Appendix D – 2013 Full River Reconnaissance Study and Quality Assurance Project Plan

Quality Assurance Project Plan
FirstLight 2013 Full River Reconnaissance Turners Falls Impoundment of the Connecticut River

Prepared by:
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Prepared for:
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Date: August 14, 2013

1 Title and Approval Page

John Howard — Date
FirstLight, Director – FERC Hydro Compliance, Northfield Mountain Station

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Charles Momnie — Date
FirstLight – Project QA/QC Engineer

Dr. Robert Simons — Date
Simons & Associates – Project Director, Fluvial Geomorphologist

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Michael Marcus — Date
New England Environmental, Inc. – Project Manager

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List of Tables and Figures

3 Distribution List

The following individuals will receive a copy of this Quality Assurance Project Plan (QAPP) upon approval.

Table 1: QAPP Distribution List

QAPP Recipient Name	Project Role	Organization	Telephone Number and Email Address
John Howard	Director, FERC Hydro Compliance, Project Director for FirstLight	FirstLight Power Resources Services, LLC	413-659-4489 John.howard@gdfsuezna.com
Charles Momnie	Senior Engineer, Project Coordinator /Project Review for FirstLight	FirstLight Power Resources Services, LLC	413-659-4472 Charles.momnie@gdfsuezna.com
Robert Simons	Project Director/Fluvial Geomorphologist	Simons & Associates	970-988-2880 rksimons@rksimons.com
Michael Marcus	Senior Scientist/Project Manager	New England Environmental, Inc.	413-658-2050 mmarcus@neeinc.com
Gregg Simons	Hydraulic Engineer, data collection, ArcGIS map preparation and analysis	Simons & Associates	970-988-2880 greggrsimons@gmail.com
Christin McDonough	Staff Scientist, data collection, preparation of ArcGIS maps, documentation	New England Environmental, Inc.	413-658-2063 cmcdonough@neeinc.com
Sean Werle	Staff Scientist, equipment maintenance	New England Environmental, Inc.	413-658-2051 swerle@neeinc.com
Mark Wamser	FERC Relicensing Project Manager	Gomez and Sullivan Engineers, P.C.	603-428-4960 mwamser@gomezandsullivan.com

4 Project and Task Organization

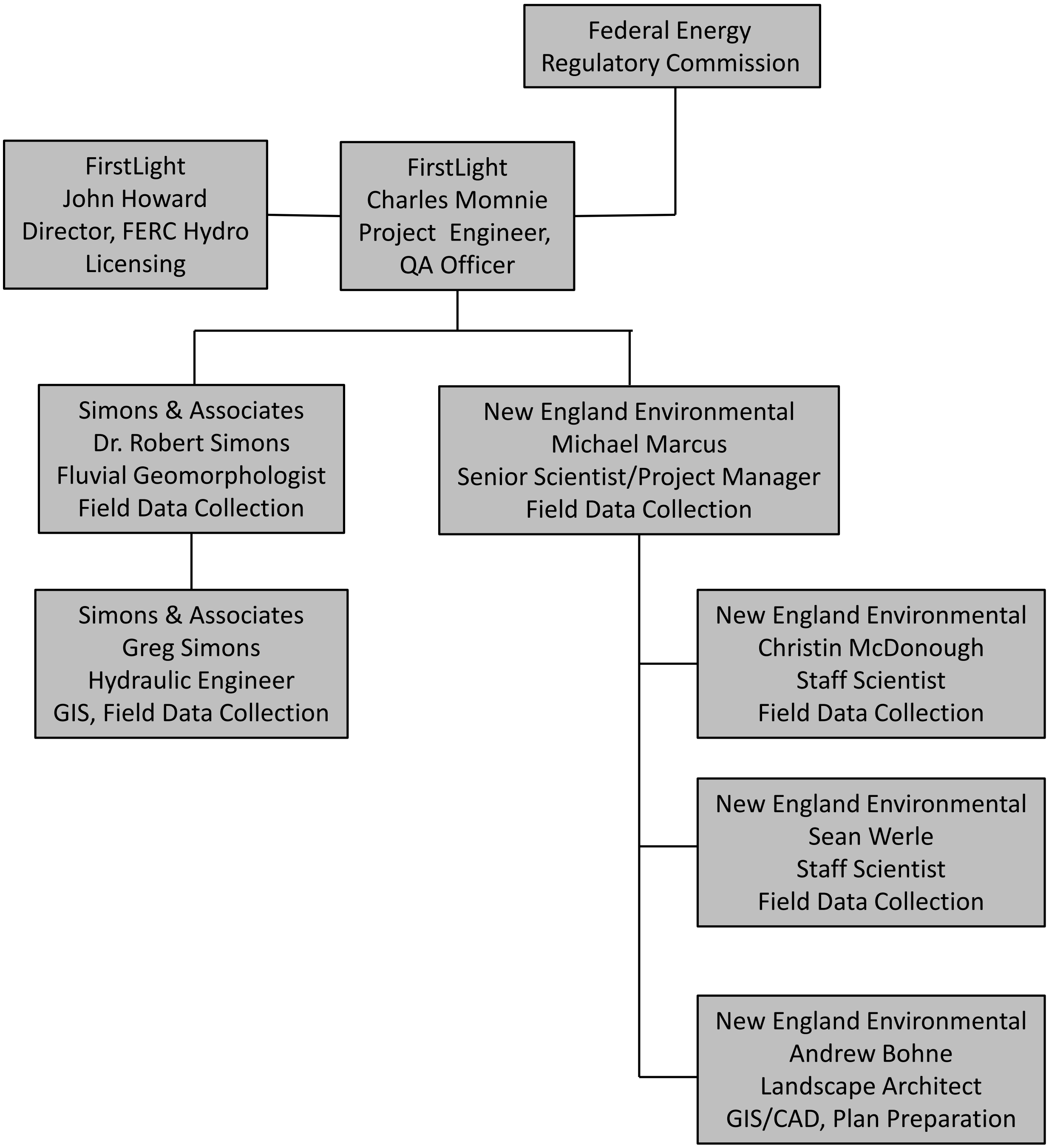
The 2013 Full River Reconnaissance (FRR) Quality Assurance Project Plan (QAPP) was prepared by Simons & Associates (S&A) and New England Environmental, Inc. (NEE) for FirstLight Power Resources Services, LLC c/o FirstLight Hydro Generating Company (FirstLight). FirstLight is required by the Federal Energy Regulatory Commission (FERC) to conduct FRRs every 3-5 years in accordance with the Northfield Mountain Project's Erosion Control Plan (ECP)(Simons, 1999) and to satisfy compliance requirements associated with the Turners Falls Project (FERC No. 1889) and Northfield Mountain Project (FERC No. 2485) licenses.

This study is a combined effort of FirstLight, Simons and Associates (S&A), and New England Environmental, Inc. (NEE). The following is a list of individuals and organizations involved with this project, showing their respective roles and responsibilities. Figure 1 displays the organization flow chart for this study. See Table 1 for contact information.

Table 2: Names, Organizations and Responsibilities Associated with 2013 FRR

Name	Organization	Responsibility
John Howard	FirstLight	QAPP Review, draft and final document review
Charles Momnie	FirstLight, Project Engineer /Quality Assurance Officer	QAPP Review, draft and final document review Responsible for overall project management and completion
Project Director		
Dr. Robert Simons	Simons & Associates (S&A)	Responsible for overall project design and completion. Data collection, data management and analysis, documentation of results and report
Project Manager		
Michael J. Marcus	New England Environmental (NEE)	Supervision of scientific staff, supervision of data collection, staff training, data management
Field Assistant/Hydraulic Engineer		
Gregg Simons	S&A	Field work, data logging, ArcGIS mapping and analysis
Field Assistant/Staff Scientist		
Christin McDonough	NEE	Field work, data entry develop ArcGIS maps
Field Assistant/Staff Scientist		
Sean Werle	NEE	Boat Operator, maintenance of instruments
Andrew Bohn	NEE	Landscape Architect/Planner

Figure 1: Project Organization Chart



5 Problem Definition / Background

FirstLight owns and operates the Northfield Mountain Pumped Storage Project (Northfield Mountain Project), a 1,119 -MW pumped storage hydroelectric project constructed in 1972 along the Connecticut River near Northfield, MA. The Northfield Mountain Project consists of an Upper Reservoir, an underground pressure shaft and four unit penstocks, an underground powerhouse, four reversible pump-turbine generators, and a mile-long tailrace tunnel connecting the powerhouse to a 20-mile-long reach of the Connecticut River known as the Turners Falls Impoundment, which functions as a Lower Reservoir. The manmade Upper Reservoir was formed with four earth-core rock fill embankment structures and a concrete gravity dam.

FirstLight also owns and operates the Turners Falls Project, a 67.709 MW hydroelectric project located in Montague MA, in the village of Turners Falls. The Turners Falls Dam forms the Turners Falls Impoundment, shown in Figure 2.

The Turners Falls Project and Northfield Mountain Project are licensed by FERC. In compliance with relevant articles of the FERC licenses for both projects, a reconnaissance survey of the Turners Falls Impoundment was conducted in 1998 to map riverbank characteristics and to prioritize erosion sites to be considered for stabilization. As a result of this work, an "*Erosion Control Plan for the Turners Falls Pool of the Connecticut River*," (Simons, 1999) – commonly referred to as the Erosion Control Plan (ECP) was developed. The ECP provides for FirstLight to conduct FRR studies to document existing riverbank conditions within the Turners Falls Impoundment every 3 to 5 years. Since the development of the initial ECP, four FRRs (1998, 2001, 2004, and 2008) have been conducted to date. The next FRR is scheduled for 2013.

Although not germane to this QAPP, the FERC licenses for both projects expire on April 30, 2018. FirstLight has initiated the process of relicensing the Turners Falls and Northfield Mountain Projects, using FERC's Integrated Licensing Process (ILP), with the filing of their Pre-Application Document (PAD) and Notice of Intent (NOI). These documents were filed with FERC on October 31, 2012. Although the 2013 FRR is being conducted to comply with the ECP, FERC has requested that it be included as part of the relicensing studies for the Projects as well. Due to this request, FirstLight developed a study plan based on FERC's study plan criteria which was included in the Revised Study Plan (RSP) for the Project. Readers should reference Study No. 3.1.1- *Full River Reconnaissance* in the RSP for additional details. Further details relative to the FERC relicensing schedule are provided later in this document (Table 2).

Due to a variety of factors, the riverbanks along the Connecticut River, not just in the Turners Falls Impoundment, have a history of being susceptible to erosion. The Connecticut River is an alluvial river; that is one which deposits clay, silt, sand, gravel or similar detrital material, and is therefore subject to dynamics such as lateral shifting, erosion, and deposition. These natural processes and the dynamic responses of the river may be further affected by land-use practices, modified flow/water level regime, motorized boating, and other factors.

