TRANSCANADA HYDRO NORTHEAST INC.

ILP Study 1
Historical Riverbank Position and Erosion Study

Study Report

In support of Federal Energy Regulatory Commission Relicensing of:

Wilder Hydroelectric Project (FERC Project No. 1892-026)
Bellows Falls Hydroelectric Project (FERC Project No. 1855-045)
Vernon Hydroelectric Project (FERC Project No. 1904-073)

Prepared for

TransCanada Hydro Northeast Inc.
4 Park Street, Suite 402
Concord, NH 03301

Prepared by

Field Geology Services, LLC
P.O. Box 985
Farmington, ME 04938

and

Normandeau Associates, Inc.
25 Nashua Road
Bedford, NH 03110

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EXECUTIVE SUMMARY

The Historical Riverbank Position and Erosion Study (ILP Study 1) was conducted to collect information on how the Connecticut River channel's position and the rate of bank erosion within TransCanada's Wilder, Bellows Falls, and Vernon Project boundaries have changed through time. Several sources of information were utilized such as historical aerial photographs, historical ground photographs, historical topographic maps and surveys, and past maps showing the location of erosion in the Wilder, Bellows Falls, and Vernon impoundments and riverine areas downstream of each dam. These sources were collected online, at historical societies in towns within the study area, State offices, from landowners that responded to a letter seeking information, at U.S. Natural Resource Conservation Service (NRCS) field offices, and from TransCanada's own archives.

A comparison of digitized erosion maps from 1958 and 1978 shows how erosion locations have changed through time and where portions of the riverbank stabilized. Despite variations in location, the overall amount of erosion between 1958 and 1978 remained relatively unchanged. Digitized bank lines created from georeferenced historical aerial photographs from the 1940's, 1950's, 1970's, and 2010 were used to calculate the amount and rate of bank erosion along the river.

Initial analysis suggests the rate of bank erosion has remained steady or decreased through time at a majority of sites analyzed; a trend confirmed, in part, by rephotographed historical ground photographs that show bank stabilization occurring at many previously eroding sites. Further analysis as part of Study 3 – Riverbank Erosion Study is needed to confirm this trend and to ascertain potential project-effects on bank erosion trends in the study area.

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List of Abbreviations

FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
GIS	Geographic Information System
ISR	Initial Study Report
LiDAR	Light detection and ranging
NRCS	U.S. Natural Resource Conservation Service
PAD	Pre-Application Document
SPD	Study Plan Determination
USACE	U.S. Army Corps of Engineers

1.0 INTRODUCTION

The Historical Riverbank Position and Erosion Study (ILP Study 1) was undertaken to determine how the Connecticut River channel's position and bank erosion rates within TransCanada's Wilder, Bellows Falls, and Vernon Project boundaries have changed through time. Historical data analyzed as part of this study came from several sources including historical aerial photographs, historical ground photographs, historical topographic maps and surveys, and past mapping of erosion in the three study impoundments. The information was gathered at local historical societies in towns within the study area, various state offices, from landowners that responded to a letter seeking historical information, at NRCS field offices, from the internet, and from TransCanada's own files. The acquired data are compiled into appendices introduced in the following sections or, for larger data sets, is available upon request. Although some initial analysis has been undertaken herein, a more thorough analysis and a discussion of its significance will be included in reports for Study 2 (Riverbank Transect Study) and Study 3 (Riverbank Erosion Study) for which the historical information will be most valuable. Those studies are not yet complete.

2.0 STUDY GOALS AND OBJECTIVES

The goal of this study was to assess the historical erosion and riverbank movement within the Wilder, Bellows Falls, and Vernon Project boundaries to consider the effect and contribution of project operations on erosion in a reasoned way. Documentation of historical riverbank information, surveys, and photographs provides an opportunity to quantify or compare changes over an extended period and potentially enables quantification, at least on a relative scale, of erosion rates over time at various locations within each project along the Connecticut River. FERC contends (in its March 1, 2013 Pre-Application Document (PAD) Deficiencies, Additional Information Requests, and Comments letter) that although erosion, in and of itself, is not necessarily an adverse effect, areas of excessive erosion that are a direct result of project operations or that may be having an adverse effect on another resource are of concern. Potential resources that may be affected are aquatic, terrestrial, cultural, recreation, and/or socioeconomic.

The primary objectives of this study were to:

- Compile information and materials relevant to historical erosion and riverbank movement (e.g., historical aerial photographs).
- Process collected information in a format useful for analysis as part of other related studies (e.g., shapefiles of past river positions derived from georeferenced historical aerial photographs).

- Compare historical information with recent conditions (e.g., rephotographing historical ground photographs from the same location).

While some initial analysis of the results of this study is presented below, Study 1 was largely conceived as a data collection exercise with more thorough analysis to be conducted as part of two related studies: Study 2 (Riverbank Transect Study) and Study 3 (Riverbank Erosion Study). As such, data collected during the course of Study 2 and Study 3, such as the results of the erosion monitoring and erosion mapping, are not included in the Study 1 results presented below. However, to provide some context to the Study 1 results, photographs retaken in 2015 at the same locations as historical ground photographs found in the TransCanada files are included in this report as little explanation of the photographs is required. In contrast, the 2014 erosion mapping is not included here for comparison with historical erosion mapping because a thorough explanation of the mapping methods used in 2014 is required and is beyond the scope of Study 1. Furthermore, erosion mapping completed in 2010 (Kleinschmidt, 2011) is also not presented as part of Study 1 as the mapping methods appear to be inconsistent with the mapping completed in 2014 and in earlier efforts. Consequently, the 2010 mapping data will be discussed, analyzed, and compared in the Study 3 report where the various methodologies can be thoroughly discussed and the reliability of the results carefully analyzed.

Taken together, the three related erosion studies are intended to provide conclusions as to the association and effect of project operations on active erosion at various locations within or areas affected by the three projects. The Revised Study Plan for this study was approved without modification in FERC's September 13, 2013 Study Plan Determination.

3.0 STUDY AREA

The study area includes the shoreline of the Wilder, Bellows Falls, and Vernon impoundments, as well as the shoreline of the riverine reaches downstream of the Wilder and Bellows Falls dams, and is limited to approximately 1.5 miles downstream of Vernon dam to the lower extent of Stebbins Island.

4.0 METHODS

The following methods were employed to complete Study 1:

- Document search within TransCanada's own records to identify historical information on project maps showing the locations of bank erosion and ground photographs of such erosion.

- Review of available Federal Emergency Management Agency (FEMA) flood insurance studies to identify field surveys conducted at key locations within the study area.

- Compilation of available historical aerial photographs from local NRCS field offices serving locations within the study area.
- Conduct archival searches at state and local historical societies for additional sources of information.
- Outreach to riverfront landowners and municipalities to gather additional maps and other relevant information.
- Download historical topographic maps of the study area from the University of New Hampshire library.
- Georeference historical aerial photographs to identify channel changes through time.
- Digitize river's banks, islands, and bars for each of the georeferenced aerial photographs to create GIS shapefiles of the river's position and channel features.
- Compare the locations of erosion displayed on maps from 1958 found in TransCanada's files with mapping completed by the U.S. Army Corps of Engineers in 1978 (Simons et al., 1979).

Further information regarding the methods for georeferencing historical aerial photographs and digitizing river features is provided in the following subsections. Minor additional details about the other methods are integrated, as warranted, into the analysis and discussion of the data in Section 5.0.

4.1 Georeferencing Historical Aerial Photographs

Georeferencing aerial photographs is a process that allows photographs from the same area taken at different times and at different scales to be overlayed in order to determine how various features, such as a river's position, have changed through time. The georeferencing completed for this study followed the procedures described by Hughes et al. (2006) that was designed specifically for measuring lateral channel movement. For this study, historical aerial photographs covering the entire study area from the 1953/1955 series and the 1970/1975 series were georeferenced to overlay on 2010 digital orthophotographs. An orthophotograph is an aerial photograph that is geometrically corrected (or orthorectified) in order to provide a uniform scale with the same lack of distortion as a map. Historical aerials from the 1939/1940 series were also georeferenced but only partial coverage of the study area was available. The three historical aerial sets were gathered at local NRCS field offices, while the 2010 orthophotographs were obtained online at the New Hampshire Granit GIS clearinghouse (Web citation 1). For clarification, the 2010 orthophotographs are distinct and unrelated to the erosion mapping completed in the field during the same year and reported on in Kleinschmidt (2011).

For each of the complete historical aerial photo sets, dozens of individual paper photographs were scanned and then a minimum of eight control points on each photo, if possible, were matched with identical points on the 2010 digital orthophotographs. To ensure accuracy, these control points were limited to very specific points, such as the corners of houses and the right angle where a main building and an L-shaped wing meet. Due to the poor quality (low resolution and occasional photo damage) of the 1953/1955 series and the large amount of developmental change over more than 70 years, especially in buildings, eight control points were often difficult to find. In these cases, less than eight control points were used to avoid reliance on poor control points that would compromise the accuracy of the georeferencing process. The georeferencing process creates distortions as the historical aerials are stretched and otherwise fitted to match the digital orthophotograph base layer, especially at the edges of each georeferenced photo.

4.2 Digitizing River Features

To create geographic information system (GIS) shapefiles showing the location of erosion on the historic erosion maps (from 1958 from the TransCanada files and from 1978 from Simons, et al. [1979]) and the river's edge based on the georeferenced historical aerial photographs, the position of erosion and the river's edge was hand digitized based on visual inspection of the maps and aerial photographs. The hand digitizing of the erosion maps required that the location of erosion shown on the 1958 and 1978 maps (shown as dark bolded lines along the river's edge) be transferred to the 2010 digital orthophotographs. To do this, the precise location of a discrete eroding segment on the historic map was found on the recent orthophotograph by identifying bends in the river, roads, or other features that appear on both the map and orthophotograph. The extent of the erosion was then transferred by digitizing the extent of the erosion onto the digital orthophotograph. The hand digitizing was completed using ArcMap 9.3.

Given the likelihood that the various historical aerial photographs were taken at different water levels in the river, the wetted margin of the river channel could not be used to delineate the river's edge. Instead, an attempt was made to hand digitize the top edge of the river bank for each set of aerial photographs by delineating the center of trees on the river's edge in wooded areas, the edge of pastures, fields, or wetlands where trees were absent, and, where visible, the top of bank armor or bare (eroding) banks. By using the limit of vegetation and the top of the bank as the delineated margin of the river, variations in water stage between photo years does not introduce errors in the determination of river bank movement through time. This approach to defining the river's edge has been used in other similar studies and has become the standard when measuring changes in riverbank position on a series of historical aerial photographs (Merritt and Cooper, 2000; Winterbottom, 2000; Wellmeyer et al., 2005).

5.0 RESULTS AND DISCUSSION

The results derived from using the methods described in Section 4.0 are presented in the subsections below.

5.1 Document Search within TransCanada's Records

TransCanada's records that might relate to historic channel changes were reviewed at the Bellows Falls Project offices. The most valuable information identified was previous maps, ground photographs, and reports on the location of erosion completed periodically from 1951 to 1991. In addition, ground photographs at several erosion sites were taken between 1942 and 1948. The first year in which the erosion monitoring was completed comprehensively across all three projects was 1958 and the erosion data from that year were hand digitized using methods discussed in Section 4.2. The GIS shapefile derived from the digitizing was compared with similarly digitized erosion data from U.S. Army Corps of Engineers mapping in 1978 (Simons et al., 1979). The comparison shows the apparent amount of overall change in erosion for the entire study area and documents the length of new erosion and stabilizing banks (see Appendix A). Similar comparisons will be made in Study 3 with that study's new erosion data set collected in 2014 to better understand how the rate of erosion varies through time.

A select number of ground photographs taken at mapped erosion sites over the years were selected from the TransCanada files to enable visual comparisons and document changes through time. Photographs from 1942, 1951, 1953, 1954, 1955, 1964, 1973, 1984, and 1991 were used, although photographs from all years were not available at any of the sites (Appendix B). The sites chosen were selected to ensure that: 1) they could be easily relocated so a current photograph could be retaken as part of Study 3; 2) a wide geographic range across the three projects was covered; 3) a range of conditions were represented; and 4) photographs were of a reasonable resolution and quality to see details of the riverbank condition. Appendix B contains a series of overview maps with photograph match numbers that correspond to the photograph pages (refer to the summary table following maps in the Appendix).

The written notes and reports accompanying the erosion maps and ground photographs also provided valuable information. The date of a large meander cutoff in the Wilder impoundment was documented as occurring in early 1954 as the Wilder Pond Bank Inspection (June 28-July 1, 1954) report by L.D. Pierce (internal New England Power Co. document) in 1954 states: "At mile 33.3 the river has cut across a narrow section of this finger-like area forming a channel about 75' wide with bottom below Elev. 380.0 and isolating the end of the meadow. There was no indication of this last year and it must have occurred during the high water period this spring." Historical aerial photographs would be sufficient only to say that the cutoff occurred within a range of several years, so the notes provide critical information not provided in the erosion maps, historical aerial photographs, or ground photographs.

5.2 Review of FEMA Flood Insurance Studies

FEMA flood insurance studies are available online for the study area (Web citation 2). FEMA flood insurance rate maps are based on hydraulic modeling that determines flood elevations for a given discharge. To complete the modeling, periodic topographic cross sections must be surveyed across the river of interest. As a result, FEMA surveyed several cross sections across the Connecticut River in the past, primarily in the 1970's. The flood insurance studies covering the study area were gathered and reviewed. While general information from the various FEMA-surveyed cross sections were provided (e.g., cross-sectional area, width of the floodway), the actual surveyed cross sections are not available in the study reports. As a consequence, comparisons with those earlier cross sections were not possible.

5.3 Compilation of Historical Aerial Photographs

Local NRCS field offices are found throughout the United States with each typically retaining several sets of historical aerial photographs sometimes extending back to the 1930's. Several local field offices in Vermont and New Hampshire were visited to compile historical aerial photographs of the study area. Complete coverage of the study area was obtained for the 1953/1955 series and the 1970/1975 series (the two years listed for each series indicates the years in which aerial photographs were flown over the entire study area in that given series). While other complete sets of aerial photographs were flown in the 1960's, 1980's, and 2000's, the two sets selected were the most complete, highest resolution, and with a sufficient spread to provide an understanding of changes in river position through time when compared with the most recent 2010 digital orthophotographs. Historical aerial photographs from 1939/1940 were also compiled but a complete set was not available, so select photographs were chosen from given areas where the later photographs documented significant channel changes. To quantify changes to the channel, the aerial photographs were georectified using the methods described in Section 4.1.

5.4 Archival Searches

Local and state historical societies often have old maps, ground photographs, and written documents that can be valuable in determining how a river has changed and how humans have manipulated the river in the past. Thirty-one historical societies in towns within the study area were visited and most had useful information that was obtained for the study (Table 5.4-1). The Vermont and New Hampshire state historical societies and archival offices were also visited and several sources of online records searched including from Dartmouth Digital Library Collections (Web citation 3) and the Vermont Landscape Change Program (Web citation 4). Staff members working at each historical society visited were asked for any information they might have related to the Connecticut River, how the river has changed, and how the river was used in the past. The maps, ground photographs, and written documents that were considered relevant to this study and the related erosion studies were scanned when permissible or downloaded online. The

information gathered will be incorporated into the Study 2 and Study 3 analysis as warranted.

Table 5.4-1. Historical societies in the study area visited as part of archival research.

Towns	
Barnet, VT	Bath, NH
Bellows Falls, VT	Charlestown, NH
Bradford, VT	Chesterfield, NH
Brattleboro, VT	Claremont, NH
Concord, VT	Cornish, NH
Dummerston, VT	Hanover, NH
Fairlee, VT	Haverhill, NH
Guilford, VT	Hinsdale, NH
Hartford, VT	Lebanon, NH
Hartland, VT	Lyme, NH
Newbury, VT	Monroe, NH
Norwich, VT	Orford, NH
Putney, VT	Piermont, NH
Rockingham, VT	Plainfield, NH
Ryegate, VT	Walpole, NH
Springfield, VT	Westmoreland, NH
Thetford, VT	
Vernon, VT	
Waterford, VT	Westminster, VT
Weathersfield, VT	Windsor, VT

5.5 Outreach to Riverfront Landowners and Municipalities

A letter dated July 2, 2014 was sent to all riverfront landowners and municipalities requesting any information they might be willing to share regarding the river and changes through time. Approximately 1,200 letters were sent out with 88 returned undelivered and 23 responses received by either email or phone. Dr. John Field of Field Geology Services followed up with all of those that responded and made 9 site visits to landowner properties. Landowners provided a variety of useful data including: 1) historical ground photographs; 2) designs and verbal recollections regarding previously installed bank stabilization projects; 3) a partial set of New England Power Service Company topographic maps from the Wilder impoundment surveyed in 1930-31; 4) dates of when riverbank features were first observed along the river (that were located on a map when shown); and 5) historical land surveys with distances of certain features (e.g., edge of road) to the top of the riverbank. The gathered information will be used in Study 3 in a variety of ways including: resurveying distances to the top of the riverbank shown on old surveys to calculate bank erosion rates; rephotographing bank stabilization projects to document their

success or failure through time; and noting features on the 1939/1940 topographic maps that are no longer present to document the impact of the raising of Wilder Dam in 1950.

5.6 Historical Topographic Maps

Historical topographic maps for all of New England are available online from the University of New Hampshire Library (Web citation 5). The earliest maps for the study area were downloaded and reviewed. However, the accuracy of the georectification (available on New Hampshire Granit) is suspect given the lack of sufficient high quality control points, so the topographic maps were not overlayed with the 2010 digital orthophotographs. However, significant channel changes that occurred prior to the earliest aerial photographs will be identified as part of Study 3 through visual inspection and incorporated into the analysis.

5.7 Georeferencing Historical Aerial Photographs

Historical aerial photographs covering the entire study area from the 1953/1955 series and the 1970/1975 series were georeferenced to overlay on the 2010 digital orthophotographs. Historical aerials from the 1939/1940 series were also georeferenced but only partial coverage of the study area was available. The georeferenced aerial photographs were used to digitize the river's edge using methods described in Section 4.2 and presented in Section 5.8.

5.8 Digitizing River Features

The results of the digitized erosion maps were discussed in Section 5.1. Changes in the river over time can be determined by comparing the digitized position of the river's edge for the different photo years. The range of river changes that have occurred in the study area can be illustrated at eleven sites where erosion or other channel changes have occurred (see Appendix C). The eleven sites were selected for illustrative purposes only as part of Study 1 with a more thorough analysis of changes observed on the historical aerial photographs to be conducted as part of Study 3.

The eleven sites include locations where erosion has occurred:

- on the outside bend with deposition on the inside bend (Site 01-W02, Plate C-2; and Site 01—W03, Plate C-3)
- on the inside bend with deposition on the outside bend (Site 01-W01, Plate C-1; site 01-B03, Plate C-8; Site 01-B04, Plate C-9; Site 01-V01, Plate C-11)
- on the inside bend with no deposition on outside bend (Site 01-W05, Plate C-5)
- along one bank of a straight reach of river (Site 01-B01, Plate C-6)

- only minor erosion has occurred (Site 01-BR01, Plate C-10)
- a meander cutoff occurred (Site 01-W04, Plate C-4)
- an island in the middle of the river has eroded away completely (Site 01-B02, Plate C-7)

The variety of conditions represented by the 11 sites indicate that erosion in the study area cannot simply be ascribed to a simple model where erosion occurs on the outside of meander bends due to higher velocity flow and deposition on the slower inside bends of meanders; a discussion for the reasons and causes for the observed complex patterns of erosion and deposition is beyond the scope of Study 1 but will be examined in detail as part of Study 3.

Measurement of the amount of movement in the riverbank's position at each of the 11 sites depicted in Appendix C enabled calculation of the amount of bank erosion and aggradation (i.e., deposition) in linear feet and acreage over a given river length; an annual rate of erosion or aggradation could then be established based on the length of time between photo years examined. The Light Detection and Ranging (LiDAR) data collected in 2013 for the whole study area was used to determine the bank height at each of the 11 sites and when combined with area enabled estimates to be made of the volume of soil eroded or deposited at each area examined. (The LiDAR data and the detailed topographic information it provides will be described further and used to a greater extent in Study 3 to describe other subtle topographic features related to erosion identified at various discrete locations in the study area that are not otherwise visible with standard topographic maps or aerial photographs.)

Bank erosion rates in terms of both the length of bank recession and volume of soil loss have decreased at a majority of the 11 sites from 1970/75 to 2010 compared to the period between 1950/53 and 1970/75. The only sites where the rate has increased during those time periods are in the upper Wilder Impoundment. More detailed analysis of the historical aerial photograph data to be completed as part of Study 3 will attempt to determine if this general trend at the 11 sites holds at other locations. The 11 sites presented in Appendix C were selected by visual observation of the data and do not represent a systematic sampling of changes along the river. To more confidently establish how the rate of erosion is changing through time over the entire study area, a more thorough investigation will be completed as part of Study 3 using the shapefiles of historic banklines created as part of Study 1.

6.0 ASSESSMENT OF PROJECT EFFECTS

This study was largely a data collection effort with detailed analysis to occur as part of other related studies, particularly Study 3. As such, the results of this study alone are insufficient to make an accurate assessment of project effects. An assessment of project effects on erosion will be included in the Study 3 report.

Study 3 will provide mapping data on the current location of erosion that will enable comparisons with the historical data gathered in Study 1. Additional information gathered as part of Study 3 related to channel position (e.g., islands, location in meander bends), tributary inputs (e.g., deltas at the mouths of tributaries), valley constrictions (e.g., what areas are upstream of valley constrictions) will be used to better understand the distribution of erosion in the study area and ascertain the potential project related and non-project related causes for erosion. The historical context provided by Study 1 will be invaluable in this analysis by providing a better understanding of how the location and rate of erosion in the study area has changed through time.

7.0 LITERATURE CITED

Hughes, M.L., McDowell, P.F. and Marcus, W.A. 2006. Accuracy assessment of georectified aerial photographs: Implications for measuring lateral channel movement in a GIS. Geomorphology, v. 74, p. 1-16.

Kleinschmidt (Kleinschmidt Associates, Inc.). 2011. Lower Connecticut River Shoreline Survey Report—2010: Bellows Falls Project (FERC No. 1855), Wilder Project (FERC No. 1892), Vernon Project (FERC No. 1904). Prepared for TransCanada Hydro Northeast Inc., Westborough, MA. March 2011.

Merritt, D.M., and Cooper, D.J., 2000, Riparian vegetation and channel change in response to river regulation: A comparative study of regulated and unregulated streams in the Green River Basin, USA: Regulated Rivers: Research and Management, v. 16, p. 543-564.

Simons, D.B., Andrews, J.W., Li, R.M., and Alawady, M.A. 1979. Connecticut River Streambank Erosion Study Massachusetts, New Hampshire, and Vermont. Prepared for USACE, New England Division.

Wellmeyer, J.L., Slatterly, M.C., and Phillips, J.D., 2005, Quantifying downstream impacts of impoundment on flow regime and channel planform, lower Trinity River, Texas: Geomorphology, v. 69, p. 1-13.

Winterbottom, S.J., 2000, Medium and short-term channel planform changes on the Rivers Tay and Tummel, Scotland: Geomorphology, v. 34, p. 195-208.

Web citations

Web citation 1: www.granit.unh.edu

Web citation 2: https://msc.fema.gov/portal/advanceSearch

Web citation 3: http://libarchive.dartmouth.edu/cdm/search/searchterm/wilder%20dam/order/nosort

Web citation 4: http://www.uvm.edu/landscape/

Web citation 5: http://docs.unh.edu/nhtopos/nhtopos.htm

APPENDIX A

Comparison of 1958 and 1978 Erosion Maps

(see also accompanying ARC GIS shapefiles)

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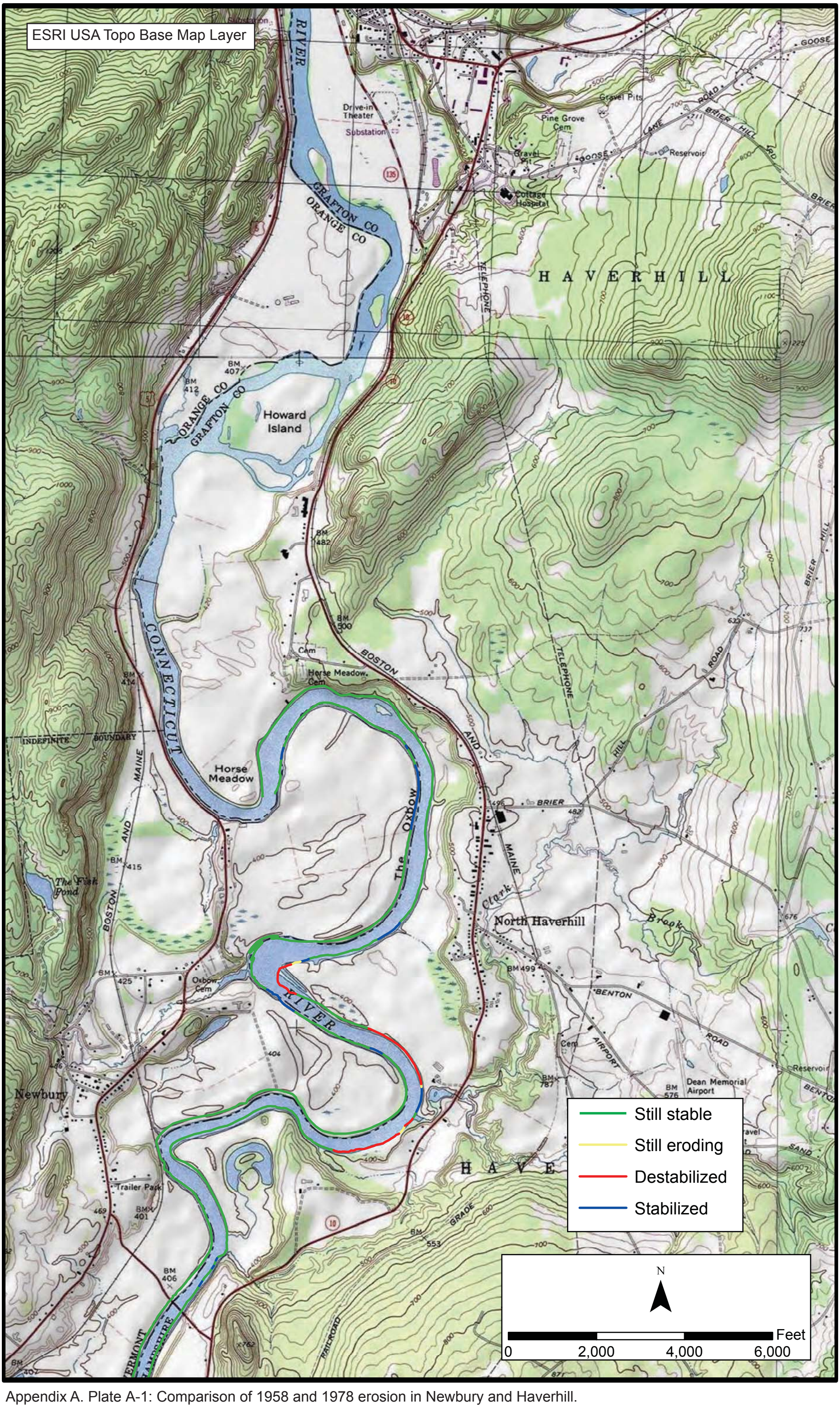
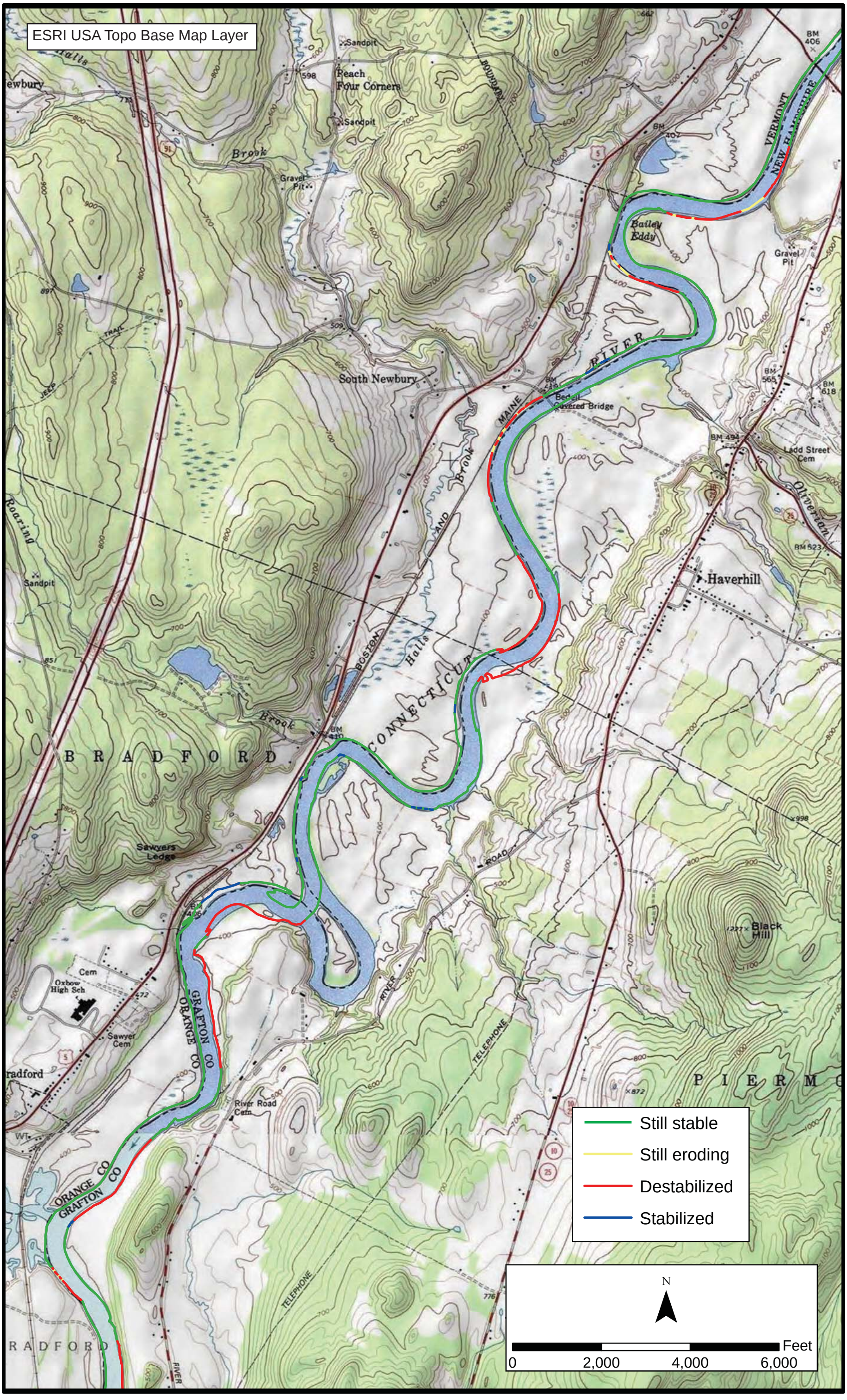
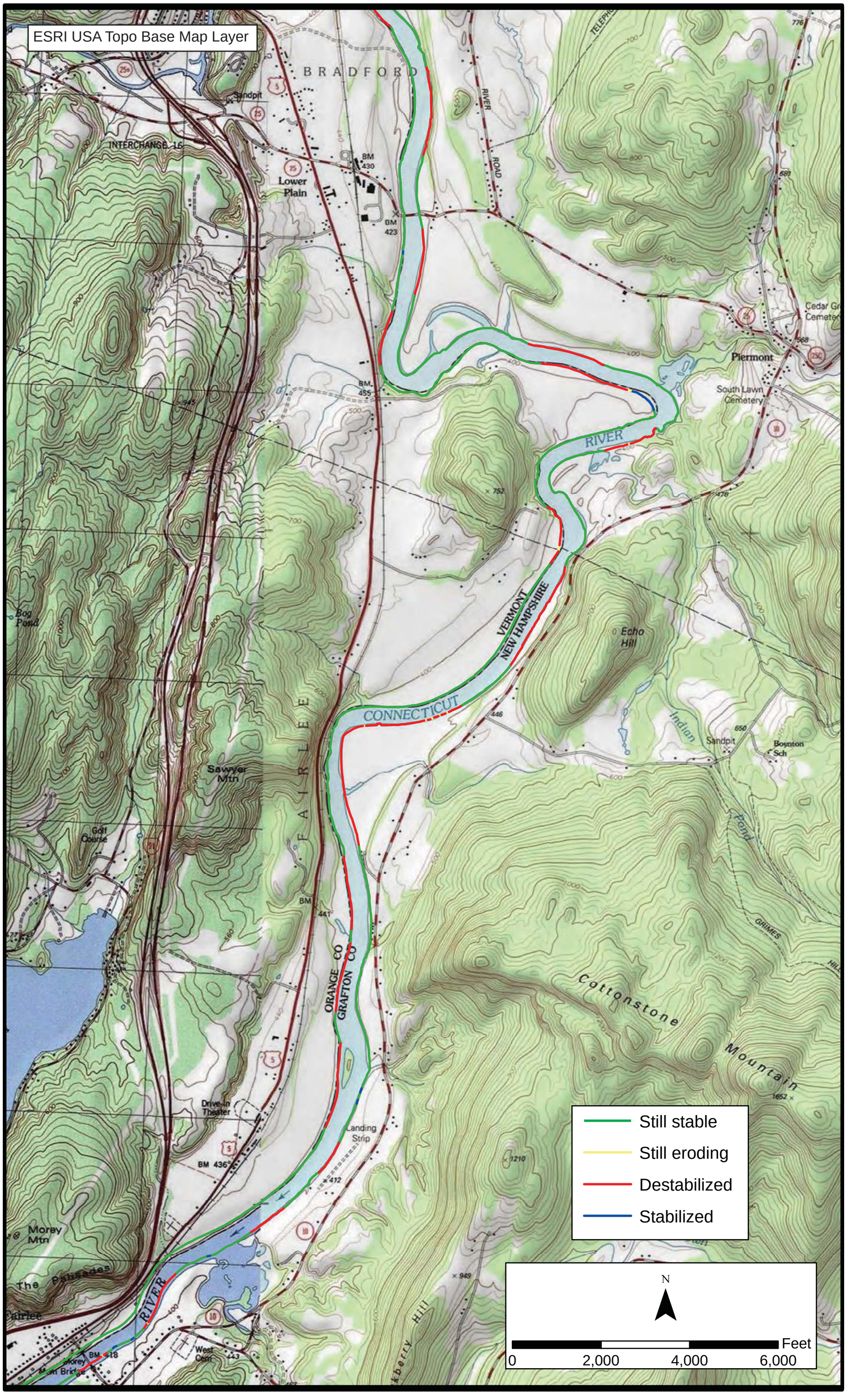


