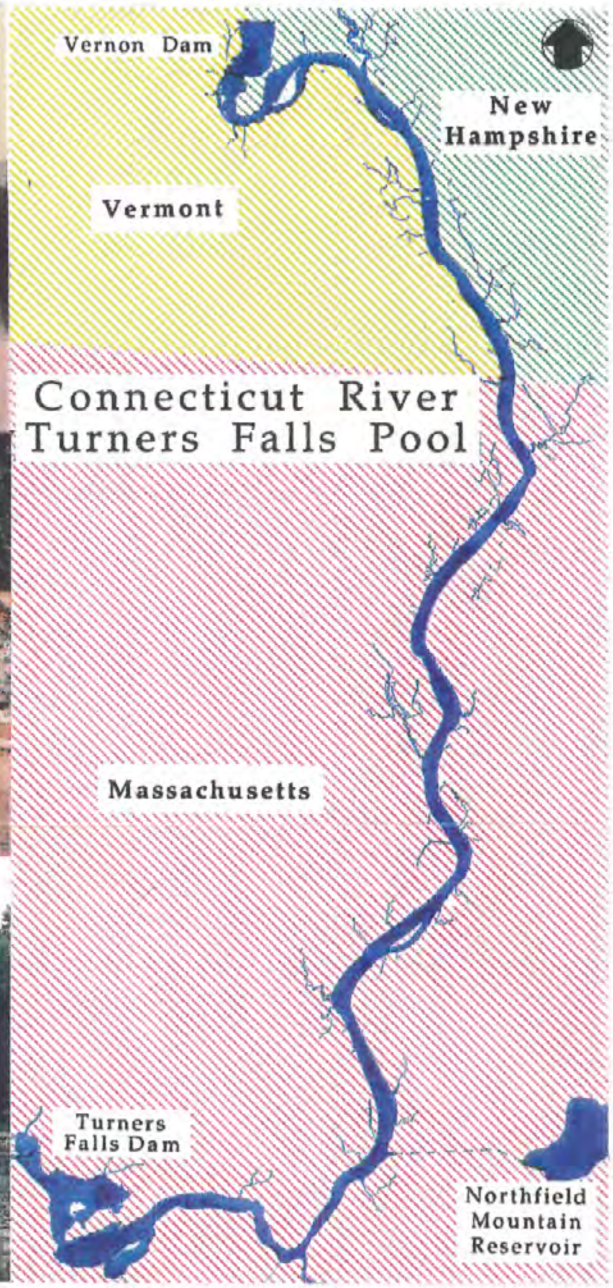
CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

(DRAFT)



NORTHEAST UTILITIES SERVICE CO., INC.

JUNE 1991

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

(DRAFT)

prepared by

NORTHROP, DEVINE & TARBELL, INC.

for

NORTHEAST UTILITIES SERVICE CO., INC.

JUNE 1991

NORTHROP, DEVINE & TARBELL, INC.
ENGINEERING AND ENVIRONMENTAL SCIENCE

90-200-00

June 17, 1991

Mr. Charles Momnie
Project Manager
Northeast Utilities Service Co., Inc.
P.O. Box 270
Hartford, CT 06141-0270

Subject: **Submittal of Draft Connecticut River Riverbank Management Master Plan**

Dear Chuck:

Northrop, Devine & Tarbell, Inc. (ND&T) is pleased to submit the following Draft Connecticut River Riverbank Management Master Plan to Northeast Utilities Service Company, Inc. (NUSCO). The Master Plan has been prepared for submittal to the Federal Energy Regulatory Commission (FERC) and the Massachusetts Environmental Protection Act (MEPA) Unit for review and comment. The Plan inventories and analyzes riverbank conditions and environmental resources within the Turners Falls Pool of the Connecticut River and recommends a plan of action for future management.

The staff of ND&T wish to extend their gratitude to a vast group of individuals and organizations who contributed their time, energy and resources to the creation of the Connecticut River Riverbank Management Master Plan. This plan incorporates a wide variety of disciplines and interests. Riverbank landowners provided insight and information regarding the use of the river and offered their perspectives regarding its future. From the federal to the local level, government agencies supplied critical data. Professors from the University of Massachusetts at Amherst, Hampshire College, and the University of Michigan provided important research data concerning the past and present state of the river and also offered input concerning riverbank stabilization alternatives.

The most dedicated voluntary contribution came from the Master Plan Workshop Group. Formed during the initial stages of the master planning process, this group consists of a collective of local and state government agency representatives, local riverbank landowners, and NUSCO and ND&T staff members. Ten evening meetings were held between March, 1990 and May, 1991. Workshop members offered suggestions and concerns regarding the various stages of the Master Plan's development. The input provided by each member was an integral component of this Master Plan. However, it must be noted that the findings and recommendations presented in this plan are solely the

Main Office: 500 Washington Avenue • Portland, ME 04103 • Tel. (207) 775-4495 • FAX (207) 775-1031
Branch Office: 1 Cumberland Place • Suite 204 • Bangor, ME 04401 • Tel. (207) 942-0999 • FAX (207) 942-1092

responsibility of NUSCO. A list of the workshop members who graciously provided their time and energy to this effort is provided below.

John Bennett - Montague Town Planner
Terry Blunt - Mass. Department of Environmental Management Connecticut River Action Program
Dick Holbrook - Riverbank landowner from Hinsdale, NH
Eugene & Bonnie L'Etoile - Riverbank landowners from Northfield
Bill Llewelyn - Northfield Conservation Commission & riverbank landowner
Tony Matthews - Gill Conservation Commission
Lynn Rubenstein - Franklin County Planning Commission
Ralph Taylor - District Manager of Mass. Division of Fisheries and Wildlife
Henry Waidlich - Montague Conservation Commission
Chuck Momnie - NUSCO
John Howard - NUSCO
Paul Gamache - NUSCO
Rich Thomas - NUSCO
John Devine - ND&T
Rob Mitchell - ND&T
Rob Foltan - ND&T

In addition to these workshop members, numerous other individuals attended workshop meetings or provided information to NUSCO regarding the river and are listed below.

Allan & Shirley Flagg - Gill riverbank landowners
Fritz & Allison Kaufhold - Gill riverbank landowners
Tim Storrow - Gill Conservation Commission
Paul Seamans - Gill riverbank landowner
Richard Hubbard - Mass. Dept. of Food & Agriculture, APR Program Manager
Les Lewis - Mass. Department of Environmental Management, Division of Waterways
Jay Copeland - Mass. Division of Fisheries & Wildlife, Natural Heritage and Endangered Species Program
Charles Weiner, Bill Swaine, Tom Marcotte - US Army Corps of Engineers
Charles Truax - US Dept. of Agriculture, Soil Conservation Service

Special thanks are also extended to Dr. John Reid of the Hampshire College Geology Department for his interest in the Master Plan and his willingness to share important information concerning river dynamics. Also from the same department, Peter Easton and Sean Carbine provided key field data throughout the summer. Dr. Mitch Mulholland and Richard Holmes of the Archaeological Services Department of the University of Massachusetts at Amherst studied the archaeological significance of the Turners Falls Pool and documented resource probability zones. Dr. Donald Gray of the University of Michigan Department of Civil Engineering provided detailed information concerning riverbank stabilization options and offered his recommendations regarding the viability of various options within the Turners Falls Pool.

We also wish to thank Western Massachusetts Electric Company (WMECO) staff at the Northfield Mountain Pumped Storage Hydroelectric Facility, the Northfield Mountain Visitor Center and the Barton Cove Recreation Area for their assistance and patience throughout the past year as the Master Plan was created.

Sincerely,

NORTHROP, DEVINE & TARBELL, INC.

John Devine

John J. Devine, P.E.
Project Manager

JJD/jeb

Enclosure

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I. MASTER PLAN SUMMARY

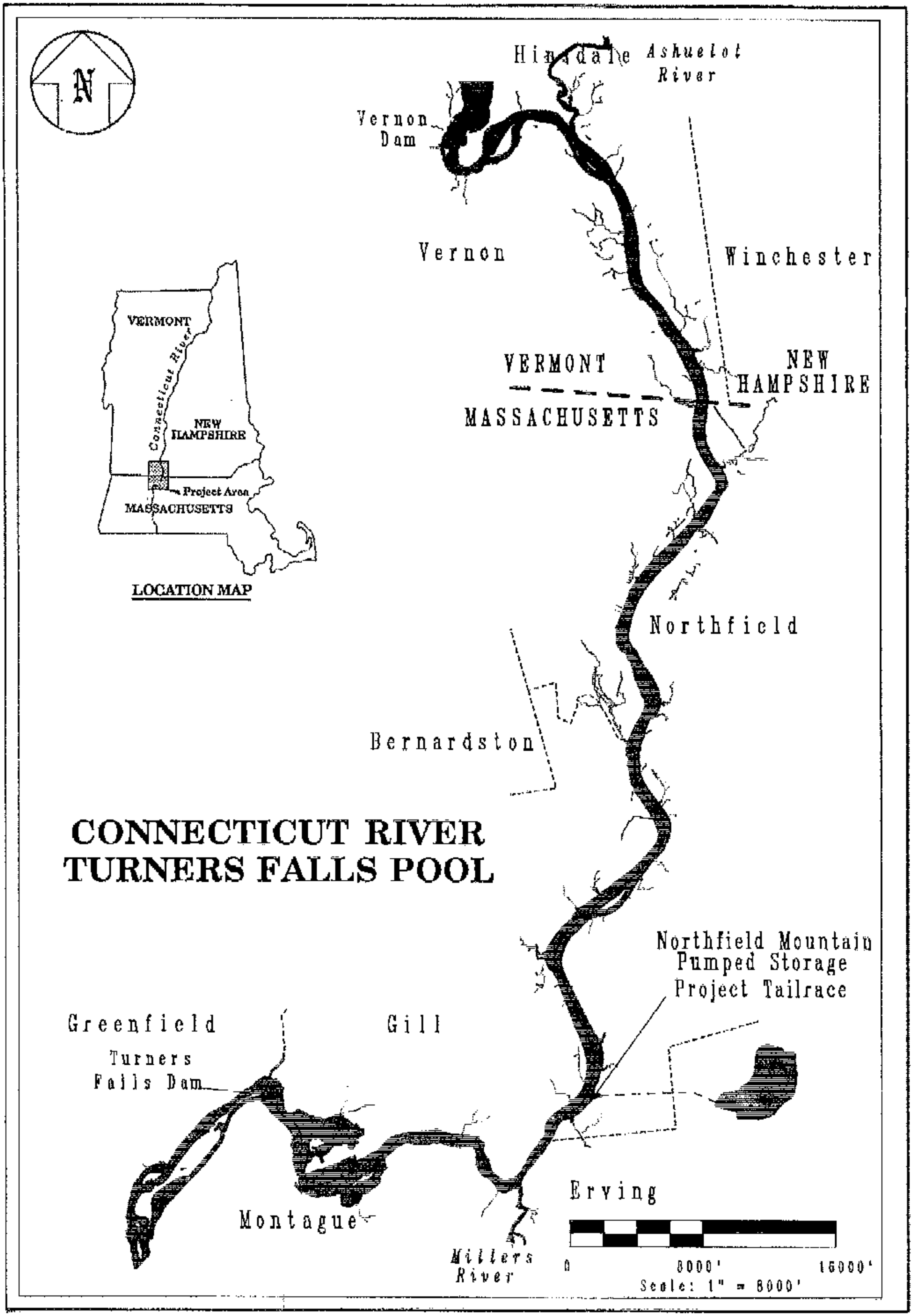
A. Overview of the Scope and Purpose of the Master Plan

The Connecticut River Riverbank Management Master Plan has been prepared for submittal to the Federal Energy Regulatory Commission (FERC) by Northeast Utilities Service Company, Inc. (NUSCO) in response to concerns raised regarding bank erosion and its effect on the environmental resources of the Turners Falls Pool. The Turners Falls Pool is a 22-mile stretch of the Connecticut River between Turners Falls Dam in Turners Falls, MA and Vernon Dam in Vernon, VT and Hinsdale, NH. Map I-1 shows the study area.

The Master Plan encompasses the licensed Project boundary for the Turners Falls Project (FERC No. 1889) and the Northfield Project (FERC No. 2485). The Turners Falls Project is owned and operated by the Western Massachusetts Electric Company (WMECO). The Northfield Project is jointly owned by WMECO and the Connecticut Light and Power Company (CL&P) and operated by WMECO. Both WMECO and CL&P are operating subsidiaries of Northeast Utilities, Inc. (NU). NUSCO is a non-operating subsidiary of NU.

The Master Plan is also being voluntarily submitted to the Massachusetts Environmental Protection Act (MEPA) Unit of the Executive Office of Environmental Affairs as part of the consultation effort with Massachusetts resource agencies. Resource agencies in Vermont and New Hampshire have also been consulted as part of the process of developing the Master Plan.

The Master Plan examined whether, and to what extent, erosion may be adversely affecting the riverbank resources along this particular reach of the Connecticut River. The primary purpose of the Master Plan was to evaluate the extent of bank erosion occurring along the Turners Falls Pool and identify the site-


N
Hinsdale
Ashuelot River
Vernon Dam
Vernon
Winchester
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
Connecticut River
Project Area
LOCATION MAP
Northfield
Bernardston
CONNECTICUT RIVER
TURNERS FALLS POOL
Northfield Mountain
Pumped Storage
Project Tailrace
Greenfield
Gill
Turners
Falls Dam
Erving
Montague
Millers
River
0
8000'
16000'
Scale: 1" = 8000'

specific impacts to environmental resources resulting from this erosion. To meet this objective, a system was developed which would integrate, at any given erosion site, the erosion conditions, the degree of impact to environmental resource values, the contributing causes of erosion and the likely costs of bank stabilization. The field work and analyses conducted resulted in the development of an implementation plan for monitoring and evaluating future erosion activity and a decision making process for determining when bank stabilization would be justified. The decision making process has been designed to define when environmental resources are sufficiently affected by erosion to require action.

The overall scope of this Master Plan is shown on Figure I-1 in a Project Flow Chart. Existing data was collected from a wide variety of public and private sources and then supplemented by data from extensive field observations and investigations conducted throughout 1990. The resulting inventory of engineering and environmental data was entered into a computerized geographic information system (GIS) data base using ARC INFO software, and then compiled to produce a complete characterization and documentation of existing conditions within the Turners Falls Pool.

Individual erosion sites were identified in the field, based primarily on soil exposure and the degree of apparent bank movement. A site-specific methodology was developed to rate erosion severity and environmental resource values at each erosion site. The rating system provided a comprehensive, quantified rating value for each site, which was then used to assess and compare the extent and effects of erosion at sites throughout the Turners Falls Pool.

Parallel to this effort, an investigation of the causes of erosion within the study area was initiated in May, 1990. Analysis of engineering data and both ground-level and aerial

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PROJECT FLOW CHART

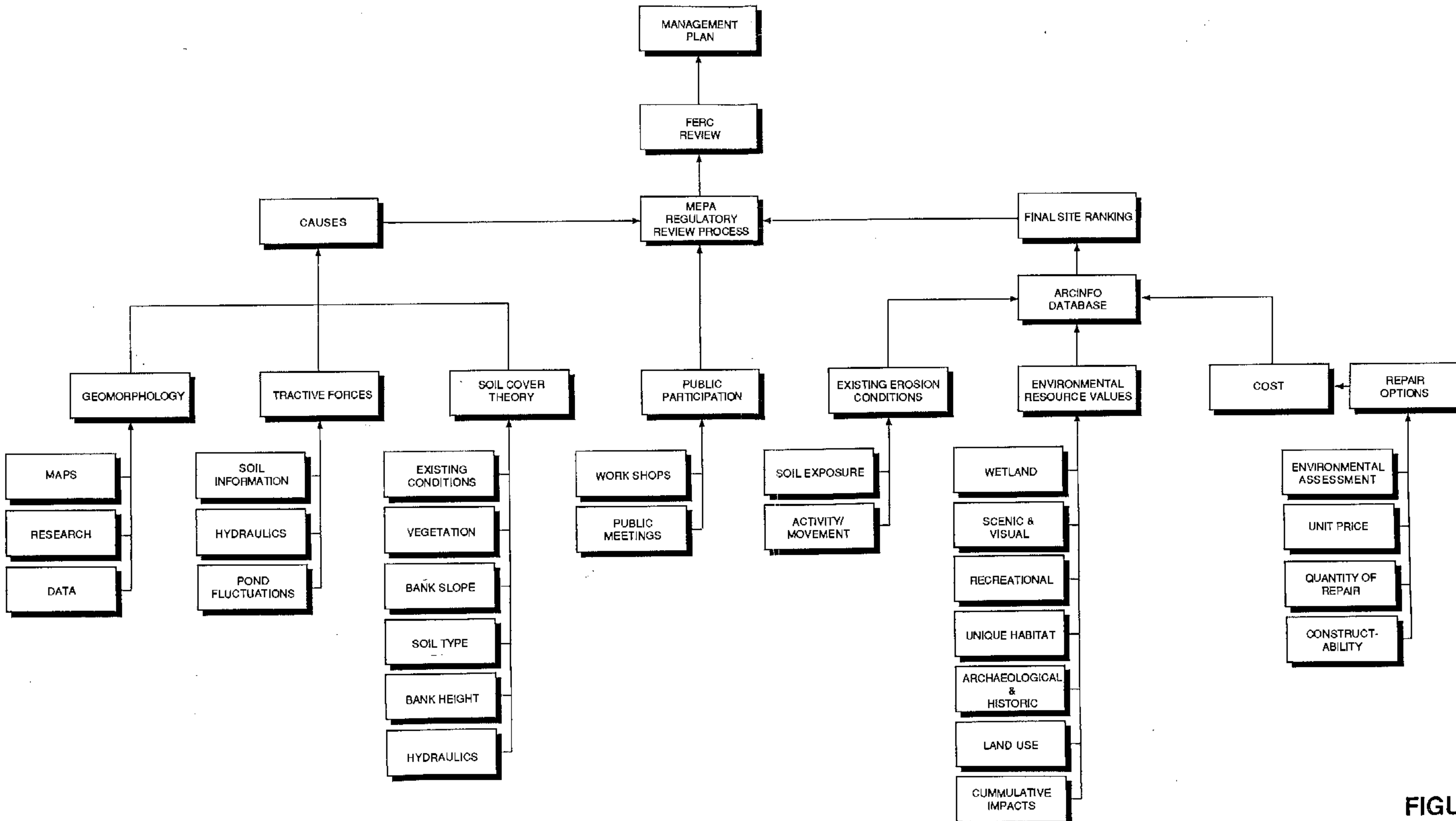

FIGURE I-1

photos took place in order to evaluate the relationship between erosional activity and the physical characteristics of the river and its banks. Alternative bank stabilization techniques and cost estimates were prepared for specific erosion sites to understand the cost of representative repairs and the environmental impacts associated with such construction.

The entire Master Plan effort was coordinated with a Workshop Committee representing riverbank landowners and local and state officials, which met ten times to review methodology, results, and progress. The workshop group provided input to the master planning process; however, the Master Plan findings and recommendations are solely the responsibility of NUSCO.

This report and its appendices contain a complete description of the work undertaken within the Master Plan. Section I of the Master Plan presents an executive summary of the Plan. Section II describes the purpose and objectives of this report, the scope of the Plan and the methodology employed in formulating this plan. Section III describes the study area, including NUSCO's hydroelectric operations, the physical and environmental setting of the Turners Falls Pool, existing erosion conditions, and bank stabilization methods which were previously undertaken. Section IV provides an assessment of available bank stabilization techniques and outlines options that are most appropriate for the Turners Falls Pool. Section V describes the methodology and results of the system developed to rate erosion sites on a common basis. This section includes a description of the method used to characterize and classify erosion severity, and the method used to evaluate the existing environmental resources, all leading to a comprehensive ranking. Section VI provides a preliminary analysis of the contributing causes of erosion, and Section VII presents recommendations on how to best manage the study area's riverbanks and protect the important environmental resources that were identified.

B. Summary of Findings of Field Investigations and Analyses

Extensive field observations conducted during the spring and summer of 1990 resulted in the identification of a total of 76 individual erosion sites, ranging in relative activity from low-to-moderate erosion to severe erosion. The evaluation of erosional activity was based on the percentage of exposed or unvegetated soil evident at a given site and the percentage of remaining vegetated bank which shows signs of bank movement. Erosion sites cover 13.6 miles, or 31%, of the 44 miles of riverbanks within the Turners Falls Pool. Of the riverbank area considered eroded, 33.8% is considered low-to-moderate, 38.2% is moderate, 24.2% is moderate-to-severe and 3.6% is severe. WMECO and CL&P own the riverbank property at 81.3% of the land associated with these erosion sites, New England Power Company owns an additional 9.4% and private landowners own 9.3%. Maps A1-1 through A1-7, which appear in Attachment A at the end of the Master Plan, show the locations and degree of erosion assigned to all 76 erosion sites.

The environmental resource rating defined for each erosion site considered six separate categories - wetlands, plant and wildlife habitat, scenic resources, archaeological/historical value, riverbank recreational use, and adjacent upland land use. Extensive field observations and analysis of existing data and aerial photographs were utilized to generate a thorough inventory of these six data types. Maps A2-1 through A2-7, which appear in Attachment A, show the interrelationship of these various environmental features within the Turners Falls Pool.

Once the erosion sites were rated for these two distinct categories - erosional activity and resource value - a comprehensive rating was established by averaging the combined score of the two categories. The resulting comprehensive ratings are provided on Table V-11, indicating the relative significance of erosion at each site. The comprehensive site ratings are intended to prioritize erosion sites when evaluating the need to implement either bank stabilization or riverbank resource management programs. In general, the site ratings indicate that the great majority of higher-valued environmental resources in the Turners Falls Pool are not currently affected by erosion.