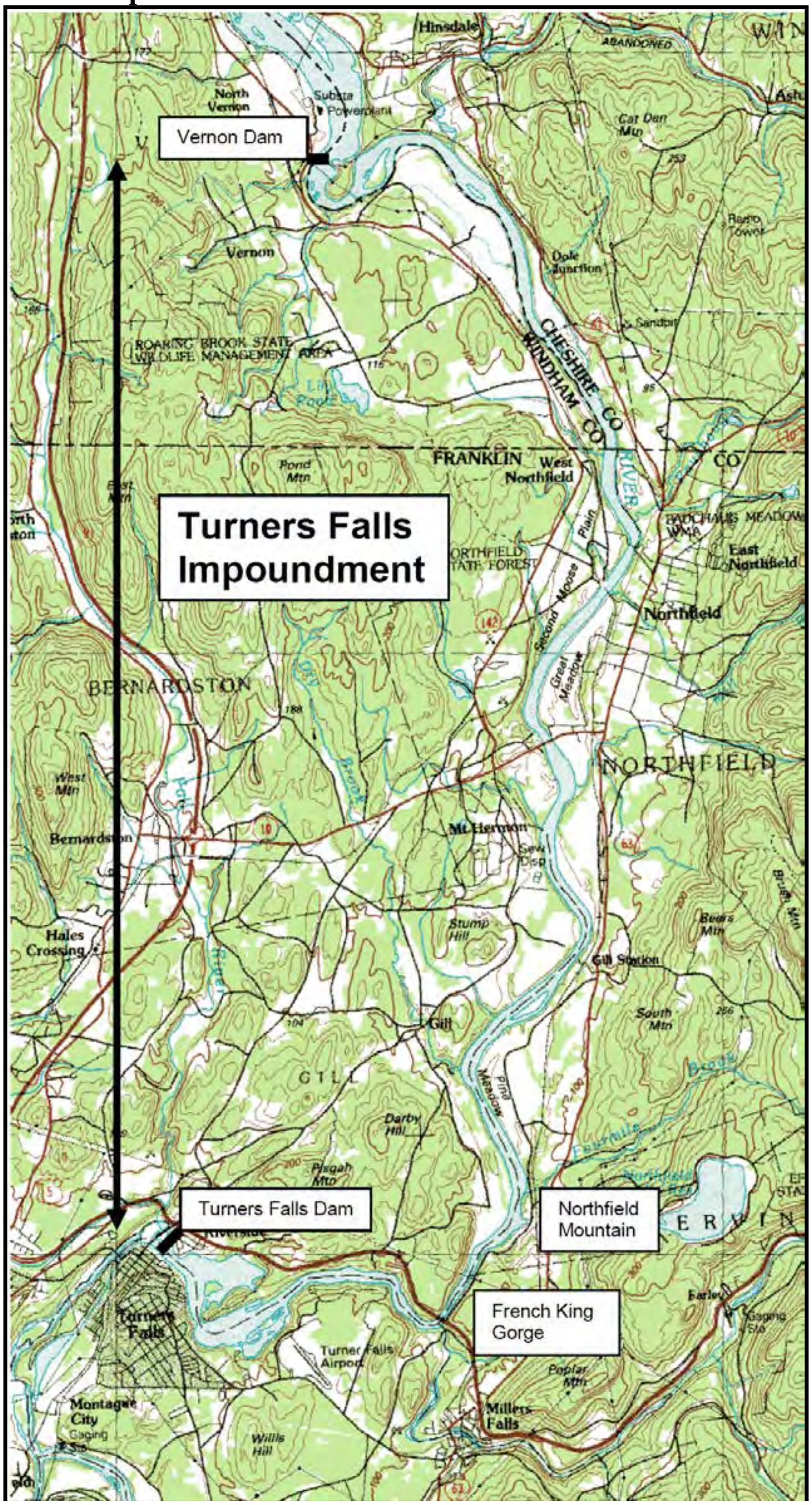
The objective of the 2013 FRR is to utilize a predetermined classification of riverbank features and characteristics, including the type, stage, extent, and indicators of erosion[1], which will document current

[1] For the purpose of this study, the type of erosion is defined as the specific active erosion process or processes occurring at a given location (i.e. falls, topples, slides, etc.). The stage of erosion is defined as the point on the temporal scale of erosion that a given bank is currently at (i.e. active erosion, eroded, stable, etc.). Indicators of

riverbank conditions in the Turners Falls Impoundment. Data collected as part of this process will be used to identify and evaluate changes in riverbank conditions over time (going back to the original FRR conducted as part of the ECP) and determining the location(s) of, and planning for, potential future restoration work. The 2013 FRR will include boat and land based surveys during leaf off conditions. The location of transition points, or end points, where riverbank conditions change from one category to another will be captured via sub-meter GPS as part of the boat survey. Summary statistics based on the data collected will be developed and maps denoting the locations of various riverbank features and conditions will be generated.

potential erosion (i.e. leaning trees, tension cracks, etc.) are processes or characteristics of a riverbank that contribute to the instability of the bank; these are used to determine locations where future erosion may occur.

Figure 2: Turners Falls Impoundment



6 Project / Task Description

The goal of the 2013 FRR is to conduct a reconnaissance level survey (boat and land based) of riverbank conditions throughout the Turners Falls Impoundment from Turners Falls Dam to Vernon Dam (Figure 2). Islands within the Turners Falls Impoundment will also be included in this survey. Field activities associated with this effort will occur in early fall (land-based survey) and late fall (boat-based survey, mid-November during leaf off conditions). Specific objectives of the 2013 FRR include:

- Conduct a land-based investigation of the riverbanks and islands to document indicators of potential erosion and potential bank instability;
- Identify land-use practices within 200 feet of the riverbank and islands from Turners Falls Dam to Vernon Dam;
- Identify and define riverbank features and characteristics such as bank slope, height, sediment composition, and vegetation using clearly defined, and easily repeatable, classification techniques;
- Identify and define the type, stage, indicators, and extent of erosion in the Turners Falls Impoundment using clearly defined, and easily repeatable, classification techniques;
- Identify and map the location(s) of sensitive receptors, including important wildlife habitat, along the riverbanks and islands of the impoundment;
- Spatially define, using a global positioning system (GPS), the transition points where riverbank characteristics or features change from one classification to another;
- Create video and photographic documentation of all riverbanks classified including geo-referenced video and reproduction of the photo log used 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* (Field, 2007);
- Conduct an evaluation of past bank stabilization projects and provide recommendations for future projects based on the results of the FRR;
- Conduct data evaluation based on the features identified in the field including, but not limited to: distribution and summary statistics, assessment of changes in riverbank conditions in context of the "*Erosion Control Plan for the Turners Falls Pool of the Connecticut River*" (ECP)(Simons, 1999), and evaluation of change in riverbank conditions since previous FRRs;
- Create various maps and geospatial datasets based on the information gathered in the field. Maps generated will include, but not be limited to: riverbank features and characteristics, erosion type, erosion stage, extent of erosion, potential bank instability, land-use, and riverbank stabilization site locations (current and recommended); and
- Develop a final report describing and summarizing the findings of the 2013 FRR including all data evaluation, mapping, and field documentation.

In order to effectively and efficiently accomplish the goals and objectives of the FRR, the study methodology has been divided into several tasks and subtasks. As such, study methods will consist of the following tasks:

- Task 1: Land-Based Observations

- Task 2: Classify Riverbank Features, Characteristics, and Erosion (Boat-Based)
- Task 3: Spatially Define Riverbank Transition Points
- Task 4: Video and Photographic Documentation
- Task 5: Riverbank Stabilization Projects

These tasks are described in greater detail in Section 10 – Survey Methods.

Once all field efforts and post-processing are completed, data review and map generation of the 2013 FRR field data will be conducted and a final report will be generated. Data review will include, but not be limited to, the development of summary statistics of riverbank classifications based on Table 4 and Table 7, assessment of trends or correlations between adjacent riverbank characteristics, land-use and erosion, and comparisons of riverbank conditions with past FRRs. Mapping developed as part of this task will include, but not be limited to, maps depicting riverbank characteristics, types, stages, and extents of current erosion, indicators of potential erosion, adjacent land-use, and the location of bank stabilization projects. Figure 4 depicts an example of riverbank characteristic maps that have been included in past FRR reports. 2013 FRR mapping will follow previous FRR mapping styles so that data are comparable. A list of maps that may be included with the final report can be found at the end of this section. All maps will be developed in ArcGIS. A detailed list of deliverables that will be included in the final report can be found in Section 20 – Reports to Management.

Conceptual Schedule

Table 3 includes the project schedule. Given that FERC has requested the 2013 FRR be folded into the FERC relicensing process, review and approval of this document is subject to the timelines dictated by the ILP. The milestones highlighted in green are dictated by the ILP (the FERC regulation is cited in the table).

As part of the relicensing process, stakeholders submitted study requests by March 1, 2013. Study requests were addressed by FirstLight in the form of a Proposed Study Plan (PSP) on April 15, 2013. Stakeholder meetings were held with on May 15 and June 14, 2013 to discuss the PSP. FirstLight filed an Updated Proposed Study Plan based on these meetings June 28. Stakeholders filed comments with FERC on the Updated PSP on or before July 15, 2013. In accordance with the ILP schedule, FirstLight will be filing its RSP on August 14, 2013. This QAPP will be incorporated into FirstLight's RSP as an Appendix to the aforementioned study plan and thus will be subject to review and comment from stakeholders based on the schedule below.

FirstLight is proposing to initiate land-based studies (Task 1, Section 10) in the early fall of 2013. Boat based, full river mapping (Tasks 2, 3, and 4, Section 10) will be conducted in the late fall (mid-November 2013) during leaf-off conditions. In addition, FirstLight is proposing to reproduce the 2007 photo log created as part of Field, 2007 as part of the FRR field efforts. Due to the fact that the 2007 photo log was captured during summer conditions, FirstLight is proposing to reproduce the 2007 photo log during the summer 2014 in order to allow for direct comparisons of the 2007 and 2014 photo logs. Based on the ILP schedule, and assuming there is no dispute with this particular study, FERC would issue its study plan determination letter by September 13, 2013 which would allow sufficient time to conduct the November 2013 FRR. If an agency with mandatory conditioning authority disputes this particular study, FERC would not issue its study plan determination letter until December 12, 2013. Thus, FirstLight would have to delay conducting the 2013 FRR until 2014.

FirstLight is seeking to file the final report for the FRR in September 2014, as opposed to April 2014, to match the timeline for filing other relicensing studies and to allow for the inclusion of the photo log which will be collected in the summer 2014. As such, FirstLight submitted a request for extension to FERC on June 27, 2013.

Table 3: Project Schedule/Timeline

Milestone	Schedule
Conduct full river boat tour and discussion with CRSEC and FERC Staff	November 9, 2012
Develop technical approach for field data collection (river based and ground based observation, survey, data collection)	November 2012
Develop Quality Assurance Project Plan; distribute to CRSEC	
Meet with CRSEC to discuss proposed technical approach and QAPP	December 5, 2012
Draft Review of QAPP by Ct. River Streambank Erosion Committee and landowners	February 4, 2013
QAPP Preparation	March 2013
Stakeholders submit study requests (§5.9)	March 1, 2013
FirstLight files its PSP, which includes the FRR and QAPP (§5.11a)	April 15, 2013
Stakeholder Meetings to Discuss PSP (§5.11e)- specifically geology and soils	May 14-15, 2013
Stakeholders file written comments on PSP (§5.12)	July 14, 2013
FirstLight files its Revised Study Plan (RSP) (§5.13a)	August 14, 2013
Stakeholders file comments on RSP, if necessary (§5.13b)	August 28, 2013
FERC Issues their Study Plan Determination Letter (§5.13b)	September 12, 2013
[2]Notice of Formal Study Dispute (if necessary) (§5.14a)	October 2, 2013
Study Dispute Determination (§5.14 (1))	December 2, 2013
Conduct FRR Land-based Survey	Early Fall 2013
Conduct FRR Boat-based Survey	Mid-November 2013
Reproduce Field, 2007 Photo Log	Summer 2014
File FRR Report with FERC	September 2014

Data Quality Objectives

The data collected during this effort will be used to assess riverbank conditions in the Turners Falls Impoundment from the Turners Falls Dam to the Vernon Dam. Field data will be used to develop summary statistics and maps in order to better understand riverbank conditions in the study area. Results of field efforts, data review, and map generation will be used to determine the locations of potential future stabilization projects.

