



Photo ID 547 (middle)



Photo ID 548 (middle)



**Photo ID 549** (middle)



**Photo ID 550** (U/S)



**Photo ID 551** (U/S, left of line)

**Segment 420 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Gravel
Lower Riverbank Vegetation	Moderate
Type of Erosion	
Potential Erosion Indicators	Overhanging bank, Exposed roots
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included.



Approximate Photo Location

Segment 430 – Right Bank



Photo ID 966 (mid-segment)



**Photo ID 965** (D/S, right of line)



**Photo ID 967** (middle)



**Photo ID 968** (middle)



**Photo ID 969** (middle)



Photo ID 970 (middle)



Photo ID 971 (U/S, left of line)



**Segment 430 – Right Bank**

<b>Riverbank Features</b>	<b>Characteristics</b>
<b>Upper Riverbank Slope</b>	Moderate
<b>Upper Riverbank Height</b>	High
<b>Upper Riverbank Sediment</b>	Silt/Sand
<b>Upper Riverbank Vegetation</b>	Heavy
<b>Lower Riverbank Slope</b>	Flat/Beach
<b>Lower Riverbank Sediment</b>	Cobbles
<b>Lower Riverbank Vegetation</b>	None to very sparse
<b>Type of Erosion</b>	Undercut
<b>Potential Erosion Indicators</b>	Creep/Leaning trees, Exposed roots
<b>Stage of Erosion</b>	Stable
<b>Extent of Erosion</b>	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included.



Approximate Photo Location

Segment 440 – Right Bank



Photo ID 1004 (middle to U/S)



**Photo ID 1003** (D/S, right of line)

**Segment 440 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Moderate
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Moderate
Lower Riverbank Sediment	Bedrock
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	
Potential Erosion Indicators	None
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed.



Approximate Photo Location

Segment 450 – Right Bank



Photo ID 1036 (U/S)



Photo ID 1034 (D/S, right of line)



Photo ID 1035 (middle)

**Segment 450 – Right Bank**

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 to very sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Creep/Leaning trees, Exposed roots
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included.



Approximate Photo Location

Segment 460 – Right Bank



Photo ID 1066 (mid-segment)





**Photo ID 1064** (D/S, right of line)



**Photo ID 1065** (middle)



**Photo ID 1067** (middle)



**Photo ID 1068** (middle)



**Photo ID 1069** (U/S, left of line)

**Segment 460 – Right Bank**

<b>Riverbank Features</b>	<b>Characteristics</b>
<b>Upper Riverbank Slope</b>	Moderate
<b>Upper Riverbank Height</b>	High
<b>Upper Riverbank Sediment</b>	Silt/Sand
<b>Upper Riverbank Vegetation</b>	Heavy
<b>Lower Riverbank Slope</b>	Flat/Beach
<b>Lower Riverbank Sediment</b>	Silt/Sand
<b>Lower Riverbank Vegetation</b>	None to very sparse
<b>Type of Erosion</b>	Undercut
<b>Potential Erosion Indicators</b>	Creep/Leaning trees, Exposed roots
<b>Stage of Erosion</b>	Stable
<b>Extent of Erosion</b>	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included.



Approximate Photo Location

Segment 470 – Right Bank



Photo ID 1093 (U/S)



Photo ID 1090 (D/S, right of line)



Photo ID 1091 (middle)



**Photo ID 1092** (middle to U/S)

**Segment 470 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	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 to very sparse
Type of Erosion	Slide
Potential Erosion Indicators	Overhanging bank, Exposed roots, Creep/leaning trees
Stage of Erosion	Eroded
Extent of Erosion	Some

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included.



Approximate Photo Location



Segment 480 – Right Bank



Photo ID 1104 (photo covers segment)

**Segment 480 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Moderate
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	Slide
Potential Erosion Indicators	Exposed roots, Overhanging bank, Creep/leaning trees
Stage of Erosion	Eroded
Extent of Erosion	Some

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included.



Approximate Photo Location

Segment 490 – Right Bank



Photo ID 1114 (photo covers segment)

**Segment 490 – Right Bank**

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

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed.



Approximate Photo Location

Segment 500 – Right Bank



Photo ID 1155 (D/S)



**Photo ID 1156** (U/S, left of line)

**Segment 500 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Moderate
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Moderate
Lower Riverbank Sediment	Cobbles
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	
Potential Erosion Indicators	None
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed.



Approximate Photo Location

Segment 510 – Right Bank



Photo ID 1183 (D/S to mid-segment)





**Photo ID 1184** (middle)



**Photo ID 1185** (U/S, left of line)

**Segment 510 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
Upper Riverbank Height	Low
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Creep/leaning trees
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed.



Approximate Photo Location

Segment 520 – Right Bank



Photo ID 1223 (U/S)



**Photo ID 1219** (D/S, right of line)



**Photo ID 1220** (middle)



**Photo ID 1221** (middle)



**Photo ID 1222** (middle to U/S)

**Segment 520 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
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 to very sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Creep/leaning trees, Exposed roots
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included.



Approximate Photo Location

Segment 530 – Right Bank



Photo ID 1241 (U/S)



Photo ID 1239 (D/S, right of line)



Photo ID 1240 (middle)



**Segment 530 – Right Bank**

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	Gravel
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Creep/leaning trees, Exposed roots
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included.



Approximate Photo Location

Segment 540 – Right Bank



Photo ID 1257 (photo covers segment)



**Photo ID 1258** (U/S, left of line)

**Segment 540 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
Upper Riverbank Height	High
Upper Riverbank Sediment	Bedrock
Upper Riverbank Vegetation	Moderate
Lower Riverbank Slope	Steep
Lower Riverbank Sediment	Bedrock
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	
Potential Erosion Indicators	None
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed.



Approximate Photo Location

Segment 550 – Right Bank



Photo ID 1298 (middle to U/S)



**Photo ID 1297 (D/S to middle)**

**Segment 550 – Right Bank**

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 to very sparse
Type of Erosion	
Potential Erosion Indicators	Creep/leaning trees, Notch
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included.



Approximate Photo Location

Segment 560 – Right Bank



Photo ID 1318 (mid-segment)





**Photo ID 1317 (D/S to middle)**



**Photo ID 1319 (U/S, left of line)**

**Segment 560 – Right Bank**

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

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed.



Approximate Photo Location

Segment 570 – Right Bank



Photo ID 1339 (mid-segment to U/S)



**Photo ID 1338 (D/S, right of line)**

**Segment 570 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
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 to very sparse
Type of Erosion	
Potential Erosion Indicators	None
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed.



Approximate Photo Location

Segment 580 – Right Bank



Photo ID 1370 (middle to U/S)



Photo ID 1367 (D/S, right of line)



Photo ID 1368 (middle)



Photo ID 1369 (middle)



Photo ID 1371 (U/S, left of line)



**Segment 580 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Moderate
Upper Riverbank Height	High
Upper Riverbank Sediment	Bedrock
Upper Riverbank Vegetation	Moderate
Lower Riverbank Slope	Moderate
Lower Riverbank Sediment	Bedrock
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	
Potential Erosion Indicators	None
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed.



Approximate Photo Location

**Segment 590 – Right Bank**

No photo available. This segment was conducted by walking along island because water was too shallow to navigate through this channel on the back side of the island.

<b>Riverbank Features</b>	<b>Characteristics</b>
<b>Upper Riverbank Slope</b>	Moderate
<b>Upper Riverbank Height</b>	Medium
<b>Upper Riverbank Sediment</b>	Bedrock
<b>Upper Riverbank Vegetation</b>	Moderate
<b>Lower Riverbank Slope</b>	Moderate
<b>Lower Riverbank Sediment</b>	Bedrock
<b>Lower Riverbank Vegetation</b>	None to very sparse
<b>Type of Erosion</b>	
<b>Potential Erosion Indicators</b>	None
<b>Stage of Erosion</b>	Stable
<b>Extent of Erosion</b>	None/Little

Segment 12 – Left Bank



Photo ID 252 (U/S to middle)

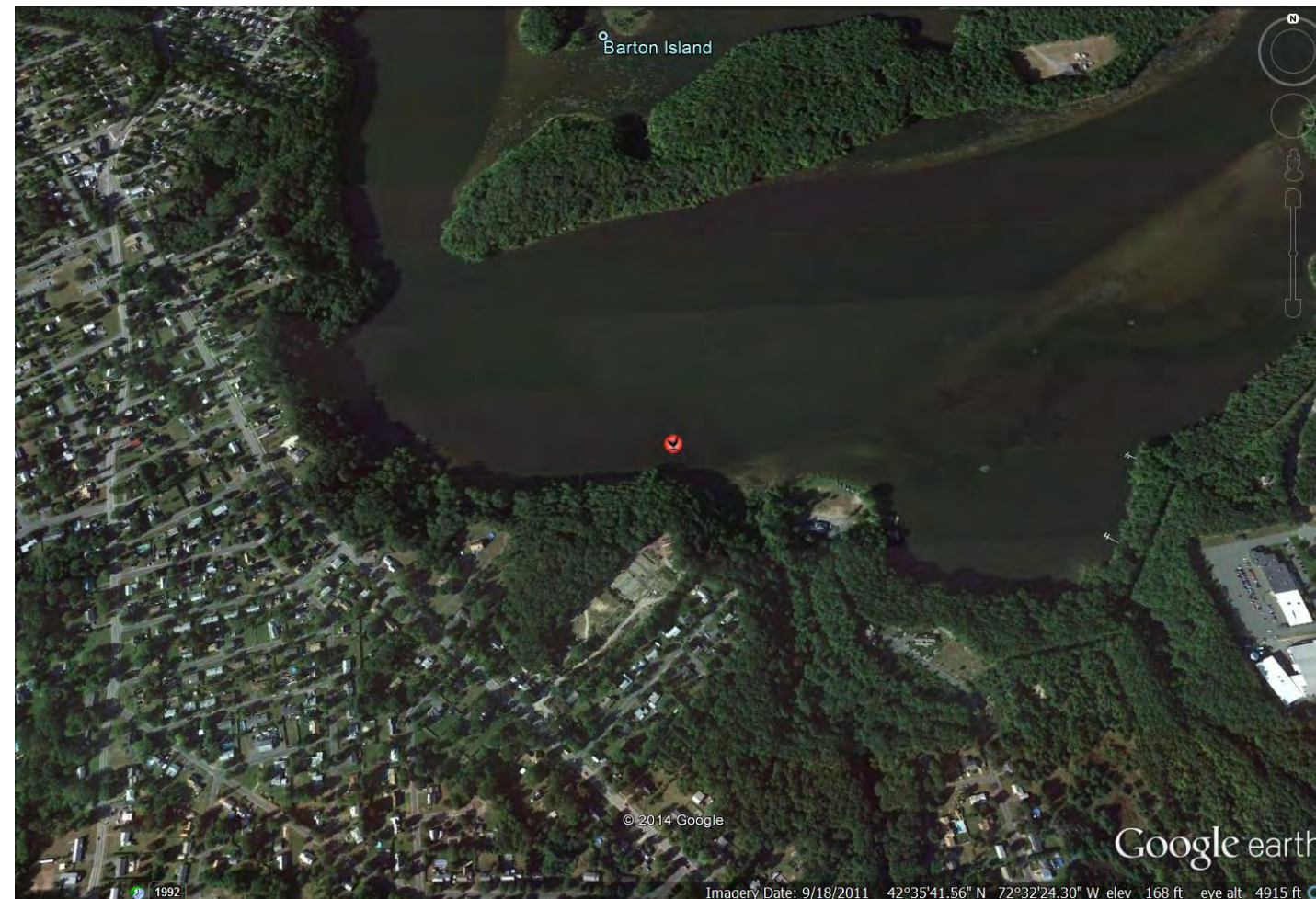


**Photo ID 253** (middle to D/S)

**Segment 12 – Left Bank**

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	Planar Slip, Overhanging Bank
Potential Erosion Indicators	Overhanging Bank, Creep/leaning trees, Exposed roots, Other
Stage of Erosion	Active Erosion
Extent of Erosion	Extensive

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included.