ND&T's work also included the identification and review of various techniques for bank stabilization and the definition of site-specific repair schemes at erosion sites along the Turners Falls Pool.

In general, ND&T considered three means of bank stabilization: vegetative, slope reinforcement, and structural. Appropriate design concepts for each were developed and applied on a site-by-site basis, depending on site conditions and the apparent cause of erosion.

Generally, the Workshop Committee showed a preference for a vegetative method of repair. This would likely consist of the planting of sedges and rushes below the normal high-water line, red osier dogwood at and just above high-water, and red osier dogwood and purple osier willow on the upper slope. As an alternative to a strictly vegetative solution, the repair could combine a structural/vegetative solution consisting of a live crib wall up to the normal high-water line with vegetation on the upper bank. Typical cross sections of these concepts are shown in Figure I-2.

Cost estimates for stabilizing the 12 highest rated erosion sites[1] were developed and impacts of construction were

----

1. The 12 sites referenced for cost estimates were based on an initial ranking performed by ND&T. Subsequent changes in updated archaeological rating numbers resulted in a final ranking which differed from this initial ranking. Consequently, site 76, which ranked 11th, did not receive a stabilization assessment, while site 21 did.

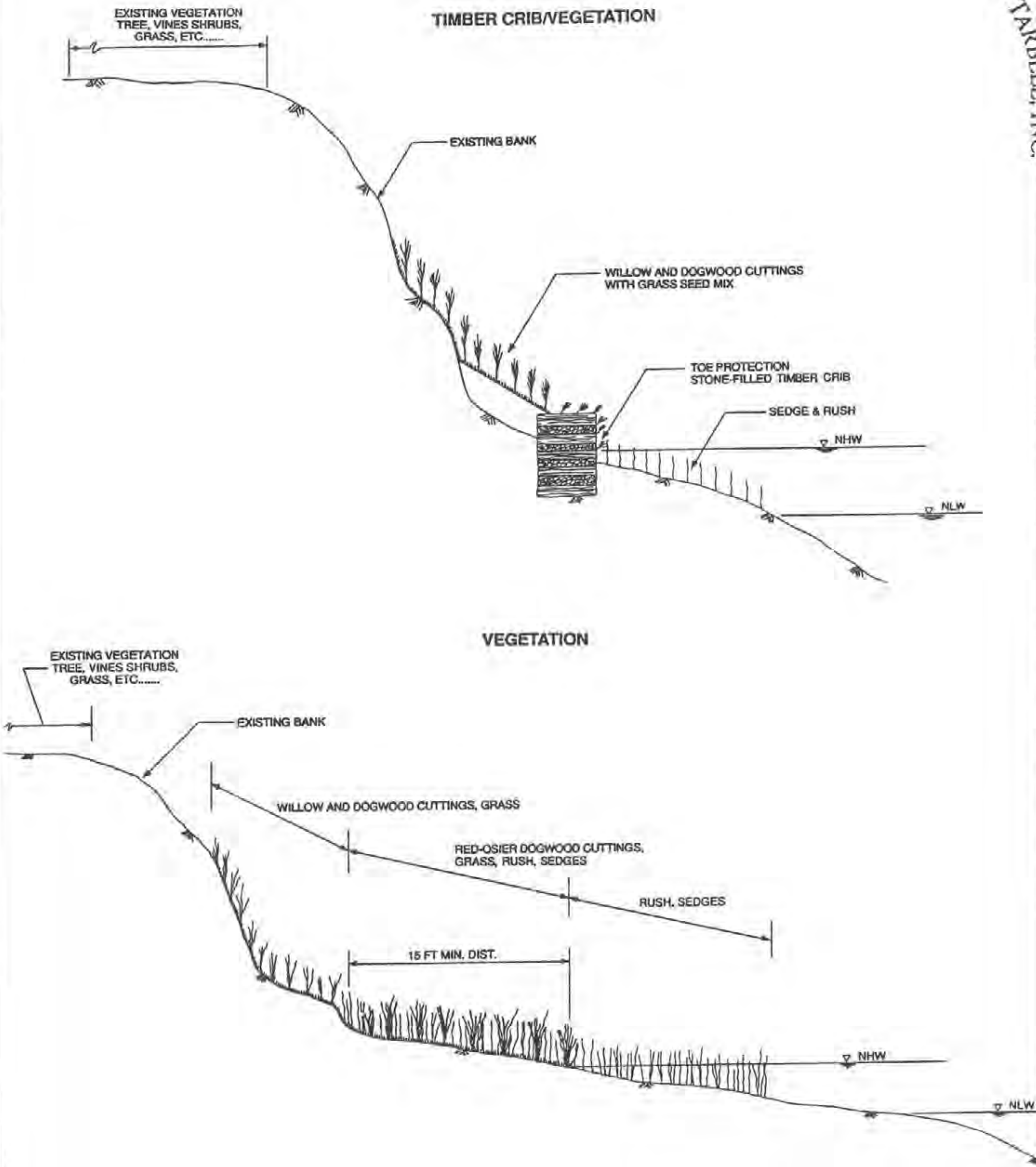

FIGURE I-2
CONNECTICUT RIVER
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identified. The cost estimates were performed to provide an indication of the magnitude of cost associated with bank stabilization and to integrate cost into the erosion site prioritization process. A summary of these cost estimates is provided in Table VII-1 in Section VII of this report. This site-specific work was limited to 12 sites because they provide a balanced representation of the various types, conditions, and lengths of erosion sites on the river and also display the greatest incidence of significant environmental resource values.

At the outset of the development of the Master Plan, the New England Division of U.S. Corps of Engineers (COE) was simultaneously planning to undertake an investigation regarding the causes of erosion within the study area. However, the Corps did not initiate its detailed evaluation and in May, 1990 NUSCO began to investigate the contributing causes of erosion. Section VI of the Master Plan describes the investigations conducted. The five probable causes identified and analyzed were:

- Forces exerted on the bank due to flowing water, particularly at flood stages (tractive forces)
- Pond fluctuations (resulting from normal hydroelectric project operations)
- Riverbank soil type and adequacy of vegetative cover
- Wave action
- Natural river meandering processes

A methodology was developed to provide a preliminary quantitative evaluation of the contribution to erosion that could be reasonably assigned to the construction and operation of the Northfield Project. This method was based on analysis of aerial photographs from 1952, 1971, 1980, and 1990, and other photographs and survey data. Section VI contains a complete discussion of the results of the study of the cause of erosion.

C. Conclusions of Master Plan

Based upon the field work and analyses conducted as part of the Master Plan, certain conclusions regarding current riverbank conditions were drawn. These conclusions primarily address the overall assessment of impact to the existing riverbank environment and the assessment of factors contributing to erosion.

Overall Assessment of Impact to Riverbank Environment

- The field inventory and the analysis of environmental data indicate that erosion along the Turners Falls Pool is not, at the present time, resulting in adverse affects to significant environmental resources, with the possible exception of potential archaeological resources at certain localized sites. In numerous instances environmental conditions have been enhanced by the presence of erosion; most notably, the creation of favorable bank swallow habitat, and the expansion of shoreline beach areas. The areas of severe and moderate-to-severe erosion create some habitat diversity in contrast with the remaining 90% of the riverbank area.

- The economic and environmental costs associated with bank repair are both potentially high. Based on the stabilization costs forecast for the 12 highest rated erosion sites, it can be concluded that the cost of bank repair is unreasonably high in relation to the environmental benefits that may be created.

  This conclusion is based on a qualitative judgment of the value of affected environmental resources. A standard cost-benefit analysis is difficult to utilize when comparing expected stabilization costs with perceived environmental resource values; particularly when attempting to assign a monetary value to wetlands, scenic resources, rare plants or archaeological artifacts. Land use loss is more easily valued (i.e., the loss of 1.3 acres of pasture land at market value is worth a fixed dollar value). In general, the comparison between a cost of $600,000 to stabilize a riverbank area to protect agricultural land valued at $25,000 illustrates the vast dichotomy when using this type of benefit:cost assessment. Consequently, NUSCO supports the use of its erosion site rating and ranking method as the best means of producing a more meaningful and relative quantified indication of resource value at any given erosion site. When compared to a given stabilization cost, the rated environmental resource value indicates the incidence and importance of a resource value and allows a judgment of both the positive and negative impacts associated with potential stabilization.

- The environmental laws regulating bank stabilization activity generally favor minimum disturbance of a given site in order to protect the environmental resources that are present.

- The Master Plan defines in detail the present conditions within the Turners Falls Pool. Further monitoring of erosion and riverbank resources at particular sites is necessary to allow an assessment of the rate and stage of erosion activity at any given site and to determine changes in effects on environmental resources. Follow up investigations should be conducted using the same methods employed during the creation of the Master Plan to ensure consistency and accuracy.

Assessment of Factors Contributing to Erosion

- The alluvial soils generally found on the low-lying floodplain "terraces" are much more susceptible to erosion than the higher-banked, wooded areas ("ridges") which generally contain cohesive soils. The erosion susceptibility of the alluvial terraces is readily influenced by the activities of man, such that any activity which changes the relationship between the river and its channel/banks can impact erosion susceptibility. Erosion of the alluvial soils is particularly sensitive to the type and quality of the vegetative cover.

- The raising of the Turners Falls Pool elevation in 1970, associated with the construction of the Northfield Mountain Pumped Storage Project, inundated part of the lower vegetated bank that existed along the alluvial terraces. The resulting loss of vegetative cover, and subsequent exposure of the highly erodible soils to tractive forces, accelerated erosional activity at certain specific sites. However, the contribution to erosion at any particular site caused by the raising of the Turners Falls Dam is variable.

- Fluctuation of the impoundment does not appear to contribute significantly to the erosional activity along the river, since significant seepage forces are not generally encountered, and the greatest part of the fluctuations generally takes place over the relatively flat beach areas.

  The vast majority of emergent and submergent vegetation within the fluctuating zone appears in the three-mile river stretch immediately upstream of Turners Falls

Dam. According to water elevation readings presented in Section III.B and in Appendix E, this is also the portion of the Turners Falls Pool experiencing the greatest range of fluctuation. Fluctuations are not, in and of themselves, considered a deterent to vegetative reestablishment in the eroded areas. Significant riverine currents during normal spring flows and summer freshets, erodible soils, steep slope and lack of adequate nutrients play a much larger role in precluding vegetative growth in the eroded areas.

* Recreational power boating is a contributor to erosion, but primarily as a secondary factor, by accelerating erosion in areas with exposed, highly erodable soils.

* The river's tendency to meander determines its course over the long-term. This process is considered to be a less significant factor for the erosional activity being experienced along Turners Falls Pool in the recent past.

* As an overview, it is important to remember that the erosion caused by one major flood event may result in greater overall loss of soils, sediment deposition, and changes in bank geometry than the erosion activity presently underway.

D. Master Plan Recommendations

Based on the analysis of the field data gathered during the master planning process, recommendations have been developed which provide a framework for future decision making regarding the extent of erosion and the need for action to protect environmental resources. In this regard, the Master Plan represents the beginning of a process of resource observations and management designed to continually update environmental impacts and assess the need for resource protection within the

Turners Falls Pool. The Master Plan has concluded that, with some notable exceptions as discussed below, bank erosion along this stretch of the Connecticut River has not reached the point where repairs are justified on the basis of environmental impact.

In total, there are four recommended components of the final Master Plan consisting of the creation of a process for determining when sites should become candidates for bank stabilization and how to then evaluate these sites, development of an on-going comprehensive erosion site monitoring program, a boater awareness program designed to bring together boaters and resource managers to discuss key issues, and the implementation of a bank stabilization demonstration project at Site 60, which will be followed by the stabilization of all of Site 60. These four components and an implementation schedule are described in detail in Section VII of the Master Plan and are summarized below.

1. ESTABLISHMENT OF A DECISION PROCESS FOR SELECTING BANK STABILIZATION CANDIDATES AMONG 76 EROSION SITES IDENTIFIED.

This recommendation provides the primary method to be utilized in the future for updating and periodically evaluating both erosion and environmental conditions within the Turners Falls Pool, and selecting appropriate responses where environmental resource degradation is occurring. It uses the rating method developed during the master planning process as the basis for updating conditions at each erosion site. The degree of attention afforded a particular site is based directly upon the rating it receives, either now or after future monitoring. Figure I-3 is a flow diagram showing this method, which is described in detail in Section VII.

The decision-making process outlined uses a triggering mechanism which then defines certain site-specific resource analysis to be done. Sites can qualify for one of three possible actions. Sites rated less than 40 will be reevaluated and rated every four

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PROPOSED ND&T PROCESS FOR SELECTING RIVERBANK STABILIZATION CANDIDATE

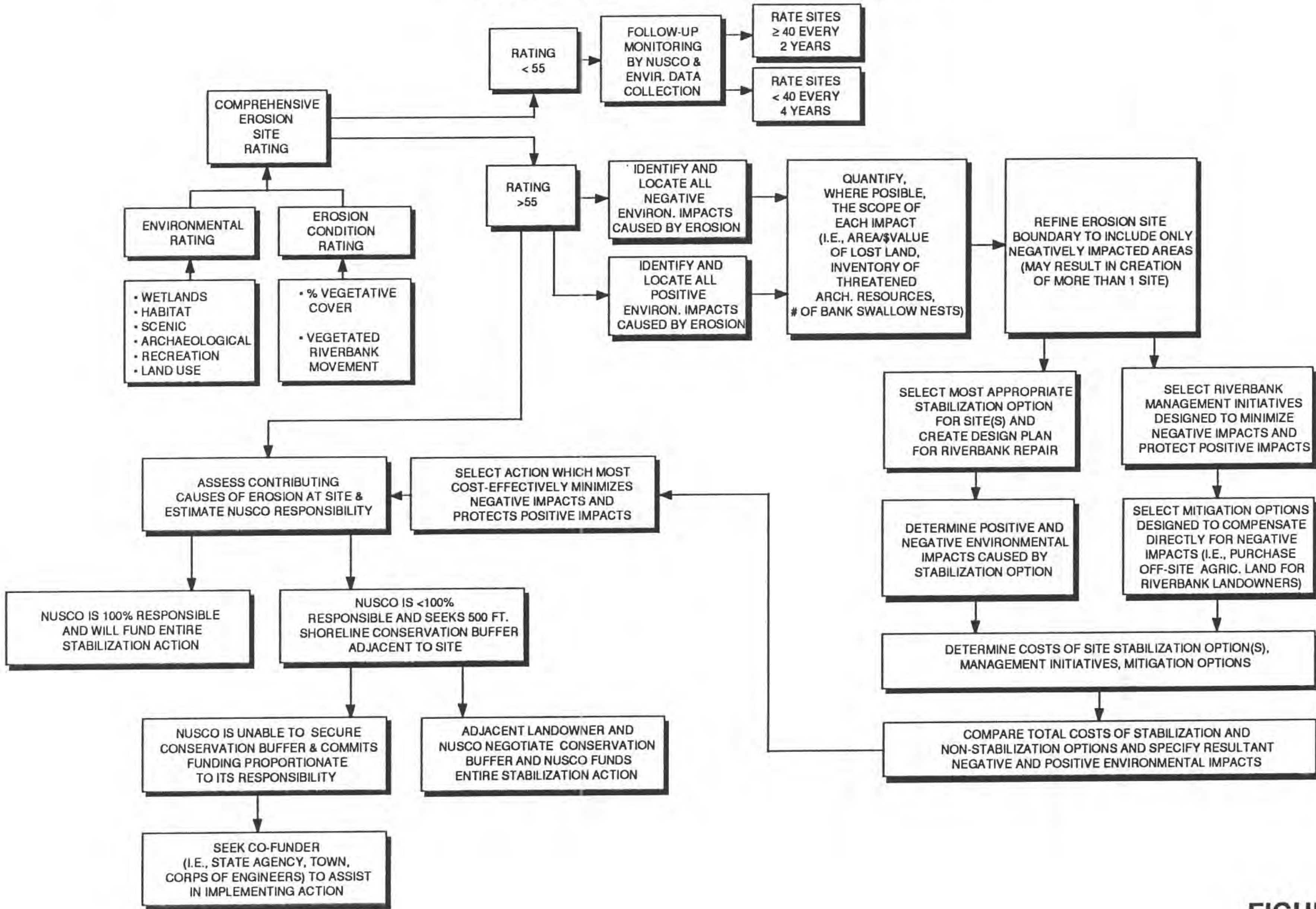


FIGURE I-3

years. Sites greater than or equal to 40 will be reevaluated and rated every two years. Sites rated over 55 will qualify as a "candidate" for stabilization. Once a detailed site analysis is performed concerning the nature and location of threatened environmental resources, appropriate bank stabilization options will be developed for candidate sites and cost estimates will be generated. Non-structural, site-specific riverbank management concepts will also be investigated. Where possible, mitigation (i.e., off-site donation of agricultural land to an affected landowner) will also be evaluated. A cost comparison will be performed to determine which type of initiative will most prudently and effectively protect the environmental resources identified.

Based on a determination of erosion causes, a decision will be made regarding responsibility for funding the remedial action needed to protect any environmental resources impacted by erosion. NUSCO will fund the entire stabilization effort if it is considered 100% responsible for the erosion, or if a 500 foot shoreline conservation buffer can be established adjacent to a repair site. The buffer zone establishment will be dependent upon cooperation with adjacent landowners and is designed to prohibit future development, and thus provide long-term protection for the environmental resources that NUSCO is committing to protect through a given stabilization effort. If a 500 foot buffer can not be established, NUSCO will seek co-funding to assist in any stabilization efforts.

2. ENACT AN EROSION SITE MONITORING PROGRAM UTILIZING THE EVALUATION AND RATING METHOD DEVELOPED IN THE MASTER PLAN.

Through an erosion site monitoring program, NUSCO intends to periodically reevaluate both the erosion conditions and associated environmental resource values at erosion sites. As described above, the frequency of monitoring will be based on the rating score assigned to a given site in this Master Plan. All 76 sites will be investigated and rated again in 1994 and every following four years. Erosion sites with a rating of 40 or above will be rated again in two years and will continue to be rated every two years as long as the value remains above 40.

The rating method will be that which was developed through the master planning process. In this way, a common basis of evaluation will be used in future years and comparisons of conditions over time will be meaningful. Data used for site ratings will be similar to that used in 1990. Site visits, photographs, videotape, riverbank surveys and the analysis of new aerial photos will be utilized. This information will also fortify the baseline knowledge available to continue assessing the probable causes of erosion within the Turners Falls Pool.

3. IMPLEMENT A BANK STABILIZATION DEMONSTRATION PROJECT AT SITE 60 TO TEST BIOENGINEERING SOLUTIONS AND SELECT STABILIZATION ACTION FOR IMPLEMENTATION AT SITE 60.

In order to determine what type of biotechnical bank stabilization is best suited for the riverbank conditions encountered within the Turners Falls Pool, NUSCO proposes to install a demonstration stabilization project at Site 60, opposite Kidds Island, downstream of Otter Run Brook. This site was chosen since it exhibits the most severe erosion condition identified within the study area and possesses important environmental resources that are currently impacted. Since it received a comprehensive rating of 61, Site 60 qualifies as a stabilization candidate and is scheduled for full stabilization in 1993-1994, based upon the outcome of the demonstration project.

This demonstration project is explained in detail in Section VII of the Master Plan and will involve three different stabilization options over a 180 foot stretch of the river. Option 1 consists of a combination of vegetation and rock-filled timber cribbing. Option 2 consists of a combination of vegetation and a rock-filled coconut-fiber mattress. Option 3 consists of a geotextile slope reinforcement method combined with vegetative treatment. For each option, vegetation will be introduced on the upper portion of the bank and the rock-filled crib, mattress or geotextile fabric will be installed in and just above the zone of fluctuation at the riverbank. In Section VII, construction activities have been detailed and probable environmental impacts are also described.

ND&T believes that it is essential to implement a demonstration project in the Turners Falls Pool prior to implementing any biotechnical stabilization techniques. This will attempt to show that these methods, which have not been tested on large rivers, are viable prior to using them in the future in the Turners Falls Pool and particularly at Site 60. The project can also be used to demonstrate the degree of disturbance which occurs during installation of the bank stabilization work and the effort needed to protect existing environmental resources during construction. This approach serves to minimize construction costs and related construction impacts. These methods are being tested as alternatives to conventional structural methods of repair and must prove their integrity before they can be a reasonable alternative for Connecticut River riverbank stabilization. If they prove successful upon follow up monitoring, these solutions will allow future bank stabilization to occur in a manner which emphasizes environmental resource compatibility while displaying the ability to prevent erosion. The demonstration project will also allow a clear understanding to be developed regarding the capital and maintenance costs associated with bank repair.

4. NUSCO WILL SPONSOR A BOATER AWARENESS PROGRAM

Although present findings do not warrant restrictions on the growing number of boaters using the Turners Falls Pool, boat waves are considered a secondary factor in exacerbating lower bank erosion in highly erodable soils. As such, NUSCO advocates sponsoring an awareness program featuring discussion sessions with boaters, local officials and State resource management agencies, and will also sponsor the dissemination of information to boaters regarding boating activity and erosion.

E. Master Plan Implementation Schedule

Figure I-4 provides a schedule through 1996 showing how NUSCO will implement the recommendations put forward in the Master Plan. The schedule includes each of the four primary recommendations mentioned above, and also includes plans for future stabilization efforts, subject to the results of the demonstration project and follow-up monitoring of erosion sites. A comprehensive Master Plan progress report, including revised recommendations, is scheduled for submission to FERC by the end of 1996.