Field personnel will be equipped with field data sheets containing a description, photo, profile, and plan view of each type of erosion. Field datasheets used will be similar to Table 5, 6, and 7 and will also contain the reference photographs found in Appendix D. When classifying a riverbank segment during the boat-based survey, field personnel can quickly reference the field data sheet to ensure accurate classification of the features present. Field data sheets will also contain descriptions regarding the classification criteria for riverbank features and the stage, indicators, and extent of erosion based on Tables 5 and 7 as well as the reference photographs found in Appendix D. In addition, the 2013 FRR has been expanded to include a land-based assessment of the riverbanks. The land-based assessment will provide a means of identifying and mapping features that may not be visible during the boat-based survey (i.e. tension cracks).

Quality control following field data collection will be provided by comparing the data logging files, or field data sheets, of riverbank features and characteristics collected in the field with the geo-referenced

[2] Note that only agencies with mandatory conditioning authority can file for dispute resolution.

digital video showing the riverbanks at the time of the FRR (Task 4, Section 10). Given that the entire riverbank of the Turners Falls Impoundment will be surveyed and digitally videoed, if a question arises concerning the classification of any segment information in the data logging file(s) can be compared to an image or video of any such segment.

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.

Equipment Specifications & Accuracy

Equipment used during 2013 FRR field data collection will include: 1) sub-meter GPS; 2) laser range finder; 3) data-logger; and 4) geo-reference video equipment. The Trimble GeoXT Sub-Meter GPS and the Laser Technology, Inc. TruPulse 360B laser range finder will be used as the sub-meter GPS, data-logger, and laser range finder for this survey. Additional details and equipment specifications on this equipment can be found in Appendix A, B, and C.

The accuracy of a sub-meter GPS is assumed to be within one meter; however, the accuracy of any GPS depends on the availability of a sufficient number of satellites and the differential correction that is applied during data post processing. In order to ensure the most accurate data collection possible the location/time of day of the satellites will be determined for optimal GPS readings prior to initiation of GPS mapping. The GPS unit will collect the coordinates of the boat at the location where the riverbank classification is recorded. The laser range finder then calculates the azimuth and distance from the boat to the riverbank feature(s). The coordinates of the riverbank feature(s) will be calculated by combining these three measurements (boat location, distance, azimuth) to conduct an offset.

The position of the riverbank point will be shot from the boat using the laser range finder. The accuracy of a mapping grade laser rangefinder is +/- 1 foot for distance and +/- 1 degree for azimuth. Assuming the length of the shots from the laser range finder is 100 feet, an accuracy of one degree translates into approximately +/- 1.7 feet distance when projected along the length of the bank (100 times sine of 1 degree). Therefore, the combination of the accuracy of the sub-meter GPS and the laser range finder would be approximately +/-6 feet, with an estimated accuracy of within 10 feet for 90% of the measurements made.

Representativeness

All riverbanks and islands within the Turners Falls Impoundment from the Turners Falls Dam to the Vernon Dam will be included in this assessment. The comprehensive nature of the study area will allow for a representative dataset depicting the current riverbank features and conditions in the impoundment.

In order to ensure that GPS data collected in the field is representative of the actual riverbank features present a field test will be conducted using the GPS unit and laser range finder prior to the initiation of FRR mapping. The field test will consist of identifying a fixed, known point on the bank from a slow moving boat. The GPS unit and laser range finder will then be used to collect the position of the known point. The known point will be surveyed multiple times and the difference in location will be determined.

This approach will ensure representative riverbank transition points are captured in the field via GPS within the accuracy limits of the equipment.

In addition to field testing the GPS and laser range finder system, geo-referenced video will be taken of all riverbanks at the time of classification as a form of reference checking and quality control. Field datasheets containing descriptions, photos, profiles, and plan views of each type of erosion (Table 7) as well as descriptive information about the stage, extent, and indicators of erosion will be utilized and referenced by field personnel. This approach was described in more detail earlier in this section.

Comparability

Field collected data will be preliminarily reviewed and compared at the end of each day to ensure consistency in data collection methods and to identify any potential data collecting errors or anomalies. Any data that is found to be questionable will be flagged and reviewed in greater detail by the Project Manager. If data collection errors are present the data will be discarded and recollected.

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.

Following all field data collection efforts and post processing a comparison of the 2013 FRR will be made to the previous FRRs using summary statistics in ArcGIS. Comparison efforts will include evaluating changes in the length of riverbank shoreline experiencing erosion, severity of erosion, length of riverbank stabilization, success of erosion remediation efforts, identification of new erosion areas, etc. The purpose of these comparisons is to evaluate the temporal trends in riverbank erosion and to determine if an equilibrium of erosion and stabilization is developing.

Comparisons of the 2013 FRR with past FRRs will account for any differences in methods and the accuracy of the technology used in collecting the spatial component of the data. Comparisons with previous FRRs can be made due to the fact that each FRR is internally consistent regarding the characterization of riverbank segments and overall length of river covered in mapping. Summary statistics can be compared between each FRR conducted over time based on identifying identical or reasonably similar categories from one FRR to another on an overall length or percentage basis. However, a direct comparison of maps and spatial data in GIS software is not appropriate unless the differences in survey equipment and techniques are quantitatively addressed and incorporated into the analysis. To conduct a direct comparison without this key step may result in erroneous analysis and invalid conclusions. Additionally, given the expanded nature of the 2013 FRR, not all 2013 field data can be compared to previous FRRs due to the fact that previous FRRs may not have identified certain characteristics (e.g. stage of erosion, indicators of potential erosion, etc.).

Completeness

The methodology proposed in this QAPP, combined with the extent of the study area, will provide a complete and representative dataset of riverbank conditions in the Turners Falls Impoundment. When it is found that data do not meet the quality objectives outlined from this section the Project Manager or QA

Officer will determine what corrective action(s) must be taken. Incomplete data, as determined by the Project Manager or QA Officer, may lead to the need for re-assessment of a particular area if it is found that the available data are insufficient to meet project goals.

7 Training Requirements

The Project Manager and QA Officer will ensure that all field technicians have current training in the operation of all field data collection equipment (Section 6 – Equipment Specifications). In addition, the Project Manager will provide oversight and support to the field technicians when needed. There are no other specialized training or certification requirements needed to perform the tasks outlined within this QAPP.

8 Documents and Records

The Project Manager will be responsible for ensuring project staff review the QAPP, understand the data forms, and are fully trained in operating project equipment. All field data will be obtained in digital form as recorded on the data-logger and digital video/still photography. This information will be stored on various computer systems and servers at S&A and NEE offices.

To ensure that digital data files are secure, data logging files will be downloaded onto two computers at the end of each field day. At the end of the field data collection process, all digital files will be stored on computers/servers at S&A and NEE. Digital files from the data-logger and the geo-referenced video files will also be provided to FirstLight.

Field mapping equipment that will be used includes a sub-meter GPS, data-logger, and laser range-finder. Equipment maintenance schedule records will be maintained by the Project Manager at NEE in Amherst, MA. Copies of all maintenance records will be maintained by the Project Director at his office.

9 Sampling Process Design (Experimental Design)

The purpose of the FRR is to conduct a reconnaissance level survey that will provide an overview of riverbank conditions throughout the Turners Falls Impoundment. Study methods will include identifying and defining riverbank features and characteristics and the types, stages, indicators, and extent of erosion. This methodology was designed such that the classification criteria for riverbank characteristics and types, stages, and indicators of erosion are clearly defined and can be easily reproduced. The overall design of the survey is a census of all riverbanks within the Turners Falls Impoundment as opposed to sampling which would assume that only a portion of the area would be surveyed.

10 Survey Methods

The 2013 FRR methodology has been divided into several tasks and subtasks designed to effectively and efficiently accomplish the goals and objectives previously outlined in this QAPP. As such, study methods will consist of the following tasks:

- Task 1: Land-Based Observations
- Task 2: Classify Riverbank Features, Characteristics, and Erosion
- Task 3: Spatially Define Riverbank Transition Points
- Task 4: Video and Photographic Documentation

- Task 5: Riverbank Stabilization Projects

In order to show the full range of conditions that are observed within the Turners Falls Impoundment, and to be consistent with previous FRRs, the 2013 FRR will include the entire length of the impoundment from Vernon Dam to Turners Falls Dam. Islands within the Turners Falls Impoundment will also be included in this study. While reviewing the methodology it is important to note that the FRR is a reconnaissance level survey intended to provide an overview of riverbank conditions in the impoundment.

Task 1: Land-Based Observations

Based on comments received from various Agency and stakeholder groups a land-based assessment of the Turners Falls Impoundment riverbanks has been added to the 2013 FRR. Observations made as part of this evaluation will include identifying and defining areas of slope instability and potential future erosion as well as land-use assessments of adjacent properties.

Task 1a: Identify and Define Indicators of Potential Erosion

A land-based assessment of the riverbanks in the Turners Falls Impoundment will be implemented in order to identify and define indicators of potential erosion and bank instability. This assessment will include the entire Turners Falls Impoundment from the Vernon Dam to the Turners Falls Dam, including islands, except in areas where: 1) access is not possible or the area is impassible; 2) access is unsafe as determined by the field crew; or 3) bank conditions do not warrant assessment (e.g., bedrock areas). The field survey will be conducted by a fluvial geomorphologist/hydraulic engineer, geotechnical engineer, and riverbank stabilization/environmental consultant during the fall of 2013 prior to the boat-based survey described in Task 2.

Field observations will be based on the criteria found in Table 4 and will include: 1) gathering basic positional attribute information of the features identified; 2) identifying the locations of sensitive receptors; and 3) identifying and investigating indicators of potential erosion or bank instability that would not be readily visible from a boat. Indicators of potential erosion (excluding tension cracks) such as exposed roots, creep, overhanging banks, and notching are anticipated to be more easily identifiable from a boat than from walking along the riverbanks. As a result, these features will not be investigated in-depth as part of this task but will instead be included in the boat-based survey discussed in Task 2b. The primary focus of the land-based assessment will be to identify the location of and investigate tension cracks or other indicators of potential erosion that will not be clearly identifiable from a boat. For the purpose of this study tension cracks are defined as a cracks formed at the top edge of a bank that potentially could lead to topples or slides (Field, 2007). Figure 3 depicts an example of a tension crack.

Classification of the type(s), stage(s), and extent of erosion will not be included in this task as they will be more easily identified from a boat and therefore are included in Task 2b. However, if during the field investigation any types of erosion are observed that may not be easily identifiable from a boat those features will be documented. Classifications of the type of erosion that may be conducted as part of this task will follow the same methodology identified in Task 2b. Detailed discussion regarding the type(s), stage(s), indicators, and extent of erosion can be found in Task 2b, Table 5, 6, and 7.

Sensitive receptors, such as important wildlife habitat located at or near the riverbank, will be identified during both the boat and land-based surveys. The riverbank stabilization/environmental consultant will be responsible for the identification of these features. Sensitive receptors that will be documented will include, but not be limited to, bank swallow colonies, kingfisher nests, eagle nests, and prime odonate and mussel habitat.

When conducting the land-based assessment, the field crew will walk along the top of the banks to identify and note the location of tension cracks, sensitive receptors, or other features that may not be visible from a boat. The locations of these features will be captured via sub-meter GPS where satellite coverage will allow[3]. If GPS data collection is not possible, the location of the features will be approximated on field maps using aerial imagery. All field observations will be entered into a data-logger or recorded on field datasheets similar to Table 4. Geo-referenced digital photographs will be taken to document the features identified in the field and as a means of data control and reference checking.

Task 1b: Land-use Mapping

In addition to identifying and defining indicators of potential erosion, the land-uses of all properties adjacent to the riverbank will be identified as part of the land-based assessment.