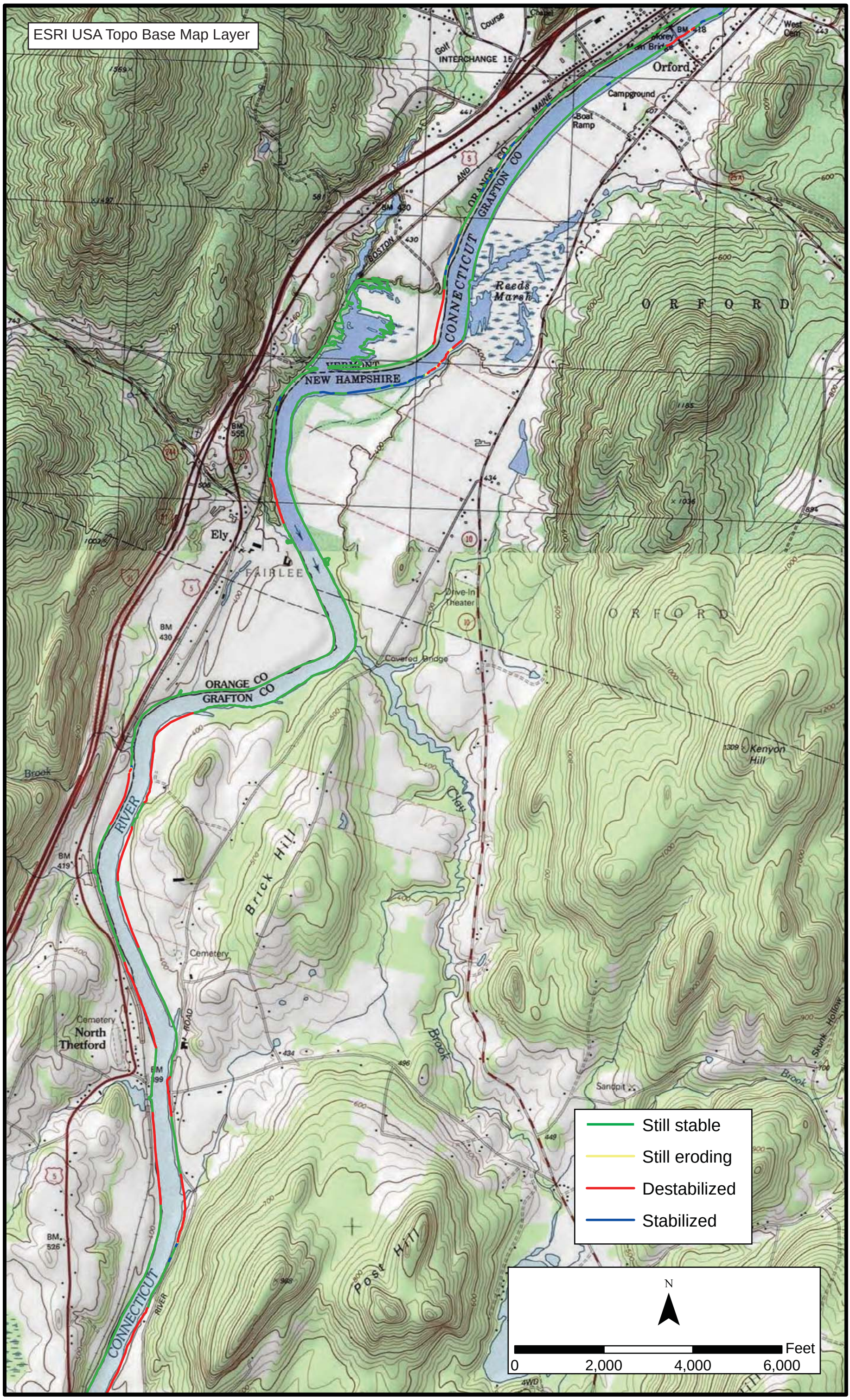
Appendix A. Plate A-1: Comparison of 1958 and 1978 erosion in Newbury and Haverhill.



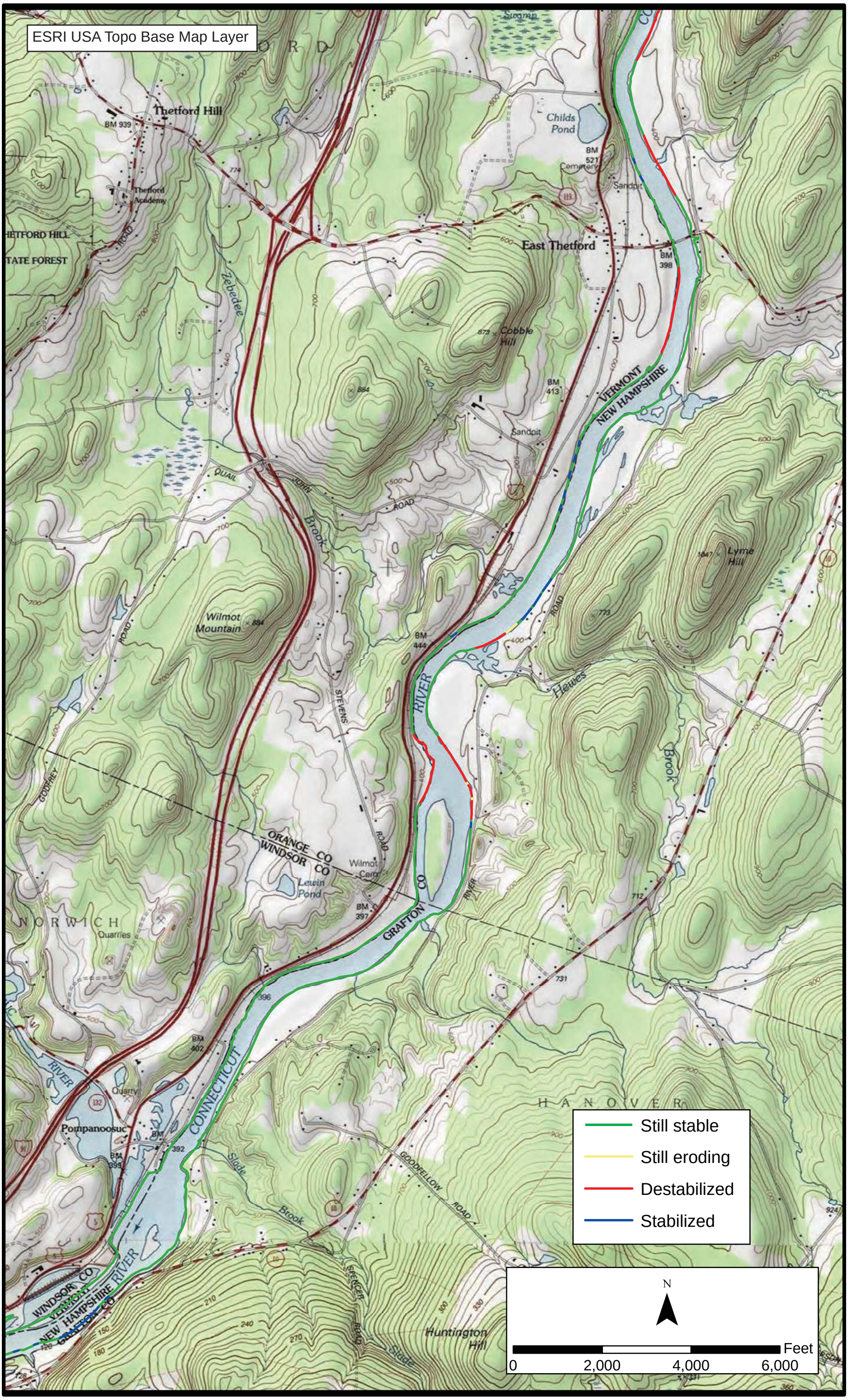
Appendix A. Plate A-2: Comparison of 1958 and 1978 erosion in Bradford and Haverhill.



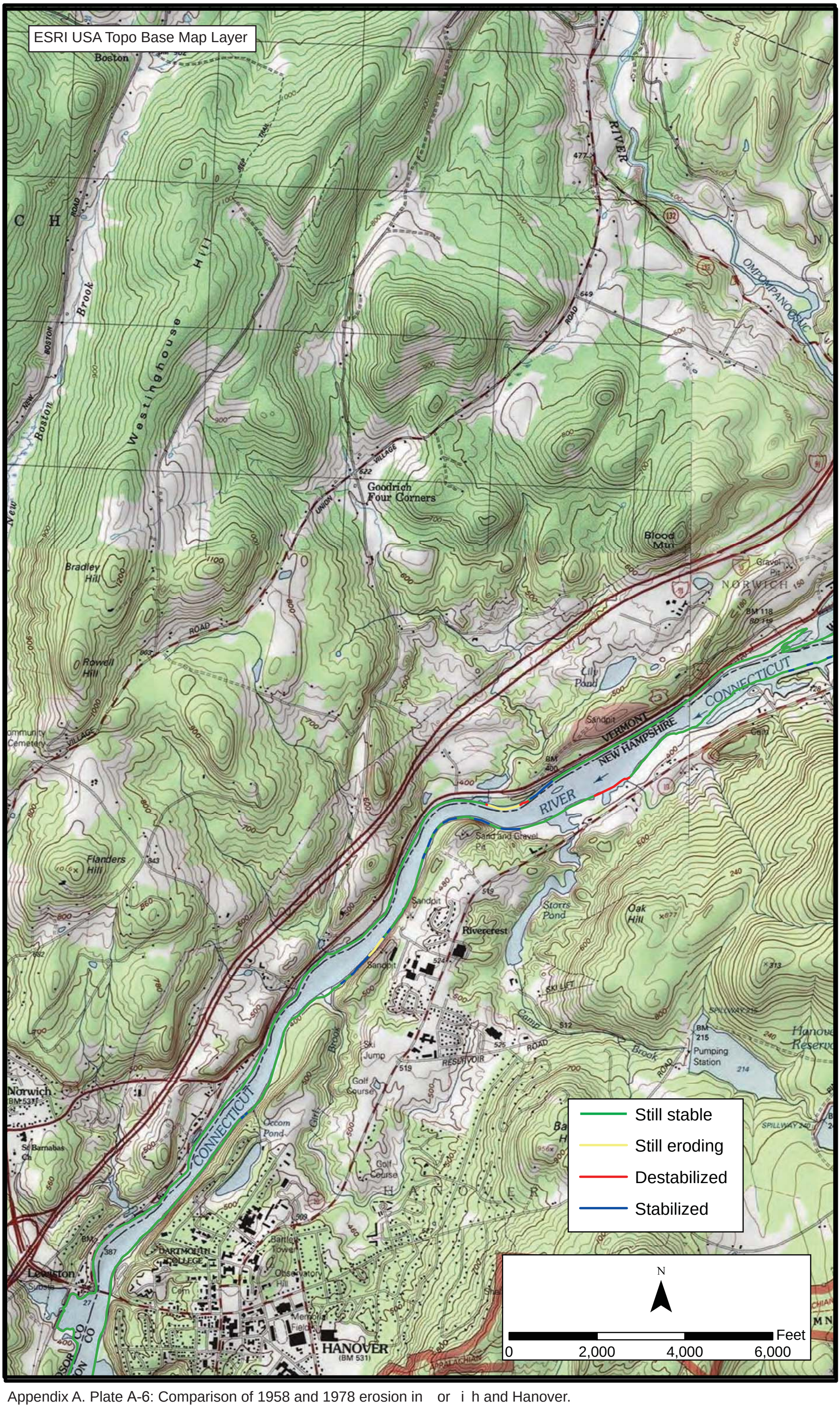
Appendix A. Plate A-3: Comparison of 1958 and 1978 erosion in Fairlee and rford.



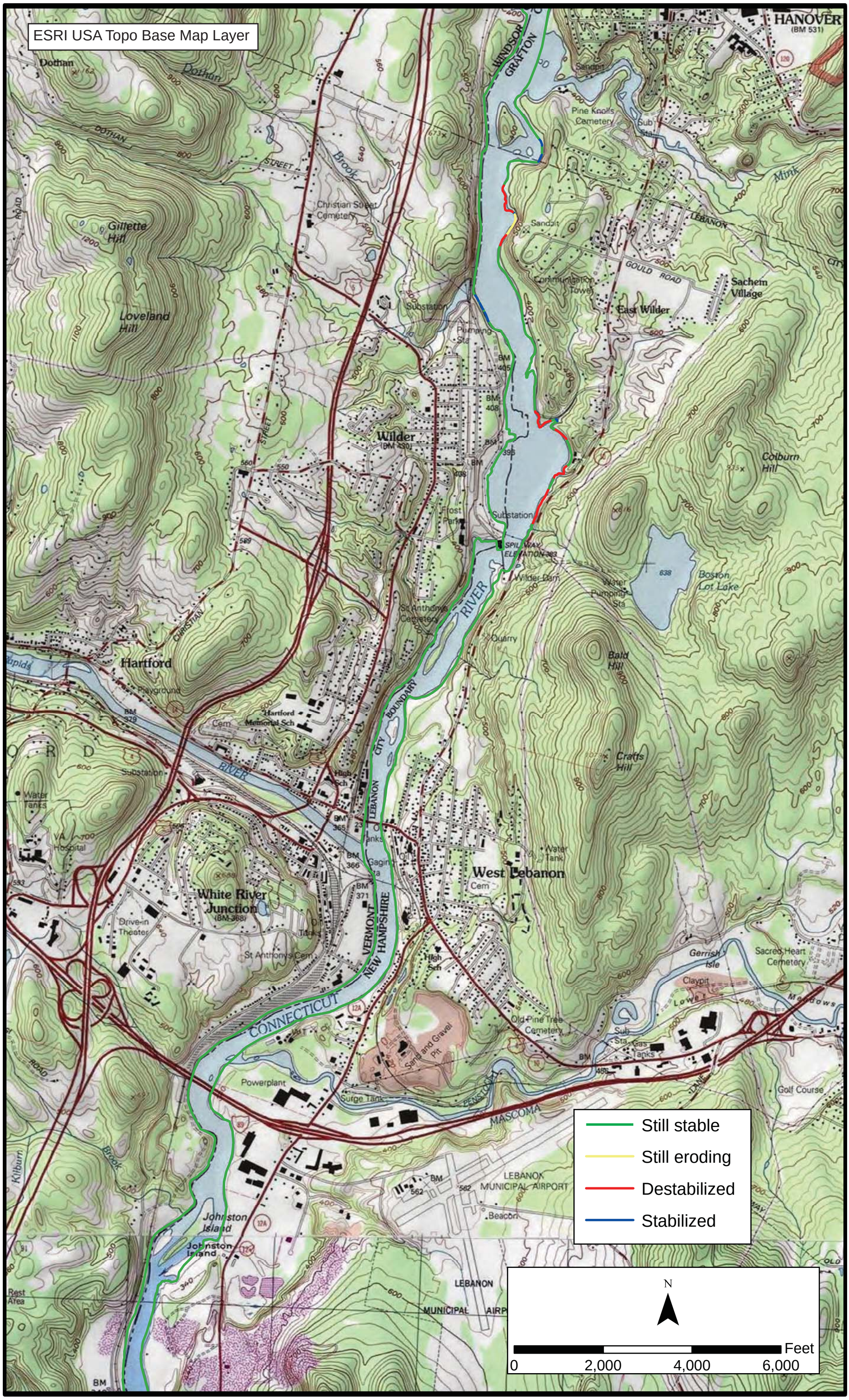
Appendix A. Plate A-4: Comparison of 1958 and 1978 erosion in Thetford and rford.



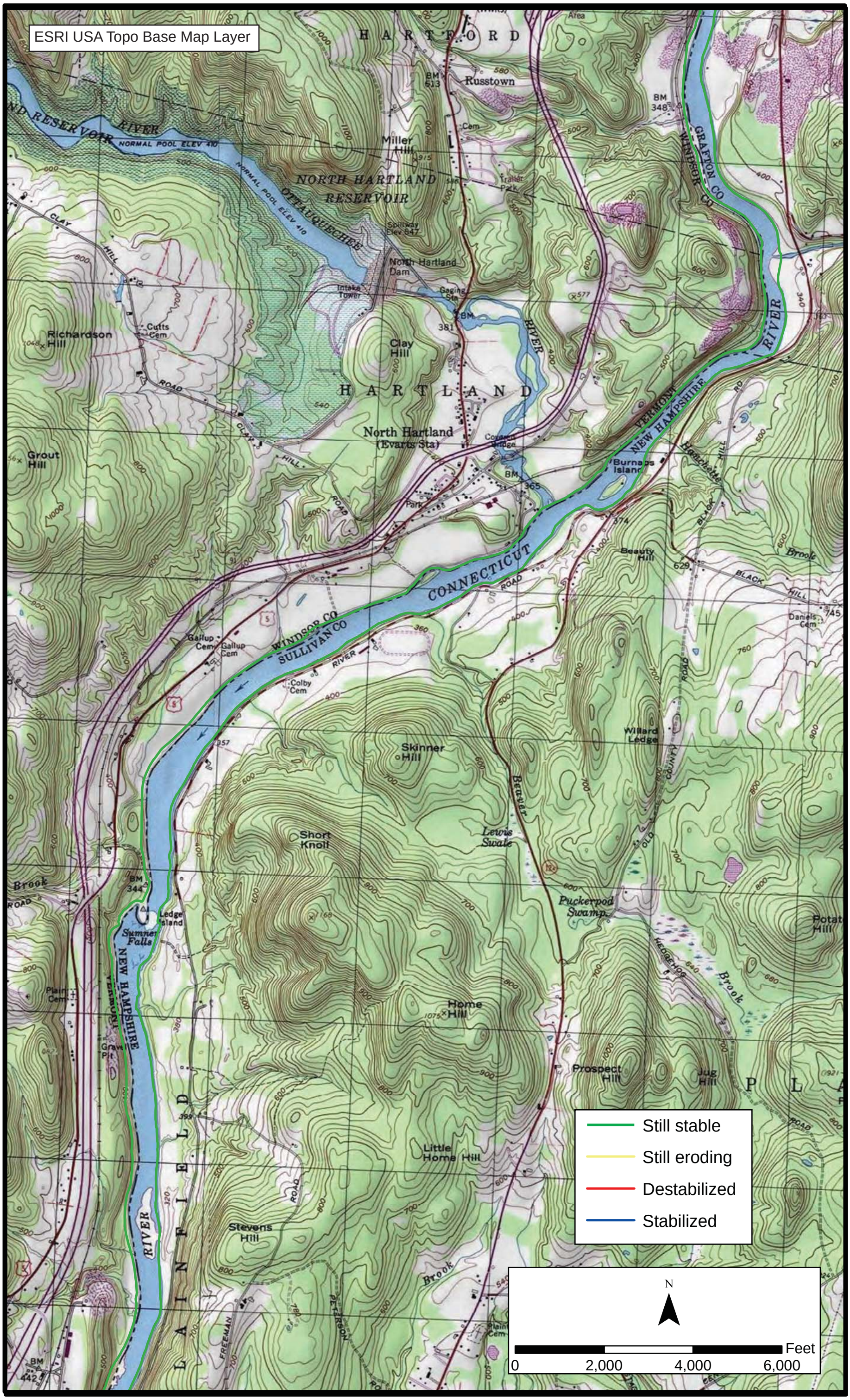
Appendix A. Plate A-5: Comparison of 1958 and 1978 erosion in or i h and Hanover.



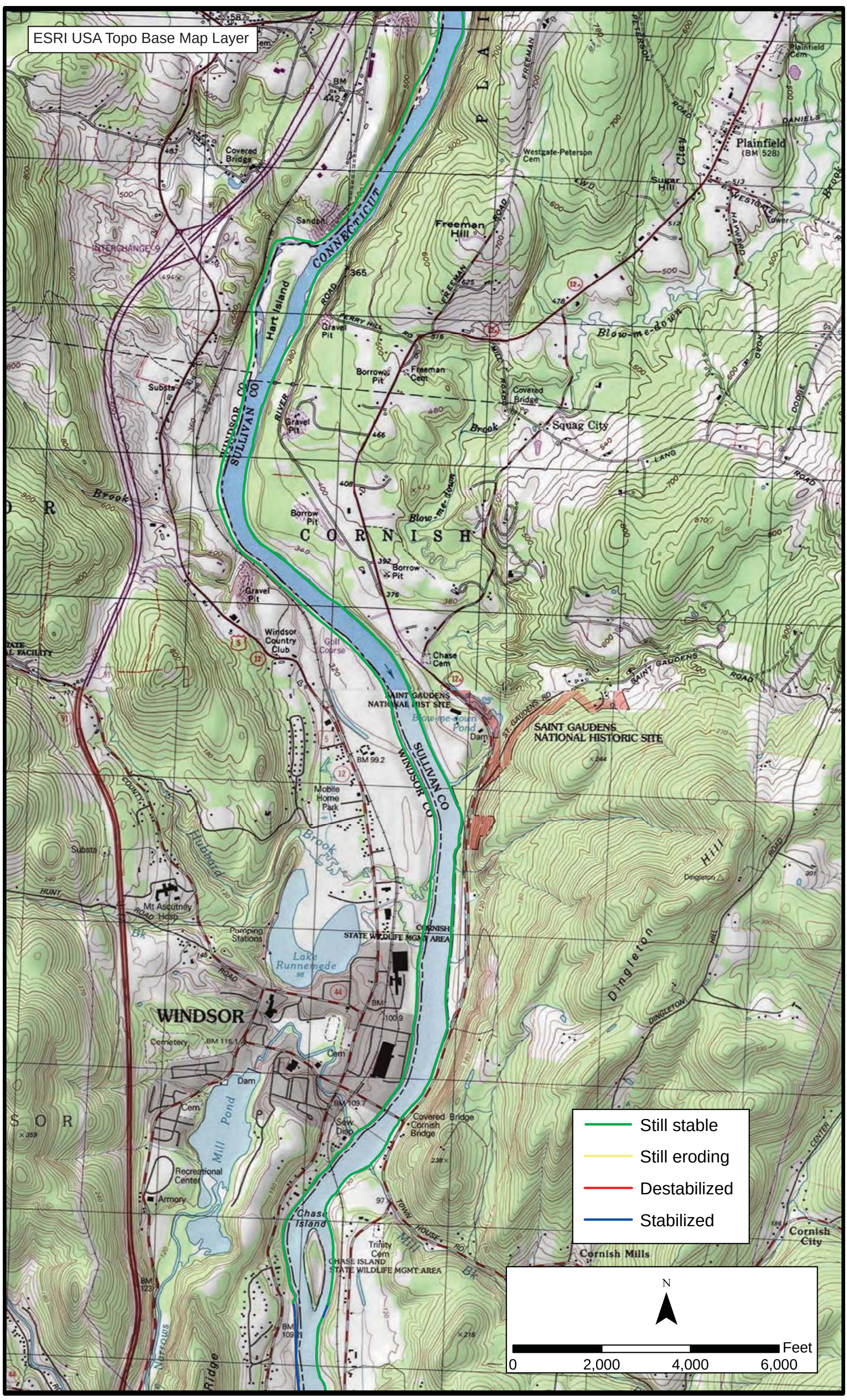
Appendix A. Plate A-6: Comparison of 1958 and 1978 erosion in or i h and Hanover.



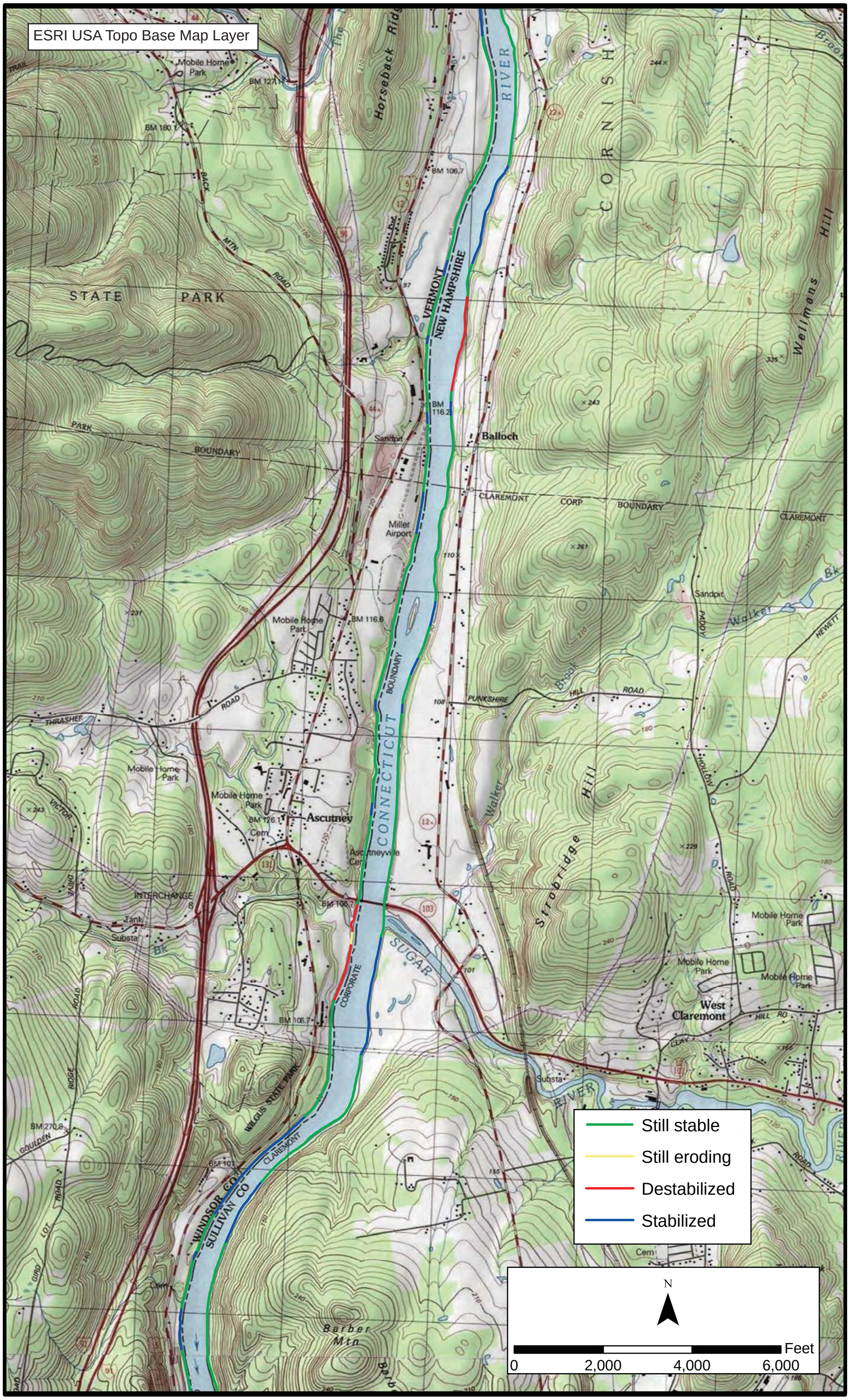
Appendix A. Plate A-7: Comparison of 1958 and 1978 erosion in Hartford and Lebanon.



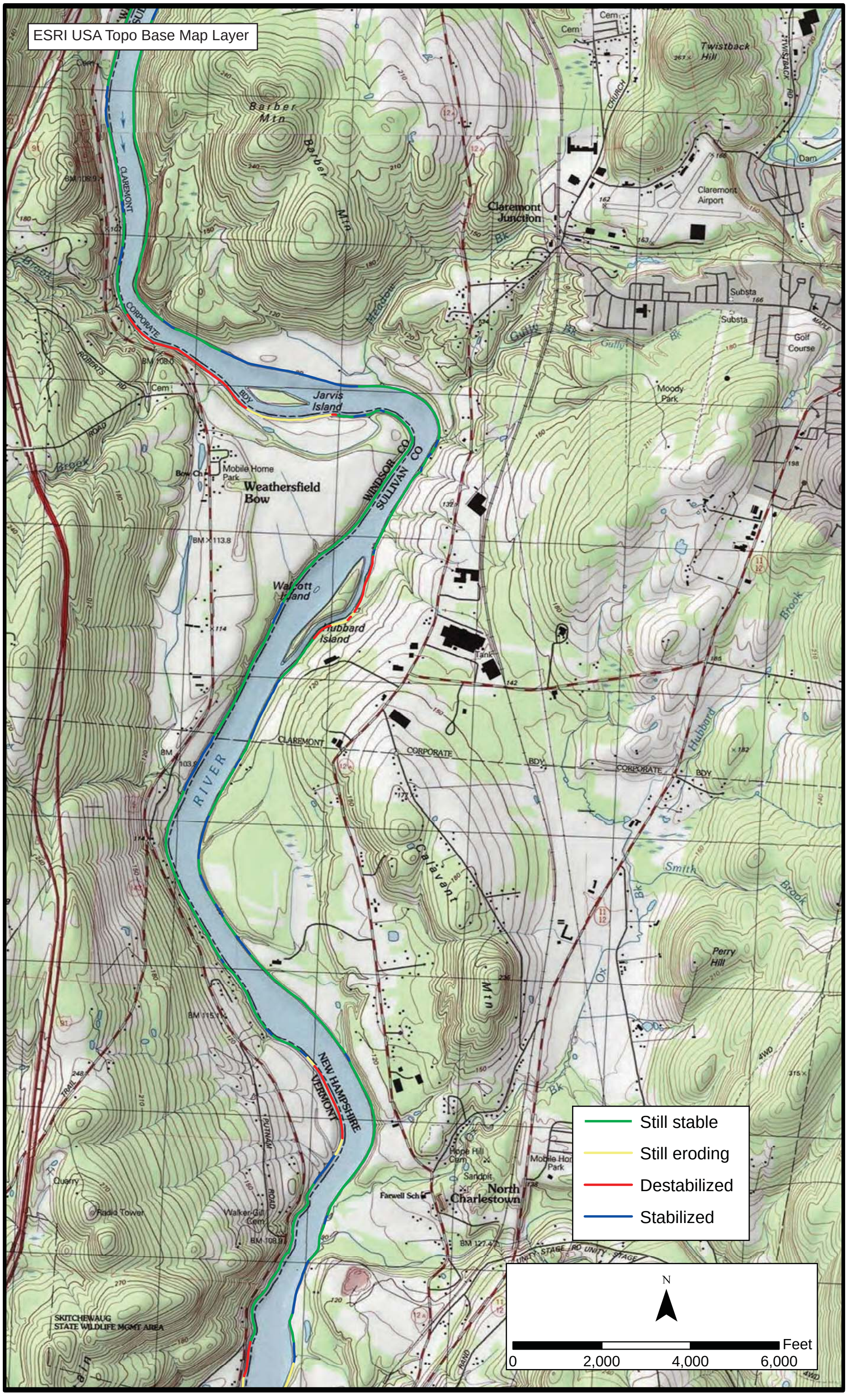
Appendix A. Plate A-8: Comparison of 1958 and 1978 erosion in Hartland and Plainfield.