Approximate Photo Location

Segment 89 – Left Bank



Photo ID 609 (D/S to middle)



**Photo ID 607** (D/S, left of line)



**Photo ID 608** (D/S)



**Photo ID 610** (middle)



**Photo ID 611** (middle)





**Photo ID 612** (middle)



**Photo ID 613** (U/S, right of line)

**Segment 89 – Left Bank**

<b>Riverbank Features</b>	<b>Characteristics</b>
<b>Upper Riverbank Slope</b>	Moderate
<b>Upper Riverbank Height</b>	High
<b>Upper Riverbank Sediment</b>	Silt/Sand
<b>Upper Riverbank Vegetation</b>	Heavy
<b>Lower Riverbank Slope</b>	Moderate
<b>Lower Riverbank Sediment</b>	Cobbles
<b>Lower Riverbank Vegetation</b>	None to very sparse
<b>Type of Erosion</b>	Undercut
<b>Potential Erosion Indicators</b>	Exposed roots
<b>Stage of Erosion</b>	Stable
<b>Extent of Erosion</b>	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed. Segment added as a site of interest due to planned repair to existing restoration to deal with undercut and exposed roots.



Approximate Photo Location

Segment 182 – Left Bank

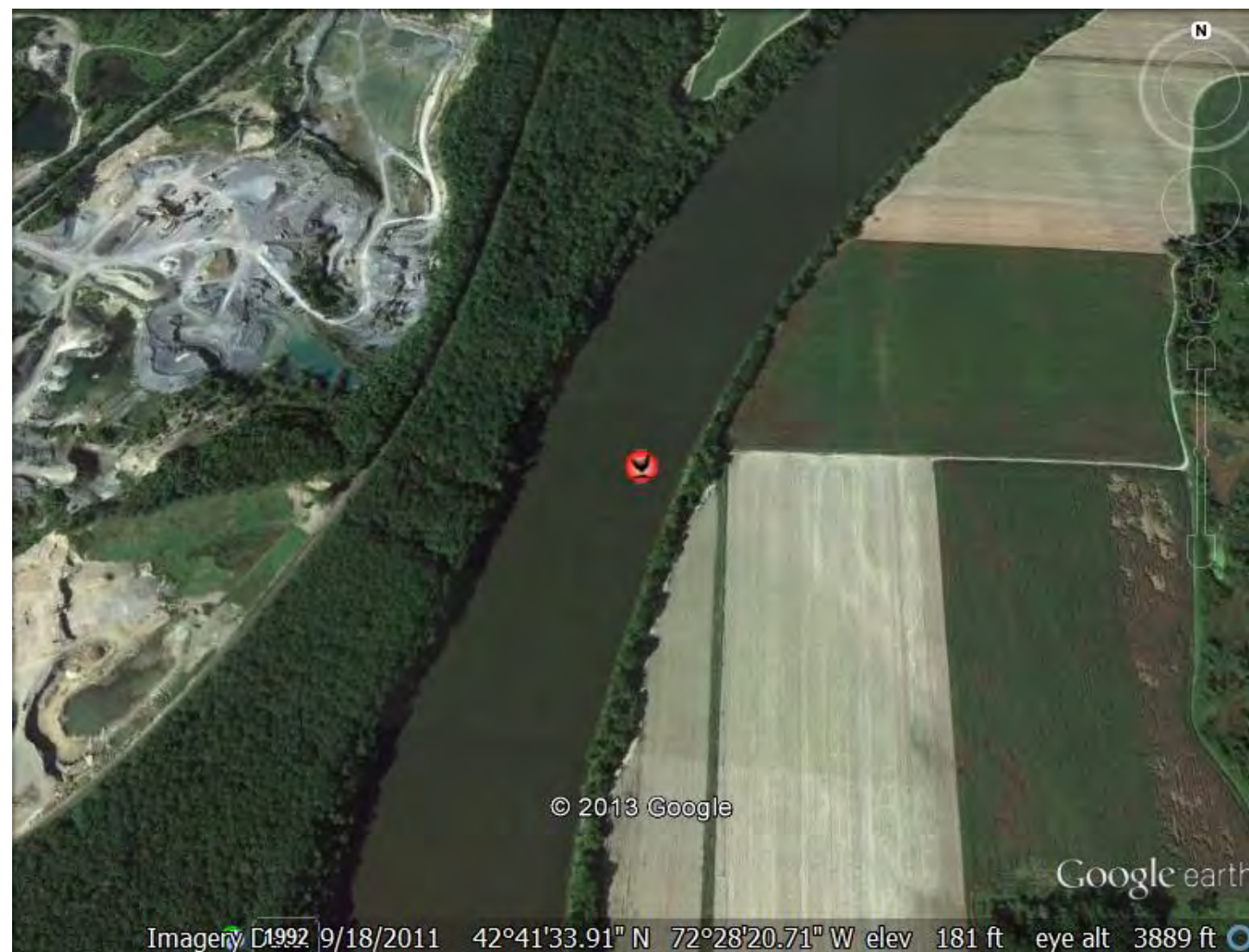


Photo ID 845 (photo covers segment)

**Segment 182 – Left Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
Upper Riverbank Height	Low
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	Gully
Potential Erosion Indicators	Exposed roots
Stage of Erosion	Eroded
Extent of Erosion	Some

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed. Segment added to include gully.



Approximate Photo Location

Segment 279 – Left Bank



Photo ID 1631 (photo covers segment)

**Segment 279 – Left Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Gravel
Lower Riverbank Vegetation	Sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Creep/Leaning Trees, Exposed roots
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included. Segment added to include sparse lower riverbank vegetation.



Approximate Photo Location

Segment 332 – Left Bank



Photo ID 1425 (photo covers segment)

**Segment 332 – Left Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Moderate
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Moderate
Lower Riverbank Slope	Moderate
Lower Riverbank Sediment	Clay
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	Slide
Potential Erosion Indicators	Overhanging, Exposed roots
Stage of Erosion	Potential Future Erosion
Extent of Erosion	Some

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed and additional indicators of potential future erosion were included. Segment added to include clay.



Approximate Photo Location



Segment 403 – Right Bank



Photo ID 480 (mid-segment)



**Photo ID 479** (D/S, right of line)



**Photo ID 481** (middle)



**Photo ID 482** (U/S, left of line)

**Segment 403 – Right Bank**

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
Upper Riverbank Height	High
Upper Riverbank Sediment	Bedrock
Upper Riverbank Vegetation	Moderate
Lower Riverbank Slope	Vertical
Lower Riverbank Sediment	Bedrock
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	
Potential Erosion Indicators	None
Stage of Erosion	Stable
Extent of Erosion	None/Little

**QA Observations:** Upon review of the photos for this segment, classification made in the field was confirmed. Segment added to include vertical lower riverbank.



Approximate Photo Location

**ATTACHMENT B: 2007-2014 Photo Log Comparison**

In the summer of 2007, photographs of the Turners Falls Impoundment (Impoundment) riverbanks were captured by Field Geology Services as part of the report titled "*Fluvial Geomorphology Study of the Turners Falls Pool on the Connecticut River between Turners Falls, MA and Vernon, VT.*" In 2013, FirstLight conducted the most recent Impoundment Full River Reconnaissance Survey (FRR) in accordance with the methodology detailed in the Revised Study Plan (RSP, Study No. 3.1.1). As part of the 2013 FRR, FirstLight replicated, as closely as possible, the 2007 photo log during the summer of 2014. This attachment presents the findings of the comparisons made between the 2007 and 2014 photos in accordance with the RSP.

Task 4 of the RSP calls for a comparison of the 2007 and 2014 photo logs, where applicable. Upon review of the photo logs, it became very clear that the presence of summer foliage along the riverbanks greatly limits the usability of the photos to draw definitive conclusions of changes in riverbank conditions from 2007 to 2014. The ability to see subtle changes in the riverbank or to detect specific features or characteristics is greatly reduced due to the leaf-on conditions. The 2013 FRR survey was specifically conducted during leaf-off conditions (November and December) to better observe riverbank features and characteristics.

A comparison of photographs captured in 2007 and 2014 at 22 sites throughout the longitudinal extent of the Impoundment are presented in this addendum. These sites were chosen for comparison due to the fact that they 1) spanned the longitudinal extent of the Impoundment; and 2) included sites of noted interest. Observable changes in the bank structure, vegetation, or sensitive receptor sites are described within the photo pages enclosed. Included in these comparisons are sites which were noted as containing specific bank or erosional features on farms or known areas of interest (photo sets 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 19); past bank restoration sites (photo sets 2, 13, 14, 15, 18, and 22); and potential future restoration sites which were identified in the 2013 FRR report (photo sets 2, 16, 17, 20, 21, and 22).

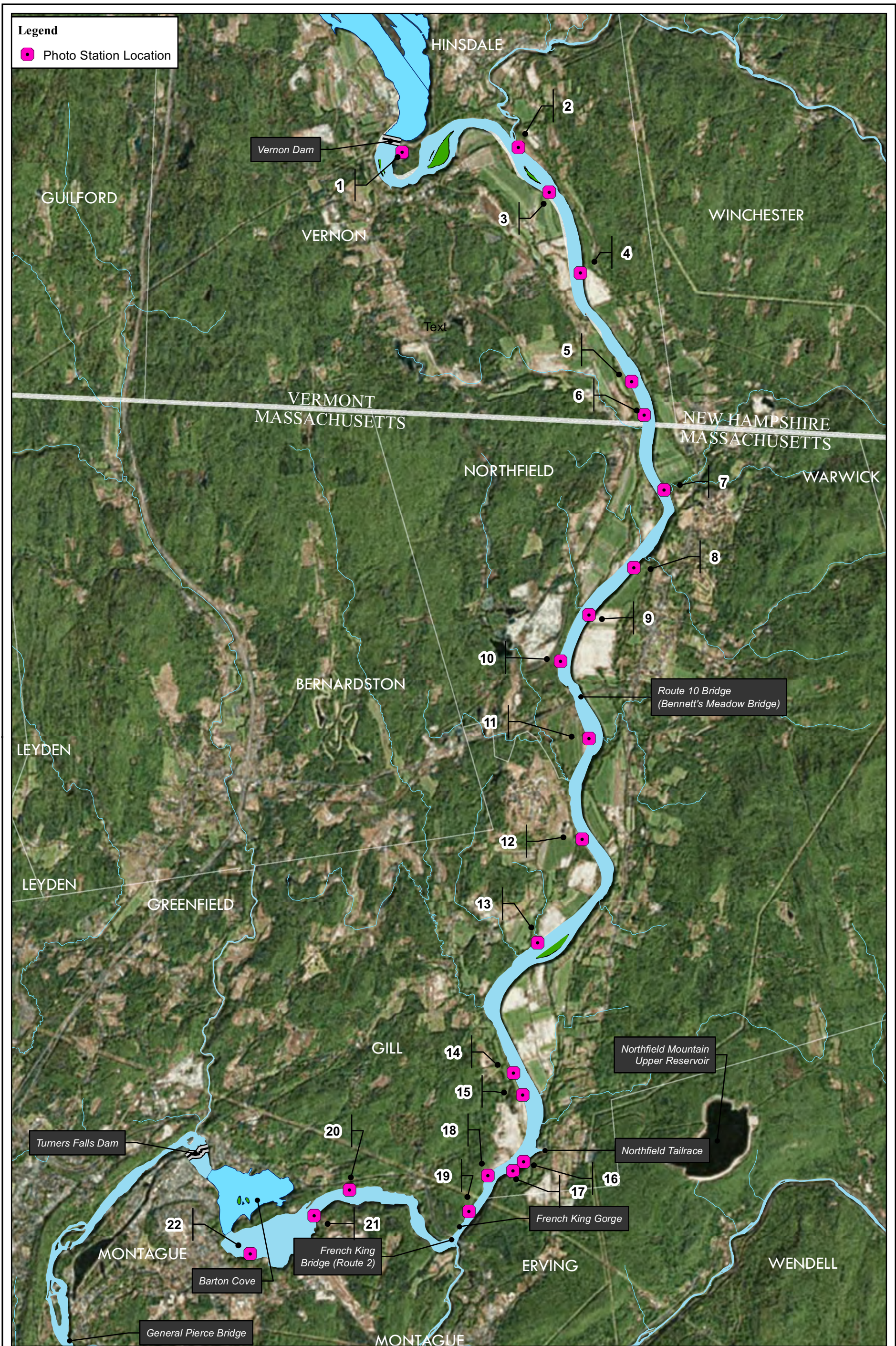
FirstLight attempted to recreate the 2007 photo log as closely as possible, however, due to a variety of factors, exact replication proved to be difficult. The 2007 photo set lacked embedded GPS coordinates and aspect (direction) which did not permit an exact photo station comparison. The 2014 photographs had both the GPS coordinates and the aspect embedded into each photograph. Furthermore, due to the distance from the bank, the 2007 photos lacked detail of important bank areas. As observed in the enclosed comparisons, water levels during 2007 and 2014 were similar and typical of summer conditions. Water levels often changed during the course of a given day, but in general, both photo sets were taken during periods of similar summertime low water flows. Additional replication or comparison challenges included:

- Some photographs are zoomed in, while the comparison photograph may be zoomed out. Additionally, the distance from shore may be different between the two years.
- The angle and direction of the two comparison photographs may be different.
- It is very difficult to compare riverbank features and characteristics due to the presence of heavy vegetation/leaf cover.