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN
MASTER PLAN IMPLEMENTATION SCHEDULE 1991-1996

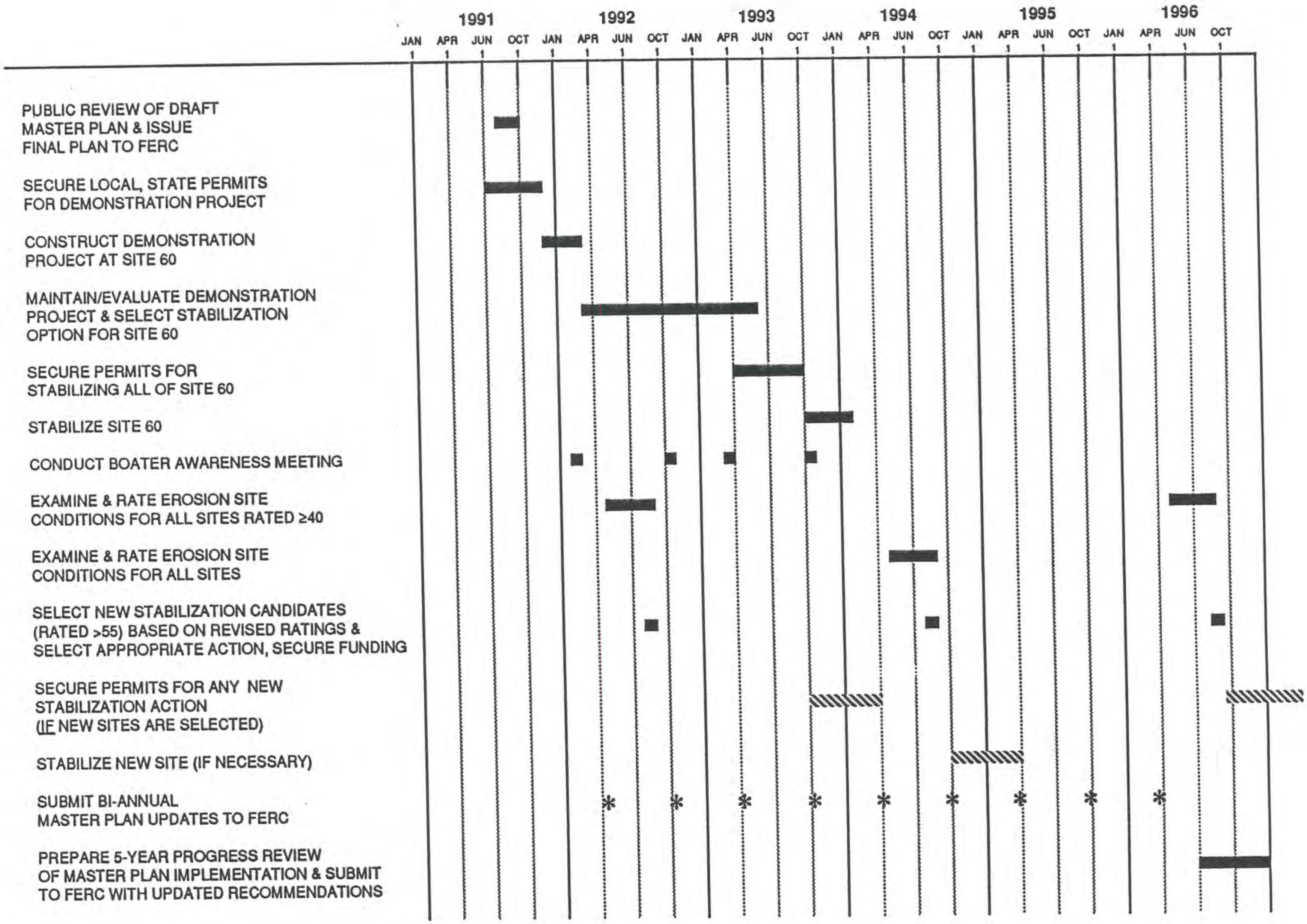


FIGURE I-4

II. INTRODUCTION

A. Purpose and Need

The Connecticut River Riverbank Management Master Plan was prepared by ND&T of Portland, Maine for NUSCO, headquartered in Berlin, Connecticut. NUSCO owns and operates the Turners Falls Hydroelectric Project (FERC Project No. 1889) and the Northfield Mountain Pumped Storage Project (FERC Project No. 2485), both of which are located in the Turners Falls Pool of the Connecticut River. The Master Plan is being submitted to the Federal Energy Regulatory Commission (FERC).

The Turners Falls Project is a conventional hydroelectric facility dating back to 1867. Its most recent reconstruction occurred in 1970 when the dam was raised approximately 6 ft to an elevation of 185.5 ft in conjunction with the construction of the Northfield Mountain Pumped Storage Project. The Northfield Mountain Project involves the pumping of Connecticut River water up to the Northfield Mountain Reservoir (upper reservoir) during periods of low electrical demand where it is then released during periods of high demand to generate power on its way back to Turners Falls impoundment (lower reservoir). The Northfield Mountain Project is a 1,080 megawatt facility which began commercial operation in 1972. The Master Plan study area consists of the 22-mile reach of the Connecticut River referred to as the Turners Falls Pool reaching between Vernon Dam and Turners Falls Dam and bordering land in Erving, Montague, Gill and Northfield, Massachusetts, as well as Vernon, Vermont and Hinsdale, New Hampshire.

The Master Plan was conceived by NUSCO as a means of investigating riverbank erosion and its associated impact upon important environmental resources occurring in the Turners Falls Pool. Its contents are the product of extensive input and feedback from local citizens and numerous local, state and federal agency representatives. Local concern had been expressed that the operation of the Northfield Mountain Pumped Storage facility and the fluctuating river elevations that result from the daily pump/discharge cycles used to generate electricity may be accelerating riverbank erosion in some areas within the Turners Falls Pool. Erosion has also been variously attributed to natural river meandering, seasonal spring high flows, increased surface runoff, wave action caused by boaters, and other factors.

In response to the allegation that the operation of Northfield may be a significant contributor to the cause of riverbank erosion, and in compliance with its FERC license obligation to minimize riverbank erosion, NUSCO developed a comprehensive plan to study the erosion conditions within the Turners Falls Pool and recommend a riverbank stabilization and management strategy for future implementation. NUSCO developed an outline for its Master Plan and circulated an initial scoping document to approximately fifty government agencies and interested parties in September 1989. After incorporating comments submitted over the next two months, the revised scoping document was endorsed by FERC in its January 30, 1990 letter to NUSCO. The Study Area for the Master Plan was defined as the Turners Falls Pool.

The resultant plan was designed to comprehensively characterize hydraulic conditions within the river, inventory and describe existing erosion conditions along all riverbank areas, identify important environmental resources and land use values, and evaluate the success of previously employed riverbank stabilization methods. The Plan also analyzes the contributing causes of erosion within the study area, assesses the viability of alternative riverbank stabilization methods, identifies preferred stabilization methods for erosion sites which ranked highest in terms of erosion activity and environmental resource values. The plan concludes with a recommended implementation schedule and a framework for periodic review of the plan.

FERC has asked NUSCO to submit this draft plan for review by all interested parties. Copies have been made available in the town halls of each of the six previously mentioned riverbank communities. Copies have also been submitted to local government officials, state environmental agency representatives in Massachusetts, New Hampshire and Vermont and interested riverbank landowners. In addition to FERC, the US Soil Conservation Service and the US Army Corps of Engineers have also received copies for review and comment.

The Master Plan has also been filed as an Environmental Impact Report directly with the Massachusetts Environmental Protection Act (MEPA) Unit of the state's Executive Office of Environmental Affairs. The MEPA unit serves as a clearinghouse to coordinate the environmental review of projects that may potentially alter the existing environment. The MEPA Unit requested that NUSCO file its plan as an EIR so that it could comprehensively assess the impacts associated with any proposed stabilization work and evaluate the method used to select candidates for riverbank stabilization. This submission to MEPA was not required by FERC, but serves to provide a comprehensive consultation process with state resource agencies. It also benefits both the states and NUSCO by combining a proposed series of riverbank management recommendations into one comprehensive document.

Once the Master Plan consultation process is completed and both MEPA and FERC authorize the contents of the plan, NUSCO will coordinate the implementation of the plan. FERC has requested that NUSCO submit bi-annual updates regarding the status of the plan's implementation and make these updates available to interested parties for review. Each subsequent riverbank stabilization project will be subject to the permitting requirements established by the respective state and town where the project resides. A Federal permit from the U.S. Army Corps of Engineers is also required for dredging or filling at each site.

B. Master Plan Objective and Scope

The primary objectives of the Master Plan are to comprehensively inventory and investigate riverbank conditions within the Turners Falls Pool, assess the magnitude and environmental consequences of significant riverbank erosion, evaluate the potential causes of erosion, identify suitable stabilization options, and formulate an action plan which will implement the findings of the Plan. The primary focus was the identification and protection of important environmental resources within and adjacent to the riverbanks that were being threatened by erosion. A major emphasis has been placed on evaluating each erosion site in relation to both the positive and negative impacts to existing environmental resources.

The Connecticut River along the Turners Falls Pool is a unique resource. It is the largest river in New England and flows through what is primarily a rural, agricultural area. This reach of the Connecticut River is host to a wide variety of uses and resources.

NUSCO understands that the development and implementation of its Master Plan depends on cooperation and input from a diverse group of individuals and organizations, each of which utilizes the Connecticut River for specific purposes. Consequently, another key objective that NUSCO has strived to meet throughout the creation of this Master Plan is to regularly coordinate its activities with the local, state and federal parties interested in the Turners Falls Pool area. Through public meetings and regular project workshop meetings, NUSCO has sought to inform concerned parties of its approach, investigations, and findings, and create a productive atmosphere where important information is shared between users of the river.

Prior to the initiation of the Master Plan, three public workshop meetings were held between August 10, 1989 and September 24, 1989 in order to discuss and debate the scope and content of the Master Plan. Monthly workshop meetings have been held since March, 1990 in order to provide updates on NUSCO's progress in uncovering and generating data and in formulating methods of analysis during the Master Plan's creation. The workshop group consists of representatives from NUSCO, ND&T, assorted state environmental agencies, the Franklin County Planning Commission, conservation commissions from each riverbank community and riverbank landowners. A list of workshop group members is provided in Table II-1. Table II-2 summarizes the workshop meetings. The scope of the Master Plan has consequently incorporated the comments and concerns raised at these meetings. In addition, public meetings were held on January 15, 1990, February 22, 1990 and May 24, 1990. A public meeting will also be held in conjunction with the release of this report.

The scope of the Master Plan, as agreed upon in January, 1990, included the following eight components:

1. <u>Scoping</u>: Initial formulation of the Master Plans's purpose and anticipated outline. Also, the establishment of a mechanism for public input.

2. <u>Inventory</u>: Review all existing data regarding physical, environmental and engineering data associated with the project area. Also, conduct additional field work as needed to provide important missing data and update previously recorded information.

TABLE II-1

Connecticut River Riverbank
Stabilization and Management Master Plan

Workshop Member List

Name	Affiliation
Chuck Momnie	Northeast Utilities
John Howard	Northeast Utilities
John Devine	Northrop, Devine & Tarbell, Inc.
Rob Mitchell	Northrop, Devine & Tarbell, Inc.
Tony Matthews	Gill Conservation Commission
Norman Emond	Erving Conservation Commission
Bill Llewelyn	Northfield Conservation Commission
Henry Waidlich	Montague Conservation Commission
John Bennett	Montague Town Planner
Lynn Rubenstein	Franklin County Planning Commission
Dick Holbrook	Riverbank landowner - Hinsdale, NH
Terry Blunt	Massachusetts Dept. of Environmental Management = Conn. River Action Program
Ralph Taylor	Massachusetts Division of Fisheries & Wildlife: District Manager
Gene L'Etoile	Riverbank landowner - Northfield, MA

TABLE II-2

SUMMARY OF CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN WORKSHOP MEETINGS

Workshop Meeting	Date
Workshop 1: Project Description and Project Site Orientation (Guest Speaker - Bob Bellows, Operations Supervisor for Northfield Mtn. Facility)	March 22, 1990
Workshop 2: Power Plant Field Trip, Geology/Soils Discussion and Presentation (Guest Speaker - Dr. John Reid, Ph.D. - Geology, Hampshire College)	April 19, 1990
Workshop 3: Environmental Data Collection Review, Archaeology Presentation (Guest Speaker - Dr. Mitch Mulholland, Ph.D. - Archaeology, U. Mass.)	May 17, 1990
Workshop 4: Discuss Erosion Site Identification and Assessment Method	June 20, 1990
Workshop 5: Riverboat Field Trip and Erosion Site Rating Method Review	July 25, 1990
Workshop 6: Detailed Environmental Resource Rating Method Review	August 29, 1990
Workshop 7: Erosion Site Stabilization Methods Review (Guest Speaker - Dr. Donald Gray, Ph.D. - Civil Engineering, U. Michigan)	October 11, 1990
Workshop 8: Present overview of preliminary findings - erosion site rating and environmental resource descriptions and comprehensive site ranking	December 12, 1990
Workshop 9: Present proposed Master Plan recommendations	February 13, 1991
Workshop 10: Workshop member comments on Draft Master Plan (Invited Guest - Mr. Julian Flint, FERC)	May 16, 1991

3. Options: Research engineering solutions designed to adequately stabilize riverbanks and explore land management options designed to reduce riverbank erosion.

4. Assessment: Analyze the available resource and engineering data to assess the existing state of erosion along the riverbank and characterize the related environmental resources.

5. Plan Formulation: Based on the previous steps, formulate a Draft Master Plan which recommends actions which will meet the plan's objectives. The plan will be publicly presented and a 60-day public/agency review period will take place.

6. Final Plan: Incorporate review comments and produce a Final Master Plan for distribution.

7. Concurrence: The last step is to seek concurrence from all interested participants in the master planning process and to establish the framework for the Master Plan's implementation.

8. Updates: Bi-annual updates will be provided to FERC and all interested parties.

In addition to the components of this initial scope, NUSCO has assumed the lead role in analyzing the possible causes of erosion within the Turners Falls Pool. Concurrent with the formulation of the Master Plan's initial scope in late 1989, NUSCO and other interested parties worked with US Representative Silvio Conte to secure federal funding for the US Army Corps of Engineers to investigate erosion in the Turners Falls Pool. NUSCO desired that the Corps study the causes of erosion between the Vernon Dam and Turners Falls Dam, as a follow up to the

Corps' 1979 report on Connecticut River erosion. However, the Corps chose not to investigate the issue of erosional causes and instead plans on characterizing the present state of erosion along the riverbanks. Since FERC has requested that the causes of erosion be studied in conjunction with the Master Plan, NUSCO chose to add this project component to the scope of the Master Plan in May, 1990. The Master Plan reflects this addition as evidenced in Section VI.

C. Baseline Data Collection

As outlined in the above-stated scope, NUSCO began its master planning effort by inventorying all available data concerning the physical and environmental features of the Turners Falls Pool. ND&T contacted the following parties to gather data on the project area:

Local:

1. NUSCO
2. Riverbank landowners or landowners adjacent to NUSCO riverbank property.
3. Town governments in Vernon, VT, Hinsdale, NH, Gill, MA, Northfield, MA, Montague, MA, Erving, MA.
4. Franklin County Planning Commission
5. University of Massachusetts, Dept. of Archaeology - Amherst, MA
6. Hampshire College, Dept. of Geology - Amherst, MA

State:

1. Massachusetts State House
2. Massachusetts Executive Office of Environmental Affairs
   - Mass. Environmental Protection Act Unit (MEPA)
3. Massachusetts Department of Environmental Protection (DEP) - Division of Water Pollution Control

4. Massachusetts Department of Environmental Management (DEM) - Division of Water Resources
   - Division of Waterways
   - Division of Land Planning
   - Connecticut River Valley Action Program
5. Massachusetts Department of Food & Agriculture (DFA)
6. Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement (DFWELE)
   - Division of Fisheries and Wildlife
7. Vermont Agency of Natural Resources
   - Department of Fish and Wildlife
   - Department of Environmental Conservation
8. New Hampshire Department of Resources and Economic Development
   - Fish and Game Department

Federal:

1. US Environmental Protection Agency (EPA)
2. US Geological Survey (USGS)
3. US Fish and Wildlife Service (USFWS)
4. Federal Emergency Management Agency (FEMA)
5. US Department of Agriculture (USDA)
   - Soil Conservation Service (SCS)
   - Division of Aerial Photo Services
6. US Army Corps of Engineers
7. Federal Energy Regulatory Commission (FERC)

After collecting relevant baseline data and information from previous engineering and scientific studies conducted within the study area, ND&T worked with NUSCO to identify gaps in the existing data. A field work plan was then created which was designed to fill these data gaps and strengthen the baseline information available to assess the Turners Falls Pool's existing riverbank conditions.

Field work conducted between February and October of 1990 included data collection in the following areas:

1. Hydraulic/Geotechnical Data

a. Ten complete river cross-section surveys and numerous bank measurements taken at various locations to profile riverbank and determine river section parameters.

b. Nine staff gages installed near cross-section locations. River elevations were recorded over two separate weekly periods to determine river elevation fluctuations and relate elevations and fluctuations to elevations recorded at the Northfield tailrace.

c. Soil borings were conducted at 12 locations and shallow-depth soil samples were taken at 31 additional locations. Follow up laboratory analysis were also conducted.

2. Erosion Site Classification

a. All 44-miles of riverbank were comprehensively reviewed by boat and on foot between February and August, 1990. Riverbank characteristics were photographed, videotaped and field mapped in order to determine erosional severity, soil and vegetation characteristics, and bank geometry.

b. Previously repaired erosion areas were reviewed in order to determine how successful these stabilization methods were.

3. Environmental Data

a. Field review of severe, moderate-to-severe, and moderate erosion areas and adjacent upland bank areas in order to inventory unique plant and wildlife habitat resources.

b. Field level classification of scenic viewsheds within the Turners Falls Pool, photo documentation of river views from all public access points along riverbanks and determination of erosion sites within view of identified viewpoints.

c. Record recreational activity within project area during four separate weekend or holiday periods and analyze boat wave impacts at predetermined erosion sites.

d. Field walkover of riverbank areas with above average probability of containing archaeological resources.

e. Confirmation of land uses and determination of impact of various land uses on bank conditions.

The data collected during these field visits was reviewed and integrated with existing engineering and environmental data to form the basis for the analysis phase of the Master Plan. The compiled data was then transferred from field notes and reports into a computerized geographic information system (GIS). Using the ArcInfo software package, all reliable geographic data was digitized into the computer as a series of data coverages. Associated statistical attributes related to each data coverage were also entered into the computer, thus allowing the creation of both maps and statistical tables.

The data coverages entered into the GIS computer system are listed below:

1. Boundary of Turners Falls Pool study area
2. State and Town boundaries
3. NUSCO Project boundary (as dictated by FERC license)
4. Topographic contours
5. Surface waters
6. Roads and bridges
7. Railroads, utility lines
8. River cross-section and staff gage locations
9. Soils and data from 1990 soils tests
10 Wetlands
11. Unique plant and wildlife habitat
12. Vegetative cover
13. Recreational use sites
14. Scenic resource values and viewpoints
15. Archaeological sites and probability zones
16. Land Use type
17. Landowner boundaries
18. Existing erosion sites and characterization
19. Previously stabilized riverbank areas

ArcInfo was used to overlay these various coverages in order to compare and analyze resource features within the project area. This has allowed ND&T a great deal of flexibility in analyzing relationships between erosion site severity and assorted engineering and environmental data. The maps presented in this Master Plan have each been created by using ArcInfo in order to ensure accuracy and clarity.

Supplementing the ArcInfo data base has been the collection and analysis of both historic and current aerial photos, ground-level photos, river cross-sections and hydraulic data. NUSCO and ND&T have placed a major emphasis on compiling as comprehensive a collection of reliable data concerning the Turners Falls Pool as possible. The use of photo documentation and qualified surveyed data is meant to ensure the integrity of the findings presented in this plan. Of special importance has been the use of cross-section data from 1913, 1966, 1976 and 1990; and aerial photos from 1929, 1939, 1952, 1966, 1971, 1973, 1980 and 1990. This data has allowed comparisons of project conditions over time using the greatest degree of reliability possible.

D. Analytical Methods

In order to compare from a common baseline the physical and environmental resource values and erosion severity evident at sites within the Turners Falls Pool, ND&T developed a comprehensive rating system designed to allow the ranking of identified sites. The system consists of two overall categories - classification of erosion severity and categorization and evaluation of environmental resource value. The boundaries of individual erosion sites were field delineated based on continuity of site conditions.

The classification of erosion condition relied on evaluating two factors - the percentage of exposed or unvegetated soil evident within a given site, and the percentage of remaining vegetated bank which showed signs of bank movement or erosional activity (i.e., tension cracks, sloughed vegetation, etc.). The total numerical value assigned to each site for classification of the erosion condition results in a site characterization ranging from none-to-low erosion to severe erosion.