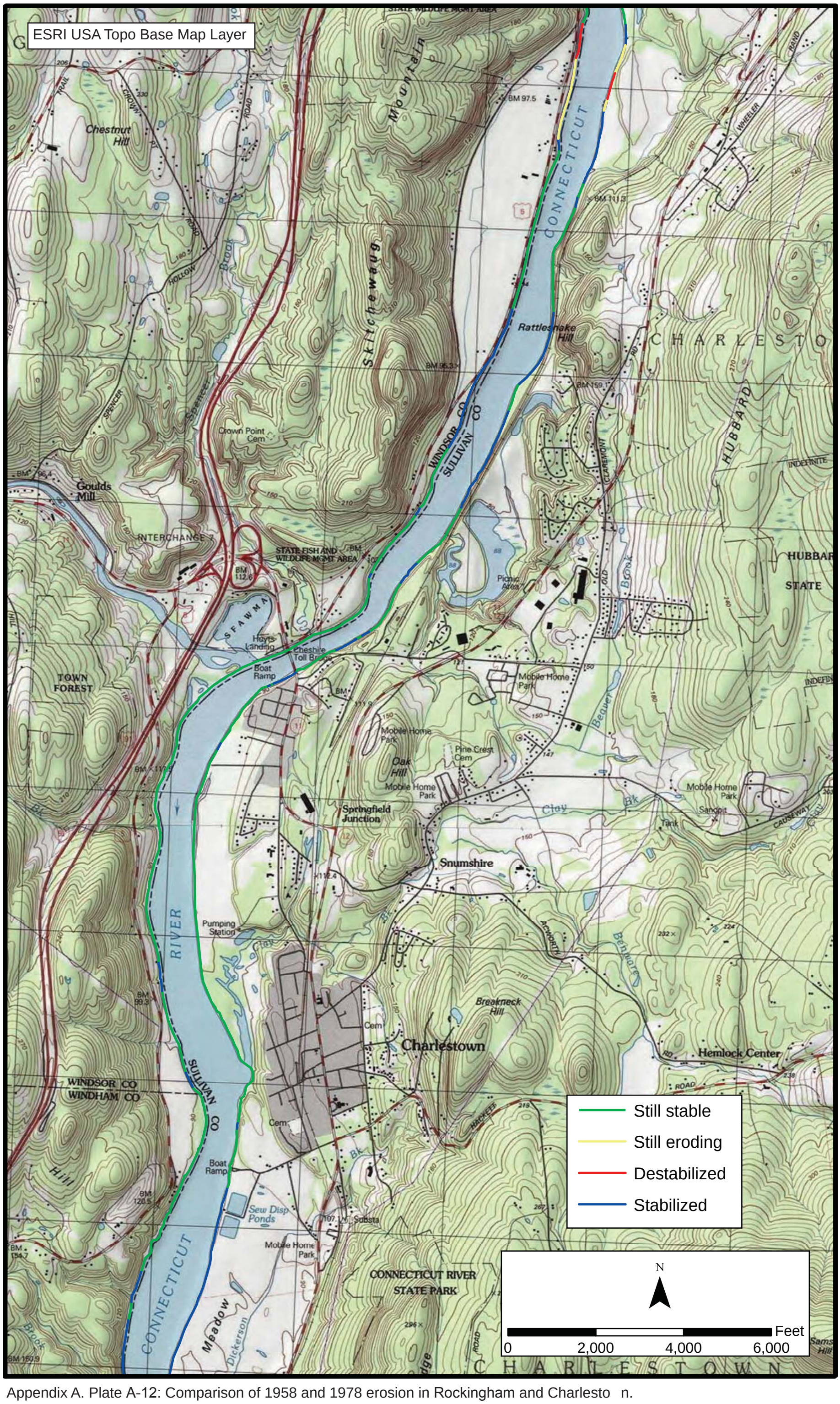
Appendix A. Plate A-9: Comparison of 1958 and 1978 erosion in indsor and Cornish.



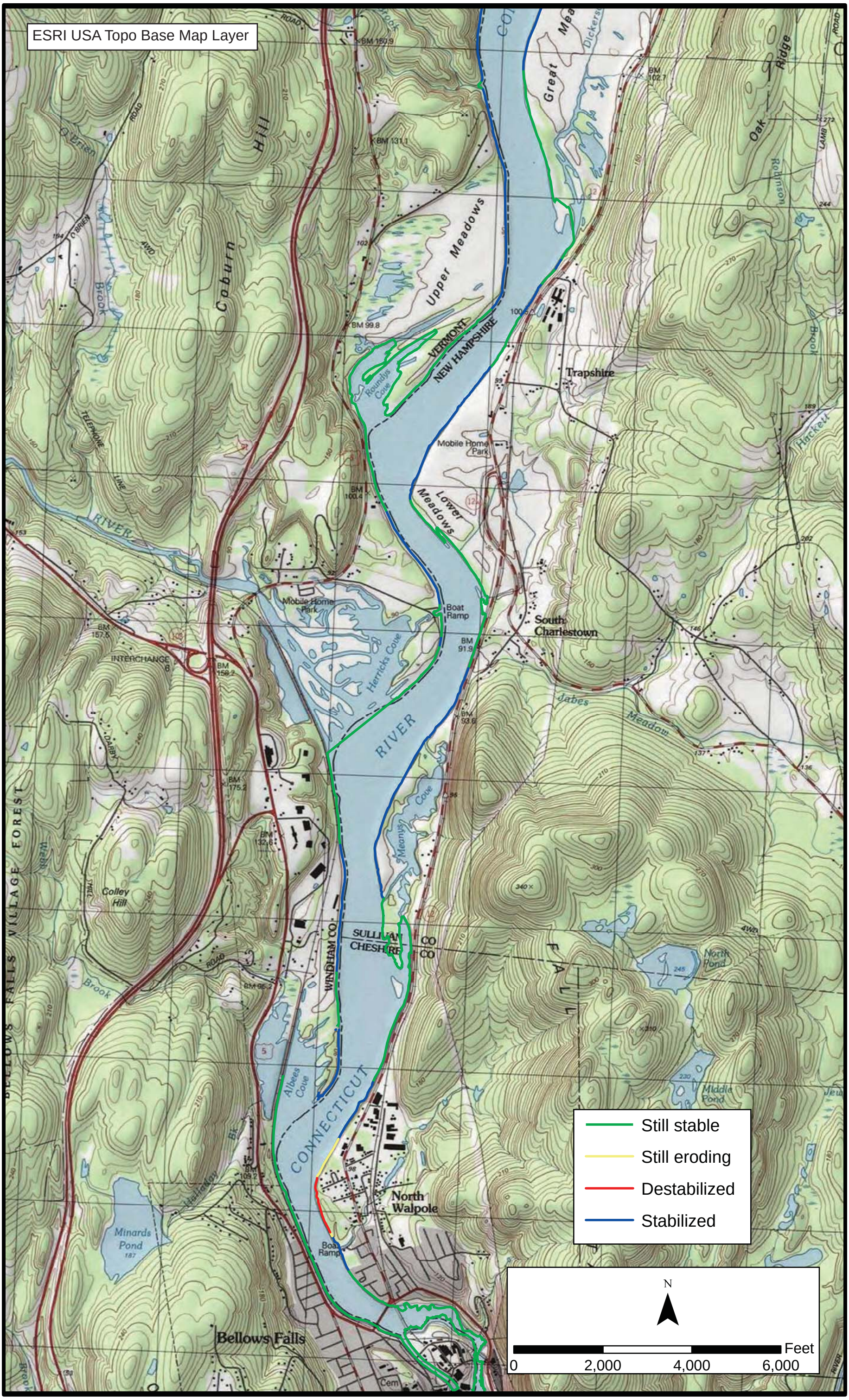
Appendix A. Plate A-10: Comparison of 1958 and 1978 erosion in As tney and Claremont.



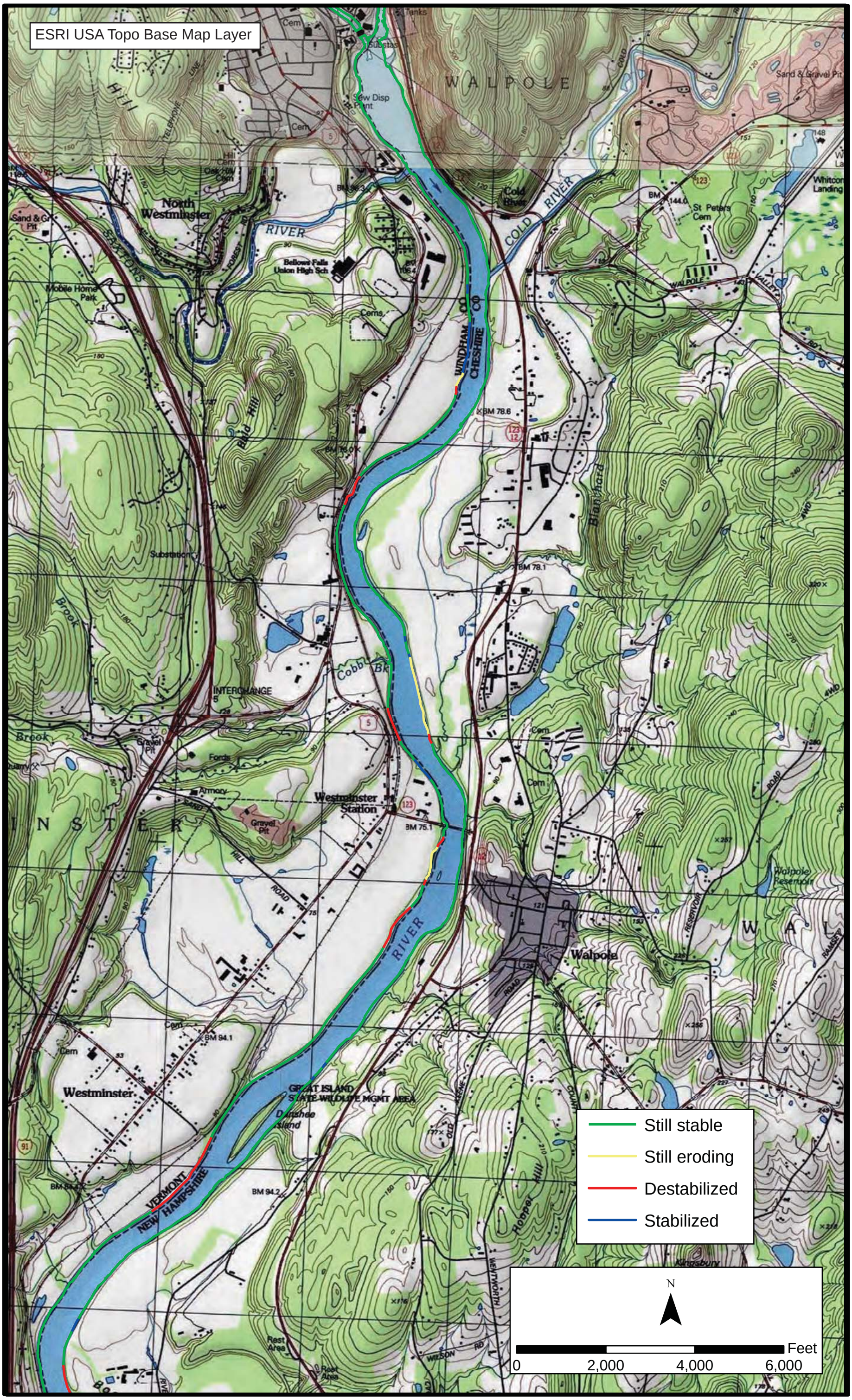
Appendix A. Plate A-11: Comparison of 1958 and 1978 erosion in Springfield and Charlesto n.



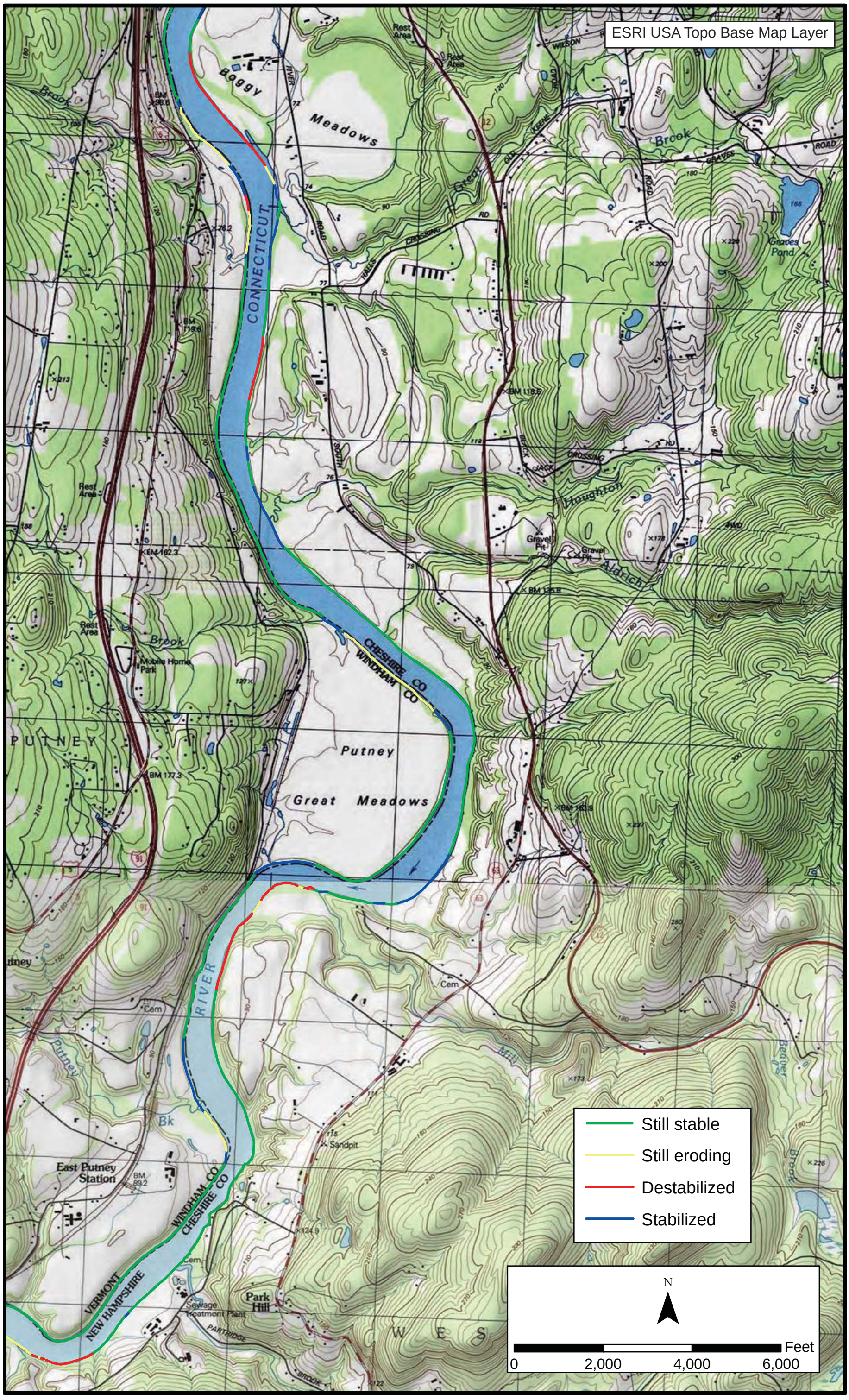
Appendix A. Plate A-12: Comparison of 1958 and 1978 erosion in Rockingham and Charlesto n.



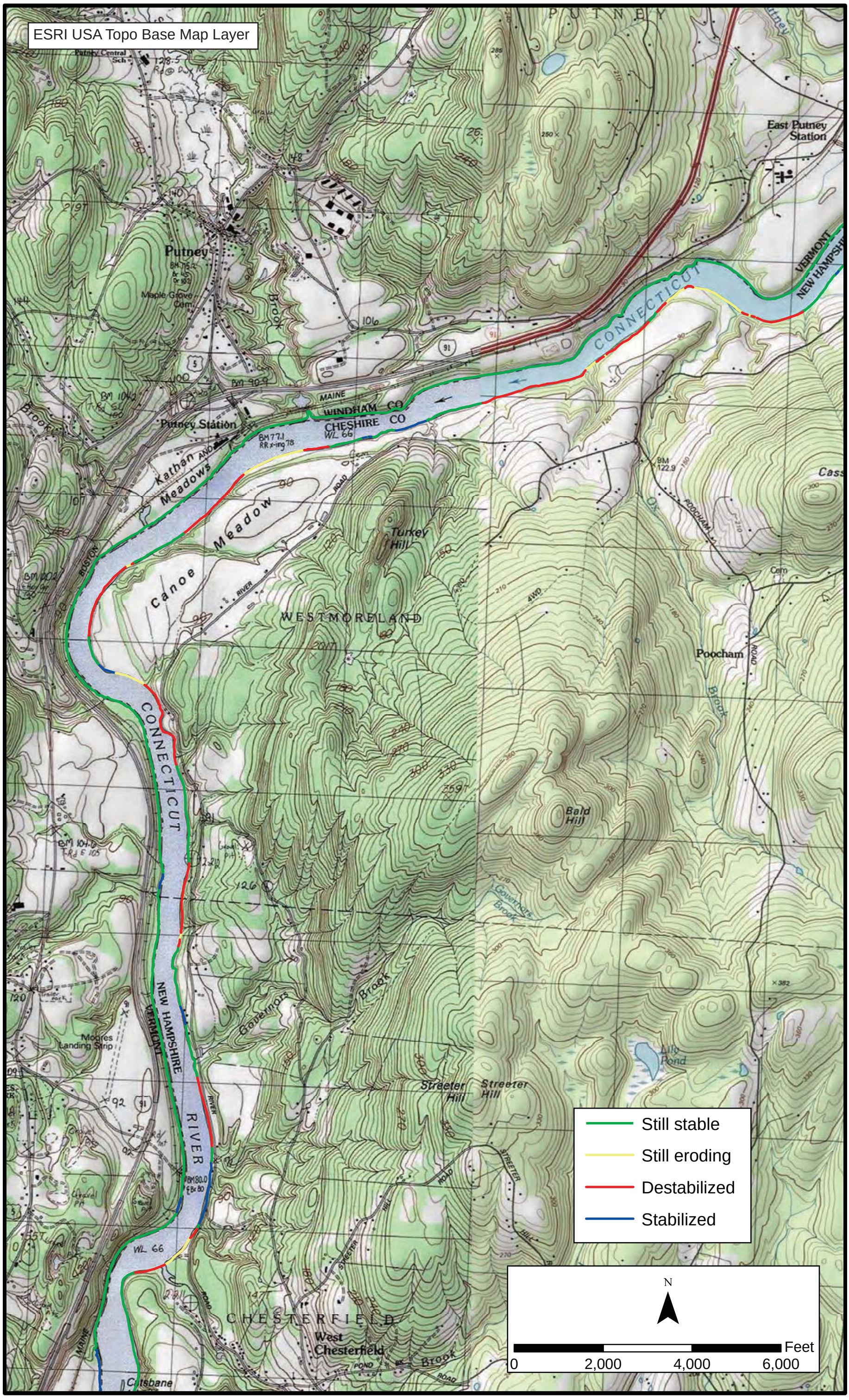
Appendix A. Plate A-13: Comparison of 1958 and 1978 erosion in Rockingham and alpole.



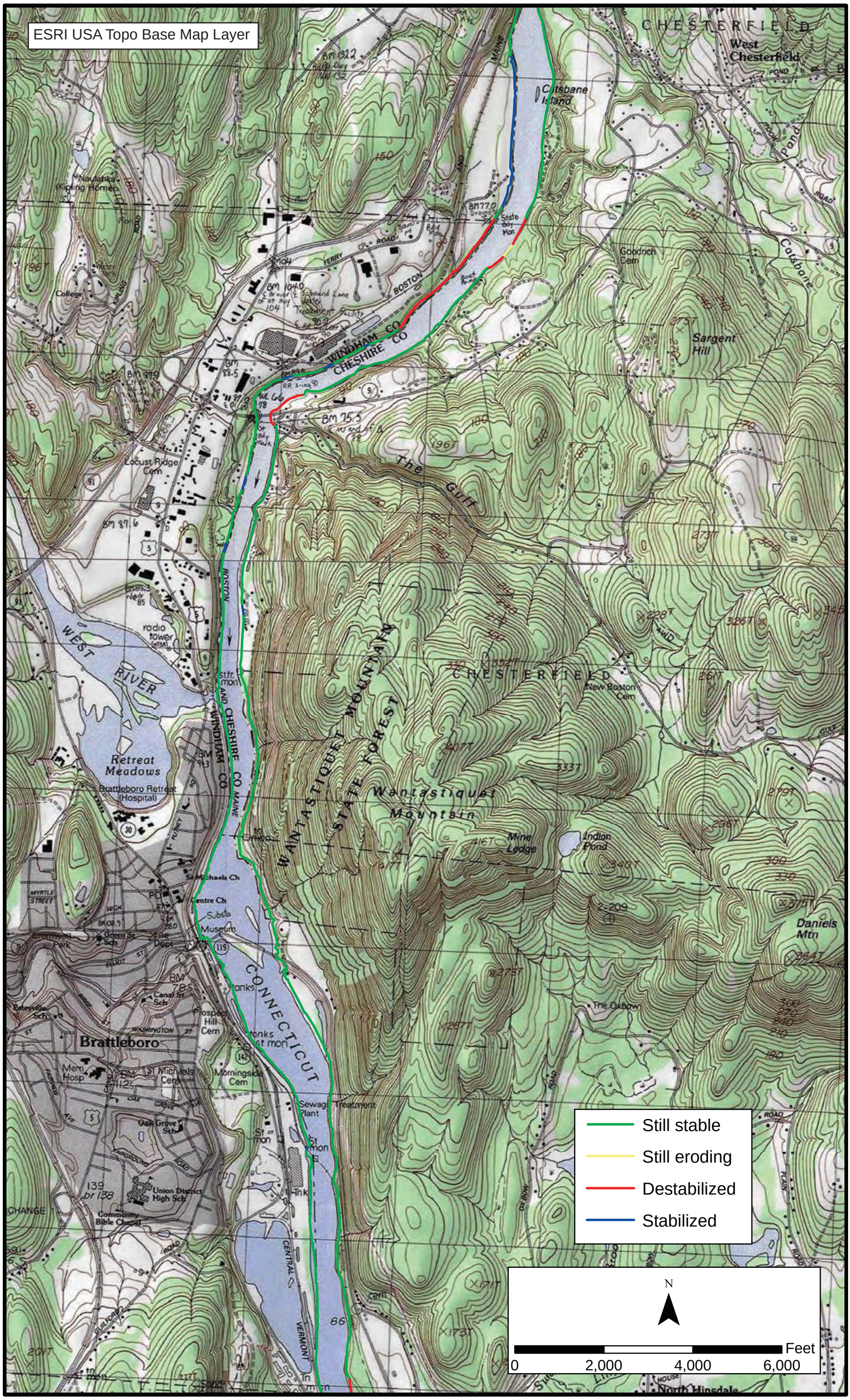
Appendix A. Plate A-14: Comparison of 1958 and 1978 erosion in estminster and alpole.



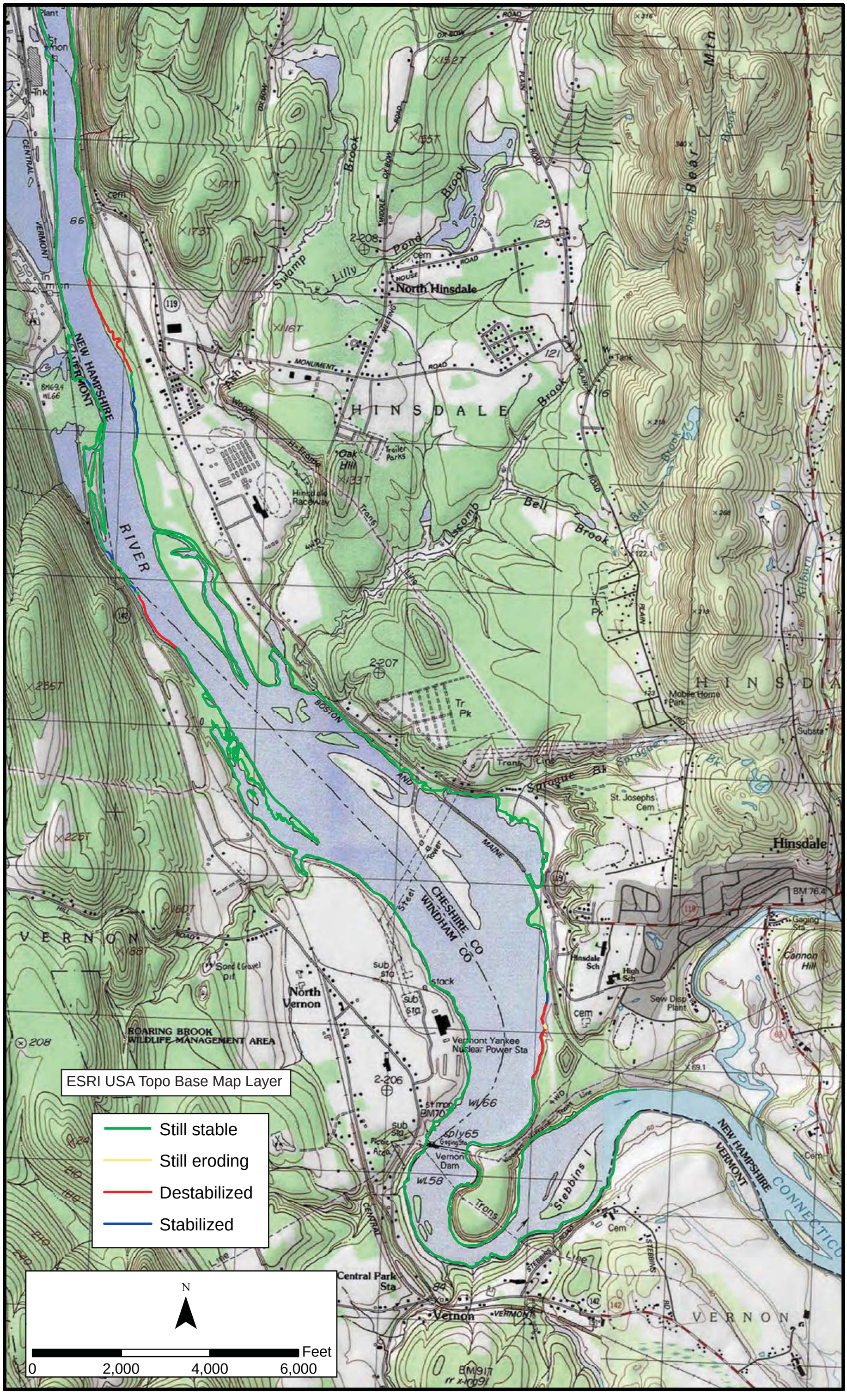
Appendix A. Plate A-15: Comparison of 1958 and 1978 erosion in P tney and estmoreland.



Appendix A. Plate A-16: Comparison of 1958 and 1978 erosion in P tney and estmoreland.



Appendix A. Plate A-17: Comparison of 1958 and 1978 erosion in Brattleboro and Hinsdale



Appendix A. Plate A-18: Comparison of 1958 and 1978 erosion in ernon and Hinsdale.