The 2007 Field Geology Services photographs were collected over a period of four days (June 15, 19, 20, and 21, 2007) by boat. The 2007 photo set included several thousand photographs. The spatial datum for these photos is WGS 84; the camera used was a Canon EOS digital Rebel XT. The GPS coordinates and azimuth are not embedded into the photographs, but were provided in an excel worksheet.

On the days when photographs were taken in 2007, the flows released from Vernon ranged from approximately 2,000 to 7,600 cfs. Water levels at the Northfield tailrace ranged from approximately 181 to 184 ft. On the days when photographs were taken in 2014, the releases from Vernon ranged from approximately 4,000 to 13,000 cfs while the water levels at the Northfield tailrace ranged from approximately 181 to 184 (data was only available for July 28<sup>th</sup>). Flows through the Impoundment were relatively low for both time periods; however, 2014 flows were a few thousand cfs higher.

The 2014 photographs were collected over three days (July 27, 28, and August 3, 2014) also by boat. The spatial datum for the 2014 photos is WGS 84; the camera used was a Canon EOS-1DX. The GPS coordinates and the photo aspect data were embedded into each photograph. Over four thousand photographs were collected to document the riverbank conditions in 2014.



**FIRSTLIGHT POWER RESOURCES**  
 RELICENSING STUDY 3.1.1  
 2013 FULL RIVER RECONNAISSANCE  
 TURNERS FALLS IMPOUNDMENT



Addendum Figure 1:  
 Photo Station Locations for Comparison of  
 2007 Photographs (Field) and  
 2014 Photographs (NEE)

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

**PHOTO SET #1****2007 Photo:** Vernon Dam: Located immediately downstream of the Vernon Dam on the left bank.**2014 Photo:** Vernon Dam

**Observations:** The young trees present in the photo from 2007 have grown, additional coarse woody debris has accumulated on the bench since the 2007 photo, and some of the trees fell since the 2007 photograph. The overhang at the top of the bank appears to have receded back indicated by the toppled trees at the top of bank but the lower bank appears to have remained in place allowing increased growth of vegetation.



**PHOTO SET #2**

**2007 Photo:** Bonnette Farm: Located in New Hampshire on the left bank.



**2014 Photo:** Bonnette Farm



**Observations:** Dense and well established vegetation are observed in both photographs, indicative of relative stability. Since the 2007 photograph, the bank has become more vegetated due to the planting of hundreds of shrubs on the bank. Oriental bittersweet vines are common. There were sensitive receptor sites (kingfisher next cavity) present in 2007 and in 2014.

**PHOTO SET #3**

**2007 Photo:** Vermont Farm: Located in Vermont on the right bank. Note the bank is steep, and there are exposed roots at the toe.



**2014 Photo:** Vermont Farm



**Observations:** Banks in both photos support a significant density of trees. An increase in lower level vegetative growth, including a patch of emergent vegetation on the bench which was not observed in the 2007 photo, can be observed in the 2014 photo.

**PHOTO SET #4**

**2007 Photo:** New Hampshire Site: Located in New Hampshire on the left bank. The bench is gravelly at this site, with some areas of exposed bedrock, and some patches of emergent vegetation.



**2014 Photo:** New Hampshire Site



**Observations:** No significant changes in the bank at this location are observed.

**PHOTO SET #5**

**2007 Photo:** Downstream from Kendall, Site 1: Located in Vermont on the right bank, and immediately downstream from the Kendall restoration site.



**2014 Photo:** Downstream from Kendall, Site 1



**Observations:** Banks in both photos are well-vegetated, however, since the 2007 photograph oriental bittersweet has overgrown many of the trees.

**PHOTO SET #6**

**2007 Photo:** Downstream from Kendall, Site 2: Located further downstream from the Kendall restoration site than Photo set 5, this site is located in Vermont on the right bank.



**2014 Photo:** Downstream from Kendall, Site 2



**Observations:** The banks appear to be similar in both time periods with heavy vegetation. The oriental bittersweet has become denser.

**PHOTO SET #7**

**2007 Photo:** Pauchaug: Located upstream of the Pauchaug boat launch site on the left bank of the River, in Northfield, Massachusetts.



**2014 Photo:** Pauchaug



**Observations:** Both photographs indicate dense vegetation on the upper bank as well as dense vegetation on the lower bank/beach area. Since the 2007 photograph, the bench has accumulated sediment and the emergent vegetation has become very well established. The extent of the *Phragmites* colonization has grown since 2007.

**PHOTO SET #8**

**2007 Photo:** Downstream from the old Railroad Bridge: Located on the left bank of the River.



**2014 Photo:** Downstream from the old Railroad Bridge



**Observations:** Bank conditions appear similar in both sets of photographs but oriental bittersweet has become more established since 2007 at this location. There is a kingfisher nest cavity in the 2014 photograph (white arrow).

**PHOTO SET #9**

**2007 Photo:** Northfield Farm: Located in Northfield, Massachusetts, on the left bank



**2014 Photo:** Northfield Farm



**Observations:** Bank conditions do not appear to have changed significantly from 2007 to 2014. The vegetated riparian buffer along this farm field is narrow, and has not changed since 2007.



**PHOTO SET #10**

**2007 Photo:** Upstream from the Rt. 10 Bridge: Located upstream of the Route 10 Bridge on the right bank in Northfield, this section of Riverbank is very steep, and is heavily forested.



**2014 Photo:** Upstream from the Rt. 10 Bridge



**Observations:** No significant changes can be seen at this site since 2007.

**PHOTO SET #11**

**2007 Photo:** Downstream from the Rt. 10 Bridge: Located in Northfield, Massachusetts, on the right bank.



**2014 Photo:** Downstream from the Rt. 10 Bridge



**Observations:** There are no significant changes at this photo station since 2007.

**PHOTO SET #12**

**2007 Photo:** Upstream from Urgiel (upstream) restoration site: Located in Gill, Massachusetts, on the right bank.



**2014 Photo:** Upstream from Urgiel Upstream restoration site



**Observations:** Bank conditions appear to be similar in both photographs. This photograph shows the location of a linear erosion feature with a vertical exposed face ranging from 1 to 2 feet high that extends longitudinally through part of the repaired segment (Urgiel) as well as farther upstream even crossing through a small drainage feature.

**PHOTO SET #13**

**2007 Photo:** Flagg Farm: This site is located at the downstream end of the Flagg restoration site, on the right bank, in Gill, Massachusetts.



**2014 Photo:** Flagg Farm



**Observations:** Since the 2007 photograph the bank face has become more vegetated and recovering from past grazing activity by cattle since this site was restored in 1999. Sediment has deposited on the lower bank and emergent vegetation is becoming established and growing. Close observation of this site during field data collection for the erosion causation study showed that a number of cottonwood seedlings have become established on this lower bank. There were several bank swallow nest cavities observed at this site in 2007, but there were none observed in 2014.

**PHOTO SET #14**

**2007 Photo:** Wallace Watson: This photo shows a portion of the Wallace/Watson restoration site prior to restoration efforts. It is located in Gill, Massachusetts, on the right bank.



**2014 Photo:** Wallace Watson



**Observations:** This site was restored using bioengineering techniques in 2013. Techniques utilized included, building up the lower bank/beach with gravel, imbedding large woody debris, and planting vegetation. Since the 2007 photo was taken, new vegetation has become established on the bench. There are bank swallow and kingfisher cavities along this section of the riverbank.

**PHOTO SET #15**

**2007 Photo:** Bathory-Gallagher Oak Tree: This photo station is at the downstream end of the Bathory/Gallagher restoration site, prior to restoration efforts, in Gill, Massachusetts, on the right bank.



**2014 Photo:** Bathory Gallagher Oak Tree



**Observations:** This site was restored using bioengineering techniques in 2013. Techniques utilized included, building up the lower bank/beach with gravel, imbedding large woody debris, and planting vegetation. Since the 2007 photo was taken, new vegetation has become established on the bench. There are bank swallow and kingfisher cavities along this section of the riverbank.

**PHOTO SET #16**

**2007 Photo:** Located downstream from the tailrace in Northfield, Massachusetts, on the left bank.



**2014 Photo:** Downstream from the tailrace



**Observations:** Erosion is occurring at this site and has been recommended for preventative maintenance and/or bank stabilization work in the 2013 FRR report.

**PHOTO SET #17**

**2007 Photo:** Downstream from Tailrace at Unnamed Brook Inlet: This site is located at the mouth of an unnamed brook (USGS topographic map) near Pine Meadow Road in Northfield, MA, on the left bank.



**2014 Photo:** Downstream from Tailrace at Unnamed Brook Inlet - This photo is a close-up of the area shown in photo 17a (white arrow), which is at the mouth of an unnamed brook inlet.



**Observations:** This site has been eroded for some time and was recommended for preventative maintenance and/or bank stabilization work in the 2013 FRR report.



**PHOTO SET #18**

**2007 Photo:** Lower Split River Farm: Located at Lower Split River Farm restoration site prior to restoration efforts, in Gill, MA, on the right bank.



**2014 Photo:** Lower Split River Farm



**Observations:** This site was restored using bioengineering techniques in 2009. Techniques utilized included, placement of gravel on the lower bank/beach, adding large woody debris, and planting vegetation. Since the 2007 photo was taken, new emergent vegetation has become established on the bench.

**PHOTO SET #19**

**2007 Photo:** Upstream from French King Bridge: This photo station is located upstream from the French King Bridge in Gill, MA, on the right bank.



**2014 Photo:** Upstream from French King Bridge



**Observations:** This is a stable section of riverbank; no observable changes are noted between these photos.

**PHOTO SET #20**

**2007 Photo:** Camp 2W: This station is located at Camp Site 2W, on the right bank, in Gill, MA.



**2014 Photo:** Camp 2W



**Observations:** This site (see white arrow location in the 2007 photo) has been recommended for preventative maintenance and/or bank stabilization work in the 2013 FRR report.

**PHOTO SET #21**

**2007 Photo:** Camp 4E: This camp is located in Montague, MA, on the left bank.



**2014 Photo:** Camp 4W



**Observations:** This camp site has been recommended for preventative maintenance and/or bank stabilization work in the 2013 FRR report.

**PHOTO SET #22**

**2007 Photo:** Montague: Located downstream from the Montague Rod & Gun Club, in Montague, MA, on the left bank.



**2014 Photo:** Montague



**Observations:** Erosion has been ongoing at this site for quite some time and has been recommended for preventative maintenance and/or bank stabilization work in the 2013 FRR report.

## **ATTACHMENT C – STAKEHOLDER CONSULTATION**



February 24, 2015

**VIA EMAIL**

Brandon Cherry, FERC  
Patrick Crile, FERC  
Chris Chaney, FERC  
Brian Harrington, MADEP  
David Cameron, MADEP  
David Foulis, MADEP  
Mike Bathory, LCCLC

Russ Cohen, MA Riverways  
Bill McDavitt, NMFS  
Kimberly Noake MacPhee, FRCOG  
Andrea Donlon, CRWC  
Tom Miner, CRSEC  
John Bennett, FCD

Re: 2013 Full River Reconnaissance – 2015 Addendum

Dear All,

On January 22, 2015, the Federal Energy Regulatory Commission (FERC) issued their Determination on Requests for Study Modifications and New Studies for the Turners Falls Hydroelectric Project (P-1889) and the Northfield Mountain Pumped Storage Project (P-2485). Included in the FERC determination letter was the recommendation for FirstLight Hydro Generating Company (FirstLight) to file an addendum to the 2013 Full River Reconnaissance (FRR, Study No. 3.1.1) final report. Specifically, FERC recommended that the addendum include: (1) a comparison of the specific riverbank features and characteristics from data logging files, or field data sheets, collected during the field surveys to a photograph of that segment of riverbank captured from the digital geo-referenced video; and (2) a comparison of 2007 and 2014 photo logs. The addendum is to be filed with FERC within 90 days of the issuance of the determination letter (April 22, 2015).