The environmental resource valuation system considered six factors - wetlands, scenic resources, unique plant or wildlife habitat, recreational value, archaeological/historical value and land use adjacent to the riverbank. Figures II-1 and II-2

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

EXISTING EROSION CONDITIONS RATING SYSTEM

RANKING VALUE	PERCENT SOIL EXPOSURE	RANKING VALUE	LEVEL OF ACTIVITY/MOVEMENT WITHIN VEGETATED BANK
10	FROM 0 TO 10%	5	FROM 0 TO 10%
20	FROM 10 TO 25%	10	FROM 10 TO 25%
30	FROM 25 TO 50%	15	FROM 25 TO 50%
40	FROM 50 TO 75%	20	FROM 50 TO 75%
50	FROM 75 TO 100%	25	FROM 75 TO 100%

COMPOSITE VALUE	EROSION SITE CHARACTERIZATION
15	NONE TO LOW
20/25	LOW TO MODERATE
30/35	MODERATE
40/45	MODERATE TO SEVERE
>50	SEVERE

FIGURE II-1

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

ENVIRONMENTAL RESOURCE VALUE RATING SYSTEM FOR EROSION SITES
(All variables rated from 0 to 100%)

WETLANDS - 15%

- WETLAND SITE IDENTIFICATION/PROXIMITY 100%

SCENIC/VISUAL - 15%

- WITHIN SIGHT OF RESIDENCE/VIEWPOINT 50%
- LANDSCAPE CHARACTER 25%
- DOMINANCE OF EROSION SITE 25%

HABITAT VALUE - 15%

- RIVERINE HABITAT 25%
- UPLAND HABITAT 25%
- BIRDS/WATERFOWL HABITAT 25%
- PLANTS/FLORA 25%

RECREATION - 15%

- RIVERBANK RECREATION SITE 100%

ARCHAEOLOGICAL/HISTORICAL - 15%

- DOCUMENTED PRESENCE OF RESOURCES OR PROBABILITY OF FINDING RESOURCES 100%

LAND USE - 25%*

- AGRICULTURAL
- RESIDENTIAL
- COMMERCIAL/ INDUSTRIAL
- UNDEVELOPED LAND
- UTILITY, ROAD, RR

*IF ONE LAND USE, MULTIPLY RATING BY 1.0
IF TWO LAND USES, MULTIPLY TOTAL FIGURE BY 0.6
IF THREE LAND USES, MULTIPLY TOTAL FIGURE BY 0.5
IF FOUR LAND USES, MULTIPLY TOTAL FIGURE BY 0.4

FIGURE II-2

highlight the components of the rating system and include the numerical range used for rating these factors and the weighting values assigned within each category. Further explanations of these methods and the resultant ratings are described later in this report and in Appendices I and J.

The site ratings for erosion severity and environmental resource value were combined to yield a comprehensive erosion site ranking. This ranking was intended to indicate priority of consideration when addressing the need for bank stabilization. The rating numbers will also provide a common baseline for comparison to future ratings conducted during follow-up monitoring.

In concert with this method to developing a comprehensive rating, ND&T identified and analyzed the probable causes of erosion within the study area. The analysis of cause was combined with the site ranking to trigger the development of cost estimates for stabilization leading to a final implementation plan. This overall method of analysis is designed to consider all pertinent variables necessary to formulate a comprehensive set of recommendations. Analyses of cause included quantitative analysis of tractive forces, wave forces, river meandering, photo analysis, and bank movement.

The rating system as it appears in this report is the result of review and discussion from portions of three workshop meetings. In June, 1990 the framework for the rating scheme was presented to the workshop group and the factors to be rated were agreed to. In July a detailed rating method was presented to the workshop members which included all variables and numerical values to be assigned to the rating factors. In August an entire workshop meeting was held to systematically review and refine the environmental resource value rating system. ND&T felt it important to present and debate the rating method being used in the Master Plan and incorporate the comments and suggestions of participating local and state officials and landowners. This component of the master planning process represents a coordinated effort at striving to fairly assess what is deemed important to both the residents and local users of the river as well as agencies responsible for regulating resources within the river.

This system allows the ranking of erosion sites to occur comprehensively or for individual erosion characteristics or resource values. For instance, all sites can be ranked separately for their unique habitat value and then compared to the overall rating for existing erosion condition. Or, all sites can be ranked in terms of the percentage of remaining vegetated bank which shows signs of bank movement and then cross-referenced with highly rated sites with soil types that are highly susceptible to erosion. The flexibility built into the system is designed to allow any combination of features to be compared and analyzed. Combined with the coverage overlay capability inherent in the GIS computer data management system, rating numbers assigned to each erosion site can be compared to any of the 19 informational layers added to the data base.

It is also important to remember that this document is a Master Plan and, therefore, was prepared in a format which easily allows for the updating of existing data and the addition of new data as it becomes available. The GIS data base is tailor-made to suit this objective. The rating method, likewise, was designed to create a consistent and comprehensive method for future periodic ratings to be compared with the initial ratings provided in this report. The success or failure of riverbank management initiatives implemented through this report can be consistently tracked using this rating method.

III. DESCRIPTION OF STUDY AREA AND PHYSICAL RESOURCES

The Connecticut River gently meanders through a rural, country setting along the Turners Falls Pool. This section of the largest river in New England, remains unique in that its banks largely remain in agricultural use. However, like all the major rivers in the region, the Connecticut is a working river as well and is subject to ever-increasing demands by the people in the area. The important resources of the river are summarized below. To allow for easier reading, all tables, photo panels and maps will be arranged after the narrative descriptions in each of the following subsections.

A. Description of Hydroelectric Facilities

The Study Area includes two interrelated FERC-licensed Projects owned and operated by NUSCO. The Turners Falls Hydroelectric Project (FERC Project No.1889) consists of the Turners Falls Dam and the associated hydroelectric facilities at Cabot Station and Turners Falls Station. The Northfield Mountain Pumped Storage Hydroelectric Project (FERC Project No. 2485) consists of the Northfield Mountain Reservoir (upper reservoir), an underground 1,080 megawatt hydroelectric power generating station and the Turners Falls Pool (lower reservoir). The Turners Falls Pool consists of the 22-mile Connecticut River impoundment between Turners Falls Dam and the Vernon Dam in Vernon, VT and Hinsdale, NH. The FERC Project boundary for the two combined projects consists of the Turners Falls Pool and its adjacent 50-year floodplain, as well as the utility company's hydroelectric physical plant. Maps III-1A and III-1B show this FERC Project boundary and also show NUSCO's property ownership in relation to the boundary. NUSCO ownership is referred to as Western Massachusetts Electric Company (WMEC) on the maps within the plan.

1. Turners Falls Dam

The Turners Falls Project is a conventional hydroelectric facility located in Turners Falls, Massachusetts. The present Turners Falls Dam consists of the Montague spillway and the Gill spillway. Both structures have a crest elevation of 185.5 ft and were most recently modified in 1970 when the dam was raised and new gates were installed. The Montague spillway contains bascule gates and the Gill spillway contains radial gates. Adjacent to the western side of the dam is a gatehouse leading to a power canal and a fish passage facility. Figure III-1 shows an illustration of the general arrangement of the dam and Map III-2 shows the Turners Falls Dam area.

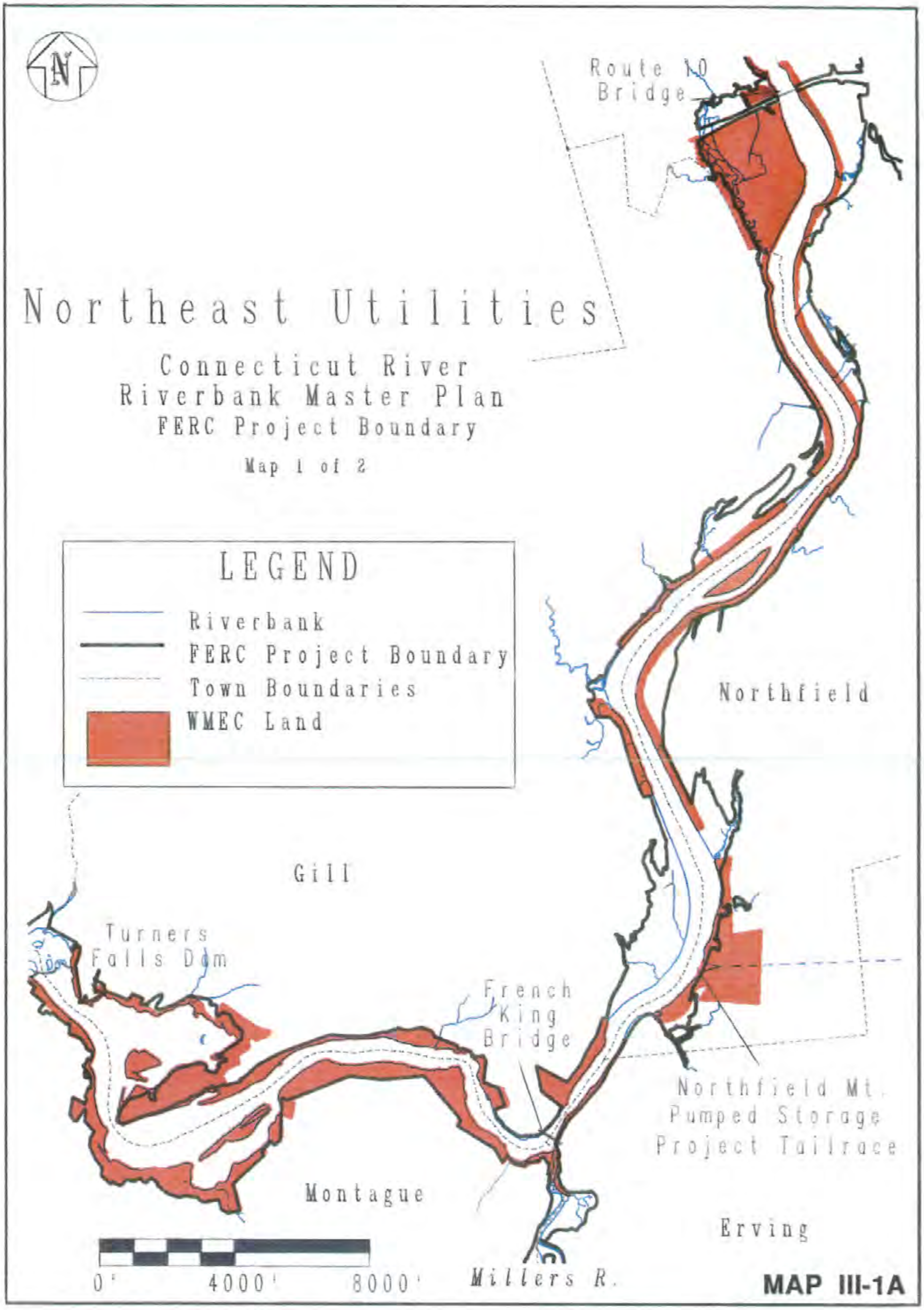
The history of the dam at Turners Falls is by and large integral with the history of the entire Turners Falls area. The original structure built at Turners Falls, then referred to as Great Falls, was a log crib diverting dam intended for public transportation purposes. The dam, built around 1800, extended halfway across the river and diverted water to a canal and a series of locks. As freight train transportation became more popular, use of the facility for transportation decreased. In 1866 Colonel Alvah Crocker planned the replacement of the existing facility with a water power facility.

The new facility was completed in 1867 and included a 1,200 ft. long, 35 ft. high stone filled timber crib, a cofferdam, a fishway, log sluice and a gatehouse for a power canal. The crest elevation of the dam was 169.26 ft. Immediately after the dam was complete the power canal was constructed. The canal was 600 ft. long, 50 ft. wide and ten ft. deep. Over the next thirty years, the powerhouses off the canal produced an aggregate of approximately 10,000 horsepower.

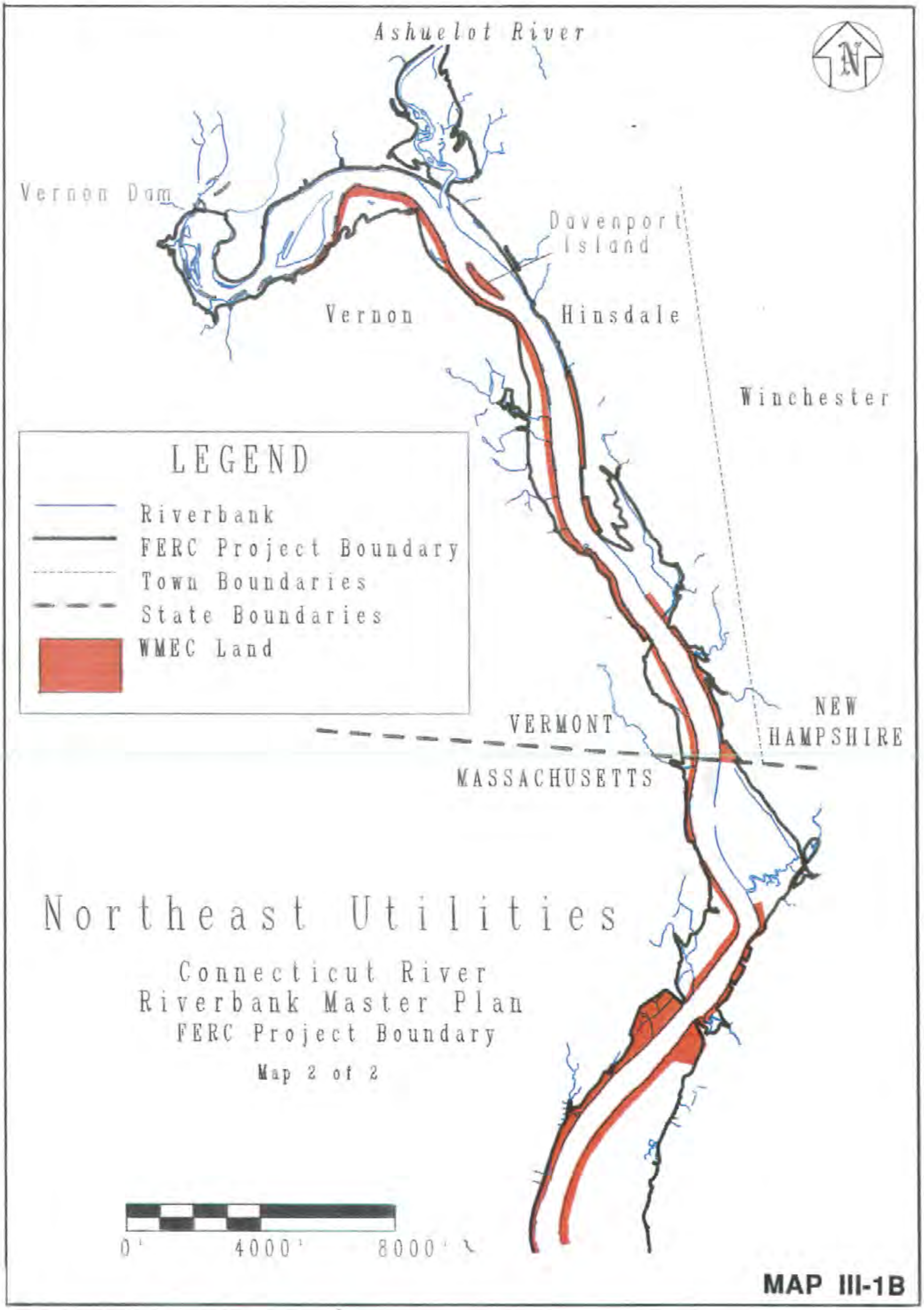
In the 1870's the canal was extended 1,500 ft. and in 1906 it was extended 1,000 ft. and widened to 125 ft. A power station with the generating capacity of 5,000 kW was also erected at the end of the canal. The power produced by the station was sold to the Connecticut River Transmission Company and the station went on line in 1907.

In 1912 construction commenced to replace the Montague portion of the old timber crib dam with a concrete dam with sluice gates. In 1914 the dam was raised three feet to an elevation of 172.26 ft. In 1915 the Gill Dam was completed, also utilizing sluice gates and built to an elevation of 172.26 ft.

Immediately after the completion of the Gill Dam, flashboards were installed on both dams. This increased the combined dam crest to 179.59 ft. During the construction of the dams, the power canal was extended approximately 1.75 miles and a new power station was constructed. The dam remained at this elevation until 1970 when the dam was raised to its current elevation. These 1970 modifications were performed to accommodate the design requirements of the new Northfield Mountain Pumped Storage Facility.



Route 10
Bridge
Northeast Utilities
Connecticut River
Riverbank Master Plan
FERC Project Boundary
Map 1 of 2
LEGEND
Riverbank
FERC Project Boundary
Town Boundaries
WMEC Land
Northfield
Gill
Turners
Falls Dam
French
King
Bridge
Northfield Mt.
Pumped Storage
Project Tailrace
Montague
Erving
0'
4000'
8000'
Millers R.
MAP III-1A


Ashuelot River
N
Vernon Dam
Davenport Island
Vernon
Hinsdale
Winchester
LEGEND
Riverbank
FERC Project Boundary
Town Boundaries
State Boundaries
WMEC Land
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
Northeast Utilities
Connecticut River
Riverbank Master Plan
FERC Project Boundary
Map 2 of 2
0'
4000'
8000'
MAP III-1B

NORTHROP, DEVINE & TARBELL, INC.

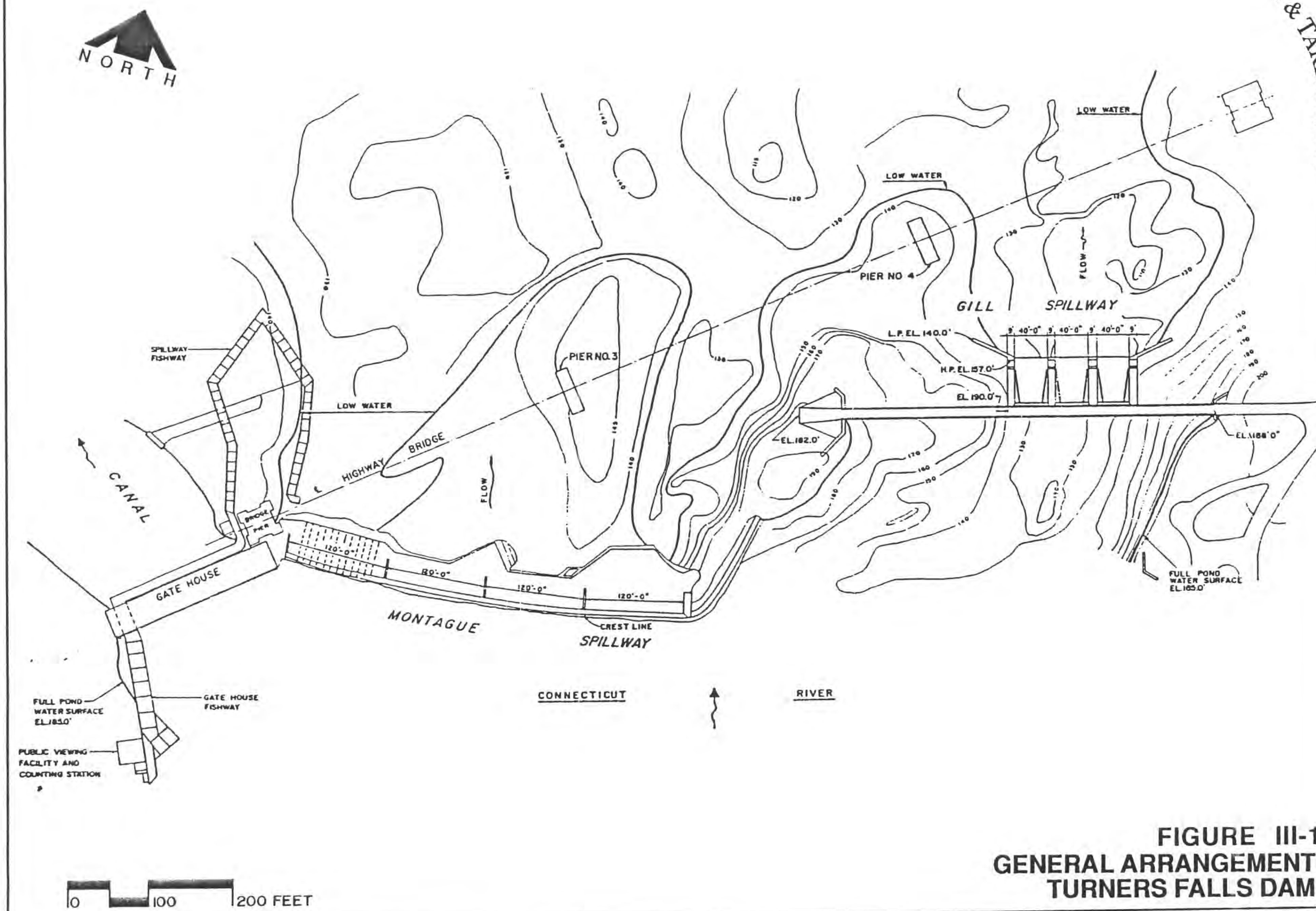
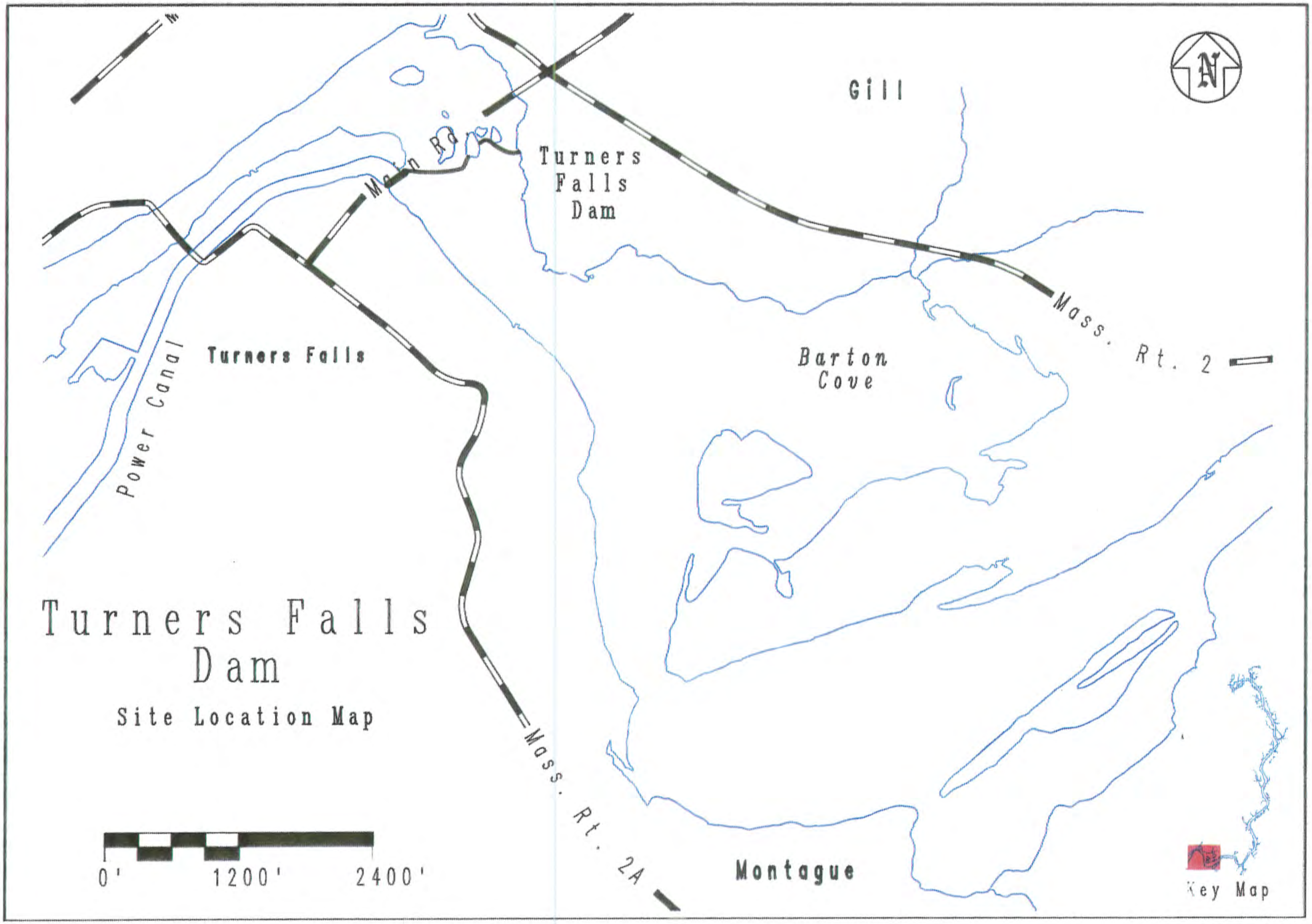


FIGURE III-1
GENERAL ARRANGEMENT
TURNERS FALLS DAM


Turners Falls Dam
Site Location Map
Gill
Turners Falls Dam
Main Rd
Mass. Rt. 2
Barton Cove
Turners Falls
Power Canal
Mass. Rt. 2A
Montague
0'
1200'
2400'
N
Key Map

MAP III-2

2. Northfield Mountain Pumped Storage Hydroelectric Project

The Northfield Mountain Pumped Storage Project was licensed for construction in May, 1968 and was brought on line in 1972. Figures III-2 and III-3 show the layout of the Project and its interconnection with the Turners Falls Pool. Photo Panel III-1 shows the Project tailrace location, where water enters and leaves the Connecticut River. The Project consists of an upper reservoir (Northfield Mountain Reservoir), a lower reservoir (Turners Falls Pool - the Connecticut River between Turners Falls Dam and Vernon Dam), a penstock and a generating/pumping facility. Map III-3 shows the location of these project features.

