the upstream end, Northfield Mountain Pumped Storage Project in the lower middle reach, and Turners Falls Hydroelectric Project at the downstream end

The broad range of riverbank features and characteristics as well as the comprehensive geographic distribution of the selected locations provide a robust set of transects and detailed study points which will be integral in achieving the objectives of this study. The results of the data collection and analyses conducted at the representative locations will be used to understand the forces related to each primary cause of erosion, including the magnitude, duration, and location of those forces on a given riverbank. By understanding the effect the forces of each primary cause of erosion have on a riverbank, the causes of erosion can then be quantified and ranked on a site by site basis based on the forces that are present. Given that the detailed study locations selected for this study are representative of all features, characteristics, and erosion conditions found in the Impoundment, primary causes of erosion can then be interpolated or extrapolated for the whole Impoundment. This extrapolation will also take into consideration how hydraulic forces vary throughout the Impoundment and the spatial distribution of riverbank features, characteristics, and erosion conditions. The end result of this analysis will be the quantification, based on relative percentages, of the primary causes of erosion at each detailed study site and in the Turner Falls Impoundment overall (FirstLight, 2013).

Supplemental information related to each selected location can be found in Appendix B while detailed discussion as to how and why each location was selected can be found in Appendix C.

[24] Sites classified as Stable represent locations that were Stable at the time of observation.

Table 7-1 Overview of Representative and Calibration Locations for Detailed Study

Location ID	Source	Bank[25]	Representative or Calibration Site	Comments
BC1-R	Existing, Permanent Transect	Right Bank	Both	Surveyed transect at the entrance to Barton Cove
2L	Existing, Permanent Transect	Left Bank	Both	Surveyed transect just downstream of major tributary (Ashuelot River), erosion with recent stabilization using vegetation only.
3L	Existing, Permanent Transect	Left Bank	Calibration	Surveyed transect, right bank – stabilized (2007, Kendall site), left bank – located downstream of Kendall with multiple types of erosion and indicators of potential erosion. Both banks of the surveyed transect includes an area with erosion occurring prior to stabilization in 2007 and stabilization since then with the opposite bank experiencing several types of erosion and potential erosion indicators with concurrent survey data.
3R	Existing, Permanent Transect	Right Bank	Calibration	
4L	Existing, Permanent Transect	Left Bank	Both	Surveyed transect – cross-section shows some change and left bank exhibits potential erosion indicators and erosion (right bank stable with limited potential indicators of future erosion)
5C-R	Existing, Permanent Transect	Right Bank	Calibration	Surveyed transect with right bank showing erosion and multiple types of potential erosion, left bank previously stabilized by COE experimental techniques (tires).
6A-L	Existing, Permanent Transect	Left Bank	Calibration	Surveyed transect at a location of erosion and heavy boat use in the past with both banks stabilized (Flagg, 2000 and Skalski, 2004). An island bank that is not stabilized is also included to be studied.
6A-R	Existing, Permanent Transect	Right Bank	Calibration	
7L	Existing, Permanent Transect	Left Bank	Both	Surveyed transect with one forested high bank and the other a farmed terrace with indicators of potential future erosion.
7R	Existing, Permanent Transect	Right Bank	Both	
8B-L	Existing, Permanent Transect	Left Bank	Both	Surveyed transect with one bank with erosion and indicators of potential future erosion and other bank with erosion that is in the process of being stabilized with current techniques of large woody debris, built-up toe and vegetation (Wallace, Bathory/Gallagher, 2012). Detailed study will occur at both banks of the transect.
8B-R	Existing, Permanent Transect	Right Bank	Calibration	
9R	Existing, Permanent Transect	Right Bank	Calibration	Surveyed transect with right bank that had eroded but stabilized with preventative maintenance measures (Campground Point, 2008)
10L	Existing, Permanent Transect	Left Bank	Calibration	Surveyed transect with erosion occurring before stabilization in 2001-2002 on right bank (Urgiel upstream), stable left bank. A recent vertical shift in the bank has developed both through the stabilized site and upstream which is of interest in understanding and monitoring.
10R	Existing, Permanent Transect	Right Bank	Both	
11L	Existing, Permanent Transect	Left Bank	Calibration	Surveyed transect through island, left bank and bank of island exhibits erosion and potential erosion indicators
18	FRR Land-based Survey	Left Bank	Representative	Land-based point located between surveyed Transects 2 and 3, multiple indicators of potential erosion
21	FRR Land-based Survey	Right Bank	Representative	The land-based point is experiencing more than one type of erosion and multiple indicators of potential erosion and may be considered for some type of future stabilization
26	FRR Land-based Survey	Right Bank	Representative	Land-based site exhibits various types of erosion and potential future erosion and may represent bank conditions prior to stabilization of transect 10 - right bank.
29	FRR Land-based Survey	Right Bank	Representative	Located between transects 4 and 5A, erosion and multiple indicators of potential erosion
12(B)	FRR Boat-based Survey	Left Bank	Representative	Boat-based segment with extensive, active erosion and limited vegetation; located downstream of French King Gorge and just upstream of Barton Cove
75(B)	FRR Boat-based Survey	Left Bank	Representative	Boat-based segment with extensive, active erosion just downstream of the Northfield Mountain Tailrace.

[25] Defined as looking downstream

Location ID	Source	Bank[25]	Representative or Calibration Site	Comments
87(B)	FRR Boat-based Survey	Left Bank	Representative	Boat-based segment exhibits eroded conditions and several indicators of potential future erosion; located upstream of Northfield Mountain Tailrace and a short distance downstream of Shearer stabilization site
119(B)	FRR Boat-based Survey	Left Bank	Representative	Boat-based segment exhibits eroded conditions and several indicators of potential future erosion; located near the downstream end of Kidds Island
303(B)	FRR Boat-based Survey	Left Bank	Representative	Boat-based segment located downstream of the Ashuelot River confluence. Segment exhibits Heavy lower riverbank vegetation and Medium upper riverbank height.

9	*Supplemental sites selected based on the results of the 2013 FRR*
7	*Existing, permanent transect sites that will be used as both representative and calibration locations*
9	*Existing, permanent transect sites that will be used as supplemental calibration locations*
25	

Table 7-2 Summary of Riverbank Features and Characteristics –Representative and Calibration Locations for Detailed Study

Location ID	Bank	Source	Representative or Calibration	UPPER RIVERBANK				LOWER RIVERBANK			Type of Erosion	Indicator(s) of Potential Erosion	Stage of Erosion	Extent of Current Erosion
				Slope	Height	Sediment	Vegetation	Slope	Sediment	Vegetation				
BC1-R	Right Bank	Existing, Permanent Transect	Both	Moderate	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None/Very Sparse	Undercut	Creep/Leaning Trees	Stable	None/Little
2L	Left Bank	Existing, Permanent Transect	Both	Vertical	High	Silt/Sand	Moderate	Flat/Beach	Silt/Sand	None to Very Sparse	Rotational Slump	Creep/Leaning Trees, Overhanging	Eroded	Some
3L	Left Bank	Existing, Permanent Transect	Calibration	Moderate	Low	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut, Rotational Slump	Creep/Leaning Trees, Overhanging	Eroded	Some
3R	Right Bank	Existing, Permanent Transect	Calibration	Moderate	High	Silt/Sand	Heavy	Moderate	Gravel	None to Very Sparse	-	-	Stable	None/Little
4L	Left Bank	Existing, Permanent Transect	Both	Moderate	Medium	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None to Very Sparse	-	Creep/Leaning Trees	Stable	None/Little
5C-R	Right Bank	Existing, Permanent Transect	Calibration	Steep	High	Silt/Sand	Moderate	Flat/Beach	Silt/Sand	None to Very Sparse	Slide or Flow	Overhanging Bank, Exposed Roots, Creep/Leaning Trees	Eroded	Some
6A-L	Left Bank	Existing, Permanent Transect	Calibration	Moderate	High	Silt/Sand	Heavy	Moderate	Cobbles	None to Very Sparse	-	-	Stable	None/Little
6A-R	Right Bank	Existing, Permanent Transect	Calibration	Steep	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	Heavy	-	-	Stable	None/Little
7L	Left Bank	Existing, Permanent Transect	Both	Steep	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut	Creep/Leaning Trees	Potential Future Erosion	None/Little
7R	Right Bank	Existing, Permanent Transect	Both	Moderate	High	Silt/Sand	Heavy	Moderate	Boulders	None to Very Sparse	-	-	Stable	None/Little
8B-L	Left Bank	Existing, Permanent Transect	Both	Steep	High	Silt/Sand	Moderate	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut	Creep/Leaning Trees, Exposed Roots, Overhanging Bank	Potential Future Erosion	Some
8B-R	Right Bank	Existing, Permanent Transect	Calibration	Steep/Overhanging	High	Silt/Sand	Heavy	Flat/Beach	Gravel	None to Very Sparse	-	Overhanging	In process of stabilization	None/Little
9R	Right Bank	Existing, Permanent Transect	Calibration	Moderate	High	Silt/Sand	Moderate	Flat/Beach	Silt/Sand	None to Very Sparse	-	Creep/Leaning Trees	Stable	None/Little
10L	Left Bank	Existing, Permanent Transect	Calibration	Moderate	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None to Very Sparse	-	-	Stable	None/Little
10R	Right Bank	Existing, Permanent Transect	Both	Moderate	High	Silt/Sand	Heavy	Moderate	Cobbles	Sparse	-	-	Stable	None/Little
11L	Left Bank	Existing, Permanent Transect	Calibration	Moderate	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut	Undercut, Creep/Leaning trees	Stable	None/Little

Location ID	Bank	Source	Representative or Calibration	UPPER RIVERBANK				LOWER RIVERBANK			Type of Erosion	Indicator(s) of Potential Erosion	Stage of Erosion	Extent of Current Erosion
				Slope	Height	Sediment	Vegetation	Slope	Sediment	Vegetation				
18	Left Bank	FRR Land-based Survey	Representative	Moderate	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None/Very Sparse	Undercut	Undercut, Exposed Roots, Creep/Leaning Trees	Eroded	Some
21	Right Bank	FRR Land-based Survey	Representative	Steep (some vertical)	High	Silt/Sand	Moderate	Flat/Beach	Gravel, Silt/Sand	None/Very Sparse	Rotational Slump, Undercut	Undercut, Exposed Roots, Creep/Leaning Trees	Active	Some to extensive
26	Right Bank	FRR Land-based Survey	Representative	Steep/Overhanging	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None/Very Sparse	Rotational Slump, Undercut	Undercut, Exposed Roots, Creep/Leaning Trees	Active	Some
29	Right Bank	FRR Land-based Survey	Representative	Steep (near vertical)	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None/Very Sparse	Rotational Slump, Undercut	Undercut, Exposed Roots, Creep/Leaning Trees	Active	Some
12(B)	Left Bank	FRR Boat-based Survey	Representative	Steep	High	Silt/Sand	Sparse	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut	Exposed Roots, Overhanging Bank	Active	Extensive
75(B)	Left Bank	FRR Boat-based Survey	Representative	Vertical	High	Silt/Sand	Sparse	Flat/Beach	Silt/Sand	None to Very Sparse	Topple, Overhanging Bank	Creep/Leaning Trees, Overhanging Bank	Active	Extensive
87(B)	Left Bank	FRR Boat-based Survey	Representative	Overhanging	High	Silt/Sand	Sparse	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut, Rotational Slump	Exposed Roots, Creep/Leaning Trees, Overhanging Bank	Eroded	Some to Extensive
119(B)	Left Bank	FRR Boat-based Survey	Representative	Steep	High	Silt/Sand	Sparse	Flat/Beach	Silt/Sand	None to Very Sparse	Slide or Flow	Exposed Roots, Creep/Leaning Trees, Overhanging Bank	Eroded	Some to Extensive
303(B)	Left Bank	FRR Boat-based Survey	Representative	Moderate	Medium	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	Heavy	-	-	Stable	None/Little

Table 7-3 Summary of Riverbank Features and Characteristics –Representative Locations for Detailed Study

FEATURES	CHARACTERISTICS[26]					
Upper Riverbank Slope	**Overhanging** 26, 87(B)	**Vertical** 2L, 21, 29, 75(B)	**Steep** 7L, 8B-L, 12(B), 21, 26, 29, 119(B)	**Moderate** 4L, 7R, 10R, 18, 303B, BC-1R	Flat	
Upper Riverbank Height	Low	**Medium** 4L, 303B	**High** 2L, 7L, 7R, 8B-L, 10R, 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B), BC-1R			
Upper Riverbank Sediment[27]	Clay	**Silt/Sand** 2L, 4L, 7L, 7R, 8B-L, 10R, 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B), 303B, BC-1R	Gravel	Cobbles	Boulders	Bedrock
Upper Riverbank Vegetation	**None to Very Sparse**	**Sparse** 12(B), 75(B), 87(B), 119(B)	**Moderate** 2L, 8B-L, 21	**Heavy** 4L, 7L, 7R, 10R, 18, 26, 29, 303B, BC-1R		
Lower Riverbank Slope[28]	Vertical	Steep	**Moderate** 7R, 10R	**Flat/Beach** 2L, 4L, 7L, 8B-L, 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B), 303B, BC-1R		

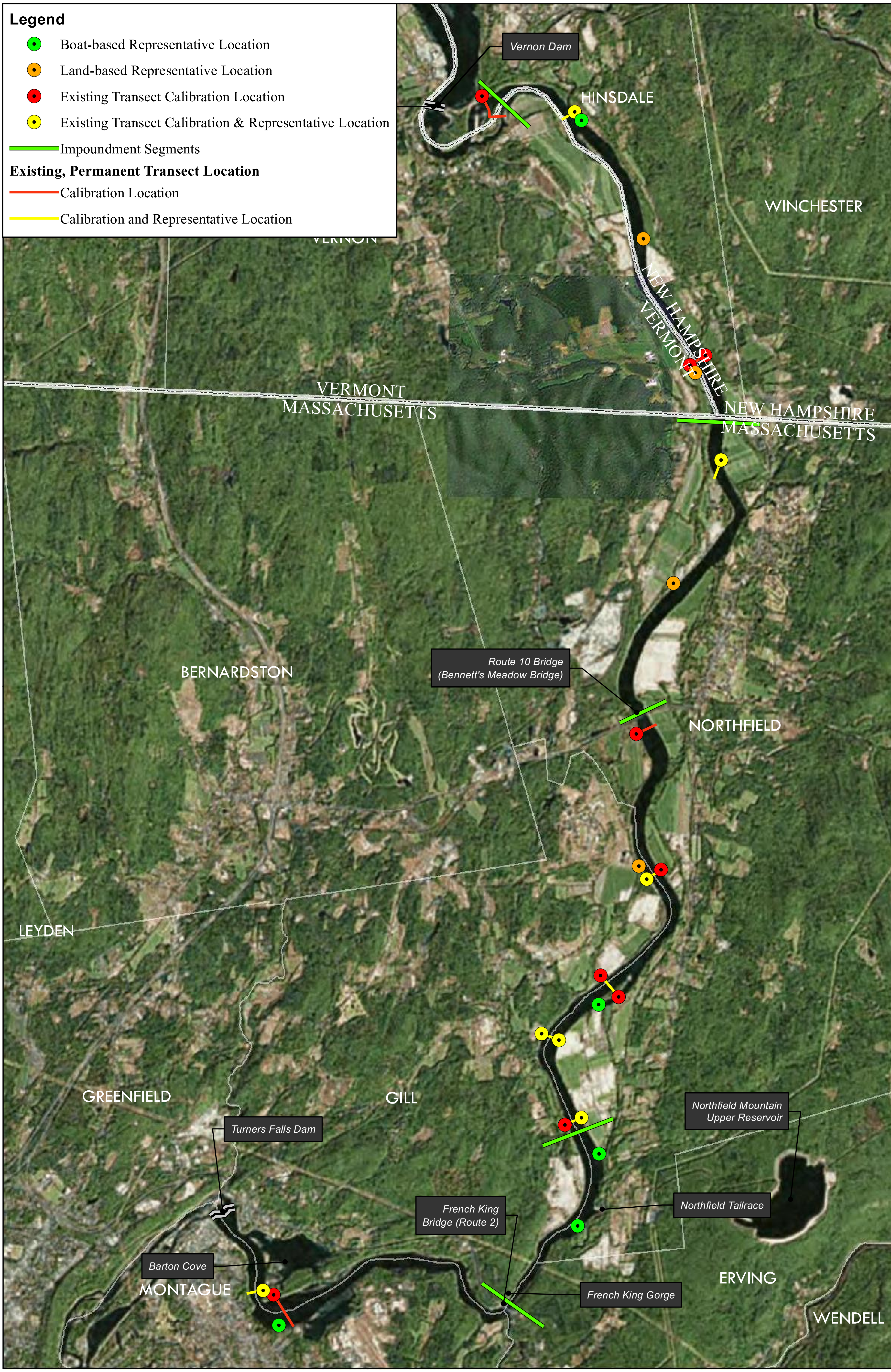
[26] Categories that are highlighted in yellow were identified as characteristics that are indicative of areas where active erosion is most likely to occur or the potential for future erosion is high. Highlighted categories were identified based on review of historic geomorphic data and the results of the 2013 FRR. Transects and detailed study points that will be used for investigation and analyses associated with Study No. 3.1.2 are based on the highlighted categories.

[27] While clay, gravel, cobble, boulder, and bedrock upper riverbank sediments may exist in some locations throughout the Impoundment, these locations are rare and therefore are not representative of riverbank features and characteristics found in the study area. As such, these characteristics are not of interest to the objectives of this study.

[28] Vertical and Steep lower riverbank slopes are typically indicative or areas where active erosion is occurring or the potential for future erosion is high and therefore would normally be highlighted in yellow. These categories are not highlighted, however, as these specific riverbank conditions do not exist in the Impoundment.

FEATURES	CHARACTERISTICS[26]					
Lower Riverbank Sediment	Clay	**Silt/Sand** 2L, 4L, 7L, 8B-L, 12(B), 18, 26, 29, 75(B), 87(B), 119(B), 303B, BC-1R	**Gravel** 21	**Cobbles** 10R	**Boulders** 7R	Bedrock
Lower Riverbank Vegetation	**None to Very Sparse** 2L, 4L, 7L, 7R, 8B-L, 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B), BC-1R	**Sparse** 10R	**Moderate**	**Heavy** 303B		
Stage of Erosion	**Potential Future Erosion** 7L, 8B-L	**Active Erosion** 12(B), 21, 26, 29, 75(B)	**Eroded** 18, 2L*, 87(B), 119(B)	Stable 4L, 7R, 10R, 303B, BC-1R		
Extent of Current Erosion	**None/Little** 4L, 7L, 7R, 10-R, 303B, BC-1R	**Some** 2L, 8B-L, 18, 26, 29	**Some to Extensive** 21, 87(B), 119(B)	**Extensive** 12(B), 75(B)		

*In process of stabilization as part of the Erosion Control Plan (Simons, 1999).



FIRSTLIGHT POWER RESOURCES

RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

Figure 7-1:
Proposed Representative and Calibration Locations for Detailed Study

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community

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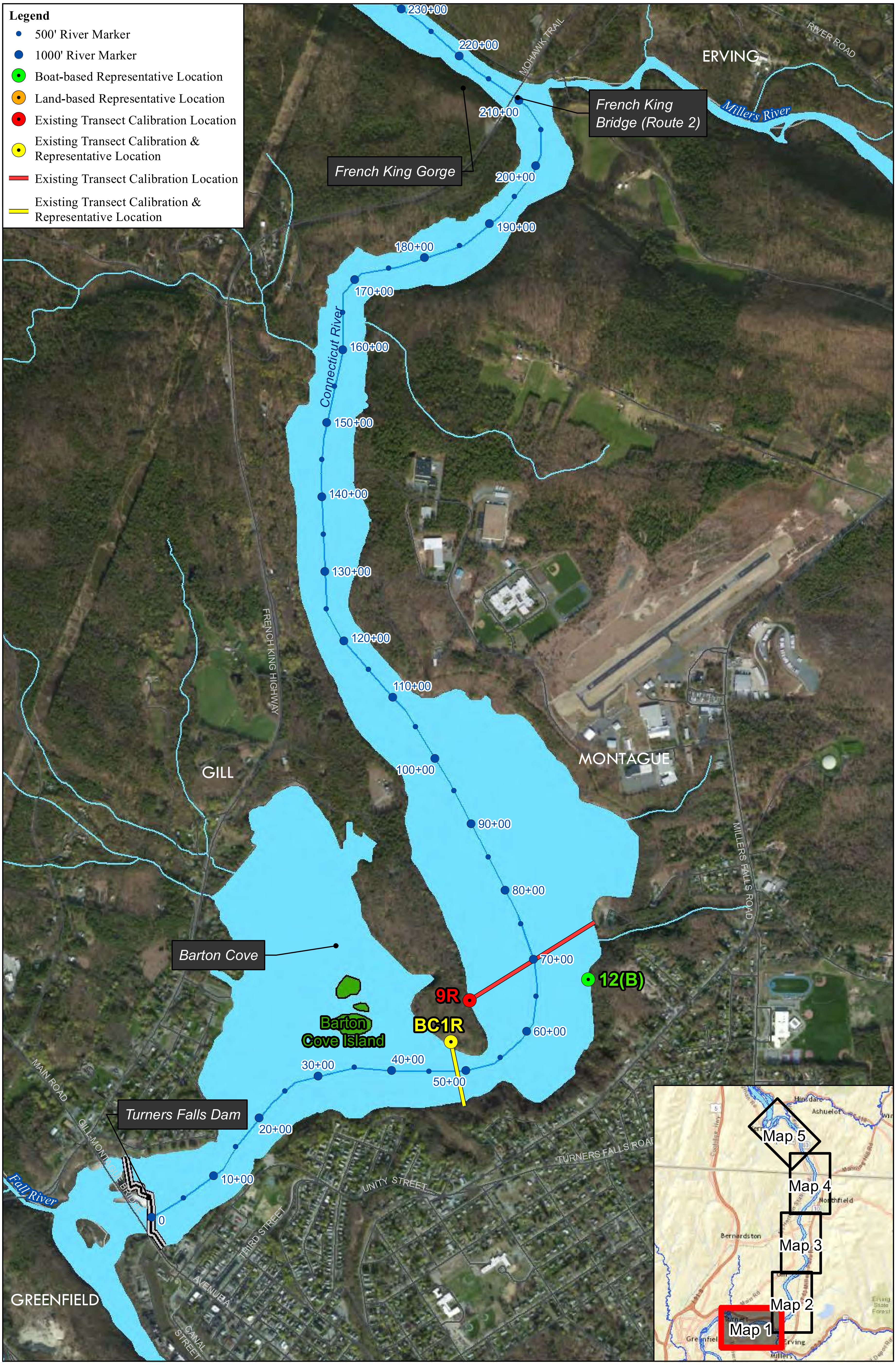

FirstLight GDF SUEZ

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7-2:
Proposed Representative & Calibration Locations for Detailed Study
Map 1

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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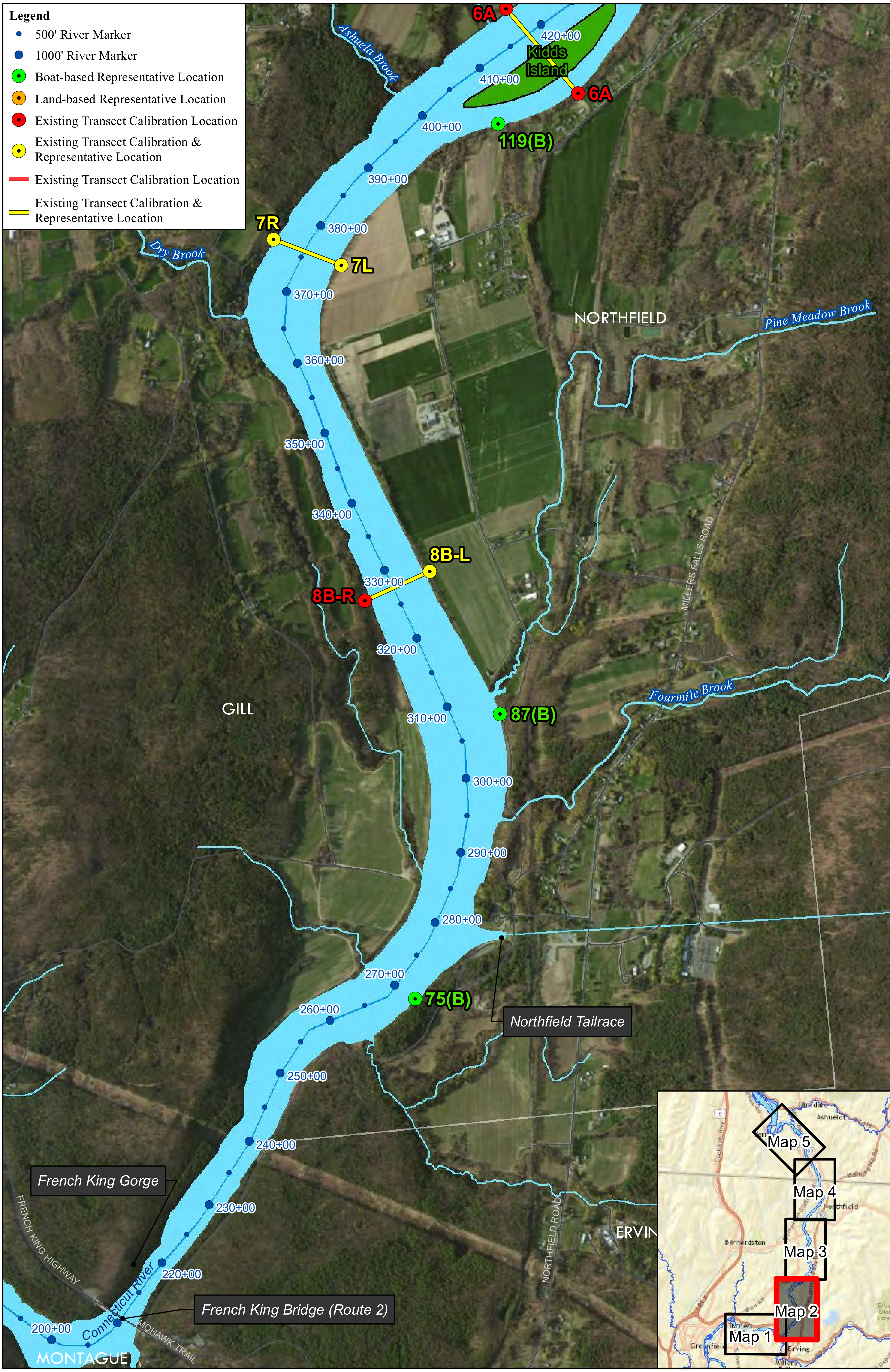

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

N

0 625 1,250 2,500 Feet

Figure 7-3:
Proposed Representative & Calibration Locations for Detailed Study
Map 2

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7-4:
Proposed Representative & Calibration Locations for Detailed Study
Map 3

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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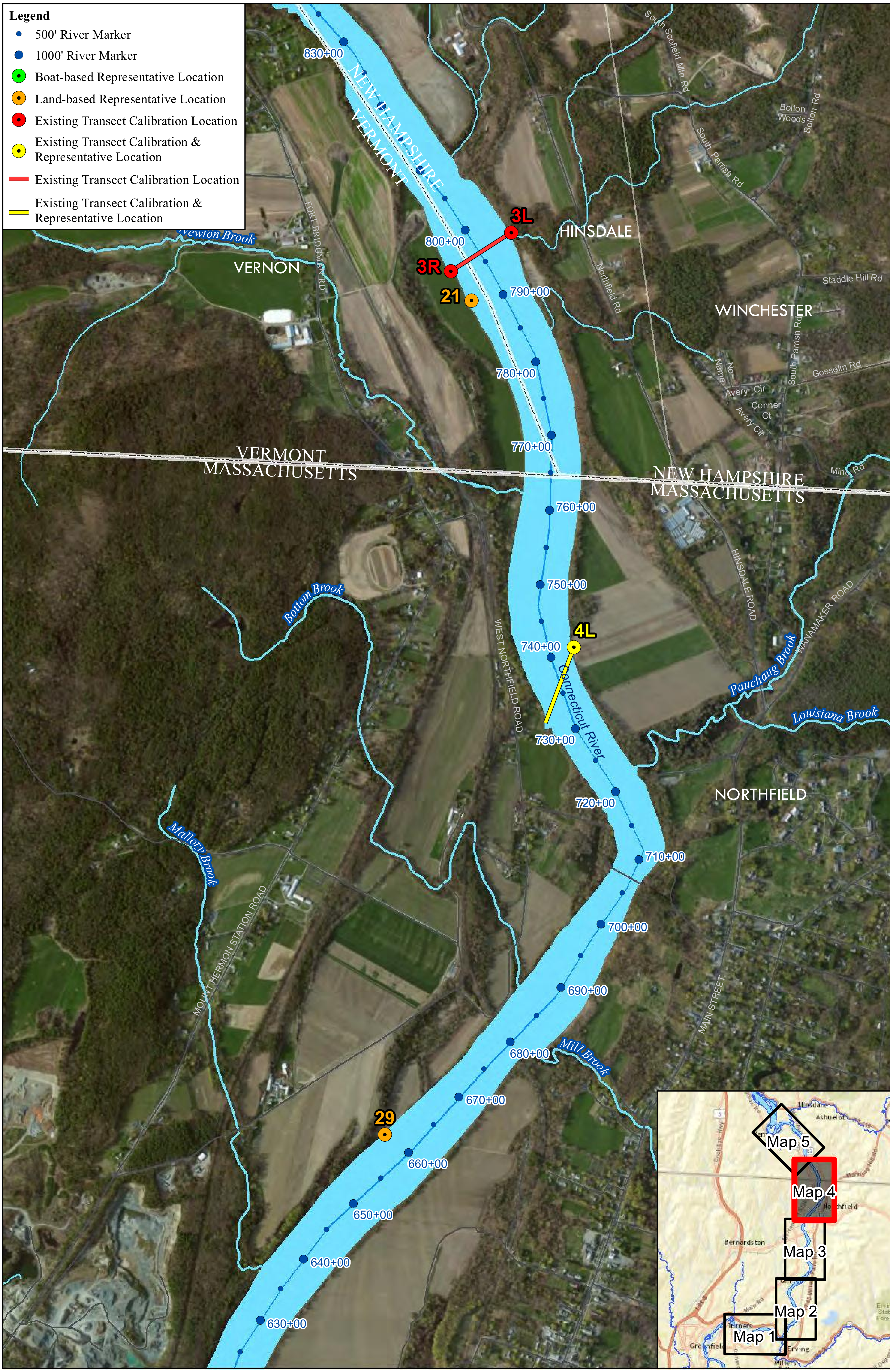

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FIRSTLIGHT POWER RESOURCES

RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7-5:
Proposed Representative & Calibration Locations for Detailed Study
Map 4

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7-6:
Proposed Representative & Calibration Locations for Detailed Study
Map 5

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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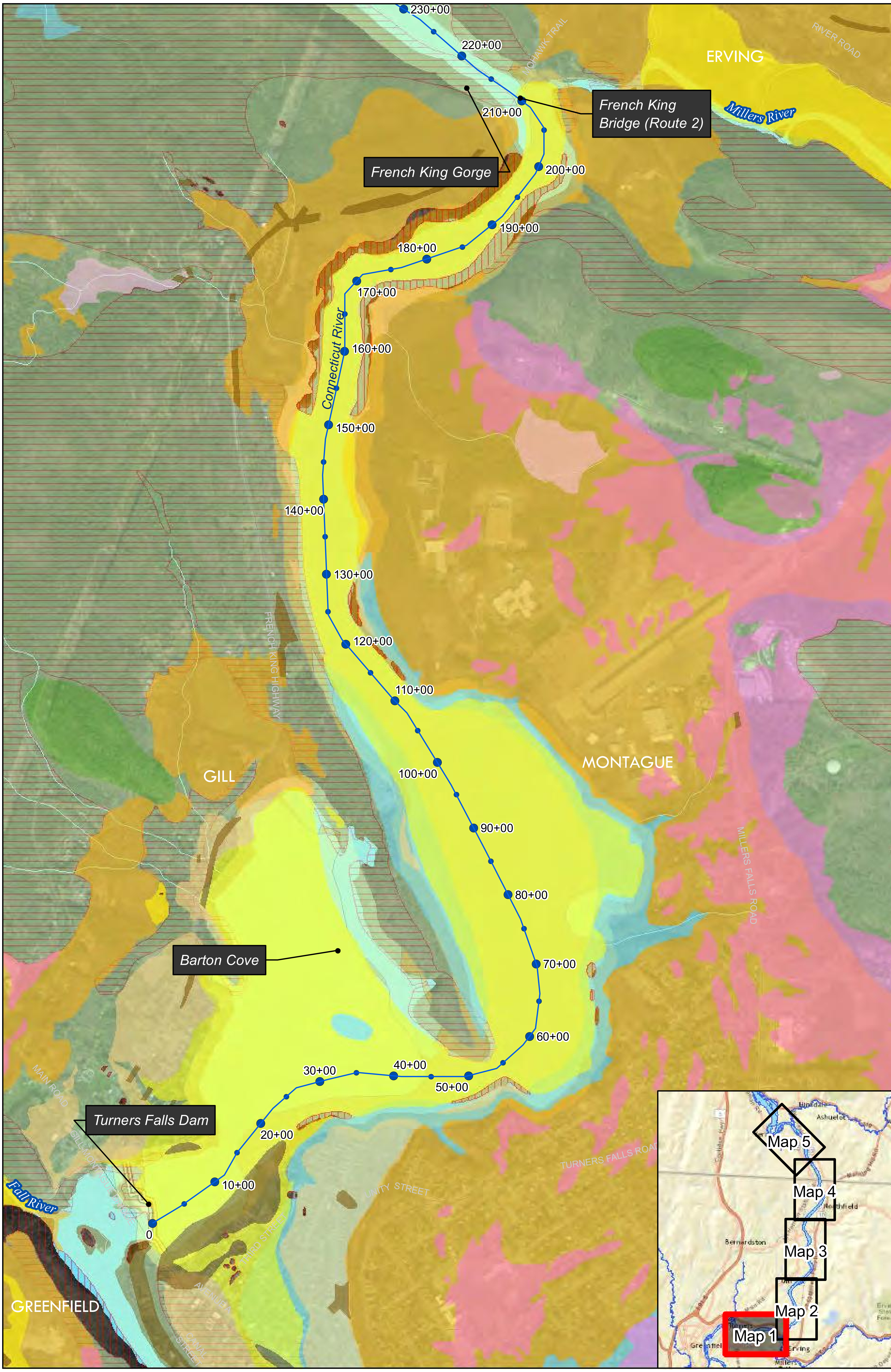
Appendix A
Surficial Geology Maps