Furthermore, FERC requested that FirstLight consult with the Connecticut River Streambank Erosion Committee (CRSEC) and the Connecticut River Watershed Council (CRWC) prior to filing the final addendum. In accordance with this request, enclosed please find the following DRAFT documents for your review and comment:

- Attachment A – Riverbank Segment QA Comparison; and
- Attachment B – 2007 to 2014 Photo Comparison

FirstLight will be hosting a meeting for interested Stakeholders on Wednesday March 4<sup>th</sup> from 9:00-11:00 at the Hampton Inn in Greenfield, MA to discuss the draft addendum. Following the meeting, Stakeholders will have the opportunity to file comments with FirstLight until Friday April 3<sup>rd</sup>. Upon receipt of all comments, FirstLight will review the submittals, update the addendum (as appropriate) or provide responses to comments, and file with FERC by Wednesday April 22<sup>nd</sup>.

**John S. Howard**

Director FERC Compliance, Hydro

FirstLight Power Resources, Inc.  
99 Millers Falls Road  
Northfield, MA 01360  
Tel. (413) 659-4489/ Fax (413) 422-5900/  
E-mail: john.howard@gdfsuezna.com

If you have any questions in advance of the March 4<sup>th</sup> meeting, please feel free to contact me at (413) 659-4489 or via email at [john.howard@gdfsuezna.com](mailto:john.howard@gdfsuezna.com).

Sincerely,

A handwritten signature in black ink, appearing to read "John Howard". The signature is fluid and cursive, with the first name "John" being more prominent than the last name "Howard".

John Howard





## Meeting Minutes

March 4, 2015

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### Attendees:

David Foulis	MA Department of Environmental Protection (MADEP), <i>via phone</i>
Brian Harrington	MADEP, <i>via phone</i>
Bob Kubit	MADEP, <i>via phone</i>
Bill McDavitt	National Marine Fisheries Service (NMFS), <i>via phone</i>
Patrick Crile	Federal Energy Regulatory Commission (FERC), <i>via phone</i>
Chris Chaney	FERC, <i>via phone</i>
Mike Bathory	Landowners and Concerned Citizens for License Compliance (LCCLC)*
Andrea Donlon	Connecticut River Watershed Council (CRWC)*
Anne Wibiralske	Connecticut River Streambank Erosion Committee*, <i>via phone</i>
John Howard	FirstLight
Mark Wamser	Gomez and Sullivan Engineers, DPC (Gomez and Sullivan)^
Tom Sullivan	Gomez and Sullivan^
Tim Sullivan	Gomez and Sullivan^
Bob Simons	Simons & Associates (S&A)^
Mickey Marcus	New England Environmental (NEE)^
Christin McDonough	NEE^
Adam Kahn	Foley Hoag (FH)^

\*Member of CRSEC

^Consultant to FirstLight

### Meeting Location:

Hampton Inn, Greenfield, MA

### Re:

Relicensing of the Turners Falls Hydroelectric Project (FERC No. 1889) and Northfield Mountain Pumped Storage Project (FERC No. 2485): 2013 Full River Reconnaissance Consultation Meeting (Relicensing Study No. 3.1.1)

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### Background

On January 22, 2015, FERC issued their *Determination on Requests for Study Modifications and New Studies*. As part of this issuance, FirstLight is required to file an addendum to Study No. 3.1.1 – Full River Reconnaissance (FRR) with FERC no later than April 22, 2015. Prior to that filing, FirstLight was required to meet with Stakeholders to discuss the addendum. The Stakeholder consultation meeting was held on March 4, 2015 at the Hampton Inn in Greenfield, MA. A draft of the addendum and PowerPoint presentation were circulated to the attendees in advance of the meeting. The PowerPoint presented at the meeting is included as an attachment to these minutes.

### Introduction

FirstLight opened the meeting and had all parties introduce themselves. FirstLight reviewed the agenda and explained that the purpose of the meeting was to discuss the FRR addendum.

FirstLight explained that in FERC's Determination on Requests for Study Modifications and New Studies, issued on January 22, 2015, it recommended that FirstLight file an addendum to the 2013 FRR final report. FERC recommended that the FRR addendum include:

- A comparison of specific riverbank features and characteristics from data logging files, or field data sheets, collected during the field surveys to a photograph of that segment of riverbank captured from the digital geo-referenced video, and
- A comparison of 2007 and 2014 photo logs

FERC recommended that FirstLight consult with the Stakeholders, specifically the Connecticut River Streambank Erosion Committee (CRSEC) and Connecticut River Watershed Association (CRWC) and provide a minimum of 30 days for Stakeholders to comment and provide recommendations. If FirstLight does not adopt a recommendation, the addendum should include FirstLight's reasons. The addendum is due at FERC no later than April 22, 2015. FirstLight explained that two documents were developed to address the addendum—Attachment A and B.

### **Attachment A- Riverbank Segment Quality Assurance (QA) Comparison**

FirstLight explained that there were approximately 600 riverbank segments that were delineated and classified as part of the field survey. At each segment geo-tagged photos and videotape were taken at the time of classification.

FirstLight went through the site selection process, specifically discussing the methodology used to determine which sites would be used for quality assurance (QA) comparisons. The process included:

- Every 10th riverbank segment was selected for QA comparison to ensure an unbiased approach that covered the longitudinal extent of the Turners Falls Impoundment (the Impoundment)
- The riverbank features and characteristics at the 59 segments were reviewed to identify data gaps
- 6 additional riverbank segments were then added to the list to fill an existing data gap or because they were located at an area of interest.
- The final set of QA sites included 65 riverbank segments which covered almost all riverbank features and characteristics discussed in the Revised Study Plan (RSP).

CRWC asked what the data gaps were from the original 59 segments and how the six (6) additional riverbank segments were selected. FirstLight explained that in the original 59 segments, certain features which are typically present in the Impoundment were not represented, including planar slips, clay (lower riverbank), and sparse lower riverbank vegetation. Supplemental sites which exhibited these features were then selected to fill these gaps. This left 4 features from the original RSP table uncovered. FirstLight explained that the 4 features not represented in the QA process were left out due to the fact that they generally do not exist in the Impoundment. FirstLight explained that in Table 1 of the PowerPoint (slide 6) the red boxes represent features/characteristics not dominantly observed during the field survey.

CRWC asked if FirstLight considered a random sampling method. FirstLight noted that it decided on a systematic approach and filled in segments (the additional 6 noted above) to cover the full range of features and characteristics. FirstLight stated that with the systematic approach it covered the entire length of the TF impoundment, whereas a random sampling method may not have.

CRWC asked if any segments were thrown out for any reason. FirstLight noted they were not.

FirstLight explained that slides 7-11 show the Impoundment and the location of the 65 segments.

### *Slide 12- Methodology and Results*

Once the final set of QA sites were determined, FirstLight cross-checked the observations made during the 2013 FRR field survey with the geo-tagged photograph(s) of the associated riverbank. During this process, the field observations were either confirmed or updated as appropriate. FirstLight then explained that at the conclusion of the QA process the following deliverables were created for each site:

- (1) All photographs for each selected segment;
- (2) One photograph per segment labeled to demonstrate the identification of various riverbank features and characteristics;
- (3) A table of riverbank features and characteristics of that segment;
- (4) A Google Earth screenshot depicting the approximate location of the photograph; and
- (5) A brief sentence detailing any QA observations

CRWC asked if the videotape was used during the QA process. FirstLight indicated that they relied primarily on the photographs because they were of better quality and lent themselves better to this application.

### *Attachment A Examples*

FirstLight reviewed numerous photographs of the riverbank and the notations shown on the photographs. This was done for the following segments:

- Segment 500- Stable Example #1
- Segment 280- Stable Example #2 (3 photographs along segment) - some indicators of erosion but they are relatively minor. Example of a site where you see some of the typical types of characteristics you might see in a riverbank. See flat beach, dense vegetation, but it does have some indicators of potential erosion. Bank somewhat undercut, though minor, some trees that are leaning, and some exposed roots, and typically where you have those, there is some overhanging banks. Classified as Stable even though there are some indicators; the indicators are relatively minor.
- Segment 70- Active Erosion Example: overhanging bank, a slide, a pretty significant area of active erosion where soil is exposed. This area was characterized as actively eroding, and although it was fairly small in length, it is one that is recommended for consideration for preventative maintenance and restoration. National Marine Fisheries Services (NMFS) asked if Segment 70 is just downstream of the Northfield Mountain Tailrace and near the mouth of a tributary. FirstLight indicated yes, Turners Falls Impoundment will fluctuate on the order of 3-4 feet here. NMFS noted that they believed FirstLight was proposing a project boundary change at this location. FirstLight stated they were not aware of any proposed project boundary change at this location. NMFS asked if the photograph was taken during a high or low water level. FirstLight did not immediately know the answer noting if you look in Appendix B you can see some other photos and we do have flow rates.

CRWC asked if the tributary shown in the photograph (Segment 70) is part of the next segment. FirstLight noted yes – it's a very small tributary and is included in the next segment. CRWC asked how tributaries were handled. FirstLight noted the mouth of the tributary was included with the segment at minor tributaries.

- Segment 170- Eroded Example (upstream of the Route 10 Bridge) - FirstLight explained that there are hydraulic factors at this location contributing to the erosion. Also an area that has been eroding for some time but because it's adjacent to Route 10 Bridge, there are factors other than the normal hydraulics. Mix of stable and erosion. An example of an eroded site, which appears to be getting more vegetated over time but it's still an area of erosion.
- Segment 230- Potential Future Erosion Example: CRWC asked why Segment 230 was classified as "future erosion". FirstLight stated that in the previous photograph (Segment 170 - Eroded) there was raw/exposed bank; whereas in this photograph (Segment 230) there is considerably more vegetation present.

#### *Q&A on Attachment A*

CRWC noted the attachment is set up where it shows several photographs. CRWC requested a summary of the segments where field observations were updated or changed based on the QA review. Did it occur more than once? What kinds of things were observed differently? CRWC would like an index of the segments and include a table of contents so it's apparent what file each segment is in.

FirstLight noted that in regard to the summary of changes that there were a handful—perhaps 5 or so. One, for example, where there was lower riverbank vegetation. CRWC asked if it is worth re-doing the analysis. FirstLight noted most of the changes were minor; it did not change the study findings. FirstLight then clarified that the QA process was conducted immediately after the field work, prior to publishing the FRR report. Therefore, changes made during the QA process would not affect the published results. The addendum was done to summarize that QA process which had previously been completed. CRWC acknowledged understanding.

CRWC noted that in their comments to FERC they requested all of the data for the segments. CRWC noted that in the current data it is unclear to them who conducted the classification/observation at each segment and when it was conducted. CRWC cited the site sketches done by Kit Choi as making it clear who did them and what day they were done. CRWC noted that in the FRR tables and the electronic files there was no information clearly identifying this. CRWC can't tell if the approved personnel were conducting the work—there was no documentation. CRWC requested documentation. FirstLight noted that the report clearly states the dates the survey was conducted and the personnel that were present.

#### **Attachment B- 2007 to 2014 Photo Comparison**

FirstLight provided the following background on the 2007 and 2014 photo comparison:

- In June 2007, Field Geology Services collected photographs of the Impoundment riverbanks. Summer foliage along the riverbank limited the usability of the photos and did not allow for FirstLight to draw definitive conclusions of changes in riverbank conditions from 2007 to 2014. As such, 22 sites (as opposed to the 65 sites in Attachment A) were selected for comparison. FirstLight noted that the 22 sites were selected since they spanned the longitudinal extent of the Impoundment and/or included noted sites of interest.

- FirstLight explained that generally comparison observations were limited to changes in vegetation, sensitive receptors, or other non-erosion related riverbank characteristics.
- FirstLight showed the spatial distribution of the sites which span from Vernon to Barton Cove.

CRWC asked for clarification on the selection of 22 sites and if there was any other selection criteria other than what was listed on slide 25. FirstLight noted that the criteria listed on slide 25 were the main criteria used. FirstLight further explained that it was pretty clear looking at the vegetation present on the photos that it would be difficult to compare sites. Given this, FirstLight felt it was appropriate to limit the comparison sites to those 22 sites of interest included in the addendum.

#### *Q&A on Attachment B*

NMFS asked if FirstLight has any sense of the amount of invasive species that have spread in the past seven years. FirstLight noted that in examining the photos that Bittersweet has been the most noticeable invasive species. FirstLight indicated that the presence of Bittersweet has increased considerably and noted that it is likely to see more dead trees along the riverbank due to its spread. NMFS noted that this may increase the complexity of the Rip Root model analysis associated with Study No. 3.1.2. NMFS further noted that factors such as Bittersweet taking over a tree and toppling it increase the complexity of the bank erosion study, making it a daunting task.

CRWC noted that the comparison of the site just downstream of the Vernon Dam was interesting. CRWC also agreed that comparisons between the two years were difficult due to the presence of the vegetation on the photos.