The basic operating principle of the Project is to provide electricity to the public during periods of peak electrical use. The Project operation consists of pumping water from the Turners Falls pool to the upper reservoir during periods of low electrical demand, then releasing this water for power generation back to the lower reservoir during peak demand periods. During hours of low, off-peak power use, the pumping facility moves water from the lower reservoir to the upper reservoir. In the case of the Northfield facility, this is usually between the hours of 12:00 am and 6:00 am. At the beginning of each work day, when the regional consumption of energy increases, water is released from the upper reservoir through the underground penstock to the pump/turbines which generate the electricity required to meet the energy demands of the public. Water flows from the turbines, through an underground tailrace canal and is released into the Connecticut River. The Northfield facility is operated on a weekly cycle under the premise that the upper reservoir will be at full capacity on Monday mornings.

During the week, the upper reservoir is continuously filled and depleted. However, the water level rarely reaches the level attained on Monday morning. This is due to the limit on the amount of time the Northfield facility has to pump storage water to the upper reservoir. By Friday, the upper reservoir level reaches its low point within the cycle. During the weekend, when energy consumption is reduced from its normal levels, the upper reservoir is replenished. By Monday morning, the upper reservoir is filled to capacity and is able to handle the drawdown from generation of electricity during the following week.

The operation of the Northfield Mountain Hydroelectric Project also influences the river elevation within the Turners Falls Pool. An explanation of this influence and its relative impact at various locations within the 22-mile reach of the lower reservoir is provided in Section III.B.3 of this Master Plan.

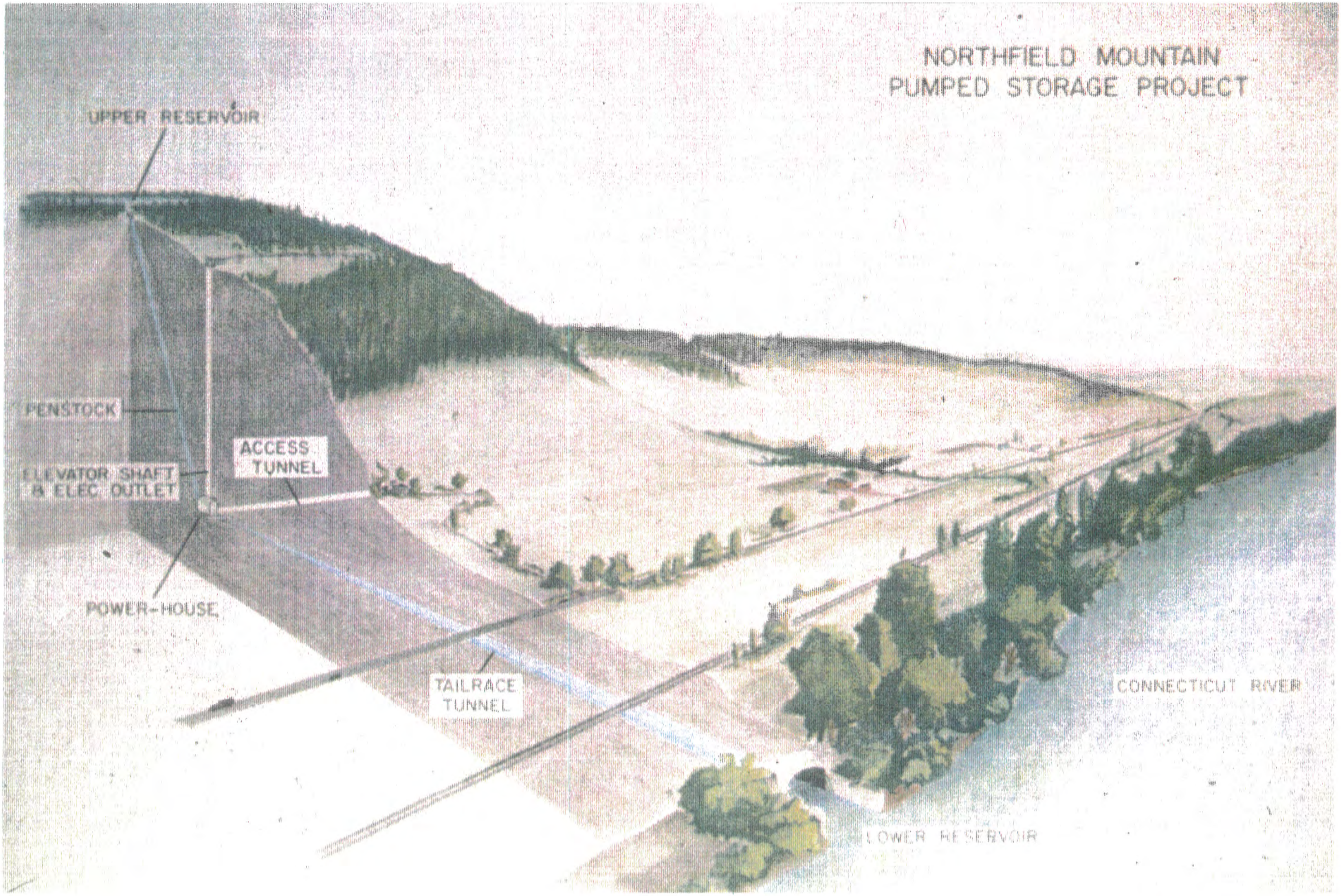

NORTHFIELD MOUNTAIN
PUMPED STORAGE PROJECT
UPPER RESERVOIR
PENSTOCK
ACCESS TUNNEL
ELEVATOR SHAFT & ELEC OUTLET
POWER-HOUSE
TAILRACE TUNNEL
CONNECTICUT RIVER
LOWER RESERVOIR

FIGURE III-2

NORTHROP, DEVINE & TARBELL, INC.

LEGEND

1. NORTHFIELD MOUNTAIN RESERVOIR (UPPER RESERVOIR - EL. 1004')
2. INTAKE CHANNEL
3. PRESSURE SHAFT
4. STEEL LINED PENSTOCKS (FOUR)
5. UNDERGROUND POWERHOUSE
6. GENERATOR/MOTORS (FOUR)
7. PUMP/TURBINES (FOUR) - EL. 72.0'
8. TAILRACE TUNNEL
9. TAILRACE CANAL
10. CONNECTICUT RIVER (LOWER RESERVOIR - EL. 180')
11. ACCESS TUNNEL
12. 345kV SUBSTATION
13. VENTILATION SHAFT
14. WATER SUPPLY DIVERSION INTAKE

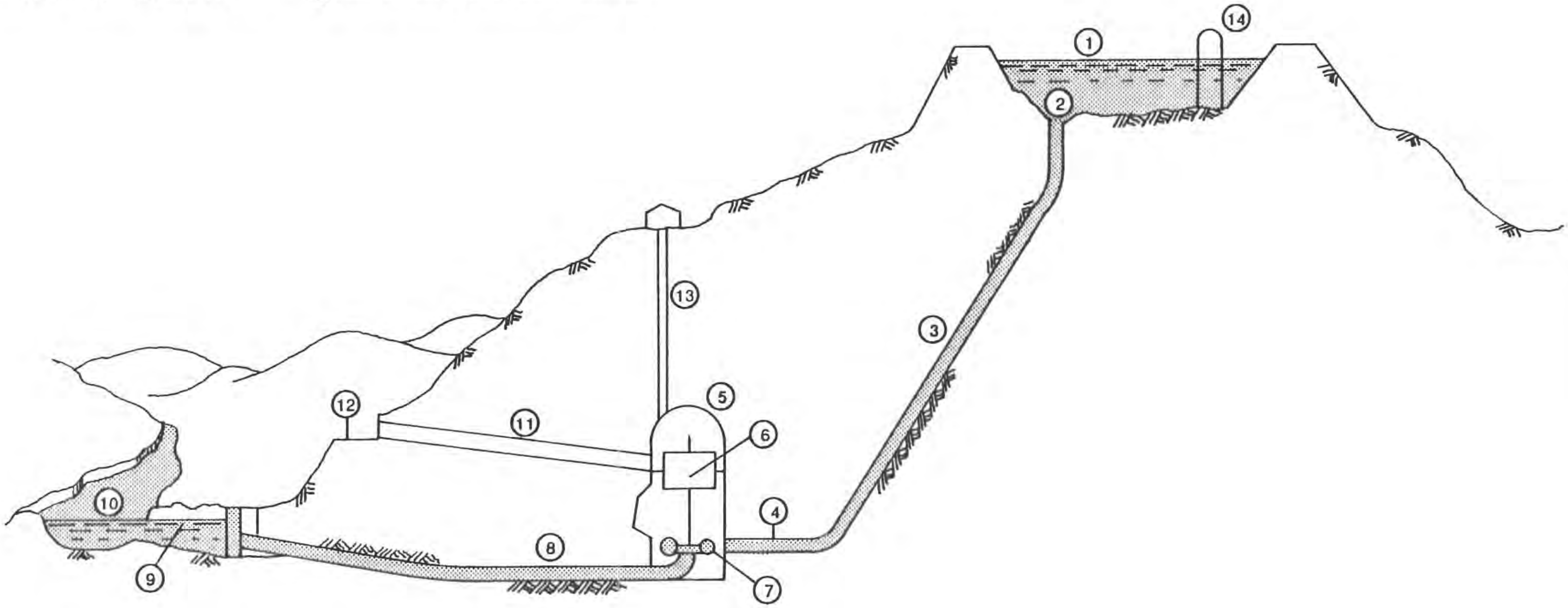
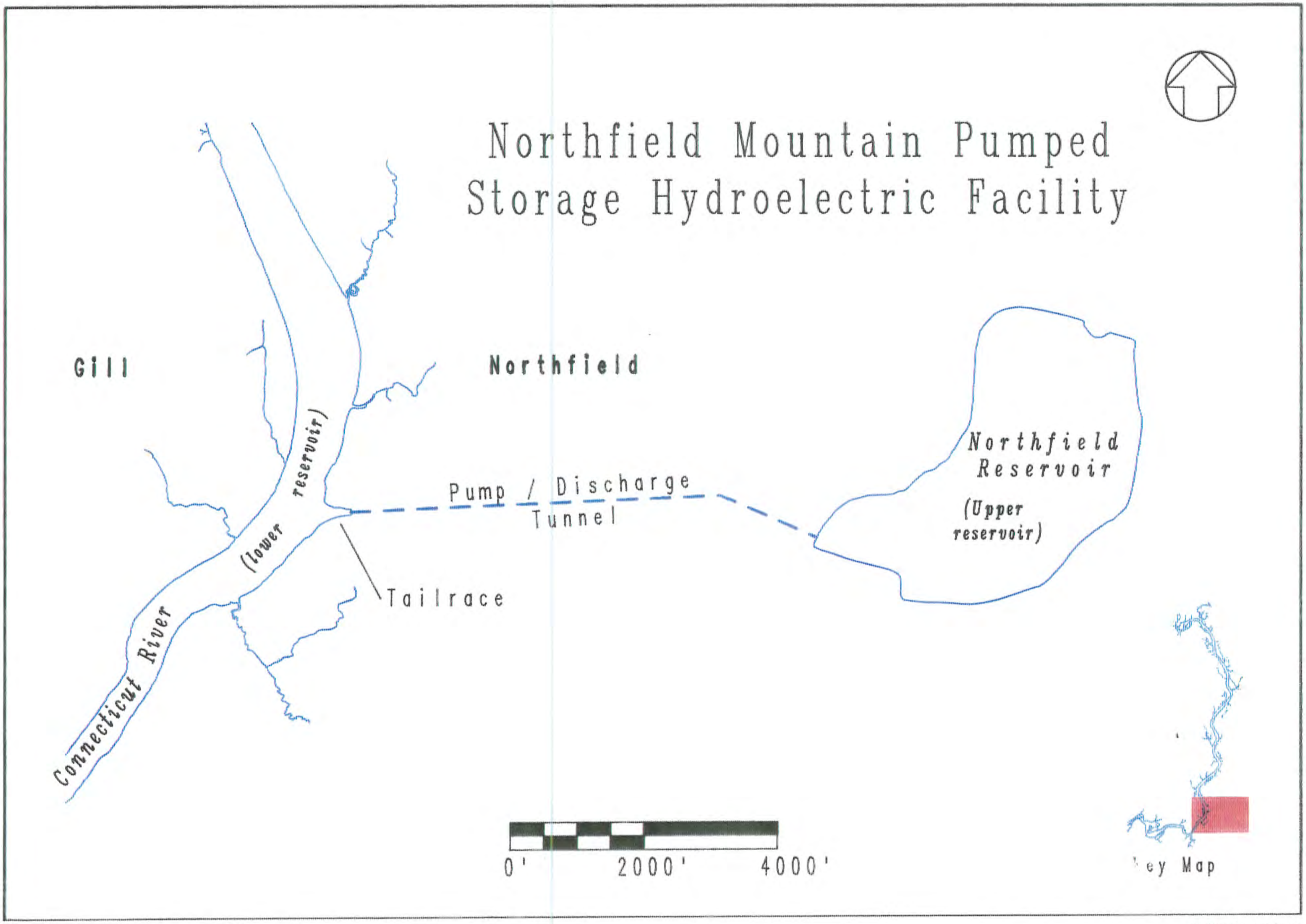


FIGURE III-3
CROSS SECTION
NORTHFIELD MOUNTAIN
PUMPED STORAGE PROJECT

Construction site of Northfield Mountain Pumped Storage Facility Tailrace - 1969.

Northfield Mountain Pumped Storage Facility Tailrace - 1981.

PHOTO PANEL III-1


Northfield Mountain Pumped
Storage Hydroelectric Facility
Gill
Northfield
(lower
reservoir)
Connecticut River
Pump / Discharge
Tunnel
Tailrace
Northfield
Reservoir
(Upper
reservoir)
0'
2000'
4000'
Key Map

MAP III-3

D. General Study Area Setting

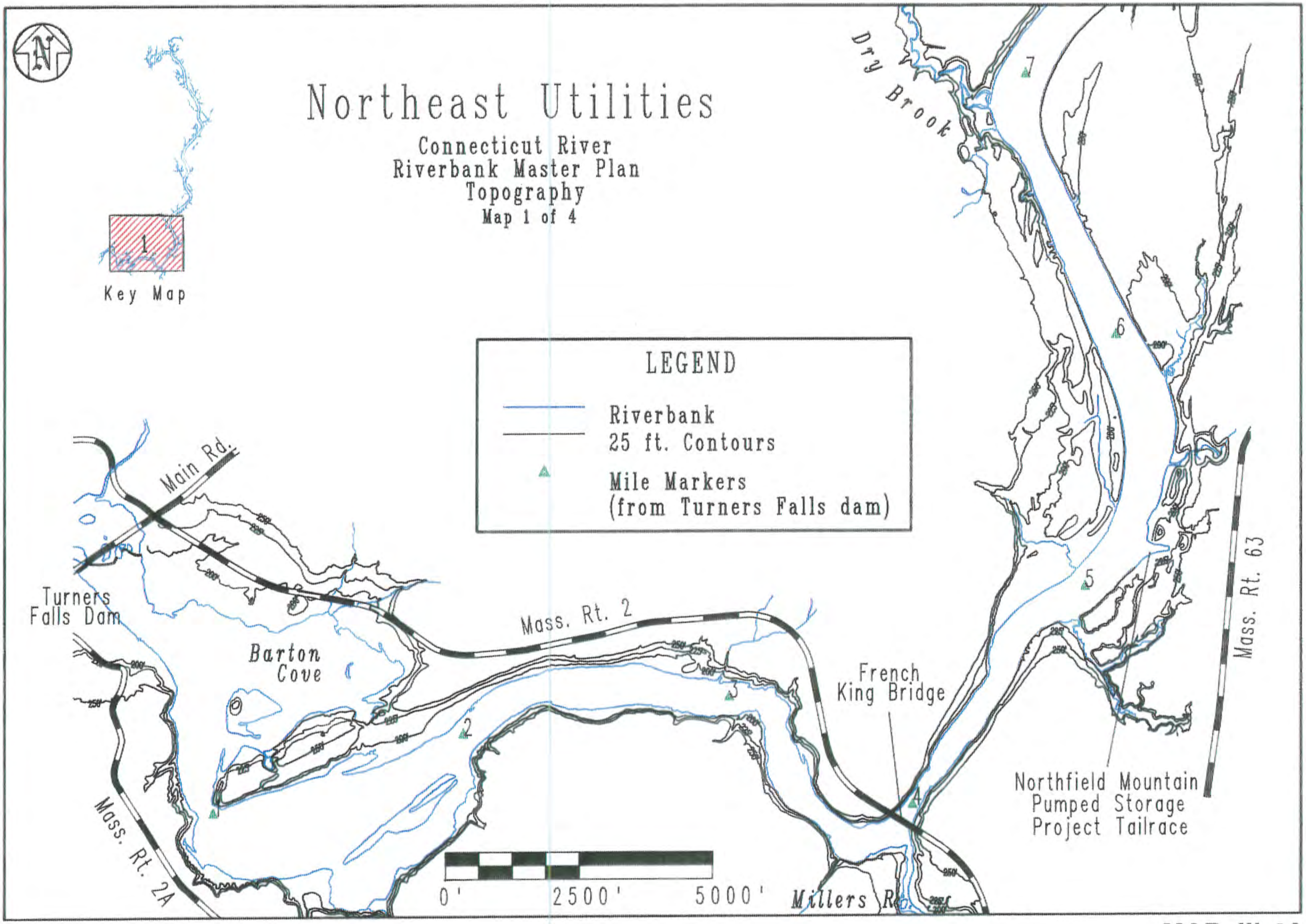
1. General Topography

The Turners Falls Pool of the Connecticut River stretches approximately 22 miles between the Vernon Dam in Vernon, Vermont and the Turners Falls Dam in Montague, Massachusetts. The total Connecticut River drainage area upstream of Turners Falls Dam is 7,138 square miles. The drainage area between Vernon Dam and Turners Falls Dam is 872 square miles. The river meanders in a series of bends and generally flows south from Vernon to the river's confluence with the Millers River in Erving. At its confluence with the Millers River a relatively narrow, steep gorge, referred to as the French King Gorge, channels the river abruptly to the west. The river continues in this direction to a broad pool, referred to as Barton Cove, before reaching the Turners Falls Dam. Four distinct islands are located on the river - Stebbins Island, Davenport Island, Kidds Island and Barton Island. The Ashuelot River (drainage area = 420 sq miles) and Millers River (drainage area = 375 sq miles) are the two primary tributaries feeding the Turners Falls Pool.