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FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Surficial Geology
Map 1

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap

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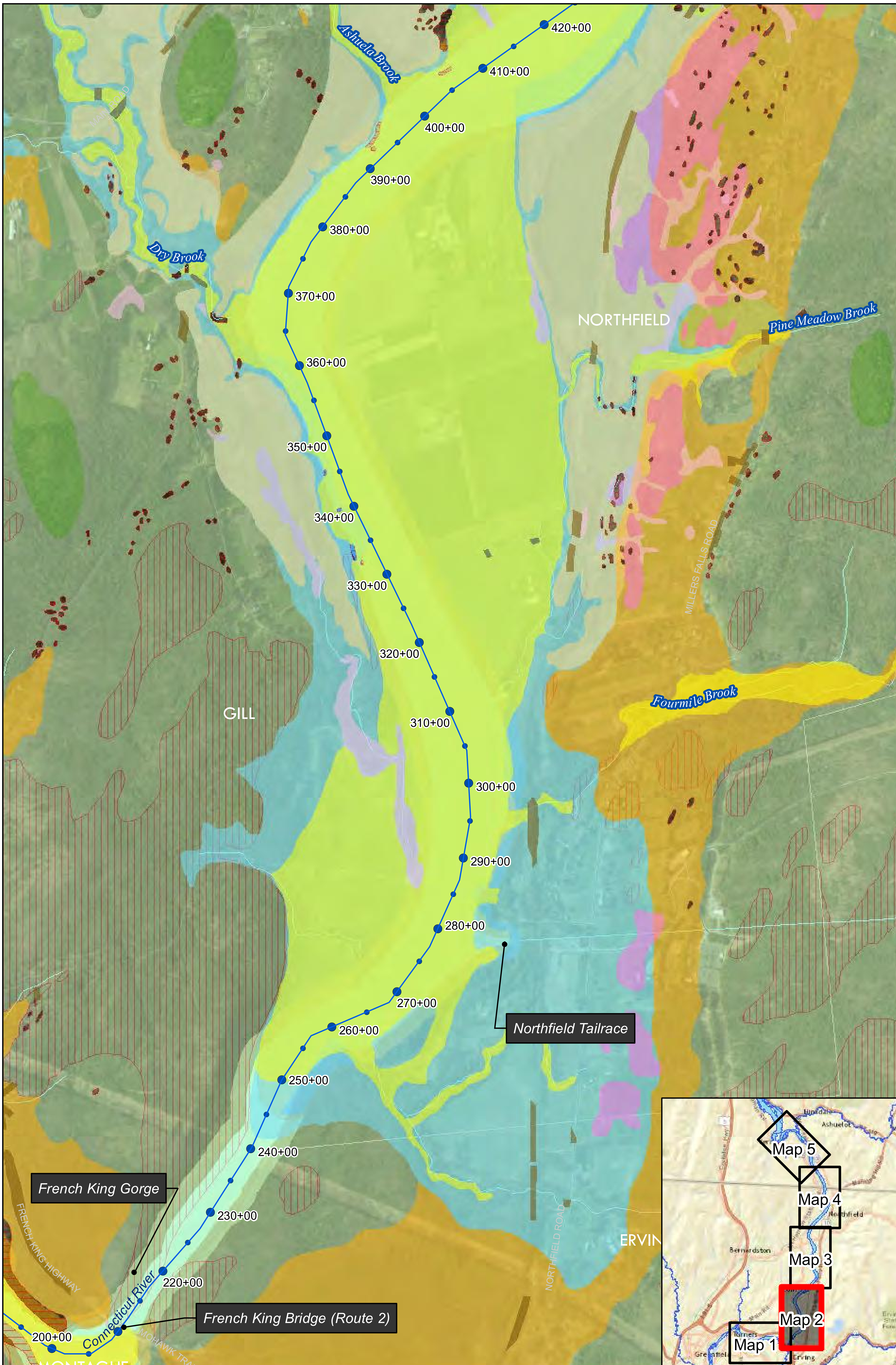

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FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Surficial Geology
Map 2

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Surficial Geology
Map 3

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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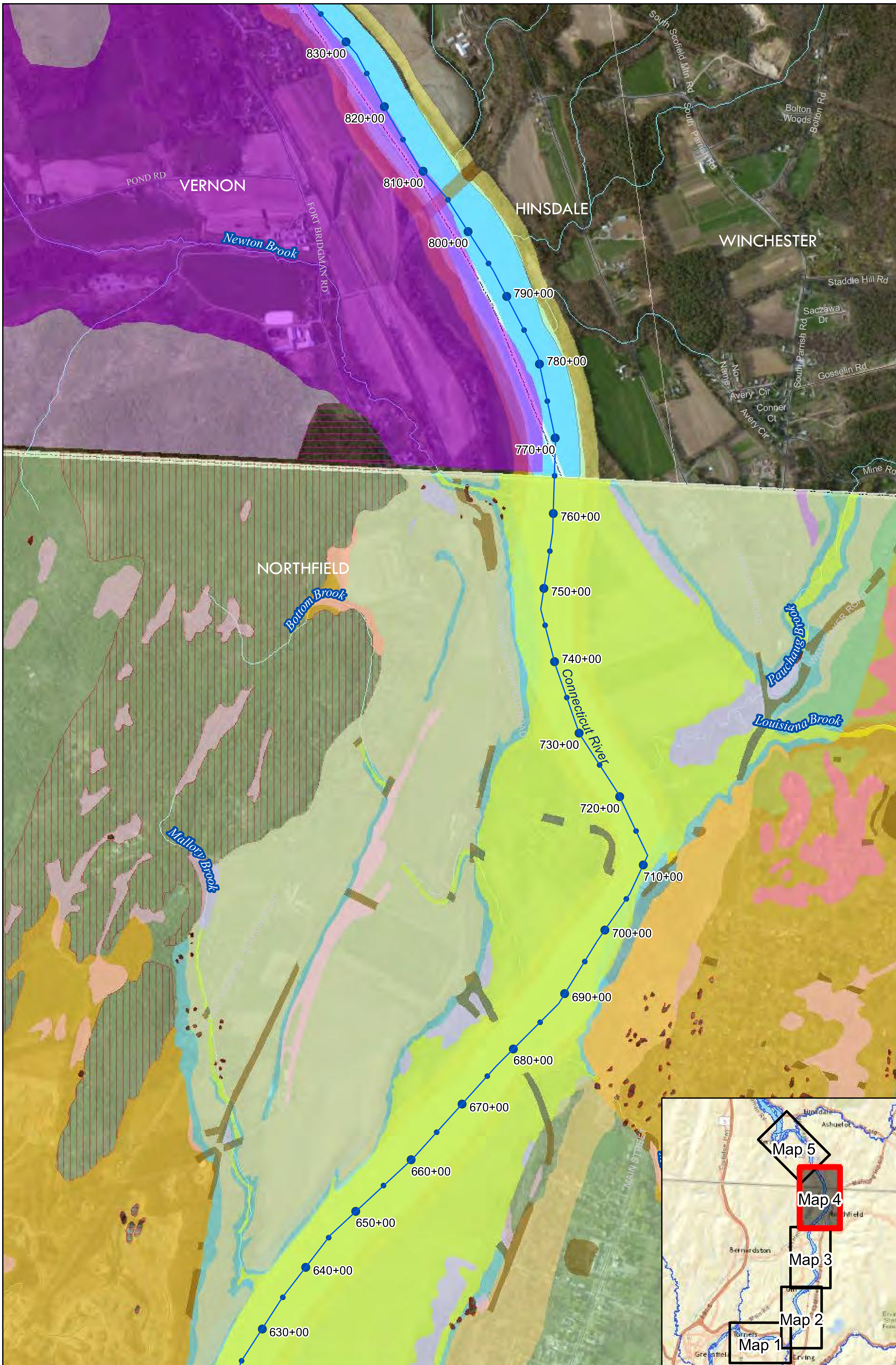

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

Surficial Geology
Map 4

0 625 1,250 2,500 Feet

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap

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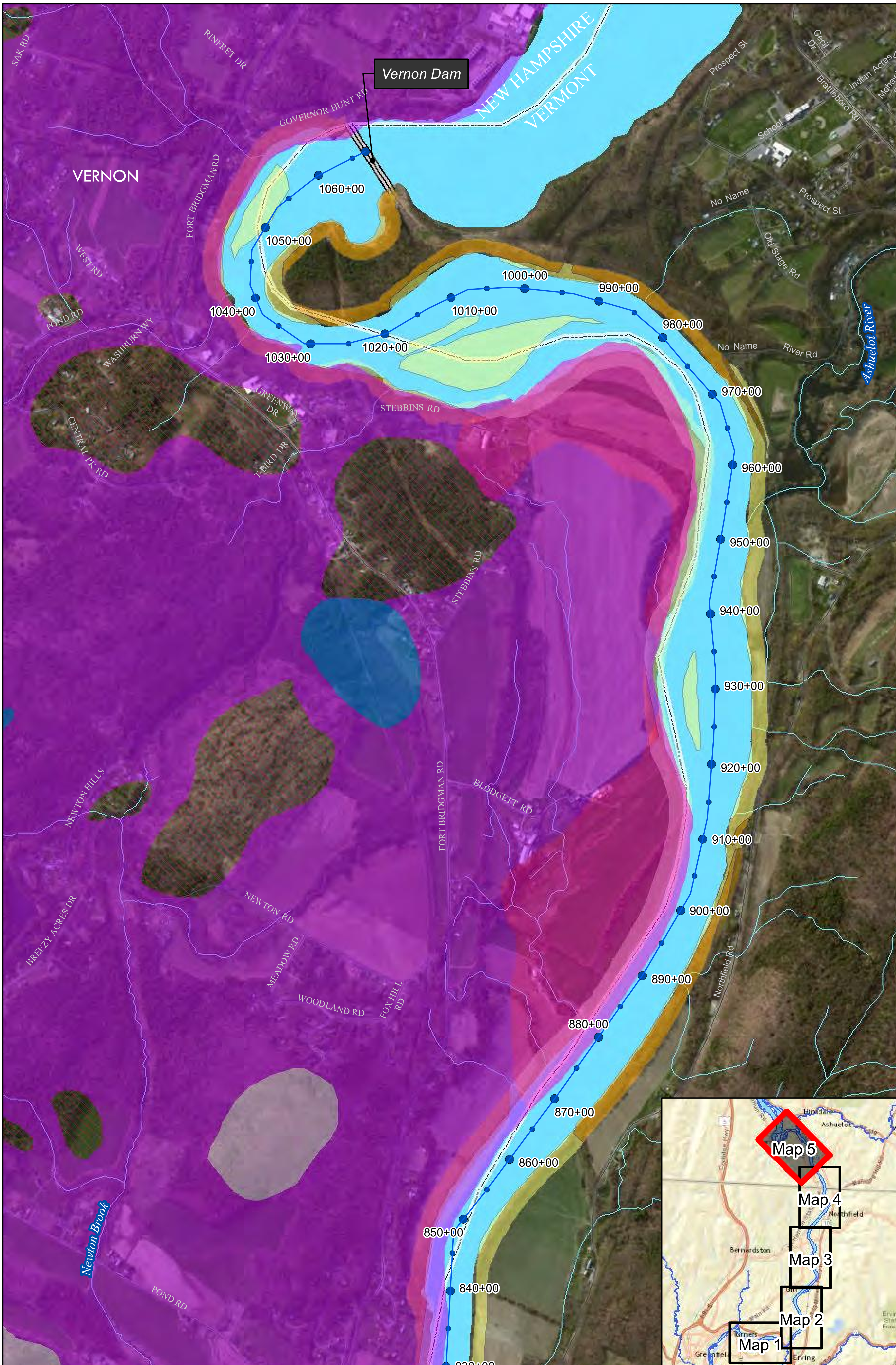

FIRSTLIGHT POWER RESOURCES

RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Surficial Geology
Map 5

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap

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Legend

VT Surficial Geology

- Bedrock exposure
- Eolian deposit
- Glacial deposit
- Glaciofluvial deposit
- Glaciolacustrine deposit
- Pluvial deposit
- Postglacial fluvial deposit
- Surface Water

MA Surficial Geology

Postglacial Deposits

- Artificial Fill
- Floodplain Alluvium
- Swamp Deposit

Early Postglacial Deposits

- Alluvial-Fan Deposit
- Inland-Dune Deposit
- Stream-Terrace Deposit
- Talus Deposit

Glacially Stratified Deposits

- Coarse Deposit
- Fine Deposit

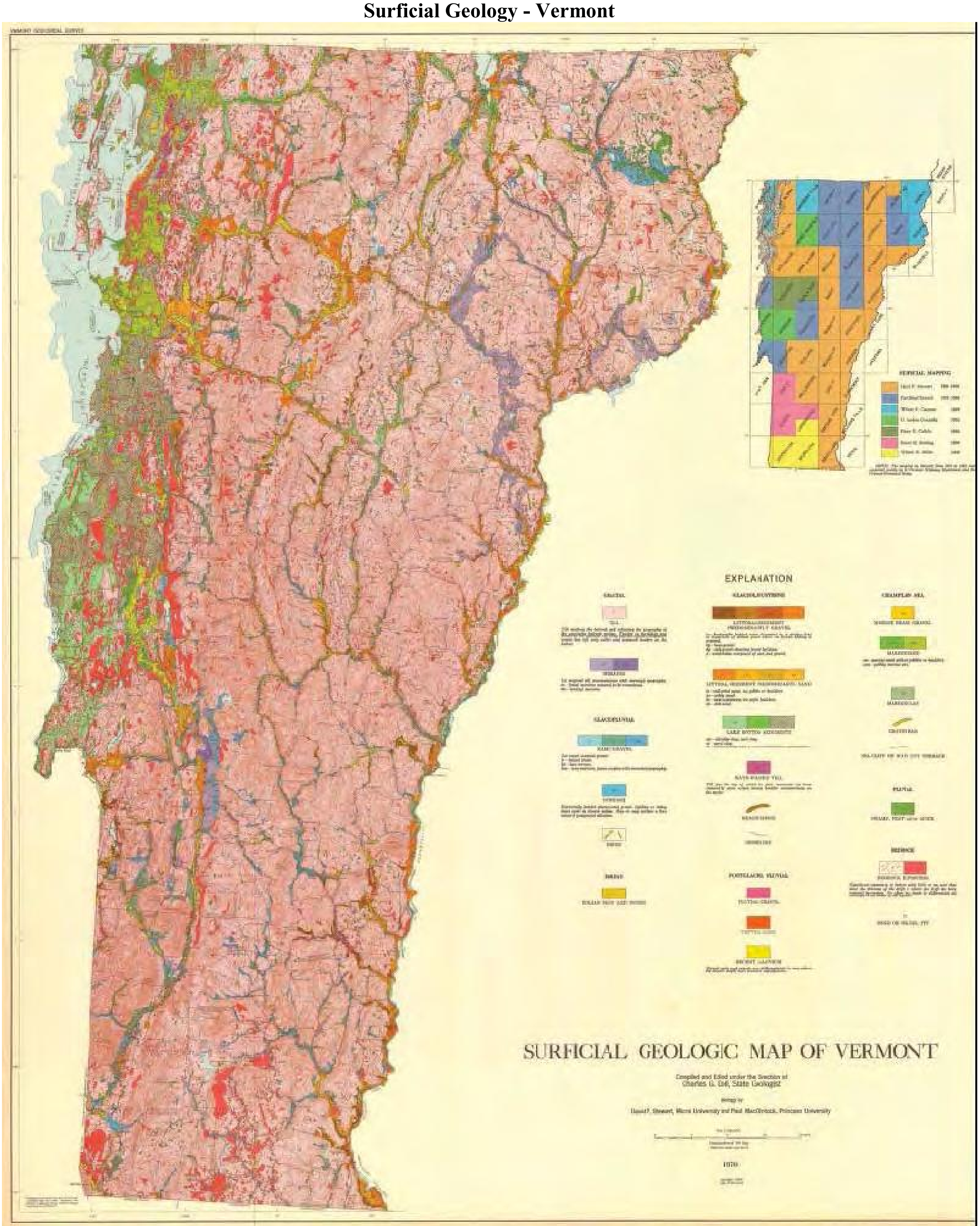
Till and Bedrock

- Abundant Outcrop or Shallow Bedrock
- Bedrock Outcrop
- Thick Till
- Thin Till
- Waterbody (Soil not classified)

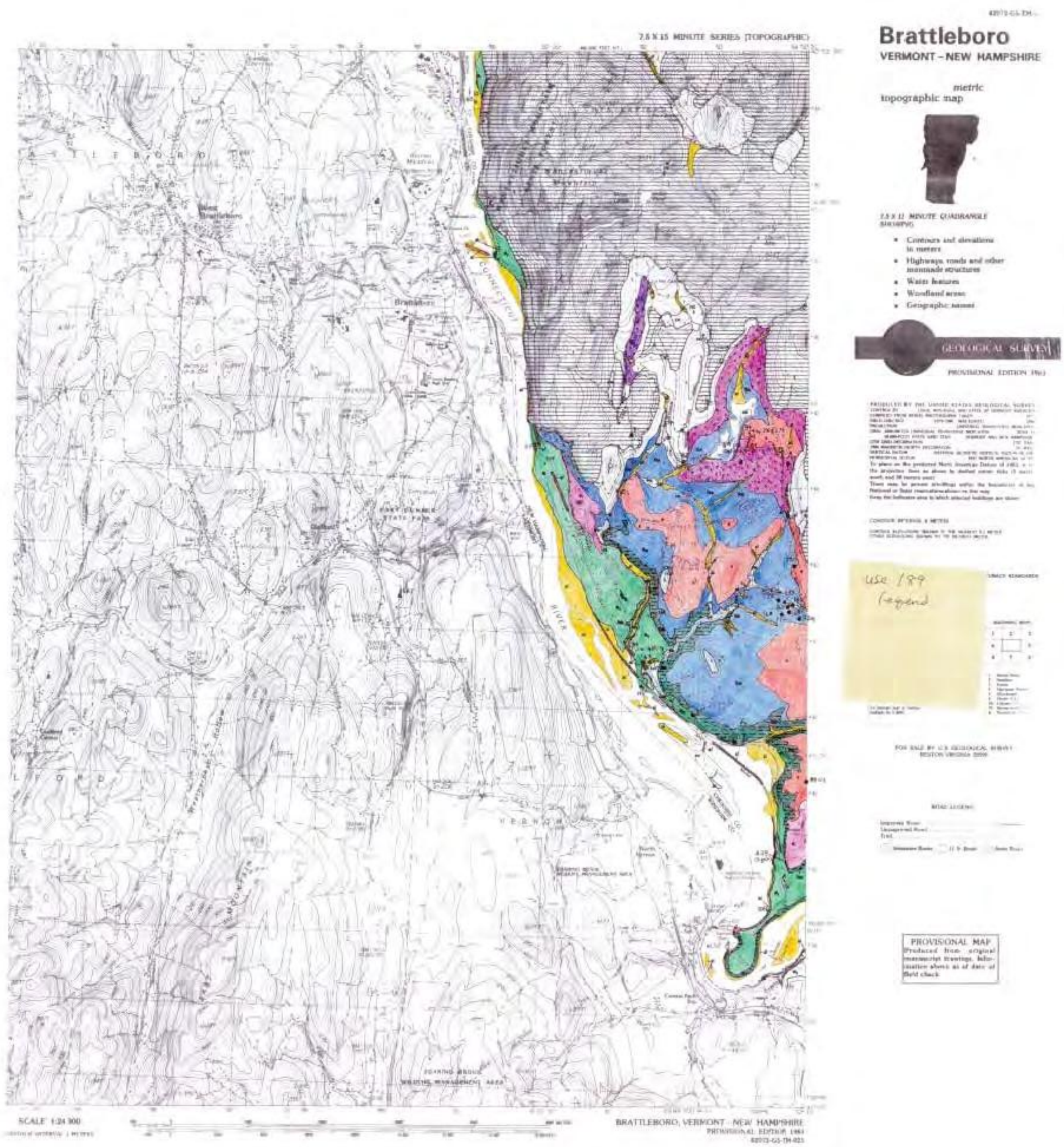
New Hampshire Surficial Geology

- Glacial lake deposits, fine and well sorted deposits
- Glacial lake deposits, sand and gravel
- Till or bedrock
- Floodplain alluvium
- Artificial fill

Surficial Geology - Vermont



Surficial Geology – Brattleboro (East), New Hampshire



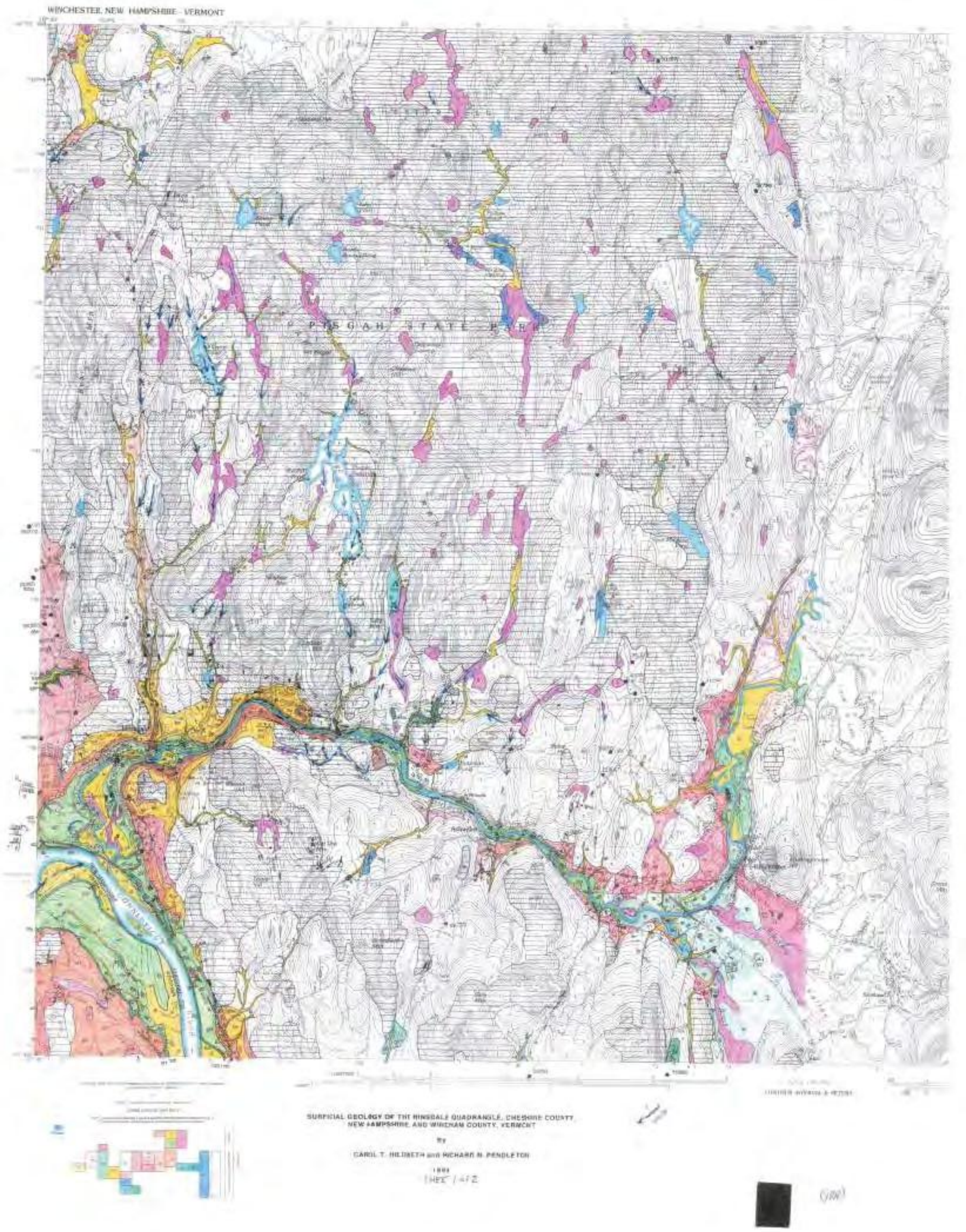
SCALE 1:24,000
CONTOUR INTERVAL 6 METERS
DATUM IS MEAN SEA LEVEL

SURFICIAL GEOLOGIC MAP OF THE NEW HAMPSHIRE PORTION OF THE BRATTLEBORO (EAST), QUADRANGLE, CHESHIRE COUNTY, NEW HAMPSHIRE

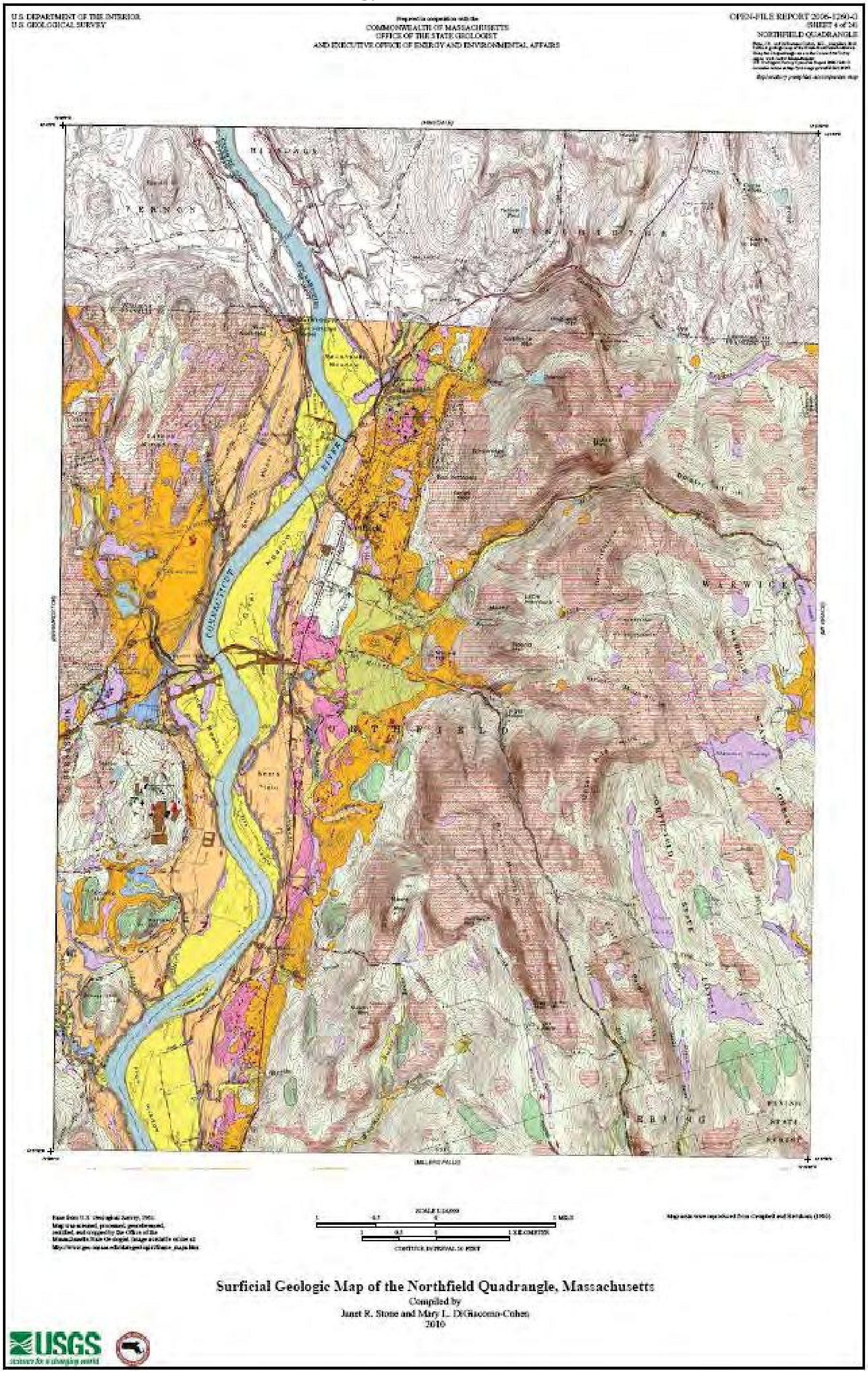
By
Richard M. Pendleton
200X
(Mapped in 200X)

Brattlebo
1:24,00

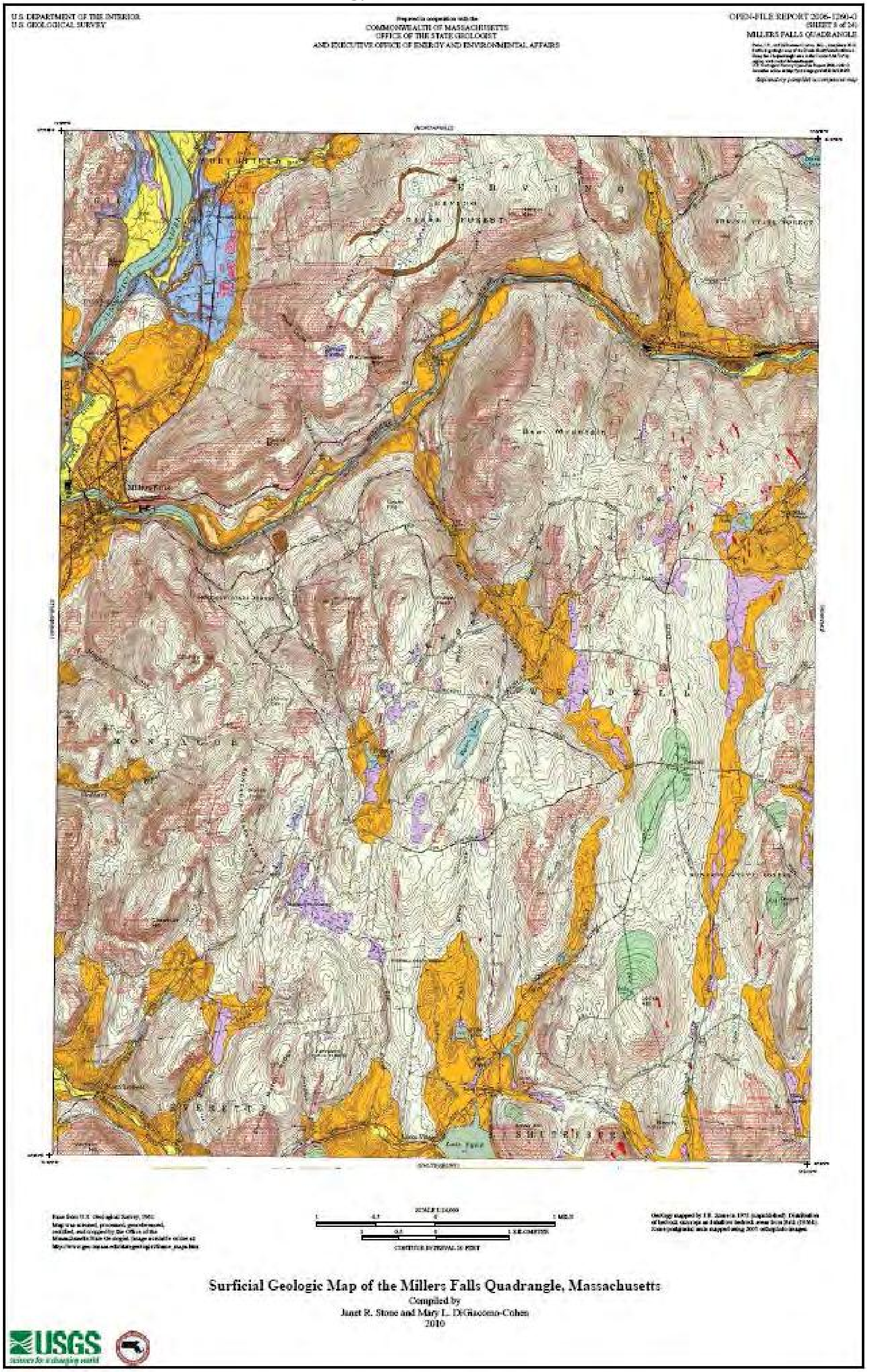
Surficial Geology – Hinsdale, New Hampshire



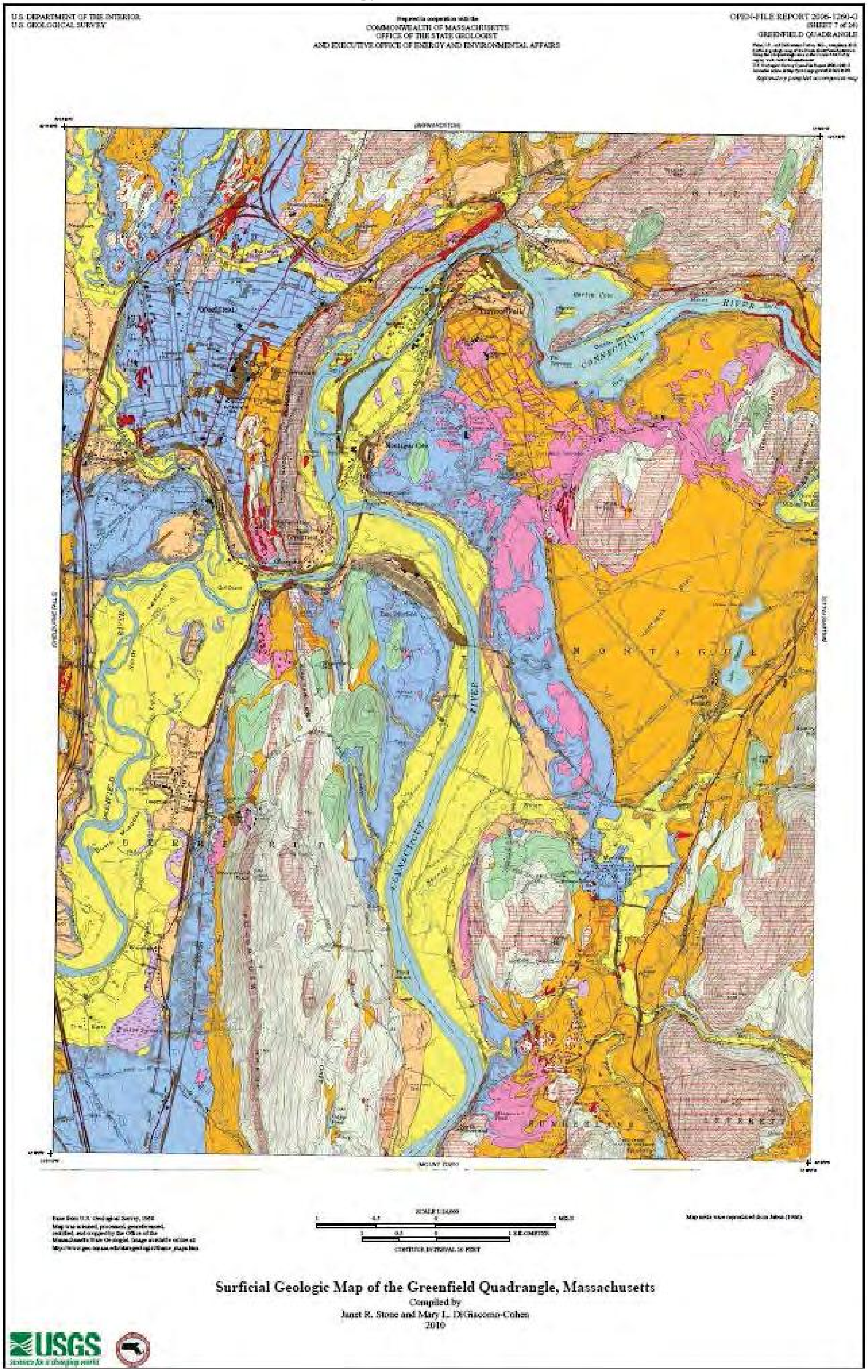
Surficial Geology – Northfield, Massachusetts



Surficial Geology – Millers Falls, Massachusetts



Surficial Geology – Greenfield, Massachusetts



Surficial Geology Map Legends

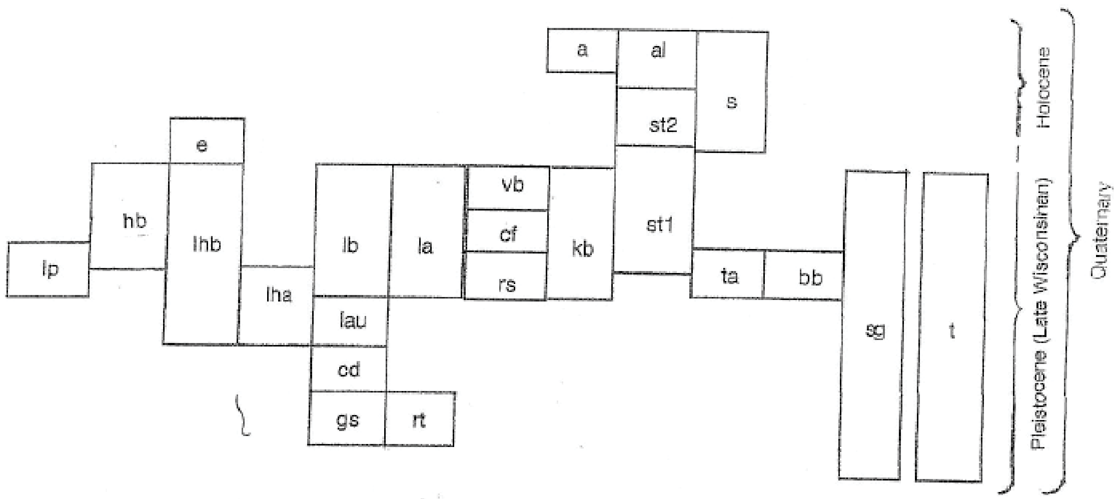
SURFICIAL GEOLOGY OF THE HINSDALE QUADRANGLE, CHESHIRE COUNTY, NEW HAMPSHIRE AND WINDHAM COUNTY, VERMONT

By

CAROL T. HILDRETH and RICHARD M. PENDLETON

CORRELATION OF MAP UNITS

NOTE: All units are Quaternary in age and symbols normally would be preceded by a "Q." Correlation between isolated deposits and between map units is tentative.