CRSEC asked if there is a citation for the FRR methodology that was used for this study. FirstLight explained that the RSP was the guiding methodology source. Bob Simons further noted that a paper written in 2000 by Simons and Associates may be an appropriate example of another instance a similar methodology was used. CRSEC requested the citation or a copy of the paper. FirstLight agreed to provide the 2000 Simons & Associates paper.

#### *Schedule*

Stakeholders can file comments with FirstLight until April 3, 2015. Comments should be sent via email to John Howard, Bob Simons, and Tim Sullivan. FirstLight will review the comments, update the addendum as appropriate, and file with FERC no later than April 22, 2015.

NMFS asked for an update on Study No. 3.1.2. FirstLight noted that the data collected during the 2014 field season is in the process of being reviewed and finalized, the BSTEM model is currently being setup, and model calibration should begin in the near future. FirstLight also noted that several raw datasets would be distributed to the Stakeholders by the end of March as promised in the response to Initial Study Report Comments.

**FirstLight**<sup>TM</sup>  
Power Resources

**GDF SUEZ**

# **RSP Study No. 3.1.1 *2013 Full River Reconnaissance* 2015 Report Addendum**

March 4, 2015



# Agenda

- Addendum Background and Overview
- Attachment A – Riverbank Segment QA Comparison
  - *Background, Methodology, and Results*
  - *Discussion and Questions*
- Attachment B – 2007 to 2014 Photo Comparison
  - *Background, Methodology, and Results*
  - *Discussion and Questions*
- Schedule and Next Steps

### **Study 3.1.1:**

- FERC issued their *Determination on Requests for Study Modifications and New Studies* on January 22, 2015
- FERC recommended that FirstLight file an addendum to the final report
- FERC recommended that the FRR Addendum include:
  - A comparison of specific riverbank features and characteristics from data logging files, or field data sheets, collected during the field surveys to a photograph of that segment of riverbank captured from the digital geo-referenced video; and
  - A comparison of 2007 and 2014 photo logs



# FRR Report Addendum

## Addendum:

- FERC recommended that FirstLight consult with the Stakeholders, specifically CRSEC and CRWC, and provide a minimum of 30 days for Stakeholders to comment and provide recommendations
- If FirstLight does not adopt a recommendation, the addendum should include FirstLight's reasons
- FirstLight is required to file the Addendum with FERC no later than April 22, 2015
- In order to satisfy FERC's recommendations, FirstLight has developed the following documents based on the Revised Study Plan (RSP) and/or Quality Assurance Project Plan (QAPP):
  - Attachment A – Riverbank Segment QA Comparison; and
  - Attachment B – 2007 to 2014 photo comparison

# Attachment A – Riverbank Segment QA Comparison

## Background:

- Attachment A was developed in accordance with the FRR QAPP, specifically:
  - “An appendix to the FRR report will include a comparison of the specific riverbank features and characteristics from the data logging files, or field data sheets, collected during the field surveys to a photograph of that same segment of riverbank captured from the digital geo-referenced video. A discussion will be presented in the FRR report based on this comparison. The process of comparing the data logging files to video/still images of a selected percentage of segments, or any segment of particular interest, provides a high level of quality assurance and control on the field data collected. This approach also provides a method for reference checking any subsequent interpretation of the field survey data after the survey has been completed.” [Page 13]
- During the 2013 FRR, approximately 600 riverbank segments were delineated and classified as part of the field survey
- Geo-tagged photos and video were taken of each segment at the time of classification

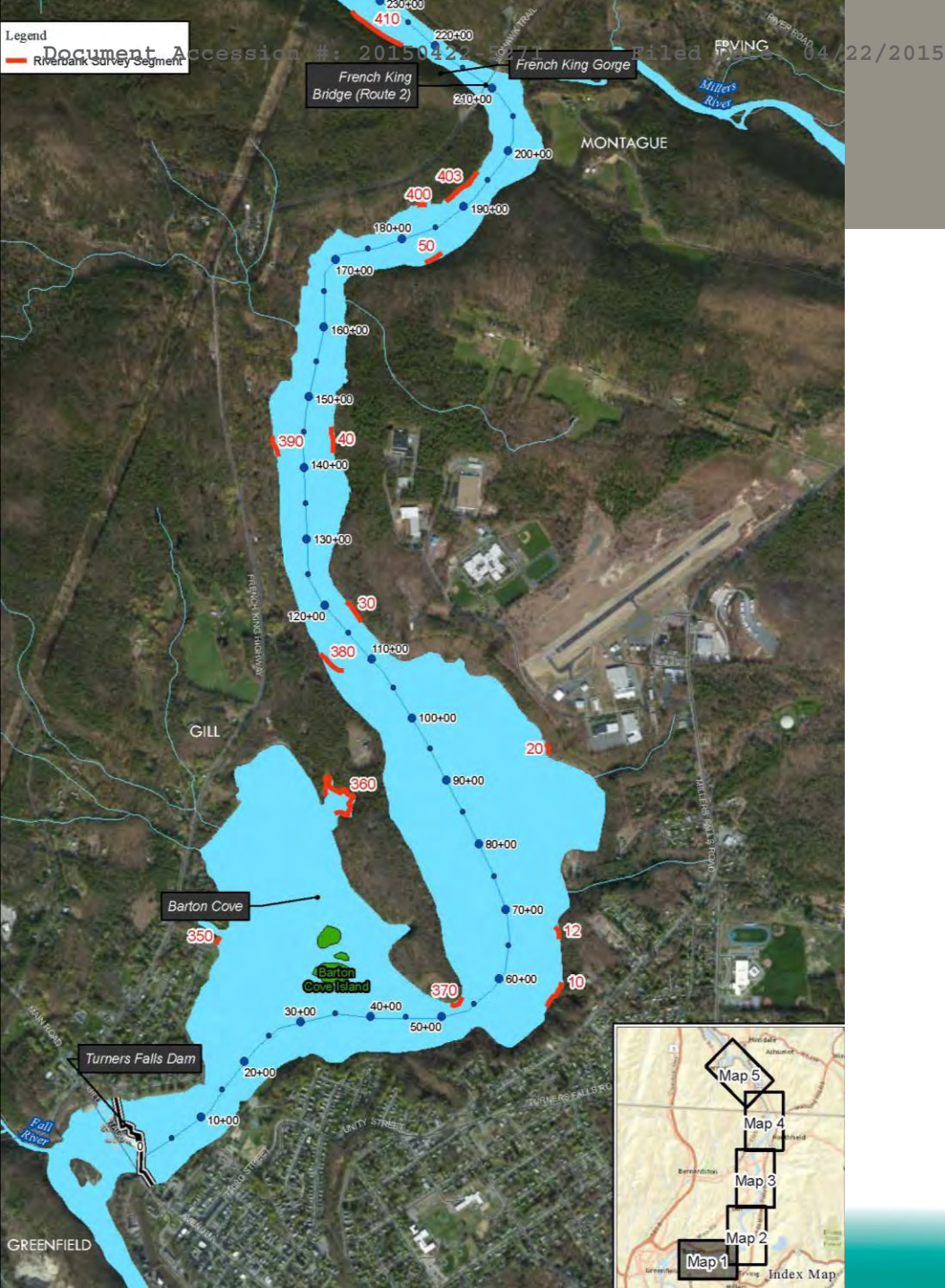
# Attachment A – Riverbank Segment QA Comparison

## Site Selection:

- The following methodology was employed to determine which sites would be used for QA comparisons:
  - Every 10<sup>th</sup> riverbank segment (Segment ID 10, 20, 30, etc.) was selected for QA comparison to ensure an unbiased approach that covered the longitudinal extent of the Turners Falls Impoundment (the Impoundment)
  - The riverbank features and characteristics at the 59 segments (10-590) were reviewed to identify data gaps
  - 6 additional riverbank segments were then added to the list to fill an existing data gap or because they were located at an area of interest
  - The final set of QA sites included 65 riverbank segments which covered almost all riverbank features and characteristics discussed in the RSP.

Table 1 - Summary of riverbank features and characteristics: Every tenth segment plus supplemental segments

Riverbank Features	Characteristics					
Upper Riverbank Slope	Overhanging Yes	Vertical Yes	Steep Yes	Moderate Yes	Flat Yes	
Upper Riverbank Height	Low Yes	Medium Yes	High Yes			
Upper Riverbank Sediment	Clay No	Silt/Sand Yes	Gravel No	Cobbles No	Boulders Yes	Bedrock Yes
Upper Riverbank Vegetation	None to Very Sparse Yes	Sparse Yes	Moderate Yes	Heavy Yes		
Lower Riverbank Slope	Vertical Yes	Steep Yes	Moderate Yes	Flat/Beach Yes		
Lower Riverbank Sediment	Clay Yes	Silt/Sand Yes	Gravel Yes	Cobbles Yes	Boulders Yes	Bedrock Yes
Lower Riverbank Vegetation	None to Very Sparse Yes	Sparse Yes	Moderate Yes	Heavy Yes		
Type of Erosion	Falls-Undercut Yes	Falls-Gullies Yes	Topples Yes	Slide or Flow Yes	Planar Slip Yes	Rotational Slump Yes
Potential Erosion Indicators	Tension Cracks No	Exposed Roots Yes	Creep/Leaning Trees Yes	Overhanging Bank Yes	Notch Yes	Other Yes
Stage of Erosion	Potential Future Erosion Yes	Active Erosion Yes	Eroded Yes	Stable Yes		
Extent of Erosion	None/Little Yes	Some Yes	Some to Extensive Yes	Extensive Yes		



# Riverbank Segments Selected for QA

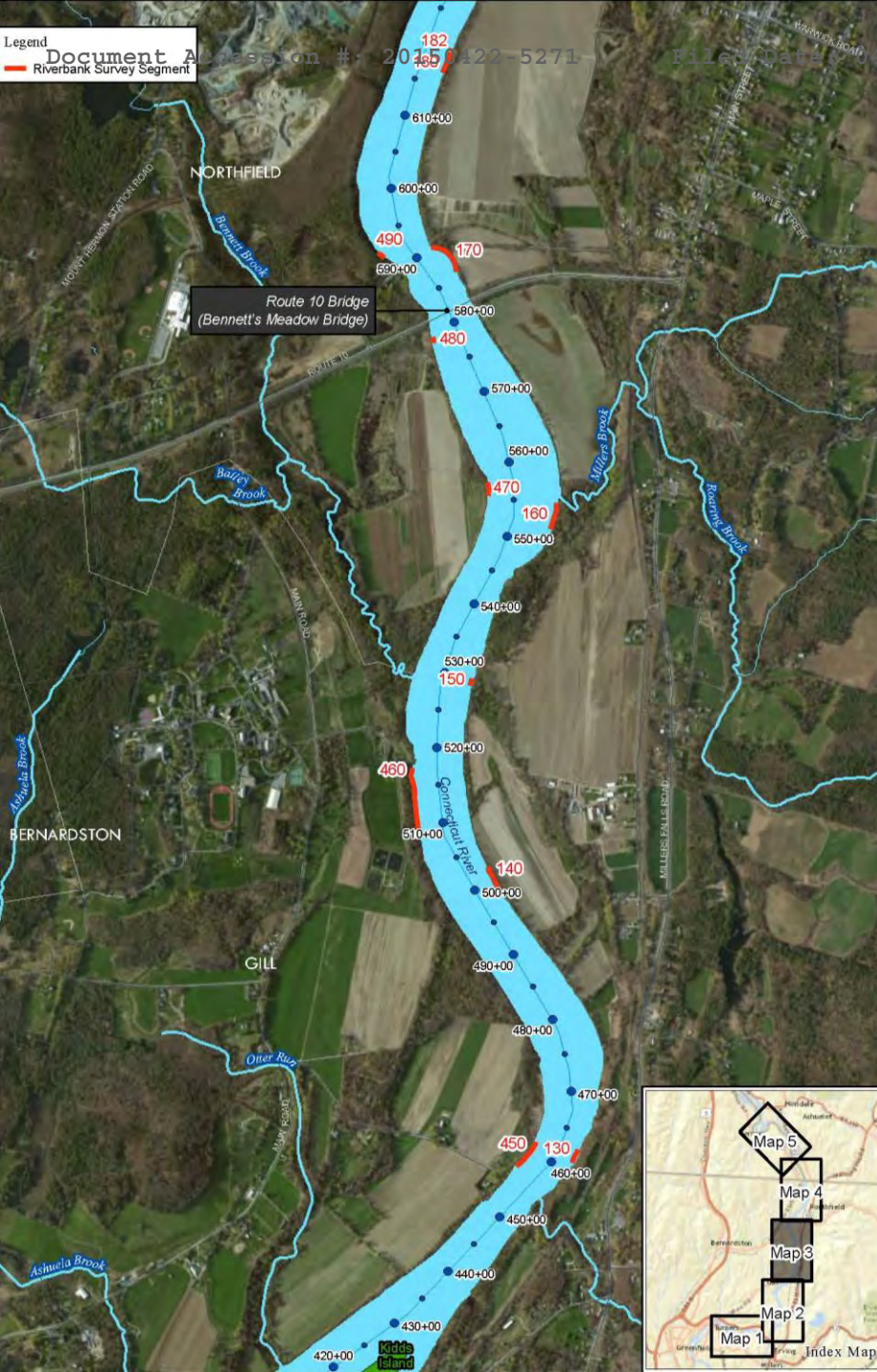
Geographic Distribution of the Riverbank Segments selected for QA