APPENDIX B

Historical Ground Photographs and 2015 Matches

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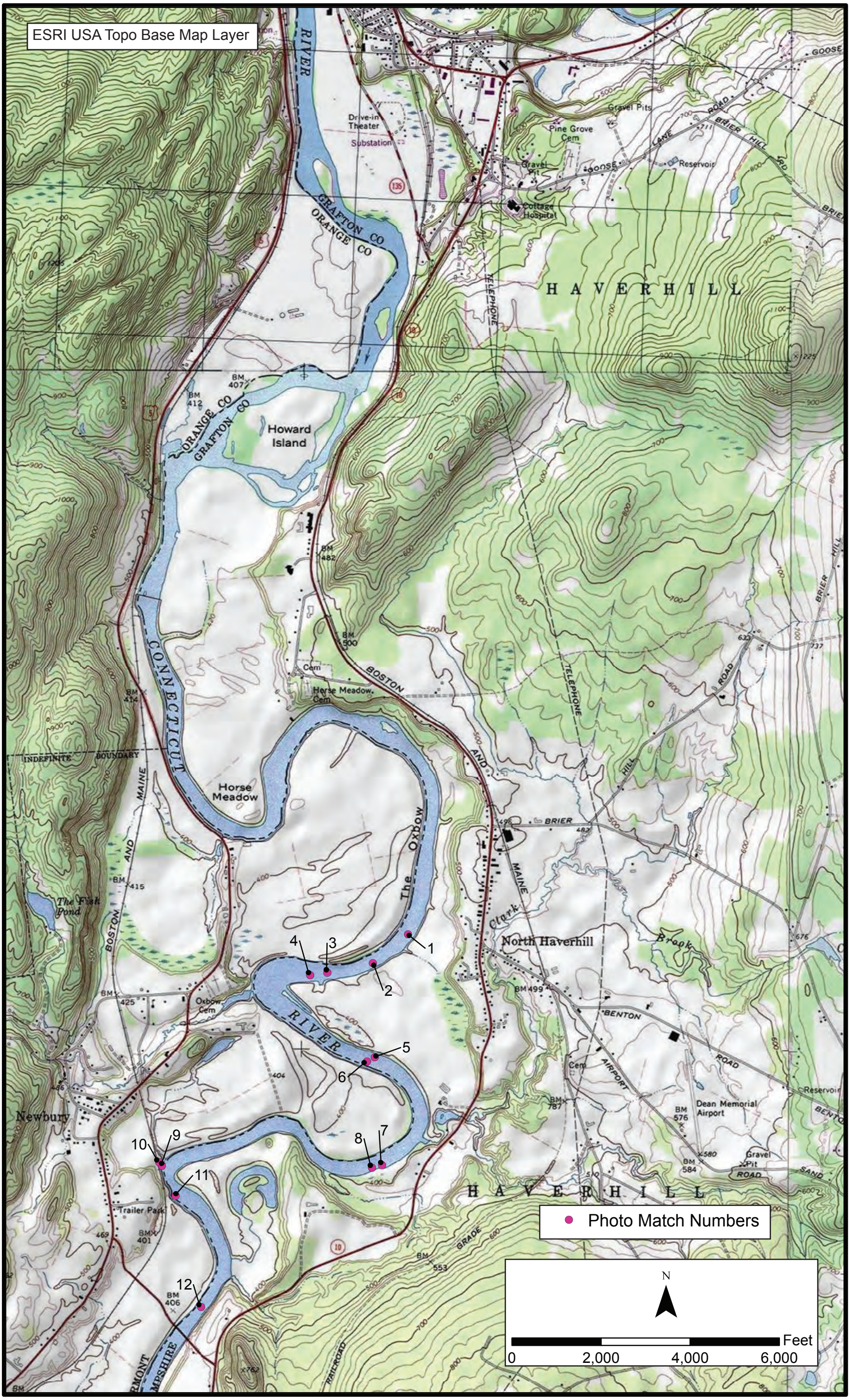
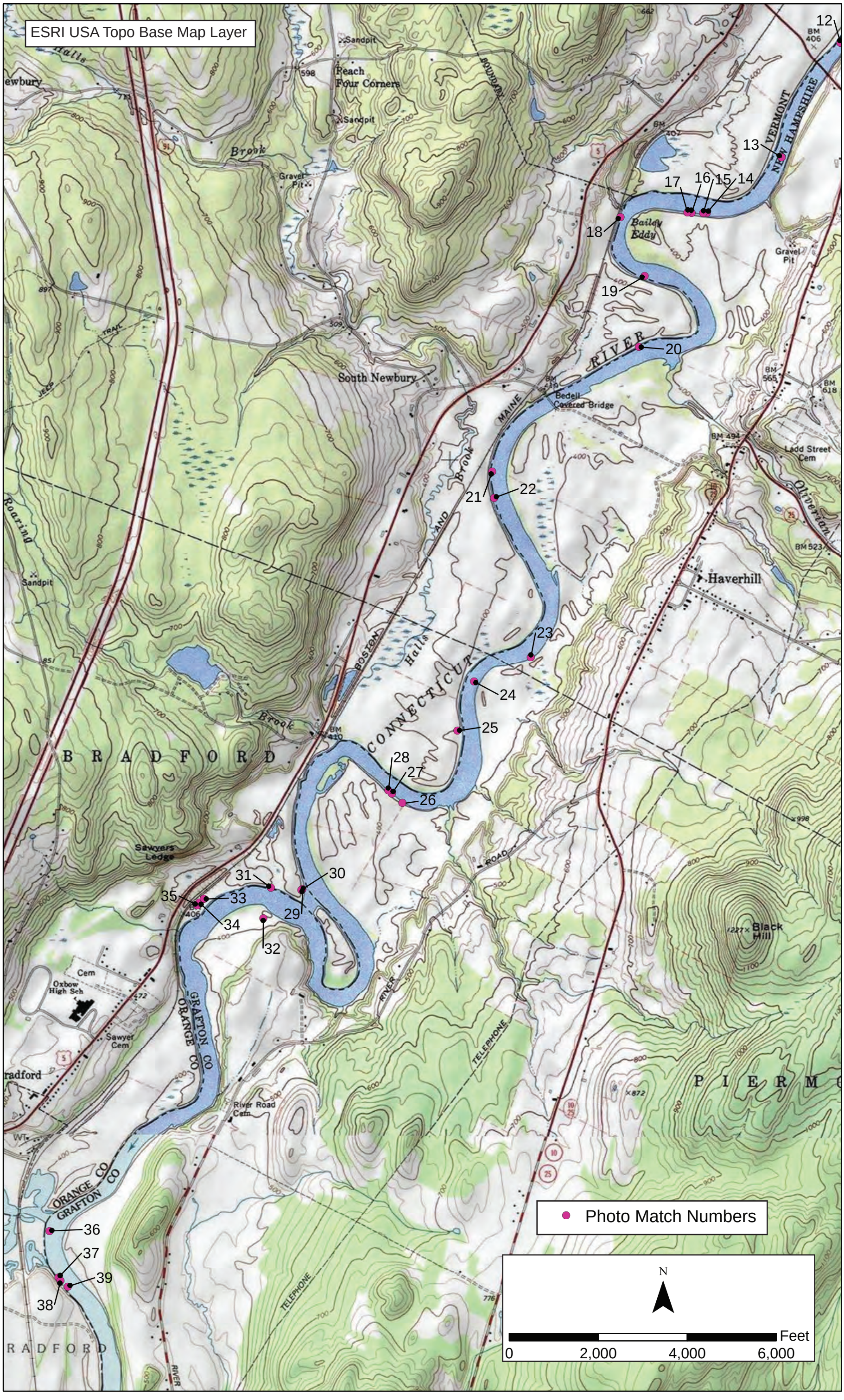
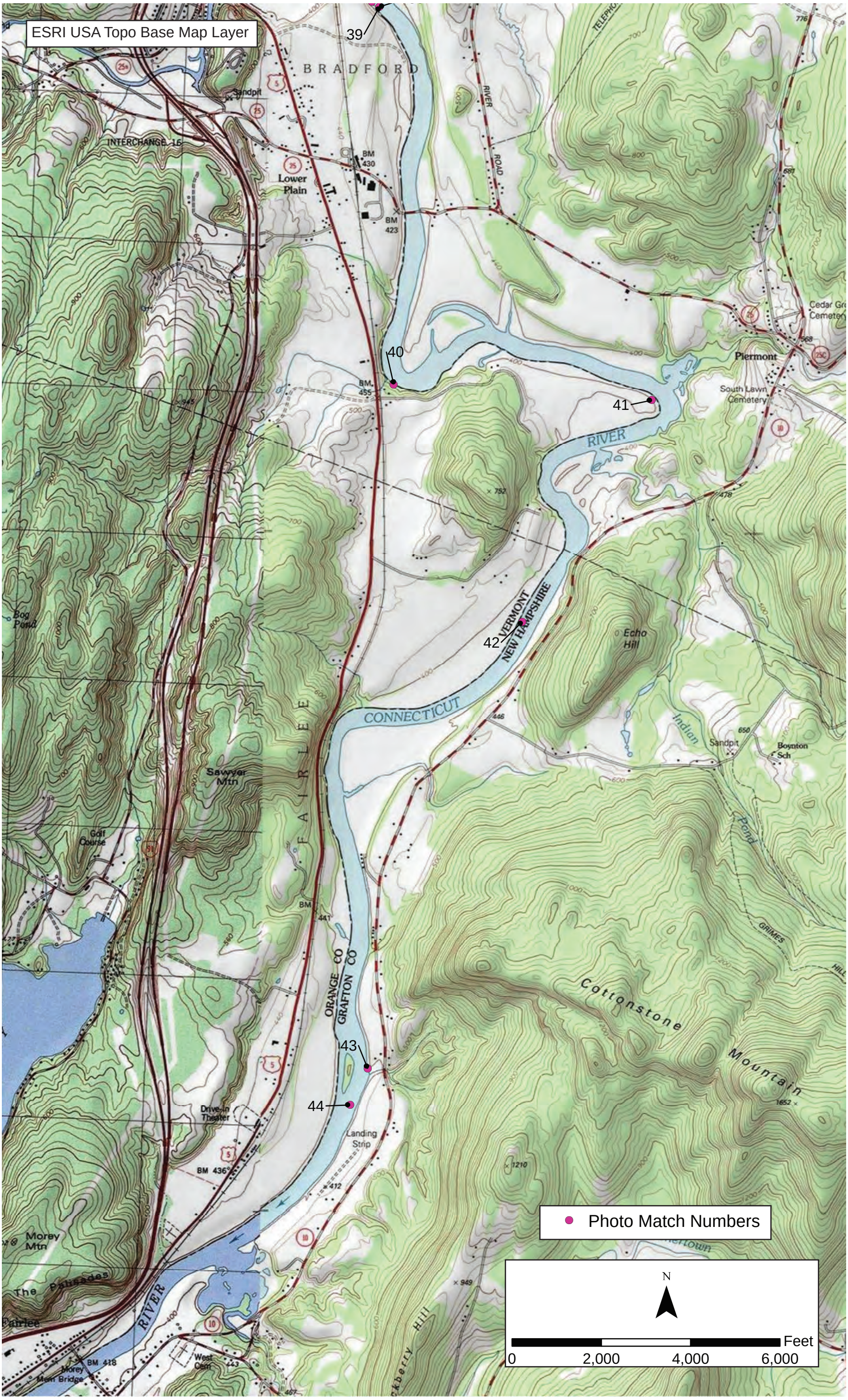


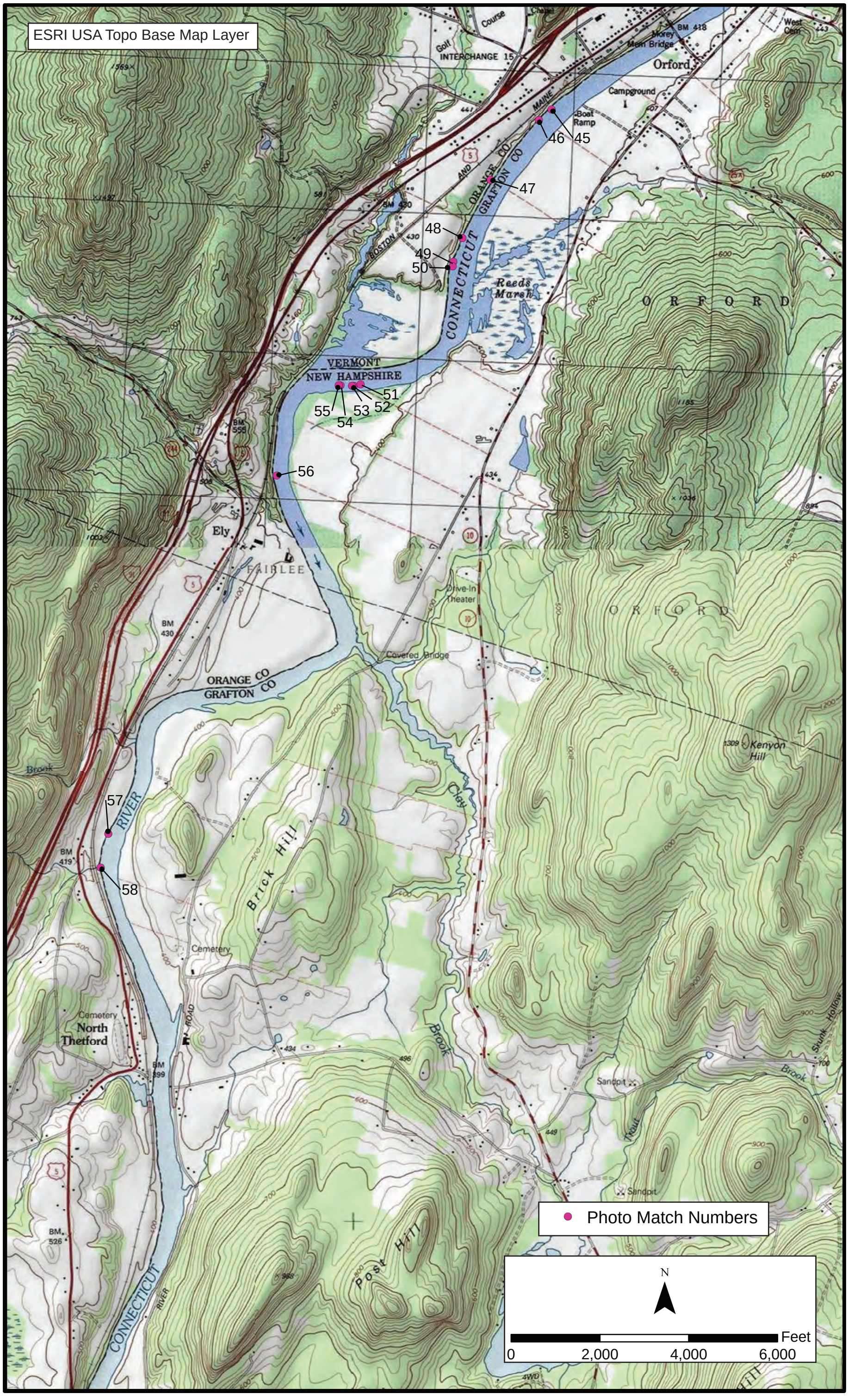
Appendix B. Plate B-1: Map of Historic Ground Photographs and 2015 Matches



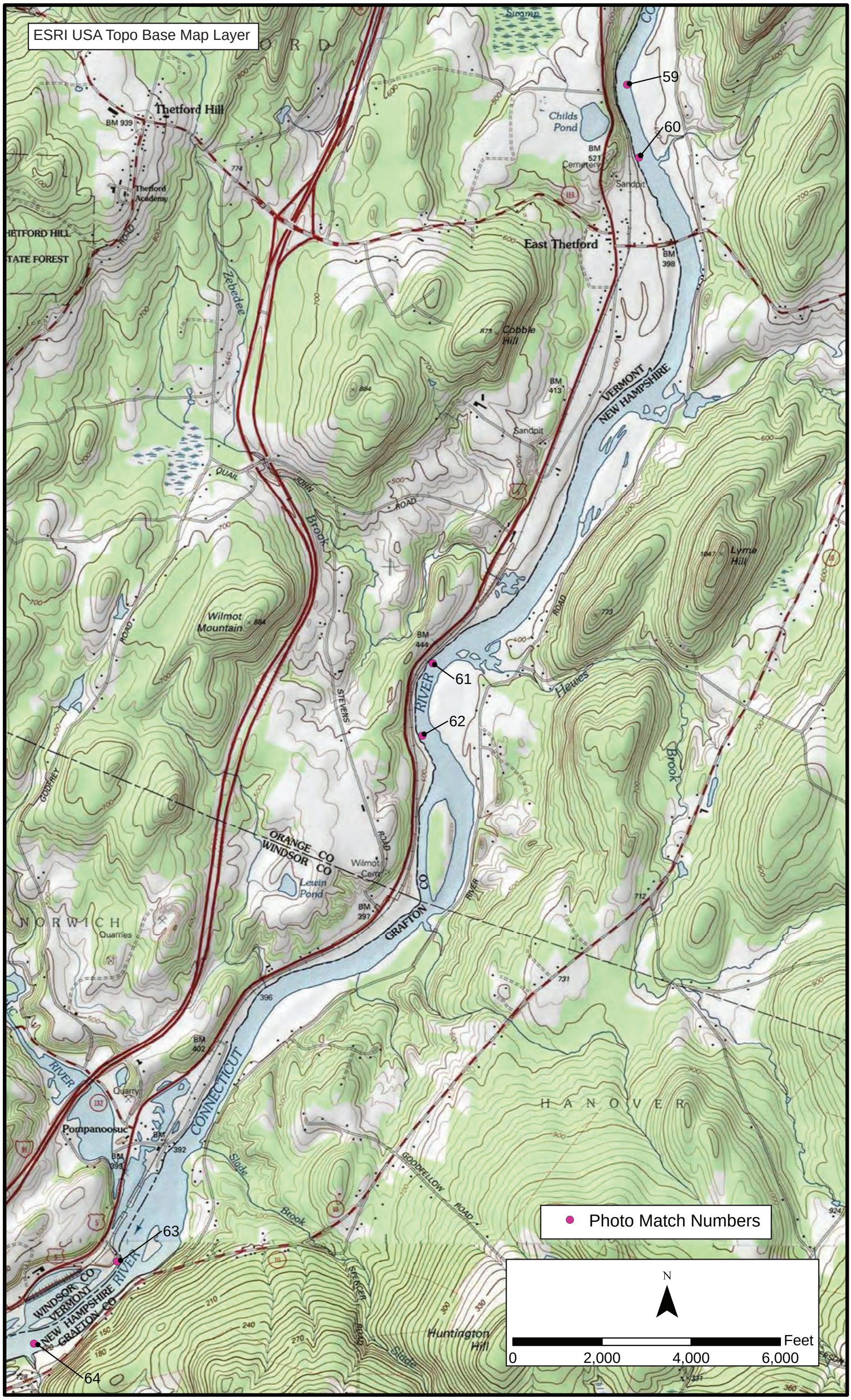
Appendix B. Plate B-2: Map of Historic Ground Photographs and 2015 Matches.



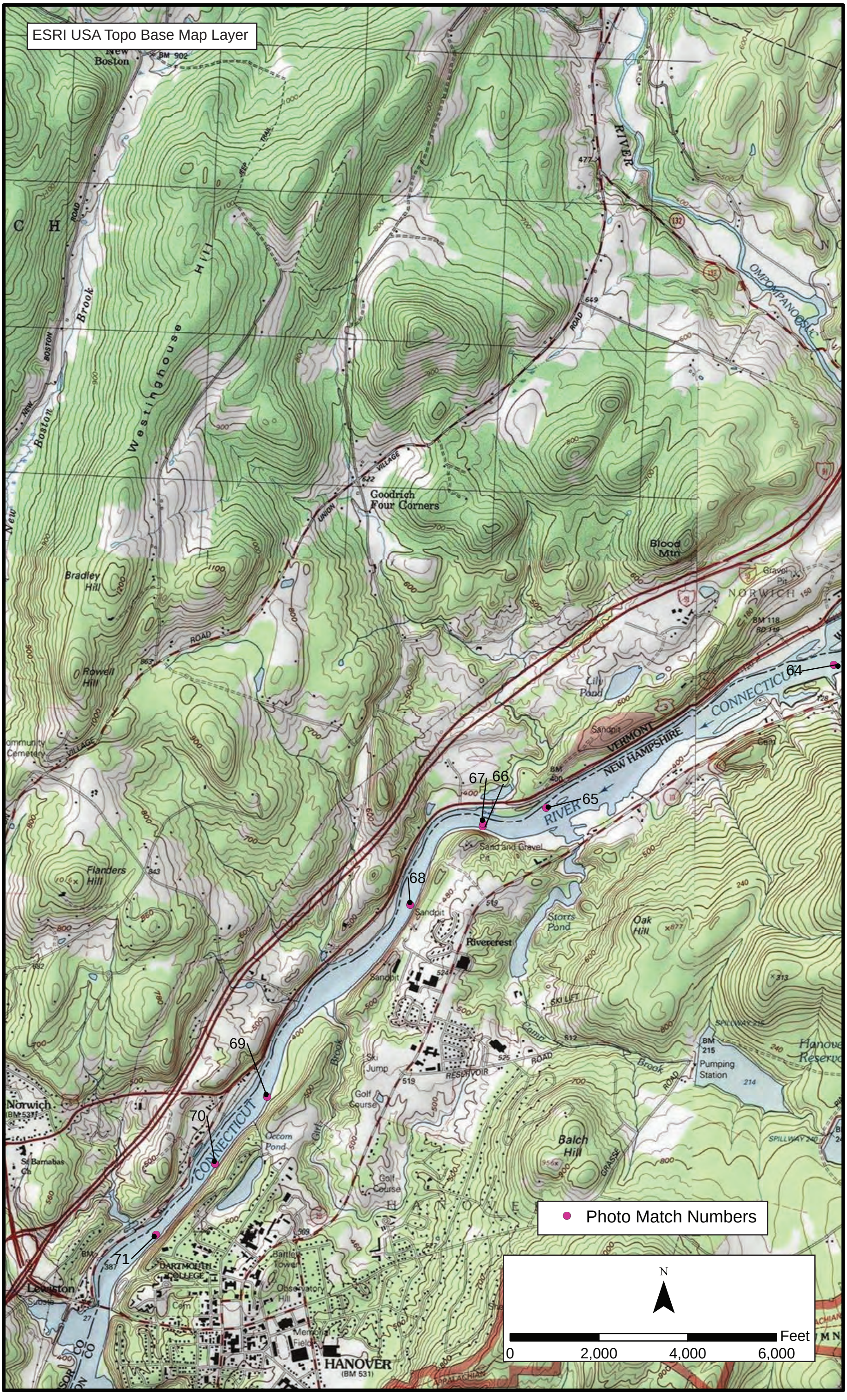
Appendix B. Plate B-3: Map of Historic Ground Photographs and 2015 Matches.



Appendix B. Plate B-4: Map of Historic Ground Photographs and 2015 Matches.

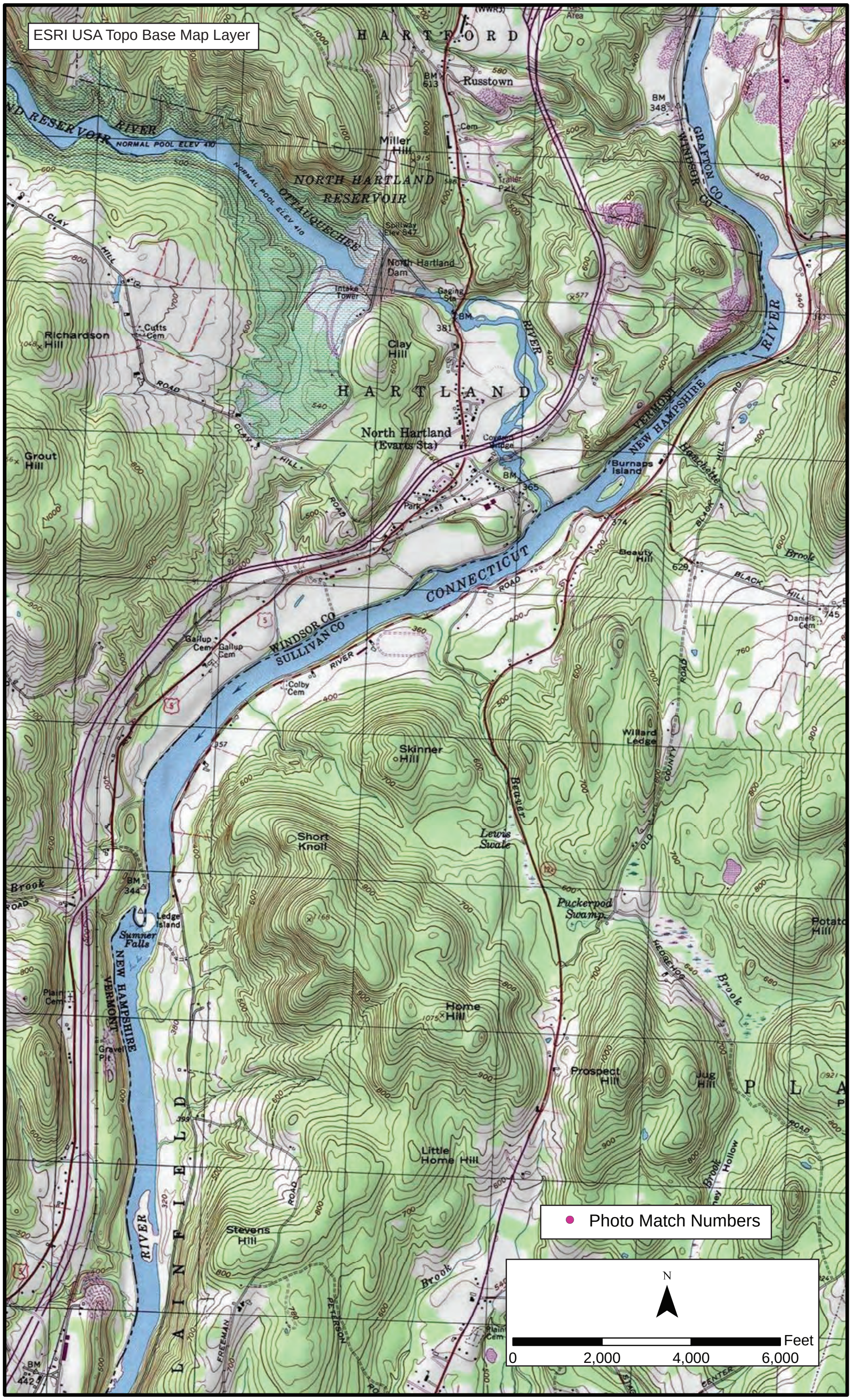


Appendix B. Plate B-5: Map of Historic Ground Photographs and 2015 Matches.

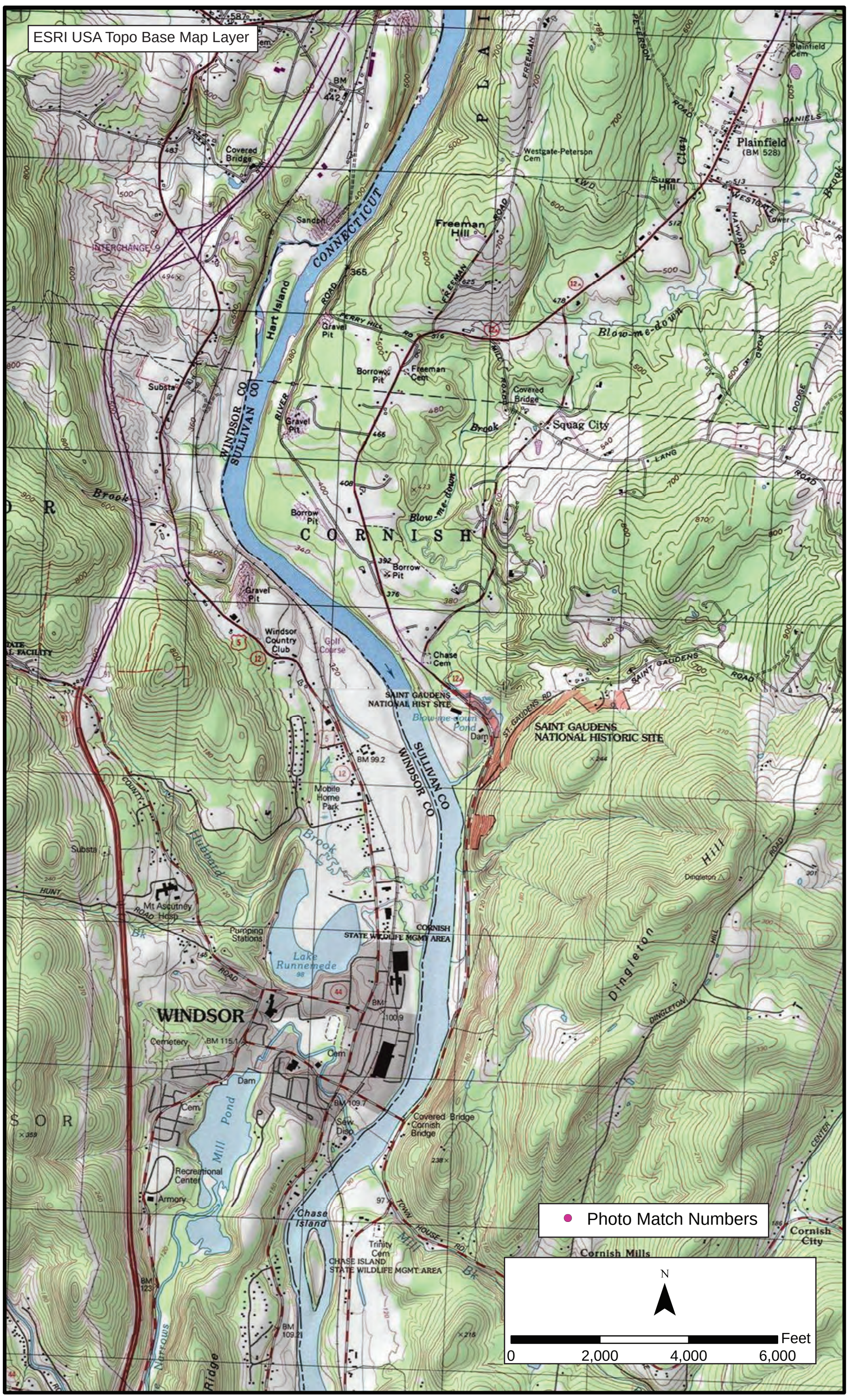


Appendix B. Plate B-6: Map of Historic Ground Photographs and 2015 Matches.

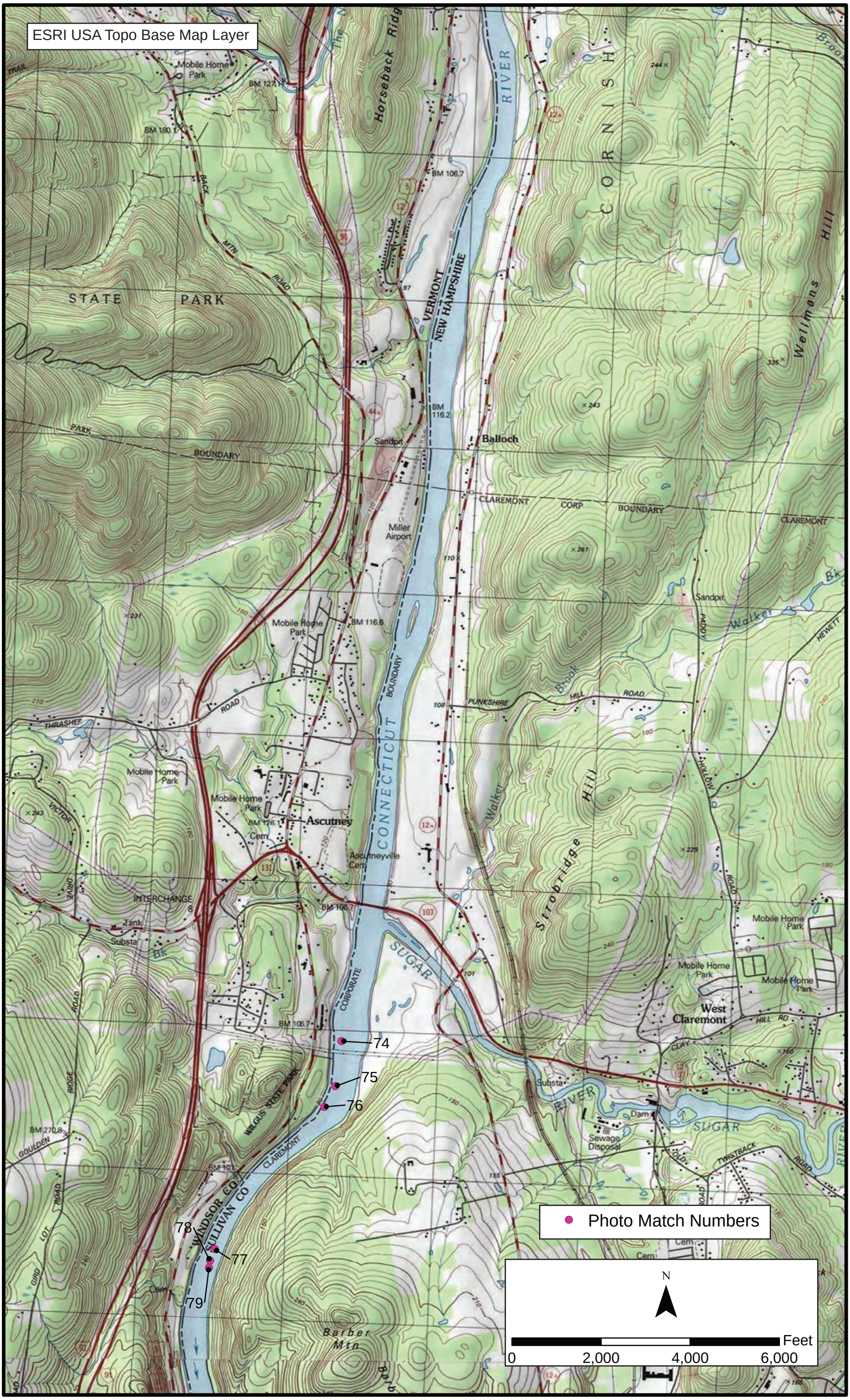
Appendix B. Plate B-7: Map of Historic Ground Photographs and 2015 Matches.



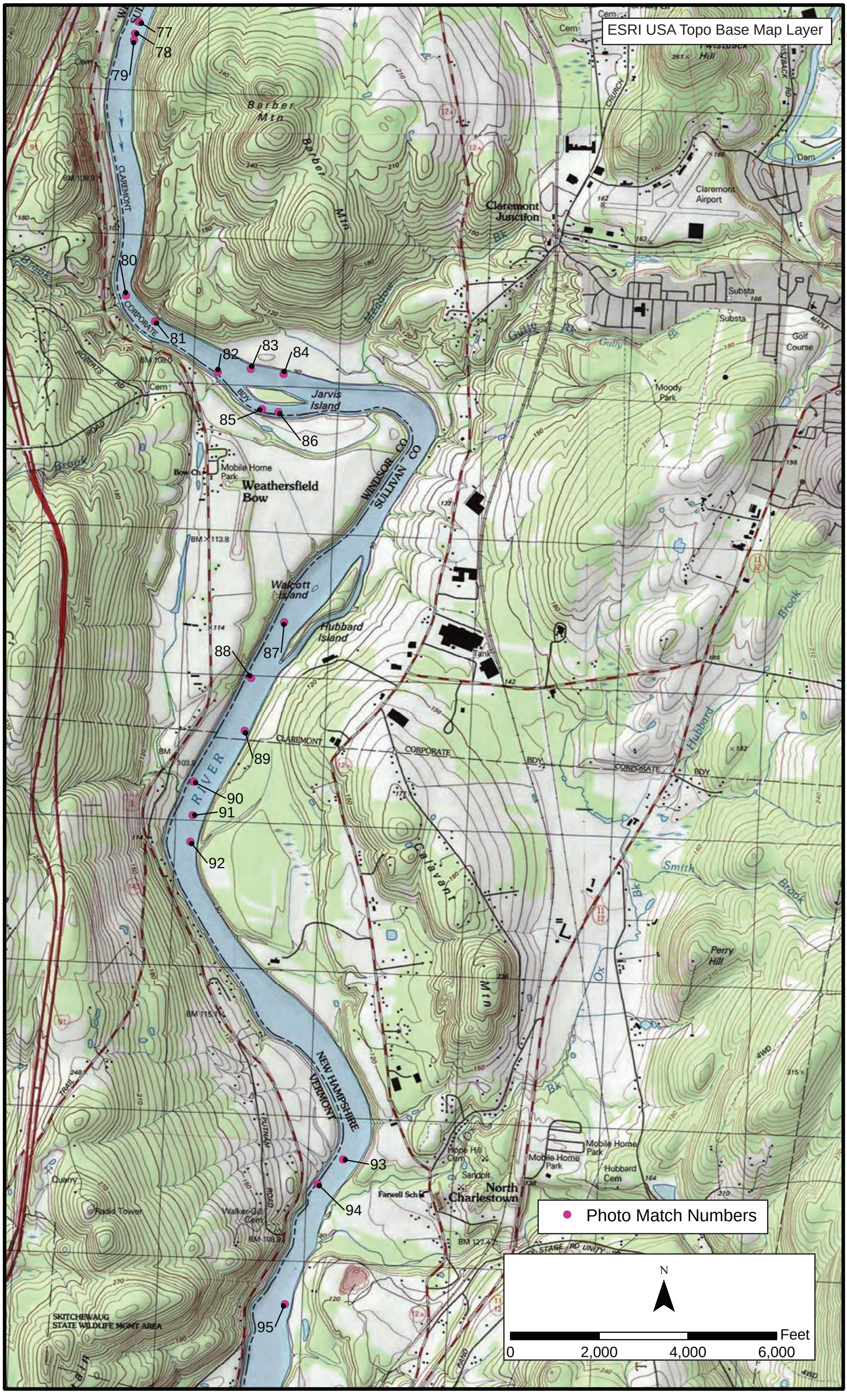
Appendix B. Plate B-8: Map of Historic Ground Photographs and 2015 Matches.