SURFICIAL GEOLOGY OF THE HINSDALE QUADRANGLE, CHESHIRE COUNTY, NEW HAMPSHIRE AND WINDHAM COUNTY, VERMONT

DESCRIPTION OF MAP UNITS

By

Carol T. Hildreth and Richard M. Pendleton

(NOTE: All units are Quaternary in age and symbols normally would be preceded by a "Q")

(Mapped in 1998 and 1999--Scale 1:24,000)

A layer of windblown sand and silt, generally mixed with underlying glacial deposits, is present over much of the map are but is not shown.

NOTE: Correlation between isolated deposits and between map units is tentative.

a ARTIFICIAL CUT AND FILL--Manmade. Material of fill varies from natural sand and gravel to quarry wastes to sanitary landfill. Depth of cuts and thickness of fill variable. Not extensively mapped in urbanized areas.

al ALLUVIUM (HOLOCENE)--Sand, silt, gravel and minor muck in flood plains along present rivers and streams. As much as 3 meters (10 feet) thick. Extent of alluvium indicates most areas flooded in the past which may be subject to future flooding. In areas upstream from dams, the al unit may be a drowned stream terrace. In places, indistinguishable from swamp deposits (s) or lake-bottom deposits (lb, lhb). Areas mapped as al based in part on evidence indicating they are flooded every few years.

s SWAMP DEPOSITS (HOLOCENE)--Muck, peat, silt, and sand. Generally 1/2 meter to 3 meters (1 foot to 10 feet) thick, but may be as much as 9 meters (30 feet) thick. In places, indistinguishable from alluvium (al).

e EOLIAN DEPOSITS (HOLOCENE AND PLEISTOCENE)--Sand, fine- to medium-grained, and silt, well-sorted. Found as a thin blanket to small dunes on a variety of older glacial deposits. Thickest deposits, most of which do not have a distinct morphology in this quadrangle, occur on high ground east of the Connecticut River, indicating deposition by prevailing west to northwest winds shortly after glacial Lake Hitchcock drained, exposing its bottom sediments to wind erosion. "These dunes cannot readily be distinguished from low sandy kames by their moundlike form; but where the interior is revealed as in roadcuts, the uniform coarseness of the sand and the utter absence of pebbles and stones will identify them as windblown" Goldthwaite and others, 1951, p. 51). As much as 6 meters (20 feet) thick.

STREAM-TERRACE DEPOSITS (HOLOCENE AND LATE PLEISTOCENE)--Sand, gravel, silt, and minor muck, generally on terraces cut by the late-glacial and post-glacial Connecticut and Ashuelot Rivers and their tributaries, as they cut down their channels when base levels dropped due to failure of glacial drift dams within their watersheds. Deposits in the Connecticut River drainage were deposited on the floodplain of the Early Holocene-Late Pleistocene Connecticut River, as it cut down through lake-bottom and deltaic deposits of former glacial-Lake Hitchcock; and most of these terrace deposits disconformably overie varved clay. Deposits near the top of a scarp may be as much as 12 meters (40 feet) thick, while those near the base of the next highest scarp commonly form discontinuous patches that overlie varved clay (Campbell and Hartshorn, 1980). Several terrace levels were identified, but were combined into two units. The higher, older unit was probably graded to the Lily Pond bedrock barrier near Turners Falls in the Greenfield quadrangle, Massachusetts (Campbell and Hartshorn, 1980; Jahns and Willard, 1942). The lower unit consists of several terrace levels that were graded to stages of the Connecticut River intermediate between the older terrace and modern levels. More detailed study of these terraces could potentially lead to identification of two or more units, similar to those identified for the Cold River area by Ridge (1988). Stream terrace units identified in the Hinsdale quadrangle also include erosional terraces discontinuously veneered with stream-terrace deposits.

st_2 Higher stream-terrace deposits. From 1/2 to 12 meters (1 to 40 feet) thick.

st_1 Lower stream-terrace deposits. From 1/2 to 6 meters (1 to 20 feet) thick.

hb GLACIAL-LAKE AND GLACIAL-STREAM DEPOSITS IN THE HUBBARD BROOK--LILY POND AREA (PLEISTOCENE)-- Sand, gravel, silt, an minor clay and flowtill deposited in contact with or beyond adjacent ice as kame-terrace, ice-channel, and/or esker materials laid down by south-flowing meltwaters graded to the drainage divide between Hubbard Brook and Lily Pond Brook through the col at 216-222 meters (709-728 feet) altitude along the dirt road near the northwest edge of the quadrangle. Contemporaneous in part with units lp, lhb, lb, la, kb, st1, ta, and bb. As much as 9 meters (30 feet) thick .

lp GLACIAL-STREAM DEPOSITS IN THE LILY POND BROOK AREA (PLEISTOCENE)-- Sand, gravel, silt, and minor clay deposited in contact with or beyond adjacent ice as kame-terrace and outwash deposits by meltwaters flowing south down the Lily Pond drainage.
Contemporaneous in part with units lhb, lha, lb, la, kb, st1, ta, and bb. As much as 3 meters (10 feet) thick.

sg UNCORRELATED GLACIAL-LAKE AND GLACIAL-STREAM DEPOSITS IN THE HUBBARD BROOK, BROAD BROOK, AND WHEELOCK BROOK DRAINAGES (PLEISTOCENE)-- Small deposits, uncorrelated with any outlet, of sand, gravel, silt, deposited in contact with or byeond adjacent ice as kame-terrace, ice-channel, and/or esker materials. As much as 3 meters (10 feet) thick.

GLACIAL-LAKE HITCHCOCK DEPOSITS (PLEISTOCENE)--Sand, gravel, silt, and clay deposited by glacial meltwaters in contact with or beyond adjacent ice as kame-delta, shore, nearshore, outwash and bottom-set beds of glacial Lake Hitchcock, whose level was controlled by a glacial drift dam at Rocky Hill, Connecticut, and a spillway at New Britain, CT. Glacial-lake Hitchcock occupied the Connecticut valley for several thousands of years between around15,000-16,000 years ago to perhaps about 12,000 -11,000 years ago. The front of the Late-Wisconsinan Ice sheet may have still been in contact with the lake near its northern end when the Rocky Hill drift dam failed and the lake drained. Unit lhb consists of bottomset beds, mostly silt and clay varves as much as 50 meters (150 feet) thick. Unit lha consist of kame-delta and outwash deposits laid down by meltwaters draining the Ashuelot River valley, mostly sand and gravel grading west and south to finer grained sand where the meltwaters entered glacial Lake Hitchcock at aroundt 120 + meters (394 + feet) altitude. Due to post-glacial uplift in the area, the water plane is tilted at 0.9 meters/ km (4.74 feet per mile in a N21.5°W direction, so that shore deposits and deltas built into the lake north of the area are found at respectively higher elevations (Koteff and Larsen, 1989; Larsen, 1992).

lhb Lake-bottom and nearshore deposits, as much as 50 meters (150 feet) thick.

lha Kame-delta, shore, nearshore, and outwash deposits, as much as 30 meters (100 feet) thick

kb GLACIAL-STREAM DEPOSITS OF KILBURN BROOK AREA (PLEISTOCENE)--Sand, gravel, and minor silt, clay, and muck deposited in contact with and beyond adjacent ice as kame-terrace, outwash and alluvial fan deposits by meltwaters flowing south down the valley of Kilburn Brook and its tributaries. Contemporaneous with parts of units lp, hb, lha, lb, la, st1, ta, and bb. As much as 3 meters (10 feet) thick.

GLACIAL-LAKE ASHUELOT DEPOSITS (PLEISTOCENE)--Sand, gravel, silt, and clay deposited by meltwaters in contact with or beyond adjacent ice as kame-delta, delta, shore and nearshore and bottom-set beds of glacial Lake Ashuelot, whose level was controlled by a glacial drift dam that clogged the Ashuelot River valley between the confluence of the Ashuelot with Tufts and Broad Brooks. The spillway for glacial Lake Ashuelot was a channel at altitude 138-144 meters (453-472 feet) in the hills just south of the modern river in the same area. Some varved clay deposits in the Keene area were deposited in glacial Lake Ashuelot approximately 12,600 to 12,700 years B.P.(Before Present) and there are more than 30 feet of silt and clay below that particular varved section (Larsen, 1992, p. 386).

lb Lake-bottom and nearshore deposits--Clay, silt, and fine to coarse sands overlain in places by dominantly deltaic sand and pebble gravel deposits (larsen and Kotefff, 1997). As much as 40 meters (130 feet) thick.

la Kame-delta, delta, shore, and nearshore deposits consisting of predominantly sand and pebble grave. One potential beach deposit was noted under the power lines south of Spot Meadow Brook in the east-central part of the quadrangle. As much as 18 meters (60 feet) thick.

vb Very Brook Deposit--Sand and gravel deposited adjacent to abeyond ice as kame deposits. As much as 30 m (100 ft) thick. Originally mapped in the adjacent West Swanzey quadrangle (Pendleton, 1998)

cf Camp Forest Lake Deposits--Proximal deltaic and kame sands and gravels deposited in contact with and downgradient of glacial ice. As much as 30 m (100 ft) thick. Originally mapped in the adjacent West Swanzey quadrangle (Pendleton, 1998)

rs Richmond Street Deposits--Deltaic and glaciolacustrine sands and gravels deposited into the northern portion of Sunny Valley in Winchester into Glacial Lake Ashuelot. As much as 25 m (80 ft) thick. Originally mapped in the adjacent West Swanzey quadrangle (Pendleton, 1998)

ta GLACIAL-STREAM DEPOSITS IN THE TUFTS BROOK AREA (PLEISTOCENE)-- Sand, gravel, silt, and minor clay deposited in contact with and beyond adjacent ice as kame-terrace, outwash, ice-channel filling, and/or esker deposits by south-flowing meltwaters down the Tufts Brook drainage valley. As much as 3 meters (10 feet) thick.

bb GLACIAL-STREAM DEPOSITS IN THE BROAD BROOK AREA (PLEISTOCENE)-- Sand, gravel, silt, and minor clay deposited in contact with and beyond adjacent ice as kame-terrace, outwash, ice-channel filling, and/or esker deposits by south-flowing meltwaters down the Broad Brook drainage valley. A large pot-hole scar over 2 meters (8 feet) high that was scoured out by glacial meltwaters was observed on the west side of the trail, about 1,067 meters (3,500 feet) north of where the trail crosses under the power lines. As much as 3 meters (10 feet) thick.

lau UPPER GLACIAL-LAKE ASHUELOT DEPOSITS (PLEISTOCENE)--Sand, gravel and minor silt and clay deposited in contact with and beyond adjacent ice as kame-terrace deposits graded to a higher level than the main glacial Lake Ashuelot channel (about 162-168 meters [531-551 feet] altitude) . As much as 9 meters (30 feet) thick.

cd GLACIAL-STREAM DEPOSITS EAST OF CAT DEN MOUNTAIN (PLEISTOCENE)-- Sand, gravel, flowtill, silt, and minor clay deposited in contact with and beyond adjacent ice as kame-terrace deposits laid down by meltwaters flowing westward between the mountains on the south and the ice margin on the north. As much as 3 meters (10 feet) thick.

gs GLACIAL-LAKE AND GLACIAL-STREAM DEPOSITS EAST AND SOUTH OF GUN AND SCHOFIELD MOUNTAINS (PLEISTOCENE)-- Sand, gravel, flowtill, silt, and minor clay deposited in contact with and beyond adjacent ice as kame-terrace deposits laid down by meltwaters flowing southward between the mountains on the north and east and the ice margin on the south and west. As much as 3 meters (10 feet) thick.

rt GLACIAL-STREAM DEPOSITS ALONG ROUTE 10 SOUTH (PLEISTOCENE)-- Sand, gravel, flowtill, silt, and minor clay deposited in contact with and beyond adjacent ice as kame-terrace deposits laid down by meltwaters flowing southward over a divide at 222-228 meters (728-748 feet) altitude about 0.75 km (1/2 mile) south of the quadrangle border. As much as 3 meters (10 feet) thick.

t TILL (PLEISTOCENE)--Light- to dark-gray, nonsorted to poorly sorted mixture of clay, silt, and, pebbles,cobbles and boulders; contains some gravel. Thickness varies and generally is less than 6 meters (20 feet), but is commonly more than 24 meters (80 feet) under the crest of most drumlins.

BEDROCK EXPOSURES--Individual outcrops not shown completely. Solid is individual outcrop; ruled pattern indicates areas of abundant exposures and areas where surficial deposits are generally less than 10 feet thick. Mapped in part from aerial photos and Soil Surveys (Simmons and others, 1949, and Rosenberg, 1985).

MATERIALS OBSERVATIONS--Surficial materials in exposures, well holes and test holes. Letters indicate texture in decreasing order of abundance. Number indicates thickness in feet.

g gravel
b boulder
c cobble
p pebble
s sand (as separate beds; not including sand in matrix of gravel)
F fine sand
$\not{s}$ silt
$\not{c}$ clay
t till
R rottenstone
G grüss (a granular form of rottenstone derived from weathering of granitic rocks)

WELL-HOLE AND TEST-HOLE DATA--Materials for some holes described. Approximately located from New Hampshire Department of Environmental Services, Water Resources Division, Concord, N.H., and Moore and others (1994, pl. 2) .

Well or test hole reported as ending in bedrock or refusal. Where only a number is given, it represents depth to bedrock in feet. Where surficial materials were identified by driller, said materials and their thickness in feet are given (add thickness of all materials in each hole to find depth to bedrock). Altitude to bedrock suface in feet above mean sea level given in parentheses where known.

Well or test hole that did not reach bedrock or refusal. Depth reached indicated (in feet).

Koteff, Carl, Stone, J.R., Larsen, F.D., Ashley, G.M., Boothroyd, J.C., and Dincauze, D.F., 1988, Glacial Lake Hitchcock, postgracial upift, and post-lake archaeology, *in* Brigham-Grette, Julie, ed., Fieldtrip Guidebook of 1988 AMQUA meeting, University of Massachusetts Department of Geology and Geography Contribution No. 63, p. 169-208.

______ and Larsen, F.D., 1989. Postglacial uplift in western New England: Geologic evidence for delayed rebound, *in* Gerersen, S., and Basham, P.W., eds., Earthquakes at North Atlantic passive margins: Neotetonics and postgacial rebound: Norwell, Massachusetts, Kluwer Academic Publishers, p. 105-123.

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______ and Koteff, Carl, 1997, Surficial geology of the Keene 7.5-minute metric quadrangle, Cheshire County, New Hampshire, scale, 1:24,000

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Simmons, C.S., Latimer, W.J., Layton, M.H., Coates, W.H., Lyford, W.H., and Scripture, P.N., 1949, Soil Survey of Cheshire and Sullivan Counties, New Hampshire: U.S. Soil Conservation Service Series 1937, No. 23, 82 p., map scale 1:62,500.

Note: Mapped in cooperation with the National Geologic Map Program; STATEMAP program

TEXTURE OF STRATIFIED DEPOSITS--Indicated to a depth of at least l/2 meter (1.5 feet)

Pebble to boulder gravel

Mixed sand and gravel

Sand

Sand, fine sand, silt and clay

Borrow pit, small

Borrow pit, small-abandoned

Borrow pit, large, or cut bank

Approximate extent of glacial Lake Ashuelot, projected N21.5W, 0.9 meters/mile from the spillway at an altitude of 138-144 meters (453-472 feet) (Larsen, 1992) (see discussion above). Shown as a solid line where corresponds with a unit contact.

Abandoned glacial meltwater and modern stream channels. Direction of flow shown by arrow

Shallow scour channels on stream terraces and modern alluvial plains.

Scarp

SITE

Glacial striations. Point of observation is at southern end of line.

Drumlin form. Some are classic drumlin shape and others are just sreamlined hills, inferred to Indicate general direction of glacial ice movement

la

138-144

Threshold (outlet) to which designated glacial deposits are graded. Number gives approximate elevation in meters. Symbol(s) is (are) unit(s) graded to the threshold.

REFERENCES:

Campbell, K.J., and Hartshorn, J.H., 1980, Surficial geologic map of the Northfield quadrangle, Massachusetts, New Hampshire, and Vermont: U.S. Geol. Quad. Map GQ-1440, scal 1:24,000.

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Appendix B
Final Detailed Study Site Locations

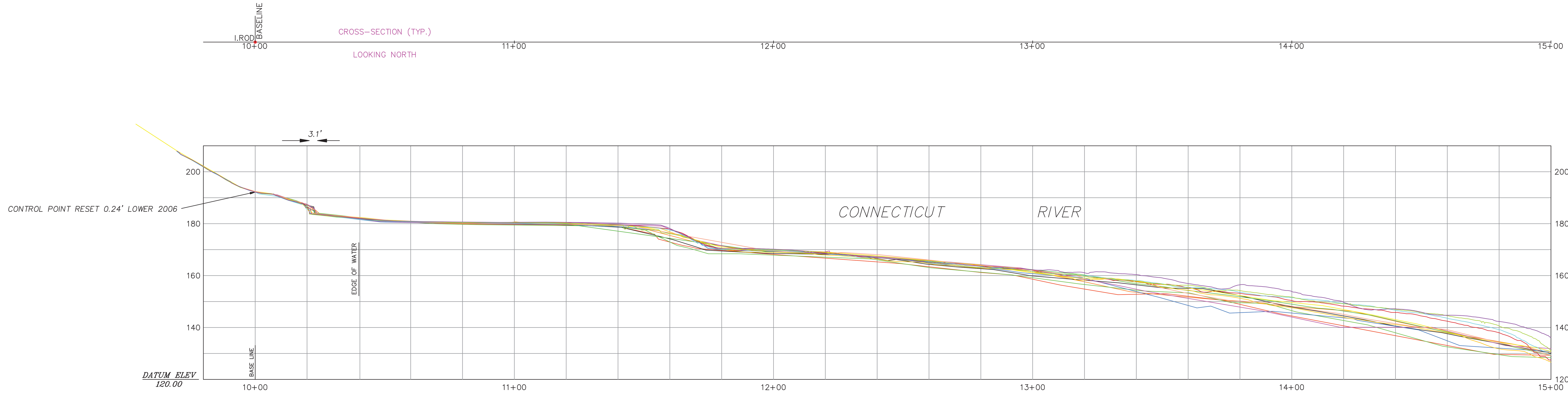
FINAL EXISTING, PERMANENT TRANSECT LOCATIONS FOR DETAILED STUDY -

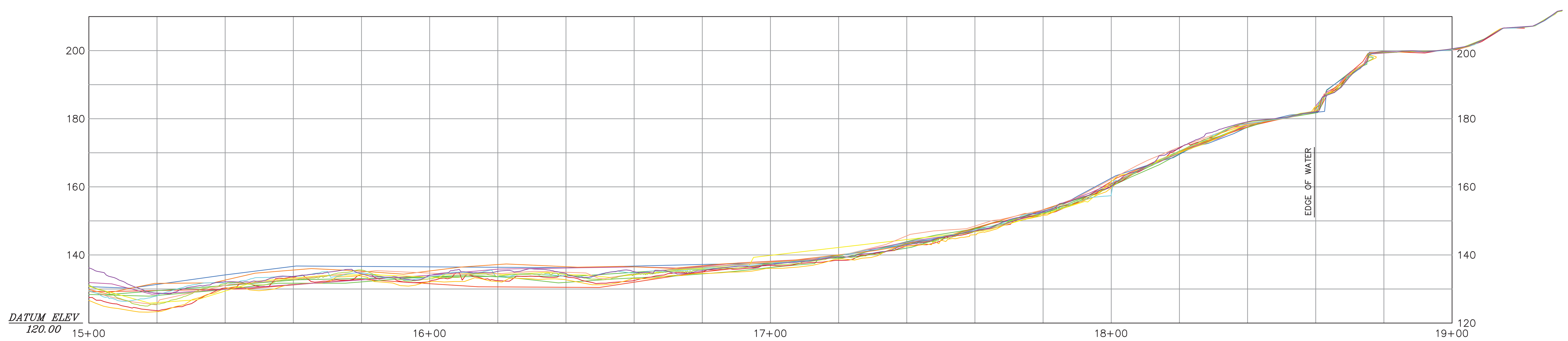
EXISTING PERMANENT TRANSECT # BC1

Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Moderate	Moderate
Upper Riverbank Height	High	High
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Heavy	Heavy
Lower Riverbank Slope	Moderate	Flat/Beach
Lower Riverbank Sediment	Boulders	Silt/Sand
Lower Riverbank Vegetation	None/Very Sparse	None/Very Sparse
Type of Erosion	None	Undercut
Potential Erosion Indicators	None	Creep/Leaning Trees
Stage of Erosion	Stable	Stable
Extent of Current Erosion	None/Little	None/Little

TRANSECT #BC1 - Left Bank (274)

TRANSECT #BC1 - Right Bank (377)





SECTION BC-1

(LOOKING UPSTREAM)

LEGEND

SERIES	WATER ELEVATION	DATE	FIELD BOOK
6th	179.8	12/16/99	252 PG 62
7th	181.9	06/05/00	250 PG 42
8th	182.7	10/11/00	254 PG 26
9th	180.8	07/30/01	260 PG 29
10th	188.9	07/08/02	268 PG 11
11th	180.6	07/14/03	269 PG 30, DATA COLLECTOR
12th	182.2	06/02/04	274 PG 12, DATA COLLECTOR
13th	180.6	7/05	277 PG 8, DATA COLLECTOR
26th	180.3	7/06	277 PG 65, DATA COLLECTOR
27th	182.8	10/07	4 PG 73, DATA COLLECTOR
28th	180.8	08/18/08	7 PG 9, DATA COLLECTOR
29th	181.3	7/09	8 PG 71, DATA COLLECTOR
30th	183.7	7/2010	11 PG 4, DATA COLLECTOR
31th	182.5	6/28/2011	11 PG 11, DATA COLLECTOR

GRAPHIC SCALE

20 0 10 20 40 80

(IN FEET)
1 inch = 20 ft.

NOTE: For display purposes only; not drawn to scale.

NOTES:
ELEVATIONS ARE BASED UPON NGVD 1929
REFERENCE DRAWINGS: 75735, 75738-1, 75739, 75816, 75816A

FirstLight Power Resources

FOR
FIRSTLIGHT HYDRO GENERATING Co.

TITLE
CONNECTICUT RIVER EROSION MONITORING
CROSS SECTION #BC1
HILLSIDE AVENUE, TURNERS FALLS, MA

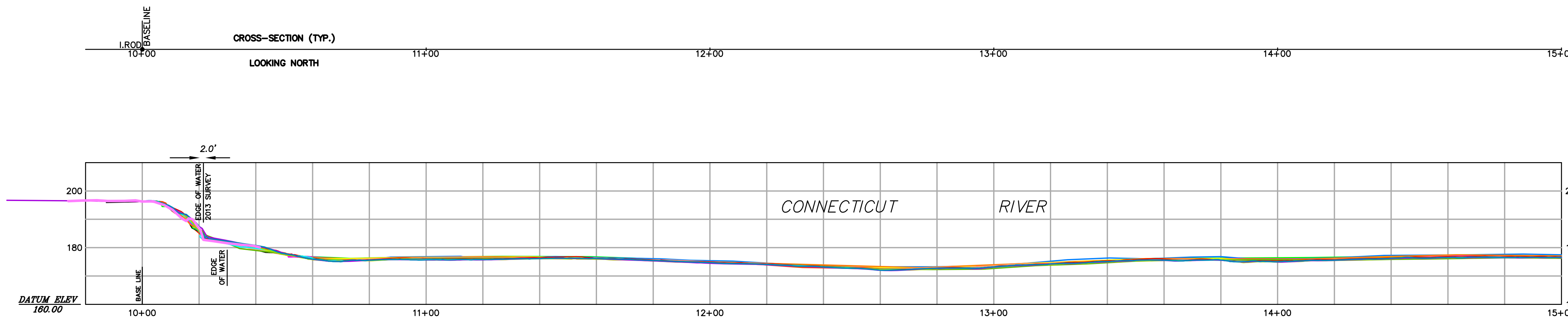
BY JM/KK	REV RRH	APP	APP
DATE 09/15/1998	DATE 02/07/2012	DATE	DATE
SCALE HORZ. & VERT. 1"=20'	MICROFILM DATE	DWG. NO. 75816B-BC1	
		PROJ. #0-50.80	V.S. W-5-8-A

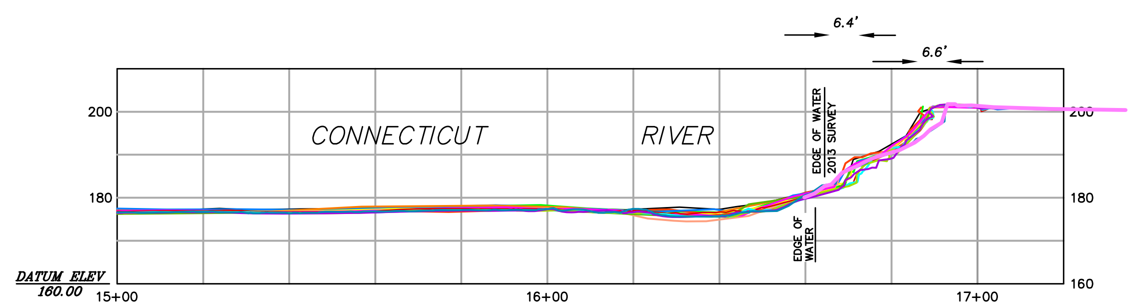
EXISTING PERMANENT TRANSECT #2

Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Vertical	Steep
Upper Riverbank Height	High	Low
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Moderate	Moderate
Lower Riverbank Slope	Flat/Beach	Flat/Beach
Lower Riverbank Sediment	Silt/Sand	Silt/Sand
Lower Riverbank Vegetation	None to very sparse	None to very sparse
Type of Erosion	Rotational slump	Undercut
Potential Erosion Indicators	Creep/Leaning trees	Creep/Leaning Trees, Other
Stage of Erosion	Eroded	Stable
Extent of Current Erosion	Some	None/Little

TRANSECT #2 - Left Bank (1573)

TRANSECT #2 - Right Bank (1321)





SECTION 2

(LOOKING UPSTREAM)

LEGEND

SERIES	WATER ELEVATION	DATE	FIELD BOOK
18th	182.4	11/08/99	247 PG 73
19th	181.7	06/20/00	250 PG 63
20th	181.7	10/24/00	254 PG 56
21th	180.1	07/31/01	260 PG 35
22nd	181.5	07/10/02	268 PG 10
23rd	181.4	07/14/03	269 PG 30, DATA COLLECTOR
24th	182.1	06/12/04	274 PG 13, DATA COLLECTOR
25th	182.0	7/05	277 PG 9, DATA COLLECTOR
26th	185.9	7/06	277 PG 65, DATA COLLECTOR
28th	186.3	7/08	7 PG ?, DATA COLLECTOR
29th	182.7	7/09	8 PG 70, DATA COLLECTOR
30th	182.9	7/2010	11 PG 2, DATA COLLECTOR
31th	181.7	8/19/2011	11 PG 13, DATA COLLECTOR
32nd	183.9	7/2/2012	11 PG 18, DATA COLLECTOR
33rd		10/02/2013*	DATA COLLECTOR

* LAND BASED RIVERBANK SURVEY

REVISIONS:

No. DATE

GENERAL NOTES:

1. 2013 ELEVATIONS PRESENTED ON THE PLAN REPRESENT RESULTS OF ON-THE-GROUND AND HYDROGRAPHIC SURVEYS PERFORMED BY CHA CONSULTING, INC. BETWEEN JULY AND OCTOBER 2013. REUSE OF THIS INFORMATION BY THE CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT THE LIABILITY TO CHA CONSULTING, INC.

2. RIVER CROSS-SECTIONS FOR YEARS PRIOR TO 2013 ARE FROM A DRAWING ENTITLED "CONNECTICUT RIVER EROSION MONITORING CROSS SECTION #2 ASHUELOT RIVER, HINSDALE VT" PREPARED BY NORTH BY NORTHEAST SURVEY AND MAPPING CONSULTANTS, LAST REVISED JANUARY 6, 2013.

3. GROUND SURVEY AND SURVEY VESSEL HORIZONTAL POSITIONING IS BASED ON TOTAL STATION AND REAL-TIME KINEMATIC (RTK) GPS OBSERVATIONS RESPECTIVELY. HORIZONTAL COORDINATES BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ZONE 2001 AND ARE EXPRESSED IN U.S. SURVEY FEET.

4. THE ELEVATIONS ON THIS PLAN ARE EXPRESSED IN U.S. SURVEY FEET AND ARE REFERENCED TO THE PROJECT DATUM (REPORTED TO BE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29)).

CHA
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Norwell, MA 02061
Main: (781) 982-5400 · www.chacompanies.com

TITLE:

CONNECTICUT RIVER CROSS-SECTIONS

SECTION #2

ASHULEOT RIVER HINSDALE, VERMONT

PREPARED FOR:

FIRST LIGHT POWER RESOURCES/GDF SUEZ
99 MILLERS FALLS ROAD
NORTHFIELD, MA 01360

DATE: JANUARY 14, 2014
COMP./DESIGN: BAS/AMC
CHECK: MWR/EJP
DRAWN: AMC
SCALE: 1"=20'

1 of 1

JOB NO.: F:\Project\...\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg
DWG NO.: 22 SECTIONS 2013.DWG

20 10 0 20 40

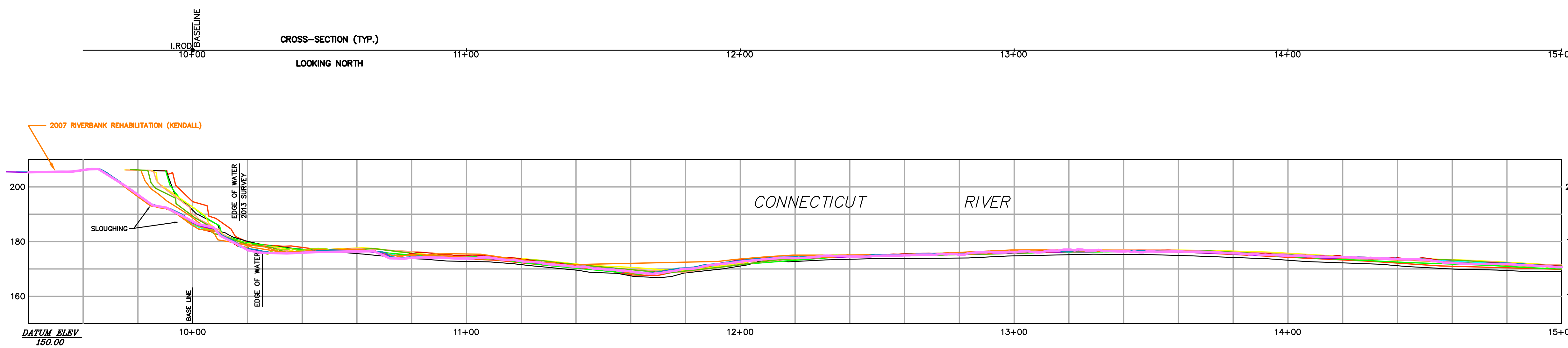
NOTE: For display purposes only; not drawn to scale.