Prior to field investigation, existing aerial imagery will be used to: 1) determine the width of riparian buffers; 2) develop a list of predetermined land-use categories that will be used during field classification; and 3) identify other pertinent land use information that may be useful during the field survey. MassGIS land-use layers may also complement preliminary analysis of the land-uses within the study area. As part of the land-based assessment, land-uses will be mapped for an area of approximately 200 feet horizontally from the top of the slope. The assessment will also determine the specific agricultural land-use in 2013 such as row or crop cover, measurement of riparian areas, and other land-use data not apparent from the aerial imagery or MassGIS layer(s). All observations will be stored on a data-logger or recorded on field datasheets similar to Table 4. The start and end points of land-use segments will be captured via sub-meter GPS where satellite coverage will allow. If GPS data collection is not possible, the location of the features will be approximated on field maps using aerial imagery.

The results of the land-use mapping combined with aerial imagery, MassGIS layers, and property ownership information obtained from the Town Assessor's in VT, NH, and MA will be combined to develop a geospatial dataset from which a series of land-use maps and land-use analyses will be generated. Areas that are observed to have a direct correlation between adjacent land-use and erosion will be documented.

[3] Due to extensive vegetation and tree cover found throughout the Turners Falls Impoundment (even in the fall) satellite coverage may be difficult to obtain in some areas and GPS data collection may not be possible.

Table 4: Connecticut River – Turners Falls Impoundment Riverbank Classifications for Land-based Survey

RIVERBANK FEATURE POSITIONAL ATTRIBUTES						
Right or Left Bank[4]						
Coordinates *(Start-End)*						
Distance from River						
Height above River						
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.*					
Adjacent Land Use						
EROSION CLASSIFICATION[5]						
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
Notes						

[4] As looking downstream
[5] Refer to Task 2 (Tables 6 and 7) for a complete list of classification definitions. Erosion types and indicators of erosion (excluding tension cracks) will be more easily identified by boat and therefore will not be a primary focus of the land-based survey. The primary objective of the land-based survey is to identify the locations of tension cracks, adjacent land-use, and other features that would not be easily identifiable from a boat. The methodology defined in Task 2 will not be duplicated as part of this task.

Figure 3: Example of Tension Cracks

(Field, 2007)

Task 2: Classify Riverbank Features, Characteristics, and Erosion

The classification criteria and methodology discussed below are based on the approaches that have been utilized in previous FRRs, comments received from various Agencies and stakeholders as well as recommendations of Field Geology Services in the report titled, *"Fluvial Geomorphology Study of the Turners Falls Pool on the Connecticut River between Turners Falls, MA and Vernon, VT"* (Field, 2007).

The purpose of this task is to identify and define the features and characteristics of the riverbanks in the Turners Falls Impoundment from the Vernon Dam to the Turners Falls Dam, including islands (Task 2a), and to classify each riverbank segment based on the type(s), stage(s), indicators, and extent of erosion (Task 2b). The classifications conducted as part of this task will be boat-based and will occur following completion of the land-based assessment (Task 1) but simultaneously with Tasks 3 and 4. The methodology described below is specific to the boat-based portion of the FRR which will be conducted independently of, but complimentary to, the land-based assessment discussed in Task 1. FirstLight is proposing to conduct the boat survey portion of the FRR in late fall (mid-November) 2013 during leaf off conditions.

The classification methods contained in this section have been clearly defined with proper support documentation to ensure that the methodology can be easily and accurately reproducible.

Task 2a: Identify and Define Riverbank Features and Characteristics

A boat survey will be conducted to identify and define features and characteristics of the riverbanks in the Turners Falls Impoundment. Classification will be based on the criteria found in Table 5 which contains pre-determined classification categories based on observations made during past FRRs. Classification categories found in Table 5 include bank slope, height, sediment composition, and vegetative cover. Each riverbank will be classified based on one attribute per characteristic. For example, riverbank X has a Slope of "Vertical", Height of "High", Sediment composition of "Boulders", and degree of vegetative cover of "Sparse". Table 6 provides definitions and descriptions of each classification.

Based on past FRRs it has been observed that riverbanks in the Turners Falls Impoundment generally consist of an upper and lower bank. Upper banks are often above water except during high flows, while lower banks are frequently or partially submerged. In order to accurately capture the characteristics of the entire riverbank, classification will be completed for both upper and lower bank characteristics. Table 5 includes classification categories for the upper and lower banks.

Riverbank segments will be developed based on observation of common characteristics for each feature within the segment. Transition points, or end points, from one riverbank segment to another, where characteristics of any riverbank features change, will be captured via sub-meter GPS, data-logger, and laser range-finder (Task 3). For example, if a 500 ft stretch of both upper and lower riverbank exhibits a consistent bank slope, height, sediment composition, degree of vegetative cover, and extent of erosion then that 500 ft stretch would be identified as one riverbank segment. Sub-meter GPS, data-logger, and laser range-finder would then be used to collect the coordinates of the start and end point of that segment. This method would be repeated for all riverbank segments throughout the study area. Erosion classifications, discussed in Task 2b, will be conducted for each riverbank segment.

Sensitive receptors, such as important wildlife habitat located at or near the riverbank, will be identified during the boat and land-based surveys. The riverbank stabilization/environmental consultant will be responsible for the identification of these features. Features that will be documented will include, but not be limited to, bank swallow colonies, kingfisher nests, eagle nests, and prime odonate and mussel habitat. The location of sensitive receptors will be collected via sub-meter GPS where satellite coverage will allow. If GPS collection is not possible, locations will be approximated on field maps using aerial imagery. Descriptions of each habitat will be entered into the data-logger or included on field datasheets. Geo-referenced video and/or photographs will be taken at all sensitive receptor sites as a method of reference checking and data control.

Observations made as part of this task will occur from a boat approximately 50-100 ft from shore, or closer if possible. In order to ensure consistent identification during this assessment a field datasheet will be developed based on Table 5 and Table 7 as well as reference photographs found in Appendix D. The field datasheet will be carried with the field crew and referenced when classifying riverbank characteristics. Field observations will be entered into a data-logger or recorded on field datasheets. Geo-referenced video will be taken to document the features identified in the field and as a means of data control and reference checking (Task 4).

The identification of riverbank characteristics and the establishment of riverbank segments is consistent with the approach used during past FRRs. Consistency between FRRs will provide a basis for comparison of 2013 results with past FRR efforts for riverbank features and characteristics that remain consistent.

Task 2b: Identify and Define the Type(s), Stage(s), Indicators, and Extent of Erosion

While conducting Task 2a, an erosion classification will be conducted of each riverbank segment. A typical sequence of assessment would generally entail: 1) classifying the characteristics of a given riverbank segment based on the criteria found in Table 5; 2) collecting the transition points of the bank segment via sub-meter GPS; 3) conducting an erosion classification of the bank segment; and 4) moving on to the next riverbank segment and repeating steps 1-3.

The erosion classification will be based on the criteria found in Table 5 and will include identification of the type(s), stage(s), indicators, and extent of erosion. Indicators of potential erosion such as exposed roots, creep, overhanging banks, and notching will be identified as part of this task. Indicators of potential erosion, such as tension cracks, that are not clearly visible from the boat will be investigated and identified in greater detail as part of the land-based assessment discussed in Task 1. Table 6 and 7 contain detailed descriptions, photos, profiles, and plan views of the criteria that will be used for the erosion classification.

Types of erosion identified in the field are based on the recommendations made by Field, 2007 and will consist of: 1) Falls (which can be classified as Undercuts or Gullies); 2) Topples; and 3) Slides or Flows. Slides can be further subdivided into subcategories Planar slip and Rotational slump. It should be noted that Field lists Slides and Flows as two separate types of erosion, however, given the fact that the FRR is a reconnaissance level survey, it may be difficult for field personnel to make the differentiation between a slide, planar slip, rotational slump, or flow in the field. As such, for the purpose of this study, Slides and Flows have been combined into one category. If field personnel can easily identify and make the differentiation between the specific type of Slide or Flow (e.g. planar slip, rotational slump, etc.) those observations will be noted on the data-logger or field data sheet. Definitions of each type of erosion can be found in Table 6 while photos, profiles, plan views, and descriptions can be found in Table 7. Each type of erosion present in a given riverbank segment will be identified and noted.

Based on the recommendation of Field, 2007 the 2013 FRR will incorporate an assessment of the indicators of potential erosion or bank instability that are present in a given riverbank segment. Indicators of potential erosion that will be identified include: 1) tension cracks (Task 1b); 2) exposed roots; 3) creep; 4) overhanging bank; 5) notching; and 6) other indicators. Definitions and descriptions of these features can be found in Table 6 and Table 7.

Indicators of potential erosion included in this study are based on the classifications proposed in Field, 2007 with some additions. It should be noted that Field classifies creep as a type of erosion and leaning trees as an indicator of erosion, however, based on the definition provided by Field in Table 7 creep is typically defined by the presence of tree trunks that are bent downslope at the base. Based on this definition, creep has been classified as an indicator of potential erosion for the purpose of this study. The classification of “other” as an indicator of potential erosion (Table 5) will be utilized if the field crew observes potential erosion features that do not fit into one of the predefined classifications. Any features noted as “other” will be described in detail on field data sheets or in the data-logger. All indicators of potential erosion in a given riverbank segment will be documented and noted.

The 2013 FRR will also include classifying the temporal or process stage(s) of erosion of each riverbank segment based on the recommendations of Field, 2007. While Field did recommend a template for erosion stage classifications, the template was based on a hypothetical sequence of erosion composed of various types of erosion. Field’s sequence described the process of a riverbank eroding and then eventually becoming more stable after the riverbank slope has decreased in steepness and a beach has formed to protect the slope. This process occurs through an ongoing temporal riverbank transition process during stages of stability and erosion or instability. What Field had labeled as stages of erosion were actually types of erosion through the processes of riverbank evolution. These various types of erosion are already included in the erosion classification and, as such, Field’s recommended stages of erosion will not be adopted for this study. Temporal or process stages of erosion that will be included in the 2013 FRR will include: 1) Potential Future Erosion; 2) Active Erosion; 3) Eroded; and 4) Stable. Definitions and descriptions of each stage of erosion can be found in Table 6. A temporal or process stage of erosion will be assigned to each bank segment identified in Task 2a based on the type(s) of erosion and indicators of potential erosion present in that segment.

Given that multiple stages of erosion may occur at the same location or within a riverbank segment, all stages of erosion present in a segment will be identified and noted, however, for classification purposes only the dominant stage of erosion for each bank segment will be used to classify that specific segment. For example, if a bank segment contains various levels of all four stages of erosion but Potential Future Erosion is the dominant stage, that bank segment would be classified as Potential Future Erosion.

The extent of current erosion will be classified based on the amount of active erosion present over the total surface area in a given riverbank segment. Indicators of potential erosion will not be factored into determining the extent of current erosion as these indicators do not represent current erosion. Classification categories will include: 1) None/Little; 2) Some; 3) Some to Extensive; and 4) Extensive. Table 3.1.1-3 provides descriptions of each extent classification. The extent of current erosion will be based on the approximate percentage of active erosion occurring over the total surface area of a given riverbank segment. In addition, field observations of the riverbank segment will be compared to representative photographs depicting the four extent classifications as an additional form of reference checking. Photographs of the riverbanks taken during a preliminary investigation of the Turners Falls Impoundment in November 2012 during leaf off conditions will be used for this comparison. Through the qualitative approximation of the percent of active erosion present combined with the comparison of field observations with the representative photographs a determination will be made as to the extent of current erosion present. To ensure accurate and consistent classification, field personnel will be equipped with field datasheets which will contain descriptions and photographs of each extent classification. This approach is consistent with the recommendations of Field, 2007 in regard to identifying the type of erosion as well as being consistent with the methodology used for previous FRRs and the level of effort required to conduct a reconnaissance level survey. Representative photographs that will be used for this comparison are included in Appendix D.