The project area lies within the Connecticut River Valley physiographic region and is typified by elevations ranging from approximately 180 ft (USGS datum) at the Connecticut River surface to 1,200 ft at the top of upland hills to the east of the river. Maps III-4A through 4D present a contour map of the project area. From Vernon Dam downstream to the Northfield Mountain Pumped Storage Project Tailrace the immediate river valley is dominated by a periodic shift from ridge features to floodplain terrace features. On Photo Panel III-2 a typical transition from ridge to terrace is highlighted by the land use change from undeveloped woodlands to agricultural use. Heading from north to south, broad meadows are evident on the western bank downstream of Stebbin Island, at Pauchaug Meadow, Moose

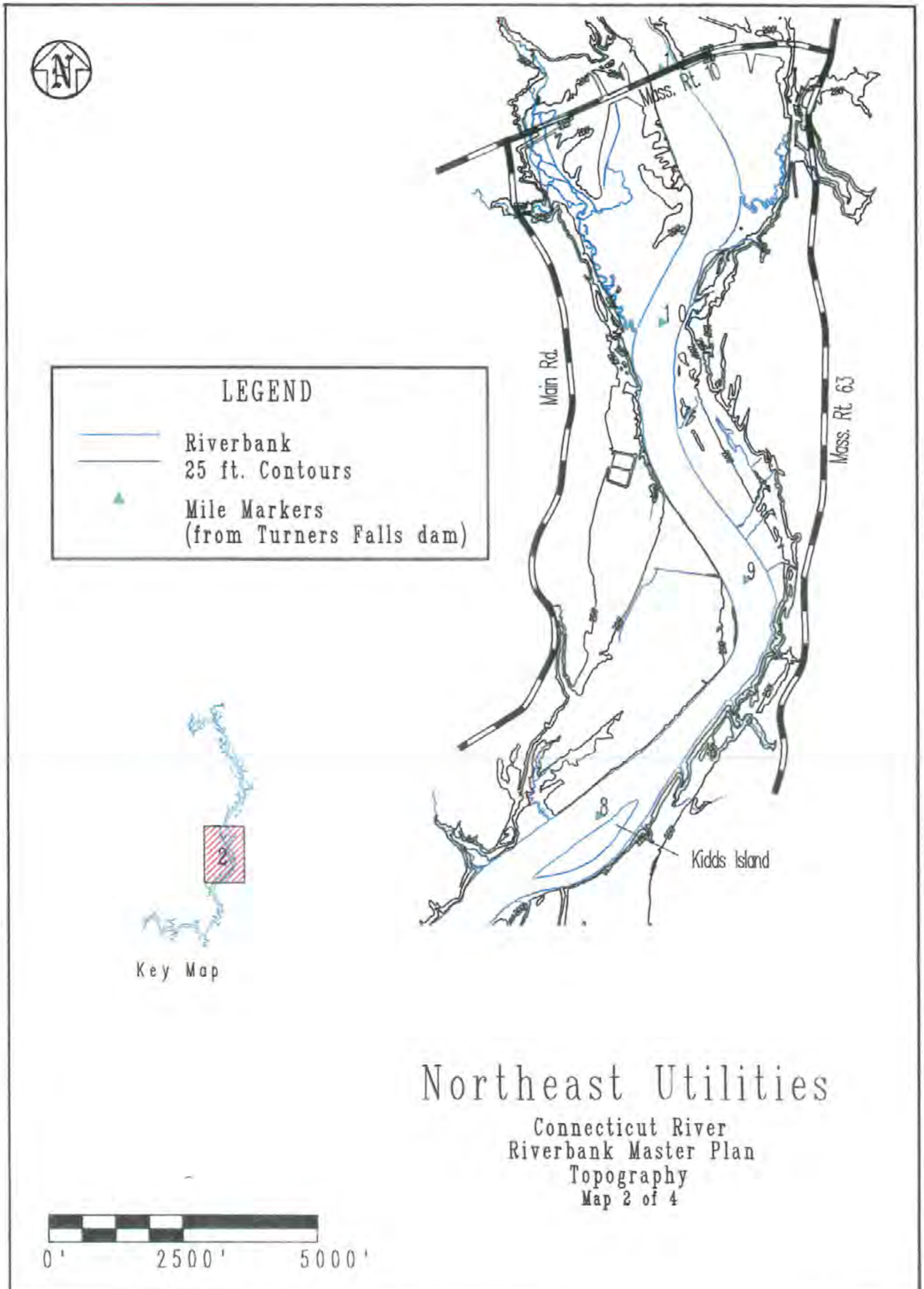
Plain, Great Meadow, Bennett Meadow, Beers Plain, the western terrace across from Munns Ferry and Pine Meadow. These meadows, which are similar in area, are each bounded by relatively steeper ridge areas which intermittently meet along the river. This general valley region is the former bed of glacial Lake Hitchcock.

South of the Northfield Tailrace, the river valley rapidly narrows and the immediate riverbanks steepen for the next 2 1/2 miles through the French King Gorge (see Photo Panel III-2). This gorge is composed of riverbanks exceeding 100 ft. in height and dominated by bedrock. Extending downstream, past the French King Gorge, the river valley changes once again to an area of low profile river banks bordered by gradually steepening uplands. The Barton Peninsula and the southern riverbank area across from it are fairly steep with pocketed wetlands adjacent to the banks. Downstream and north of Barton Peninsula, the river broadens into the Barton Cove pool. Barton Cove is atypical within the Connecticut River with its large lake-like appearance. The river valley here broadens into residentially developed terraces on either side before meeting the Turners Falls Dam.

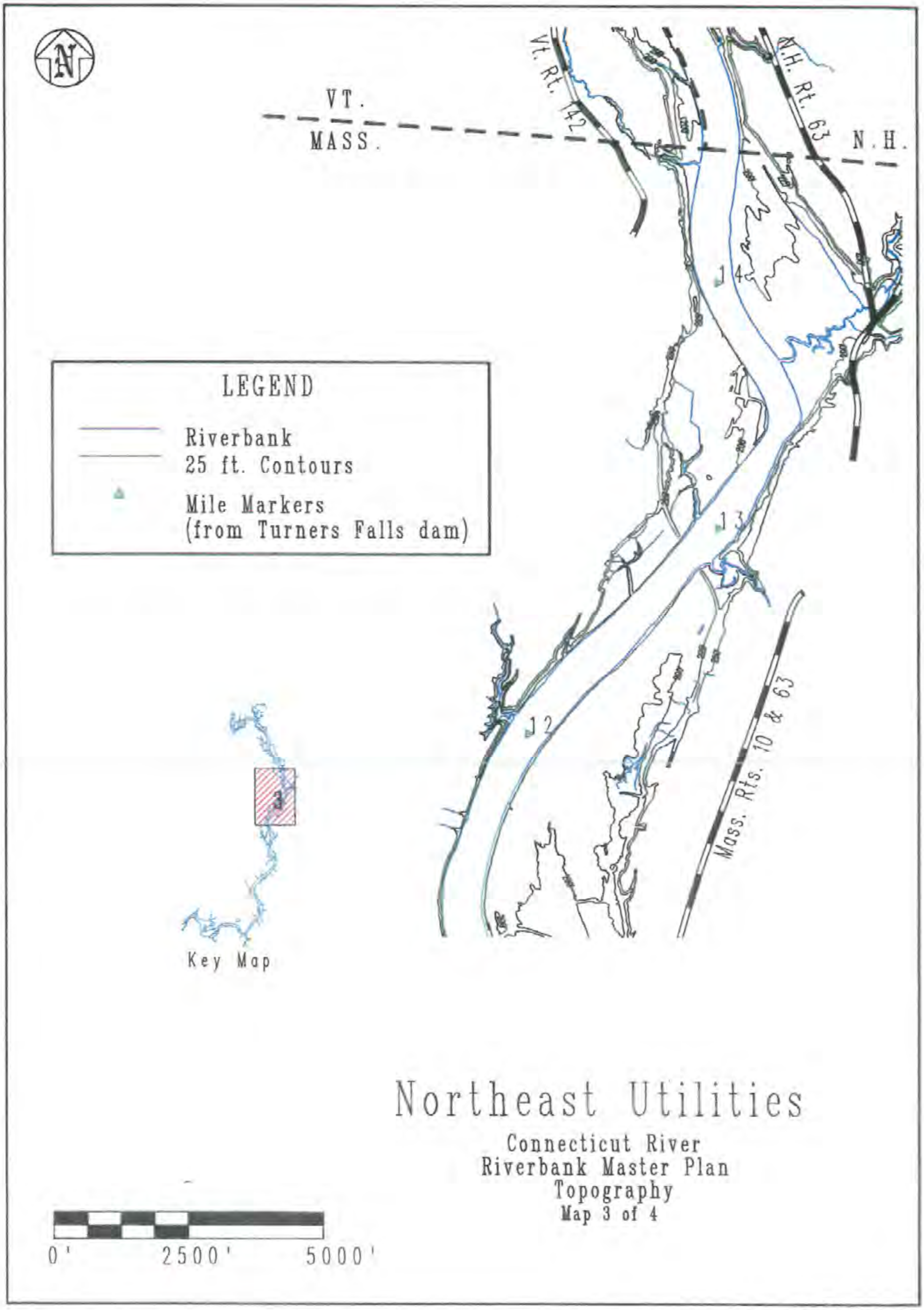


Northeast Utilities
Connecticut River
Riverbank Master Plan
Topography
Map 1 of 4
Key Map
1
LEGEND
Riverbank
25 ft. Contours
Mile Markers
(from Turners Falls dam)
Dry Brook
Main Rd.
Turners Falls Dam
Barton Cove
Mass. Rt. 2
French King Bridge
Northfield Mountain Pumped Storage Project Tailrace
Mass. Rt. 63
Mass. Rt. 2A
Millers R
0'
2500'
5000'

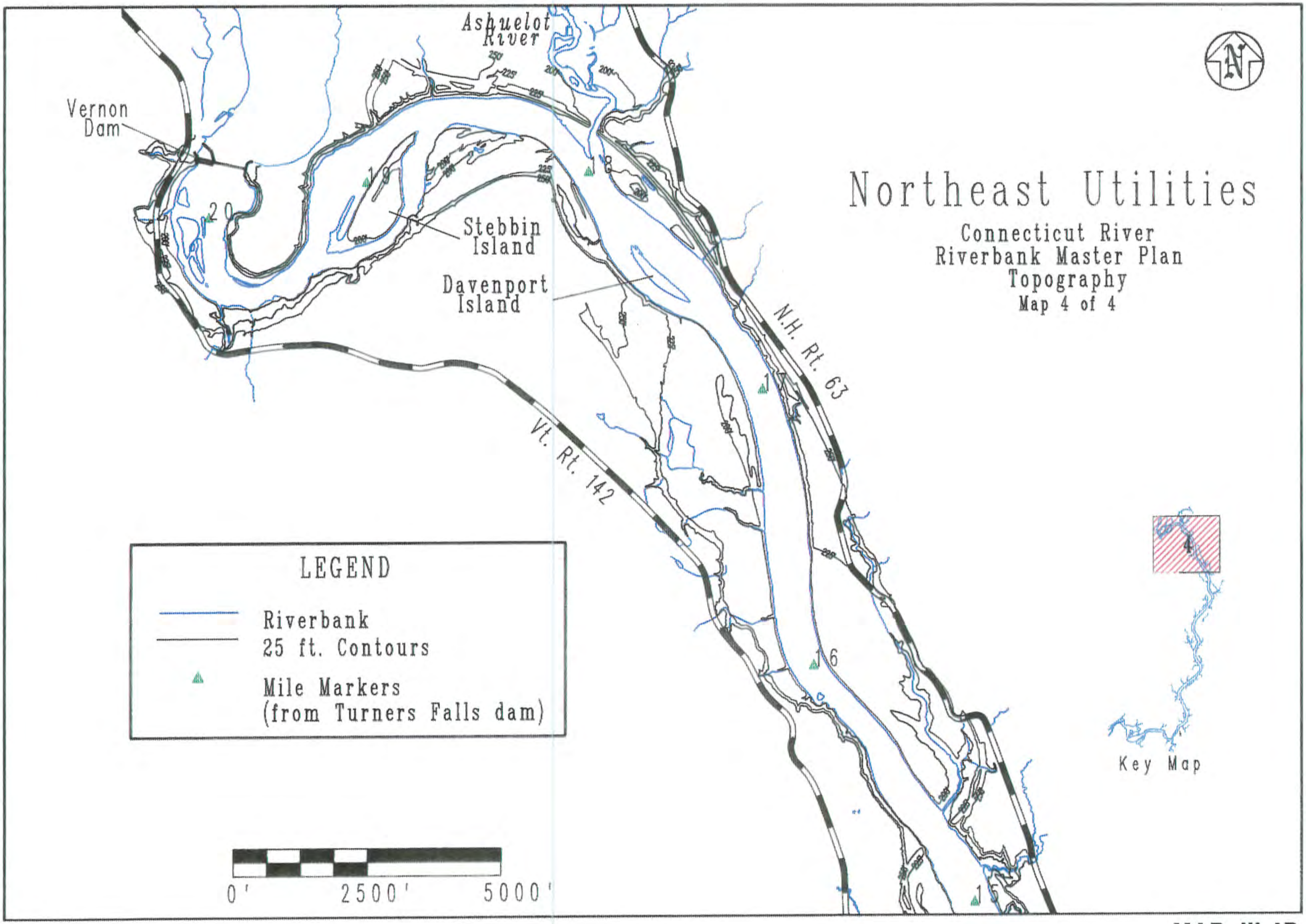
MAP III-4A


Mass. Rt. 10
Main Rd.
Mass. Rt. 63
LEGEND
Riverbank
25 ft. Contours
Mile Markers
(from Turners Falls dam)
10
9
8
Kidds Island
2
Key Map
Northeast Utilities
Connecticut River
Riverbank Master Plan
Topography
Map 2 of 4
0'
2500'
5000'

MAP III-4B

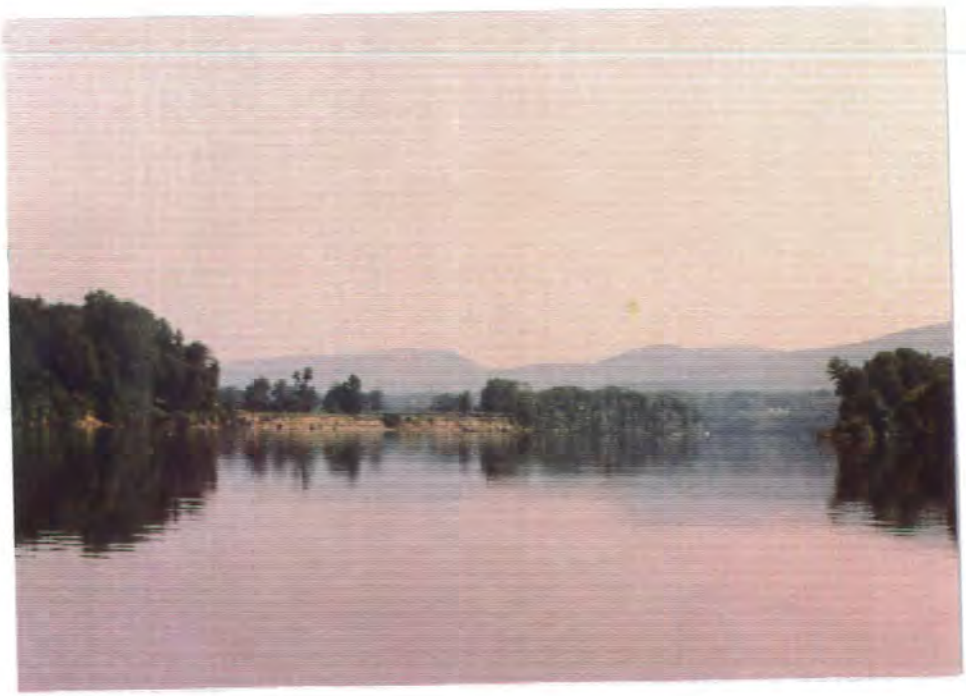

VT.
MASS.
N.H.
Vt. Rt. 142
N.H. Rt. 63
Mass. Rts. 10 & 63
14
13
12
LEGEND
Riverbank
25 ft. Contours
Mile Markers
(from Turners Falls dam)
Key Map
3
Northeast Utilities
Connecticut River
Riverbank Master Plan
Topography
Map 3 of 4
0'
2500'
5000'

MAP III-4C


Northeast Utilities
Connecticut River
Riverbank Master Plan
Topography
Map 4 of 4
Ashuelot River
Vernon Dam
Stebbin Island
Davenport Island
N.H. Rt. 63
Vt. Rt. 142
LEGEND
Riverbank
25 ft. Contours
Mile Markers
(from Turners Falls dam)
0'
2500'
5000'
Key Map

MAP III-4D

French King Gorge - Wooded uplands ascend from steep slopes in gorge before transition to upstream floodplain terrace - 1969.



Surrounding Connecticut River Valley foothills extend beyond typical terrace - ridge topography adjacent to river - Aug. 1990.

PHOTO PANEL III-2

2. Description of Soils and Geology of the Study Area

a. Geologic History

The majority of the study area is underlain by soft sedimentary rock, formed during the Triassic and Devonian periods, about 200 to 400 million years ago. Gneissic domes are reported at several locations which are believed to date back to the Devonian period, or older.

The present bedrock topography was defined in the Miocene epoch of the Tertiary period, about 19 million years ago, when fluvial erosion carved the present Connecticut River valley in the soft sedimentary rock. The surficial geology was established much more recently, during the last ice age beginning about 20,000 years ago, and is continuing to evolve today.

During the last glacial advance, surficial soils were scraped off or compacted by the sheet of ice that may have approached a mile or more in thickness. The compacted soils are referred to as glacial till. The area was deglaciated during global warming about 13,000 years ago. Glacial meltwaters accumulated behind a natural dam of glacial drift at Rocky Hill, Connecticut forming a lake, referred to as Lake Hitchcock, in the present Connecticut River valley. Sedimentation occurred in the placid lake waters, forming fine grained lake bottom deposits.

The natural dam impounding Lake Hitchcock was breached about 10,600 years ago. Erosion of the soft lake deposits occurred as the lake drained and the Connecticut River reestablished itself. River terrace deposits were laid down over the old lake bottom, as the Connecticut River meandered back and forth in the river valley. Alluvium has been deposited more recently, as excision and deposition continue along the river.

While the rock type, structure, and fault system in large part have determined the present location of the Connecticut River, the bedrock characteristics in general do not appear to play a dominant role in the existing erosion conditions. Bedrock outcrops constitute about 12% of the mapped riverbank exposures, primarily in the French King Gorge and Barton Cove areas. Elsewhere a few exposed outcrops along the river have formed erosion resistant areas ("hard points"), but the bedrock is in general overlain by 20 or more feet of overburden. These localized bedrock outcrops would undoubtedly play a role in the long-term formation of the spatial pattern of the river by influencing hydraulic and channel characteristics.

The soil conditions of the study area have been determined by glacial, lacustrine, and alluvial deposition processes.

The four principal soil types encountered within the study area are listed below, in order of their deposition (oldest to youngest).

Symbol	Description	Material
Qt	Glacial Till	Very dense heterogeneous mixture of all grain sizes from clay to boulders.
Qhl	Lake Bottom Deposits	Varved clay and silt.
Qrt	River Terrace Deposits	Interbedded silt with very fine to coarse sand, some gravel.
Qal	Alluvium	Silty very fine to coarse sand with some fine gravel.

Glacial till deposited during the last glacial transgression (and possibly during previous transgressions) about 20,000 years ago overlies the bedrock over most of the study area. The till is composed of a heterogeneous mixture of all grain sizes ranging from clay to boulders, and is very dense and impermeable. Isolated till exposures, comprising about 2% of the study area, are observed along the riverbank, and are characterized by high erosion resistance and the ability to stand on very steep slopes without vegetative cover.

Lake bottom deposits were laid down during the glacial retreat beginning about 13,000 years ago in the Northfield area. The sediments consist of clay, silt and very fine to fine sand, but generally consist of varved clay and silt where exposed within the study area.The lake bottom deposit exposures that were examined in the field consist of stiff overconsolidated varved silt and clay. The clay is highly jointed, with the principal joint set parallel to the varving, and two closely spaced near vertical sets. The varving is inclined, dipping to the east at about 20 degrees. The geologic mapping indicates that lake bottom deposits are exposed over about 20% of the study area. From a particle size viewpoint the very fine grain size would indicate that the lake bottom deposits would be subject to erosion. However, the high degree of cohesion observed in the overconsolidated crust offers substantial resistance to particle removal, and these deposits are found to be quite stable.

Alluvium is the dominant soil type in the study area, comprising about 60% of mapped exposures. The great majority of erosion problems are observed in the alluvium. Alluvium consists of silt and very fine to fine sand overlying fine to coarse sand with some gravel. Alluvium forms the floodplains along the river, and has been repeatedly deposited and excised along the riverbank in geologically recent time. Wedge shaped deposits up to 40 feet in thickness are reported. Sorting of the material is evident in the deposits, and is probably related to the distance from the point of excision and the water velocity.

Alluvium can be been broken into 3 sub-classifications for the purposes of this report, based on grain size, as determined visually and by grain size analyses:

- Qal Coarse - gravel alluvium
- Qal Fine grain non-cohesive - silty sand to fine sand alluvium
- Qal Cohesive - sandy silt alluvium

The gravel alluvium is resistant to erosion for the normal range of water velocities encountered due to the limited armoring effect of the gravel. The cohesive alluvium has a sufficient amount of fine silt and clay to act as a binder, and develop a cohesive mass. The fine grained non-cohesive alluvium is the most susceptible to removal, as it does not develop cohesion or armoring resistance.

Alluvium was encountered in all of the subsurface investigations, and was generally loose to medium dense fine grained sand or silt. The materials were found to be, in general, poorly sorted and variations in gradation were observed both laterally and vertically over a short distance at many of the sites.

Maps A3-1 through A3-7 in Attachment A show the distribution of soils along the riverbank in the study area. Photo Panels III-3 and III-4 show soil layers at two locations within the Turners Falls pool.