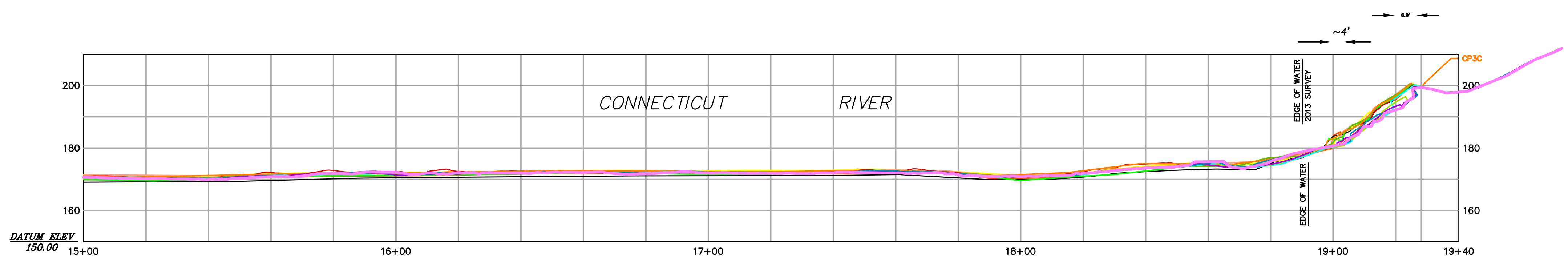
EXISTING PERMANENT TRANSECT #3

Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Moderate	Moderate
Upper Riverbank Height	Low	High
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Heavy	Heavy
Lower Riverbank Slope	Flat/Beach	Moderate
Lower Riverbank Sediment	Silt/Sand	Gravel
Lower Riverbank Vegetation	None to very sparse	None to very sparse
Type of Erosion	Undercut, Rotational Slump	
Potential Erosion Indicators	Creep/Leaning trees, Overhanging	
Stage of Erosion	Eroded	Stable
Extent of Current Erosion	Some	None/Little

TRANSECT #3 - Left Bank (1673)

TRANSECT #3 - Right Bank (1234)





SECTION 3

(LOOKING UPSTREAM)

LEGEND

SERIES	WATER ELEVATION	DATE	FIELD BOOK
18th	178.7	11/09/99	247 PG 76
19th	178.8	06/20/00	250 PG 65
20th	178.8	10/24/00	254 PG 58
21th	177.2	08/01/01	260 PG 37
22nd	177.8	07/10/02	268 PG 10
23rd	178.7	07/14/03	269 PG 30, DATA COLLECTOR
24th	179.6	06/08/04	274 PG 13, DATA COLLECTOR
25th	180.4	7/05	277 PG 9, DATA COLLECTOR
26th	182.8	7/06	277 PG 65, DATA COLLECTOR
27th	179.8	10/07	4 PG 73, DATA COLLECTOR
28th	186.3	7/08	7 PG ?, DATA COLLECTOR
29th	181.2	7/09	8 PG 70, DATA COLLECTOR
30th	182.1	7/2010	11 PG 3, DATA COLLECTOR
31th	179.8	6/20/2011	11 PG 10, DATA COLLECTOR
32nd	180.2	7/3/2012	11 PG 18, DATA COLLECTOR
33rd		9/20/2013*	DATA COLLECTOR

* LAND BASED RIVERBANK SURVEY

REVISIONS:

No. DATE

GENERAL NOTES:

1. 2013 ELEVATIONS PRESENTED ON THE PLAN REPRESENT RESULTS OF ON-THE-GROUND AND HYDROGRAPHIC SURVEYS PERFORMED BY CHA CONSULTING, INC. BETWEEN JULY AND OCTOBER 2013. REUSE OF THIS INFORMATION BY THE CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT THE LIABILITY TO CHA CONSULTING, INC.

2. RIVER CROSS-SECTIONS FOR YEARS PRIOR TO 2013 ARE FROM A DRAWING ENTITLED "CONNECTICUT RIVER EROSION MONITORING CROSS SECTION #3 ROUTE 63, HINSDALE, VT" PREPARED BY NORTH BY NORTHEAST SURVEY AND MAPPING CONSULTANTS, LAST REVISED JANUARY 6, 2013.

3. GROUND SURVEY AND SURVEY VESSEL HORIZONTAL POSITIONING IS BASED ON TOTAL STATION AND REAL-TIME KINEMATIC (RTK) GPS OBSERVATIONS RESPECTIVELY. HORIZONTAL COORDINATES BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ZONE 2001 AND ARE EXPRESSED IN U.S. SURVEY FEET.

4. THE ELEVATIONS ON THIS PLAN ARE EXPRESSED IN U.S. SURVEY FEET AND ARE REFERENCED TO THE PROJECT DATUM (REPORTED TO BE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29)).

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TITLE:

CONNECTICUT RIVER CROSS-SECTIONS

SECTION #3

ROUTE 63
HINSDALE, VERMONT

PREPARED FOR:

FIRST LIGHT POWER RESOURCES/GDF SUEZ
99 MILLERS FALLS ROAD
NORTHFIELD, MA 01360

DATE: JANUARY 14, 2014
COMP./DESIGN: BAS/AMC
CHECK: MWR/EJP
DRAWN: AMC
SCALE: 1"=20'

1 of 1

JOB NO.: F:\Project\MA\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg
DWG NO.: 22 SECTIONS 2013.DWG

20 10 0 20 40

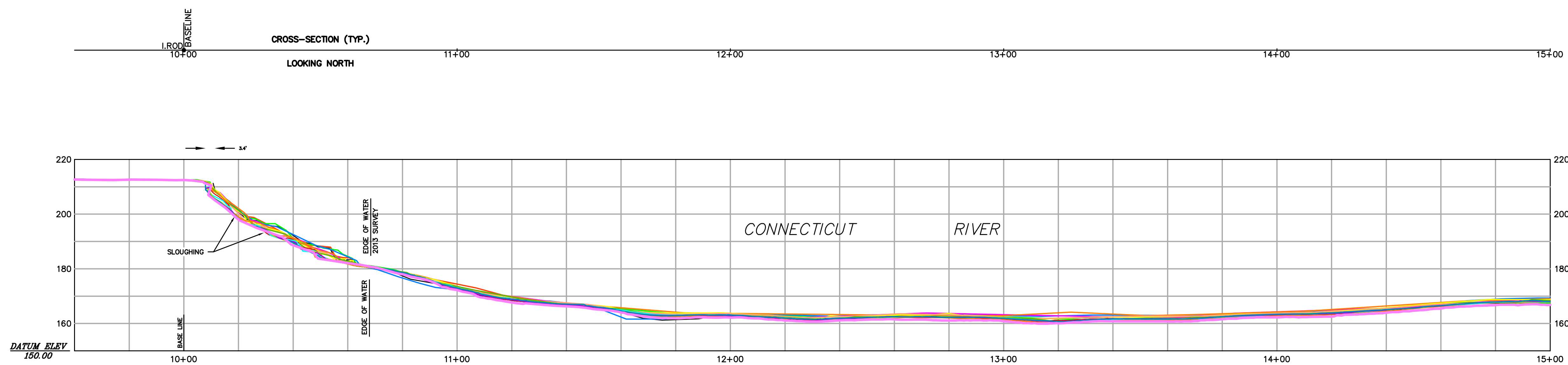
NOTE: For display purposes only; not drawn to scale.

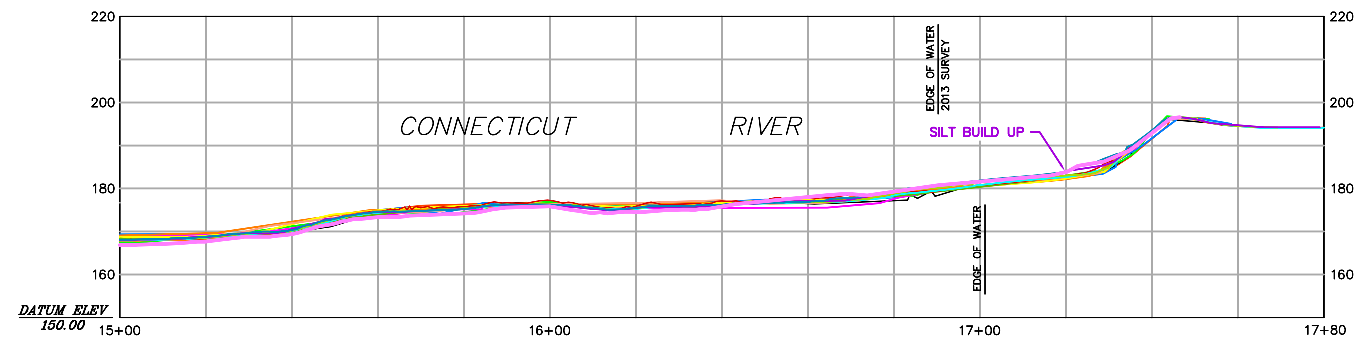
EXISTING PERMANENT TRANSECT #4

Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Moderate	Moderate
Upper Riverbank Height	Medium	High
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Heavy	Heavy
Lower Riverbank Slope	Flat/Beach	Flat/Beach
Lower Riverbank Sediment	Silt/Sand	Silt/Sand
Lower Riverbank Vegetation	None to very sparse	None to very sparse
Type of Erosion		Undercut
Potential Erosion Indicators	Creep/Leaning trees	Creep/Leaning trees
Stage of Erosion	Stable	Stable
Extent of Current Erosion	None/Little	None/Little

TRANSECT #4 - Left Bank (1708)

TRANSECT #4 - Right Bank (1198)





SECTION 4

(LOOKING UPSTREAM)

LEGEND

SERIES	WATER ELEVATION	DATE	FIELD BOOK
18th	181.3	11/09/99	252 PG 1
19th	180.5	06/19/00	250 PG 59
20th	181.0	10/20/00	254 PG 41
21th	179.9	08/01/01	260 PG 39
22nd	179.8	07/10/02	268 PG 9
23rd	181.2	07/14/03	269 PG 30, DATA COLLECTOR
24th	181.4	07/06/04	274 PG 17, DATA COLLECTOR
25th	181.3	7/05	277 PG 9, DATA COLLECTOR
26th	184.6	7/06	277 PG 65, DATA COLLECTOR
27th	182.4	10/07	4 PG 73, DATA COLLECTOR
28th	183.4	7/08	7 PG 8, DATA COLLECTOR
29th	183.5	7/09	7 PG 70, DATA COLLECTOR
30th	183.4	7/2010	11 PG 2, DATA COLLECTOR
31th	181.2	8/19/2011	11 PG 13, DATA COLLECTOR
32nd	183.0	7/3/2012	11 PG 19, DATA COLLECTOR
33rd		9/20/2013*	DATA COLLECTOR

* LAND BASED RIVERBANK SURVEY

REVISIONS:

No. DATE

GENERAL NOTES:

1. 2013 ELEVATIONS PRESENTED ON THE PLAN REPRESENT RESULTS OF ON-THE-GROUND AND HYDROGRAPHIC SURVEYS PERFORMED BY CHA CONSULTING, INC. BETWEEN JULY AND OCTOBER 2013. REUSE OF THIS INFORMATION BY THE CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT THE LIABILITY TO CHA CONSULTING, INC.

2. RIVER CROSS-SECTIONS FOR YEARS PRIOR TO 2013 ARE FROM A DRAWING ENTITLED "CONNECTICUT RIVER EROSION MONITORING CROSS SECTION #4 NORTHFIELD BOAT LAUNCH, NORTHFIELD, MA" PREPARED BY NORTH BY NORTHEAST SURVEY AND MAPPING CONSULTANTS, LAST REVISED JANUARY 6, 2013.

3. GROUND SURVEY AND SURVEY VESSEL HORIZONTAL POSITIONING IS BASED ON TOTAL STATION AND REAL-TIME KINEMATIC (RTK) GPS OBSERVATIONS RESPECTIVELY. HORIZONTAL COORDINATES BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ZONE 2001 AND ARE EXPRESSED IN U.S. SURVEY FEET.

4. THE ELEVATIONS ON THIS PLAN ARE EXPRESSED IN U.S. SURVEY FEET AND ARE REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29).

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TITLE:

CONNECTICUT RIVER CROSS-SECTIONS

SECTION #4

NORTHFIELD BOAT LAUNCH NORTHFIELD, MASSACHUSETTS

PREPARED FOR:

FIRST LIGHT POWER RESOURCES/GDF SUEZ 99 MILLERS FALLS ROAD NORTHFIELD, MA 01360

DATE: JANYARY 14, 2014
COMP./DESIGN: BAS/AMC
CHECK: MWR/EJP
DRAWN: AMC
SCALE: 1"=20'

1 of 1

JOB NO.: F:\Project\MA\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg

DWG NO.: 22 SECTIONS 2013.DWG

20 10 0 20 40

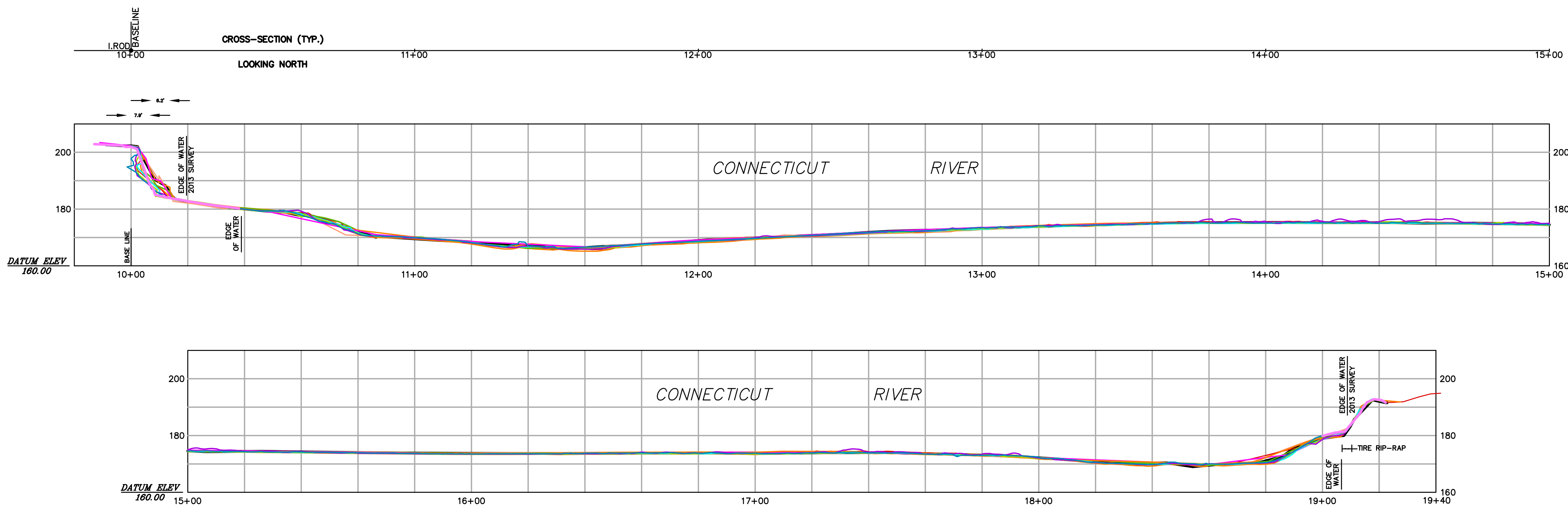
NOTE: For display purposes only; not drawn to scale.

EXISTING PERMANENT TRANSECT #5C

Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Steep	Steep
Upper Riverbank Height	High	High
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Heavy	Moderate
Lower Riverbank Slope	Moderate	Flat/Beach
Lower Riverbank Sediment	Boulders	Silt/Sand
Lower Riverbank Vegetation	None to very sparse	None to very sparse
Type of Erosion	Slide or Flow	Slide or Flow
Potential Erosion Indicators		Overhanging bank, Exposed Roots, Creep/Leaning Trees
Stage of Erosion	Stable	Eroded
Extent of Current Erosion	None/Little	Some

TRANSECT #5C - Left Bank (809)

TRANSECT #5C - Right Bank (1102)



SECTION 5C

(LOOKING UPSTREAM)

LEGEND

SERIES	WATER ELEVATION	DATE	FIELD BOOK	
18th	183.2	11/17/99	252 PG 9	REMOVED FROM DATA SET UNTIL FURTHER REVIEW
19th	182.2	06/08/00	250 PG 53	
20th	181.0	10/15/00	254 PG 37	
21th	181.1	07/02/01	260 PG 19	
22nd	181.3	07/08/02	268 PG 7	
23rd	181.6	07/14/03	269 PG 26, DATA COLLECTOR	
24th	182.7	06/04/04	274 PG 12, DATA COLLECTOR	
25th	184.6	7/05	277 PG 9, DATA COLLECTOR	
26th	183.3	7/06	277 PG 65, DATA COLLECTOR	
27th	182.9	10/07	4 PG 73, DATA COLLECTOR	
28th	184.4	7/08	7 PG 9, DATA COLLECTOR	
29th	182.4	7/09	8 PG 71, DATA COLLECTOR	
30th	183.6	7/2010	11 PG 5, DATA COLLECTOR	
31th	183.1	8/19/2011	11 PG 12, DATA COLLECTOR	
32nd	180.8	7/6/2012	11 PG 19, DATA COLLECTOR	
33rd		10/1/2013*	DATA COLLECTOR	

* LAND BASED RIVERBANK SURVEY

REVISIONS:

No. DATE

GENERAL NOTES:

1. 2013 ELEVATIONS PRESENTED ON THE PLAN REPRESENT RESULTS OF ON-THE-GROUND AND HYDROGRAPHIC SURVEYS PERFORMED BY CHA CONSULTING, INC. BETWEEN JULY AND OCTOBER 2013. REUSE OF THIS INFORMATION BY THE CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT THE LIABILITY TO CHA CONSULTING, INC.

2. RIVER CROSS-SECTIONS FOR YEARS PRIOR TO 2013 ARE FROM A DRAWING ENTITLED "CONNECTICUT RIVER EROSION MONITORING CROSS SECTION #5C BENNETT MEADOW BRIDGE, NORTHFIELD, MA" PREPARED BY NORTH BY NORTHEAST SURVEY AND MAPPING CONSULTANTS, LAST REVISED JANUARY 6, 2013.

3. GROUND SURVEY AND SURVEY VESSEL HORIZONTAL POSITIONING IS BASED ON TOTAL STATION AND REAL-TIME KINEMATIC (RTK) GPS OBSERVATIONS RESPECTIVELY. HORIZONTAL COORDINATES BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ZONE 2001 AND ARE EXPRESSED IN U.S. SURVEY FEET.

4. THE ELEVATIONS ON THIS PLAN ARE EXPRESSED IN U.S. SURVEY FEET AND ARE REFERENCED TO THE PROJECT DATUM (REPORTED TO BE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29)).

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TITLE:

CONNECTICUT RIVER CROSS-SECTIONS

SECTION #5C

BENNETT MEADOW BRIDGE NORTHFIELD, MASSACHUSETTS

PREPARED FOR:

FIRST LIGHT POWER RESOURCES/GDF SUEZ
99 MILLERS FALLS ROAD
NORTHFIELD, MA 01360

DATE: JANUARY 14, 2014
COMP./DESIGN: BAS/AMC
CHECK: MWR/EJP
DRAWN: AMC
SCALE: 1"=20'

JOB NO.: F:\Project\MA\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg

DWG NO.: 22 SECTIONS 2013.DWG

20 10 0 20 40

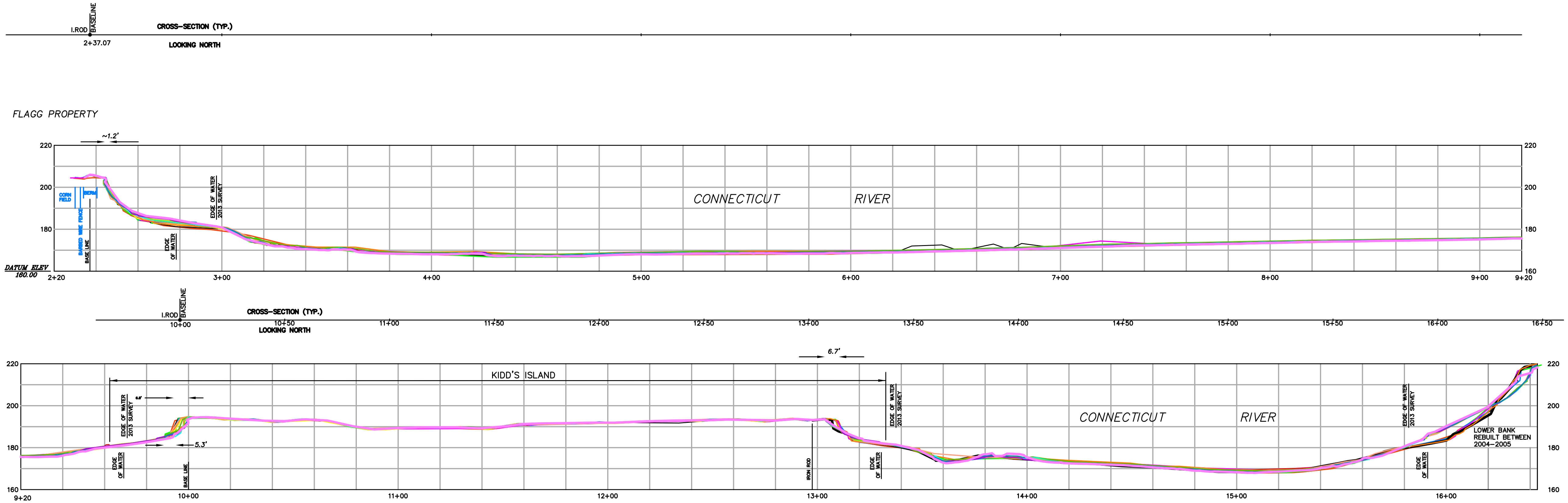
NOTE: For display purposes only; not drawn to scale.

EXISTING PERMANENT TRANSECT #6A

Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Moderate	Steep
Upper Riverbank Height	High	High
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Heavy	Heavy
Lower Riverbank Slope	Moderate	Flat/Beach
Lower Riverbank Sediment	Cobbles	Silt/Sand
Lower Riverbank Vegetation	None to very sparse	Heavy
Type of Erosion		
Potential Erosion Indicators		
Stage of Erosion	Stable	Stable
Extent of Current Erosion	None/Little	None/Little

TRANSECT #6A - Left Bank (678)

TRANSECT #6A - Right Bank (1011)



SECTION 6A

(LOOKING UPSTREAM)

LEGEND

	SERIES	WATER ELEVATION	DATE	FIELD BOOK
	18th	179.8	12/07/99	252 PG 41
	19th	181.3	06/21/00	250 PG 71
	20th	181.1	10/23/00	254 PG 47
	21th	179.7	08/08/01	260 PG 55
	22nd	180.5	07/10/02	268 PG 9
	23rd	181.3	07/14/03	269 PG 31, DATA COLLECTOR
	24th	181.1	06/07/04	274 PG 13, DATA COLLECTOR
	25th	184.8	7/05	277 PG 8, DATA COLLECTOR
	26th	182.7	7/06	277 PG 65, DATA COLLECTOR
	27th	182.7	10/07	4 PG 73, DATA COLLECTOR
	28th	181.2	7/08	7 PG 9, DATA COLLECTOR
	29th	181.9	8/09	8 PG 79, DATA COLLECTOR
	30th	183.6	8/2010	11 PG 6, DATA COLLECTOR
	31th	180.7	7/15/2011	11 PG 12, DATA COLLECTOR
	32nd	182.4	6/28/2012	11 PG 17, DATA COLLECTOR
	33rd		9/19/2013*	DATA COLLECTOR

* LAND BASED RIVERBANK SURVEY

GENERAL NOTES:

1. 2013 ELEVATIONS PRESENTED ON THE PLAN REPRESENT RESULTS OF ON–THE–GROUND AND HYDROGRAPHIC SURVEYS PERFORMED BY CHA CONSULTING, INC. BETWEEN JULY AND OCTOBER 2013. REUSE OF THIS INFORMATION BY THE CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT THE LIABILITY TO CHA CONSULTING, INC.

2. RIVER CROSS–SECTIONS FOR YEARS PRIOR TO 2013 ARE FROM A DRAWING ENTITLED "CONNECTICUT RIVER EROSION MONITORING CROSS SECTION #6A PINE MEADOW ROAD, NORTHFIELD & GILL, MA" PREPARED BY NORTH BY NORTHEAST SURVEY AND MAPPING CONSULTANTS, LAST REVISED JANUARY 6, 2013.

3. GROUND SURVEY AND SURVEY VESSEL HORIZONTAL POSITIONING IS BASED ON TOTAL STATION AND REAL–TIME KINEMATIC (RTK) GPS OBSERVATIONS RESPECTIVELY. HORIZONTAL COORDINATES BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ZONE 2001 AND ARE EXPRESSED IN U.S. SURVEY FEET.

4. THE ELEVATIONS ON THIS PLAN ARE EXPRESSED IN U.S. SURVEY FEET AND ARE REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29).

REVISIONS:

No. DATE

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TITLE:
CONNECTICUT RIVER CROSS–SECTIONS
SECTION #6A
PINE MEADOW ROAD
NORTHFIELD & GILL, MA

PREPARED FOR:
FIRST LIGHT POWER RESOURCES/GDF SUEZ
99 MILLERS FALLS ROAD
NORTHFIELD, MA 01360

DATE: JANUARY 14, 2014
COMP./DESIGN: BAS/AMC
CHECK: MWR/EJP
DRAWN: AMC
SCALE: 1"=20'
JOB NO.: F:\Project\MA\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg
DWG NO.: 22 SECTIONS 2013.DWG

1 of 1

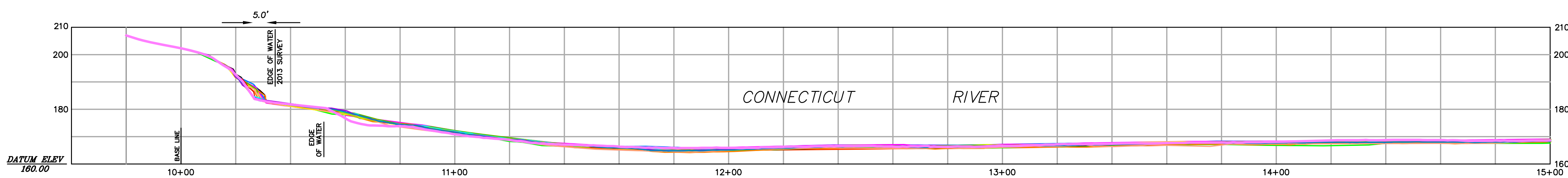
NOTE: For display purposes only; not drawn to scale.

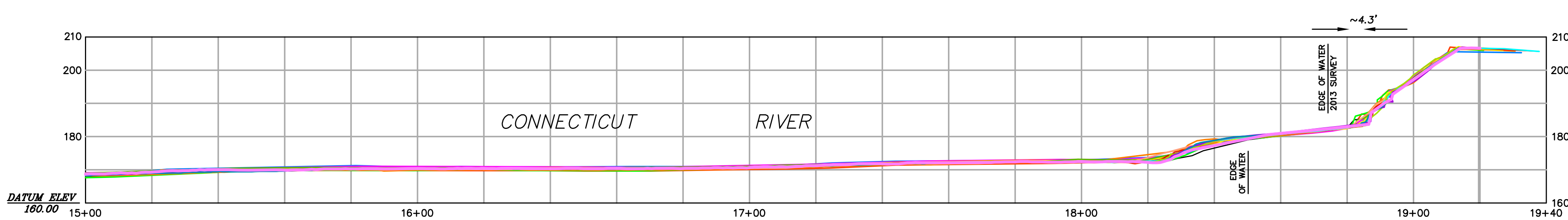
EXISTING PERMANENT TRANSECT #7

Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Steep	Moderate
Upper Riverbank Height	High	High
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Heavy	Heavy
Lower Riverbank Slope	Flat/Beach	Moderate
Lower Riverbank Sediment	Silt/Sand	Boulders
Lower Riverbank Vegetation	None to very sparse	None to very sparse
Type of Erosion	Undercut	
Potential Erosion Indicators	Creep/Leaning trees	
Stage of Erosion	Potential Future Erosion	Stable
Extent of Current Erosion	None/Little	None/Little

TRANSECT #7 - Left Bank (651)

TRANSECT #7 - Right Bank (985)





SECTION 7

(LOOKING UPSTREAM)

LEGEND

SERIES	WATER ELEVATION	DATE	FIELD BOOK
18th	182.3	12/01/99	252 PG 35
19th	179.2	06/14/00	250 PG 57
20th	180.2	10/15/00	254 PG 34
21th	180.1	07/02/01	260 PG 17
22nd	181.6	07/08/02	268 PG 7
23rd	180.1	07/14/03	269 PG 31, DATA COLLECTOR
24th	182.9	06/03/04	274 PG 12, DATA COLLECTOR
25th	185.8	7/05	277 PG 8, DATA COLLECTOR
26th	182.6	7/06	277 PG 65, DATA COLLECTOR
27th	180.8	10/07	4 PG 73, DATA COLLECTOR
28th	182.3	7/08	7 PG 9, DATA COLLECTOR
29th	180.2	8/09	8 PG 79, DATA COLLECTOR
30th	183.7	8/2010	11 PG 8, DATA COLLECTOR
31th	180.8	6/14/2011	11 PG 11, DATA COLLECTOR
32nd	181.3	6/28/2012	11 PG 17, DATA COLLECTOR
33rd		9/18/2013*	DATA COLLECTOR

* LAND BASED RIVERBANK SURVEY

REVISIONS:

No. DATE

GENERAL NOTES:

1. 2013 ELEVATIONS PRESENTED ON THE PLAN REPRESENT RESULTS OF ON-THE-GROUND AND HYDROGRAPHIC SURVEYS PERFORMED BY CHA CONSULTING, INC. BETWEEN JULY AND OCTOBER 2013. REUSE OF THIS INFORMATION BY THE CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT THE LIABILITY TO CHA CONSULTING, INC.

2. RIVER CROSS-SECTIONS FOR YEARS PRIOR TO 2013 ARE FROM A DRAWING ENTITLED "CONNECTICUT RIVER EROSION MONITORING CROSS SECTION #7 PINE MEADOW ROAD, NORTHFIELD & GILL, MA" PREPARED BY NORTH BY NORTHEAST SURVEY AND MAPPING CONSULTANTS, LAST REVISED JANUARY 6, 2013.

3. GROUND SURVEY AND SURVEY VESSEL HORIZONTAL POSITIONING IS BASED ON TOTAL STATION AND REAL-TIME KINEMATIC (RTK) GPS OBSERVATIONS RESPECTIVELY. HORIZONTAL COORDINATES BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ZONE 2001 AND ARE EXPRESSED IN U.S. SURVEY FEET.

4. THE ELEVATIONS ON THIS PLAN ARE EXPRESSED IN U.S. SURVEY FEET AND ARE REFERENCED TO THE PROJECT DATUM (REPORTED TO BE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29)).

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TITLE:

CONNECTICUT RIVER CROSS-SECTIONS

SECTION #7

PINE MEADOW ROAD NORTHFIELD & GILL, MA

PREPARED FOR:

FIRST LIGHT POWER RESOURCES/GDF SUEZ 99 MILLERS FALLS ROAD NORTHFIELD, MA 01360

DATE: JANUARY 14, 2014

COMP./DESIGN: BAS/AMC

CHECK: MWR/EJP

DRAWN: AMC

SCALE: 1"=20'

1 of 1

JOB NO.: F:\Project\MA\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg

DWG NO.: 22 SECTIONS 2013.DWG

20 10 0 20 40

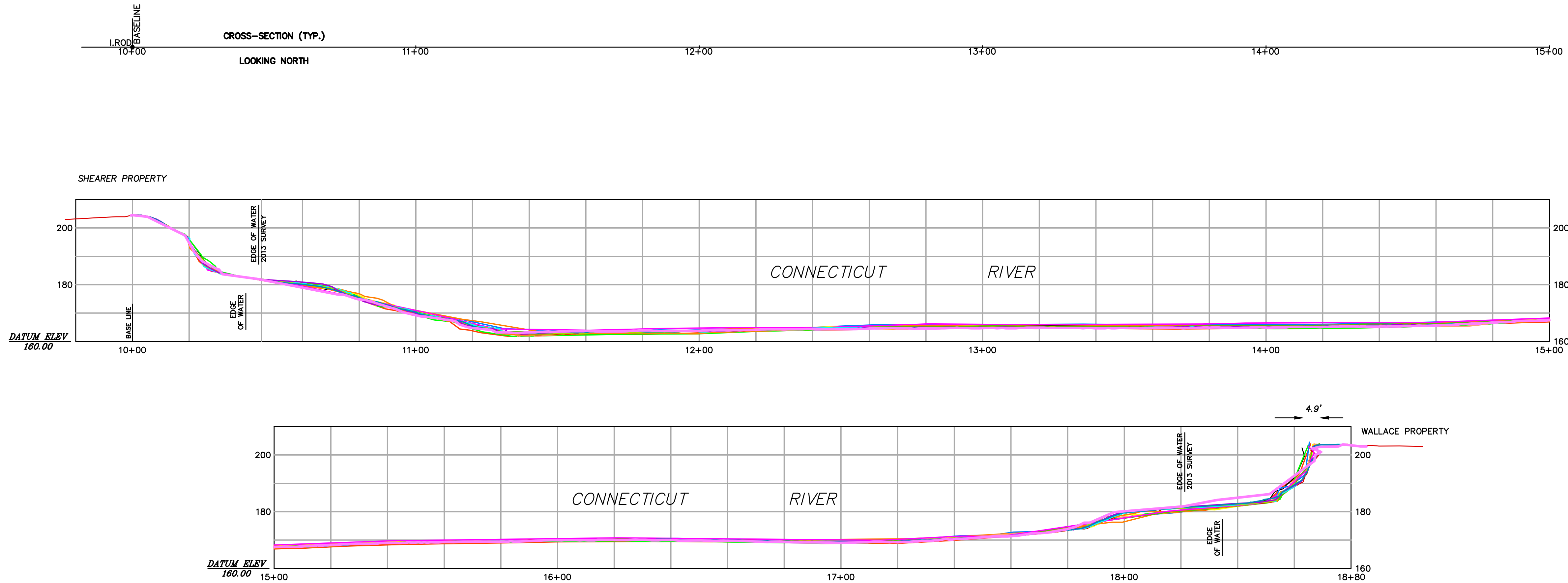
NOTE: For display purposes only; not drawn to scale.