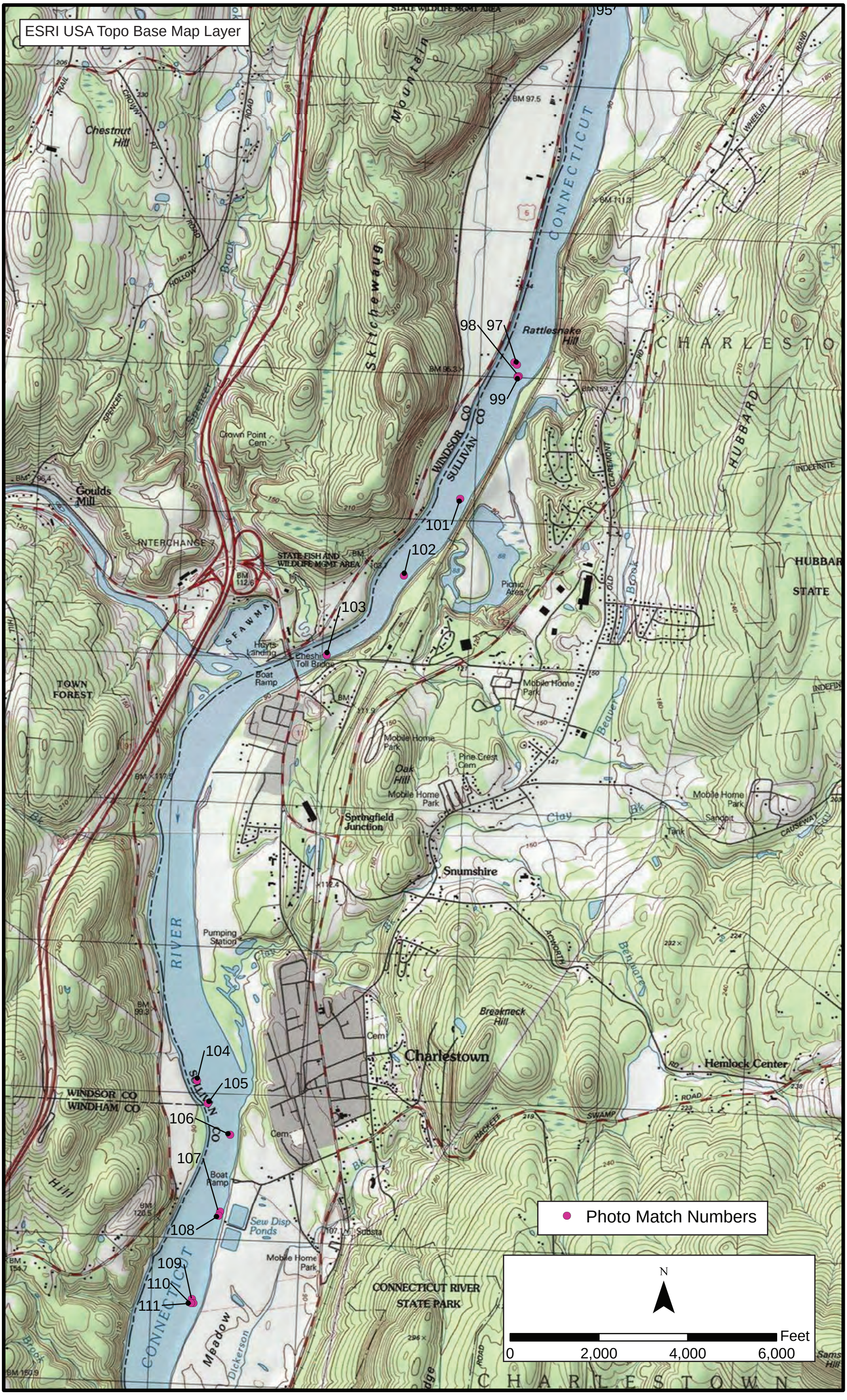
Appendix B. Plate B-9: Map of Historic Ground Photographs and 2015 Matches



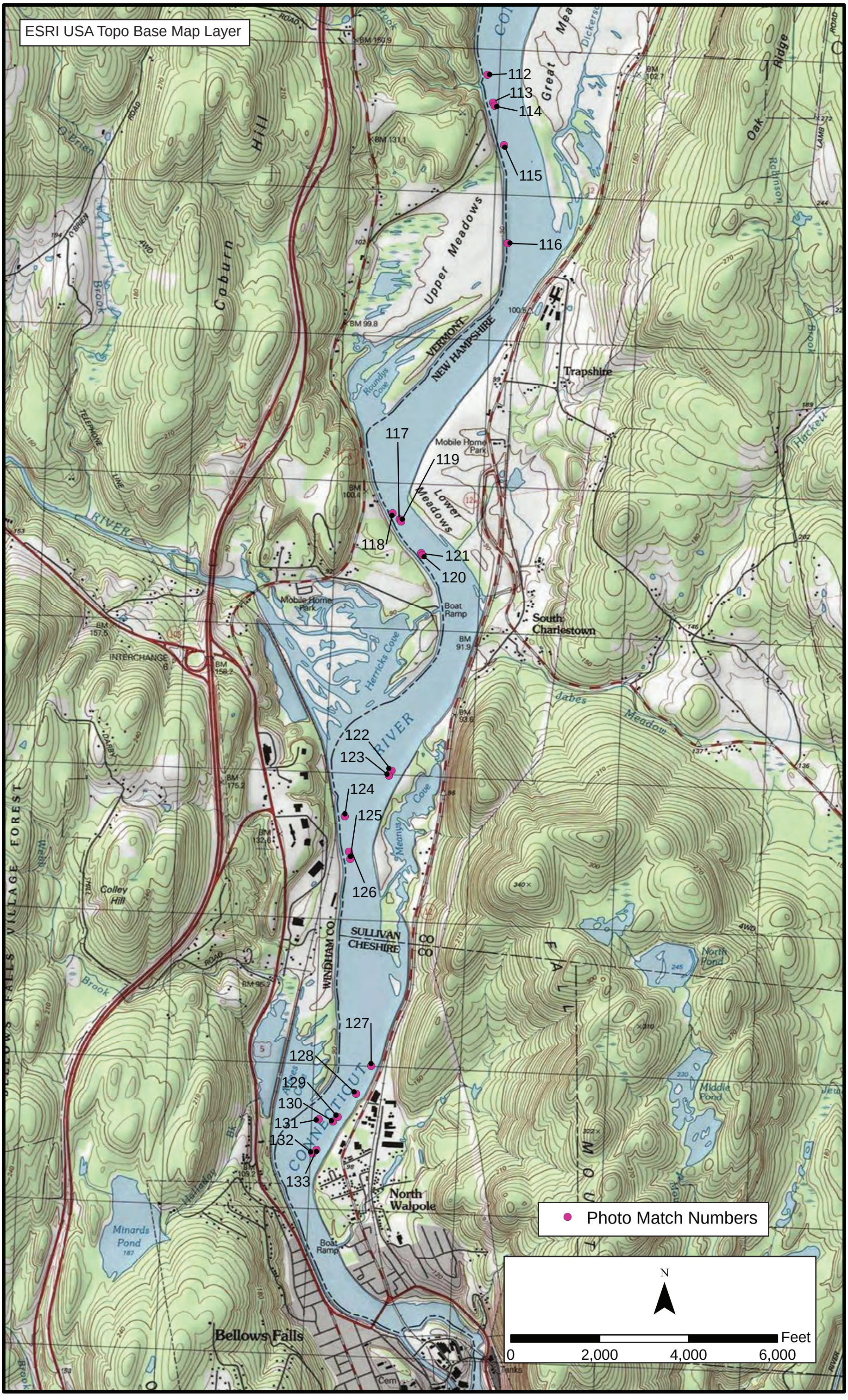
Appendix B. Plate B-10: Map of Historic Ground Photographs and 2015 Matches.



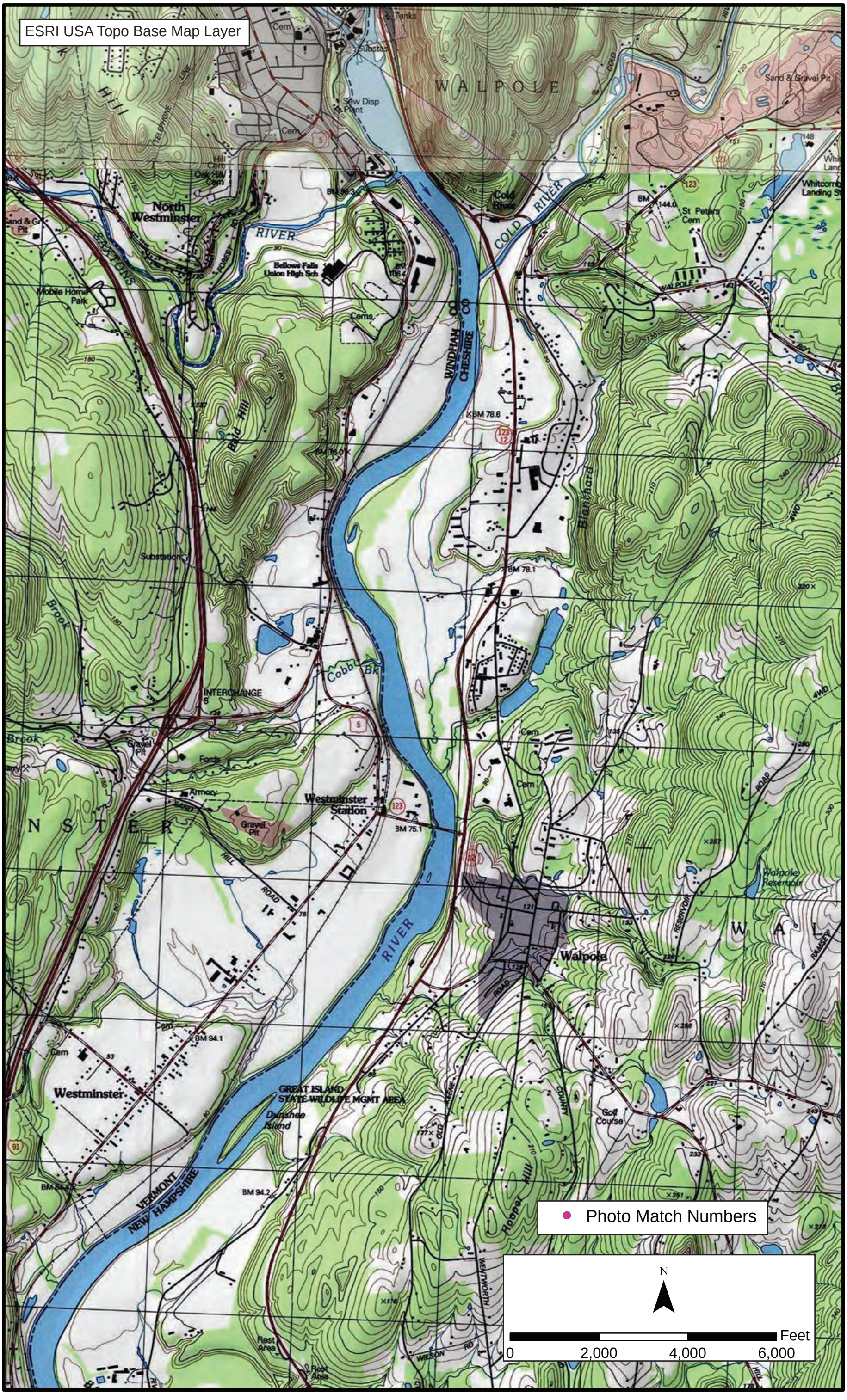
Appendix B. Plate B-11: Map of Historic Ground Photographs and 2015 Matches.



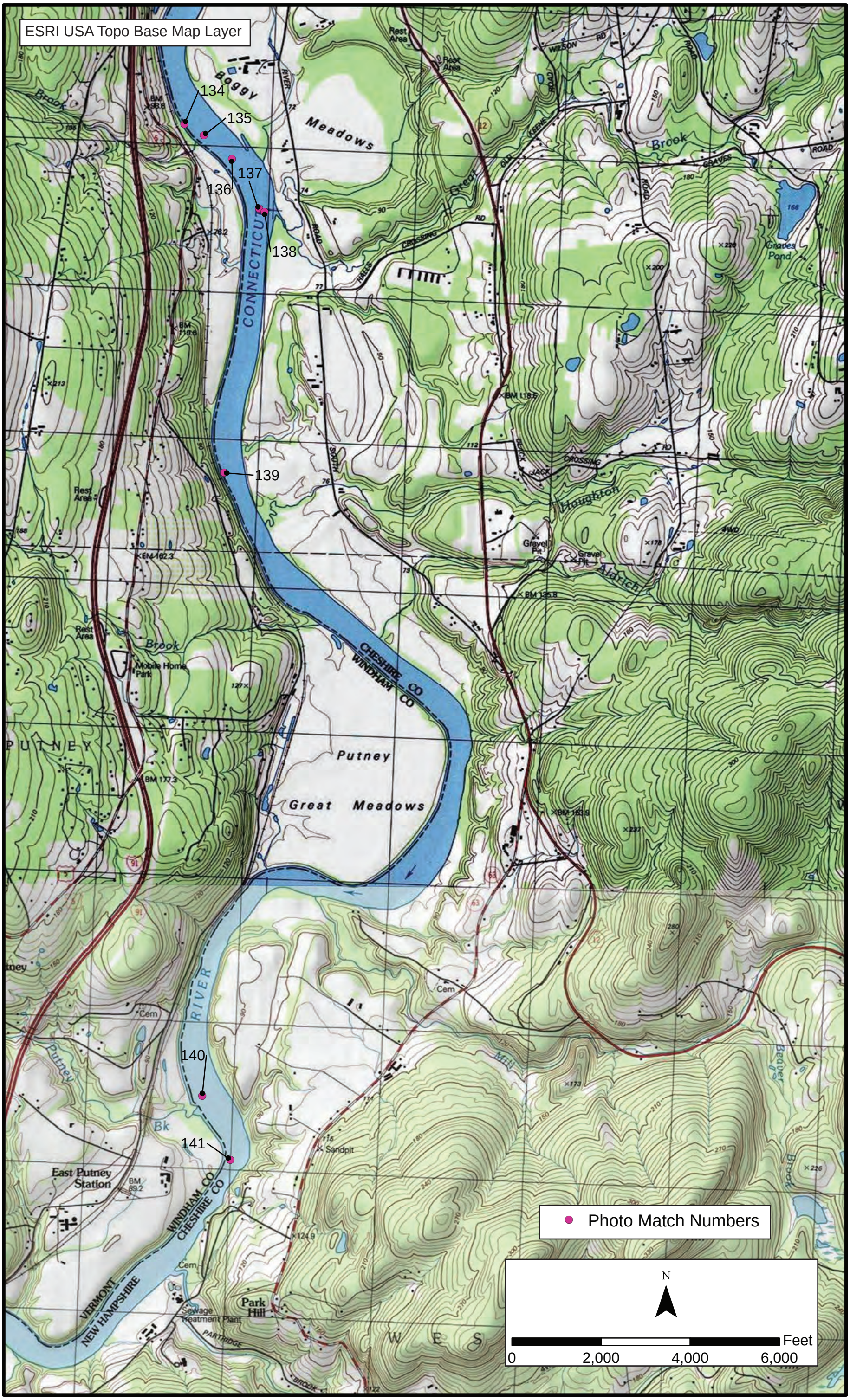
Appendix B. Plate B-12: Map of Historic Ground Photographs and 2015 Matches.



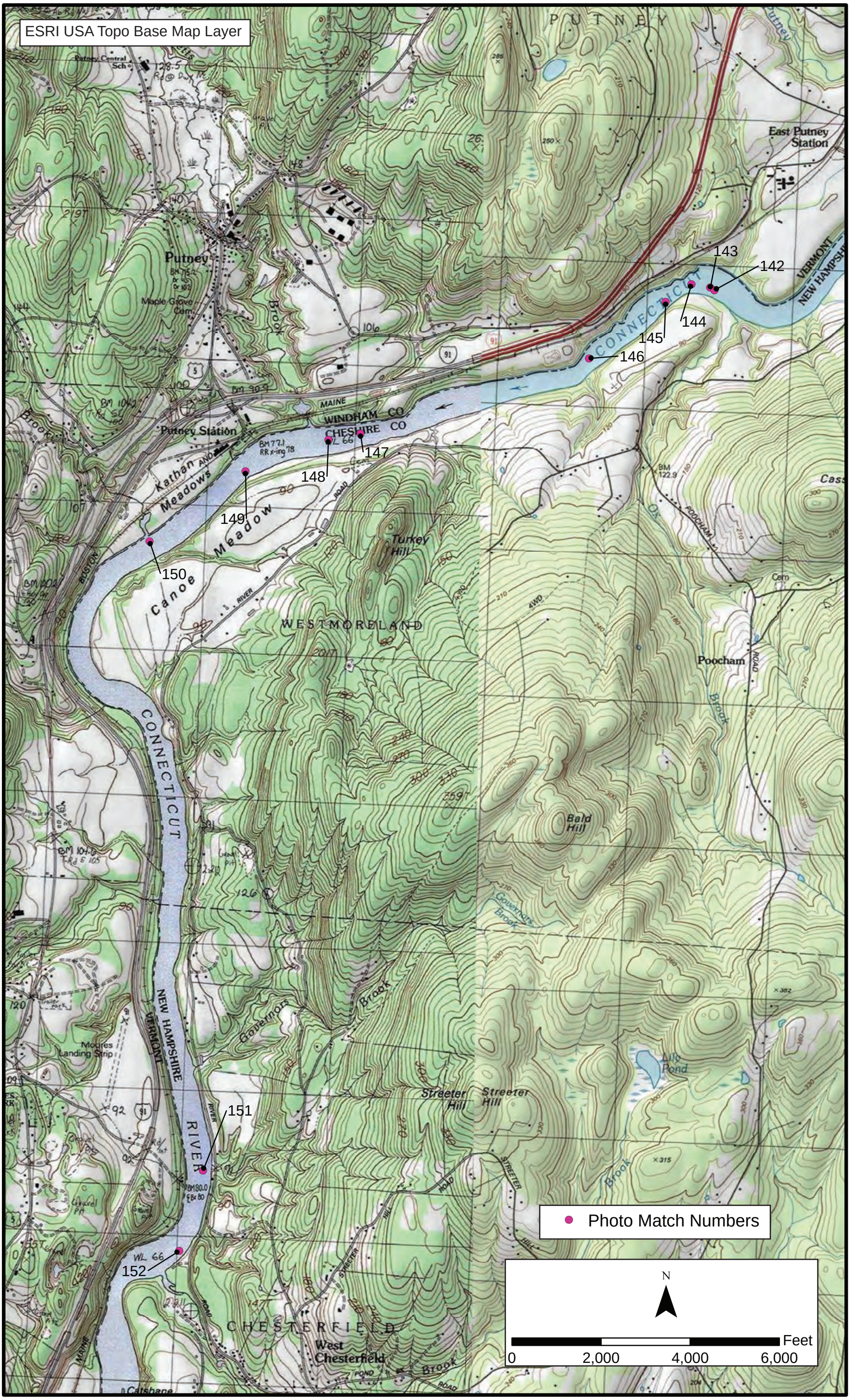
Appendix B. Plate B-13: Map of Historic Ground Photographs and 2015 Matches.



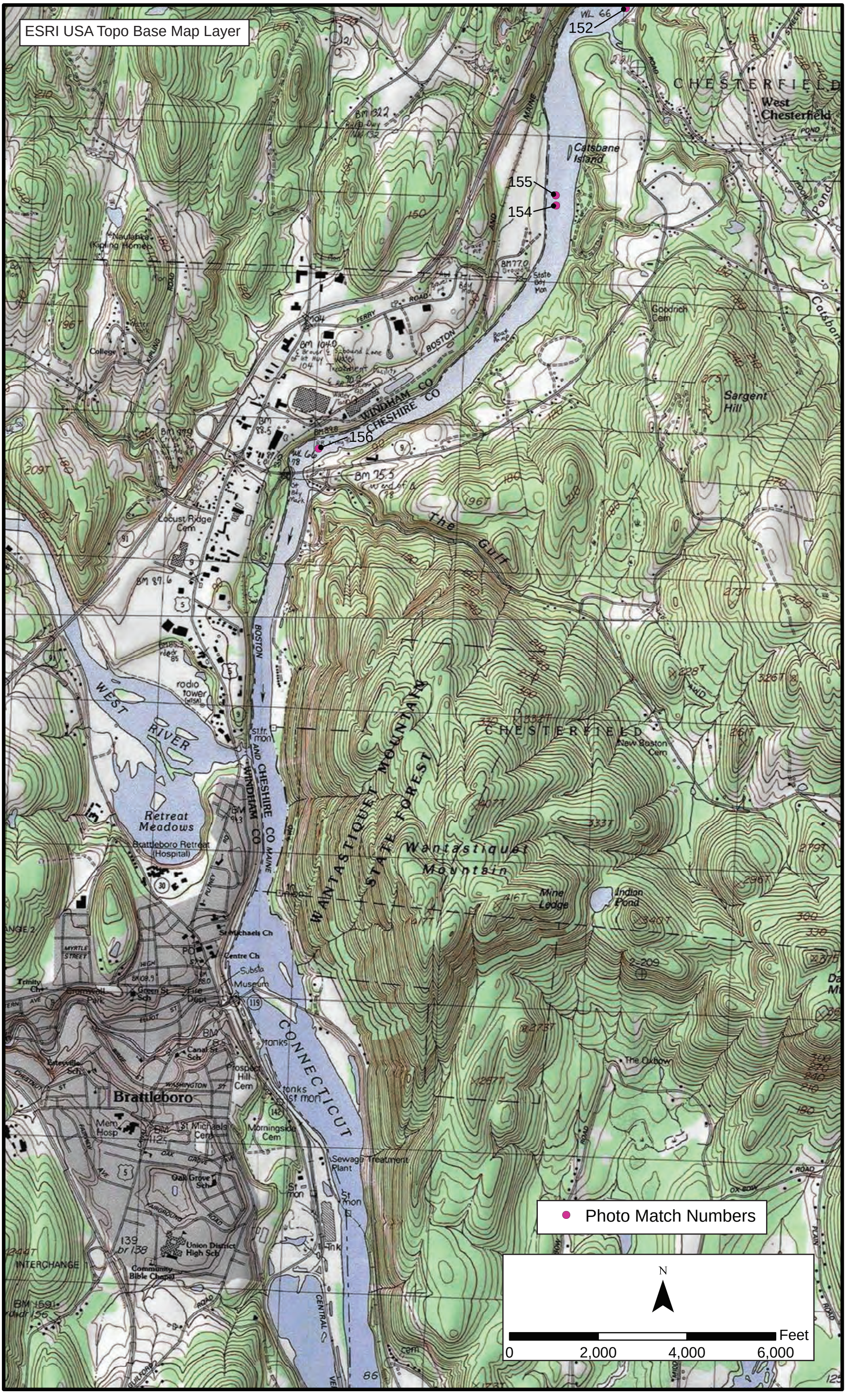
Appendix B. Plate B-14: Map of Historic Ground Photographs and 2015 Matches.



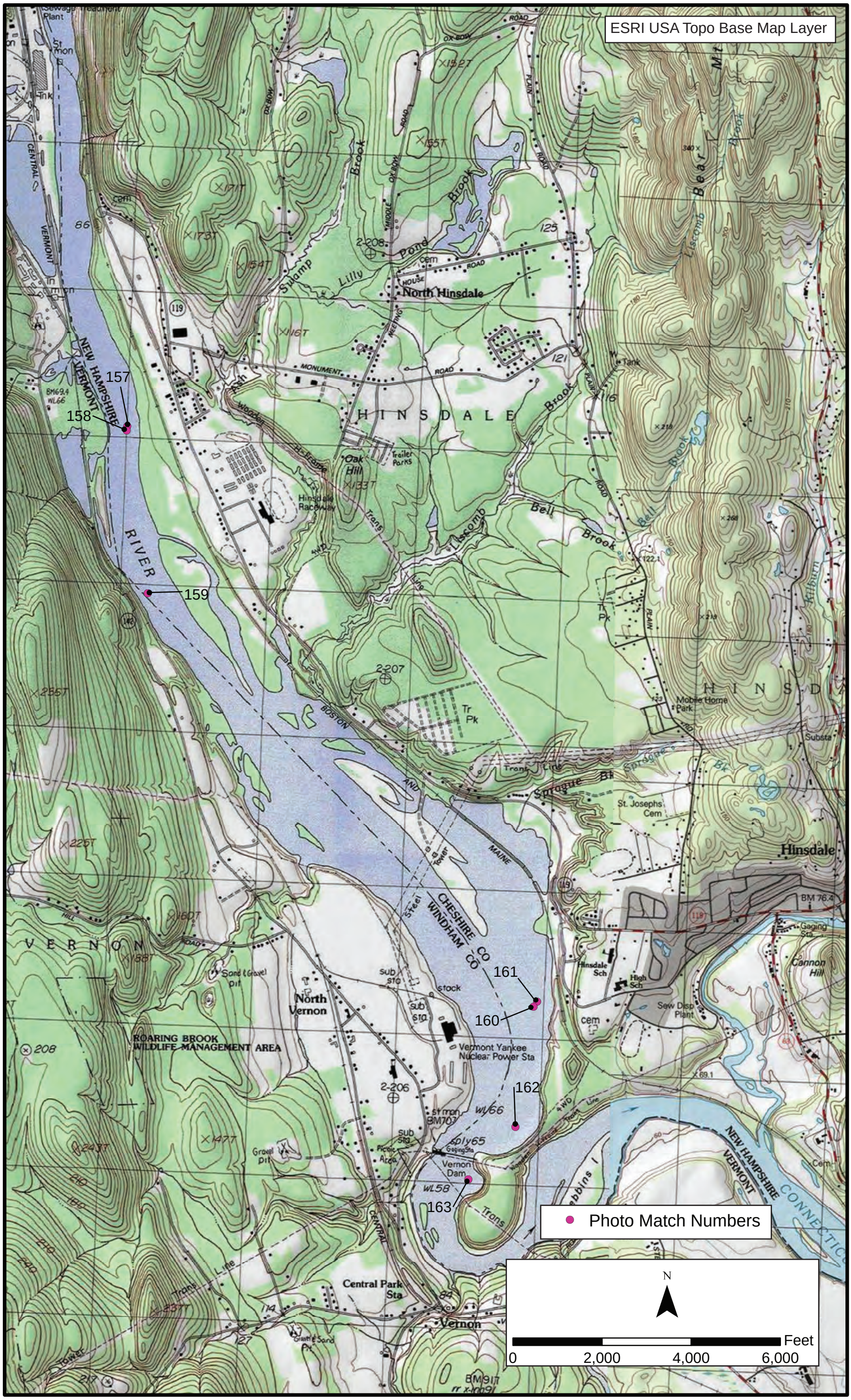
Appendix B. Plate B-15: Map of Historic Ground Photographs and 2015 Matches.



Appendix B. Plate B-16: Map of Historic Ground Photographs and 2015 Matches.



Appendix B. Plate B-17: Map of Historic Ground Photographs and 2015 Matches.



Appendix B. Plate B-18: Map of Historic Ground Photographs and 2015 Matches.