<u>b. Field Reconnaissance and Subsurface Investigations</u>

Detailed field surveys have been conducted by ND&T during the past year. These surveys were conducted from the shore and by boat.

The surveys are extensively documented in the Master Plan, supplemental reports, mapping, still photographs, and videotape filming.

Four test trenches, designated FT-1 through FT-4, and 1 test boring, designated FD-1, were performed by the U.S. Corps of Engineers (COE) in the study area in 1976. These were supplemented by a total of 12 test borings performed under the direction of ND&T in September, 1990. These are designated B90-1 through B90-13. The location of these explorations is shown on Figure III-4.

The COE investigation in the study area was concentrated in an area of severe erosion. The methods and findings of this investigation are described in the COE Connecticut River Streambank Erosion Study Preliminary Report, dated December, 1976. Test trench and boring logs from the COE report are provided in Appendix K - Soils Report.

Borings B90-1 through B90-13 were advanced to depths ranging from 26.5 feet to 41.5 feet using a 3.75 inch hollow stem auger. Standard Penetration Tests (SPT) were performed at 5 foot intervals, and split spoon samples were recovered. Copies of the boring logs are provided in Appendix K. Open standpipe piezometers were installed at Borings B90-3, 5, 9, and 11.

The most recent test borings were located at areas representative of the alluvial terraces along the river, with the exception of Boring B90-5. In general, the borings were located near the top of the riverbank and were advanced to a depth below the elevation of the normal low water elevation. The objective of the borings was to determine the composition and density of the soil profile of the riverbank where the erosion was occurring. This was difficult to do without borings, because of the deposition of sloughed material and the presence of varying degrees of vegetative cover on the slopes.

Open standpipe piezometers were installed at four locations so that the effects of hydraulic gradients and seepage could be more accurately quantified, particularly with respect to the fluctuations caused by the operation of the pumped storage project.

c. Laboratory Testing

Laboratory testing consisted of ten mechanical and ten hydrometer grain size analyses performed on spoon samples of predominately granular material recovered between the normal low and normal high water elevations for each of the borings. An Atterberg Limits test was performed on the one cohesive sample recovered. The purpose of these tests was to evaluate the erosion susceptibility of bank material based on published relationships between grain size and critical tractive force and to estimate the potential for apparent cohesion. The results of these tests are shown in Appendix K and summarized in Table III-1.

d. Summary of Findings

As with most riverine environments, a significant portion of the banks along the Turners Falls Pool have seen some degree of erosion. Understanding the geology of the study area is critical to developing an appreciation of the erosion susceptibility and characteristics of the riverbanks along the Turners Falls headpond. The riverbank soils vary from highly resistant to erosion to highly susceptible to erosion.

The fine grained, non-cohesive alluvial soils are the most susceptible to particle removal and transport by moving water. There is no cohesive resistance to particle removal, and tractive forces generated by relatively slow moving currents or waves are sufficient to remove and transport the particles. Active erosion of fine sands will take place where wave activity or currents impinge on exposed soil. Rapid undermining of slopes occurs, leading to progressive slope failures. These soils are also highly vulnerable to erosion due to surface runoff.

Vegetative cover is important in slowing the rate of or eliminating erosion of susceptible soils, and in stabilizing the slopes that have been undermined. Areas where a dense cover and root mass is maintained are still susceptible to erosion at the toe, as evidenced by undercuts with exposed roots at some locations; but, the rate of erosion is several orders of magnitude less at these locations than at sites without significant vegetative cover. Where slope failures on heavily vegetated slopes do occur, often the vegetative cover remains intact, temporarily restabilizing the bank in the slumped configuration.

Once the vegetative cover on riverbanks composed of fine sand is removed or impaired, it appears that progressive slope failure is sufficiently rapid so that the vegetation cannot be reestablished prior to the next cycle of erosion. The slumped material is transported downstream or slides toward the deepest part of the channel. These areas continue to erode until the slope is flattened, until a beach is formed by slumped material or cutting back of the slope, or until the hydraulics are changed.

Fluctuation of the impoundment, in and of itself, does not appear to contribute significantly to the erosional activity along the river. The apparent inability of vegetation to develop within a given fluctuating zone is attributed much more to erodability of the beach soils, steepness of the upper slope and to high river velocities than to fluctuation. Where the slopes are relatively flat and velocities are low, even during normal spring flows, emergent and submergent vegetation grow in abundance, despite fluctuations. In contrast, the fluctuating zone in the more riverine areas upstream of the Northfield Mountain tailrace possess little vegetation. This is primarily due to the adverse influence of high velocities associated with normal spring flows and summer freshets, the lack of stable riverbank soils necessary to support germination and growth, and the likelihood that the eroded beaches contain nutrient-poor soils.

Problems caused by hydraulic gradients within the groundwater can be encountered with pumped storage projects, resembling the rapid drawdown condition in earth dams. Localized high groundwater tables are established in pervious soils during periods of high headpond, and may create seepage with sloughing, or may cause hydraulic blowout of dense impermeable vegetation when the headpond is drawn down. This behavior has not been observed to any appreciable extent during the reconnaissance along the banks, and is not considered to be a major factor here, due to the relatively small swings in hydraulic gradient, and the fact that seepage erosion appears to be relatively insignificant when compared to the other processes observed.

The only area where seepage appears to be a factor is at two localized zones within site 64 downstream of the irrigation pump, where high seepage has created essentially quick conditions, destabilizing the toe of the slope. It is believed this condition is caused by the orientation of permeable and impermeable strata, creating an artesian condition at the toe of the slope. Minor seeps were observed at several other areas, but were not judged to be significant. For example, another potential location is at site 57, on the west bank upstream of Kidds Island, although the seepage observed is not associated with extensive erosion.

Much of the riverbank stands on steep or near vertical slopes, even in the predominately granular alluvial deposits. These banks are at the point of incipient failure, and would be determined to be unstable using theoretical analyses. The effects of vegetation, apparent cohesion and cementation act temporarily to stabilize the bank. It should be noted that apparent cohesion is due to capillarity, and does not act when soils are submerged, and cementation may be less effective in the submerged state. These banks will be prone to erosion until they are cut back or flattened to less than the theoretical angle of repose.

Kidds Island - East bank approximately 100 ft downstream of the northern end of the island. July 25, 1990.

Kidds Island - East bank approximately 100 ft downstream of the northern end of the island. July 25, 1990.

West bank soil strata approximately 2,000 ft downstream of Dry Brook. July 25, 1990.

Kidds Island - East bank; approximately 300 ft downstream of the northern end of the island. July 25, 1990

PHOTO PANEL III-4

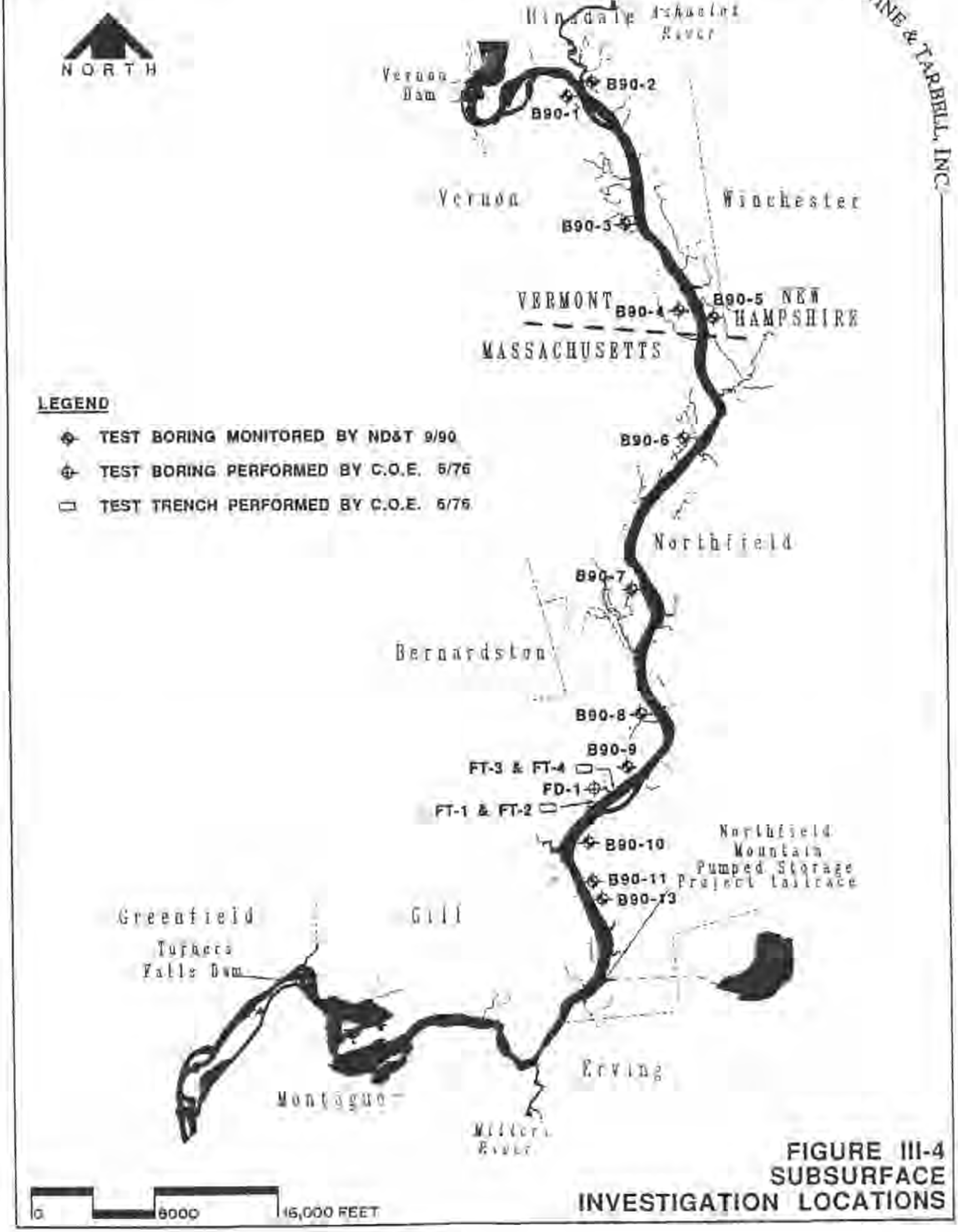


FIGURE III-4
SUBSURFACE
INVESTIGATION LOCATIONS

TABLE III-1

SUMMARY OF BORING RESULTS

BORING	ADJACENT PROPERTY OWNER	SITE NO.	SAMPLE NO.	ELEVATION OF RECOVERED SAMPLE (ft)	GRAIN SIZE PARAMETERS: D_{25} (inch)	D_{50} (inch)	FRACTION PASSING No. 200 SIEVE (%)	FRACTION SMALLER THAN .005 INCH (%)
B90-1	Rondau	15	53	185	.05	.1	34	3
B90-2	Dolbec	None	54	182	.04	.08	43	3
B90-3	Wright	None	55	182	.03	.06	59	4
B90-4	Kendall	21	56	182	.07	.12	27	2
B90-5	Holbrook	23					100	
B90-6	NUSCO	None			No Sample Recovered			
B90-7	NUSCO	40	55	182	.04	.08	48	3
B90-8	Llewelyn	50	54	180	.04	.08	43	3
B90-9	Flagg	57	55	184	.03	.07	57	4
B90-10	L'Etoile	63	56	180	.05	.095	35	2
B90-11	L'Etoile	64	55	180	.045	.11	36	3
B90-12	BORING NOT PERFORMED							
B90-13	L'Etoile	64	56	179	.1	.5	23	2
COE-FD1	Flagg	60	J2	.6- 4.1[1]	.03	.07	57	5
COE-FD1	Flagg	60	J6	5.0- 5.6	.075	.11	24	2
COE-FD1	Flagg	60	J7	5.6- 9.3	.03	.06	64	5
COE-FD1	Flagg	60	J10	10.0-12.4	.05	.075	45	4
COE-FD1	Flagg	60	J12	12.7-13.4	.025	.06	66	7
COE-FD1	Flagg	60	J13	13.4-15.0	.045	.08	41	3
COE-FD1	Flagg	60	J16	18.6-19.8	.025	.055	66	6
COE-FD1	Flagg	60	J19	20.0-24.3	.17	.4	15	2
COE-FD1	Flagg	60	J23	25.0-28.8	.4	.8	6	-
COE-FD1	Flagg	60	J24	28.8-30.0	.0035	.007	100	35

1. Depth of Recovered Sample; Elevations Not Available

3. Description of Hydraulic Characteristics of the Turners Falls Impoundment

a. Historical Perspective

The first dam was built at Turners Falls at Great Island in 1867 with a top elevation of 169.3 ft (mean sea level datum). This dam was rebuilt in 1912 and raised to elevation 172.3 ft in 1913. At this elevation, the pond formed by the dam extended up to the French King Gorge, but not beyond the gorge. Flashboards were added to the dam in 1915 raising the water level to elevation 179.6 ft. At this point, the pond extended upstream to about the Ashuelot River.

Prior to 1970, the Turners Falls headpond was fluctuated between elevations 176 ft and 179.6 ft to improve the generating capability of the Cabot and Turners Falls No. 1 hydroelectric stations. When river flows were less than the hydraulic capacity of the stations, the pond would be fluctuated to coincide with efficient operation of the turbine-generator units. This fluctuation occurred approximately 60% of the time.

In 1970, NUSCO completed construction of the 1,080 MW Northfield Mountain Pumped Storage Project. This project was one of the largest of its kind in the world at the time of construction. This project consists of the upper reservoir, an underground pump/generating plant, and the lower reservoir formed by the Turners Falls Dam. In conjunction with the Northfield Project, the dam at Turners Falls was raised six feet to accommodate a normal high water level of 185.5 ft.

The Northfield Project's hydraulic connection to the Turners Falls headpond is located on the east bank of the river

6,300 ft upstream of the French King Bridge. The Northfield Project is designed to pump water from storage in the Turners Falls pond to the upper reservoir during periods of low electrical demand. During periods of high electrical demand, the water stored in the upper reservoir is released through the pump/turbines to generate a maximum of 1,080 MW of electricity and, in the process, releases water back to the Turners Falls headpond.

b. Hydraulic Summary of the Present Operation

The Northfield Project operates on a daily cycle of pumping from the lower reservoir during nighttime hours and discharging to the lower reservoir during daytime hours. The daily cycle results in fluctuations in the Turners Falls headpond. As water is pumped to the upper reservoir, the headpond is lowered. As water is released from the upper reservoir, the headpond is raised. The Project is permitted to cycle the lower reservoir between elevation 176 ft and 185 ft, however, the normal cycle is substantially less. The amount of fluctuation is dependent upon electrical demand, river flow, and the storage characteristics of the Turners Falls pool.

To accurately establish the amount of pond fluctuation and the changes in river elevation that actually occur at different locations along the lower reservoir, ND&T analyzed data obtained from plant operation and from staff gages established for this study. In addition, a hydraulic backwater model was run to define baseline water surface elevations at a variety of flows in the Turners Falls headpond.

Figure III-5 summarizes the analyses conducted. The backwater profile at a flow of 12,000 cfs for both normal maximum and normal minimum headwater level is provided. The difference between these levels represents the storage available to the Northfield Project at that flow. The actual use of this volume of storage is depicted in the elevation - duration curves which are also provided in Figure III-6.

These duration curves describe the amount of time any given elevation is exceeded at a particular location along the headpond and, therefore, they provide an indication of the extent of pond fluctuations which actually occur. Table III-2 gives a tabular summary of this information. Maps III-6A and III-6B show the locations of gage stations and cross-sections used for hydraulic analysis.

Based on these summaries, it can be seen that the great majority of the time, daily pond fluctuations are within 2.5 ft to 3.0 ft.

Appendix E to the Master Plan provides a summary study of the water levels experienced in the Turners Falls impoundment.

NORTHROP, DEVINE & TARBELL, INC.

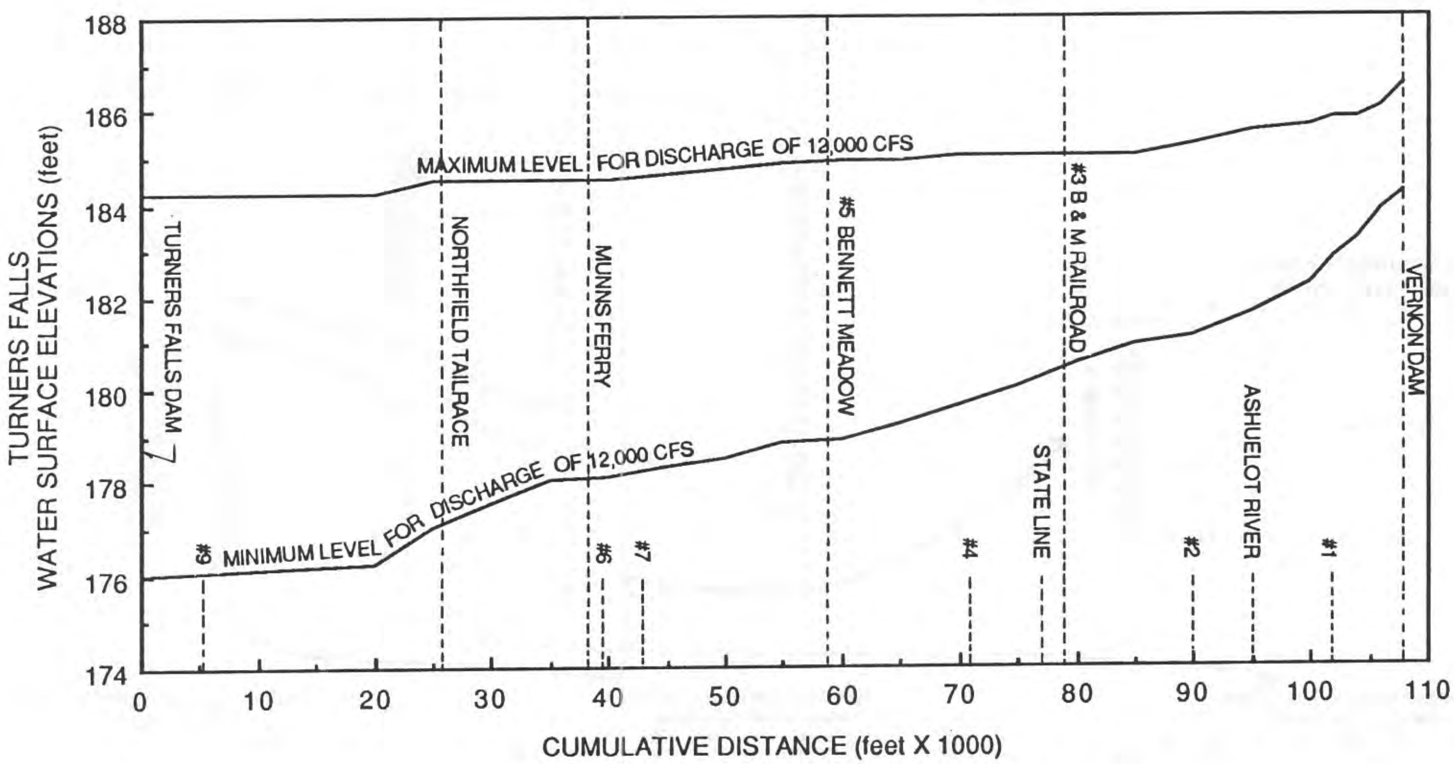


FIGURE III-5
LOCATION OF ELEVATION GAGES
AND REPRESENTATIVE WATER LEVELS

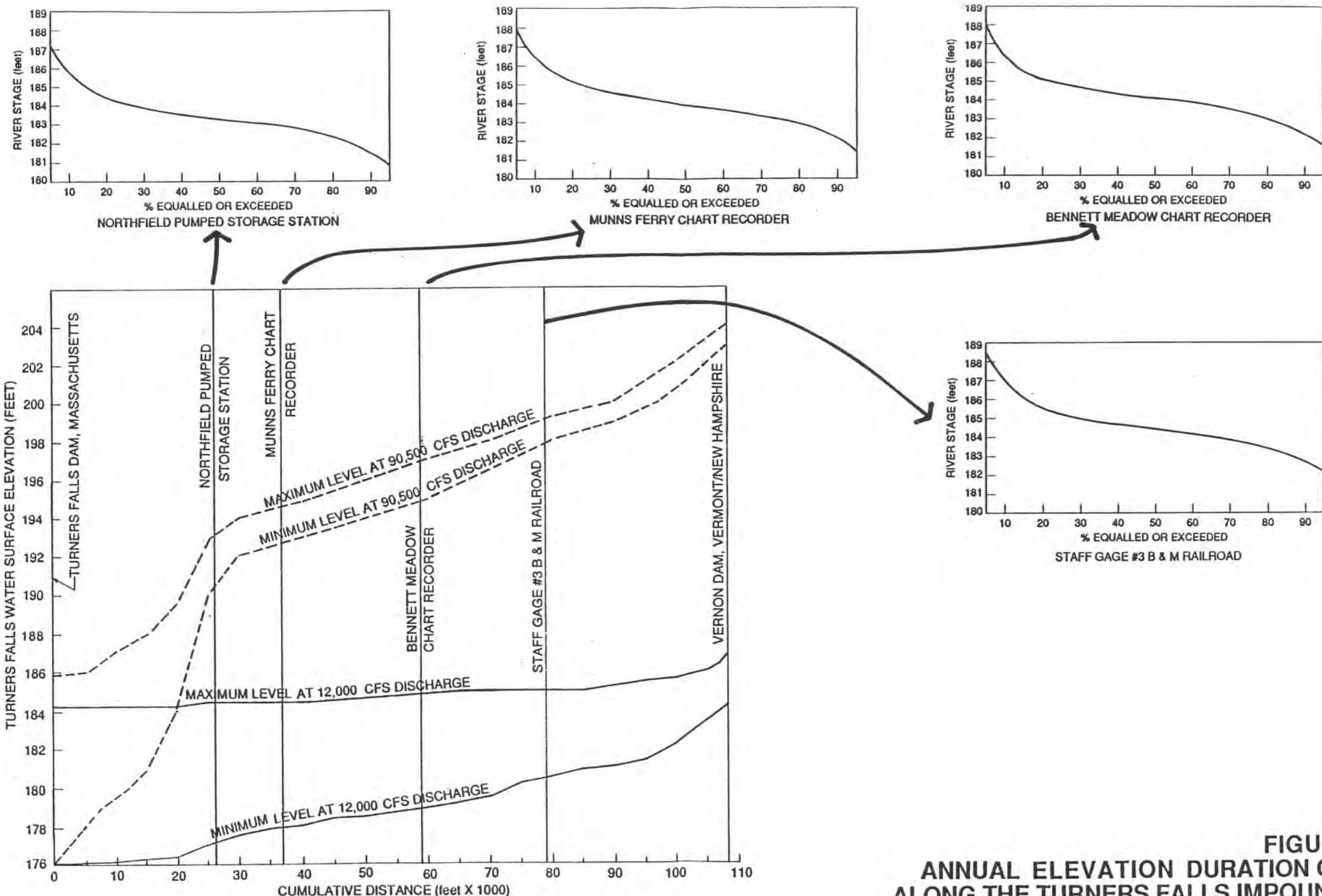


FIGURE III-6
ANNUAL ELEVATION DURATION CURVES ALONG THE TURNERS FALLS IMPOUNDMENT

TABLE III-2

SUMMARY OF FLUCTUATIONS TURNERS FALLS IMPOUNDMENT

Location	Normal Fluctuation[1] (ft)	Between Elevations (ft)
Project Tailrace	≤ 2.6	181.4 to 184.0
Munn's Ferry	≤ 2.4	182.2 to 184.6
Bennett Meadow	≤ 2.4	182.3 to 184.7
Boston & Maine RR	≤ 2.4	182.4 to 184.8