All erosion classifications conducted as part of this task will occur from a boat approximately 50-100 ft from shore, or closer if possible. In order to ensure consistent identification during this assessment a field datasheet will be developed based on Table 5, 6, 7, as well as the representative photographs included in Appendix D. The field datasheet will be carried with the field crew and referenced when conducting the erosion classification. Field observations will be entered into a data-logger or recorded on field datasheets. Geo-referenced video will be taken to document the features identified in the field and as a means of data control and reference checking (Task 4).

Table 5: Connecticut River – Turners Falls Impoundment Riverbank Classifications for Boat-based Survey

UPPER RIVERBANK CHARACTERISTICS[6]						
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%)*		

[6] 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 field measurements of characteristics.

Table 6: Riverbank Classification Definitions

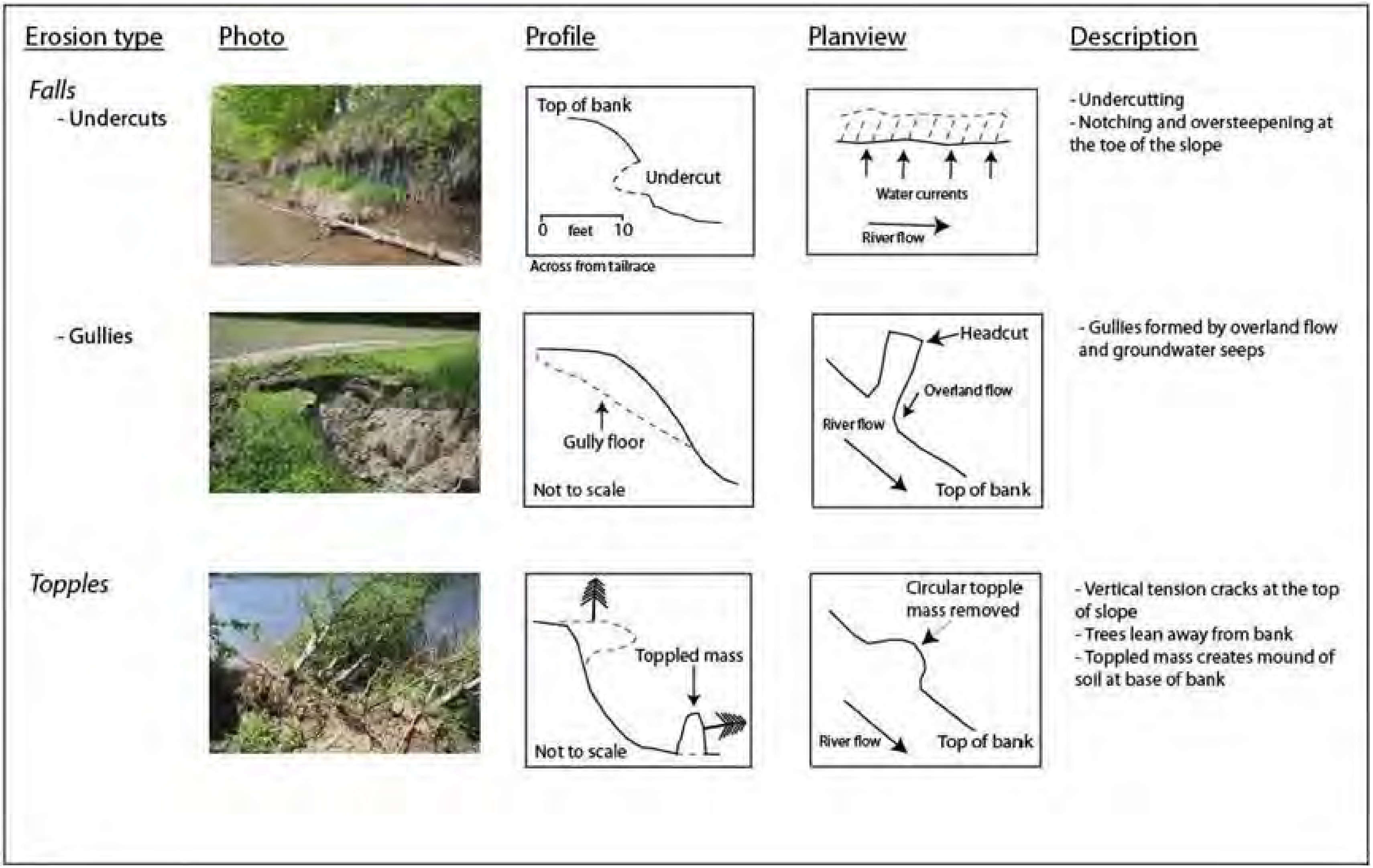
RIVERBANK CHARACTERISTICS *(Upper and Lower)*[7]	
Riverbank Slope	**Overhanging** – any slope greater than 90º
	Vertical – slopes that are approximately 90º
	Steep – exhibiting a slope ratio greater than 2 to 1
	Moderate – ranging between a slope ratio of 4 to 1 and 2 to 1
	Flat – exhibiting a slope ratio less than 4 to 1[8]
Riverbank Height	**Low –** height less than 8 ft above normal river level[9]
	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 2 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[10]	**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.
Stage(s) of Erosion	**Potential Future Erosion –** riverbank segment exhibits multiple or extensive indicators of potential erosion

[7] All quantitative classification criteria (e.g. slope, height, vegetation, extent, etc.) will be based on approximate qualitative estimates made during field observations of riverbanks. The FRR is a reconnaissance level survey that will not include quantitative analysis.
[8] Beaches are defined as a lower riverbank segment with a flat slope
[9] 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').
[10] Field, 2007

	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[11] –** 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

[11] 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.

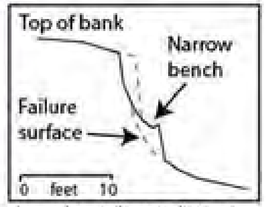
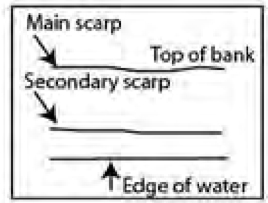
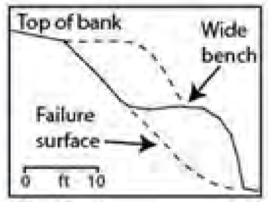
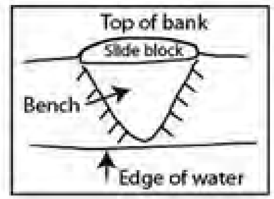
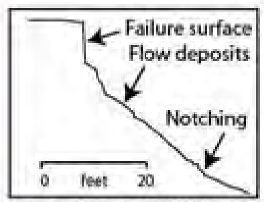
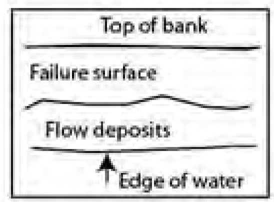
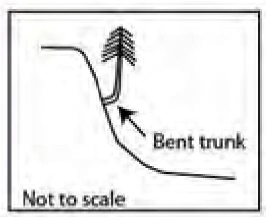
Table 7: Types of Erosion Occurring in the Turners Falls Impoundment and their Characteristics



Erosion type	Photo	Profile	Planview	Description
Falls - Undercuts		Top of bank; Undercut; 0 feet 10; Across from tailrace	Water currents; River flow	- Undercutting - Notching and oversteepening at the toe of the slope
- Gullies		Gully floor; Not to scale	Headcut; Overland flow; River flow; Top of bank	- Gullies formed by overland flow and groundwater seeps
Topples		Toppled mass; Not to scale	Circular topple mass removed; River flow; Top of bank	- Vertical tension cracks at the top of slope - Trees lean away from bank - Toppled mass creates mound of soil at base of bank

(Field, 2007)

Table 7: Types of Erosion Occurring in the Turners Falls Impoundment and their Characteristics (continued)

Erosion type	Photo	Profile	Planview	Description
Slides - Planar slip		 Across from tailrace (Split River)		- Vertical tension cracks at top of slope - Top surface of slide mass has flatter slope than rest of bank (narrow bench) - Trees lean in towards bank - Trees can remain in growth position despite sliding
- Rotational slump		 Munns Ferry		- Vertical tension cracks at top of slope - Deeper seated than slips - Trees lean in towards bank - Arcuate failure surfaces
Flows - Grain flows		 Downstream RR Bridge in VT (Kendall)		- Colluvial deposits created by flows accumulate at base of slope to form concave up surfaces
Creep			Not applicable	- Tree trunks bent downslope at base

(Field, 2007)

Task 3: Spatially Define Riverbank Transition Points

As an integral part of classification of a riverbank segment (Task 2), the locations of transition points, or end points, from one riverbank segment to another will be captured via sub-meter GPS, data-logger, and laser range-finder (Task 3). Classification of features (Task 2), mapping of transition points, and video and photographic documentation (Task 4) will occur from a boat approximately 50-100 ft from the bank line, or closer if possible.

The individual conducting the classification (Task 2, Table 5) will select a point of transition from one riverbank segment to another and "shoot" this point with the laser range-finder to determine the distance and azimuth to the riverbank from the boat. At the same time, the sub-meter GPS unit will collect the position of the boat. The distance and azimuth from the laser range-finder is automatically entered into the data-logger. The data-logger will then conduct an offset using the combination of these three measurements (boat GPS location, distance, and azimuth) to calculate the coordinates of the transition point. Once the offset has been conducted the data-logger will alert the user that the coordinates of the transition point were stored successfully. This process will be repeated at each transition point. Appendix A and B provide specifications for the sub-meter GPS and laser range-finder models that have been selected for this survey.

All GPS data will be collected using a standard coordinate system such as NAD 83 State Plane or UTM coordinates. The accuracy of the sub-meter GPS is assumed to be within one meter; however, the accuracy of any GPS in the field can vary depending on several factors including satellite availability, multipath interference (i.e. trees), and the differential correction solution. To test the positional accuracy of the GPS/laser range-finder system a known, fixed point will be located on the bank from a slow moving boat. The GPS unit and laser range-finder will then be used to collect the location of the known point. The point will be surveyed multiple times and the difference in location will be determined.

The number of riverbank segments identified will depend on the frequency of transitions between various features and classifications observed in the field. There is no set distance of segmentation along the river[12]; however, segments shorter than 20 ft will not be captured due to accuracy limitations of the equipment.

The location of sensitive receptors, such as important wildlife habitat, will also be mapped via sub-meter GPS.

Task 4: Video and Photographic Documentation

As a means of data control and reference checking, video and photographic documentation will be taken of all riverbank segments identified in Tasks 2 and 3. Geo-referenced video of all riverbanks will be taken from a boat at an appropriate distance from the bank line so that the image of the riverbank fills most of the screen while still including the necessary perspective of the water line and some water. This work will be conducted immediately prior to or following classification of the riverbank (Task 2). If questions arise regarding how a riverbank segment was classified the videos and photos depicting the specific features and characteristics present can be referenced. Geo-referenced photographs will be taken to document observations of selected riverbank features and characteristics as part of the land-based

[12] Previous FRRs have resulted in a range of segment lengths from 20 ft to over 4,000 ft, with average segment lengths from 480 ft to 1,267 ft. The 2008 FRR resulted in the smallest average segment length of the various FRRs compared (*"Response to Field Geology Services' 2011 'Detailed Analysis of the 2008 Full River Reconnaissance of the Turners Falls Pool on the Connecticut River,' July 2012.")*

survey (Task 1). Additionally, the photo log created as part of Field, 2007 will be reproduced, to the best extent possible, during summer 2014. Given that the 2007 photo log was collected in the summer, reproduction of the photo log in the summer of 2014, as opposed to the fall 2013, will allow for direct comparison between the photo logs.