Project	Town	Photo Match	Bank	Series 1	PID 1	Series 2	PID 2	Series 3	PID 3	Series 4	PID 4
Wilder	Haverhill, NH	1	L	1951	2	2015	103				
Wilder	Haverhill, NH	2	L	1951	3	2015	104				
Wilder	Haverhill, NH	3	L	1942	30158	2015	105				
Wilder	Haverhill, NH	4	L	1991	A7	2015	106				
Wilder	Haverhill, NH	5	L	1991	A10	2015	107				
Wilder	Newbury, VT	6	R	1991	A11	2015	108				
Wilder	Haverhill, NH	7	L	1991	A13	2015	109				
Wilder	Haverhill, NH	8	L	1951	6	2015	110				
Wilder	Newbury, VT	9	R	1942	30122	2015	111				
Wilder	Newbury, VT	10	R	1942	30123	2015	111B				
Wilder	Newbury, VT	11	R	1942	30167	2015	112				
Wilder	Haverhill, NH	12	L	1973	62072	2015	113				
Wilder	Haverhill, NH	13	L	1973	62073	2105	114				
Wilder	Haverhill, NH	14	L	1942	30146	2015	115				
Wilder	Haverhill, NH	15	L	1991	A19	2015	116				
Wilder	Haverhill, NH	16	L	1942	30149	2015	117				
Wilder	Haverhill, NH	17	L	1991	A20	2015	118				
Wilder	Newbury, VT	18	R	1951	13	2015	119				
Wilder	Newbury, VT	19	R	1991	A24	2015	120				
Wilder	Newbury, VT	20	R	1951	19	2015	121				
Wilder	Newbury, VT	21	R	1951	21	2015	122				
Wilder	Newbury, VT	22	R	1951	24	2015	123				
Wilder	Haverhill, NH	23	L	1991	B3	2015	124				
Wilder	Piermont, NH	24	L	1991	B5	2015	125				
Wilder	Bradford, VT	25	R	1973	62079	2015	126				
Wilder	Piermont, NH	26	L	1942	30140	2015	127				
Wilder	Piermont, NH	27	L	1942	30141	2015	128				
Wilder	Piermont, NH	28	L	1942	30142	2015	129				
Wilder	Bradford, VT	29	R	1951	33	2015	131				
Wilder	Bradford, VT	30	R	1973	62084	2015	132				
Wilder	Bradford, VT	31	R	1942	13B	2015	133				
Wilder	Piermont, NH	32	L	1991	B13	2015	134				
Wilder	Bradford, VT	33	R	1942	30120	2015	130				
Wilder	Bradford, VT	34	R	1942	30121	2015	135				
Wilder	Bradford, VT	35	R	1951	39	2015	136				
Wilder	Bradford, VT	36	R	1991	B16	2015	137				
Wilder	Bradford, VT	37	R	1973	62088	2015	138				
Wilder	Bradford, VT	38	R	1991	B17	2015	139				
Wilder	Bradford, VT	39	R	1973	62089	2015	140				
Wilder	Bradford, VT	40	R	1991	B20	2015	141				
Wilder	Bradford, VT	41	R	1973	62092	2015	142				
Wilder	Fairlee, VT	42	R	1951	43	2015	143				
Wilder	Orford, NH	43	L	1991	B25	2015	144				
Wilder	Orford, NH	44	L	1973	62094	2015	145				
Wilder	Fairlee, VT	45	R	1973	62097	2015	74				
Wilder	Fairlee, VT	46	R	1991	C3	2015	75				
Wilder	Fairlee, VT	47	R	1991	C5	2015	76				
Wilder	Fairlee, VT	48	R	1951	44	2015	77				
Wilder	Fairlee, VT	49	R	1973	62100	1991	C6	2015	78		
Wilder	Fairlee, VT	50	R	1951	45	2015	79				

Note: R and L refer to River Right and River Left when looking downstream
PID refers to Photo Identification Number

Project	Town	Photo Match	Bank	Series 1	PID 1	Series 2	PID 2	Series 3	PID 3	Series 4	PID 4
Wilder	Orford, NH	51	L	1991	C9	2015	80				
Wilder	Orford, NH	52	L	1951	49	2015	81				
Wilder	Orford, NH	53	L	1973	62102	2015	82				
Wilder	Orford, NH	54	L	1951	50	2015	83				
Wilder	Orford, NH	55	L	1973	62103	2015	84				
Wilder	Fairlee, VT	56	R	1991	C11	2015	85				
Wilder	Thetford, VT	57	R	1991	C14	2015	86				
Wilder	Thetford, VT	58	R	1991	C15	2015	87				
Wilder	Lyme, NH	59	L	1991	C17	2015	88				
Wilder	Thetford, VT	60	R	1991	C18	2015	89				
Wilder	Thetford, VT	61	R	1951	57	2015	90				
Wilder	Thetford, VT	62	R	1991	D5	2015	91				
Wilder	Norwich, VT	63	R	1991	D15	2015	92				
Wilder	Hanover, NH	64	L	1991	D17	2015	93				
Wilder	Norwich, VT	65	R	1991	D21	2015	94				
Wilder	Hanover, NH	66	L	1991	D22	2015	95				
Wilder	Hanover, NH	67	L	1991	D23	2015	96				
Wilder	Hanover, NH	68	L	1991	D25	2015	97				
Wilder	Hanover, NH	69	L	1991	E3	2015	98				
Wilder	Hanover, NH	70	L	1991	E4	2015	99				
Wilder	Hanover, NH	71	L	1991	E9	2015	100				
Wilder	Hanover, NH	72	L	1973	62132	2015	101				
Wilder	Lebanon, NH	73	L	1973	62134	2015	102				
Bellows Falls	Weathersfield, VT	74	R	1984	B1	2015	150				
Bellows Falls	Weathersfield, VT	75	R	1984	B2	2015	151				
Bellows Falls	Weathersfield, VT	76	R	1964	56376	2105	152				
Bellows Falls	Claremont, NH	77	L	1954	43913	2015	153				
Bellows Falls	Claremont, NH	78	L	1953	41945	2015	154				
Bellows Falls	Claremont, NH	79	L	1954	43914	2015	155				
Bellows Falls	Weathersfield, VT	80	R	1953	41952	2015	156				
Bellows Falls	Claremont, NH	81	L	1984	B5	2015	157				
Bellows Falls	Weathersfield, VT	82	R	1964	56380	2015	158				
Bellows Falls	Claremont, NH	83	L	1964	56379	2015	161				
Bellows Falls	Claremont, NH	84	L	1964	56382	2015	160				
Bellows Falls	Weathersfield, VT	85	R	1964	56381	2015	168				
Bellows Falls	Weathersfield, VT	86	R	1954	43918	2015	159				
Bellows Falls	Weathersfield, VT	87	R	1953	41955	2015	162				
Bellows Falls	Weathersfield, VT	88	R	1984	B9	2015	163				
Bellows Falls	Claremont, NH	89	L	1964	56384	2015	164				
Bellows Falls	Springfield, VT	90	R	1964	56385	2015	165				
Bellows Falls	Charlestown, NH	91	L	1984	B11	2015	166				
Bellows Falls	Charlestown, NH	92	L	1954	43925	1984	B12	1964	56386	2015	167
Bellows Falls	Springfield, VT	93	R	1953	41956	1964	56387	2015	1		
Bellows Falls	Springfield, VT	94	R	1964	56388	2015	2				
Bellows Falls	Charlestown, NH	95	L	1954	43927	2015	3				
Bellows Falls	Springfield, VT	96	R	1953	41961	2015	5				
Bellows Falls	Springfield, VT	97	R	1964	56400	2015	6				
Bellows Falls	Charlestown, NH	98	L	1953	41962	2015	7				
Bellows Falls	Charlestown, NH	99	L	1964	56399	2015	8				
Bellows Falls	Charlestown, NH	100	L	1984	C9	2015	9				

Note: R and L refer to River Right and River Left when looking downstream

PID refers to Photo Identification Number

Project	Town	Photo Match	Bank	Series 1	PID 1	Series 2	PID 2	Series 3	PID 3	Series 4	PID 4
Bellows Falls	Charlestown, NH	101	L	1953	41964	1964	56402	2015	10		
Bellows Falls	Charlestown, NH	102	L	1954	43936	1984	C11	2015	11		
Bellows Falls	Charlestown, NH	103	L	1954	43937	1984	D1	1964	56403	2015	12
Bellows Falls	Springfield, VT	104	R	1954	43938	2015	13				
Bellows Falls	Springfield, VT	105	R	1964	56405	2015	14				
Bellows Falls	Charlestown, NH	106	L	1954	44138	1953	41968	1984	D5	2015	15
Bellows Falls	Charlestown, NH	107	L	1984	D6	2015	16				
Bellows Falls	Charlestown, NH	108	L	1964	56408	2015	17				
Bellows Falls	Charlestown, NH	109	L	1954	44139	2015	18				
Bellows Falls	Charlestown, NH	110	L	1984	D7	2015	19				
Bellows Falls	Charlestown, NH	111	L	1964	56409	2015	20				
Bellows Falls	Rockingham, VT	112	R	1954	44143	1984	D9	2015	21		
Bellows Falls	Rockingham, VT	113	R	1954	44144	1964	56412	1984	D10	2015	41
Bellows Falls	Rockingham, VT	114	R	1953	41974	2015	42				
Bellows Falls	Rockingham, VT	115	R	1953	41975	2015	43				
Bellows Falls	Rockingham, VT	116	R	1964	56414	2015	22				
Bellows Falls	Rockingham, VT	117	R	1953	41981	2015	23				
Bellows Falls	Rockingham, VT	118	R	1984	E2	2015	24				
Bellows Falls	Rockingham, VT	119	R	1954	43944	2015	25				
Bellows Falls	Rockingham, VT	120	R	1964	56418	2015	27				
Bellows Falls	Rockingham, VT	121	R	1954	44146	2015	26				
Bellows Falls	Charlestown, NH	122	L	1953	41985	2015	28				
Bellows Falls	Charlestown, NH	123	L	1964	56420	2015	29				
Bellows Falls	Rockingham, VT	124	R	1964	56421	1953	41986	2015	33		
Bellows Falls	Rockingham, VT	125	R	1984	E7	2015	32				
Bellows Falls	Rockingham, VT	126	R	1964	56422	2015	30				
Bellows Falls	Walpole, NH	127	L	1964	56423	2015	34				
Bellows Falls	Walpole, NH	128	L	1964	56424	2015	35				
Bellows Falls	Walpole, NH	129	L	1964	56426	2015	36				
Bellows Falls	Walpole, NH	130	L	1953	41990	2015	37				
Bellows Falls	Walpole, NH	131	L	1984	E8	2015	38				
Bellows Falls	Walpole, NH	132	L	1964	56427	2015	39				
Bellows Falls	Walpole, NH	133	L	1953	41991	2015	40				
Vernon	Westminster, VT	134	R	1942	30130	2015	44				
Vernon	Westminster, VT	135	R	1955	45995	1964	56433	2015	47		
Vernon	Westminster, VT	136	R	1991	A13	2015	48				
Vernon	Walpole, NH	137	L	1955	45996	2015	49				
Vernon	Walpole, NH	138	L	1955	45997	1964	56435	2015	50		
Vernon	Westminster, VT	139	R	1991	A15	2015	51				
Vernon	Putney, VT	140	R	1991	A23	1955	45897	1964	56439	2015	46
Vernon	Putney, VT	141	R	1991	A24	1955	45898	2015	45		
Vernon	Westmoreland, NH	142	L	1964	56440	2015	53				
Vernon	Westmoreland, NH	143	L	1991	B7	1955	45902	2015	52		
Vernon	Westmoreland, NH	144	L	1991	B8	2015	54				
Vernon	Westmoreland, NH	145	L	1955	45903	1964	56441	2015	55		
Vernon	Westmoreland, NH	146	L	1991	B9	2015	56				
Vernon	Westmoreland, NH	147	L	1991	B13	2015	57				
Vernon	Westmoreland, NH	148	L	1991	B14	2015	58				
Vernon	Westmoreland, NH	149	L	1955	45906	2015	59				
Vernon	Dummerston, VT	150	R	1991	B15	2015	60				

Note: R and L refer to River Right and River Left when looking downstream

PID refers to Photo Identification Number

Project	Town	Photo Match	Bank	Series 1	PID 1	Series 2	PID 2	Series 3	PID 3	Series 4	PID 4
Vernon	Chesterfield, NH	151	L	1964	56443	2015	61				
Vernon	Chesterfield, NH	152	L	1964	56444	2015	62				
Vernon	Dummerston, VT	154	R	1991	C3	1955	45912	2015	64		
Vernon	Dummerston, VT	155	R	1964	56445	2015	63				
Vernon	Brattleboro, VT	156	R	1955	46010	2015	66				
Vernon	Hinsdale, NH	157	L	1991	C19	1955	46012	2015	67		
Vernon	Hinsdale, NH	158	L	1964	56448	2015	68				
Vernon	Vernon, VT	159	R	1955	45917	2015	69				
Vernon	Hinsdale, NH	160	L	1964	56450	2015	72				
Vernon	Hinsdale, NH	161	L	1991	C21	1955	46013	2015	71		
Vernon	Hinsdale, NH	162	L	1991	D4	1955	46014	2015	73		
Vernon Riverine	Hinsdale, NH	163	L	1991	D6	2015	169				