EXISTING PERMANENT TRANSECT #8B

Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Steep	Steep/Overhanging
Upper Riverbank Height	High	High
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Moderate	Heavy
Lower Riverbank Slope	Flat/Beach	Flat/Beach
Lower Riverbank Sediment	Silt/Sand	Gravel
Lower Riverbank Vegetation	None to very sparse	None to very sparse
Type of Erosion	Undercut	
Potential Erosion Indicators	Creep/Leaning trees, Exposed roots, Overhanging Bank	Overhanging
Stage of Erosion	Potential Future Erosion	In process of stabilization
Extent of Current Erosion	Some	None/Little

TRANSECT #8B - Left Bank (620)

TRANSECT #8B - Right Bank (574)



SECTION 8B

(LOOKING DOWNSTREAM)

LEGEND

SERIES	WATER ELEVATION	DATE	FIELD BOOK
18th	182.2	12/02/99	252 PG 39
19th	181.9	06/02/00	250 PG 35
20th	180.5	10/23/00	254 PG 43
21st	179.6	08/02/01	260 PG 45
22nd	182.6	07/09/02	268 PG 7
23rd	180.7	07/14/03	269 PG 31, DATA COLLECTOR
24th	182.1	06/04/04	274 PG 12, DATA COLLECTOR
25th	180.3	7/05	277 PG 9, DATA COLLECTOR
26th	183.1	7/06	277 PG 65, DATA COLLECTOR
27th	182.9	10/07	4 PG 73, DATA COLLECTOR
28th	182.3	8/08	7 PG 9, DATA COLLECTOR
29th	181.4	8/09	8 PG 78, DATA COLLECTOR
30th	183.4	8/2010	11 PG 7, DATA COLLECTOR
31th	181.3	7/5/2011	11 PG 11, DATA COLLECTOR
32nd	180.8	6/28/2012	11 PG 17, DATA COLLECTOR
33rd		9/18/2013*	DATA COLLECTOR

* LAND BASED RIVERBANK SURVEY

REVISIONS:

No.	DATE	

GENERAL NOTES:

1. 2013 ELEVATIONS PRESENTED ON THE PLAN REPRESENT RESULTS OF ON-THE-GROUND AND HYDROGRAPHIC SURVEYS PERFORMED BY CHA CONSULTING, INC. BETWEEN JULY AND OCTOBER 2013. REUSE OF THIS INFORMATION BY THE CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT THE LIABILITY TO CHA CONSULTING, INC.

2. RIVER CROSS-SECTIONS FOR YEARS PRIOR TO 2013 ARE FROM A DRAWING ENTITLED "CONNECTICUT RIVER EROSION MONITORING CROSS SECTION #8B PINE MEADOW ROAD, NORTHFIELD & GILL, MA" PREPARED BY NORTH BY NORTHEAST SURVEY AND MAPPING CONSULTANTS, LAST REVISED JANUARY 6, 2013.

3. GROUND SURVEY AND SURVEY VESSEL HORIZONTAL POSITIONING IS BASED ON TOTAL STATION AND REAL-TIME KINEMATIC (RTK) GPS OBSERVATIONS RESPECTIVELY. HORIZONTAL COORDINATES BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ZONE 2001 AND ARE EXPRESSED IN U.S. SURVEY FEET.

4. THE ELEVATIONS ON THIS PLAN ARE EXPRESSED IN U.S. SURVEY FEET AND ARE REFERENCED TO THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29).

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TITLE:

CONNECTICUT RIVER CROSS-SECTIONS

SECTION #8B

PINE MEADOW ROAD NORTHFIELD & GILL, MA

PREPARED FOR:

FIRST LIGHT POWER RESOURCES/GDF SUEZ
99 MILLERS FALLS ROAD
NORTHFIELD, MA 01360

DATE: JANUARY 14, 2014
COMP./DESIGN: BAS/AMC
CHECK: MWR/EJP
DRAWN: AMC
SCALE: 1"=20'

1 of 1

JOB NO.: F:\Project\MA\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg
DWG NO.: 22 SECTIONS 2013.DWG

20 10 0 20 40

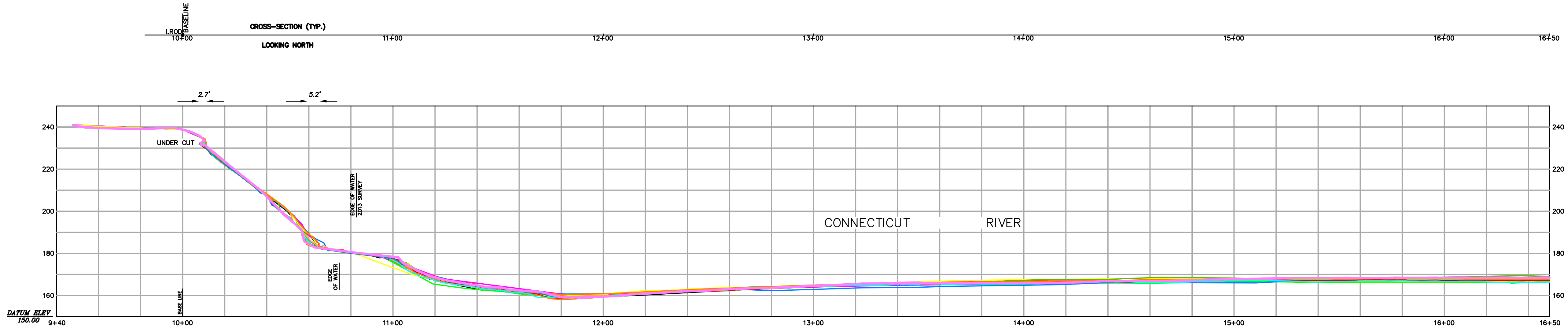
NOTE: For display purposes only; not drawn to scale.

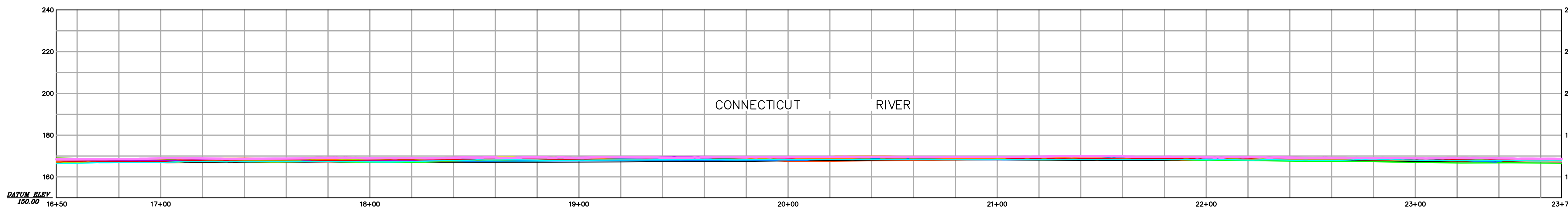
EXISTING PERMANENT TRANSECT #9

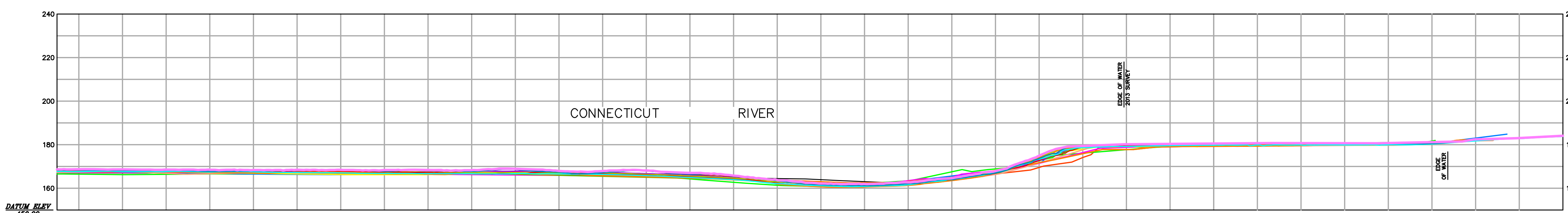
Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Flat	Moderate
Upper Riverbank Height	Low	High
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Heavy	Moderate
Lower Riverbank Slope	Flat/Beach	Flat/Beach
Lower Riverbank Sediment	Silt/Sand	Silt/Sand
Lower Riverbank Vegetation	Moderate	None to very sparse
Type of Erosion		
Potential Erosion Indicators		Creep/Leaning trees
Stage of Erosion	Stable	Stable
Extent of Current Erosion	None/Little	None/Little

TRANSECT #9 - Left Bank (247)

TRANSECT #9 - Right Bank (389)







SECTION 9
(LOOKING UPSTREAM)

LEGEND

SERIES	WATER ELEVATION	DATE	FIELD BOOK
18th	180.6	05/19/99	200 PG 63
19th	181.1	06/06/00	250 PG 47
20th	182.2	10/16/00	254 PG 31
21th	181.4	07/30/01	260 PG 31
22th	179.8	07/08/02	268 PG 11
23rd	179.8	07/14/03	269 PG 26, DATA COLLECTOR
24th	181.1	06/01/04	274 PG 11, DATA COLLECTOR
25th	181.2	7/05	277 PG 8, DATA COLLECTOR
26th	180.8	7/06	277 PG 65, DATA COLLECTOR
27th	183.3	10/07	4 PG 73, DATA COLLECTOR
28th	180.0	07/24/08	7 PG 9, DATA COLLECTOR
29th	180.6	8/09	9 PG 12, DATA COLLECTOR
30th	183.4	7/2010	11 PG 3, DATA COLLECTOR
31th	182.7	7/14/2011	11 PG 11, DATA COLLECTOR
32nd	180.8	6/01/2012	11 PG 15, DATA COLLECTOR
33rd		9/17/2013*	DATA COLLECTOR

* LAND BASED RIVERBANK SURVEY

GENERAL NOTES:

1. 2013 ELEVATIONS PRESENTED ON THE PLAN REPRESENT RESULTS OF ON-THE-GROUND AND HYDROGRAPHIC SURVEYS PERFORMED BY CHA CONSULTING, INC. BETWEEN JULY AND OCTOBER 2013. REUSE OF THIS INFORMATION BY THE CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT THE LIABILITY TO CHA CONSULTING, INC.

2. RIVER CROSS-SECTIONS FOR YEARS PRIOR TO 2013 ARE FROM A DRAWING ENTITLED "CONNECTICUT RIVER EROSION MONITORING CROSS SECTION #9 DEEP HOLE COVE, MONTAGUE, MA" PREPARED BY NORTH BY NORTHEAST SURVEY AND MAPPING CONSULTANTS, LAST REVISED JANUARY 6, 2013.

3. GROUND SURVEY AND SURVEY VESSEL HORIZONTAL POSITIONING IS BASED ON TOTAL STATION AND REAL-TIME KINEMATIC (RTK) GPS OBSERVATIONS RESPECTIVELY. HORIZONTAL COORDINATES BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ZONE 2001 AND ARE EXPRESSED IN U.S. SURVEY FEET.

4. THE ELEVATIONS ON THIS PLAN ARE EXPRESSED IN U.S. SURVEY FEET AND ARE REFERENCED TO THE PROJECT DATUM (REPORTED TO BE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29)).

REVISIONS:

No. DATE

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TITLE:
CONNECTICUT RIVER CROSS-SECTIONS
SECTION #9
DEEP HOLE COVE
MONTAGUE, MASSACHUSETTS

PREPARED FOR:
FIRST LIGHT POWER RESOURCES/GDF SUEZ
99 MILLERS FALLS ROAD
NORTHFIELD, MA 01360

DATE: JANUARY 14, 2014
COMP./DESIGN: BAS/AMC
CHECK: MWR/EJP
DRAWN: AMC
SCALE: 1"=20'
JOB NO.: F:\Project\MA\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg
DWG NO.: 22 SECTIONS 2013.DWG
20 10 0 20 40

1 of 1

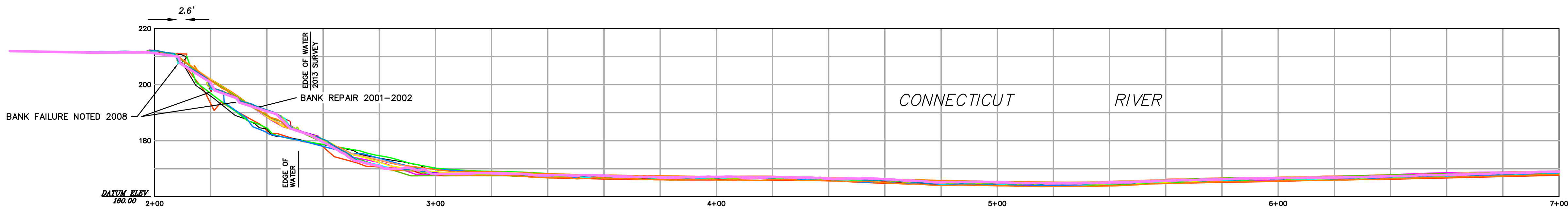
NOTE: For display purposes only; not drawn to scale.

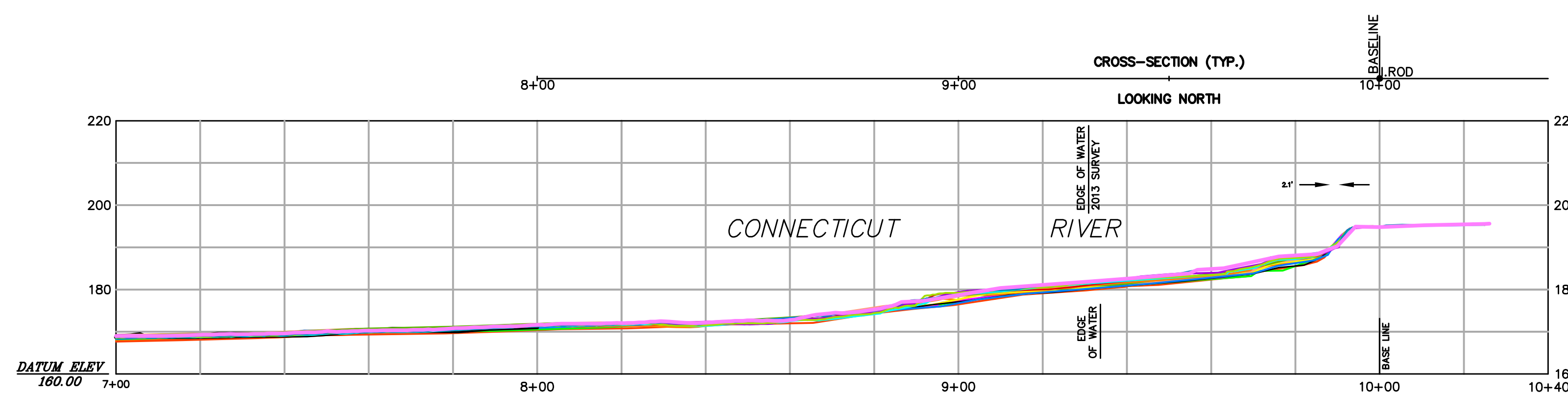
EXISTING PERMANENT TRANSECT #10

Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Moderate	Moderate
Upper Riverbank Height	High	High
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Heavy	Heavy
Lower Riverbank Slope	Flat/Beach	Moderate
Lower Riverbank Sediment	Silt/Sand	Cobbles
Lower Riverbank Vegetation	None to very sparse	Sparse
Type of Erosion		
Potential Erosion Indicators		
Stage of Erosion	Stable	Stable
Extent of Current Erosion	None/Little	None/Little

TRANSECT #10 - Left Bank (740)

TRANSECT #10 - Right Bank (1054)





SECTION 10

(LOOKING UPSTREAM)

LEGEND

SERIES	WATER ELEVATION	DATE	FIELD BOOK
18th	182.3	11/18/99	252 PG 11
19th	180.5	06/20/00	250 PG 67
20th	180.8	10/23/00	254 PG 45
21th	180.7	08/01/01	260 PG 41
22nd	180.1	07/08/02	268 PG 9
23rd	180.6	07/14/03	269 PG 26, DATA COLLECTOR
24th	184.6	5/27/04	274 PG 11, DATA COLLECTOR
25th	182.4	7/05	277 PG 9, DATA COLLECTOR
26th	183.2	7/06	277 PG 65, DATA COLLECTOR
27th	183.3	10/07	4 PG 73, DATA COLLECTOR
28th	184.0	08/14/08	7 PG 9, DATA COLLECTOR
29th	179.7	9/09	9 PG 13, DATA COLLECTOR
30th	183.7	7/2010	11 PG 5, DATA COLLECTOR
31th	183.0	7/5/2011	11 PG 12, DATA COLLECTOR
32nd	183.2	6/11/2012	11 PG 15, DATA COLLECTOR
33rd		9/19/2013*	DATA COLLECTOR

* LAND BASED RIVERBANK SURVEY

REVISIONS:

No. DATE

GENERAL NOTES:

1. 2013 ELEVATIONS PRESENTED ON THE PLAN REPRESENT RESULTS OF ON–THE–GROUND AND HYDROGRAPHIC SURVEYS PERFORMED BY CHA CONSULTING, INC. BETWEEN JULY AND OCTOBER 2013. REUSE OF THIS INFORMATION BY THE CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT THE LIABILITY TO CHA CONSULTING, INC.

2. RIVER CROSS–SECTIONS FOR YEARS PRIOR TO 2013 ARE FROM A DRAWING ENTITLED "CONNECTICUT RIVER EROSION MONITORING CROSS SECTION #10 NORTHFIELD & GILL, MA" PREPARED BY NORTH BY NORTHEAST SURVEY AND MAPPING CONSULTANTS, LAST REVISED JANUARY 6, 2013.

3. GROUND SURVEY AND SURVEY VESSEL HORIZONTAL POSITIONING IS BASED ON TOTAL STATION AND REAL–TIME KINEMATIC (RTK) GPS OBSERVATIONS RESPECTIVELY. HORIZONTAL COORDINATES BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ZONE 2001 AND ARE EXPRESSED IN U.S. SURVEY FEET.

4. THE ELEVATIONS ON THIS PLAN ARE EXPRESSED IN U.S. SURVEY FEET AND ARE REFERENCED TO THE PROJECT DATUM (REPORTED TO BE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29)).

CHA
101 Accord Park Drive
Norwell, MA 02061
Main: (781) 982-5400 · www.chacompanies.com

TITLE:

CONNECTICUT RIVER CROSS–SECTIONS

SECTION #10

NORTHFIELD & GILL, MA

PREPARED FOR:

FIRST LIGHT POWER RESOURCES/GDF SUEZ
99 MILLERS FALLS ROAD
NORTHFIELD, MA 01360

DATE: JANUARY 14, 2014
COMP./DESIGN: BAS/AMC
CHECK: MWR/EJP
DRAWN: AMC
SCALE: 1"=20'

1 of 1

JOB NO.: F:\Project\MA\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg
DWG NO.: 22 SECTIONS 2013.DWG

20 10 0 20 40

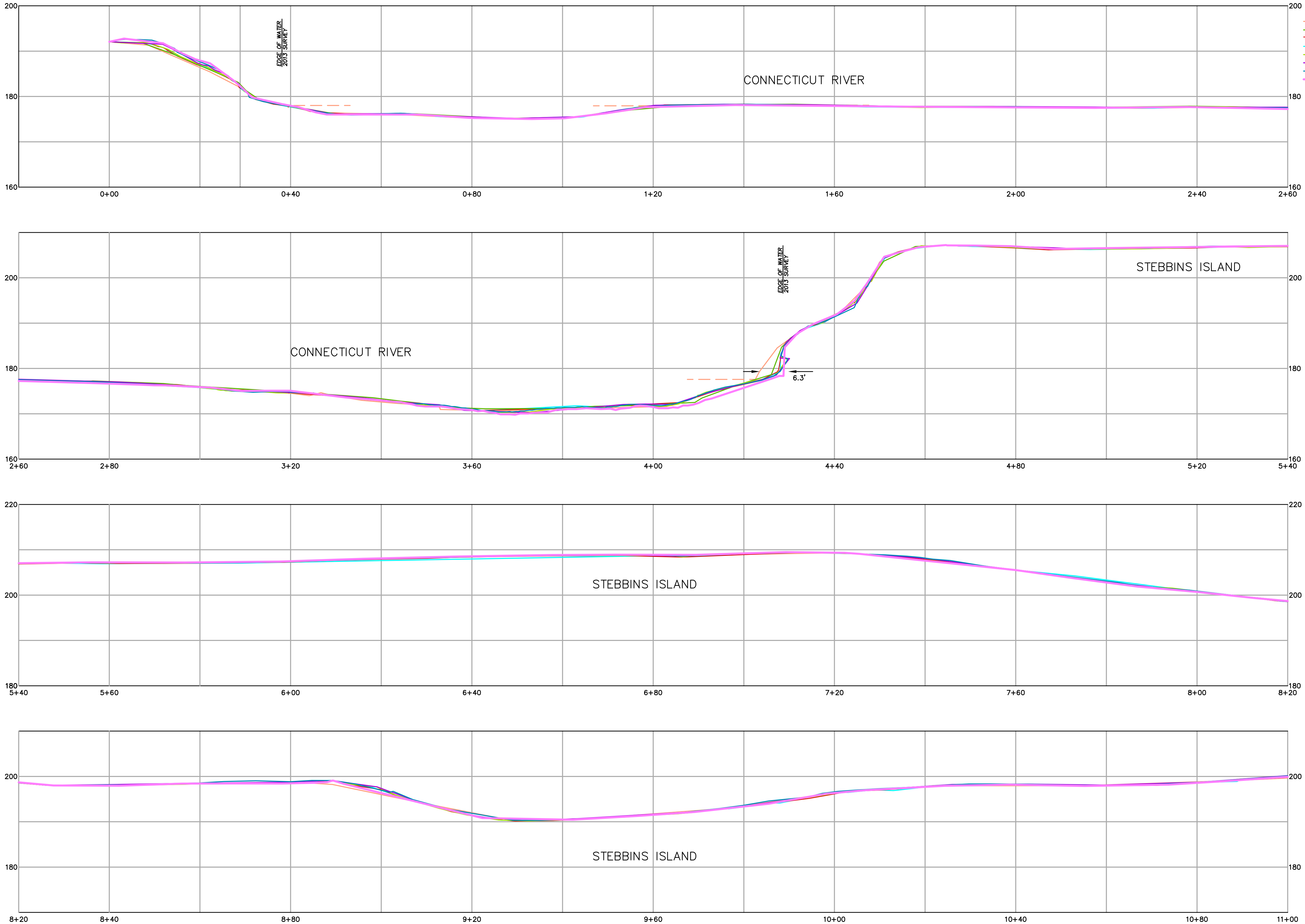
NOTE: For display purposes only; not drawn to scale.

EXISTING PERMANENT TRANSECT #11

Riverbank Features	Left Bank	Right Bank
Upper Riverbank Slope	Moderate	Moderate
Upper Riverbank Height	High	Medium
Upper Riverbank Sediment	Silt/Sand	Silt/Sand
Upper Riverbank Vegetation	Heavy	Heavy
Lower Riverbank Slope	Flat/Beach	Moderate
Lower Riverbank Sediment	Silt/Sand	Silt/Sand
Lower Riverbank Vegetation	None to very sparse	None to very sparse
Type of Erosion	Undercut	
Potential Erosion Indicators	Undercut, Creep/Leaning trees	
Stage of Erosion	Stable	Stable
Extent of Current Erosion	None/Little	None/Little

TRANSECT #11 - Left Bank (1447)

TRANSECT #11 - Right Bank (1348)



LEGEND

SERIES	WATER ELEV.	DATE	SURVEY JOB
1st	180.0	07/2005	2005-25
2nd	178.4	06/2006	2006-28
3rd	180.8	07/2008	2008-134
4th	180.6	07/2009	2009-198
5th	179.5	08/2010	2010-246
6th	176.2	08/2011	2011-287
7th	176.2	07/2012	2012-334
8th		10/28/13*	DATA COLLECTOR

* LAND BASED RIVERBANK SURVEY

REVISIONS:

No.	DATE	

GENERAL NOTES:

1. 2013 ELEVATIONS PRESENTED ON THE PLAN REPRESENT RESULTS OF ON-THE-GROUND AND HYDROGRAPHIC SURVEYS PERFORMED BY CHA CONSULTING, INC. BETWEEN JULY AND OCTOBER 2013. REUSE OF THIS INFORMATION BY THE CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT THE LIABILITY TO CHA CONSULTING, INC.

2. RIVER CROSS-SECTIONS FOR YEARS PRIOR TO 2013 ARE FROM A DRAWING ENTITLED "CROSS-SECTION #11 STEBBINS ISLAND VERNON, VERMONT" PREPARED BY NORTH BY NORTHEAST SURVEY AND MAPPING CONSULTANTS, LAST REVISED JANUARY 6, 2013.

3. GROUND SURVEY AND SURVEY VESSEL HORIZONTAL POSITIONING IS BASED ON TOTAL STATION AND REAL-TIME KINEMATIC (RTK) GPS OBSERVATIONS RESPECTIVELY. HORIZONTAL COORDINATES BASED ON THE MASSACHUSETTS STATE PLANE COORDINATE SYSTEM, ZONE 2001 AND ARE EXPRESSED IN U.S. SURVEY FEET.

4. THE ELEVATIONS ON THIS PLAN ARE EXPRESSED IN U.S. SURVEY FEET AND ARE REFERENCED TO THE PROJECT DATUM (REPORTED TO BE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29)).

CHA
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TITLE:

CONNECTICUT RIVER CROSS-SECTIONS

SECTION #11

STEBBINS ISLAND VERNON, VERMONT

PREPARED FOR:

FIRST LIGHT POWER RESOURCES/GDF SUEZ
99 MILLERS FALLS ROAD
NORTHFIELD, MA 01360

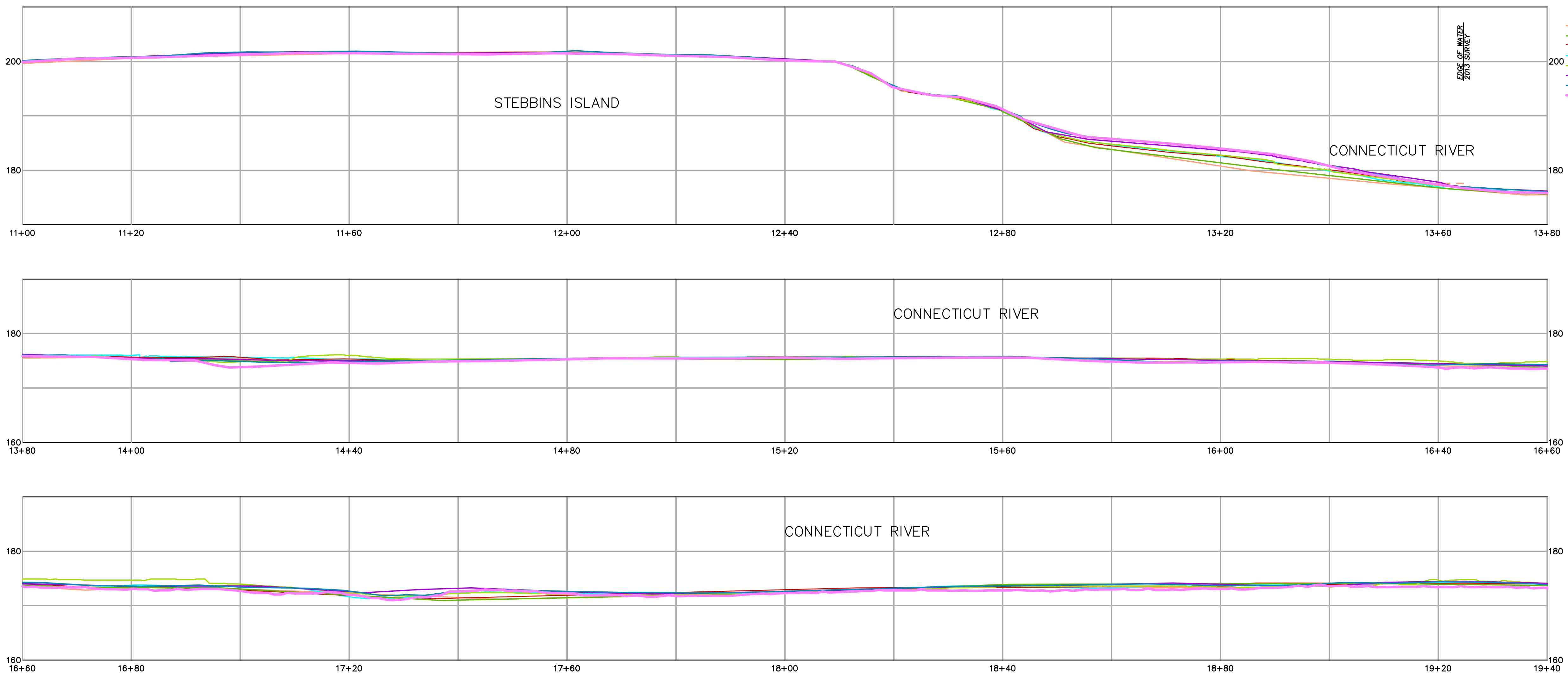
DATE: JANUARY 14, 2014
COMP./DESIGN: BAS/AMC
CHECK: MWR/EJP
DRAWN: AMC
SCALE: 1"=10'

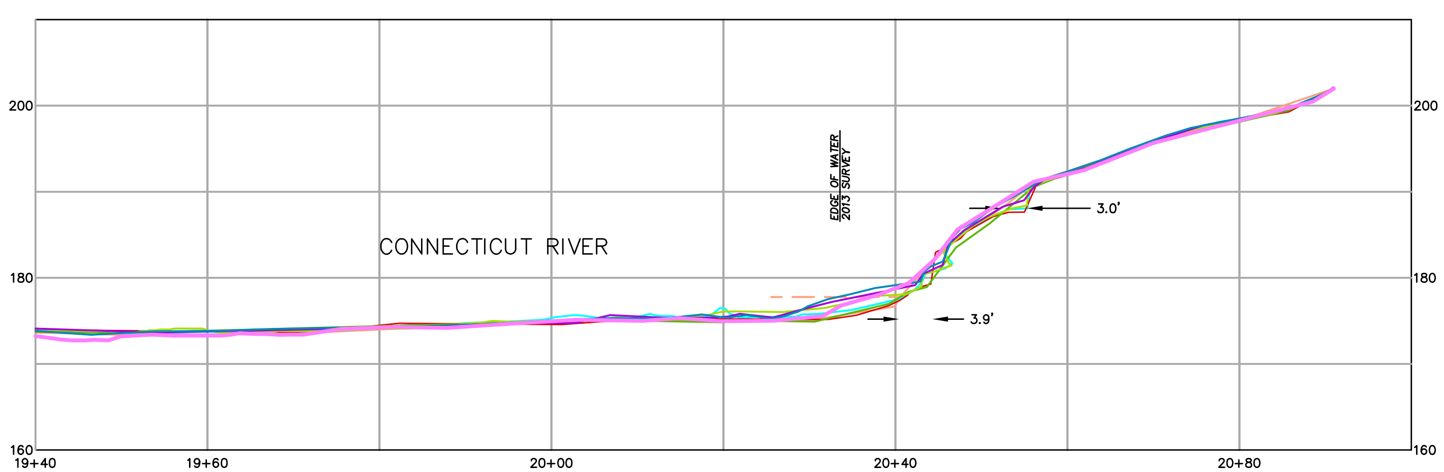
1 of 2

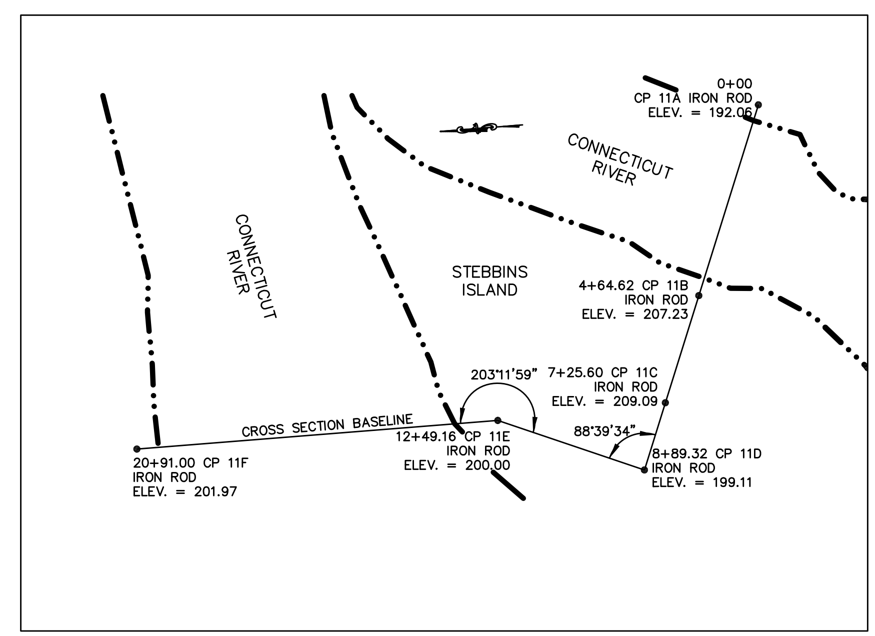
JOB NO.: F:\Project\MA\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg
DWG NO.: 22 SECTIONS 2013.DWG

10 5 0 10 20

NOTE: For display purposes only; not drawn to scale.