Task 4a: Geo-referenced Video

Geo-referenced video technology will be utilized to capture digital video images of the riverbanks as well as the coordinates where each video image was taken. The output video images and spatial locations will document and verify what the riverbanks looked like during the 2013 FRR and provide an additional source of quality control and reference checking.

The geo-referenced videotaping will be conducted using Red Hen Systems equipment; this equipment is the same equipment that was utilized for the 1998, 2001, 2004 and 2008 FRRs. Red Hen Systems will provide the hardware and software necessary to collect the geo-referenced video in the field, import the field collected data to a desktop, and generate web-based maps for analysis and to aid in the decision making process (Task 5). Components of this system include: the VMS-HDII (which includes the VMS-333 geo-referencing equipment); a compatible digital video camera; and MediaMapper Software. Appendix C provides detailed information on this system. Additional information can be found on the Red Hen Systems website (http://www.redhensystems.com).

Task 4b: Re-collection of 2007 Photo Log

The riverbank photo log completed 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"* (Field, 2007) will be repeated as part of the 2013 FRR. The replication of the 2007 photo log will be done as closely as possible to the original photos within the context of FRR field activities.

Given that the 2007 photo log was collected during summer conditions (June 15-21, 2007), the reproduction of this photo log will occur during the summer 2014, as opposed to fall 2013, in order to ensure consistency and that direct comparisons can be made. Once collected, comparisons between the 2007 and 2014 photo logs will be made to identify changes visible along the banks (Field, 2007). If deemed relevant, digital image logs taken in 2001 and 2004 may also be incorporated into this analysis where the bank position can be confirmed relative to the photo log (Field, 2007).

Task 5: Riverbank Stabilization Projects

The 2013 FRR will provide an evaluation of each of the restoration projects constructed to date as part of the ECP (Simons, 1999) as well as recommendations for potential future stabilization projects. Descriptions of the successes and failures of each design, construction implementation, revegetation, invasive species concerns, and long term maintenance recommendations will be included in this assessment. Recommendations for potential future projects will be based on the findings of the 2013 FRR mapping.

Task 5a: Evaluation of Past Bank Stabilization Projects

Each of the bank stabilization projects constructed since 1996 will be evaluated in 2013 to determine if the primary goals of erosion control, reduction of sediment supplied to the river, bank stability, and the establishment of native vegetation have been achieved. If it is determined these goals have not been met, the reasons for the failure(s) will be explored. Construction methods, site contractors, materials used, access routes, construction techniques, and plant materials have evolved between 1996 and 2013. As part of this assessment, each of these criterion and methods will be evaluated. The various techniques or methods that have been used will be discussed based on their relative success or failure in meeting the primary goals previously mentioned. Recommendations for any future bank stabilization projects will be provided based on the long term successes or failures of the previously constructed projects. Items to be evaluated will include: cultural resources; wildlife habitat; construction staging; construction access; construction equipment; specified materials; land clearing; bank grading; vegetation establishment; invasive species; long-term operations and maintenance and stability assessments; and the time of year of construction.

Task 5b: Recommendations for Future Bank Stabilization Projects

The data collected during the 2013 FRR will provide a comprehensive classification of bank erosion including identifying the locations of active and potential future erosion in the Turners Falls Impoundment. Based on these data, a hierarchy for future stabilization work will be developed. When developing this hierarchy it is important to note that not all project sites can or should have intervention. The results of this task will provide a list and map of those locations where future bank stabilization projects may be considered. In addition, specific construction techniques will be recommended where appropriate.

11 Sample Handling and Custody

No samples will be collected during the FRR.

12 Analytical Methods

Once all field efforts and post-processing are completed, data review and map generation of the 2013 FRR field data will be conducted. Data review will include, but not be limited to, the development of summary statistics of riverbank classifications based on Table 4 and Table 5, assessment of trends or correlations between adjacent riverbank characteristics, land-use and erosion, and comparisons of riverbanks conditions with past FRRs.

ArcGIS datasets (shapefiles or geodatabases) will be developed and populated utilizing the field data collected as part of Tasks 1, 2, and 3 (i.e. GPS points, field observations, etc.). All spatial analysis and map generation will occur using ArcGIS software. The raw field data (i.e. GPS points, field data sheets, data-logger files, photographs, and videos) will be stored in a secure location as a means of data control and reference checking. Geo-referenced video from the boat-based survey and geo-referenced photographs from the land-based survey will be available, upon request, in documenting and evaluating riverbank conditions.

Transition points collected via GPS as part of Task 3 will be used to develop a GIS layer containing the spatial segmentation of the riverbanks in the Turners Falls Impoundment. The attribute table(s) of this GIS layer(s) will be populated with the information gathered from Tables 4 and 5. Summary statistics and maps for each category found in these tables will be developed. In areas where erosion phenomena exist, riverbank characteristics identified in Table 5 will be documented to determine if a correlation or trend exists between specific riverbank characteristics and erosion. Land-use data compiled as part of Task 1 will also be evaluated for correlations or trends with erosion features present.

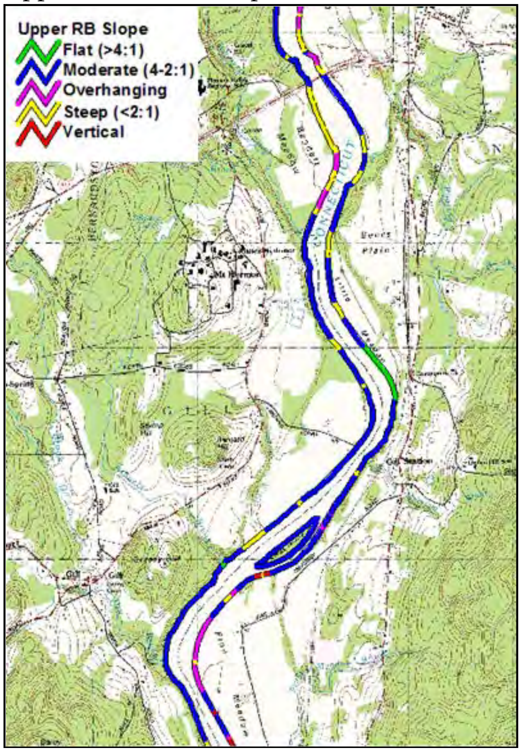
A comparison of the 2013 FRR will be made to the previous FRRs using summary statistics and analysis in ArcGIS. Comparison efforts will include evaluating changes in the length of riverbank shoreline experiencing erosion, severity of erosion, length of riverbank stabilization, success of erosion remediation efforts, identification of new erosion areas, etc. The purpose of these comparisons is to evaluate the temporal trends in riverbank erosion and to determine if an equilibrium of erosion and stabilization is developing.

Comparisons of the 2013 FRR with past FRRs will account for any differences in methods and the accuracy of the technology used in collecting the spatial component of the data. Comparisons with previous FRRs can be made due to the fact that each FRR is internally consistent regarding the characterization of riverbank segments and overall length of river covered in mapping. Summary statistics can be compared between each FRR conducted over time based on identifying identical or reasonably similar categories from one FRR to another on an overall length or percentage basis. However, a direct comparison of maps and spatial data in GIS software is not appropriate unless the differences in survey equipment and techniques are quantitatively addressed and incorporated into the analysis. To conduct a direct comparison without this key step may result in erroneous analysis and invalid conclusions. Additionally, given the expanded nature of the 2013 FRR, not all 2013 field data can be compared to previous FRRs due to the fact that previous FRRs may not have identified a given characteristic (i.e. stage of erosion, indicators of potential erosion, etc.).

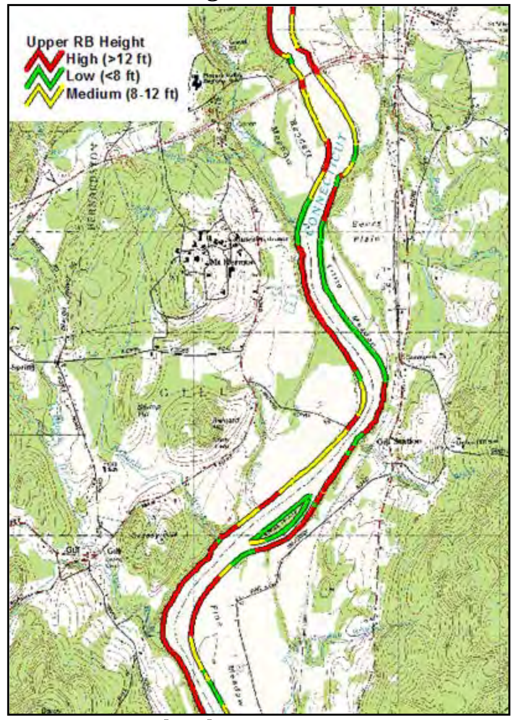
Mapping developed as part of this task will include, but not be limited to, maps depicting riverbank characteristics, types, stages, and extents of current erosion, indicators of potential erosion, adjacent land-use, and the location of bank stabilization projects. Figure 4 depicts an example of riverbank characteristic maps that have been included in past FRR reports. 2013 FRR mapping will follow previous FRR mapping styles so that data are comparable. A list of maps that may be included with the final report can be found at the end of this section. All maps will be developed in ArcGIS.

Figure 4: 2001 FRR maps for Height, Slope, Vegetation, and Material

Upper Riverbank Slope – Section 3

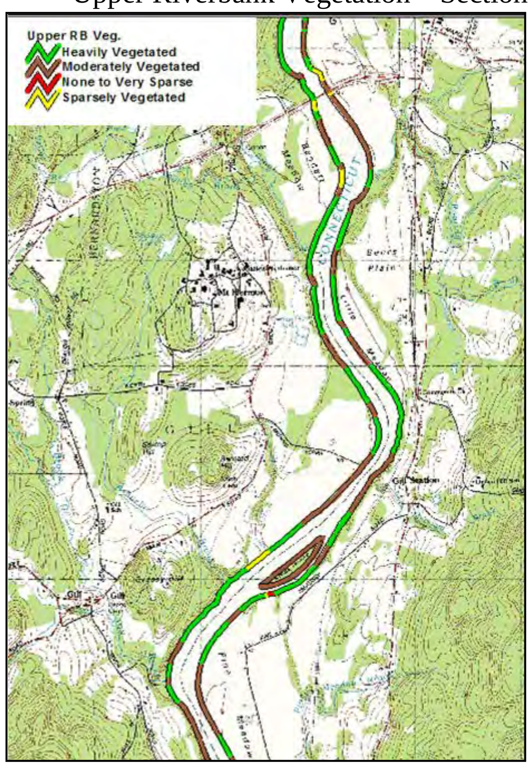


Upper Riverbank Height – Section 3



Lower Riverbank Sediment – Section 2

Upper Riverbank Vegetation – Section 3



13 Quality Control

To improve bank visibility the 2013 FRR will be conducted in November 2013 during leaf-off. A land-based bank survey and evaluation will be conducted prior to the FRR to serve as a control, and to provide additional site specific data. Pre-survey field trials were conducted in November, 2012 by S&A and NEE to calibrate sampling techniques and methods with all field staff.

The mapping and identification of erosion features has a degree of subjectivity which may lead to reduced accuracy or quantification errors. The protocols, data collection methods, and verification of data highlighted in this QAPP are intended to reduce the level of error and subjectivity as much as possible. All photographs, data collected, field forms, video, and survey information is to be maintained in its original format for future referencing if needed. Collected field data will be reviewed to document any inconsistencies in the data. All discrepancies need to be researched, and if the error is not determined, the necessary data will be measured again. If error results from improper use of equipment, or operator error, then retraining must occur before new data collection may proceed.