# Riverbank Segments Selected for QA



Geographic Distribution of the Riverbank Segments selected for QA

# Riverbank Segments Selected for QA



Geographic Distribution of the Riverbank Segments selected for QA

# Riverbank Segments Selected for QA



Geographic Distribution of the Riverbank Segments selected for QA

# Riverbank Segments Selected for QA



**Geographic Distribution of the Riverbank Segments selected for QA**



# Attachment A – Riverbank Segment QA Comparison

## Methodology & Results:

- Once the final set of QA sites were determined, FirstLight cross-checked the observations made during the 2013 FRR field survey with the geo-tagged photograph(s) of the associated riverbank
- During this process, the field observations were either confirmed or updated as appropriate
- For each site, FirstLight then created the following deliverable:
  - One photograph per segment labeled as an example to demonstrate the various features and characteristics that were present at that site
  - All photographs for each selected segment
  - A table of the riverbank features and characteristics found at that site
  - A Google Earth screenshot depicting the approximate location of the photograph
  - A brief sentence detailing any QA observations
- In general, field observations were confirmed at the vast majority of the sites and changes in classifications were not made
- Where multiple potential erosion indicators were observed, the photos were utilized to complete the riverbank characteristics table

# **Attachment A – Riverbank Segment QA Comparison**

## **Attachment A – Examples**

# Attachment A – Stable Example #1



Segment 500 – Right Bank

Riverbank Features	Characteristics
Upper Riverbank Slope	Moderate
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Heavy
Lower Riverbank Slope	Moderate
Lower Riverbank Sediment	Cobbles
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	
Potential Erosion Indicators	None
Stage of Erosion	Stable
Extent of Erosion	None/Little

# Attachment A – Stable Example #2



Segment 280 – Left Bank	
Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
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 to very sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Creep/leaning trees, Exposed roots, Overhanging bank
Stage of Erosion	Stable
Extent of Erosion	None/Little

# Attachment A – Stable Example #2



Segment 280 – Left Bank	
Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
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 to very sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Creep/leaning trees, Exposed roots, Overhanging bank
Stage of Erosion	Stable
Extent of Erosion	None/Little

Segment 280 U/S

# Attachment A – Stable Example #2



Segment 280 – Left Bank	
Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
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 to very sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Creep/leaning trees, Exposed roots, Overhanging bank
Stage of Erosion	Stable
Extent of Erosion	None/Little

# Attachment A – Stable Example #2

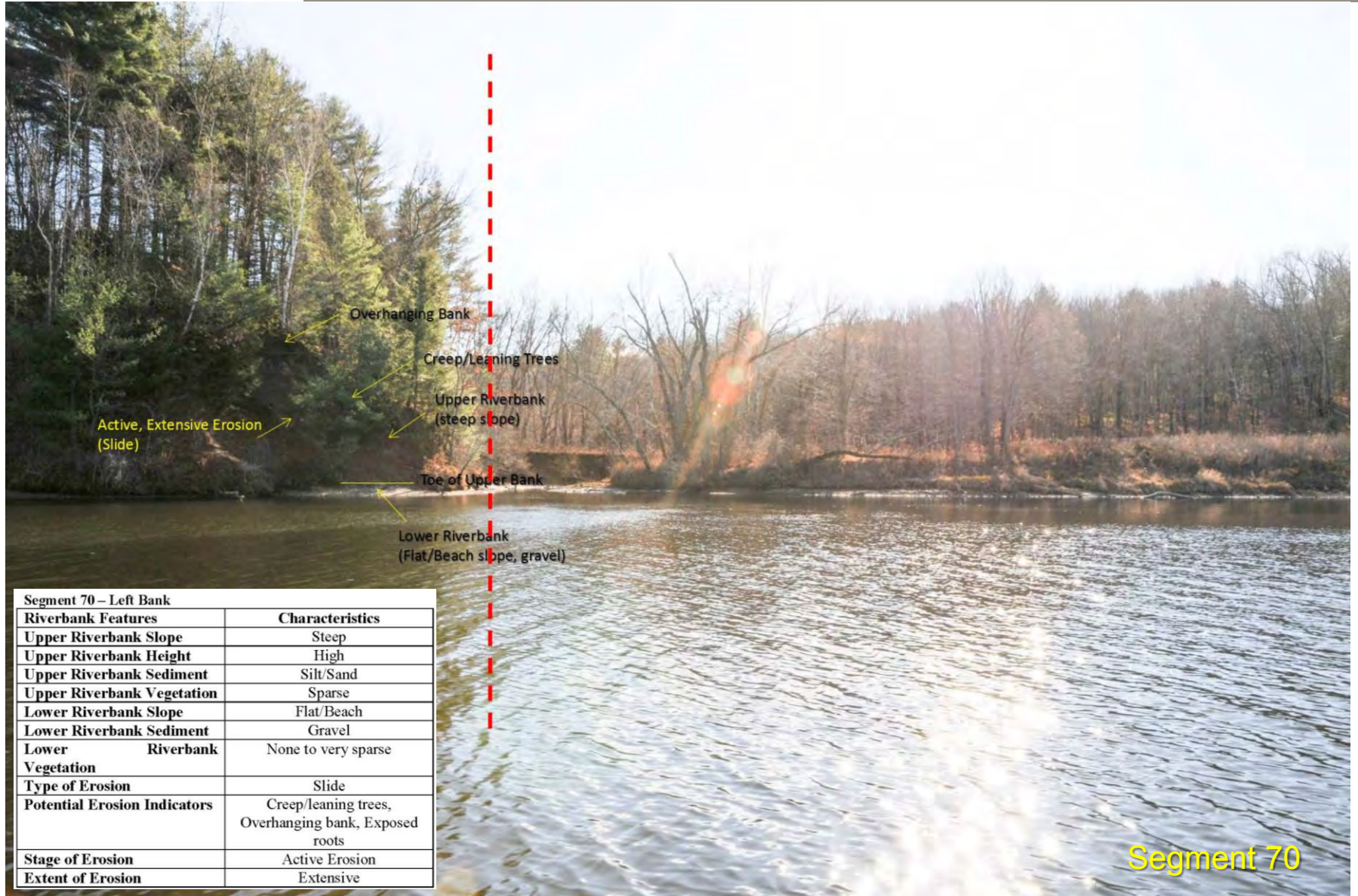


Segment 280 – Left Bank

Riverbank Features	Characteristics
Upper Riverbank Slope	Steep
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 to very sparse
Type of Erosion	Undercut
Potential Erosion Indicators	Creep/leaning trees, Exposed roots, Overhanging bank
Stage of Erosion	Stable
Extent of Erosion	None/Little

Segment 280 D/S

# Attachment A – Active Erosion Example



Segment 70 – Left Bank	
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	Gravel
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	Slide
Potential Erosion Indicators	Creep/leaning trees, Overhanging bank, Exposed roots
Stage of Erosion	Active Erosion
Extent of Erosion	Extensive