BASELINE LOCATION
1"=200'

LEGEND

SERIES	WATER ELEV.	DATE	SURVEY JOB
1st	180.0	07/2005	2005-25
2nd	178.4	06/2006	2006-28
3rd	180.8	07/2008	2008-134
4th	180.6	07/2009	2009-198
5th	179.5	08/2010	2010-246
6th	176.2	08/2011	2011-287
7th	176.2	07/2012	2012-334
8th		10/28/13*	DATA COLLECTOR

* LAND BASED RIVERBANK SURVEY

REVISIONS:

No. DATE

GENERAL NOTES:

SEE SHEET 1 FOR GENERAL NOTES.

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TITLE:

CONNECTICUT RIVER CROSS-SECTIONS

SECTION #11

STEBBINS ISLAND VERNON, VERMONT

PREPARED FOR:

FIRST LIGHT POWER RESOURCES/GDF SUEZ
99 MILLERS FALLS ROAD
NORTHFIELD, MA 01360

DATE: JANUARY 14, 2014
COMP./DESIGN: BAS/AMC
CHECK: MWR/EJP
DRAWN: AMC
SCALE: 1"=10'

2 of 2

JOB NO.: F:\Project\MA\Connecticut River\2013\River Bank Monitoring\22 Riverbank Sections\Dwg
DWG NO.: 22 SECTIONS 2013.DWG

10 5 0 10 20

NOTE: For display purposes only; not drawn to scale.

FINAL SUPPLEMENTAL REPRESENTATIVE LOCATIONS FOR DETAILED STUDY

LAND-BASED OBSERVATION POINT #18

Riverbank Features	Characteristics
Upper Riverbank Slope	Moderate
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None/Very Sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Undercut, Exposed roots, Creep/Leaning trees
Stage of Erosion	Eroded
Extent of Current Erosion	None/Little

Connecticut River – Turners Falls Impoundment Riverbank Classification for Land-Based Survey
Observation Point Number: *18* **Personnel:** *YKC, AS, MM, CM, TS*

Date: *November 15, 2013* **Time:** *10:00 am*

Station Number:*870+00* **Photo Reference Numbers:** *642 - 646*

Left or Right Bank (Looking Downstream): *Left*

Length of Representative Segment, From Station Number *867+00* **To Station Number** *925+00*

Previously Stabilized? *No*

Geologic / Geotechnical Observations:

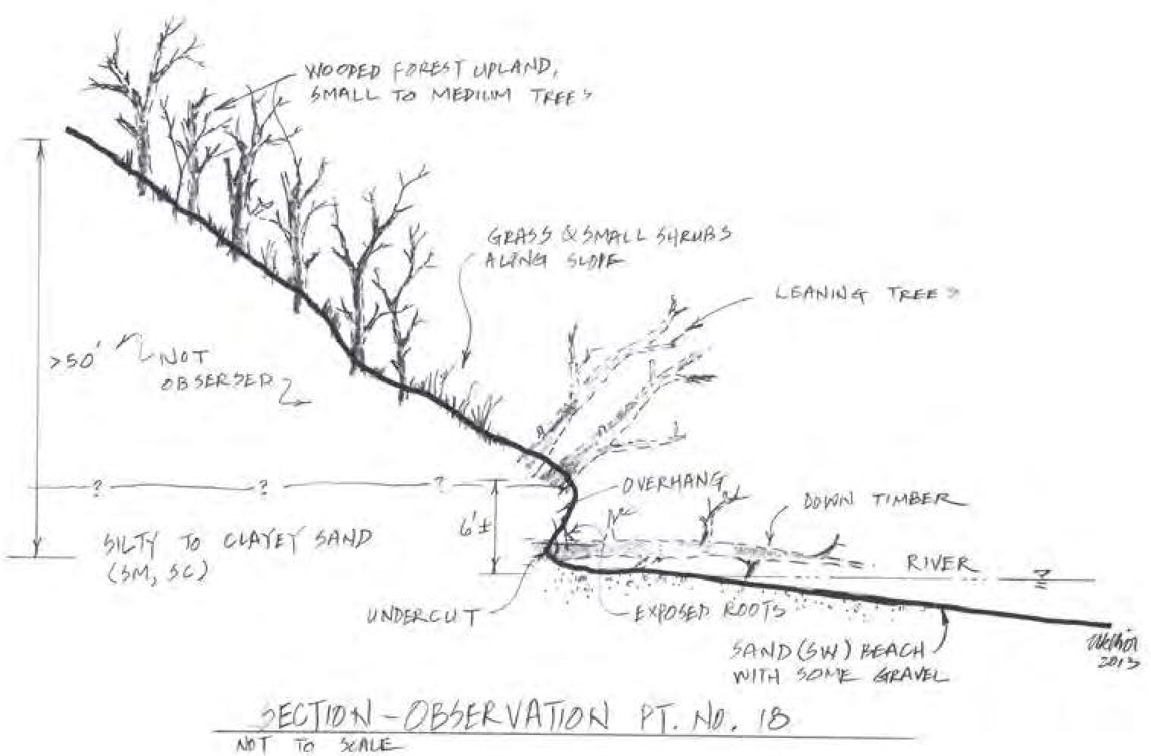
Stratigraphy:
(Refer to Site Sketch below for locations of soil/rock layers
Notations in parentheses are based on Unified Soil Classification System)

SILTY SAND (SM) to CLAYEY SAND (SC) – Mostly fine sand, 20% to 30% low- to medium-plastic fines.

Observed Erosion Features:

- *Overhangs to near-vertical scarps near toe of bank.*
- *Exposed roots of leaning trees near toe of bank at river level, with undercuts behind roots.*
- *Down timber and leaning trees near river level.*

Site Sketch:



2013 Connecticut River Full River Reconnaissance

Land-Based Observations Photographs Reference No. 642-646
Observation Point # 18 – November 15, 2013

Photo No. 645

Photo No. 646

LAND-BASED OBSERVATION POINT #21

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep (some vertical)
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Moderate
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Gravel, Silt/Sand
Lower Riverbank Vegetation	None/Very Sparse
Type of Erosion	Rotational Slump, Undercut
Potential Erosion Indicators	Undercut, Exposed roots, Creep/Leaning trees
Stage of Erosion	Active
Extent of Current Erosion	Some to extensive

Connecticut River – Turners Falls Impoundment Riverbank Classification for Land-Based Survey

Observation Point Number: *21* **Personnel:** *YKC, AS, MM, CM, TS*
Date: *November 15, 2013* **Time:** *1:50 pm*

Station Number:*792+50* **Photo Reference Numbers:** *664 - 668*

Left or Right Bank (Looking Downstream): *Right*

Length of Representative Segment, From Station Number *765+00* **To Station Number** *795+00*

Previously Stabilized? *No (Just downstream of Kendall Restoration Site)*

Geologic / Geotechnical Observations:

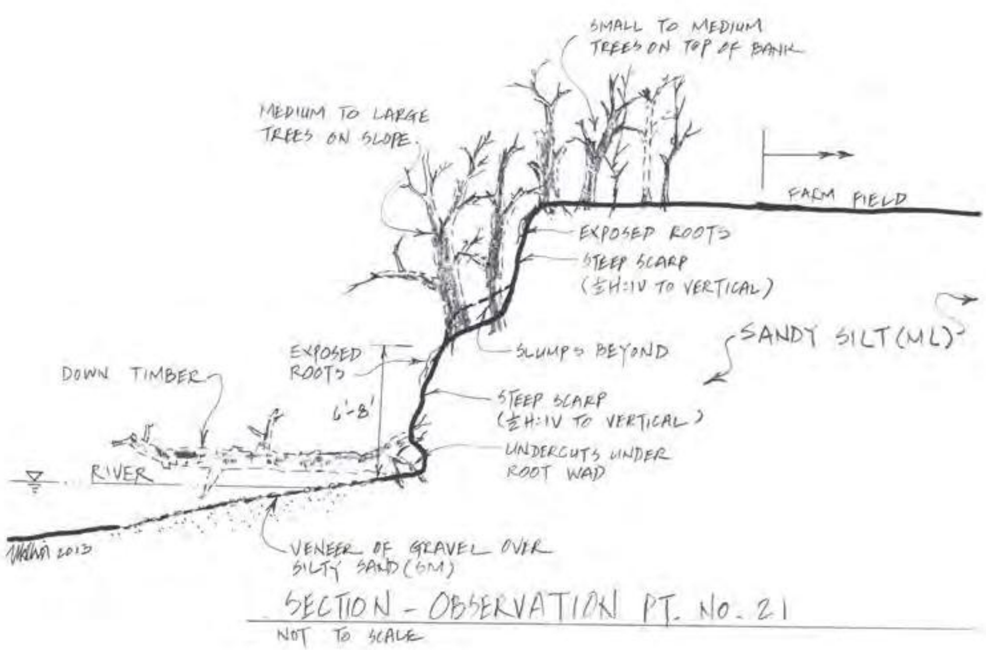
Stratigraphy:
(Refer to Site Sketch below for locations of soil/rock layers
Notations in parentheses are based on Unified Soil Classification System)

SANDY SILT (ML) – Nonplastic, 10% - 20% fine sand, gray.
Beach: GRAVEL (GP) to SILTY SAND (SM). Likely thin veneer.

Observed Erosion Features:

- *Significant erosion, with steep scarps and slumpings.*
- *Very steep banks, entire slope, with overhangs and undercuts near river level.*
- *Some slumpings.*
- *Exposed roots along scarps.*

Site Sketch:



2013 Connecticut River Full River Reconnaissance
Land-Based Observations Photographs Reference No. 664-668
Observation Point # 21 – November 15, 2013

Photo No. 664

Photo No. 665

LAND-BASED OBSERVATION POINT #26

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep/Overhanging
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None/Very Sparse
Type of Erosion	Rotational slump, Undercut
Potential Erosion Indicators	Undercut, Exposed roots, Creep/Leaning trees
Stage of Erosion	Active
Extent of Current Erosion	Some

Connecticut River – Turners Falls Impoundment Riverbank Classification for Land-Based Survey

Observation Point Number: *26* **Personnel:** *YKC, MM, CM*

Date: *November 16, 2013* **Time:** *3:30 pm*

Station Number:*485+00* **Photo Reference Numbers:** *712 - 716*

Left or Right Bank (Looking Downstream): *Right*

Length of Representative Segment, From Station Number *475+00* **To Station Number** *518+00*

Previously Stabilized? *No*

Geologic / Geotechnical Observations:

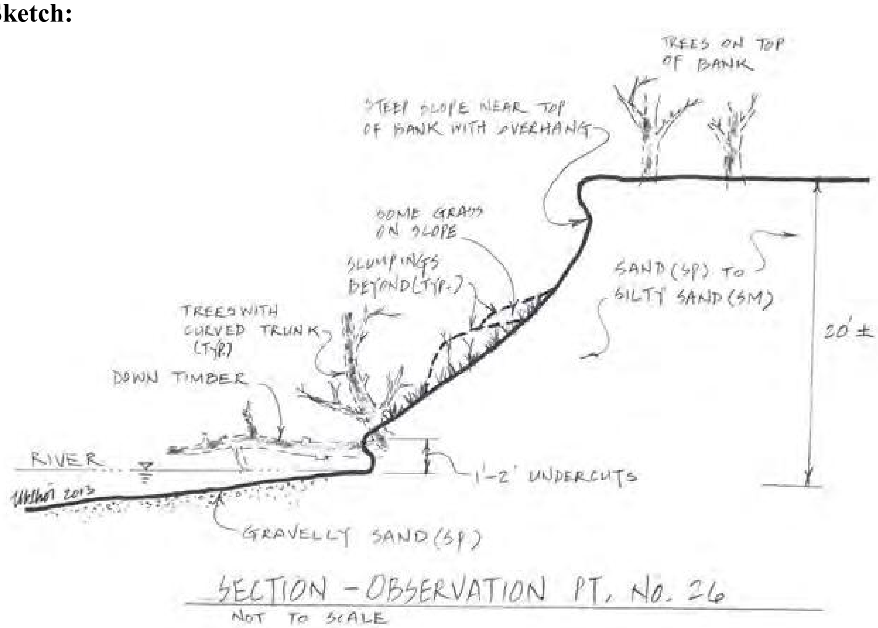
Stratigraphy:
(Refer to Site Sketch below for locations of soil/rock layers
Notations in parentheses are based on Unified Soil Classification System)

SAND (SP) to SILTY SAND (SM) – Mostly medium sand, approx. 5% - 20% nonplastic fines.
GRAVELLY SAND (SP) – Mostly medium sand, <5% nonplastic fines, 10% - 20% fine to coarse gravel, 5% - 10% cobbles

Other observations:
- *Minor recent sediments from Hurricane Irene.*

Observed Erosion Features:
- *Mass-wasting and slumping.*
- *Near-vertical scarp and overhang along top portion of upper bank.*
- *Undercuts at toe of bank at river level, especially under fell trees.*
- *Down timber, leaning and curved tree trunks indicated past ground movements.*

Site Sketch:



2013 Connecticut River Full River Reconnaissance
Land-Based Observations Photographs Reference No.712-716
Observation Point # 26 – November 16, 2013

Photo No. 712

Photo No. 713

LAND-BASED OBSERVATION POINT #29

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep (near vertical scarps)
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None/Very Sparse
Type of Erosion	Rotational Slump, Undercut
Potential Erosion Indicators	Undercut, Exposed roots, Creep/Leaning trees
Stage of Erosion	Active
Extent of Current Erosion	Some

Connecticut River – Turners Falls Impoundment Riverbank Classification for Land-Based Survey

Observation Point Number: *29* **Personnel:** *YKC, MM, CM*

Date: *November 19, 2013* **Time:** *9:30 am*

Station Number:*659+00 (Note 1)* **Photo Reference Numbers:** *740 – 744*
Note 1 – Observed area is just upstream of Wickey Site. River was high, and beach area was submerged.

Left or Right Bank (Looking Downstream): *Right*

Length of Representative Segment, From Station Number *640+00* **To Station Number** *680+00*

Previously Stabilized? *No*

Geologic / Geotechnical Observations:

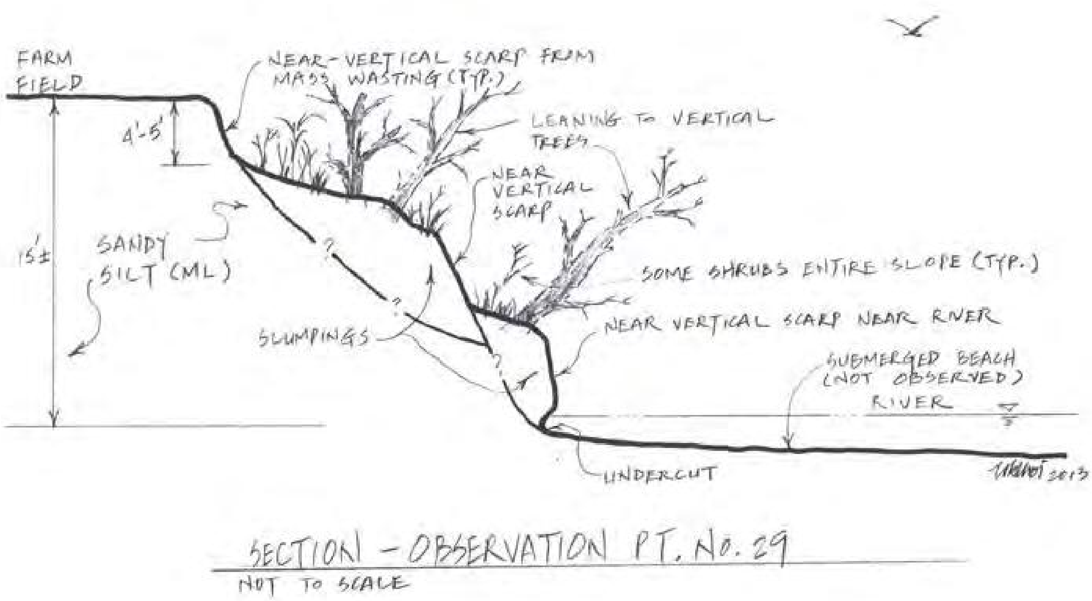
Stratigraphy:
(Refer to Site Sketch below for locations of soil/rock layers
Notations in parentheses are based on Unified Soil Classification System)

SANDY SILT (ML) – Nonplastic, 10% - 20% fine sand, gray.

Observed Erosion Features:

- *Mass-wasting along entire slope, with near-vertical slide scarps exposed.*
- *Slumpings of materials, with some leaning trees.*
- *Undercuts at river level below near-vertical scarps.*

Site Sketch:



2013 Connecticut River Full River Reconnaissance
Land-Based Observations Photographs Reference No.740-744
Observation Point # 29 – November 19, 2013

Photo No. 740

Photo No. 741

BOAT-BASED OBSERVATION POINT #12

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Sparse
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None to Very Sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Exposed Roots, Overhanging Bank
Stage of Erosion	Active
Extent of Current Erosion	Extensive

BOAT-BASED SITE #12

BOAT-BASED OBSERVATION POINT #75

Riverbank Features	Characteristics
Upper Riverbank Slope	Vertical
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Sparse
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None to Very Sparse
Type of Erosion	Topple, Overhanging Bank
Potential Erosion Indicators	Creep/Leaning Tree, Overhanging Bank
Stage of Erosion	Active
Extent of Current Erosion	Extensive

BOAT-BASED SITE #75

BOAT-BASED OBSERVATION POINT #87

Riverbank Features	Characteristics
Upper Riverbank Slope	Overhanging
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Sparse
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None to Very Sparse
Type of Erosion	Undercut, Rotational Slump
Potential Erosion Indicators	Exposed Roots, Creep/Leaning Trees, Overhanging Bank
Stage of Erosion	Eroded
Extent of Current Erosion	Some to Extensive

BOAT-BASED SITE #87

BOAT-BASED OBSERVATION POINT #119

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Sparse
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None to Very Sparse
Type of Erosion	Slide or Flow
Potential Erosion Indicators	Exposed Roots, Creep/Leaning Trees, Overhanging Bank
Stage of Erosion	Eroded
Extent of Current Erosion	Some to Extensive

BOAT-BASED SITE #119

BOAT-BASED OBSERVATION POINT #303

Riverbank Features	Characteristics
Upper Riverbank Slope	Moderate
Upper Riverbank Height	Medium
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	Heavy
Type of Erosion	
Potential Erosion Indicators	None
Stage of Erosion	Stable
Extent of Current Erosion	None/Little

BOAT-BASED SITE #303

Appendix C
Detailed Study Site Selection Process

Evaluate Existing, Permanent Transects and Identify Calibration and/or Representative Locations for Detailed Study

As stated in Section 6, the first step in selecting detailed study locations is to evaluate the riverbank features and characteristics at the existing, permanent transects located throughout the Impoundment. Based on the results of this evaluation, existing, permanent transects were identified as: 1) calibration locations; 2) both calibration and representative locations; or 3) eliminated from consideration. Transects categorized as calibration only sites are not considered representative as they are often duplicative of riverbank features and characteristics found at other selected representative locations.

Of the 21 existing, permanent transects, FirstLight has identified 11 transects (16 detailed study points) as potential calibration and/or representative locations, which are defined below.[1] Of the 16 detailed study points, 9 were identified as calibration only sites while the remaining 7 were selected to be both calibration and representative locations. Table 7.1-1 summarizes the location and general characteristics of the selected transects. Figures 7.1-1-7.1-6 depict the geographic distribution of the existing, permanent transect locations throughout the Impoundment.

Calibration Locations

Detailed study points identified as calibration only locations include:

- Transect #3 – Left Bank (3L)
- Transect #3 – Right Bank (3R)
- Transect #5C – Right Bank (5C-R)
- Transect #6A – Left Bank (6A-L)
- Transect #6A – Right Bank (6A-R)
- Transect #8B – Right Bank (8B-R)
- Transect #9 – Right Bank (9R)
- Transect #10 – Left Bank (10L)
- Transect #11 – Left Bank (11L)

Table 7.1-3 provides a summary of the riverbank features and characteristics found at each location. The transect locations listed above were not selected as representative locations due to the fact that the riverbank features and characteristics found at these locations are duplicative of the features and characteristics found at other selected representative sites. The data collected at the calibration sites in 2014 will be combined with historic transect survey information dating to the 1990's to calibrate the BSTEM model.

Once the BSTEM model is adequately calibrated using the historic survey data and the data collected in 2014 at the calibration locations, model runs will be executed at the selected representative detailed study points. Model parameters regarding erosion and geotechnical properties at representative sites will be adjusted by applying information learned from the calibration process at calibration locations that are similar to the representative sites based on comparing soil and erosion characteristics between calibration and representative sites. In other words, adjustments to parameters made at calibration sites through the calibration process will be applied to parameters at similar representative sites based on soil and erosion

[1] Due to the fact that riverbank features and characteristics vary from one bank to the other each individual transect represents two potential detailed study points (i.e. right and left bank). In the event of an island being located in the middle of a transect, four potential detailed study points exist. Depending on the features and characteristics present at each riverbank only one bank may be recommended for detailed investigation and analyses.

characteristics. The results of the erosion and stability analyses at the selected representative locations will then be extrapolated to the entire Impoundment based on common riverbank features and characteristics.

Calibration and Representative Locations

Detailed study points identified as both calibration and representative locations include:

- Transect #BC1 – Right Bank (BC1-R)
- Transect #2 – Left Bank (2L)
- Transect #4 – Left Bank (4L)
- Transect #7 – Left Bank (7L)
- Transect #7 – Right Bank (7R)
- Transect #8B – Left Bank (8B-L)
- Transect #10 – Right Bank (10R)

Brief descriptions providing the rationale for why each detailed study point was selected are included below:

Transect BC1 – Right Bank

Transect BC1 is located downstream of the French King Gorge at the entrance to Barton Cove. This detailed study site increases coverage in this portion of the Impoundment and satisfies Stakeholder requests to include at least one study site in Barton Cove.

Transect 2 – Left Bank

Transect 2L has experienced some erosion of various types along with indicators of potential future erosion. It is also a site where a light stabilization treatment was recently initiated, consisting only of planting vegetation.

Transect 4 – Left Bank

Transect 4L is a stable site with little to no erosion and relatively minor indicators of potential future erosion.

Transect 7 – Left Bank

Transect 7L currently shows limited extent of erosion but indicators of potential future erosion.

Transect 7 – Right Bank

Transect 7R is stable with boulders for lower riverbank sediment extending the range of riverbank features and characteristics for study.

Transect 8B – Left Bank

Transect 8BL exhibits some erosion as well as several indicators of potential future erosion.

Transect 10 – Right Bank

Transect 10R is stable with cobbles on the lower riverbank and some lower riverbank vegetation, expanding the range of features and characteristics for detailed study.

Tables 7.1-2 provides location and general characteristic information for each selected existing, permanent transect locations. Table 7.1-3 provides a summary of the riverbank features and characteristics found at each location. Categories highlighted in yellow represent specific riverbank characteristics that are indicative of areas where active erosion is most likely to occur or the potential for future erosion is high. Special consideration is given to these categories as they are most relevant to the objectives of this study. Highlighted categories were identified based on review of historic geomorphic data and the results of the 2013 FRR. Upon review of Table 7.1-2 it can be observed that several gaps exist for various riverbank characteristic categories. Gaps identified based on review of the table were supplemented by additional representative detailed study points identified based on the results of the 2013 FRR land- and boat-based surveys. In particular, as described later in this appendix, 9 supplemental representative locations were selected to complement the selected existing, permanent transect locations thus creating a comprehensive set of study locations representative of the range of riverbank features and characteristics found throughout the Impoundment.

Additional information for each detailed study site, including 2013 FRR classification results, photographs, and cross-section profiles, can be found in Appendix B.

Transects Eliminated from Consideration

Of the 21 existing, permanent transects located throughout the Impoundment, 10 transects were eliminated from consideration. Specific transects eliminated from consideration include:

- Transect #BC2
- Transect #BC3
- Transect #BC5
- Transect #1
- Transect #5A
- Transect #5B
- Transect #5D
- Transect #5E
- Transect #6B
- Transect #8A

Brief descriptions providing the rationale for why each transect was eliminated from consideration are included below:

Transects BC2, BC3, BC5

Transects BC2, BC3, and BC5 were not recommended as detailed study sites because they are located in Barton Cove where the Connecticut River is ponded behind Turners Falls Dam. Given the size of Barton Cove, Transect BC1 (selected as both a representative and calibration site) will be adequate to develop a representative understanding of erosion processes, hydraulics, and riverbank features and characteristics in this area. Furthermore, many of the Barton Cove transects are located in areas that have been stabilized by rip-rap, concrete, or where there are bedrock outcroppings.

Transect 1

Transect 1 is located on a power line corridor where a hillslope had been cleared. The left lower bank material consists of clay and the right bank consists of bedrock. Since these types of bank materials are not preferred for study (as defined in Table 6-1) and cleared power line crossings represent only a very small percentage of Impoundment riverbank (less than 1%), this transect was not recommended for detailed study.

Transect 5A, 5B, 5D, 5E

Transects 5B, 5D, and 5E are partial transects (one bank only) located at the Route 10 Bridge where unique and extreme hydraulic conditions have caused eddying and erosion. These hydraulic conditions are not representative of the Turners Falls Impoundment and as such are not selected for detailed study. Transect 5A is located a short distance upstream of Transect 5C (located a short distance downstream of the Route 10 Bridge). Given that Transect 5C was selected as a detailed study site, Transect 5A was not selected for detailed study as it is duplicative.

Transect 6B

Transects 6A and 6B are located in relatively close proximity and as such, hydraulic conditions with respect to longitudinal position along the Impoundment are similar. Both transects had experienced erosion and stabilization, however, Transect 6A includes Kidds Island which offers additional potential for gaining understanding regarding island erosion. As a result, Transect 6A was selected as a study site while Transect 6B was eliminated due to its proximity to Transect 6A.

Transect 8A

Transect 8A was not selected as a detailed study site due to its close proximity to Transect 8B (a selected location). Transect 8A was found to be duplicative of Transect 8B specifically in regard to hydraulic conditions and erosion and stabilization processes. Additionally, one of the banks at Transect 8A was stabilized prior to transect surveys being conducted. As a result, no record of bank change is available at this location prior to stabilization.

Table 7.1-1 Locations and General Characteristics –Existing, Permanent Transects Selected for Detailed Study

Existing Transect #	Approximate Distance Upstream of Turners Falls Dam (Feet + Station)	Description of Location	Left Bank Land-use	Right Bank Land-use
BC1	5000 (50+00))	Entrance to Barton Cove	Forest	Forest
2	94600 (940+600)	Straight reach downstream of Ashuelot	Agriculture	Agriculture
3	78600 (780+600)	Straight reach	Forest	Agriculture
4	73100 (730+100)	Diagonal across channel	Agriculture	Forest/Agriculture
5C	57300 (570+300)	Average width straight reach, downstream of Route 10 Bridge	Agriculture/COE experimental stabilization	Forest/Agriculture
6A	42000 (420+00)	Wide, straight reach, across Kidds Island	Forested/ Developed	Agriculture
7	37500 (370+500)	Bending reach (average to wide)	Agriculture	Forest
8B	32700 (320+700)	Straight reach (narrow to average)	Agriculture	Agriculture/Forest
9	7100 (70+100)	Wide section from campground peninsula across to rod and gun club	Developed	Forest
10	49000 (490+00)	Average width straight reach	Agriculture	Stabilized/Agriculture
11	100000 (1000+00)	Wide reach across Stebbins Island	Forest	Agriculture

Table 7.1-2 Summary of Riverbank Features and Characteristics –Representative Existing, Permanent Transects

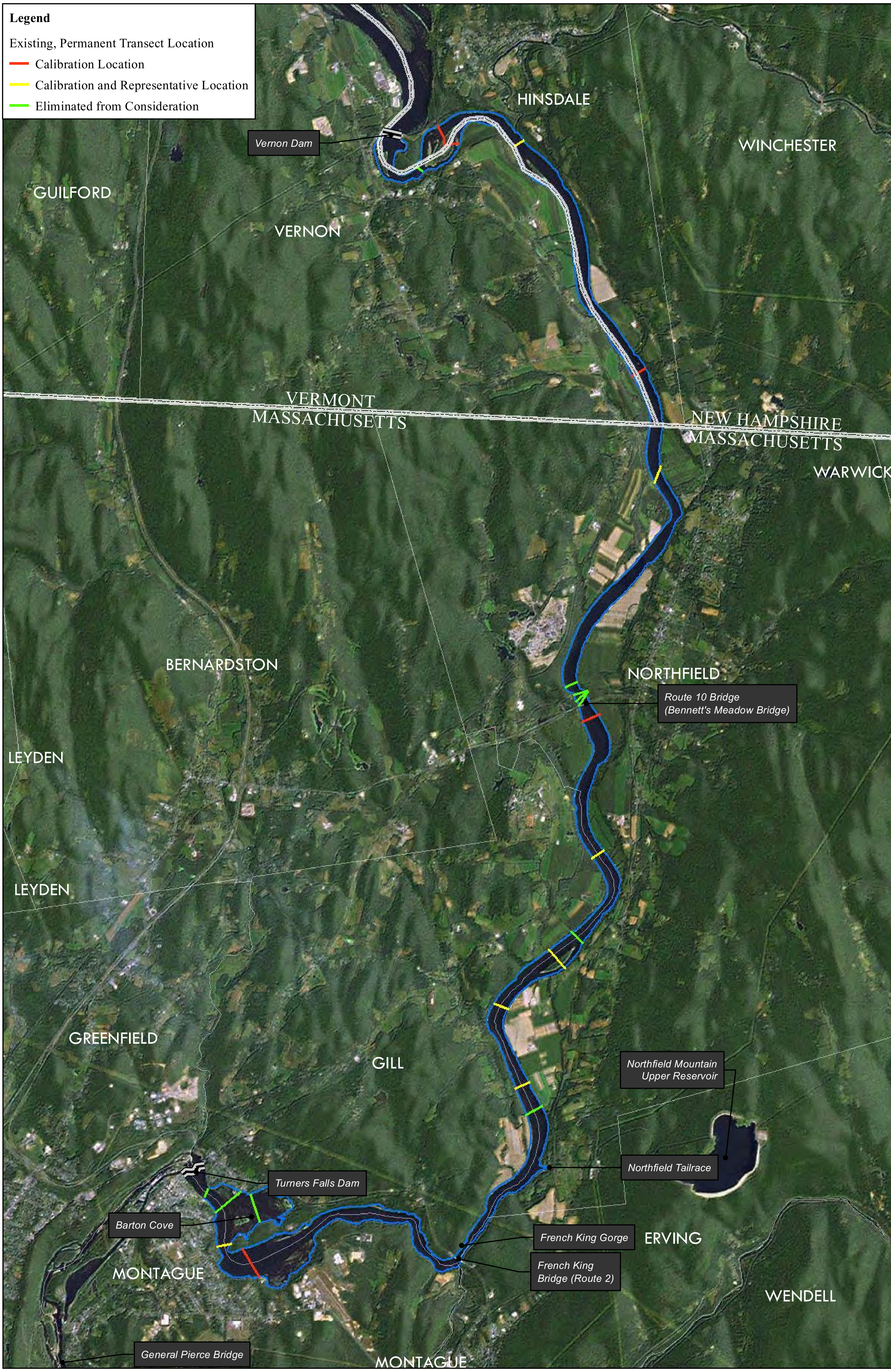
FEATURES	CHARACTERISTICS[2]					
Upper Riverbank Slope	**Overhanging**	**Vertical** 2L	**Steep** 7L, 8B-L	**Moderate** BC1-R, 4L, 7R, 10R	Flat	
Upper Riverbank Height	Low	**Medium** 4L	**High** BC1-R, 2L, 7L, 7R, 8B-L, 10R			
Upper Riverbank Sediment[3]	Clay	**Silt/Sand** BC1-R, 2L, 4L, 7L, 7R, 8B-L, 10R	Gravel	Cobbles	Boulders	Bedrock 1R
Upper Riverbank Vegetation	**None to Very Sparse**	**Sparse**	**Moderate** 2L, 8B-L	**Heavy** BC1-R, 4L, 7L, 7R, 10R		
Lower Riverbank Slope[4]	Vertical	Steep	**Moderate** 7R, 10R	**Flat/Beach** BC1-R, 2L, 4L, 7L, 8B-L		
Lower Riverbank Sediment	Clay	**Silt/Sand** BC1-R, 2L, 4L, 7L, 8B-L	**Gravel**	**Cobbles** 10R	**Boulders** 7R	Bedrock
Lower Riverbank Vegetation	**None to Very Sparse** BC1-R, 2L, 4L, 7L, 7R, 8B-L	**Sparse** 10R	**Moderate**	**Heavy**		
Stage of Erosion	**Potential Future Erosion** 7L, 8B-L	**Active Erosion**	**Eroded** 2L*	Stable BC1-R, 4L, 7R, 10R		
Extent of Current Erosion	**None/Little** BC1-R, 4L, 7L, 7R, 10R	**Some** 2L, 8B-L	**Some to Extensive**	**Extensive**		

*In process of stabilization as part of the Erosion Control Plan (Simons, 1999).

[2] Categories that are highlighted in yellow were identified as characteristics that are indicative of areas where active erosion is most likely to occur or the potential for future erosion is high. Highlighted categories were identified based on review of historic geomorphic data and the results of the 2013 FRR. Transects and detailed study points that will be used for investigation and analyses associated with Study No. 3.1.2 were based on the highlighted categories.
[3] While clay, gravel, cobble, boulder, and bedrock upper riverbank sediments may exist in some locations throughout the Impoundment, these locations are rare and therefore are not representative of riverbank features and characteristics found in the study area. As such, these characteristics are not of interest to the objectives of this study.
[4] Vertical and Steep lower riverbank slopes are typically indicative or areas where active erosion is occurring or the potential for future erosion is high and therefore would normally be highlighted in yellow. These categories are not highlighted, however, as these specific riverbank conditions do not exist in the Impoundment.