Field data will be checked at the end of each day by the Project Manager to ensure data are properly collected. All data entered on the data forms will then be checked by the QA/QC Manager. Any problems identified will be discussed with the staff and corrected in the field the following day.

Quality control following field efforts will be provided by comparing the data logging files, or field data sheets, of riverbank features and characteristics collected in the field with the geo-referenced digital video showing the riverbanks at the time of the FRR (Task 4, Section 10). Given that the entire riverbank of the Turners Falls Impoundment will be surveyed and digitally videoed, if a question arises concerning the classification of any segment information in the data logging file(s) can be compared to an image or video of any such segment.

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 collection. This approach also provides a method for reference checking any subsequent interpretation of the field survey data after the survey has been completed.

14 Instrument and Equipment Testing, Inspection, and Maintenance

Field equipment used by the field personnel will include a sub-meter GPS, a data-logger, a laser range-finder, and a geo-referenced videotaping system. Regular maintenance procedures will be conducted in accordance with the instrument manufacturer and a log of the regular maintenance will be kept. All mechanical and electronic equipment will be cleaned and dried each day if necessary. Spare parts and batteries will be readily available so there will be no interference with data collection in the case of mechanical breakdown. Records will be maintained for all instruments used to ensure conformance to the specified requirements. The instruments are to be evaluated before use to confirm proper working function to the degree of accuracy necessary to accomplish the task for which it has been assigned.

GPS units must be turned on for a minimum of 15 minutes before data collection begins to ensure the current satellite almanac has been transmitted and received by the unit. The GPS unit will be benchmarked with a position of known geographic location at the beginning and at the end of the collection period, and average precision/error can be calculated for points collected. If the error is > 49 feet, then satellite coverage was insufficient at that time, and the data will need to be recollected.

The accuracy of the sub-meter GPS is assumed to be within one meter; however, the accuracy of any GPS in the field can vary depending on several factors including satellite availability, multipath interference (i.e. trees), and the differential correction solution. To test the positional accuracy of the GPS/laser range-finder system a known, fixed point will be located on the bank from a slow moving boat. The GPS unit and laser range-finder will then be used to collect the location of the known point. The point will be surveyed multiple times and the difference in location will be determined.

At the beginning of each day the geo-referenced video equipment will be tested by taking video of a bank prior to the start of actual data collection. The test video will be played back to ensure that the video equipment is in proper working order. If the video equipment is not working, the field crew will take necessary action(s) in accordance with the equipment manual.

15 Instrument and Equipment Calibration and Frequency

Equipment and instruments used for this effort do not require calibration.

16 Inspection and Acceptance of Supplies and Consumables

General supplies will be purchased from different suppliers. These supplies will be purchased as needed by field staff and should not require special inspection.

17 Non-direct Measurements

The non-direct methods that will be used as part of the 2013 FRR include: 1) USGS topographic maps for locations in VT, NH and MA, 2) ortho-photographs for these same states and 3) historical data, previously published and prepared in ArcGIS. All non-direct methods and materials will be used to support the field work.

18 Data Management

Data collected in the field will mostly be digital. This will include the data-logger files of riverbank features and characteristics, the geo-referenced digital video, digital photos and date-logger files of the land-based field work. These files will be downloaded to computers at the end of each field day. After verification and validation is completed, the reviewed and finalized data files will be downloaded to computers/servers at both S&A and NEE.

All field data sheets will be checked for completeness after each survey, and at the end of each day. The team leader will inspect all field records before leaving the site, and field data sheets will be reviewed by the Project Manager each day. Any omissions or discrepancies will be addressed immediately. Original field data sheets will remain in the possession of the field team member, and a copy will be placed in the electronic project file along with any other pertinent site information. Any secondary data will be stored in the project file, in either hardcopy, or electronic format.

All computer generated documents will be inspected for validity, completeness and accuracy by the QC Manager and Project Manager. All project files and drawings will have a unique file name including the project number and name. Every drawing will have a backup copy. Paper files will be maintained in a secure filing cabinet. Electronic files will be password protected and will not be modified without proper authorization. Electronic files will be backed up every night and stored off site. Inactive files are archived, and once archived they are changed to read-only status.

19 Assessments and Response Actions

Attention to quality is a primary consideration of the project. The Project Manager will formally review the performance of the field technicians at times during the sampling season to ensure proper data collection. All personnel associated with the project will ensure that the standard operating procedures be followed closely. Training and maintenance records will be filled out in a timely manner. Refresher courses for the field technicians will be conducted for each new season and as needed if it is determined that the field technicians are not sampling correctly.

To ensure data quality, the QA Officer will accompany the field crew at least once during the sampling period.

Equipment errors may occur and must be accounted for by reporting them to the Project Manager. If the error is identified before sampling takes place, the equipment will be labeled as broken and repaired or replaced by properly working equipment, if available. If malfunctioning equipment affects the data, the equipment will be recorded as such on the field data sheet and immediately reported to the Project Manager.

The Project Manager is ultimately responsible for oversight of all activities of the data collection process. The QA Officer will ensure that field technicians are performing all data collection as prescribed by the QAPP.

20 Reports to Management

Following the completion of data evaluation and map generation, a final report documenting the methodology and results of the 2013 FRR will be developed. Specifically, the report will include: summary statistics of riverbank features and characteristics; data-logging and field forms; photographs; overall assessment of erosion within the Turners Falls Impoundment; long term trends and comparison of FRRs over time; evaluation of existing stabilization projects; sediment deposition at stabilization sites and recommendations for future preventative maintenance and bank stabilization work; summary of land-based erosion evaluations; recommendations for riparian buffers based on the land use mapping and adjacent erosion; and recommendations for avoidance or protection of sensitive receptors and significant wildlife habitat areas.

Deliverables in the final report will include:

<u>Task 1 – Land-Based Observations</u>

- A map of the location of tension cracks and other indicators of potential erosion that are collected as part of this task;
- Sensitive receptors map (wildlife habitat);
- Land-use mapping;
- Documentation of correlations between adjacent land-uses and erosion;
- Geo-referenced photographs; and

- Data logging and field forms

Task 2 – Classify Riverbank Features, Characteristics, and Erosion

- Riverbank characteristic maps including: slope, surficial sediment/substrate, height, and vegetation;
- Riverbank segments map;
- Riverbank erosion classification maps including: erosion types, erosion stages, indicators of potential erosion, and extent of current erosion;
- Sensitive receptors map (wildlife habitat);
- Summary statistics of riverbank characteristics and erosion features;
- Documentation of correlations between specific riverbank characteristics and erosion; and
- Data logging and field forms

Task 3 – Spatially Define Riverbank Transition Points

- Development of a spatial segmentation dataset of the riverbanks in the Turners Falls Impoundment;
- GPS data points denoting the start and end points of all riverbank segments;
- GPS data points denoting the location of sensitive receptors; and
- Data logging and field forms

Task 4 – Video and Photographic Documentation

- Geo-referenced video of the entire Turners Falls Impoundment;
- Geo-referenced photographs of ground-based observations;
- Updated 2007 photo log of riverbanks; and
- Comparison of 2007 and 2014 photo logs, where applicable

Task 5 – Riverbank Stabilization Projects

- Evaluation of existing bank stabilization projects;
- Recommendations for future preventative maintenance projects;
- Recommendations for future bank stabilization projects;
- Maps denoting the locations of all past, present, and potential bank stabilization projects; and
- Geo-referenced photographs

21 Data Review, Verification, and Validation

The project QA Officer will review all data collected as well as subsequent calculations to evaluate whether QC requirements have been met and whether data are usable to obtain the stated objectives of the project based on criteria contained in the QAPP. Subsequent final review and approval will be made by the Project Manager.

22 Verification and Validation Methods

Validation and verification of field data will be conducted on a daily basis by reviewing the data-logger files to ensure that all riverbank segments observed are fully completed, covering all features and characteristics in the classification matrix. GPS location data will be checked comparing the segment of riverbank observed each day with the locations plotted on the computer.

Field observations of riverbank features and characteristics will be compared with images captured from the geo-referenced digital video files. Since geo-referenced video will be available for the entire Turners Falls Impoundment, the classification of any riverbank segment can be verified by comparing the observations in the data-logger to the geo-referenced video.

When it is found that data do not meet the quality objectives of the QAPP, or do not adhere to the QC measures, the Project Manager may determine what corrective action must be taken:

- Incomplete data may lead to re-surveying of river bank segments if the available data are insufficient to meet project goals

- When data quality is poor, the Project Manager will apply one of the following actions:
    1. Systems audit for measurements in questions;
    2. Immediate re-survey of the river bank segments in question;
    3. Revise riverbank segment classification based on geo-referenced video;
    4. Rejection of identified data with a written explanation; or
    5. Rejection of survey segments from the assessment with recommendation for re-survey.

23 Reconciliation with User Requirements

The classification of any particular segment can be compared against the photographs referenced during classification by utilizing images from the corresponding geo-referenced video images taken during the field survey. If the project objectives are met, the user requirements have been met. If the project objectives have not been met, the corrective actions will be established by the Project Manager.

24 References

Field Geology Services (FGS). (2007). *Fluvial Geomorphology Study of the Turners Falls Pool on the Connecticut River between Turners Falls, MA and Vernon, VT.* Farmington, ME: Author.

Simons & Associates (S&A). (1999). *Erosion control plan for the Turners Falls Pool of the Connecticut River.* Prepared for Northeast Utilities. Midway, UT: Author.

Simons & Associates (S&A). (2009). *Full river reconnaissance – 2008: Turners Falls Pool, Connecticut River*. Prepared for FirstLight Power Resources. Midway, UT: Author.

APPENDIX A - TRIMBLE GEOXT SUB-METER GPS SPECIFICATIONS

Trimble GeoXT Sub-Meter GPS - Rugged and reliable data collection

The Trimble® GeoXT™ handheld from the GeoExplorer® 3000 series is the essential tool for maintaining your GIS. A high performance GPS receiver combined with a rugged handheld computer, the GeoXT handheld is optimized to provide reliable location data, when and where you need it.

It's ideal for use by utility companies, local government organizations, federal agencies, or anyone managing assets or mapping critical infrastructure who needs accurate data to do the job right—the first time. With EVEREST™ multipath rejection technology onboard, the GeoXT handheld records quality GPS positions even under canopy, in urban canyons, and in all the everyday environments you work in, so you know your GIS has the information that others can depend on.

And if you need that extra edge in precision, you can collect data with Trimble TerraSync™ software, Trimble GPScorrect™ extension for Esri ArcPad software, or Trimble Positions™ Mobile extension and then postprocess it back in the office with Trimble GPS Pathfinder® Office software, Trimble GPS Analyst™ extension for Esri ArcGIS Desktop software, or Trimble Positions Desktop add-in. These office processing suites use the new Trimble DeltaPhase™ technology to achieve 50 cm accuracy for GPS code measurements after postprocessing, and even higher levels of postprocessed accuracy are possible when you log GPS carrier data for extended periods.

With a powerful 520 MHz processor, 128 MB RAM, and 1 GB of on board storage, the GeoXT handheld is a high performance device designed to work as hard as you do. The handheld gives you all the power you need to work with maps and large data sets in the field, and its high resolution VGA display allows for crisp and clear viewing of your data.

With the GeoXT handheld you have the flexibility to work exactly the way you want to. The handheld is powered by the industry-standard Windows Mobile® version 6.1 operating system, so you can choose a software solution designed for your field requirements, whether off-the-shelf or purpose-built. And you can use the built-in wireless LAN connection to access your organization's secure network and get the most up-to-date information. You can also wirelessly connect to other devices such as Bluetooth-enabled laser rangefinders and barcode scanners for convenient cable-free solutions that keep you productive in the field.