Note: R and L refer to River Right and River Left when looking downstream

PID refers to Photo Identification Number

1951 - 2

2015 - 103

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 1

1951 - 3

2015 - 104

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 2

1942 - 30158

2015 - 105

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 3

1991 - A7

2015 - 106

1991 - A10

2015 - 107

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 5

1991 - A11

2015 - 108

1991 - A13

2015 - 109

1951 - 6

2015 - 110

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 8

1942 - 30122

2015 - 111

1942 - 30123

2015 - 111B

1942 - 30167

2015 - 112

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 11

1973 - 62072

2015 - 113

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 12

1973 - 62073

2015 - 114

1942 - 30146

2015 - 115

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 14

1991 - A19

2015 - 116

1942 - 30149

2015 - 117

1991 - A20

2015 - 118

1951 - 13

2015 - 119

1991 - A24

2015 - 120

1951 - 19

2015 - 121

1951 - 21

2015 - 122

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 21

1951 - 24

2015 - 123

1991 - B3

2015 - 124

1991 - B5

2015 - 125

1973 - 62079

2015 - 126

1942 - 30140

2015 - 127

1942 - 30141

2015 - 128

1942 - 30142

2015 - 129

1951 - 33

2015 - 131

1973 - 62084

2015 - 132

1942 - 13B

2015 - 133

1991 - B13

2015 - 134

1942 - 30120

2015 - 130

1942 - 30121

2015 - 135

1951 - 39

2015 - 136

1991 - B16

2015 - 137

1973 - 62088

2015 - 138

1991 - B17

2015 - 139

1973 - 62089

2015 - 140

1991 - B20

2015 - 141

1973 - 62092

2015 - 142

1951 - 43

2015 - 143

1991 - B25

2015 - 144

1973 - 62094

2015 - 145

1973 - 62097

2015 - 74

1991 - C3

2015 - 75

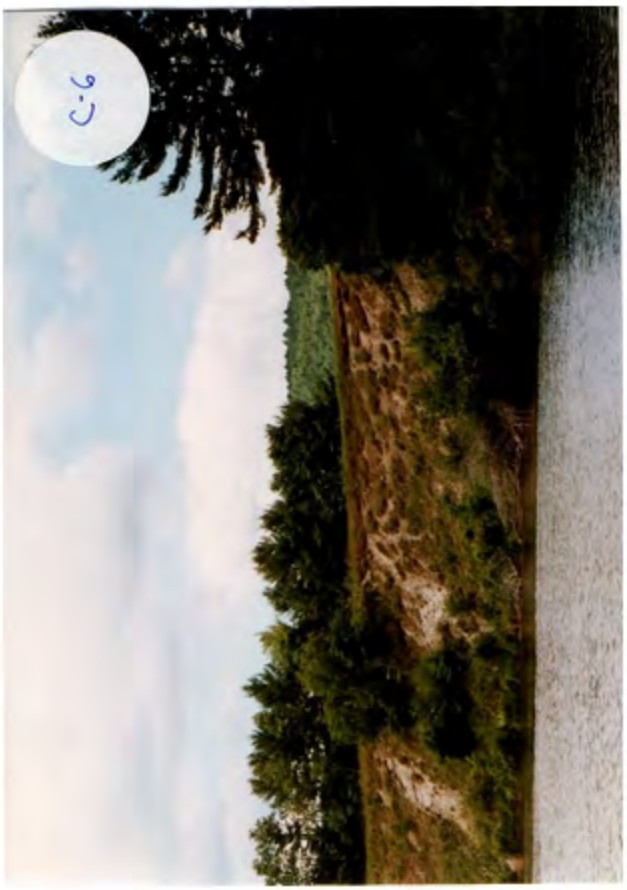
1991 - C5

2015 - 76

1951 - 44

2015 - 77

1973 - 62100



1991 - C6

2015 - 78

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 49

1951 - 45

2015 - 79

1991 - C9

2015 - 80

1951 - 49

2015 - 81

1973 - 62102

2015 - 82

1951 - 50

2015 - 83

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 54

1973 - 62103

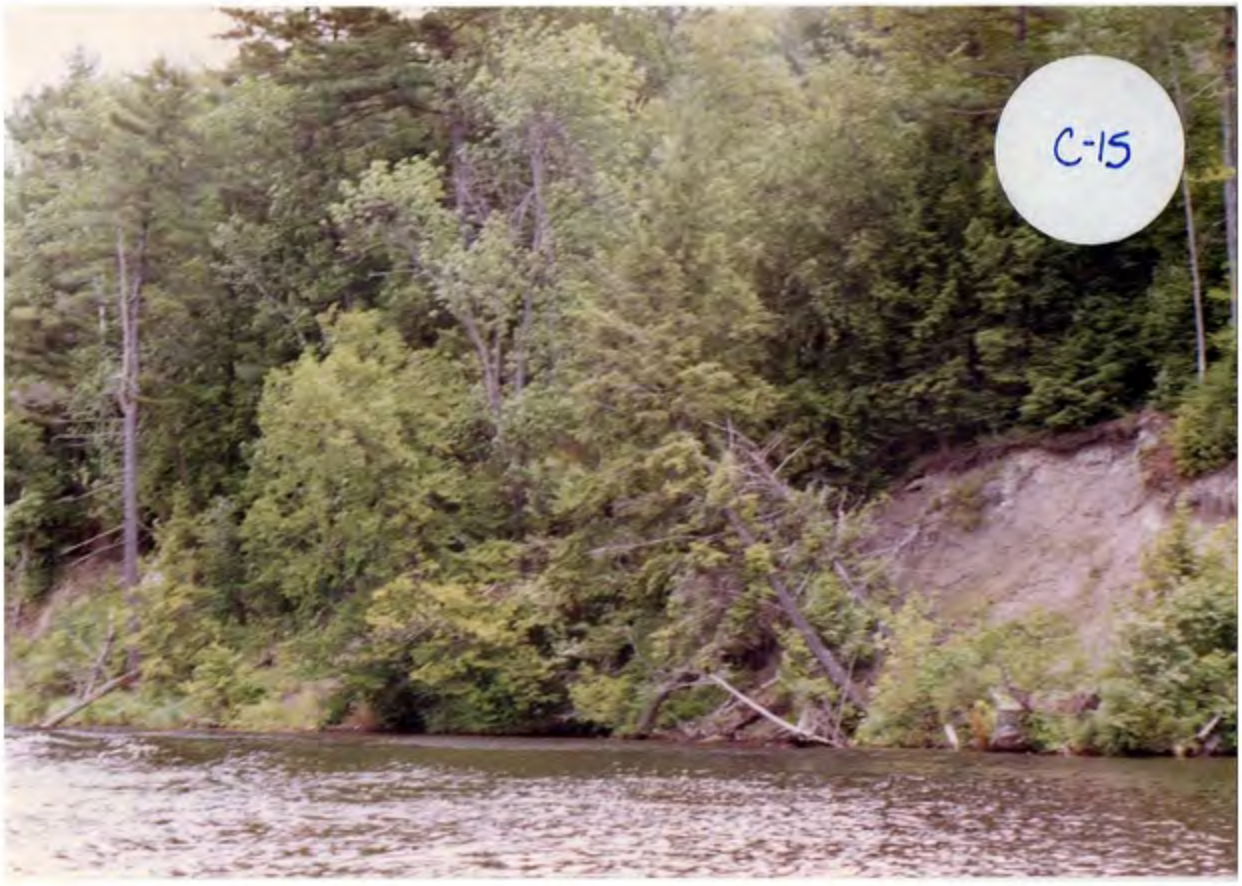
2015 - 84

1991 - C11

2015 - 85

1991 - C14

2015 - 86



1991 - C15

2015 - 87

1991 - C17

2015 - 88

1991 - C18

2015 - 89

1951 - 57

2015 - 90

1991 - D5

2015 - 91

1991 - D15

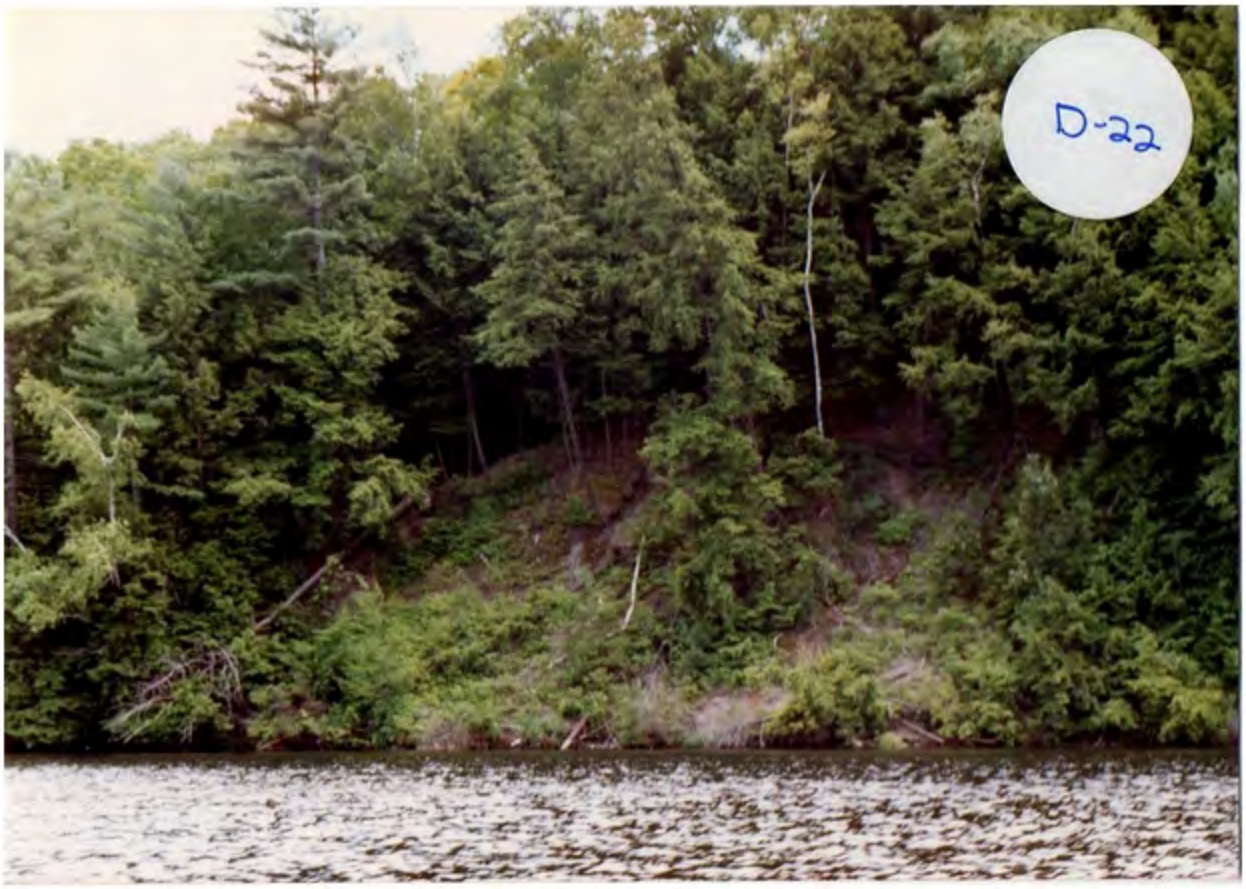
2015 - 92

1991 - D17

2015 - 93

1991 - D21

2015 - 94



1991 - D22

2015 - 95

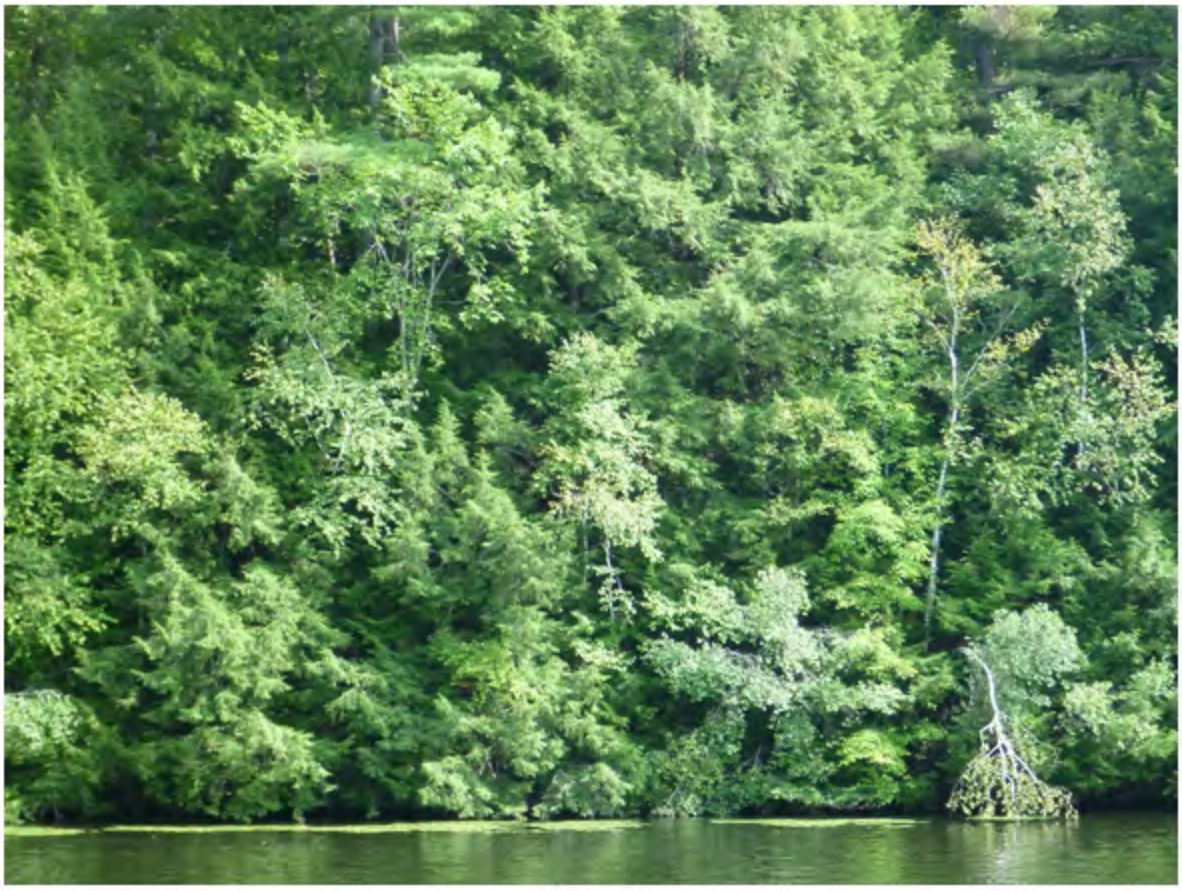
1991 - D23

2015 - 96

1991 - D25

2015 - 97

1991 - E3



2015 - 98

1991 - E4

2015 - 99

1991 - E9

2015 - 100

1973 - 62132

2015 - 101

1973 - 62134

2015 - 102

1984 - B1

2015 - 150

1984 - B2

2015 - 151

1964 - 56376

2015 - 152

1954 - 43913

2015 - 153

1953 - 41945

2015 - 154

1954 - 43914

2015 - 155

1953 - 41952

2015 - 156

1984 - B5

2015 - 157

1964 - 56380

2015 - 158

1964 - 56379

2015 - 161

1964 - 56382

2015 - 160

1964 - 56381

2015 - 168

1954 - 43918

2015 - 159

1953 - 41955

2015 - 162

1984 - B9

2015 - 163

1964 - 56384

2015 - 164

1964 - 56385

2015 - 165

1984 - B11

2015 - 166

1954 - 43925

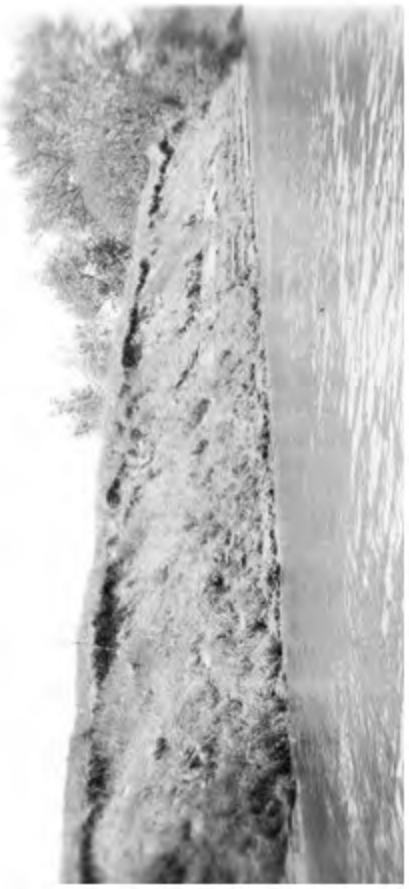
1964 - 56386

1984 - B12

2015 - 167

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 92

1953 - 41956



1964 - 56387

2015 - 1

1964 - 56388

2015 - 2

1954 - 43927

2015 - 3

1953 - 41961

2015 - 5

1964 - 56400

2015 - 6

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 97

1953 - 41962

2015 - 7

1964 - 56399

2015 - 8

1984 - C9

2015 - 9

1953 - 41964

1964 - 56402

2015 - 10

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 101

1954 - 43936

1984 - C11

2015 - 11

1954 - 43937

1964 - 56403

1984 - D1

2015 - 12

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 103

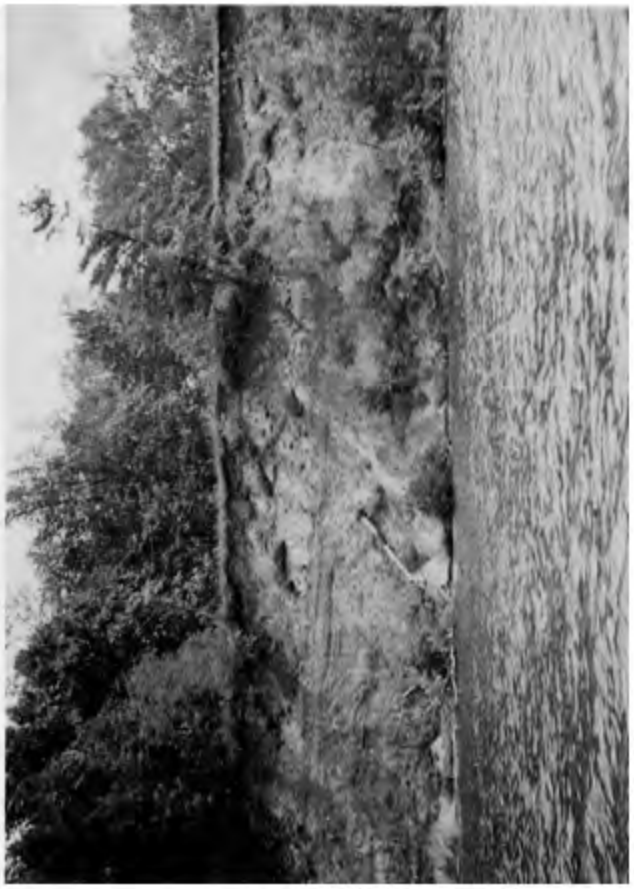
1954 - 43938

2015 - 13

1964 - 56405

2015 - 14

1953 - 41968



1954 - 44138

1984 - D5

2015 - 15

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 106

1984 - D6

2015 - 16

1964 - 56408

2015 - 17

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 108

1954 - 44139

2015 - 18

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 109

1984 - D7

2015 - 19

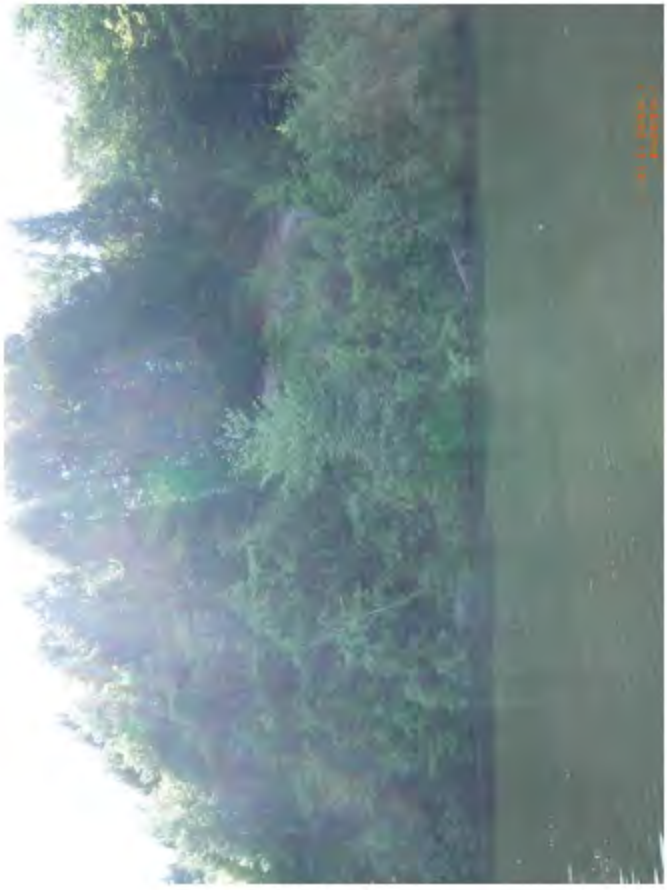
1964 - 56409

2015 - 20

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 111

1954 - 44143

1984 - D9



2015 - 21

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 112

1954 - 44144

1964 - 56412

1984 - D10

2015 - 41

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 113

1953 - 41974

2015 - 42

1953 - 41975

2015 - 43

1964 - 56414

2015 - 22

1953 - 41981

2015 - 23

1984 - E2

2015 - 24

1954 - 43944

2015 - 25

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 119

1964 - 56418

2015 - 27

1954 - 44146

2015 - 26

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 121

1953 - 41985

2015 - 28

1964 - 56420

2015 - 29

1953 - 41986

1964 - 56421

2015 - 33

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 124

1984 - E7

2015 - 32

1964 - 56422

2015 - 30

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 126

1964 - 56423

2015 - 34

1964 - 56424

2015 - 35

1964 - 56426

2015 - 36

1953 - 41990

2015 - 37

1984 - E8

2015 - 38

1964 - 56427

2015 - 39

1953 - 41991

2015 - 40

1942 - 30130

2015 - 44

1955 - 45995

1964 - 56433

2015 - 47

1991 - A13

2015 - 48

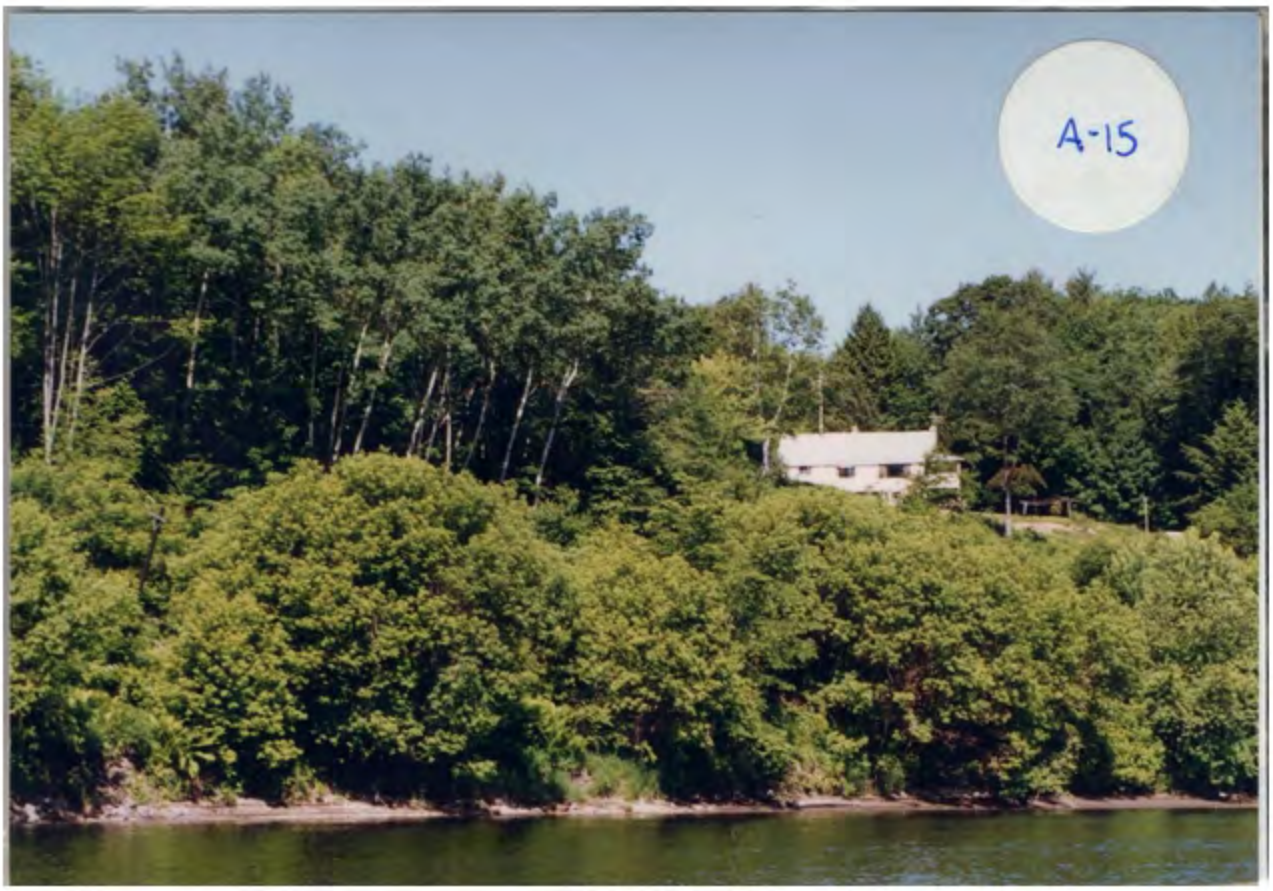
1955 - 45996

2015 - 49

1955 - 45997

1964 - 56435

2015 - 50

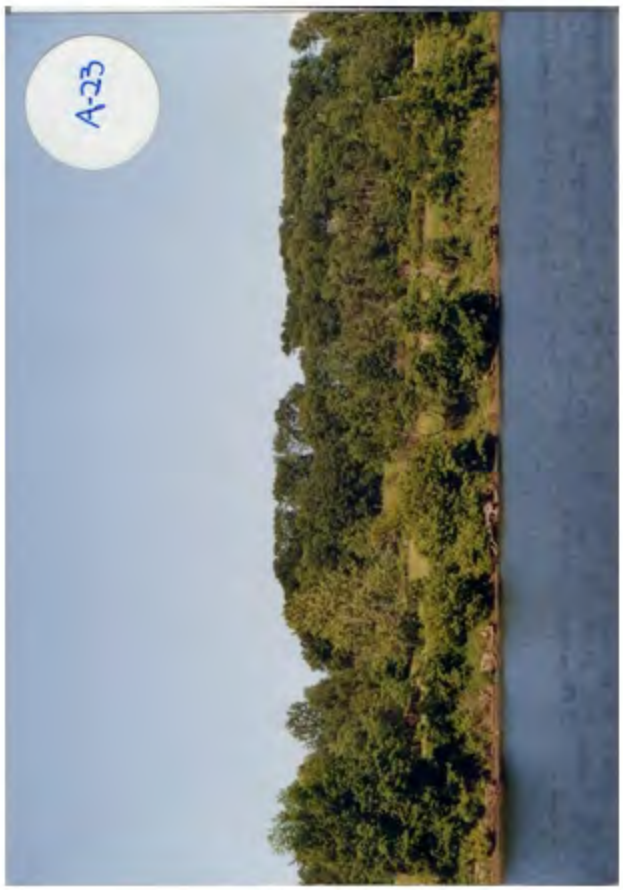


1991 - A15

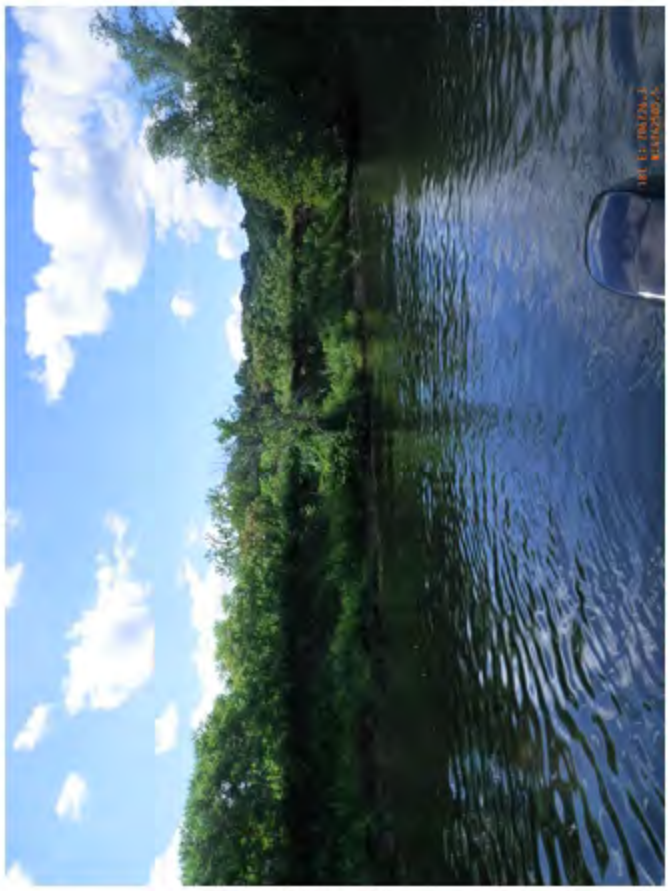
2015 - 51

1955 - 45897

1964 - 56439



1991 - A23

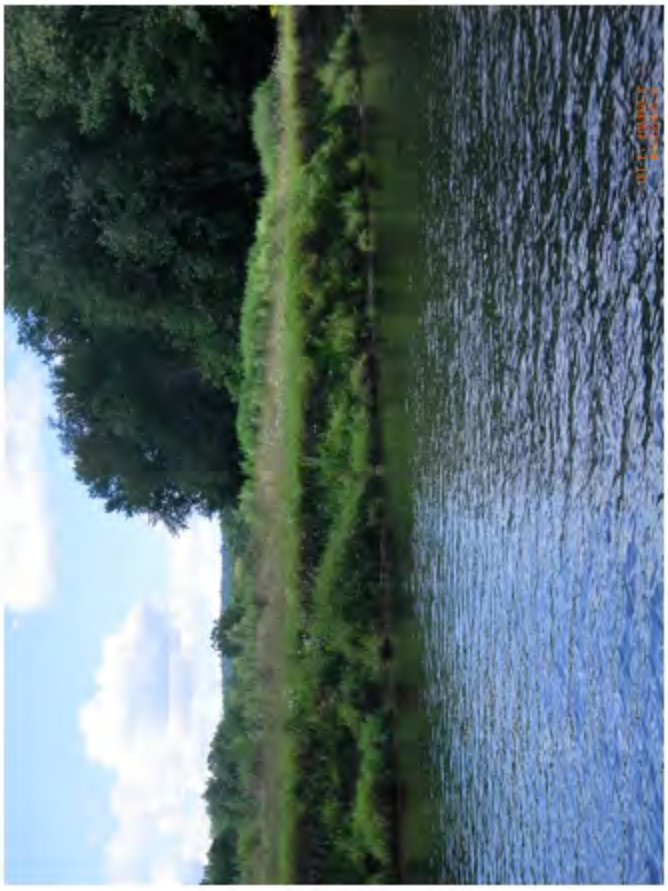


2015 - 46

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 140

1955 - 45898

1991 - A24



2015 - 45

1964 - 56440

2015 - 53

1955 - 45902

1991 - B7

2015 - 52

1991 - B8

2015 - 54

1955 - 45903

1964 - 56441

2015 - 55

1991 - B9

2015 - 56

1991 - B13

2015 - 57

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 147

1991 - B14

2015 - 58

1955 - 45906

2015 - 59

1991 - B15

2015 - 60

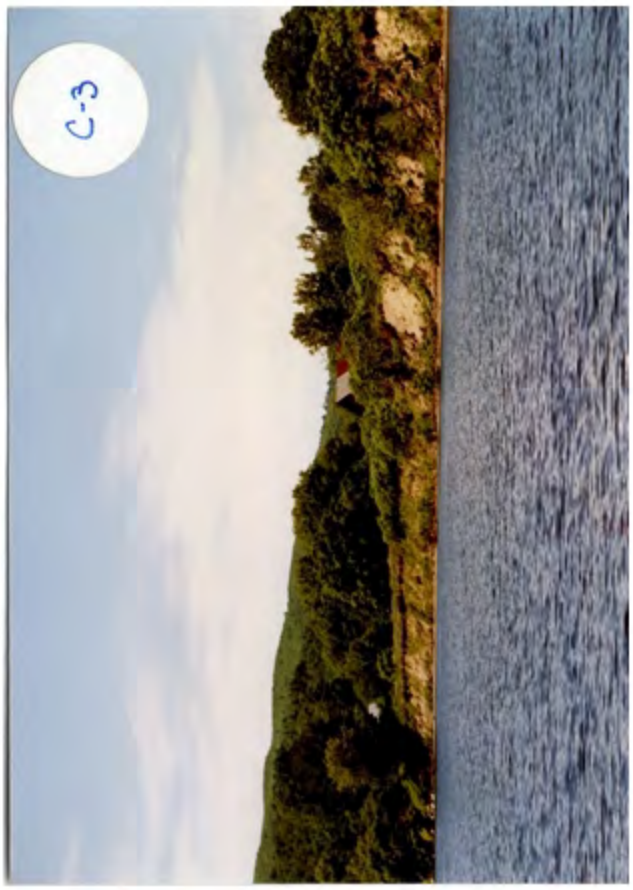
1964 - 56443

2015 - 61

1964 - 56444

2015 - 62

1955 - 45912



1991 - C3

2015 - 64

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 153

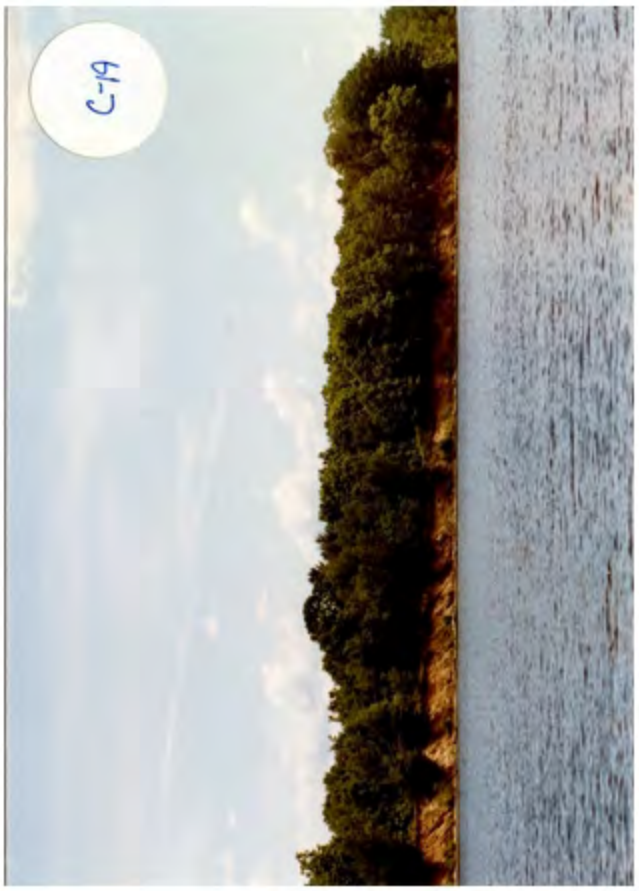
1964 - 56445

2015 - 63

1955 - 46010

2015 - 66

1955 - 46012



1991 - C19

2015 - 67

1964 - 56448

2015 - 68

1955 - 45917

2015 - 69

1964 - 56450

2015 - 72

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 159

1955 - 46013

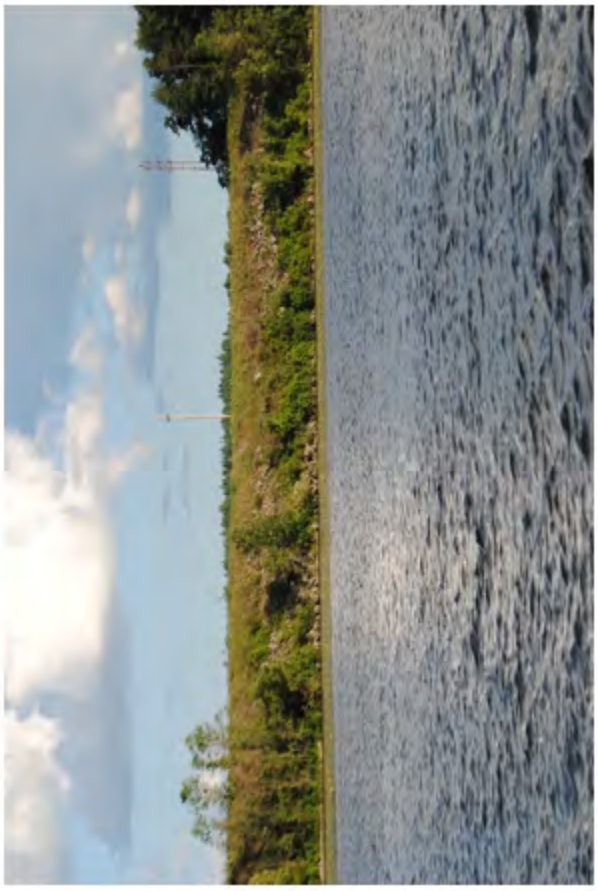
1991 - C21

2015 - 71

Appendix B. Historic Ground Photographs and 2015 Matches: Photo Match 160

1955 - 46014

1991 - D4



2015 - 73

1991 - D6

2015 - 169

APPENDIX C

Historical Aerial Photography Comparisons

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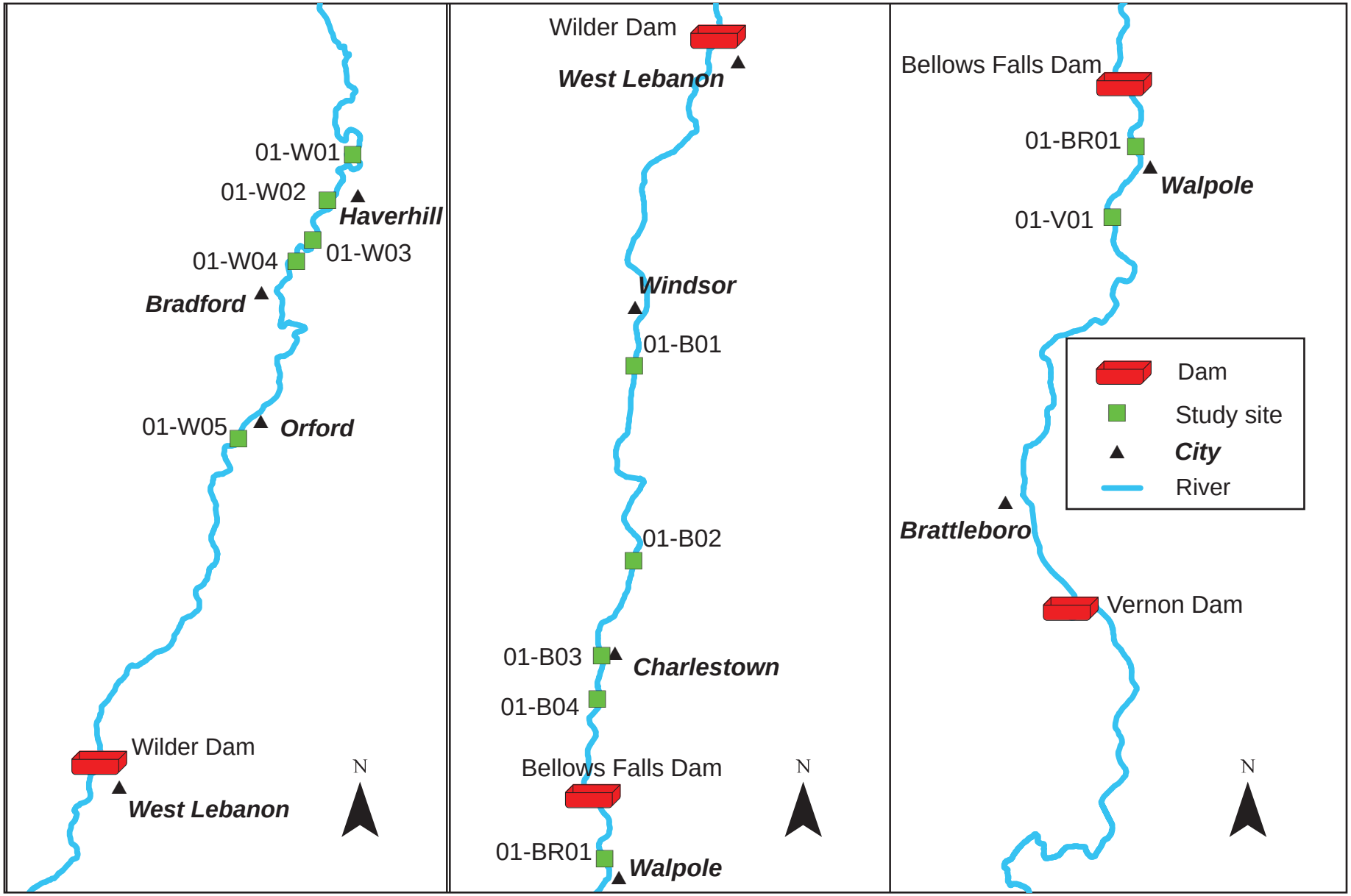
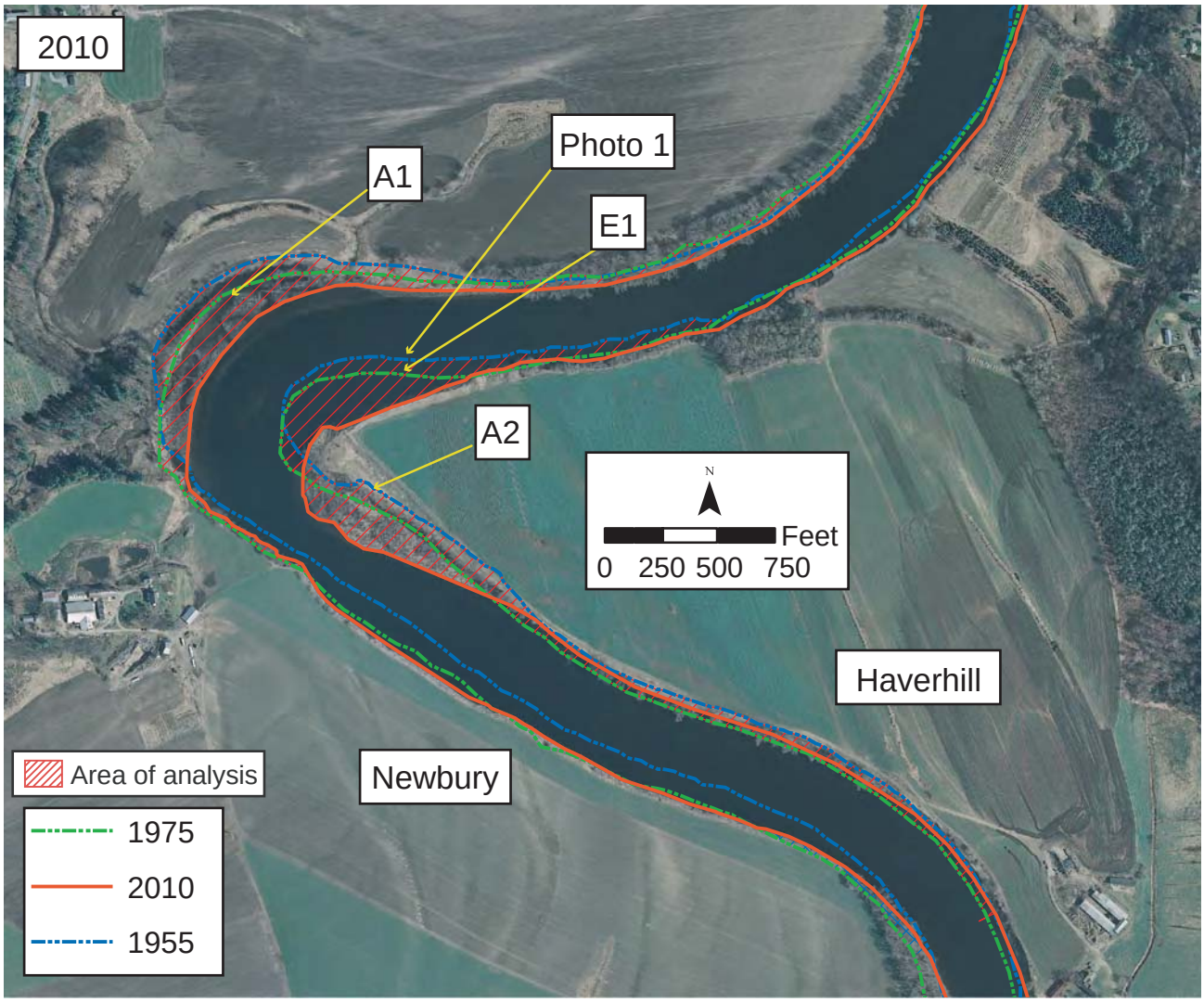


Figure C-1: Overview maps of 11 sites selected to illustrate erosion changes



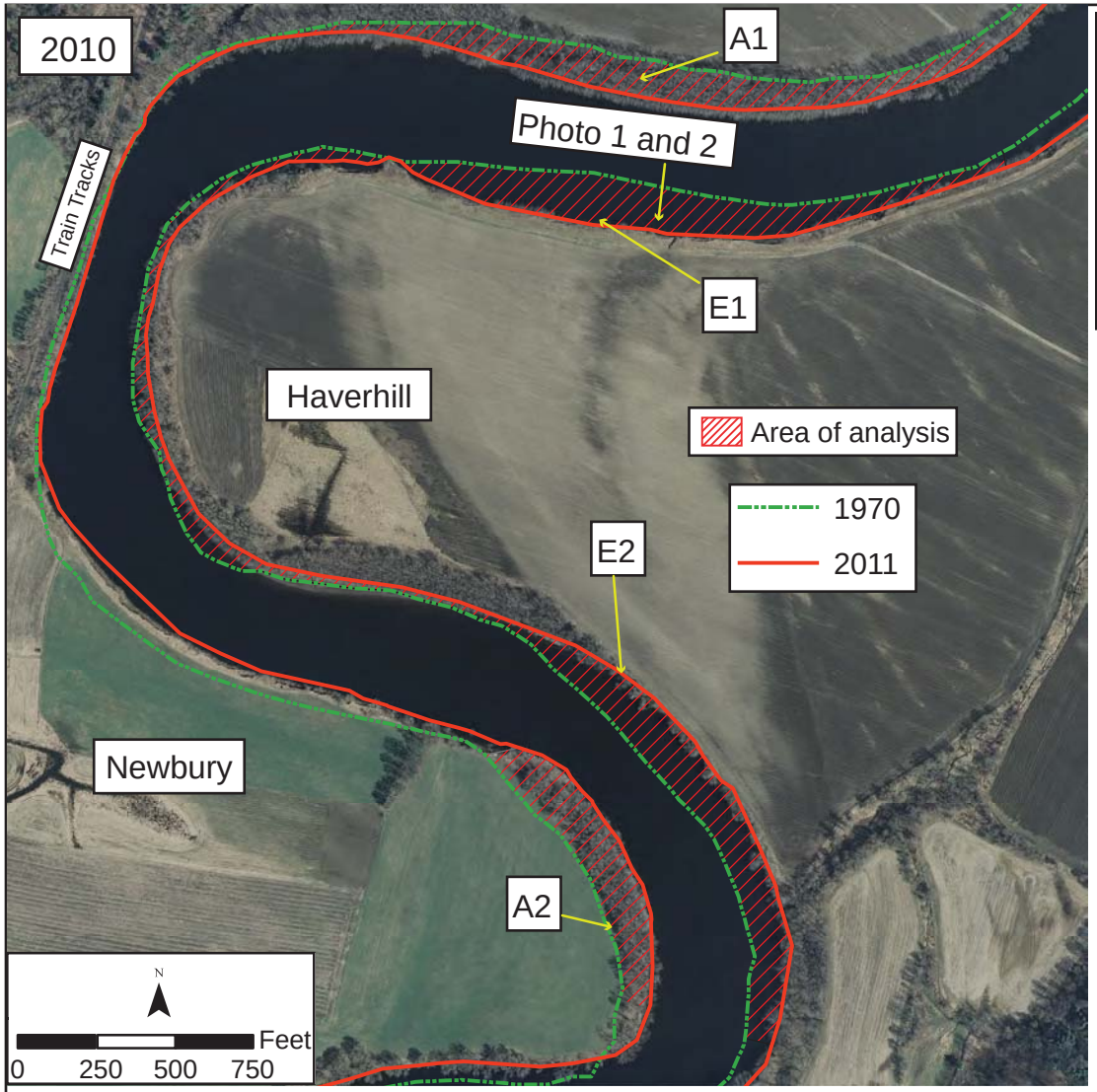
Bank Retreat

Site	Time period	Average Length (feet)	Average Rate (ft/yr)	Maximum Length (feet)	Maximum Rate (ft/yr)	Area (acres)
E1	1955 to 1975	57.0	2.9	70	3.6	2.8
	1975 to 2010	149.5	4.3	240	6.9	3.3
	1955 to 2010	206.5	3.7	310	5.6	6.0
A1	1955 to 1975	-59.4	-3.0	-100	-5.0	-2.7
	1975 to 2010	-69.4	-2.0	-180	-5.1	-7.1
	1955 to 2010	-128.8	-2.2	-280	-5.1	-9.8
A2	1955 to 1975	-60.5	-3.0	-140	-7.0	-5.6
	1975 to 2010	-100.1	-2.9	-170	-4.9	-2.5
	1955 to 2010	-160.6	-2.9	-250	-4.5	-8.1

Note: E refers to erosion, A to aggradation.
Negative values for retreat represent aggradation.

Photo 1: Left bank view in June 1991.

Appendix C. Plate C-1 Site 01-W01



Bank Retreat

Site	Time period	Average Length (feet)	Average Rate (ft/yr)	Maximum Length (feet)	Maximum Rate (ft/yr)	Area (acres)
E1	1970 to 2010	95.7	2.4	170	4.3	4.4
E2	1970 to 2010	67.2	1.7	140	3.5	7.0
A1	1970 to 2010	-68.5	-1.7	-139	-3.5	-4.4
A2	1970 to 2010	-74.3	-1.9	-141	-3.5	-6.5

Photo 1: Left Bank View June 1991.

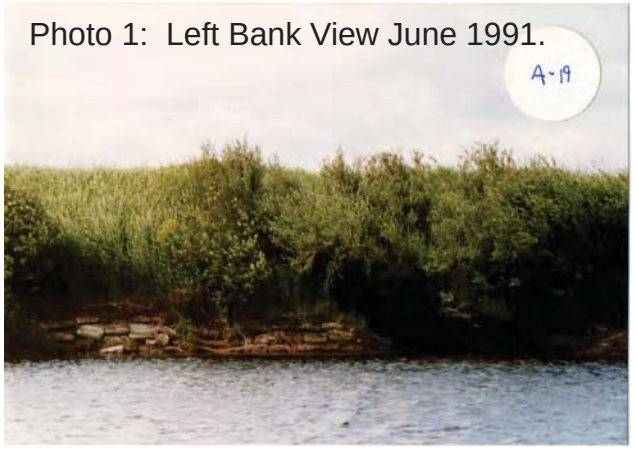
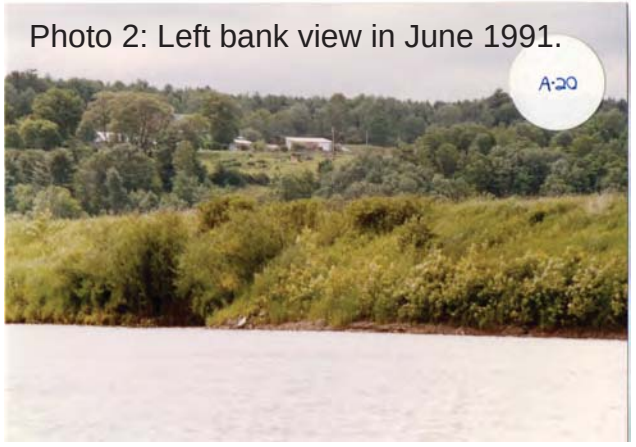
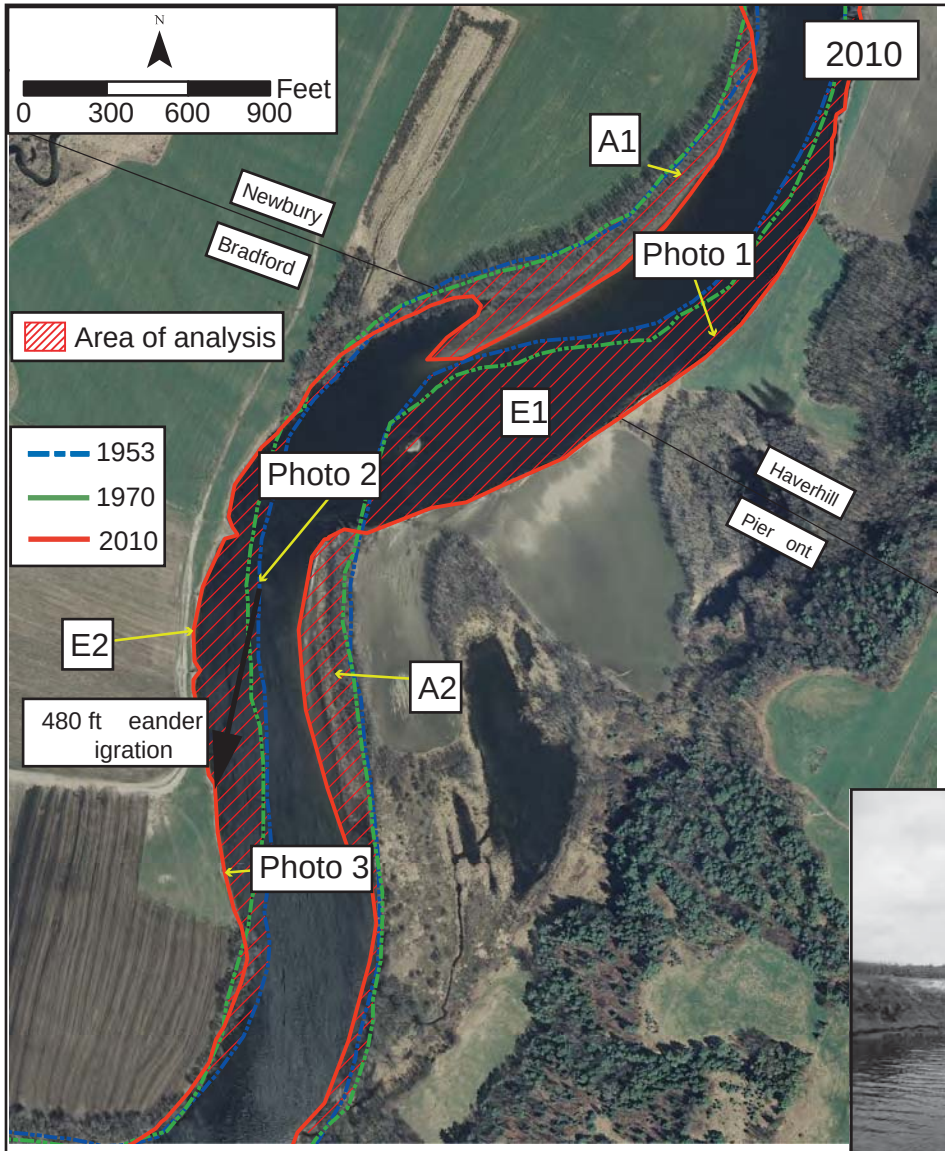


Photo 2: Left bank view in June 1991.



Note: E refers to erosion, A to aggradation.
Negative values for retreat represent aggradation.