Table 7.1-3 Riverbank Features and Characteristics –Calibration and Representative Locations at Existing, Permanent Transects

Location ID	Bank	Representative or Calibration	UPPER RIVERBANK				LOWER RIVERBANK			Type of Erosion	Indicator(s) of Potential Erosion	Stage of Erosion	Extent of Current Erosion
			Slope	Height	Sediment	Vegetation	Slope	Sediment	Vegetation				
BC1-R	Right Bank	Both	Moderate	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None/Very Sparse	Undercut	Creep/Leaning Trees	Stable	None/Little
2L	Left Bank	Both	Vertical	High	Silt/Sand	Moderate	Flat/Beach	Silt/Sand	None to Very Sparse	Rotational Slump	Creep/Leaning Trees, Overhanging	Eroded	Some
3L	Left Bank	Calibration	Moderate	Low	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut, Rotational Slump	Creep/Leaning Trees, Overhanging	Eroded	Some
3R	Right Bank	Calibration	Moderate	High	Silt/Sand	Heavy	Moderate	Gravel	None to Very Sparse	-	-	Stable	None/Little
4L	Left Bank	Both	Moderate	Medium	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None to Very Sparse	-	Creep/Leaning Trees	Stable	None/Little
5C-R	Right Bank	Calibration	Steep	High	Silt/Sand	Moderate	Flat/Beach	Silt/Sand	None to Very Sparse	Slide or Flow	Overhanging Bank, Exposed Roots, Creep/Leaning Trees	Eroded	Some
6A-L	Left Bank	Calibration	Moderate	High	Silt/Sand	Heavy	Moderate	Cobbles	None to Very Sparse	-	-	Stable	None/Little
6A-R	Right Bank	Calibration	Steep	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	Heavy	-	-	Stable	None/Little
7L	Left Bank	Both	Steep	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut	Creep/Leaning Trees	Potential Future Erosion	None/Little
7R	Right Bank	Both	Moderate	High	Silt/Sand	Heavy	Moderate	Boulders	None to Very Sparse	-	-	Stable	None/Little
8B-L	Left Bank	Both	Steep	High	Silt/Sand	Moderate	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut	Creep/Leaning Trees, Exposed Roots, Overhanging Bank	Potential Future Erosion	Some
8B-R	Right Bank	Calibration	Steep/Overhanging	High	Silt/Sand	Heavy	Flat/Beach	Gravel	None to Very Sparse	-	Overhanging	In process of stabilization	None/Little
9R	Right Bank	Calibration	Moderate	High	Silt/Sand	Moderate	Flat/Beach	Silt/Sand	None to Very Sparse	-	Creep/Leaning Trees	Stable	None/Little
10L	Left Bank	Calibration	Moderate	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None to Very Sparse	-	-	Stable	None/Little
10R	Right Bank	Both	Moderate	High	Silt/Sand	Heavy	Moderate	Cobbles	Sparse	-	-	Stable	None/Little
11L	Left Bank	Calibration	Moderate	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut	Undercut, Creep/Leaning trees	Stable	None/Little



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RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS OPERATIONS
IMPACT ON EXISTING EROSION AND
POTENTIAL BANK INSTABILITY

0 0.5 1 2 Miles

Figure 7.1-1:
Existing, Permanent Transect Location

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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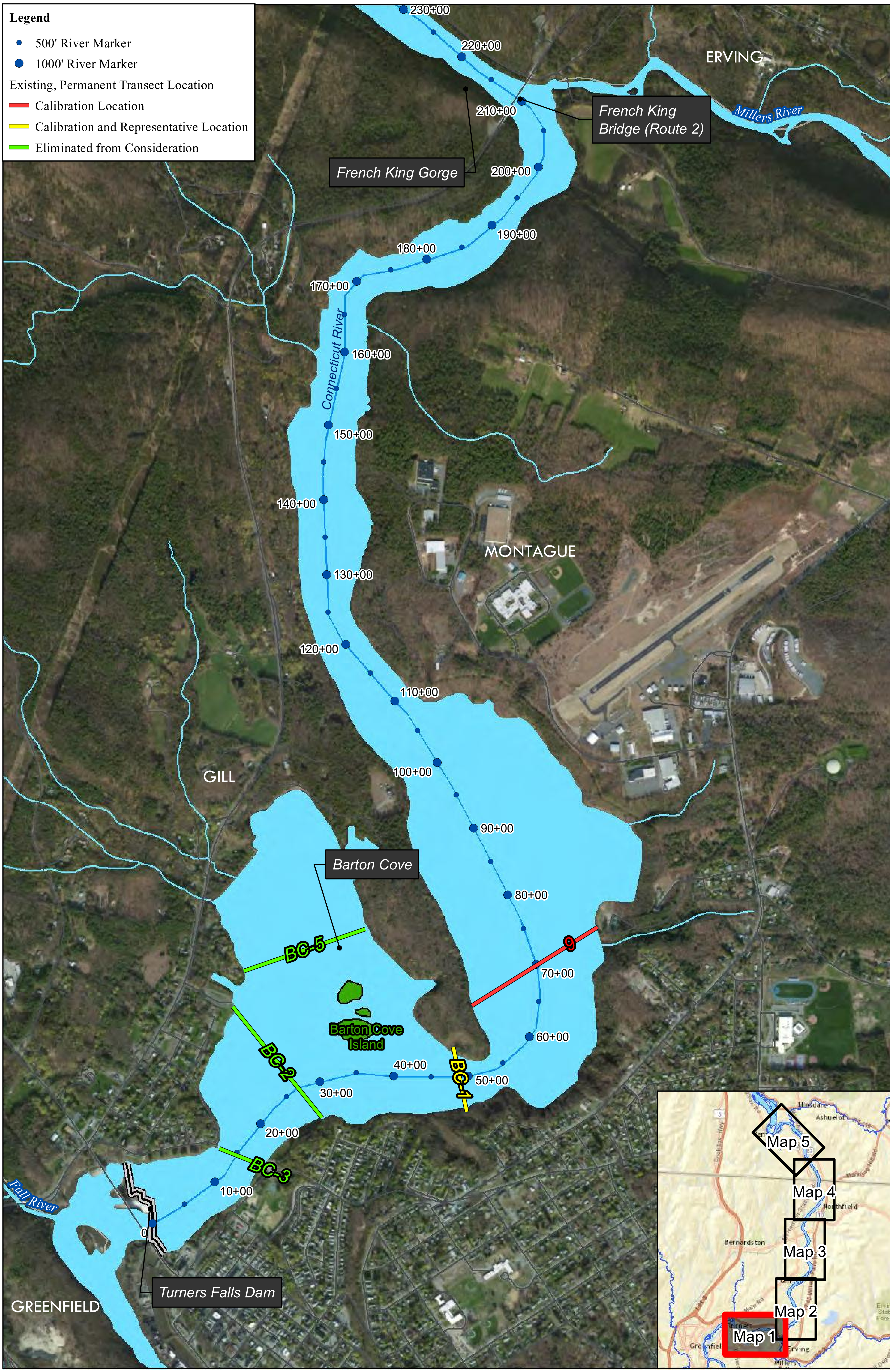

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RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7.1-2:
Existing, Permanent Transect Locations
Turners Falls Impoundment
Map 1

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
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RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7.1-3:
Existing, Permanent Transect Locations
Turners Falls Impoundment
Map 2

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap

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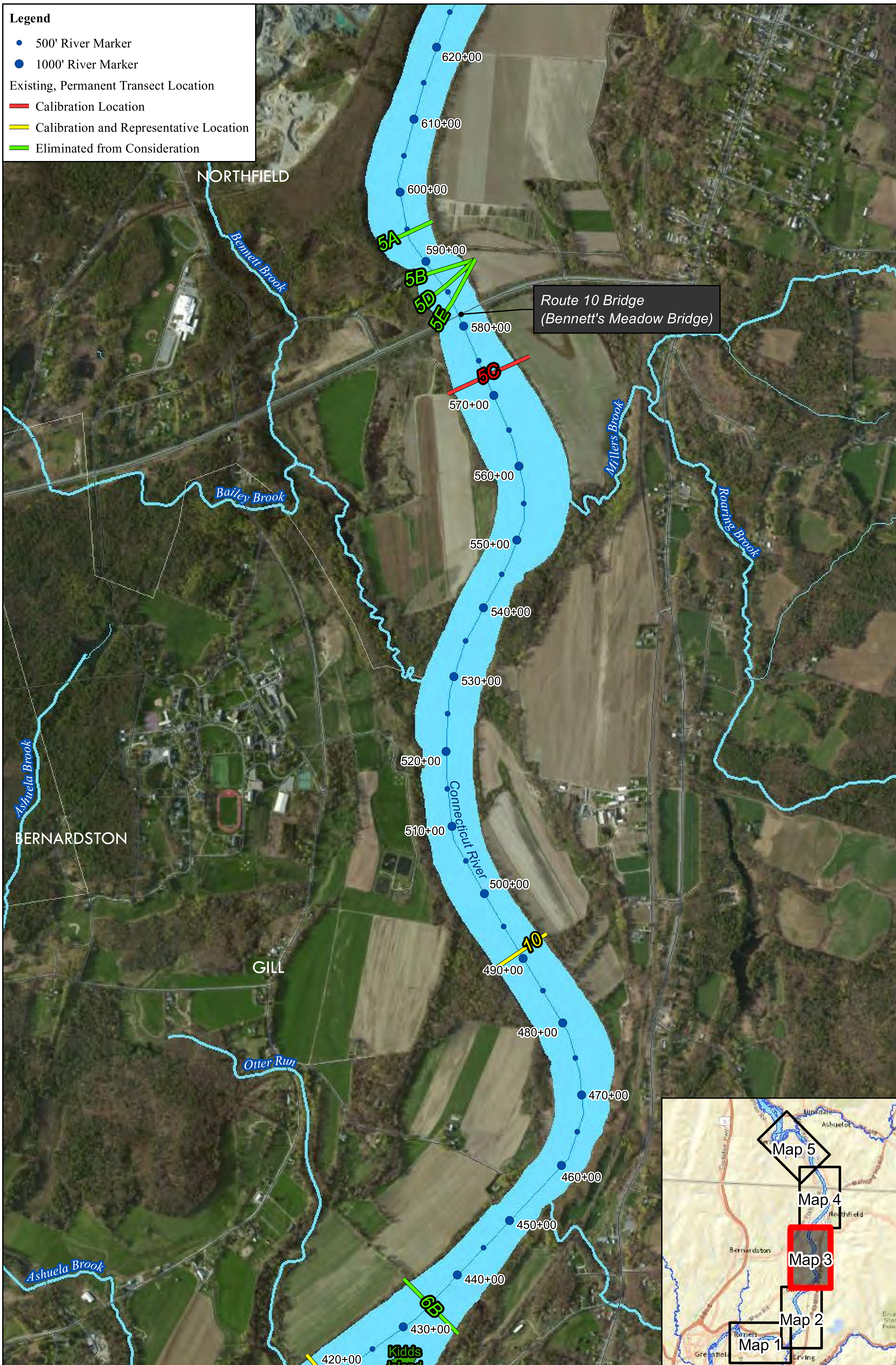

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RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

N

0 625 1,250 2,500 Feet

Figure 7.1-4:
Existing, Permanent Transect Locations
Turners Falls Impoundment
Map 3

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
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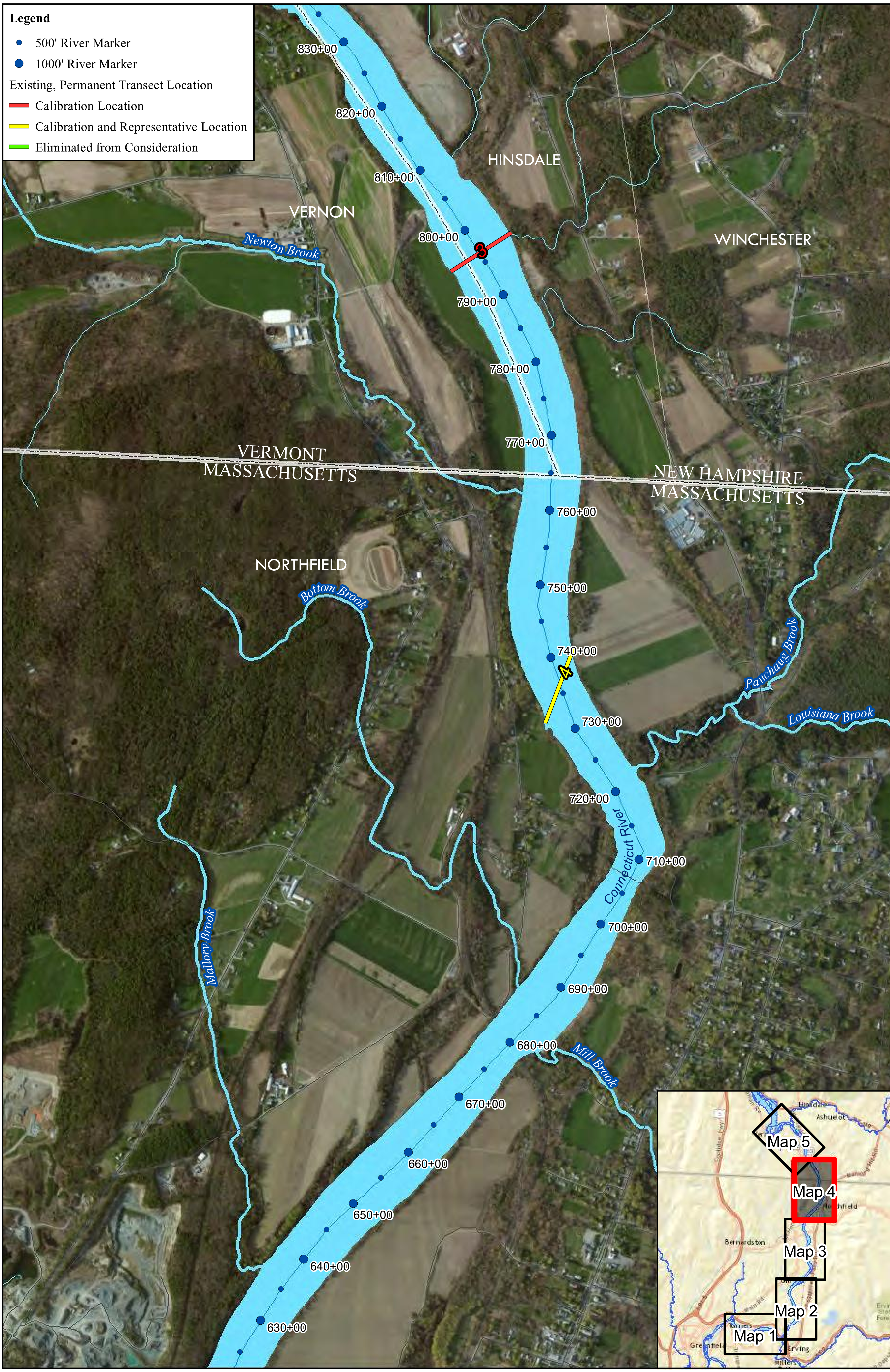

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NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7.1-5:
Existing, Permanent Transect Locations
Turners Falls Impoundment
Map 4

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap

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RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7.1-6:
Existing, Permanent Transect Locations
Turners Falls Impoundment
Map 5

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap

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Identify Supplemental Representative Locations for Detailed Study

Following completion of the existing, permanent transect evaluation Table 7.1-2 was reviewed to identify gaps in significant riverbank characteristic categories. Based on review of the table gaps such as Upper Riverbank Slope (Overhanging, Vertical, and Steep), Upper Riverbank Vegetation (Sparse and Moderate), Lower Riverbank Sediment (Gravel), Stage of Erosion (Active and Eroded), and Extent of Current Erosion (Some, Some to Extensive, and Extensive) were observed. Once these gaps were observed, the results of the 2013 FRR land- and boat-based surveys were analyzed to identify supplemental representative locations for detailed study. Based on the results of this analysis, 9 supplemental representative locations were selected. Of the 9 selected supplemental locations, 4 locations were identified as a result of the detailed geomorphic and geotechnical assessments conducted during the FRR land-based survey; while the remaining 5 were selected based on the FRR boat-based survey. The supplemental representative locations complement the selected existing, permanent transect locations thus creating a comprehensive set of study locations representative of the range of riverbank features and characteristics found throughout the Impoundment. Supplemental representative locations include:

- Land-based Observation Point #18
- Land-based Observation Point #21
- Land-based Observation Point #26
- Land-based Observation Point #29

- Boat-based Observation Point #12 (12B)
- Boat-based Observation Point #75 (75B)
- Boat-based Observation Point #87 (87B)
- Boat-based Observation Point #119 (119B)
- Boat-based Observation Point #303 (303B)

Tables 7.2-1 and 7.2-2 provide an overview of the riverbank features and characteristics found at each location. Figure 7.2-1 depicts the geographic distribution of each location throughout the Impoundment. Additional information for each location, including photos and field assessment forms, can be found Appendix B. Brief descriptions providing the rationale for why each location was selected, as well as which gap the selected location fills, are included below:

<u>Land-based Observation Points</u>

Land-based Observation Point #18

Land-based Observation Point #18, located between Transects 2 and 3, fills a longitudinal gap in this part of the Impoundment. Specific erosion condition gaps filled at this location include the Stage of Erosion (Eroded) and Extent of Current Erosion (Some).

Land-based Observation Point #21

This land-based point is experiencing multiple types of erosion and indicators of potential erosion. Due to the riverbank conditions found at this location, this site may be considered for some type of future stabilization. Land-based point #21 is located a short distance downstream of Transect #3 and the Kendall stabilization site thus providing additional insight to erosion processes occurring in this reach of the Impoundment. Specific feature and characteristic gaps filled at this location include: Upper Riverbank Slope (Vertical and Steep); Upper Riverbank Vegetation (Moderate); Lower Riverbank Sediment (Gravel); Stage of Erosion (Active); and Extent of Current Erosion (Some to Extensive).

Land-based Observation Point #26

Land-based Observation Point #26 is located just upstream of a stabilized segment of riverbank (Urgiel Upstream). This site exhibits active erosion and potential future erosion and may represent bank conditions that were found prior to the stabilization of Transect #10's right bank. A recent vertical shift in the bank has developed both through the stabilized site and upstream which is of interest in understanding and monitoring. Specific feature and characteristic gaps filled at this location include: Upper Riverbank Slope (Overhanging and Steep); Stage of Erosion (Active); and Extent of Current Erosion (Some).

Land-based Observation Point #29

Land-based Observation Point #29, located between Transects 4 and 5C, fills a longitudinal gap in this part of the Impoundment. Specific feature and characteristic gaps filled at this location include: Upper Riverbank Slope (Vertical and Steep); Stage of Erosion (Active); and Extent of Current Erosion (Some).

<u>Boat-based Observation Points</u>

Boat-based Observation Point #12

Boat-based segment #12 exhibits extensive, active erosion and limited upper and lower riverbank vegetation. Located between French King Gorge and Barton Cove, this location provides one additional point downstream of the gorge. Specific feature and characteristic gaps filled at this location include: Upper Riverbank Slope (Steep); Upper Riverbank Vegetation (Sparse); Stage of Erosion (Active); and Extent of Current Erosion (Extensive).

Boat-based Observation Point #75

Boat-based segment #75 exhibits extensive, active erosion, vertical upper riverbank slope, and limited upper and lower riverbank vegetation. Located downstream of the Northfield Mountain tailrace this site provides one additional point in the vicinity of the tailrace.

Boat-based Observation Point #87

Boat-based segment #87 exhibits eroded conditions and several indicators of potential future erosion. Located upstream of the Northfield Mountain Tailrace and a short distance downstream of the Shearer stabilization site, this location provides a site relatively close to the tailrace in an eroded area surrounded by a range of stabilization projects (upstream and downstream as well as across the river). Specific feature and characteristic gaps filled at this location include: Upper Riverbank Slope (Overhanging); Upper Riverbank Vegetation (Sparse); Stage of Erosion (Eroded); and Extent of Current Erosion (Some to Extensive).

Boat-based Observation Point #119

Boat-based segment #119 is located near the downstream end of Kidds Island and exhibits eroded conditions and several indicators of potential future erosion. Specific feature and characteristic gaps filled at this location include: Upper Riverbank Slope (Steep); Upper Riverbank Vegetation (Sparse); Stage of Erosion (Eroded); and Extent of Current Erosion (Some to Extensive).

Boat-based Observation Point #303

Boat-based segment #303 exhibits none/little erosion and is classified as stable. This site, located downstream of the Ashuelot River confluence, fills several specific feature and characteristic gaps including Upper Riverbank Height (Medium) and Lower Riverbank Vegetation (Heavy) as requested by Stakeholders.

Table 7.2-1 Summary of Riverbank Features and Characteristics –Supplemental Representative Locations for Detailed Study

FEATURES	CHARACTERISTICS[5]					
Upper Riverbank Slope	**Overhanging** 26, 87(B)	**Vertical** 21, 29, 75(B)	**Steep** 12(B), 21, 26, 29, 119(B)	**Moderate** 18, 303(B)	Flat	
Upper Riverbank Height	Low	**Medium** 303(B)	**High** 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B)			
Upper Riverbank Sediment[6]	Clay	**Silt/Sand** 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B), 303(B)	Gravel	Cobbles	Boulders	Bedrock
Upper Riverbank Vegetation	**None to Very Sparse**	**Sparse** 12(B), 75(B), 87(B), 119(B)	**Moderate** 21	**Heavy** 18, 26, 29, 303(B)		
Lower Riverbank Slope[7]	Vertical	Steep	**Moderate**	**Flat/Beach** 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B), 303(B)		
Lower Riverbank Sediment	Clay	**Silt/Sand** 12(B), 18, 26, 29, 75(B), 87(B), 119(B), 303(B)	**Gravel** 21	**Cobbles**	**Boulders**	Bedrock
Lower Riverbank Vegetation	**None to Very Sparse** 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B)	**Sparse**	**Moderate**	**Heavy** 303(B)		

[5] Categories that are highlighted in yellow were identified as characteristics that are indicative of areas where active erosion is most likely to occur or the potential for future erosion is high. Highlighted categories were identified based on review of historic geomorphic data and the results of the 2013 FRR. Transects and detailed study points that will be used for investigation and analyses associated with Study No. 3.1.2 were based on the highlighted categories.

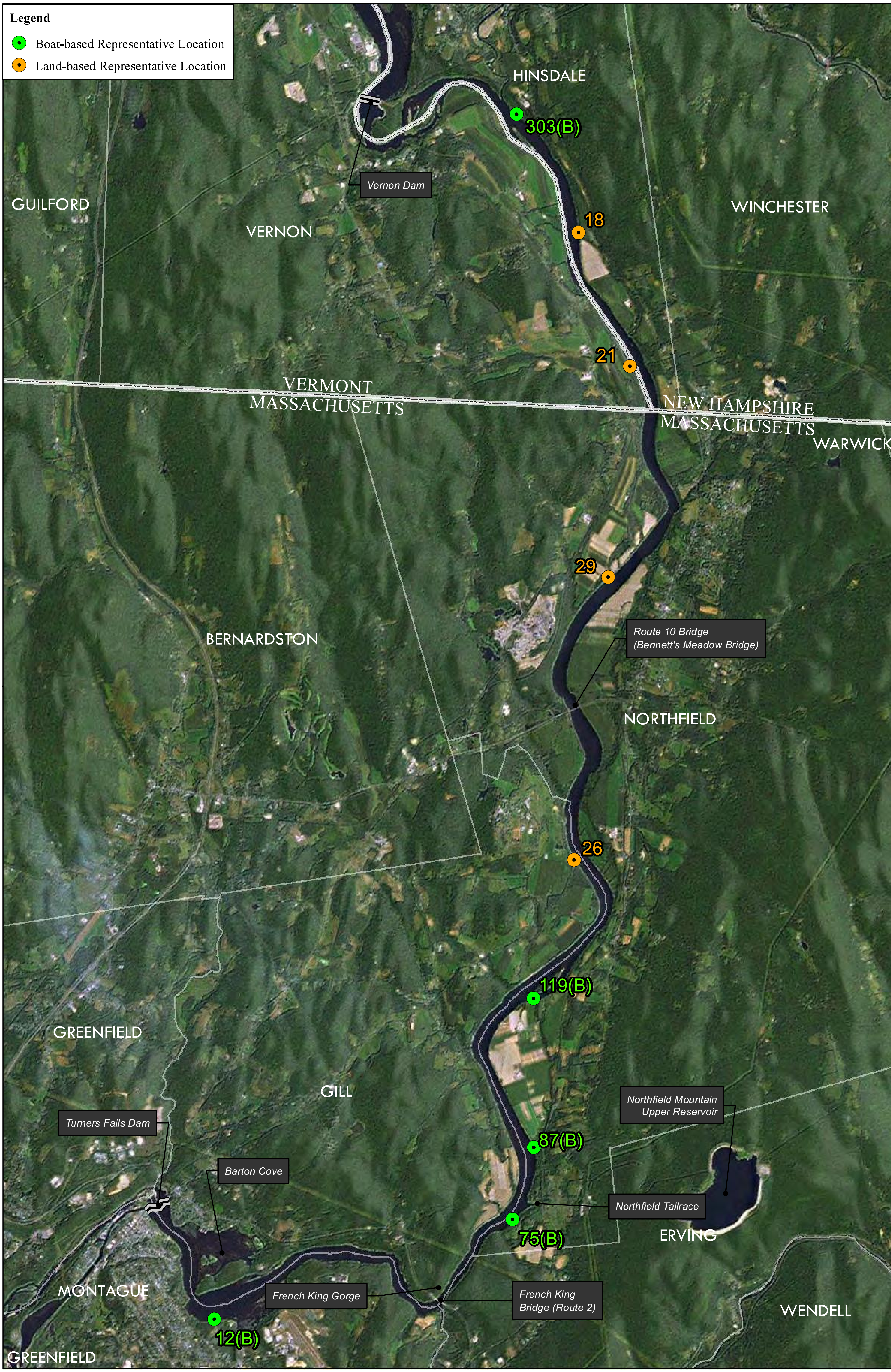
[6] While clay, gravel, cobble, boulder, and bedrock upper riverbank sediments may exist in some locations throughout the Impoundment, these locations are rare and therefore are not representative of riverbank features and characteristics found in the study area. As such, these characteristics are not of interest to the objectives of this study.

[7] Vertical and Steep lower riverbank slopes are typically indicative or areas where active erosion is occurring or the potential for future erosion is high and therefore would normally be highlighted in yellow. These categories are not highlighted, however, as these specific riverbank conditions do not exist in the Impoundment.

FEATURES	**CHARACTERISTICS**[5]				
Stage of Erosion	**Potential Future Erosion**	**Active Erosion** 12(B), 21, 26, 29, 75(B)	**Eroded** 18, 87(B), 119(B)	Stable 303(B)	
Extent of Current Erosion	**None/Little** 303(B)	**Some** 18, 26, 29	**Some to Extensive** 21, 87(B), 119	**Extensive** 12(B), 75(B)	

Table 7.2-2 Riverbank Features and Characteristics –Supplemental Representative Locations for Detailed Study

Location ID	Bank	Source	UPPER RIVERBANK				LOWER RIVERBANK			Type of Erosion	Indicator(s) of Potential Erosion	Stage of Erosion	Extent of Current Erosion
			Slope	Height	Sediment	Vegetation	Slope	Sediment	Vegetation				
18	Left Bank	FRR Land-based Survey	Moderate	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None/Very Sparse	Undercut	Undercut, Exposed Roots, Creep/Leaning Trees	Eroded	Some
21	Right Bank	FRR Land-based Survey	Steep (some vertical)	High	Silt/Sand	Moderate	Flat/Beach	Gravel, Silt/Sand	None/Very Sparse	Rotational Slump, Undercut	Undercut, Exposed Roots, Creep/Leaning Trees	Active	Some to extensive
26	Right Bank	FRR Land-based Survey	Steep/Overhanging	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None/Very Sparse	Rotational Slump, Undercut	Undercut, Exposed Roots, Creep/Leaning Trees	Active	Some
29	Right Bank	FRR Land-based Survey	Steep (near vertical)	High	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	None/Very Sparse	Rotational Slump, Undercut	Undercut, Exposed Roots, Creep/Leaning Trees	Active	Some
12(B)	Left Bank	FRR Boat-based Survey	Steep	High	Silt/Sand	Sparse	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut	Exposed Roots, Overhanging Bank	Active	Extensive
75(B)	Left Bank	FRR Boat-based Survey	Vertical	High	Silt/Sand	Sparse	Flat/Beach	Silt/Sand	None to Very Sparse	Topple, Overhanging Bank	Creep/Leaning Trees, Overhanging Bank	Active	Extensive
87(B)	Left Bank	FRR Boat-based Survey	Overhanging	High	Silt/Sand	Sparse	Flat/Beach	Silt/Sand	None to Very Sparse	Undercut, Rotational Slump	Exposed Roots, Creep/Leaning Trees, Overhanging Bank	Eroded	Some to Extensive
119(B)	Left Bank	FRR Boat-based Survey	Steep	High	Silt/Sand	Sparse	Flat/Beach	Silt/Sand	None to Very Sparse	Slide or Flow	Exposed Roots, Creep/Leaning Trees, Overhanging Bank	Eroded	Some to Extensive
303(B)	Left Bank	FRR Boat-based Survey	Moderate	Medium	Silt/Sand	Heavy	Flat/Beach	Silt/Sand	Heavy	-	-	Stable	None/Little



FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

Figure 7.2-1:
Proposed Supplemental Representative Locations for Detailed Study

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Evaluate the Range of Riverbank Features and Characteristics of Representative Locations Selected for Detailed Study

Once the list of representative transects and detailed study points were identified the range of riverbank features and characteristics of the selected locations were evaluated to ensure they are representative of significant features and characteristics found throughout the Impoundment (as defined in Table 6-1). For the purpose of this study, significant riverbank features include:

- Upper Riverbank Height;
- Upper and Lower Riverbank Slope;
- Upper and Lower Riverbank Sediment;
- Upper and Lower Riverbank Vegetation;
- Stage of Erosion; and
- Extent of Current Erosion

As discussed in Section 6, significant riverbank characteristics are those categories which are highlighted in yellow (Table 6-1). Highlighted categories represent specific riverbank characteristics that are indicative of areas where active erosion is most likely to occur or the potential for future erosion is high. These categories were identified based on review of historic geomorphic data and the results of the 2013 FRR. Special attention was paid to the highlighted categories when selecting the final list of transects and detailed study points as they are most pertinent to the objectives of this study.

In order to evaluate the representativeness of the selected locations Table 7.3-1 was developed. The riverbank features and characteristics found in this table are based on those contained in Table 6-1. By populating each riverbank characteristic with the location ID of the selected study site, comparisons can be made ensuring each characteristic is appropriately balanced and represented. While the highlighted categories are of most interest to the objectives of this study, some highlighted categories were found to be more representative than others based on the results of the 2013 FRR. Categories which were found to be more representative of riverbank conditions were typically weighted more heavily than the less representative categories (e.g. lower riverbank sediment silt/sand vs. gravel, cobbles, or boulders). Additionally, non-highlighted categories found in Table 7.3-1 are typically not represented by selected locations as they are not indicative of areas where active erosion is likely to occur or the potential for future erosion is high. As such, non-highlighted categories are generally not relevant to the objectives of this study and are not recommended to be studied in detail.

Review of Table 7.3-1 finds that, in general, the selected locations for detailed study are well represented and balanced across the various significant upper and lower riverbank characteristic categories (those highlighted in yellow). Based on the results of the 2013 FRR, highlighted categories that are not represented by a location (e.g. lower riverbank vegetation – Moderate and Heavy and upper riverbank vegetation – None to Very Sparse), or that only have one location listed, are not representative of the majority of current riverbanks. In other words, these characteristics make up such a small percentage of the overall Impoundment riverbanks they do not warrant detailed investigation and therefore are not included in the final list of representative locations. Lower riverbank vegetation classifications of Moderate and Heavy were not selected for detailed study due to the fact that locations where significant lower riverbank vegetation exists are generally relatively stable. While an increasing amount of significant lower riverbank vegetation was observed in 2013, these characteristics only represent a relatively small percentage of the overall Impoundment. Only one site where upper riverbank vegetation was categorized as None to Very Sparse was selected for detailed study (although several calibration sites also were similarly categorized). The vast majority of the Impoundment has considerably more upper riverbank vegetation so a small number of sites with no significant vegetation adequately represents this type of riverbank.

In addition to being balanced across the various significant riverbank characteristic categories, the final list of representative locations is evenly distributed over the range of erosion conditions found throughout the Impoundment (as observed during the 2013 FRR). Specific erosion conditions that were evaluated include the Stage of Erosion (Potential Future Erosion, Active Erosion, Eroded, or Stable) and the Extent of Current Erosion (None/Little, Some, Some to Extensive, or Extensive).

As shown in Table 7.3-1, the selected representative locations are balanced across the various Stages of Erosion found throughout the Impoundment. Of the 16 selected representative locations, 5 sites were selected at Stable locations while the remaining 11 sites are located where erosion processes may occur, actively occur, or have occurred, including:

- Potential Future Erosion – 2 sites;
- Active Erosion – 5 sites; and
- Eroded – 4 sites

Furthermore, as defined in the RSP (FirstLight, 2013), the final set of representative locations for detailed study includes:

- Locations where riverbanks are stable (including at least one site where bank stabilization has occurred as a result of the ECP (Simons, 1999) and at least one site that is naturally stable);
- Locations where the potential for future erosion is low;
- Locations where the potential for future erosion is high; and
- Locations where active erosion is occurring

Transects 2L, 3R, 6AL, 6AR, 8B-R, 9R, 10R are located where bank stabilization has occurred as a result of the ECP while sites BC1-R, 4L, 7R, 10L, 11L, and 303(B) have features and characteristics that are naturally stable. Transects 11L, 4L, 10L, 10R and 7R are located where the potential for future erosion is low and Transects 7L and 8B-L exhibit a high potential for future erosion. Sites 12(B), 21, 26, 29, and 75B are located where active erosion is occurring.