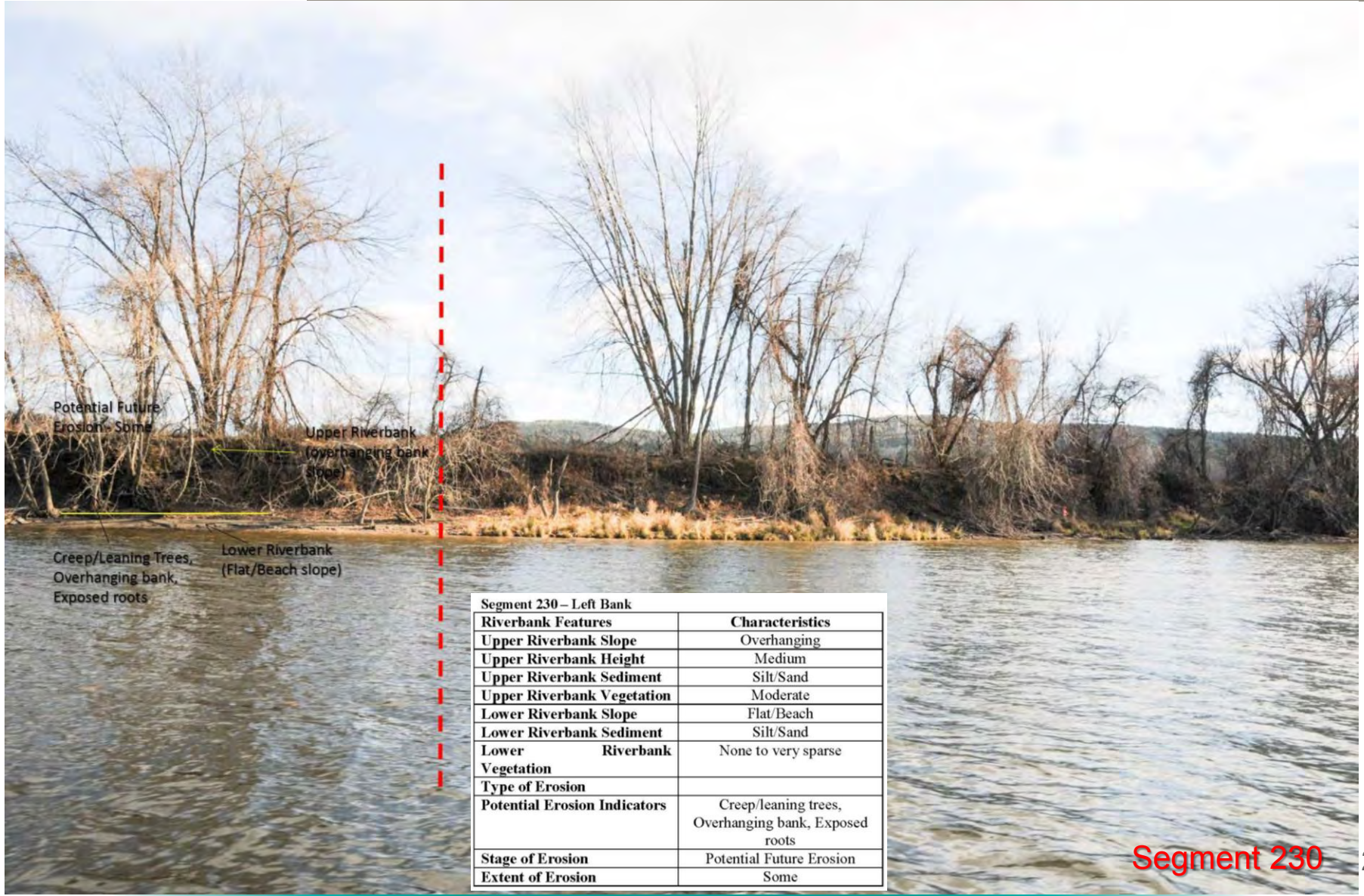


# Attachment A – Eroded Example



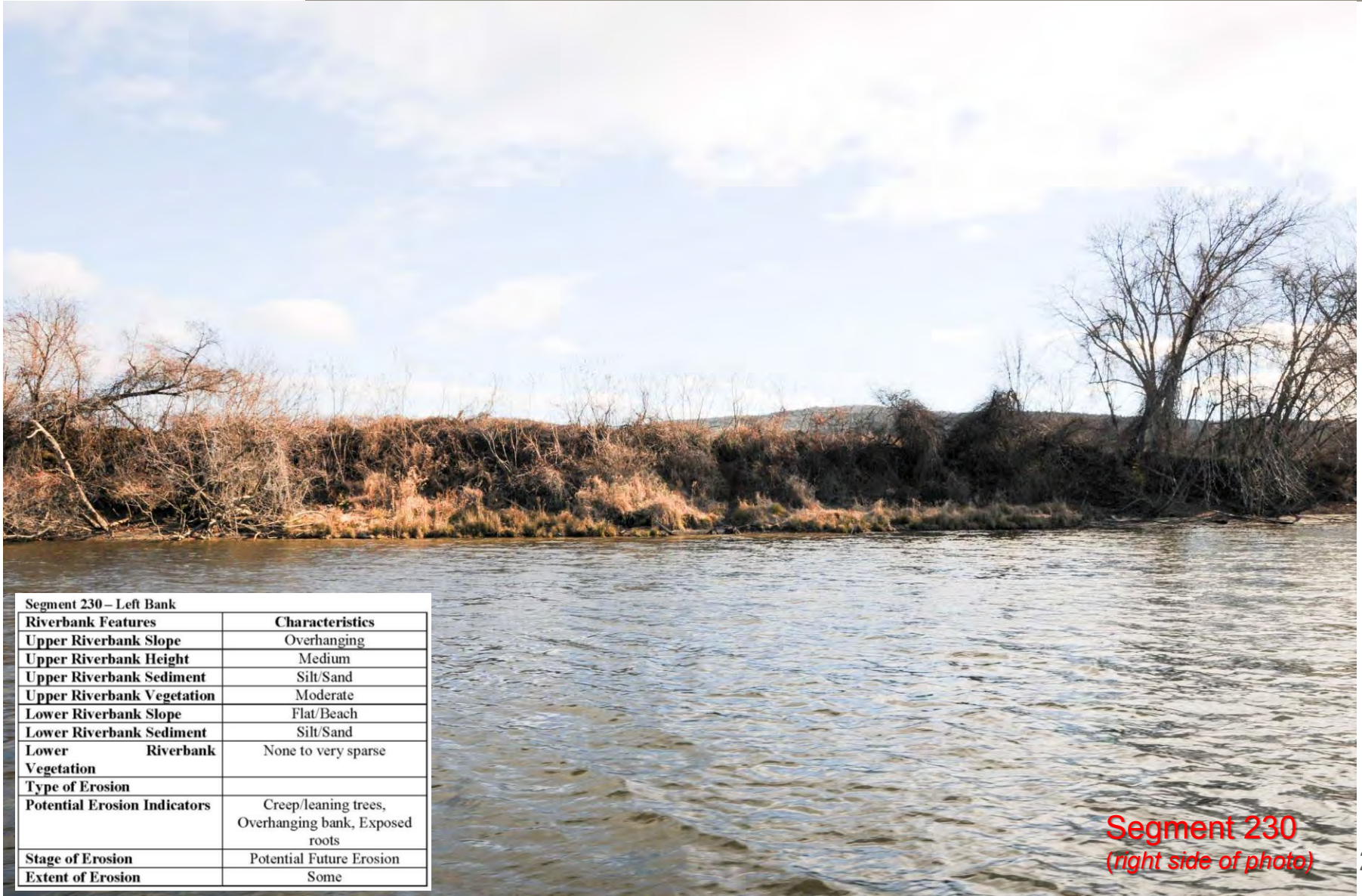
Segment 170 – Left Bank	
Riverbank Features	Characteristics
Upper Riverbank Slope	Overhanging
Upper Riverbank Height	High
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Moderate
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	Slide
Potential Erosion Indicators	Overhanging bank, Exposed roots, Creep/leaning trees
Stage of Erosion	Eroded
Extent of Erosion	Some to Extensive

# Attachment A – Potential Future Erosion Example



Segment 230 – Left Bank	
Riverbank Features	Characteristics
Upper Riverbank Slope	Overhanging
Upper Riverbank Height	Medium
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Moderate
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	
Potential Erosion Indicators	Creep/leaning trees, Overhanging bank, Exposed roots
Stage of Erosion	Potential Future Erosion
Extent of Erosion	Some

# Attachment A – Potential Future Erosion Example



Segment 230 – Left Bank

Riverbank Features	Characteristics
Upper Riverbank Slope	Overhanging
Upper Riverbank Height	Medium
Upper Riverbank Sediment	Silt/Sand
Upper Riverbank Vegetation	Moderate
Lower Riverbank Slope	Flat/Beach
Lower Riverbank Sediment	Silt/Sand
Lower Riverbank Vegetation	None to very sparse
Type of Erosion	
Potential Erosion Indicators	Creep/leaning trees, Overhanging bank, Exposed roots
Stage of Erosion	Potential Future Erosion
Extent of Erosion	Some

**Segment 230**  
*(right side of photo)*

# **Attachment A – Riverbank Segment QA Comparison**

## **Attachment A – Discussion and Questions**

# Attachment B – 2007 to 2014 Photo Comparison

## Background:

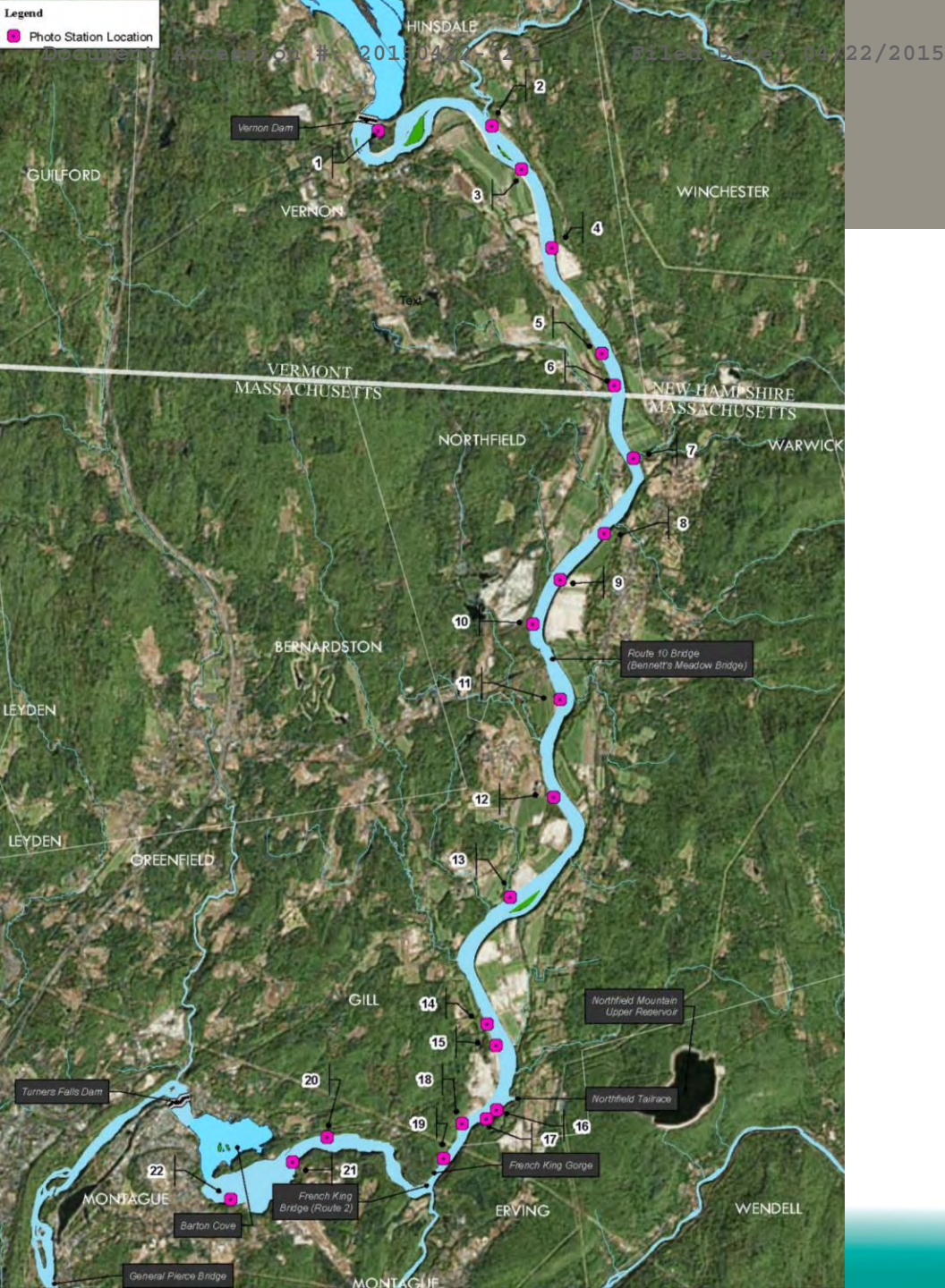
- In June 2007, Field Geology Services (Field) collected photographs of the Impoundment riverbanks as part of the report titled *“Fluvial Geomorphology Study of the Turners Falls Pool on the Connecticut River between Turners Falls, MA and Vernon, VT.”*
- One of the recommendations of the Field report was to replicate the 2007 photo log in later years as a means of comparison to identify changes visible along the banks
- As part of the 2013 FRR, FirstLight recreated the 2007 Field photo log, as closely as possible, in late July and early August 2014.
- Attachment B was developed in accordance with the FRR RSP, specifically:

*Once collected [the summer 2014 photo log] comparisons between the 2007 and 2014 logs will be made to identify changes visible along the banks, where applicable*

# Attachment B – 2007 to 2014 Photo Comparison

## Site Selection & Results:

- Initial review of the photo logs (2007 and 2014) indicated that the presence of summer foliage along the riverbanks limits the usability of the photos alone to draw definitive conclusions of changes in riverbank conditions from 2007 to 2014
- As such, 22 sites (as opposed to the 65 sites in Attachment A) were selected for comparison
- The 22 sites were selected due to the fact that they:
  - spanned the longitudinal extent of the Impoundment, and/or
  - included noted sites of interest (i.e. past bank stabilization sites, potential future restoration sites, etc.)
- In general, comparison observations were limited to changes in vegetation, sensitive receptors, or other non-erosion related riverbank characteristics. Meaningful comparisons of riverbank stability from 2007 to 2014 could generally not be conducted due to the presence of summer vegetation and leaf cover
- Other comparison challenges included:
  - Some photographs are zoomed in (2014) while the comparison photograph may be zoomed out (2007). The 2007 photos were taken too far away from shore/zoomed too far out to observe the riverbank(s) in detail
  - The angle and direction of the two comparison photographs may be different
  - The 2007 photos lacked embedded GPS coordinates and aspect (direction) which did not permit an exact photo station comparison



# Photo Comparison Locations

**Geographic Distribution of Photos Selected for Comparison (2007 to 2014)**

# **Attachment B – 2007 to 2014 Photo Comparison**

## **Attachment B – Discussion and Questions**



# Schedule

## Next Steps:

- Stakeholders can file comments with FirstLight until **Friday April 3<sup>rd</sup>**
- Comments should be submitted to:
  - John Howard ([john.howard@gdfsuezna.com](mailto:john.howard@gdfsuezna.com))
  - Tim Sullivan ([timsullivan@gomezandsullivan.com](mailto:timsullivan@gomezandsullivan.com))
  - Bob Simons ([rksimons@rksimons.com](mailto:rksimons@rksimons.com))
- FirstLight will then review all comments, update the addendum as appropriate, and file with FERC no later than **Wednesday April 22<sup>nd</sup>**



# Franklin Regional Council of Governments

## CONNECTICUT RIVER STREAMBANK EROSION COMMITTEE

April 2, 2015

Mr. John Howard  
Director FERC Compliance, Hydro  
FirstLight Power Resources, Inc.  
99 Millers Falls Road  
Northfield, MA 01360

Re: Northfield Mountain Pumped Storage Project No. 2485-063  
Turners Falls Project No. 1889-081  
Comments on Addendum to Study 3.1.1, the 2013 Full River Reconnaissance

Dear Mr. Howard:

The Connecticut River Streambank Erosion Committee (CRSEC) has reviewed the Addendum to the 2013 Full River Reconnaissance (FRR), a study related to both license compliance and Study 3.1.1 in the Integrated Licensing Process. FERC required an addendum be filed within 90 days of their January 22, 2015 "Determination on Requests for Study Modifications and New Studies for Turners Falls Hydroelectric Project and Northfield Mountain Pumped Storage Project." The Addendum was provided to CRSEC members electronically on February 24, 2015, and two of our members were available to attend the meeting held on March 4, 2015. Our comments are as follows.

### **Comparison of 2007 and 2014 photo logs**

A comparison of the photo logs from 2007 and 2014 was to have been part of Task 4 as written in the approved Revised Study Plan (RSP), but it was missing in Study 3.1.1. CRSEC member Connecticut River Watershed Council is on record for having commented that collecting a set of 2014 photos during the middle of summer was not valuable. Despite changes in technology since 2007 and difficulty repeating the same photos, the comparison is more valuable and interesting than we had expected. Looking at the changes in gross vegetation over time has some value, and we think it is interesting to see how some sites have filled in. Going forward, these photo logs can serve as a baseline for future work to document leaf on conditions and monitor changes over time.