Appendix C. Plate C-2 Site 01-W02



Bank Retreat

Site	Time period	Average Length	Average Rate	Maximum Length	Maximum Rate	Area	Volume	Rate
		feet	ft yr	feet	ft yr	acres	yd^3	yd^3 yr
E1	1953 to 1970	32.66	1.9	35	2.1	1.8	27,380	684
	1970 to 2010	195.5	4.9	440	11.0	12.9	191,098	4,777
	1953 to 2010	228.2	4.0	475.0	8.3	14.7	218,478	3,833
E2	1953 to 1970	43.94	3.3	70	4.1	3.1	31,383	1,846
	1970 to 2010	130.2	2.6	210	5.3	6.2	156,360	3,909
	1953 to 2010	174.1	3.1	280.0	4.9	9.3	187,743	3,294
A1	1970 to 2010	-85.6	-2.1	-203	-5.1	-5.4	-22,994	-575
A2	1970 to 2010	-96.5	-2.4	-185	-4.6	-5.6	-53,156	-1,329

Photo 1: Left bank view in June 1991.

Photo 3: pstrea view in June 1973.

Photo 2: ownstrea view in June 1991.

Note: E refers to erosion, A to aggradation.
Negative values for retreat represent aggradation.

Appendix C. Plate C-3 Site 01-W03

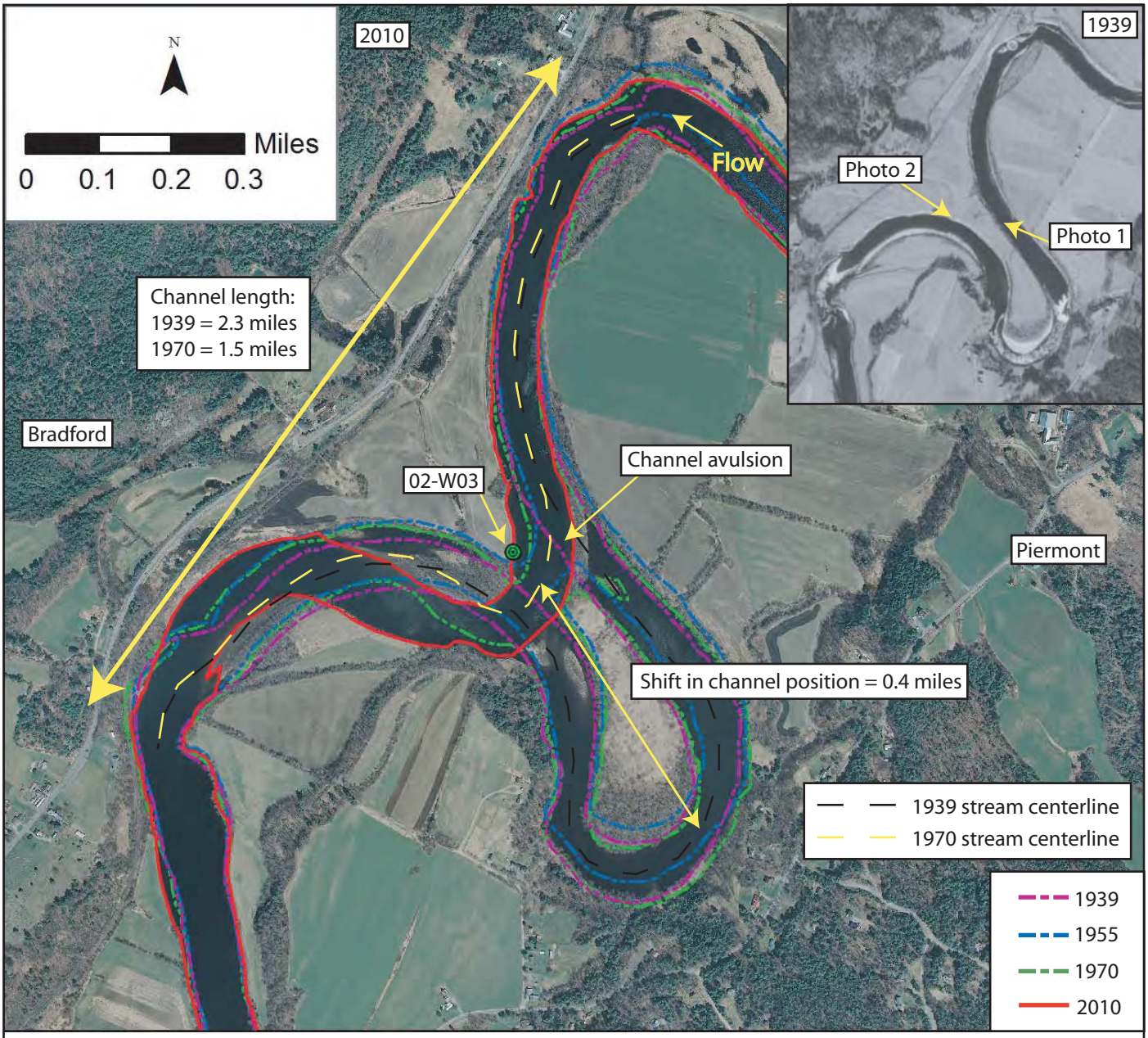


Photo 1: Upstream view in April 1942

Photo 2: Upstream view in April 1942.

Appendix C. Plate C-4 Site 01-W04

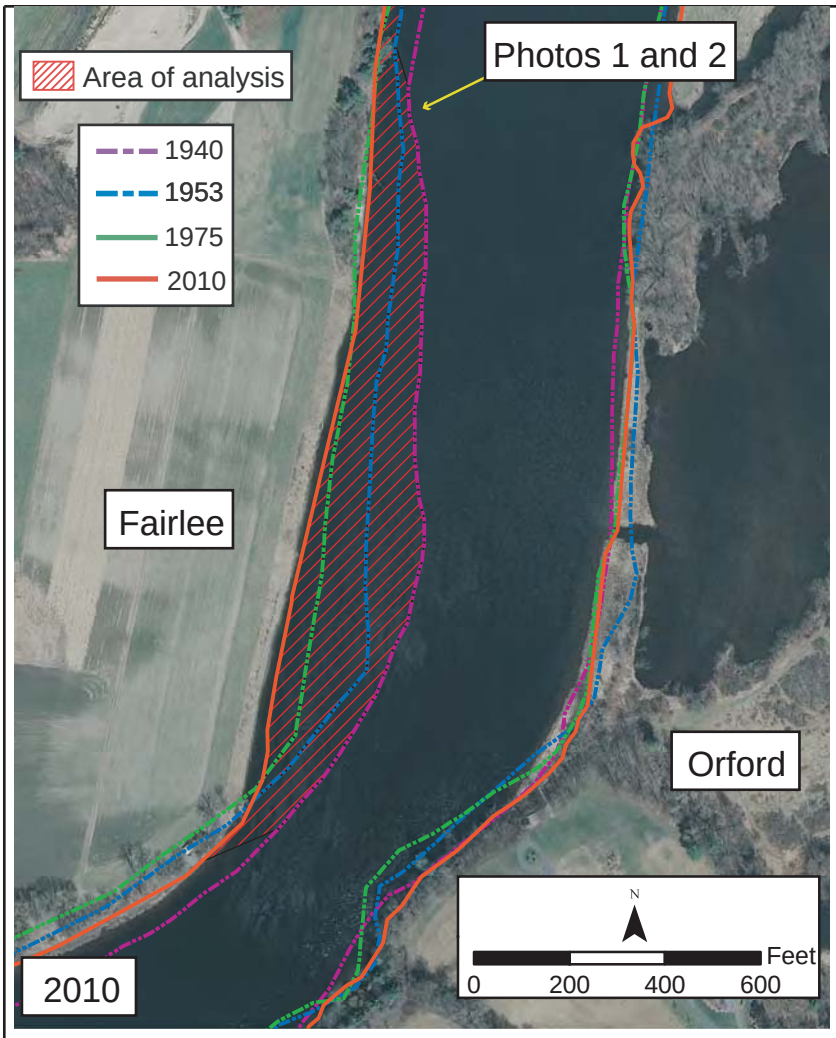


Photo 1: Right bank view in June 1973.

Bank Retreat

Time period	Average Length (feet)	Average Rate (ft/yr)	Maximum Length (feet)	Maximum Rate (ft/yr)	Area (acres)	Volume (yd^3)	Rate (yd^3/yr)
1940-1955	55.7	3.7	126.0	8.4	2.8	45,271	3,018
1955-1970	61.9	4.1	115.0	7.7	2.7	44,171	2,945
1970-2010	34.6	0.9	60.0	1.5	0.7	11,976	299
1940-2010	152.2	2.2	255.0	3.6	6.2	101,417	1449

Photo 2: Right bank view in June 1991.

Appendix C. Plate C-5 SIte 01-W05

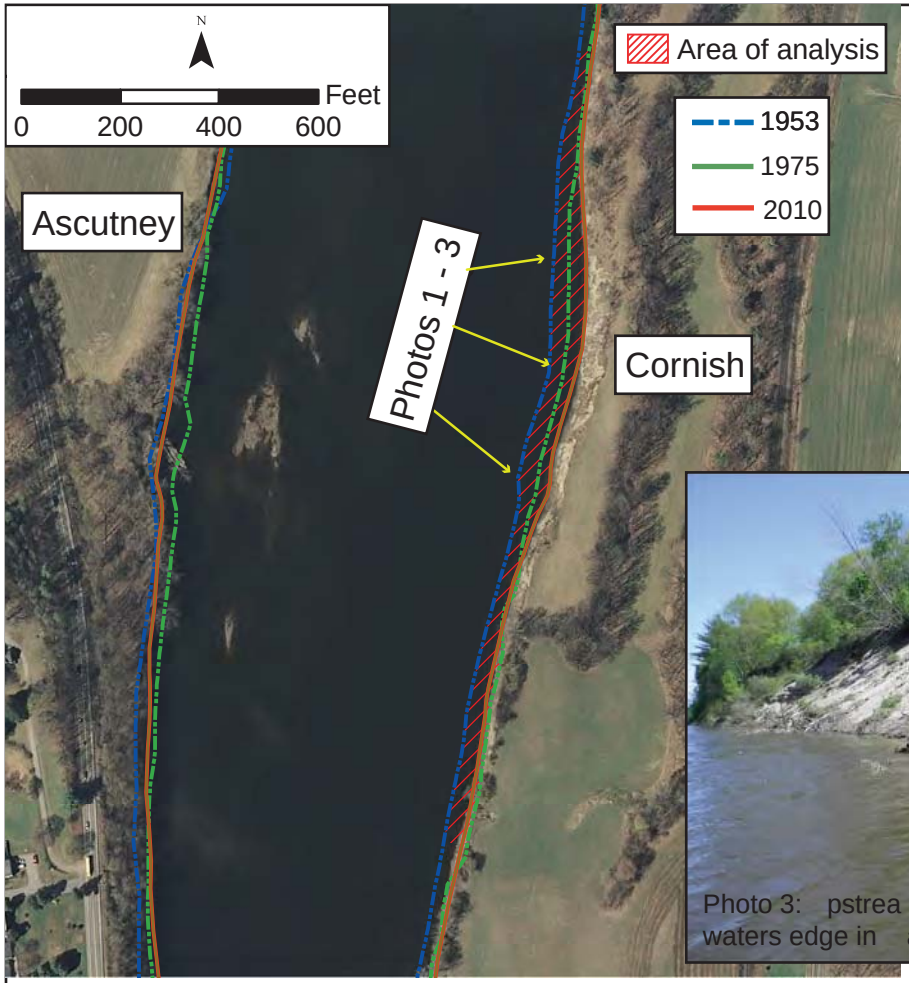


Photo 1: eft bank view in August 1953.

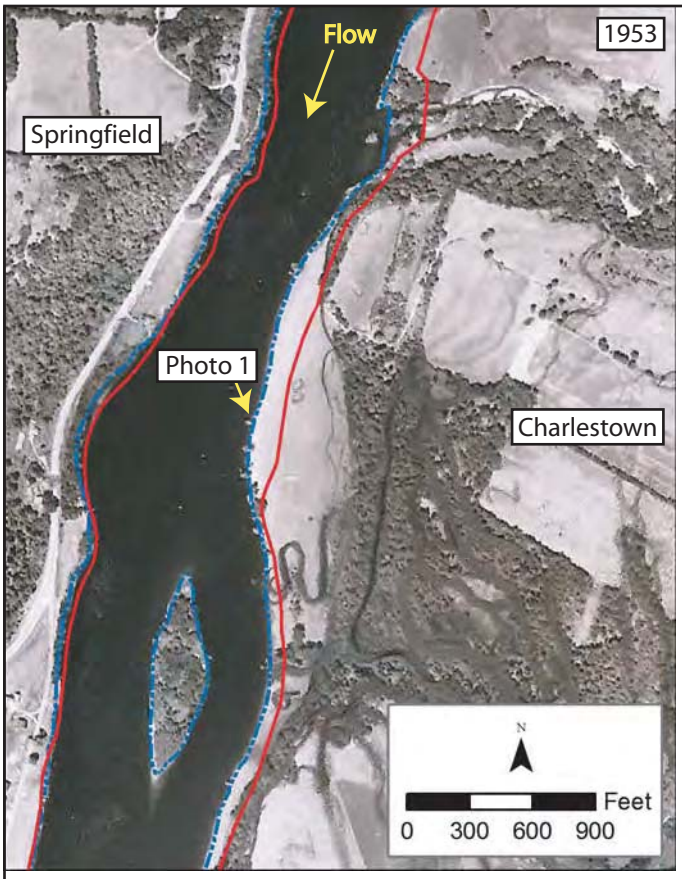
Photo 3: pstrea view at waters edge in ay 2015.

Photo 2: eft bank view in August 1953.

Bank Retreat

Time period	Average Length (feet)	Rate (ft/yr)	Maximum Length (feet)	Rate (ft/yr)	Area (acres)	Volume (yd^3)	Rate (yd^3/yr)
1953-1975	35.1	1.6	40.0	1.8	1.3	91,400	4,155
1975-2010	20.0	0.6	35.0	1.0	0.5	33,851	967
1953-2010	55.1	0.8	255.0	3.6	1.8	125,251	1,789

Appendix C. Plate C-6 Site 01- 01



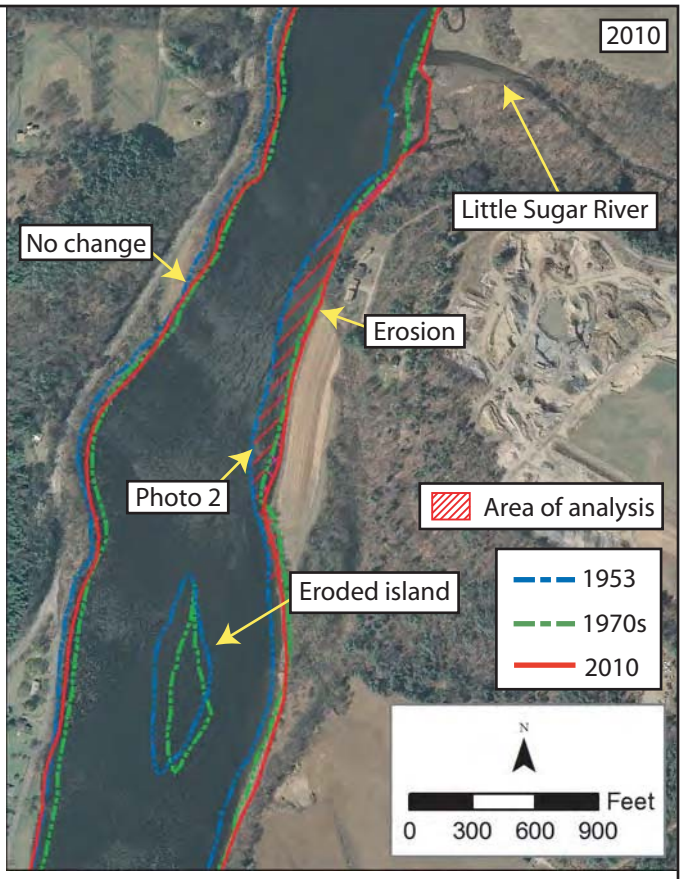


Photo 1: Downstream view in September 1954.

Photo 2: Upstream view in May 1964.

Bank Retreat

Time period	Average Length (feet)	Rate (ft/yr)	Maximum Length (feet)	Rate (ft/yr)	Area (acres)	Volume (yd^3)	Rate (yd^3/yr)
1953 to 1975	85.2	3.9	130	5.9	4.2	69,549	3,161
1975 to 2010	16.2	0.5	44	1.3	0.8	13,226	378
1953 to 2010	101.4	1.8	152	2.7	5.0	82,775	1,452

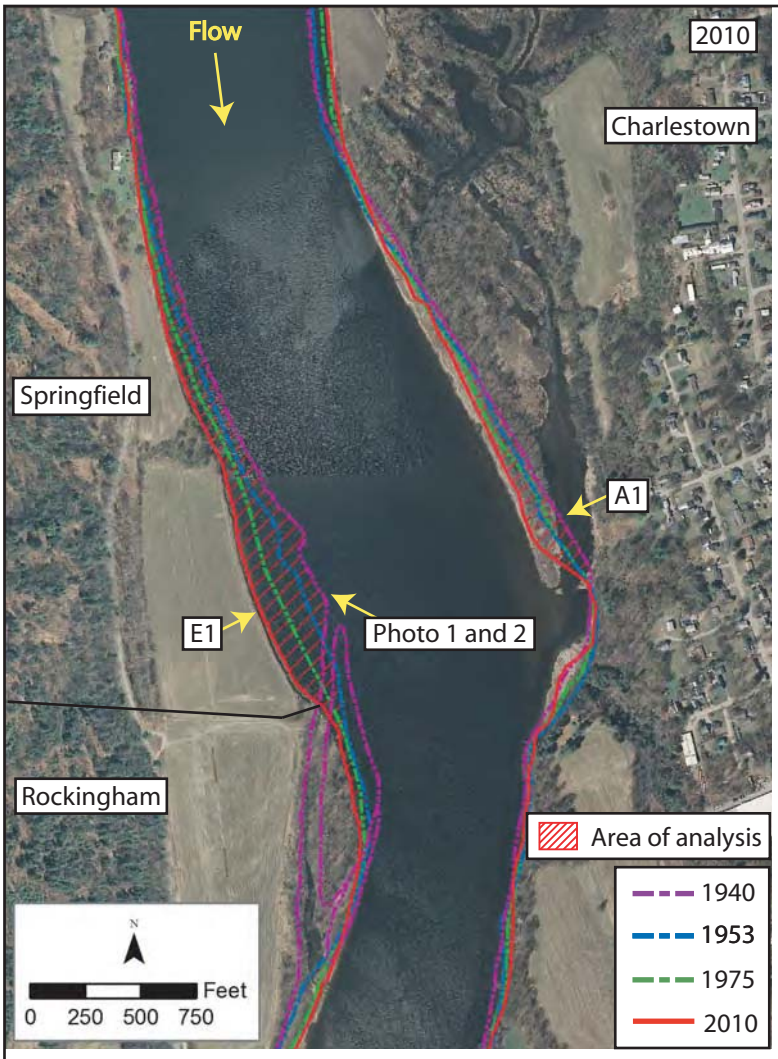


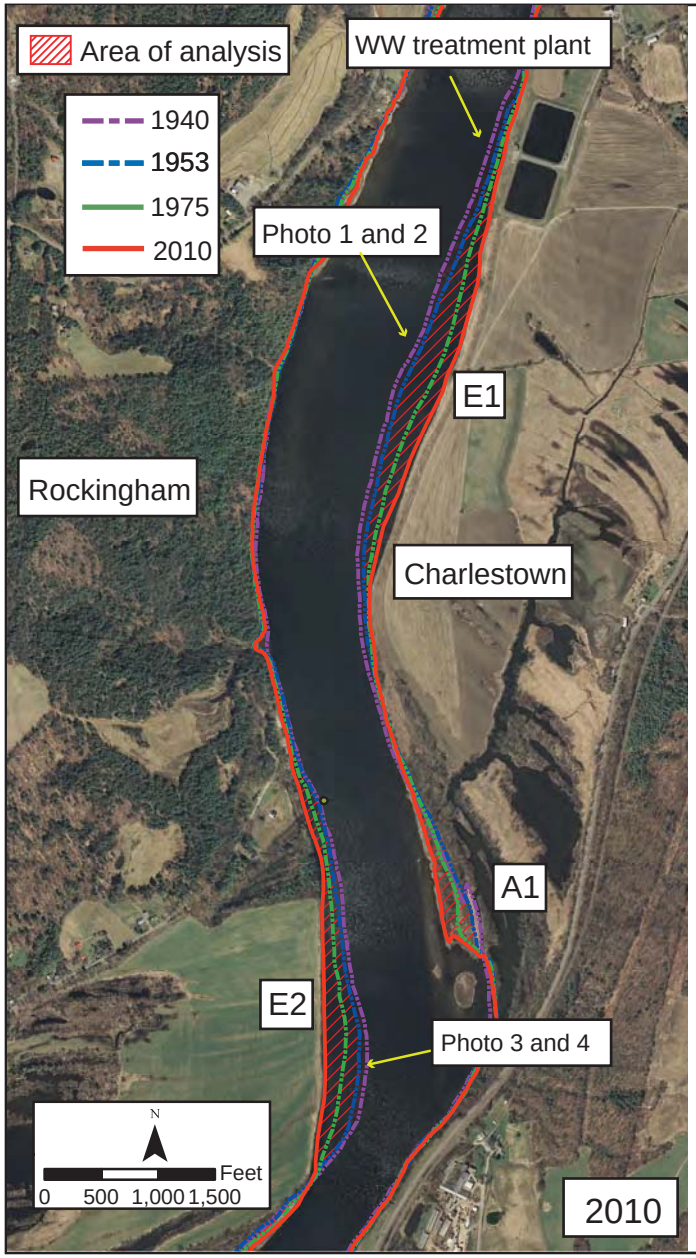
Photo 1: Upstream view in September 1954.

Photo 2: Upstream view in August 2015.

Bank Retreat

ite	Time period	Average Length (feet)	Rate (ft/yr)	Maximum Length (feet)	Rate (ft/yr)	Area (acres)	Volume (yd^3)	Rate (yd^3/yr)
1	1940 to 1953	48.7	3.7	110	8.5	3.3	50,181	3,860
	1953 to 1975	46.5	2.1	125	5.7	3.5	53,962	2,453
	1975 to 2010	47.2	1.3	102	2.9	3.9	59,078	1,688
	1940 to 2010	111.5	1.6	300	4.3	10.6	163,222	2,332
A1	1940 to 1953	-29.5	-2.3	-66	-5.1	-1.7	-9,648	-742
	1953 to 1975	-13.4	-0.6	-33	-1.5	-0.6	-3,261	-148
	1975 to 2010	-43.0	-1.2	-92	-2.6	-1.5	-8,299	-237
	1940 to 2010	-64.4	-0.9	-158	-2.3	-3.8	-21,207	-303

Note: E refers to erosion, A to aggradation.
Negative values for retreat represent aggradation.



Bank Retreat

Site	Time period	Average Length (feet)	Average Rate (ft/yr)	Maximum Length (feet)	Maximum Rate (ft/yr)	Area (acres)	Volume (yd^3)	Rate (yd^3/yr)
E1	1940 to 1953	53.4	3.6	109	7.3	9.7	166,507	11,100
	1953 to 1975	90.5	4.1	207	9.4	11.8	201,663	9,166
	1975 to 2010	66.1	1.9	155	4.4	9.1	155,419	4,441
	1940 to 2010	156.6	2.2	406	5.8	30.6	523,588	7,480
E2	1940 to 1953	34.5	2.3	88	5.9	3.8	80,129	5,342
	1953 to 1975	68.6	3.1	122	5.5	7.5	156,759	7,125
	1975 to 2010	78.9	2.3	181	5.2	8.8	183,875	5,254
	1940 to 2010	147.6	2.1	367	5.2	20.0	420,763	6,011
A1	1953 to 1975	-37.6	-1.7	-135	-9.0	-2.2	-8,288	-377
	1975 to 2010	-65.0	-1.86	-159	-7.2	-3.3	-12,408	-355
	1953 to 2010	-102.6	-1.47	-246	-3.5	-5.4	-20,696	-296

Note: E refers to erosion, A to aggradation.

Negative values for retreat represent aggradation.

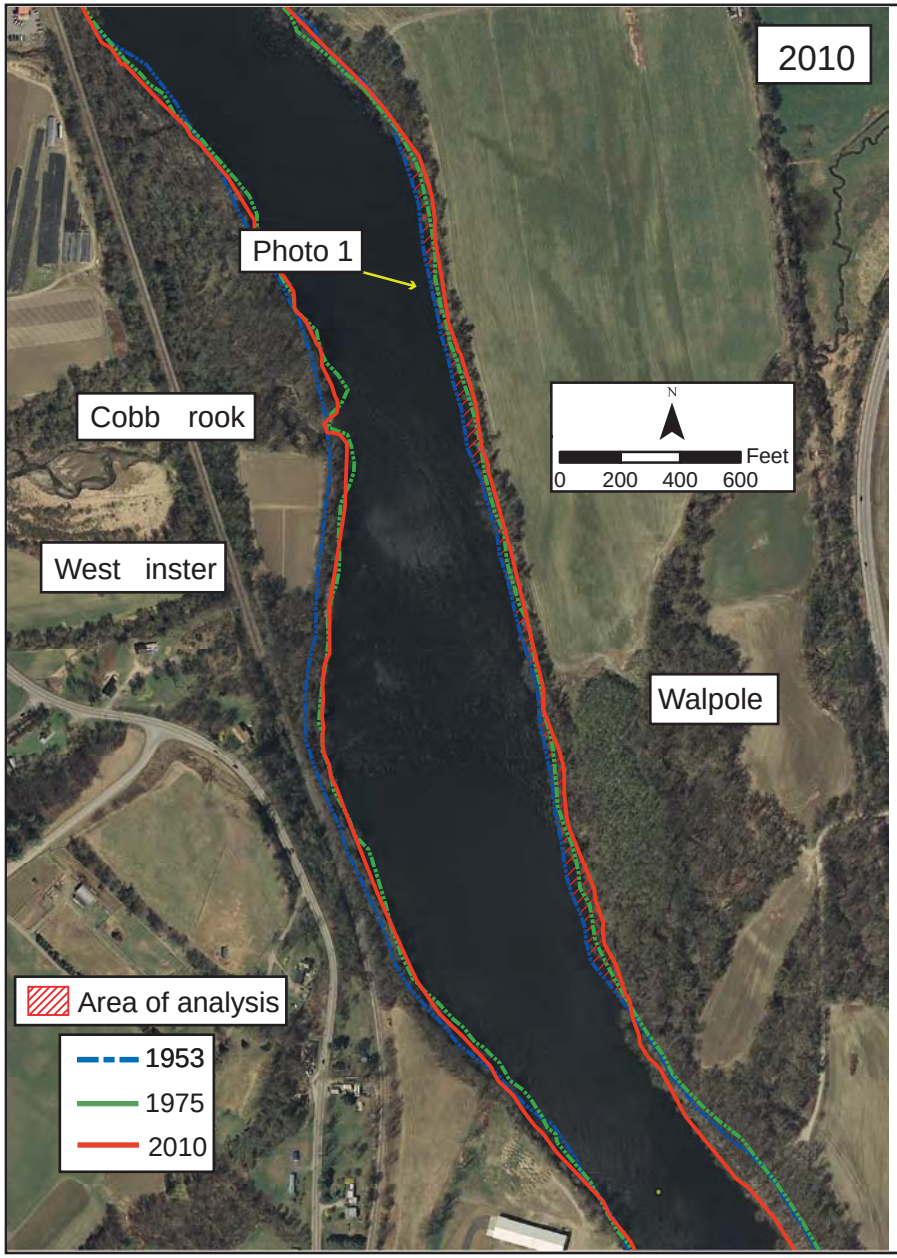
Photo 1: Downstream view September 1954.

Photo 3: Downstream view June 1964.

Photo 2: Downstream view August 2015.

Photo 4: Downstream view August 2015.

Appendix C. Plate C-9 Site 01-B04

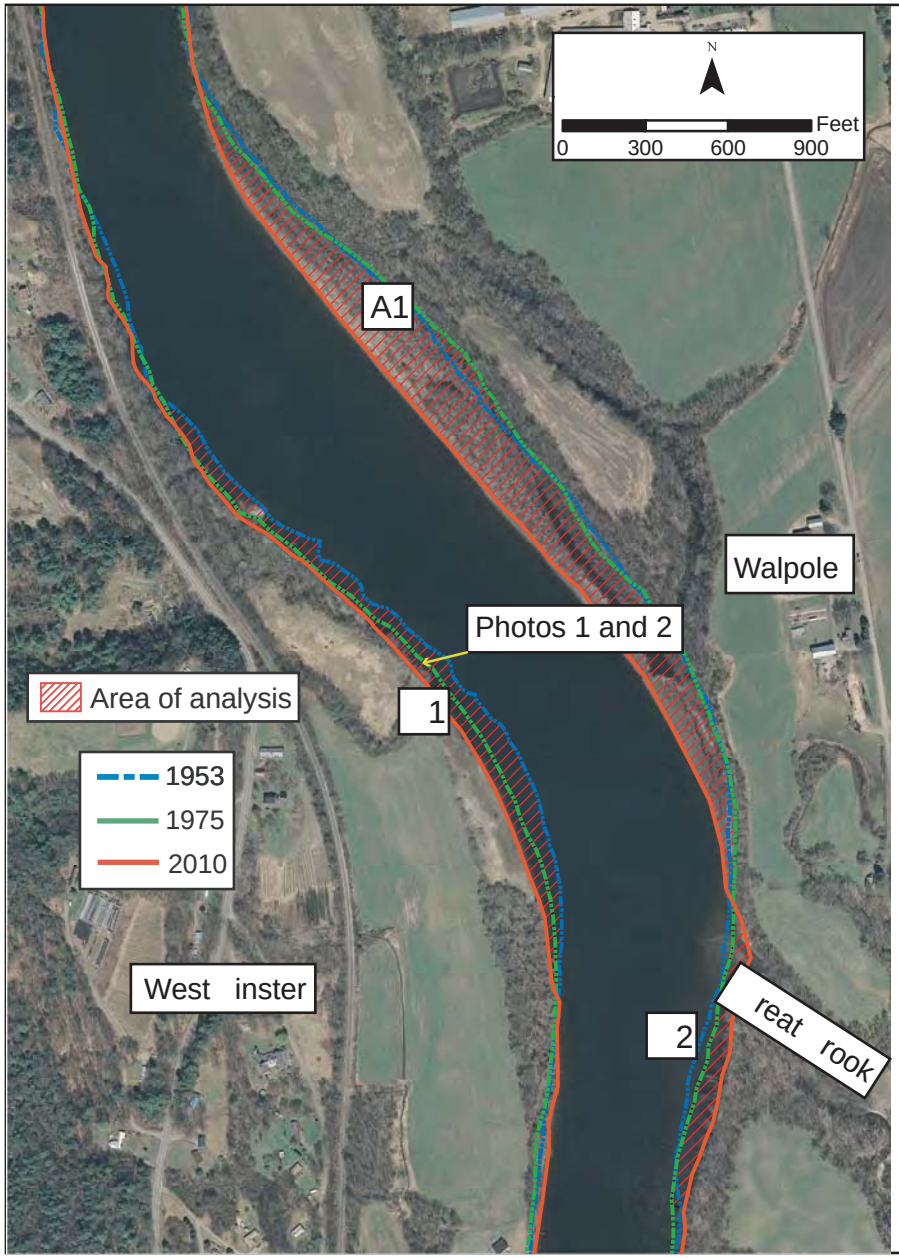


Bank Retreat

Time period	Average Length (feet)	Average Rate (ft/yr)	Maximum Length (feet)	Maximum Rate (ft/yr)	Area (acres)
1953 to 1975	25.0	1.1	43	2.0	1.8
1975 to 2010	20.9	0.6	35	1.0	0.5
1953 to 2010	45.9	0.8	75	1.3	30.6

Photo 1: eft bank view in June 1964.

Appendix C. Plate C-10 Site 01- R01



Bank Retreat

ite	Time period	Average Length (feet)	Average Rate (ft/yr)	Maximum Length (feet)	Maximum Rate (ft/yr)	Area (acres)	Volume (yd^3)	Rate (yd^3/yr)
1	1953 to 1975	43.8	2.0	88	4.0	3.4	80,872	3,676
	1975 to 2010	33.0	0.9	57	1.6	1.8	44,011	1,257
	1953 to 2010	76.8	1.3	138	2.4	5.2	124,884	2,191
2	1975 to 2010	62.2	1.8	181	5.2	8.8	183,875	5,254
A1	1975 to 2010	-150.0	-6.82	-159	-7.2	-3.3	-12,408	-355

Photo 2: Right bank view in August 2015.

Photo 1: Right bank view in June 1991.

Appendix C. Plate C-11 Site 01- 01