In addition to a balance across the various Stages of Erosion, the selected representative locations are balanced across the various Extents of Current Erosion found throughout the Impoundment. Of the 16 selected representative locations, 6 were located where None/Little erosion occurs while the remaining 10 are located where some form of erosion currently exists, including:

- Some – 5 sites;
- Some to Extensive – 3 sites; and
- Extensive – 2 sites

Based on review of the representativeness evaluation, the selected representative locations are found to be well distributed and balanced across the various significant riverbank characteristic categories (those highlighted in yellow, Table 7.3-1). Characteristic categories that were found to be more representative of riverbank conditions than others were represented more heavily. Additionally, the selected representative locations are weighted more heavily toward locations where erosion processes may occur, are actively occurring, or have occurred as required by the RSP (FirstLight, 2013). Stable sites where None/Little erosion occurs have also been selected in order to study the entire spectrum of erosion processes in the Impoundment. The 16 representative locations selected for detailed study provide a comprehensive set of study sites that are representative of riverbank features, characteristics, and erosion conditions found throughout the Impoundment.

Table 7.3-1 Summary of Riverbank Features and Characteristics –Representative Locations for Detailed Study

FEATURES	CHARACTERISTICS[8]					
Upper Riverbank Slope	**Overhanging** 26, 87(B)	**Vertical** 2L, 21, 29, 75(B)	**Steep** 7L, 8B-L, 12(B), 21, 26, 29, 119(B)	**Moderate** 4L, 7R, 10R, 18, 303B, BC-1R	Flat	
Upper Riverbank Height	Low	**Medium** 4L, 303B	**High** 2L, 7L, 7R, 8B-L, 10R, 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B), BC-1R			
Upper Riverbank Sediment[9]	Clay	**Silt/Sand** 2L, 4L, 7L, 7R, 8B-L, 10R, 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B), 303B, BC-1R	Gravel	Cobbles	Boulders	Bedrock
Upper Riverbank Vegetation	**None to Very Sparse**	**Sparse** 12(B), 75(B), 87(B), 119(B)	**Moderate** 2L, 8B-L, 21	**Heavy** 4L, 7L, 7R, 10R, 18, 26, 29, 303B, BC-1R		
Lower Riverbank Slope[10]	Vertical	Steep	**Moderate** 7R, 10R	**Flat/Beach** 2L, 4L, 7L, 8B-L, 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B), 303B, BC-1R		

[8] Categories that are highlighted in yellow were identified as characteristics that are indicative of areas where active erosion is most likely to occur or the potential for future erosion is high. Highlighted categories were identified based on review of historic geomorphic data and the results of the 2013 FRR. Transects and detailed study points that will be used for investigation and analyses associated with Study No. 3.1.2 are based on the highlighted categories.

[9] While clay, gravel, cobble, boulder, and bedrock upper riverbank sediments may exist in some locations throughout the Impoundment, these locations are rare and therefore are not representative of riverbank features and characteristics found in the study area. As such, these characteristics are not of interest to the objectives of this study.

[10] Vertical and Steep lower riverbank slopes are typically indicative or areas where active erosion is occurring or the potential for future erosion is high and therefore would normally be highlighted in yellow. These categories are not highlighted, however, as these specific riverbank conditions do not exist in the Impoundment.

FEATURES	CHARACTERISTICS[8]					
Lower Riverbank Sediment	Clay	**Silt/Sand** 2L, 4L, 7L, 8B-L, 12(B), 18, 26, 29, 75(B), 87(B), 119(B), 303B, BC-1R	**Gravel** 21	**Cobbles** 10R	**Boulders** 7R	Bedrock
Lower Riverbank Vegetation	**None to Very Sparse** 2L, 4L, 7L, 7R, 8B-L, 12(B), 18, 21, 26, 29, 75(B), 87(B), 119(B), BC-1R	**Sparse** 10R	**Moderate**	**Heavy** 303B		
Stage of Erosion	**Potential Future Erosion** 7L, 8B-L	**Active Erosion** 12(B), 21, 26, 29, 75(B)	**Eroded** 18, 2L*, 87(B), 119(B)	Stable 4L, 7R, 10R, 303B, BC-1R		
Extent of Current Erosion	**None/Little** 4L, 7L, 7R, 10-R, 303B, BC-1R	**Some** 2L, 8B-L, 18, 26, 29	**Some to Extensive** 21, 87(B), 119(B)	**Extensive** 12(B), 75(B)		

*In process of stabilization as part of the Erosion Control Plan (Simons, 1999).

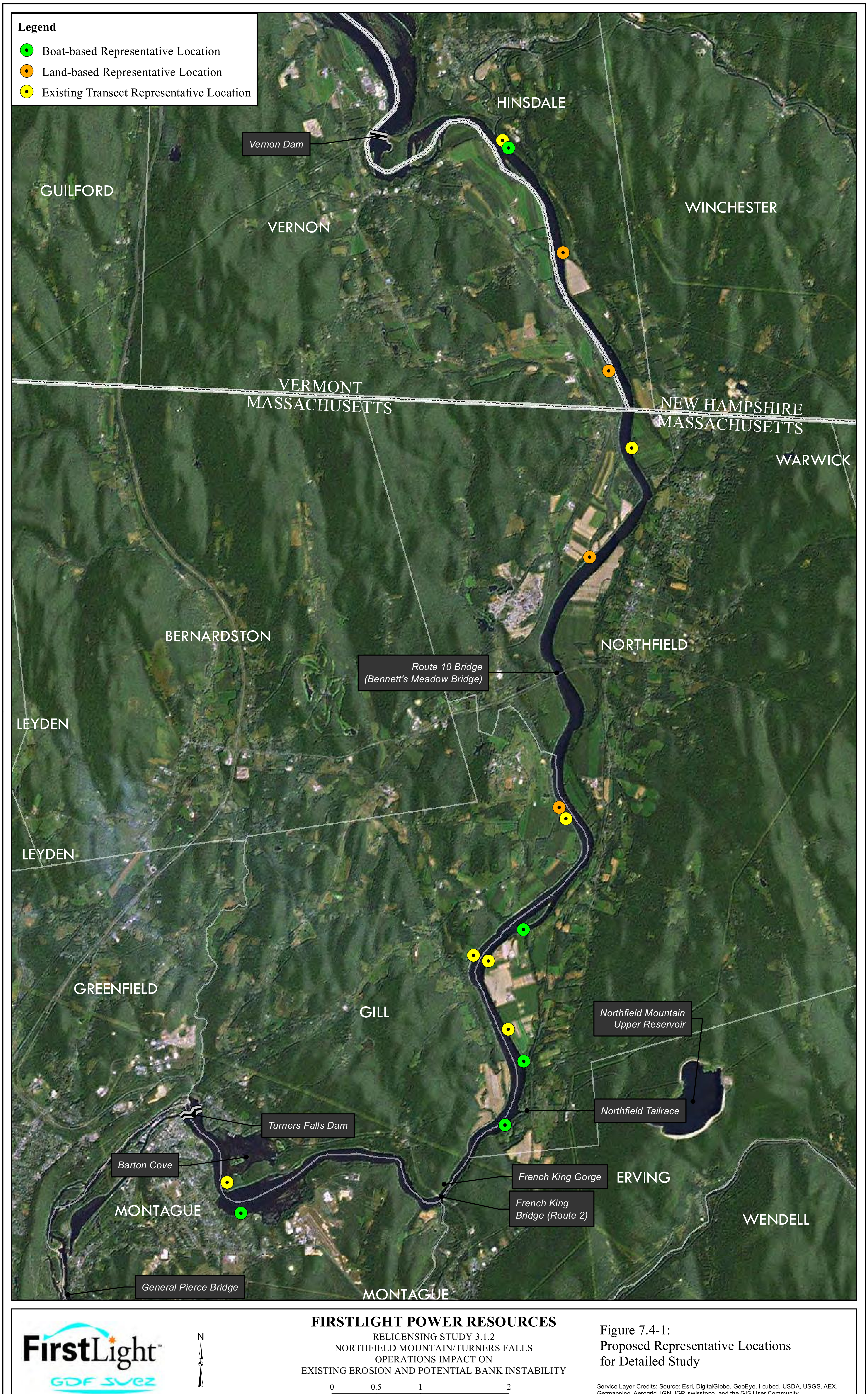
Evaluate the Geographic Distribution of the Representative Locations Selected for Detailed Study

The final step in developing the final set of representative locations for detailed study was to evaluate the geographic distribution of the selected sites throughout the Impoundment. Given the varying hydrologic and hydraulic conditions found throughout the Impoundment it is vital that the final list of representative locations are adequately distributed. Specific hydrologic and hydraulic conditions that should be taken into consideration include:

- Natural features such as the constriction at French King Gorge;
- Tributary inflows including the Ashuelot River and Millers River (and several smaller tributary inflows to the Impoundment); and
- Operation of various hydropower projects including Vernon Project at the upstream end, Northfield Mountain Pumped Storage Project in the lower middle reach, and Turners Falls Hydroelectric Project at the downstream end

Figure 7.4-1 depicts the geographic distribution of the representative locations selected throughout the Impoundment. As shown in the figure, the recommended representative locations are distributed adequately throughout the Impoundment from Vernon Dam to Barton Cove. Thus the recommended representative locations for detailed study cover the primary area of interest within the Impoundment where erosion has the potential to occur, is actively occurring, or has occurred. In addition, the geographic distribution of the representative locations covers the range of possible hydraulic conditions as imposed by the operation of the Vernon Hydroelectric Project, Northfield Mountain Pumped Storage Project, and the Turners Falls Hydroelectric Project.

Figures 7.4-2-7.4-6 present more detailed, reach by reach views of the representative locations.



FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

Figure 7.4-1:
Proposed Representative Locations
for Detailed Study

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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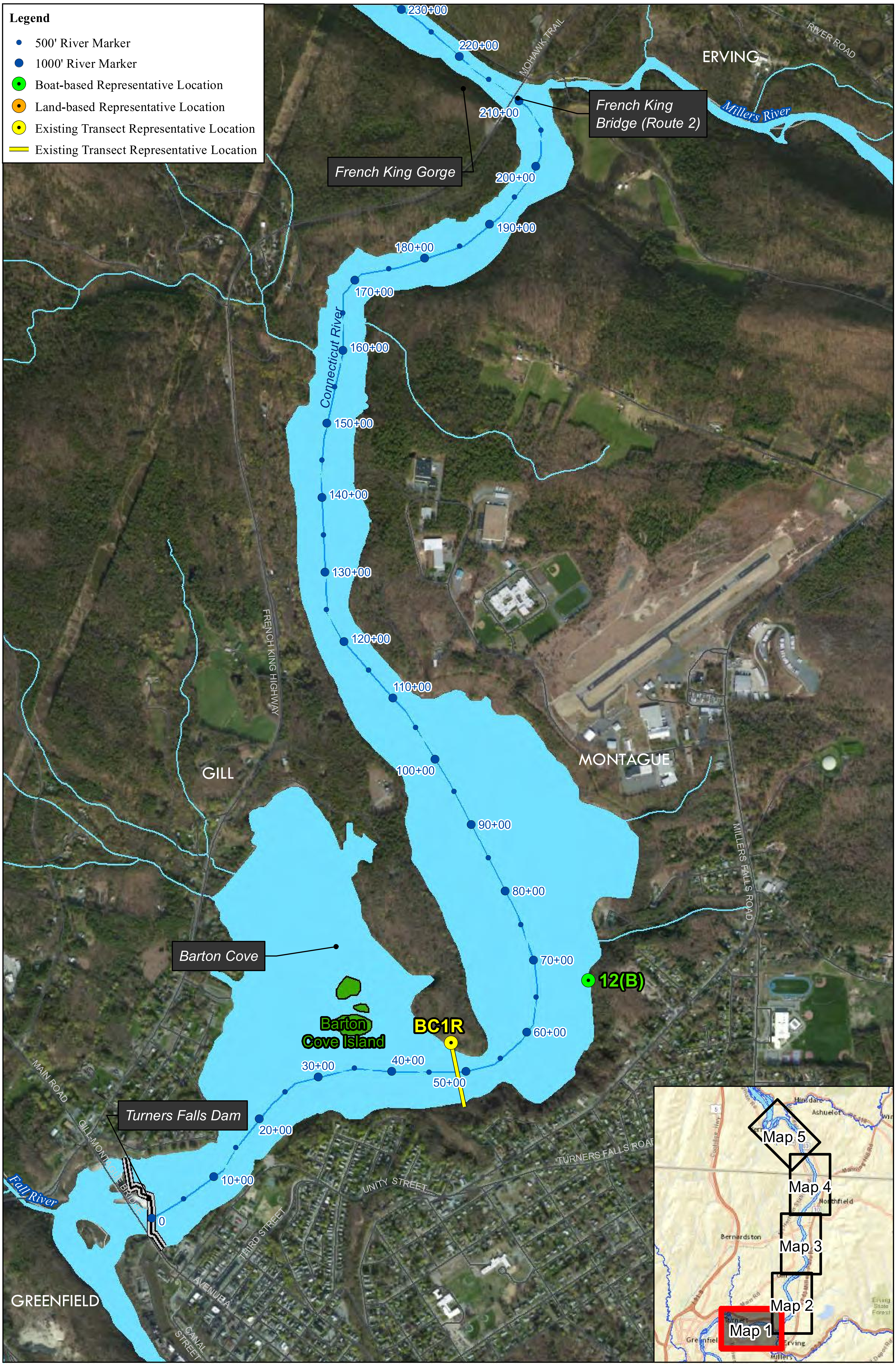

FirstLight GDF SUEZ

FIRSTLIGHT POWER RESOURCES
RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7.4-2:
Proposed Representative Locations
for Detailed Study
Map 1

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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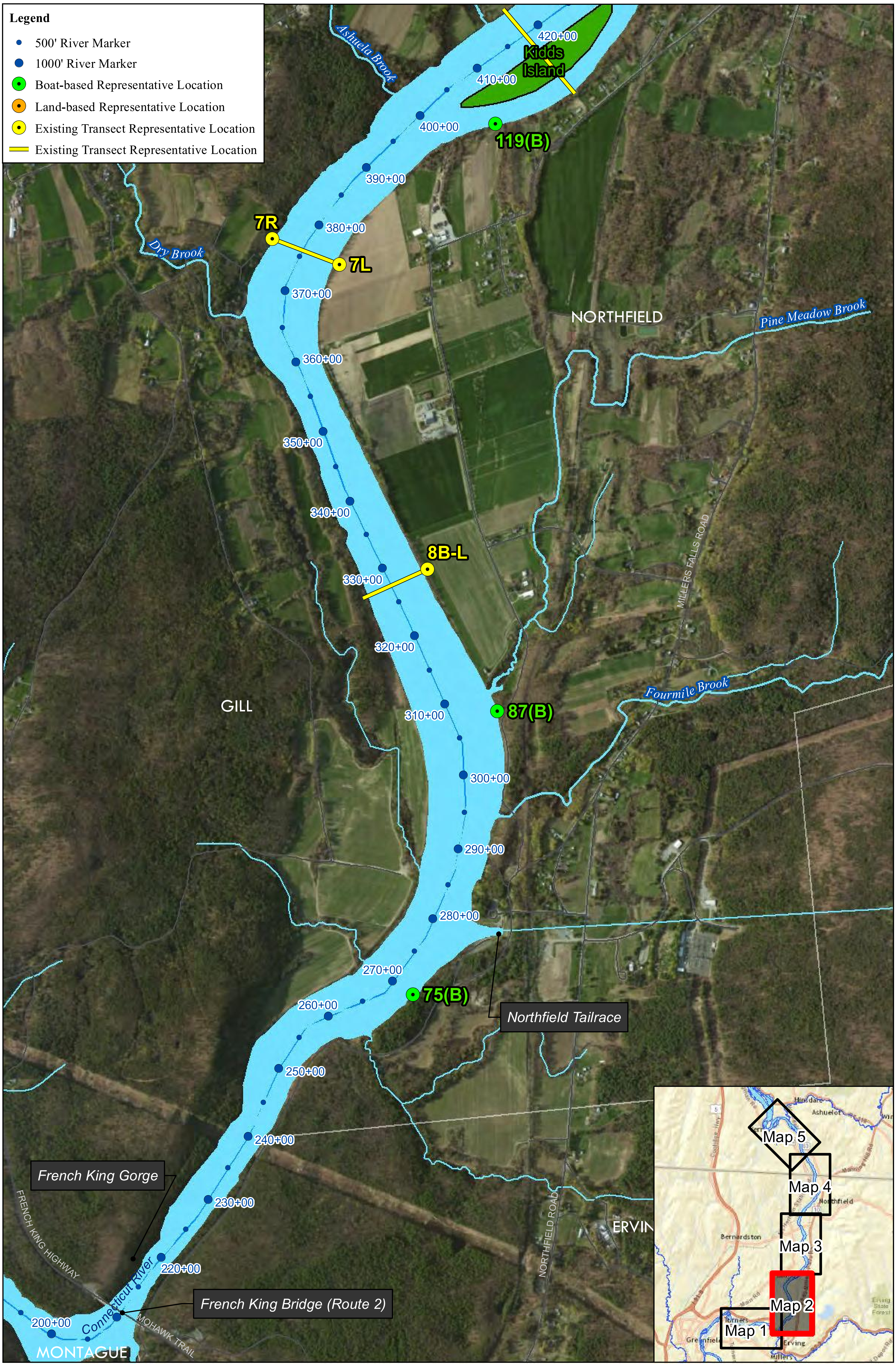

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RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7.4-3:
Proposed Representative Locations
for Detailed Study
Map 2

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7.4-4:
Proposed Representative Locations
for Detailed Study
Map 3

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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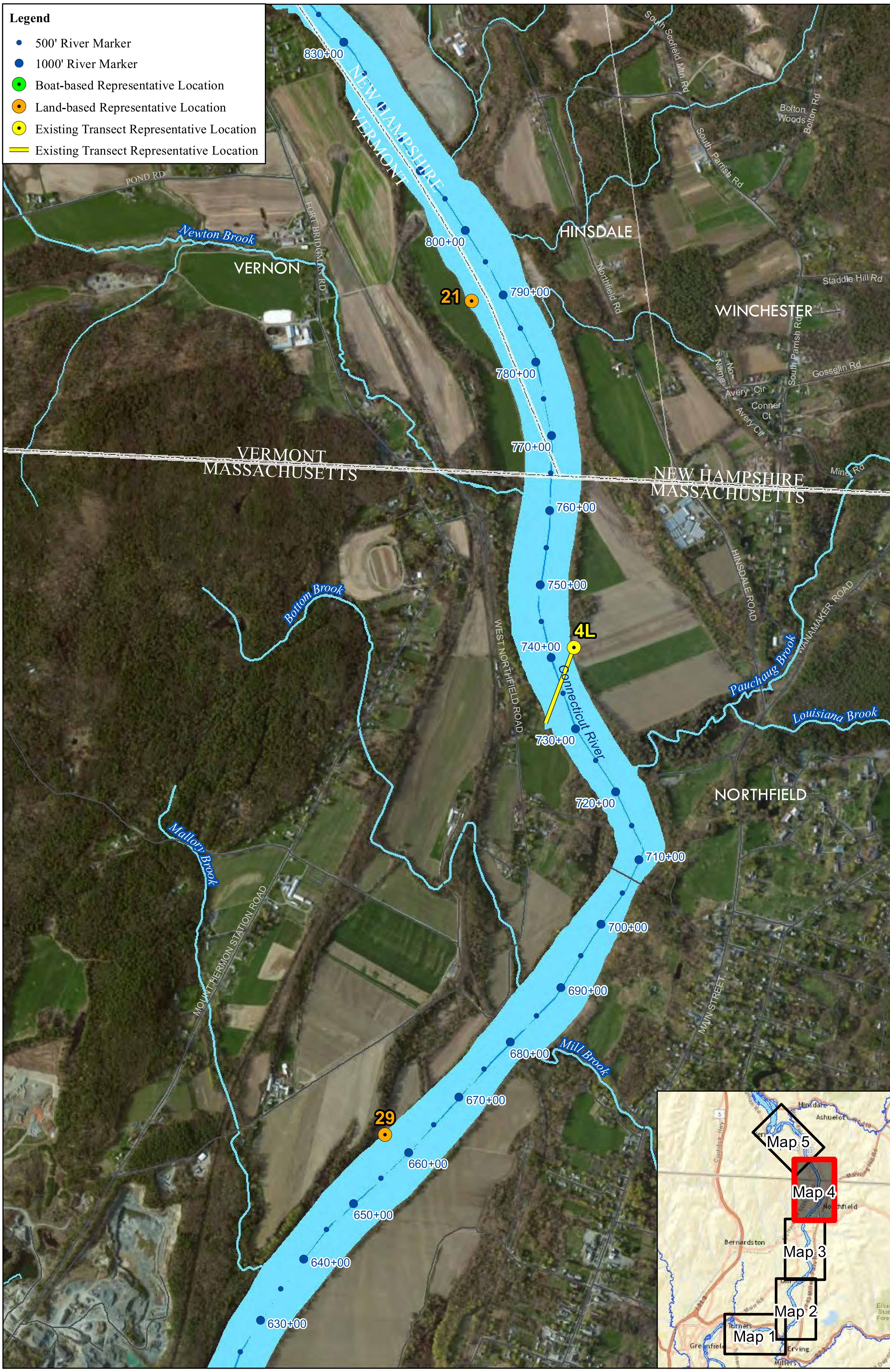

FIRSTLIGHT POWER RESOURCES

RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

N

Figure 7.4-5:
Proposed Representative Locations
for Detailed Study
Map 4

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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FIRSTLIGHT POWER RESOURCES

RELICENSING STUDY 3.1.2
NORTHFIELD MOUNTAIN/TURNERS FALLS
OPERATIONS IMPACT ON
EXISTING EROSION AND POTENTIAL BANK INSTABILITY

0 625 1,250 2,500 Feet

Figure 7.4-6:
Proposed Representative Locations
for Detailed Study
Map 5

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Appendix C Study 3.1.2 Addendum

August 12, 2014

VIA EMAIL

Brian Harrington, Massachusetts Department of Environmental Protection (MADEP)
David Foulis, MADEP
Bob Kubit, MADEP
Bill McDavitt, National Marine Fisheries Service
Russ Cohen, MA Riverways
Kimberly Noake-McPhee, Franklin Regional Council of Governments
Andrea Donlon, Connecticut River Watershed Council
Tom Miner, Connecticut River Streambank Erosion Committee
John Bennett, Franklin Conservation District
Mike Bathory, Landowners for Concerned Citizens

Re: FirstLight, Relicensing of the Turners Falls Hydroelectric Project (FERC No. 1889) and Northfield Mountain Pumped Storage Project (FERC No. 2485), Study No. 3.1.2- *Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability.*

Dear All,

FirstLight Hydro Generating Company (FirstLight) is currently in the process of relicensing its Turners Falls Hydroelectric Project (FERC No. 1889) and Northfield Mountain Pumped Storage Project (FERC No. 2485) with the Federal Energy Regulatory Commission (FERC).

On August 14, 2013 FirstLight filed its Revised Study Plan (RSP). On September 13, 2013, FERC issued its Study Plan Determination Letter (SPDL) on 20 of FirstLight's 38 proposed studies. FERC delayed issuing a SPDL on the remaining 18 studies because the Vermont Yankee (VY) Nuclear facility, which discharges heated water to the Vernon Impoundment for cooling purposes, is closing no later than December 29, 2014[1]. FERC held a meeting on November 25, 2013 with FirstLight and various stakeholders to determine which of the remaining 18 studies may need to be modified in light of the VY closure. In addition to the remaining 18 studies, Study No. 3.1.2 *Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability* for which FERC already issued a SPDL was mentioned as a study that may need to be re-evaluated due to the closure of VY. More specifically, it was noted at the November 25 meeting, that the Turners Falls Impoundment currently does not completely ice over, which could be attributable to VY's discharge of heated water to the Connecticut

[1] Entergy, owners of the Vermont Yankee facility, indicated at a November 25, 2013 meeting with FERC that the facility will close no later than December 29, 2014.

John S. Howard
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Chief Dam Safety Engineer

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E-mail: john.howard@gdfsuezna.com

River for cooling purposes. On December 13, 2013, FERC issued an Interim ILP schedule for Study Plan Determination. In the letter FERC states:

> *"In addition to the 19 deferred studies, stakeholders noted that the previously approved study 3.1.2: Project Impacts on Existing Erosion and Potential Bank Instability, did not consider ice process erosional effects within the Turners Falls reservoir. As a result, FirstLight requested that it be provided an opportunity to consider whether any modifications to the approved study are needed. Because any modifications to study 3.1.2 for this purpose could not be implemented in 2014 while Vermont Yankee is operational, we recommend that FirstLight evaluate the need for a study modification in consultation with stakeholders during the 2014 study season. FirstLight should present its findings and any proposed modifications to stakeholders, providing 30-days for stakeholder comment, and consider stakeholder input when determining the need for a modification to study 3.1.2. FirstLight should then present its findings and responses to stakeholder comments in its Initial Study Report (ISR) following the 2014 field season".*

<u>Study No. 3.1.2 Addendum</u>

FirstLight is currently in the process of conducting the field work for Study No. 3.1.2. As noted in Task 3 of this study, FirstLight recognizes ice as a potential cause of erosion. As part of the 2014 study, representative study sites, representing the range of riverbank characteristics and features of the Turners Falls Impoundment, are being selected for detailed study. FirstLight proposes the following additional steps as part of its data gathering and literature review and geomorphic understanding of the Connecticut River:

- FirstLight will review the U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory (CRREL) database to document known ice jams recorded on the Connecticut River in the between Wilder Dam and Turners Falls Dam. CRREL maintains an ice jam database and clearing house. The database will be inventoried to determine historic ice jams along the Connecticut River. Similarly, FirstLight will contact the U.S. Geological Survey (USGS) to identify any recorded ice jams or ice floes on the Connecticut River at their gaging stations. To be completed in early 2015.

- FirstLight will contact TransCanada to determine if it has any historic and current information on the timing, extent and duration of sheet ice development and ice-break up in the Wilder and Bellows Falls Impoundments. In addition, FirstLight will request any information on the thickness of the sheet ice, if available. Also of interest is whether any ice floes have been documented in these impoundments, below the dams, or at the mouths of major tributaries emptying into the impoundments. FirstLight will also research historic daily air temperature data in proximity to the Wilder and Bellows Falls Impoundment to determine any correlation between air temperature and the timing of ice sheet development and break-up for any historic ice formation data collected by TransCanada. Historic air temperature data will also be collected/obtained near the Turners Falls Impoundment. To be completed in early 2015.

- Assuming safety is not compromised, FirstLight proposes to photograph ice conditions in the Turners Falls Impoundment at relatively accessible locations (upstream and downstream) as follows:

    - Vernon Dam,
    - confluence of Ashuelot River,
    - Pauchaug Boat Launch,
    - Route 10 Bridge,
    - Northfield Tailrace,

- French King Bridge,
- confluence of Millers River, and
- Turners Falls Dam.

The photographs would be obtained from when ice sheet develops until after ice break occurs – roughly December 1 through March 31. FirstLight proposes four site visits to photograph the following:

- When sheet ice develops;
- During ice sheet formation;
- During ice break-up;
- After ice break-up occurs.

Relative to the timing of photographic documentation, FirstLight originally considered conducting the field visits from December 1, 2014 to March 31, 2015. However, VY may not shut down until December 29, 2014, thus ice formation and thickness in early 2015 would not be representative of future baseline conditions given that the thermal impacts may continue in December 2014. Given this, FirstLight proposes to conduct the photographic documentation between December 1, 2015 and March 31, 2016 to reflect baseline conditions.

FirstLight proposes to conduct the CRREL database research and TransCanada impoundment research in early 2015. Using the ice and temperature data, correlations between air temperature and ice would be developed following a similar approach to that which had been utilized to evaluate ice formation, breakup and subsequent erosion on the Platte River (*Analysis of Ice Formation on the Platte River* (Simons &Associates, 1990), *Physical Process Computer Model of Channel Width and Woodland Changes on the North Platte, South Platte and Platte Rivers* (Simons & Associates, 1990), *Calibration of SEDVEG Model Based on Specific Events from Demography Data* (Simon & Associates, 2002)].

This previous work included the development of correlations between air temperature data and ice formation as well as ice break-up. These correlations were developed into algorithms in computer models that simulated, among other processes, the effect of ice formation and breakup on riparian vegetation and erosion. The type of analyses (although not in model form since this model focused only on young vegetation, 0-5 years) would be conducted to analyze ice-related erosion processes on the Turners Falls Impoundment. Another component of the analysis is to evaluate forces that ice transmits to riverbanks and riparian vegetation. Concepts utilized in *Analysis of Bank Erosion at the Skitchwaug Site in the Bellows Falls Pool of the Connecticut River* (Simons & Associates, 1992) will also be applied regarding the forces that ice transmits to riverbanks and the type of damages that occur associated with ice. This analysis of forces will be supplemented by concepts of root strength in RIPROOT, a component of BSTEM (while BSTEM is not set up to evaluate ice, some concepts related to vegetation will be incorporated into an independent analysis of the effects of ice on riverbanks and riparian vegetation). The frequency and duration of ice-related events and associated forces will be incorporated into the analysis based on the correlation between air temperature data and ice formation/breakup.

Thus, the analysis of ice as a cause of erosion will be conducted in two main parts with the first being the data gathering and literature review as outlined above, and the second being the actual analysis which will utilize correlations between air temperature and ice formation/breakup and erosion causing forces of ice on riverbanks and riparian vegetation compared against resisting forces of the strength of vegetation and how ice impacts and disrupts riverbank soils. The frequency and duration of ice forces will be developed based on the correlation between air temperature and ice as previously described.

Given the need for additional data collection during the first full winter following the closure of VY, FirstLight anticipates that the analyses set forth in Task 5, as well as the subsequent study tasks, will be conducted after March 31, 2016, at the conclusion of all field activities.

Per FERC's December 13, 2013 letter, FirstLight requests you provide comments on the proposed addendum to Study No. 3.1.2 within 30 days or by September 11, 2014. If no response is provided by September 11h, it is assumed there are no comments.

If you have any questions, please feel free to call me.

Sincerely

John Howard

CONNECTICUT RIVER WATERSHED COUNCIL
The River Connects Us
15 Bank Row, Greenfield, MA 01301 crwc@ctriver.org www.ctriver.org

September 11, 2014

John S. Howard
Director FERC Compliance, Chief Dam Safety Engineer
FirstLight Power Resources/GDF Suez
Northfield Mountain Station
99 Millers Falls Road
Northfield, MA 01360

Re: Study 3.1.2 Addendum: Additional investigations to look at ice as a cause of erosion

Dear John,

I have reviewed the addendum to Relicensing Study 3.1.2 "Northfield Mountain/Turners Falls Operations Impact on Existing Erosion and Potential Bank Instability" dated August 12, 2014. The purpose of the study addendum is to more closely consider ice as a potential cause of erosion, since ice is likely to be more present in the Turners Falls pool during winters after the Vermont Yankee nuclear power plant closes down at the end of 2014. As part of my review of the addendum, I spoke with a scientist at the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL) who is knowledgeable about river ice. I received and reviewed several related publications from her. Below are comments submitted on behalf of the Connecticut River Watershed Council (CRWC).

1. Reviewing the CRREL database on historic ice jams along the Connecticut River, contacting USGS for similar information, and contacting TransCanada to obtain information about ice sheet development and ice break-up at their upstream hydropower facilities makes sense.

2. Based on my conversation with the CRREL staff person, useful field data for modeling the force of ice along a riverbank bank includes ice thickness, stage records, and pre-winter vs. post-winter surveys of bank morphology. CRWC recommends that 1) FirstLight collect field information and historical information on ice thickness, 2) that the study report include stage records or river level recordings for the winter, and 3) that FirstLight conduct pre-winter and post-winter surveys at established representative transects already monitored as part of this study.

3. As for photographs, these would also be helpful. Photos should verify ice thickness. They should be taken at the representative transect locations that are accessible in the winter. The sites listed in the proposal include many locations that are not interesting in terms of erosion (French King bridge, the Turners Falls dam), and in fact have little connection to the rest of the study. The addendum does not explain how FirstLight will know when the right time is for taking ice sheet formation and ice break-up photos. More detail is needed about how FirstLight staff and/or consultants plan to monitor the river and decide on the best day for a photograph. The site list should be modified to include sites that are already part of the study.

4. As for correlating air temperature to ice formation and break-up, we recommend reviewing CRREL research in addition to using the Simons & Associates studies (for example, see http://faculty.babson.edu/goldstein/goldsteingroup/TN04-3.pdf). If local temperature and ice data will be used, please identify the source.

5. Lastly, we recommend the field work for this component of Study 3.1.2 take place both this winter and next. Each winter is very different, and though Vermont Yankee may be operating this December, there may be information the rest of the winter will offer that won't be available the next winter. Moreover, if taking photographs at the right time proves to be difficult, the first winter could help iron out the kinks. Also, if FirstLight's temporary license amendment is approved by FERC, FirstLight will likely be asked to do a pre-winter and post-winter survey of bank transects that could fit nicely into this study as well. One of the papers I obtained also speaks to the longer term effects of icing that would not be observable in a single year:

   > "River-ice influences on channel morphology potentially are multiple and complex, besides the aforementioned influences on local depth and sediment transport. They are describable in terms of impacts on the channel cross section, thalweg sinuosity, anabranching and avulsion, local scour beneath the toe of an ice jam, and local bed aggradation occurring beneath and immediately upstream of an ice cover. Observations of alluvial channels indicate that morphology changes can occur over a wide range of time and length scales. Some morphology changes, such as the local scour described earlier, or a meander loop cutoff, can occur rapidly, within the duration of an ice jam. Other morphology changes, such as thalweg realignment in response to an altered rate of flow energy dissipation, can occur slowly, not being realized during a single winter."
   > "Review of Alluvial-channel Responses to River Ice" by Robert Ettema, M.ASCE1. Journal of Cold Regions Engineering, Vol. 16, No. 4, December 1, 2002

I am happy to forward you or anyone else the research studies I received from CRREL. Thank you for the opportunity to provide input on the addendum to study 3.1.2.

Sincerely,

Andrea F. Donlon
River Steward

Cc: Bob Kubit, MassDEP
David Foulis, MassDEP
Kimberly Noake MacPhee, FRCOG and other Streambank Erosion Committee members
Ken Hogan, FERC