Rugged design and powerful functionality are the hallmarks of the GeoExplorer® series. When accuracy is critical, the GeoXT handheld delivers with unprecedented efficiency and reliability, when and where you need it.

Key features:

- Real-time submeter GPS with integrated SBAS and EVEREST multipath rejection technology
- 50 cm accuracy after postprocessing with Trimble DeltaPhase technology
- High-resolution VGA display for crisp and clear map viewing
- Bluetooth and wireless LAN connectivity options
- 1 GB on board storage plus SD slot for removable cards
- Windows Mobile version 6.1 operating system

Rugged handheld with all-day battery

APPENDIX B – LASER RANGE FINDER EQUIPMENT SPECIFICATIONS

LTI TruPulse 360B

Laser Technology, Inc. http://www.quantumgear.com/trupulse-360b/

LTI TruPulse 360B

Now with TruVector Compass Technology™ and BlueTooth™ wireless transfer of data!

$1,695.00

Quantity: 1

Detailed Description

The TruPulse 360B includes all of the features of the 360 plus BlueTooth™ wireless data transfer

This model is the only all-in-one compass/laser that produces the best possible azimuth accuracy regardless of what angle you shoot from. So, whether you need accurate distance and height measurements or you want to expand your capabilities with a compass, there is a TruPulse model designed just for you. Nothing on the market offers this kind of functionality, with such a compact design and low price point. Start mapping more and moving less today.

Industries: Forestry, Natural Resources, GIS/GPS, Construction, Mining, Utilities, Telecom

Quick Links:
TruPulse Series Specs

By embedding TruVector compass technology™ into the TruPulse 360, this unit is transformed into an integrated compass, distance and height laser range finder that delivers mapping-grade accuracy without inclination limitations. With the TruPulse 360 rangefinder you can acquire multiple targets from a single location, without ever having to worry about compromising your data.

The TruPulse 360B offers increased productivity

Tilt the TruPulse 360 89 degrees, turn it on its side, or even hold it upside down, and the TruPulse 360 will give you accurate azimuth in any direction it's aimed. It even has a built in system that will alert you if you need to recalibrate the unit.The TruPulse 360 is small enough to fit in your pocket, yet powerful enough to deliver professional, mapping-grade accuracy in a hand-held, point-and-shoot package. Find a safe convenient point of view and start collecting field data.

(All specifications are subject to change without notice.)
Dimensions: 5 inches x 2inches x 3.5 inches (12 cm x 5 cm x 9 cm)
Weight: 8 ounces (220 g)
Data Communication: Serial, via wired RS232 (standard) or wireless Bluetooth (optional)
Power: 3.0 volts DC nominal
Battery Type: (1) CRV3 or (2) AA
Battery Duration: CRV3 - Approx. 15,000 measurements (12,000 w/Bluetooth enabled);
AA - Approx. 7,500 measurements (6,000 w/Bluetooth enabled)
Display: In-scope LCD displays menu options and data values
Units: Feet, Yards, Meters, and Degrees
Monopod/tripod Mount: 1/4inches - 20 female thread
Eye Safety: FDA Class 1 (CFR 21)
Environmental: Impact, water and dust resistant. NEMA 3, IP 54
Temperature: -4 F to +140 F (-20 C to +60 C)
Optics: 7x magnification (field of view: 330 ft @ 1,000 yds)
Measurement Solutions:
Distance (Horizontal, Vertical, Slope)
Inclination (Degrees and Percent Slope)
Height (Flexible three-shot routine)
Azimuth (Compass bearing for single-shot positioning)
Missing Line (Distance, Inclination and Azimuth between any two remote points)
Measurement Range:
Distance: 0 to 3,280 ft (1,000 m); typical,
6,560 ft (2,000 m); max to reflective target
Inclination: ±90 degrees
Azimuth: 0 to 359.9 degrees
Accuracy:
Distance: ±1 ft (±30 cm); typical± yd (±1 m); max
Inclination: ±0.25 degrees
Azimuth: ±1 degree; typical
Targeting Modes:
Standard, Closest, Farthest, Continuous, and Filter (requires reflector and foliage filter)
TruTargeting:
Automatically provides best possible accuracy and acquisition distance to a given target
TruVector Compass Technology™:
Provides the best possible compass accuracy regardless of the laser’s inclination. It even warns you when the compass needs calibrating.

APPENDIX C – RED HEN SYSTEMS GEO-REFERENCED VIDEO MAPPING

Red Hen Systems Geo-Referenced Video Mapping

VMS-HD Complete System Bundle Includes:

- Red Hen VMS Hardware
- Convergent Design nanoFlash HD/SD Digital Video Recorder/Player
- Desktop GIS Software: MediaMapper 5.3*
- GPS Antenna/Receiver
- Feature Trigger (on board)
- 4" Microphone Jack Cable
- Power Adapter with International Plugs
- Hirose Power Cable
- Flash Card Reader/USB Cable
- Pelican Case
- Manuals

Convergent Design nanoFlash HD/SD Digital Video Recorder/Player

Introducing the World's smallest high quality HD/SD-SDI / HDMI Recorder/Player. The nanoFlash by Convergent Design is the most versatile Recorder/Player in the World in terms of bit-rates, recording options and formats. By adding the nanoFlash , one can meet the acquisition requirements, 50 Mbps, for many networks. The nanoFlash is a state-of-the-art miniature CompactFlash HD/SD SDI and HDMI Recorder/Player. Red Hen Systems is pleased to have been selected as the premier Spatial Multimedia Reseller and GIS Integration partner for the nanoFlash by Convergent Design.

- Improves the image quality of most cameras as the HD/SD-SDI and HDMI outputs are before the compression stages.
- Many cameras only record highly compressed 4:2:0 while outputting 4:2:2 over HD-SDI or HDMI.
- The nanoFlash uses these high-quality uncompressed 4:2:2 images to produce higher quality recordings.

The nanoFlash offers a dramatically better image, free from motion artifacts and other image problems, such as mosquito noise. Typically the nanoFlash offers a better image, even from many high-end cameras.

Wide Range of Bit-Rates

- 4:2:2 Long-GOP from 50 to 180 Mbps Long-GOP
- 4:2:2 I-Frame Only from 100 to 280 Mbps
- 4:2:0 Long-GOP from 18 to 35 Mbps
- SD 5/6/7/8/9 Mbps

Wide Range of Frame Rates

- Supports HD-SDI, SD-SDI and HDMI inputs
- Works with most any camera with HD/SD-SDI or HDMI outputs HD/SD-SDI and HDMI outputs active simultaneously
- Long, Uninterrupted Recording Times

Records in:

- Native Quicktime for Final Cut Pro
- Native MXF for Avid, Sony Vegas, Edius, others
- MPG Format in SD for quick same day creation of DVD's
- MPG Format in HD - Realtime Rendering of Blu-Ray disks
- No Mandatory Transcoding - Drag and Drop Editing

- All Solid-State - No Moving Parts - No Fans - No Noise - Field Proven Rugged - Withstands Extreme Temperatures - High Humidity - High Altitudes - High Vibration - High G-Forces
- Camera Mountable - 0.85 Pounds - 1/4" x 20 Tripod Thread
- Very Low Power - 5.6 Watts maximum, 0.2 watts standby Wide Voltage Range - 6.5 to 19.5 Volts DC - Uses most any battery type - International AC Power Supply included

- Supports Timecode and Audio embedded in HD/SD-SDI
- Supports Audio embedded in HDMI
- Supports Analog Audio, 24-Bit/48K, with up to 44 dB of gain via 3.5 mm audio input, compatible with tape-out signals
- One Channel balanced audio consumer line level / mic, orT
- Two Channel unbalanced audio consumer line level / mic

All audio recorded at 24-Bit/48K Uncompressed
Headphone / Consumer line-level outputs

2 CompactFlash card slots - Records seamlessly from one card to the next
The image quality produced by the nanoFlash is exactly the same as the Flash XDR.

VMS-HDII

Our easy-to-use digital camera accessories and GPS video digital recorders let you collect video imagery - along with essential location information. Our GIS software lets you process the imagery and generate multimedia maps that bring vital information to the eyes and fingertips of decision-makers. With the click of a button you know where something is, as well as what it looks like. And you can share the maps with others over the Internet.

This system combines Red Hen's VMS-333 with the nanoFlash recorder from Convergent. Completely customizable, now add up to 4 channels of recording for UltraViolet, Infrared, Standard Definition, and/or High Definition. Expand the information in your data collect for more comprehensive results. In our most portable, light-weight size yet, the HDII is especially suited to collect geo-tagged "path" HD video from all mobile platforms, such as aircraft, ground vehicles and marine vessels.

Features:

• Format: Record in High-Definition or standard definition

• Recording: All video and GPS data encapsulated in a single file on compact flash card, seamlessly switches recording from card 1 to card 2

• GPS: WAAS-enabled for greater location accuracy in the US; supports international SBAS (Satellite Based Augmentation System) in Europe and Asia

• Feature Trigger: Allows you to "mark" points of interest for quick analysis

• Photo Capture: Automatically capture geo-referenced still photos from High-Definition video

• Analysis: MediaMapper 5.3 software allows for subject matter experts to create electronic work products

Benefits:

• Competitive price, with unprecedented High-Def and multimedia mapping functionality

• Light weight, portable — easily switch between aircraft and vehicles, or carry on foot

• Removable compact flash cards allow for archiving of original recording — ideal for law enforcement

• All Solid-State design - Ideal for Extreme Environments

Supported Video Input Formats:

· 1920x1080i @ 60, 59.94, 50 Hz

· 1920x1080p @ 30, 29.97, 25, 24, 23.98 Hz

· 1920x1080psf, @ 30, 29.97, 25, 24, 23.98 Hz

· 1280x720p @ 60, 59.94, 50 Hz

· 720x486 @ 29.97 Hz

· 720x576 @ 25 Hz

.mts & .m2ts file types may not work correctly and therefore are not supported.

APPENDIX D – RIVERBANK CLASSIFICATION REFERENCE PHOTOGRAPHS

Upper Riverbank Slope


Flat (<4:1)


Moderate (4:1-2:1)

Steep (>2:1)

Vertical (90º)

Overhanging (>90º)

Lower Riverbank Slope:

Flat/Beach (<4:1)

Moderate (4:1-2:1)

Steep (>2:1)

Vertical (90º)

Upper Riverbank Sediment:

Silt/Sand (.062-2 mm)

Bedrock

Lower Riverbank Sediment:

Silt/Sand (.062-2 mm)

Gravel (2-64 mm)

Cobbles (64-256 mm)

Boulders (256-2048 mm)

Bedrock

Clay (.001-.062 mm)

Upper Riverbank Height:

Low (<8 ft)

Medium (8-12 ft)

High (>12 ft)

Upper Riverbank Vegetation:

Heavy (>50%)

Moderate (25-50%)

Sparse (10-25%)

None to very sparse (<10%)

Lower Riverbank Vegetation:

Heavy (>50%)

Moderate (25-50%)

Sparse (10-25%)

None to Very Sparse (<10%)

Extent of Current Erosion:

None/Little (<10%)

None/Little (<10%)

None/Little (<10%)

Some (10%-40%)

Some to Extensive (40%-70%)

Extensive (>70%)

Extensive (>70%)

NOTE: All quantitative classification criteria (e.g. slope, height, vegetation, extent, etc.) will be based on approximate qualitative estimates made during field observations of riverbanks. The FRR is a reconnaissance level survey that will not include quantitative field measurements of characteristics. Photographs contained in this appendix will be used for reference checking in the field to ensure for consistent and accurate data classification.