### **2013 Full River Reconnaissance – 2015 Addendum: Riverbank Segment Quality Assurance (QA) Comparison**

The 2013 FRR Quality Assurance Project Plan (QAPP) stated: "An appendix to the FRR report will include a comparison of the specific riverbank features and characteristics from the data logging files, or field data sheets, collected during the field surveys to a photograph of that same segment of riverbank captured from the digital

FERC Project No. 2485-063

geo-referenced video. A discussion will be presented in the FRR report based on this comparison. The process of comparing the data logging files to video/still images of a selected percentage of segments, or any segment of particular interest, provides a high level of quality assurance and control on the field data collection. This approach also provides a method for reference checking any subsequent interpretation of the field survey data after the survey has been completed.”

This appendix was missing in the 2013 FRR submitted as Study 3.1.1 with the Initial Study Report in September 2014. The 2015 draft riverbank segment QA comparison submitted by FirstLight lacks key information that would “provide a high level of quality assurance” and a “method for reference checking any subsequent interpretation of the field survey data.” A complete data set for the QA comparison should be provided so that FERC staff and stakeholders can replicate the QA methods and have a high degree of confidence in the results of the 2013 FRR.

#### Methods:

FirstLight looked at every 10<sup>th</sup> segment, identified gaps, and added six supplemental segments, for a total of 65 QA segments.<sup>1</sup> While FirstLight indicated they found gaps that led to adding certain segments, they did not indicate whether or not there was an over-abundance of any riverbank characteristic. FirstLight had said in their QAPP that the QA comparison would be done using video, but they used still images instead. FirstLight states that the QA analysis led to several revisions mainly consisting of adding indicators of potential erosion to segments, but did not change overall conclusions.

#### Analysis:

CRSEC continues to believe that sections of the 2013 FRR need to be re-done pursuant to section 5.15(d) of the Commission’s regulations because the study was not conducted as provided for in the approved study plan. Specifically, the bank characterization (stage and extent of erosion) should be redone. Both the 2013 FRR and the QA comparison indicate that FirstLight did not follow the definitions laid out in Table 3.1.1-3 of the approved RSP dated August 14, 2013, for Study 3.1.1. Table 3.1.1-3 is attached to this letter.

For example, CRSEC has determined that 24 of the segments used in the QA analysis do not meet the definitions laid out in Table 3.1.1-3. These segments were classified as *stable* but had one or multiple *indicators of erosion* and often a *type of erosion* (e.g., undercut). In Table 3.1.1-3, stable is defined as “riverbank segment does not exhibit types or indicators of erosion.” The 24 segments characterized as both "stable" and with an Erosion Type and/or Indicator of Erosion are: 20, 30, 40, 50, 110, 130, 160, 180, 240, 290, 320, 390, 400, 410, 430, 440, 450, 460, 510, 520, 530, 550, 279, and 89. The following table summarizes our analysis of the segments labeled as stable.

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<sup>1</sup> CRSEC believes that stratified random sampling would have been a more effective sampling method to cover the entire Turners Falls impoundment and range of stream bank categories present, but we think that the methods that FirstLight used are adequate.

## FERC Project No. 2485-063

	# of Riverbank Segments (excluding islands)	# of Segments categorized as <i>Stable</i>	# "Stable" segments with an Erosion Type and/or Indicator of Erosion
2013 Full River Reconnaissance Report	596	459	226
2015 Addendum QA	65	47	24

Segment 230 (Addendum page A-76 and slides 21 and 22 of PowerPoint presentation for 3/4/15 meeting) exhibited three indicators of potential erosion. The stage of erosion is listed as "Potential Future Erosion" and the Extent of Current Erosion is listed as "Some," which is defined as 10-40% of the bank has active erosion. The bank indeed has erosion based on the photos. It appears that a fall has occurred where a tree that had been growing on the upper bank is now sitting on the lower bank. We are surprised that, on further analysis, it was not determined that this segment merited a state of erosion as "active erosion or eroded." When asked about this at the March 4, 2015 meeting, Bob Simons said that it was a good question, but he thought this segment had good indicators of erosion. To CRSEC, this is an indication that the FRR does not follow its approved RSP and is very subjective.

A review of the pictures and summary table information provided in the QA comparison indicates the stage and extent of erosion were not properly identified using the definitions in Table 3.1.1-3. We've discussed our concerns about characterizing banks as stable (stage of erosion). We also have concerns about the same segments being characterized as having none/little erosion (extent of erosion), which is defined as "generally stable bank where the total surface area of the bank segment has approximately less than 10% active erosion present". The stage and extent of erosion for the segments cannot be verified because FirstLight provided only partial information for each of the QA segments. We believe the data set for each QA segment should include:

1. The length of each segment clearly identified with start and end points. Part of the QA process should be verifying the characteristics that differentiate one segment from another. We noted in our November 14, 2014 comment letter that Extent of Erosion is highly dependent on the breakdown of river segments and how these segments were mischaracterized in the FRR segments.
2. The field data sheets and data logging files for each segment. This is the only record, other than photographs, of the river bank characteristics, including the stage and extent of erosion for each segment. (See our November 14, 2014 letter for a list of deliverables in the approved RSP that were not provided to stakeholders.)
3. All pictures for each segment, presented sequentially (downstream to upstream) and clearly labeled with the downstream and upstream limits of the segment and the riverbank features and erosion classifications pursuant to Table 3.1.1-3. We found that most segments are missing pictures or have pictures that show the same area. For example, the pictures for segment 10 are the same. We further note that the location of segment 10 on the map does not align with the location of the pictures included in the QA addendum.

FERC Project No. 2485-063

The QA documentation for Segment 20 does not include a photo of the upstream portion of this segment and segments 450 and 520 do not have a complete photo log.

4. A discussion of how the stage and extent of erosion was determined. When viewed in their entirety, the pictures for each segment should clearly reflect the information in the QA summary table for each segment. Most of the QA segments indicate that the bank is "stable" with "none/little" erosion. These classifications do not meet the definitions in Table 3.1.1-3 and are not supported by the QA data presented by FirstLight. (See our November 14, 2014 comment letter that included a table of segments that had been mischaracterized by FirstLight.)

Using the definition from the approved RSP that "stable" is having no types or indicators of erosion, then only 233 segments of the 459 segments categorized as "stable" meet the definition of stable (459-226 from table above). These 233 segments add up to approximately 97,500 feet of river bank length, which is about 43% of the total river bank length (not including islands). This is in stark contrast to Table 6-1 in the FRR which stated that 83.5% of the length of river bank was categorized as "stable."

Based on the information provided in the FRR Addendum, the QA/QC effort did not correct the error of interpreting stage and extent of erosion categorization differently from the definitions laid out in the approved RSP. CRSEC continues to assert that the 2013 FRR was not conducted as written in the approved RSP and instead was conducted based on subjectivity skewed to interpreting the banks as stable. The stages of erosion and extent of erosion for the 2013 FRR should be re-calculated according to FirstLight's own definition of the stages and extent (Table 3.1.1-3).

In summary, the QA addendum and the interpretation of the data collected for the 2013 FRR do not support the conclusion of overall bank stability reached by FirstLight.

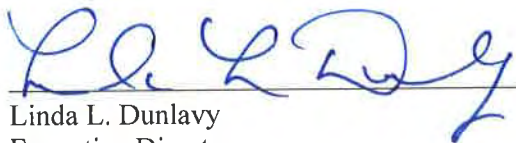
Thank you for the opportunity to comment.

Sincerely,



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Tom Miner  
Chair  
Connecticut River Streambank Erosion Committee



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Linda L. Dunlavy  
Executive Director  
Franklin Regional Council of Governments

Cc: Congressman James McGovern  
Franklin County Legislative Delegation  
Kimberly Bose, FERC

FERC Project No. 2485-063

Brandon Cherry, FERC  
Chris Chaney, FERC  
NOAA – National Marine Fisheries  
U.S. Fish and Wildlife Service  
Connecticut River Atlantic Salmon Commission  
U.S. Army Corps of Engineers  
Massachusetts Department of Environmental Protection  
Massachusetts Division of Fisheries and Wildlife  
Connecticut River Watershed Council  
Franklin Conservation District  
Windham Regional Commission  
Landowners and Concerned Citizens for License Compliance  
Town of Gill, MA Conservation Commission  
Town of Northfield, MA Selectboard and Conservation Commission

ATTACHMENT: Table 3.1.1-3

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

## REVISED STUDY PLAN

Table 3.1.1-3: Riverbank Classification Definitions

RIVERBANK CHARACTERISTICS (Upper and Lower) <sup>9</sup>	
Riverbank Slope	<b>Overhanging</b> – any slope greater than 90°
	<b>Vertical</b> – slopes that are approximately 90°
	<b>Steep</b> – exhibiting a slope ratio greater than 2 to 1
	<b>Moderate</b> – ranging between a slope ratio of 4 to 1 and 2 to 1
	<b>Flat</b> – exhibiting a slope ratio less than 4 to 1 <sup>10</sup>
Riverbank Height	<b>Low</b> – height less than 8 ft above normal river level <sup>11</sup>
	<b>Medium</b> – height between 8 and 12 ft above normal river level
	<b>High</b> – height greater than 12 ft above normal river level
Riverbank Sediment	<b>Clay</b> – any sediment with a diameter between .001 mm and 2 mm
	<b>Silt / Sand</b> – any sediment with a diameter between .062 mm and 2 mm
	<b>Gravel</b> – any sediment with a diameter between 2 mm and 64 mm
	<b>Cobbles</b> – any sediment with a diameter between 64 mm and 256 mm
	<b>Boulders</b> – any sediment with a diameter between 256 mm and 2048 mm
	<b>Bedrock</b> – unbroken, solid rock
Riverbank Vegetation	<b>None to Very Sparse</b> – less than 10% of the total riverbank segment is composed of vegetative cover
	<b>Sparse</b> – 10-25% of the total riverbank segment is composed of vegetative cover
	<b>Moderate</b> – 25-50% of the total riverbank segment is composed of vegetative cover
	<b>Heavy</b> – 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 <sup>12</sup>	<b>Falls</b> – 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.
	<b>Topples</b> – 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.
	<b>Slides</b> – Sediments move downslope under the force of gravity along one or several discrete surfaces. Can include planar slips or rotational slumps.
	<b>Flows</b> – Sediment/water mixtures that are continuously deforming without distinct slip surfaces.
Indicators of Potential Erosion	<b>Tension Cracks</b> – a crack formed at the top edge of a bank potentially leading to topples or slides ( <a href="#">FGS, 2007</a> )
	<b>Exposed Roots</b> – trees located on riverbanks with root structures exposed, overhanging.
	<b>Creep</b> – defined as an extremely slow flow process (inches per year or less) indicated by the presence of tree trunks curved downslope near their base ( <a href="#">FGS, 2007</a> )
	<b>Overhanging Bank</b> – any slope greater than 90°
	<b>Notching</b> – similar to an undercut, defined as an area which leaves a vertical stepped face presumably after small undercut areas have failed.
	<b>Other</b> – Indicators of potential erosion that do not fit into one of the four categories listed above will be noted by the field crew.
Stage(s) of Erosion	<b>Potential Future Erosion</b> – riverbank segment exhibits multiple or extensive indicators of

<sup>9</sup> All quantitative classification criteria (e.g. slope, height, vegetation, extent, etc.) will be based on approximate estimates made during field observations of riverbanks. The FRR is a reconnaissance level survey that will not include quantitative analysis.

<sup>10</sup> Beaches are defined as a lower riverbank segment with a flat slope

<sup>11</sup> 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').

<sup>12</sup> [FGS, 2007](#)

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

## REVISED STUDY PLAN

	potential erosion
	<b>Active Erosion</b> – riverbank segment exhibits one or more types of erosion as well as evidence of recent erosion activity
	<b>Eroded</b> – 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.
	<b>Stable</b> – riverbank segment does not exhibit types or indicators of erosion
<b>Extent of Current Erosion</b>	<b>None/Little</b> <sup>13</sup> – generally stable bank where the total surface area of the bank segment has approximately less than 10% active erosion present.
	<b>Some</b> – riverbank segment where the total surface area of the bank segment has approximately 10-40% active erosion present
	<b>Some to Extensive</b> – riverbank segment where the total surface area of the bank segment has approximately 40-70% active erosion present
	<b>Extensive</b> – riverbank segment where the total surface area of the bank segment has approximately more than 70% active erosion present

<sup>13</sup> 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.



Document Content(s)

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