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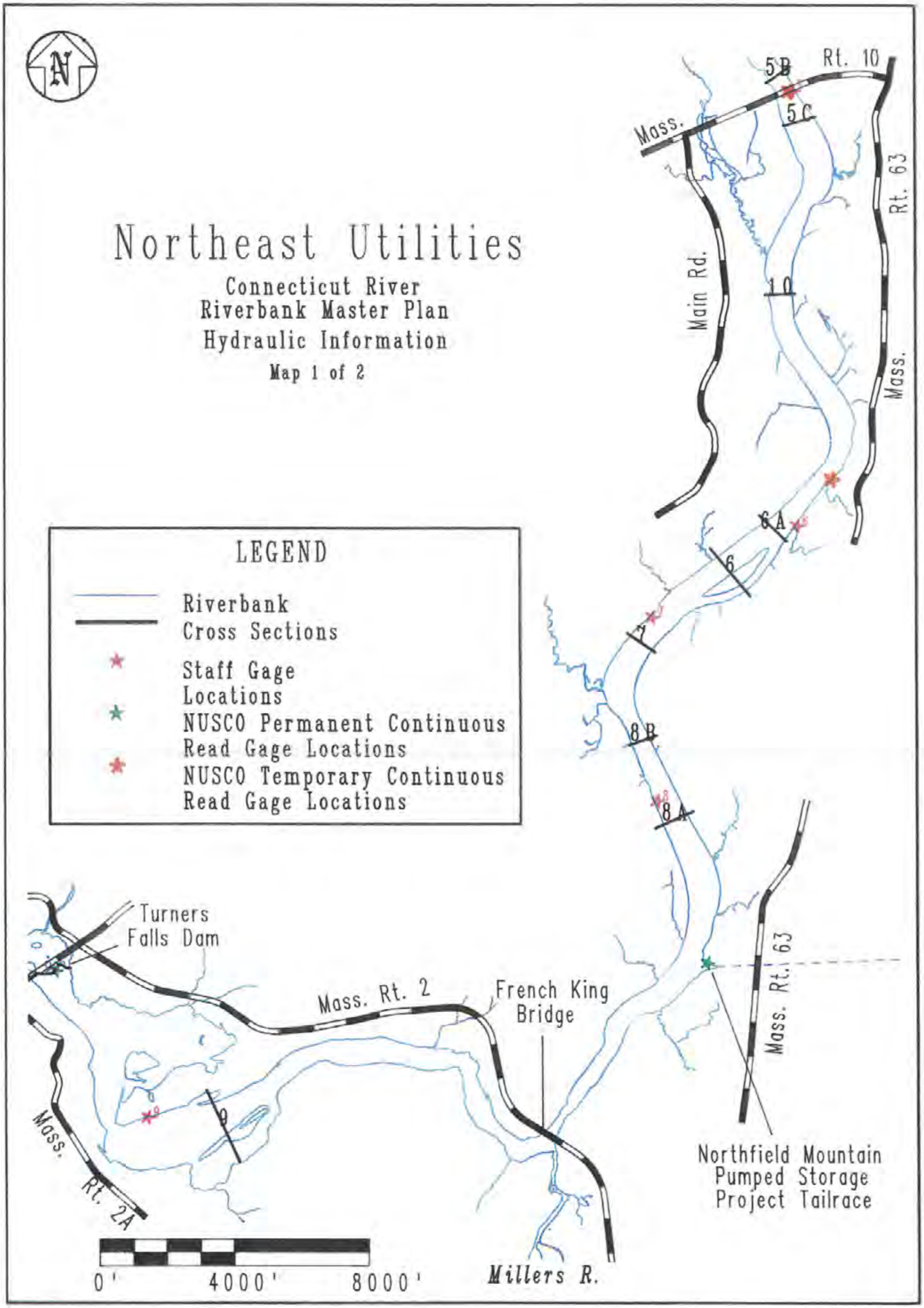
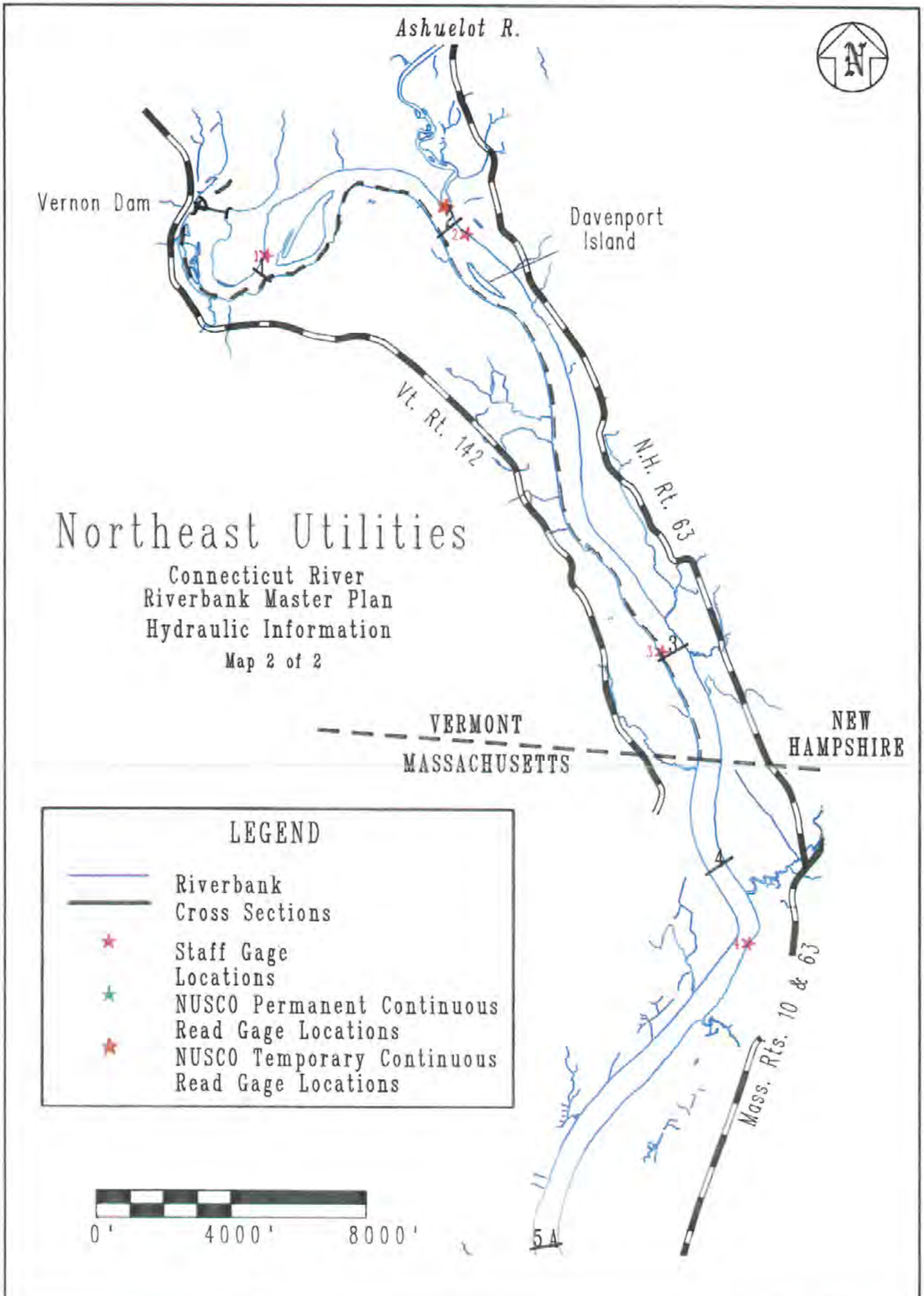
1. Defined as the fluctuation which occurs 80% of the time when the river elevation is controlled by the operation of the Northfield Project; i.e., river flow is less than 20,000 cfs (maximum generation discharge).


Northeast Utilities
Connecticut River
Riverbank Master Plan
Hydraulic Information
Map 1 of 2
LEGEND
Riverbank
Cross Sections
Staff Gage Locations
NUSCO Permanent Continuous Read Gage Locations
NUSCO Temporary Continuous Read Gage Locations
Rt. 10
Mass.
Rt. 63
Main Rd.
Mass.
5B
5C
10
6A
6
7
8B
8A
9
Turners Falls Dam
Mass. Rt. 2
French King Bridge
Mass. Rt. 63
Mass. Rt. 2A
Northfield Mountain Pumped Storage Project Tailrace
Millers R.
0'
4000'
8000'

MAP III-6A


Ashuelot R.
Vernon Dam
Davenport Island
Vt. Rt. 142
N.H. Rt. 63
Northeast Utilities
Connecticut River
Riverbank Master Plan
Hydraulic Information
Map 2 of 2
VERMONT
MASSACHUSETTS
NEW HAMPSHIRE
LEGEND
Riverbank
Cross Sections
Staff Gage Locations
NUSCO Permanent Continuous Read Gage Locations
NUSCO Temporary Continuous Read Gage Locations
0'
4000'
8000'
Mass. Rts. 10 & 63
1
2
3
4
5A

MAP III-6B

4. Water Quality

The Connecticut River is considered a Class B quality stream (suitable for bathing and for public water supply after appropriate treatment). Its overall quality has steadily increased since 1970 with the mandated control of wastewater associated with the Federal Clean Water Act. Water quality in the Turners Falls Pool is primarily influenced by pollution in the Ashuelot and Millers Rivers, runoff from agricultural lands and wastewater effluent from the Northfield Wastewater Treatment Plant. Its quality is also dictated by the upstream array of point and non-point pollutants introduced to the river within the 6,266 sq. mile drainage basin north of Vernon Dam.

The Massachusetts Department of Environmental Protection's Division of Water Pollution Control was contacted regarding water quality within the project area. The most recent and comprehensive water quality investigation undertaken within the project area took place between 1982 and 1983. A report entitled Connecticut River Water Quality and Wastewater Discharge Survey Data: 1982-1983 was received and reviewed.

The primary data collected within the project area includes results from sampling conducted at five locations. These sites are listed below.

1. Schell Bridge, Northfield
2. Route Ten Bridge, Northfield
3. Near French King Rock, Erving
4. Downstream of Millers River confluence, Montague
5. Barton Cove Narrows, Montague

Readings were taken for temperature, dissolved oxygen and percent saturation, pH, alkalinity and hardness, total suspended solids, turbidity, nitrate-nitrogen data, total phosphorous, total coliform and fecal coliform. No testing of the riverbed sediments was performed. The results indicate that water quality at each station is very close to the Class B standard set by Massachusetts, with the exception of readings for dissolved oxygen. Dissolved oxygen at each station exceeded the Class B standard in each instance for three separate reading episodes. It should be noted that dissolved oxygen levels were exceeded at over 90 percent of the forty stations monitored along the Connecticut River. In addition, fecal coliform readings were considerably higher at the Route Ten Bridge site than at the remaining four stations, although the mean calculation for each station was within the limits for Class B water.

Water quality samples were also taken at the Northfield Wastewater Treatment Plant, located off of Meadow Road in Northfield. The plant is an extended aeration unit designed to handle 275,000 gallons of inflow per day. The report notes that the facility is hampered by severe inflow/infiltration problems. Sewage disposal ponds located 1.2 miles north of Kidds Island in Gill were not tested in this report.

5. Wetlands

Wetlands within the project area were inventoried and mapped using the following approach. National Wetland Inventory maps produced by the US Fish & Wildlife Service were collected for the entire project area. The locations of these wetland areas were then transferred onto a set of aerial photos of the project area taken on April 28, 1990. Adjustments to wetland boundaries were made during this phase of the data transfer in order to better reflect the field conditions evidenced in the aerial photos. Additional wetlands not shown on the federal inventory maps were also added to the data base. Field walkovers of wetlands were conducted at four separate areas in order to verify the accuracy of the photo interpreted boundaries. Wetlands were visited at Kidds Island, the Otter Run Brook area (including Otter Run Brook), the east bank area north of the Route 10 Bridge and immediately southwest of the abandoned B&M Railroad bridge. These wetland areas are near erosion sites 59, 60, 38 and 31, respectively. Once adjustments were made to these areas, information on all wetlands was transferred to a set of 1"=200' topographic maps of the project area where final adjustments were made to incorporate topographic conditions. Each wetland site was then entered into the GIS computer data base.

In a meeting with Massachusetts MEPA Unit Director Janet McCabe in May, 1990 it was agreed that the Master Plan's representation of project wetlands could be acceptably presented using the above stated inventory method. Ms. McCabe stated that the MEPA Unit would review the stabilization recommendations proposed in the master plan and approve them on the basis that site specific wetlands subject to direct impact would have to be identified in accordance with local conservation commission conditions as dictated through local enforcement of the state Wetlands Act. NUSCO acknowledges that more detailed field investigations may be necessary at certain significant wetlands within or adjacent to proposed stabilization projects, in order to clarify their boundaries.

It is important to note that wetlands are defined and regulated differently in Massachusetts, Vermont and New Hampshire. A summary comparison of the regulations is shown on Table III-3. Of special note is Massachusetts' definition of regulated wetlands, which encompasses land under water and all streambank areas (to the annual high water mark) in addition to bordering vegetated wetlands. New Hampshire and Vermont both concentrate on bordering vegetated wetlands as the focus of their respective regulations. In order to satisfy the mutual objectives of these three sets of regulations, as well as meeting the federal guidelines for identification of wetlands, NUSCO plans on using the "three point parameter" system for any future location of wetlands in the field. This system, as explained in the January, 1989 Federal Wetland Identification Manual, bases the identification of wetlands on hydrology and the presence of hydric soils and hydrophytic vegetation. This system is sanctioned by the U.S. Army Corps of Engineers, the U.S. EPA, the U.S. Soil Conservation Service and the U.S. Fish and Wildlife Service.

Wetlands evidenced within the project area consist primarily of scattered shrub-swamp wetlands downstream of the Northfield Mountain Tailrace, palustrine forested wetlands within river terrace and tributary stream areas upstream of the tailrace, and assorted small ponds. All mapped wetlands appear on Maps III-7A through 7D. The predominance of wetlands abutting the riverbank occur at shrub-swamp wetlands between Barton Cove and the upstream side of Barton peninsula (a distance of approximately 3 miles). These are generally wetlands with low bank height and gentle slopes and are not impacted by erosion.

Other significantly sized wetlands abutting the river bank occur on the east bank just downstream of Kidds Island, on the west bank just upstream of Kidds Island, the east bank approximately 0.5 miles downstream of the Route 10 Bridge, the east bank immediately upstream from Pauchaug Brook and the east bank immediately upstream of the Ashuelot River. These sites are generally associated with the mouths of tributary streams or very flat river terraces beginning at the top of bank. Project area wetlands abut nearly two miles of shoreline upstream of the Northfield Mountain tailrace and two miles of shoreline downstream of the tailrace. Photo Panel III-5 shows examples of typical wetlands found within the project area.

All mapped wetlands appear on Maps III-7A through 7D. The total area of project area wetlands is 336 acres, comprising 101 individual wetlands. These wetlands abut existing erosion sites in eleven instances. Table III-4 provides detailed information regarding the relationship between these erosion sites and their associated wetlands.

TABLE III-3

SUMMARY OF WETLAND REGULATIONS IN MASSACHUSETTS, VERMONT AND NEW HAMPSHIRE

MASSACHUSETTS (from 310 CMR 10.00 - Mass. Regulations)

Encompasses the regulation of bordering vegetated wetlands ("freshwater wetlands bordering on creeks, rivers, streams, ponds and lakes ... where the topography is low and flat and where the soils are annually saturated. The boundary of bordering vegetated wetlands is the line within which 50% or more of the vegetational community consists of wetland plant species"), any bank (between mean annual low flow level and mean annual flood level), land under water bodies and land subject to flooding (100-year floodplain).

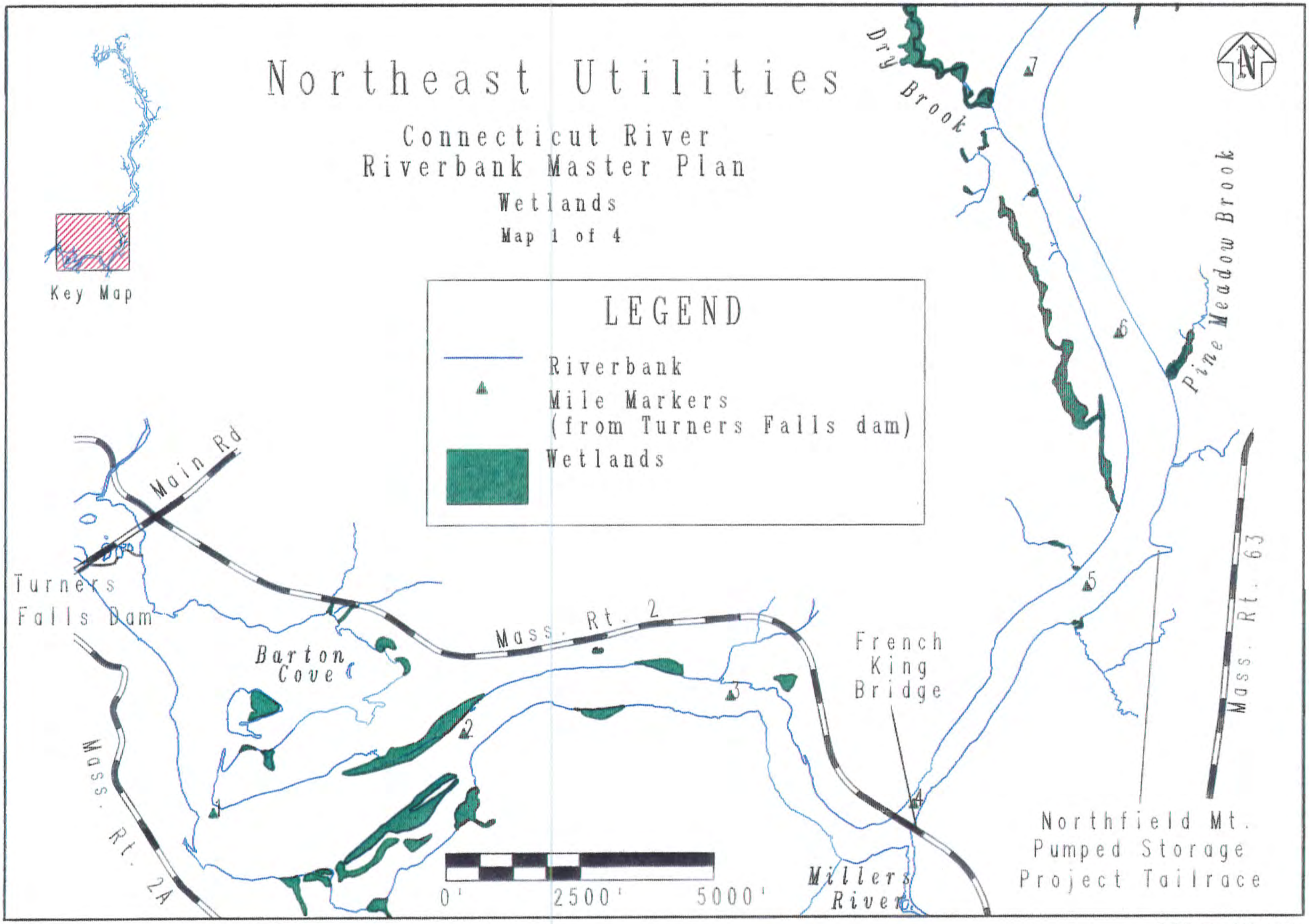
The regulated area includes any area within 100 feet of either a bordering vegetated wetland, a bank or any land under a water body. In addition, any activity within the 100-year floodplain is regulated.

VERMONT (from Vermont Wetland Rules)

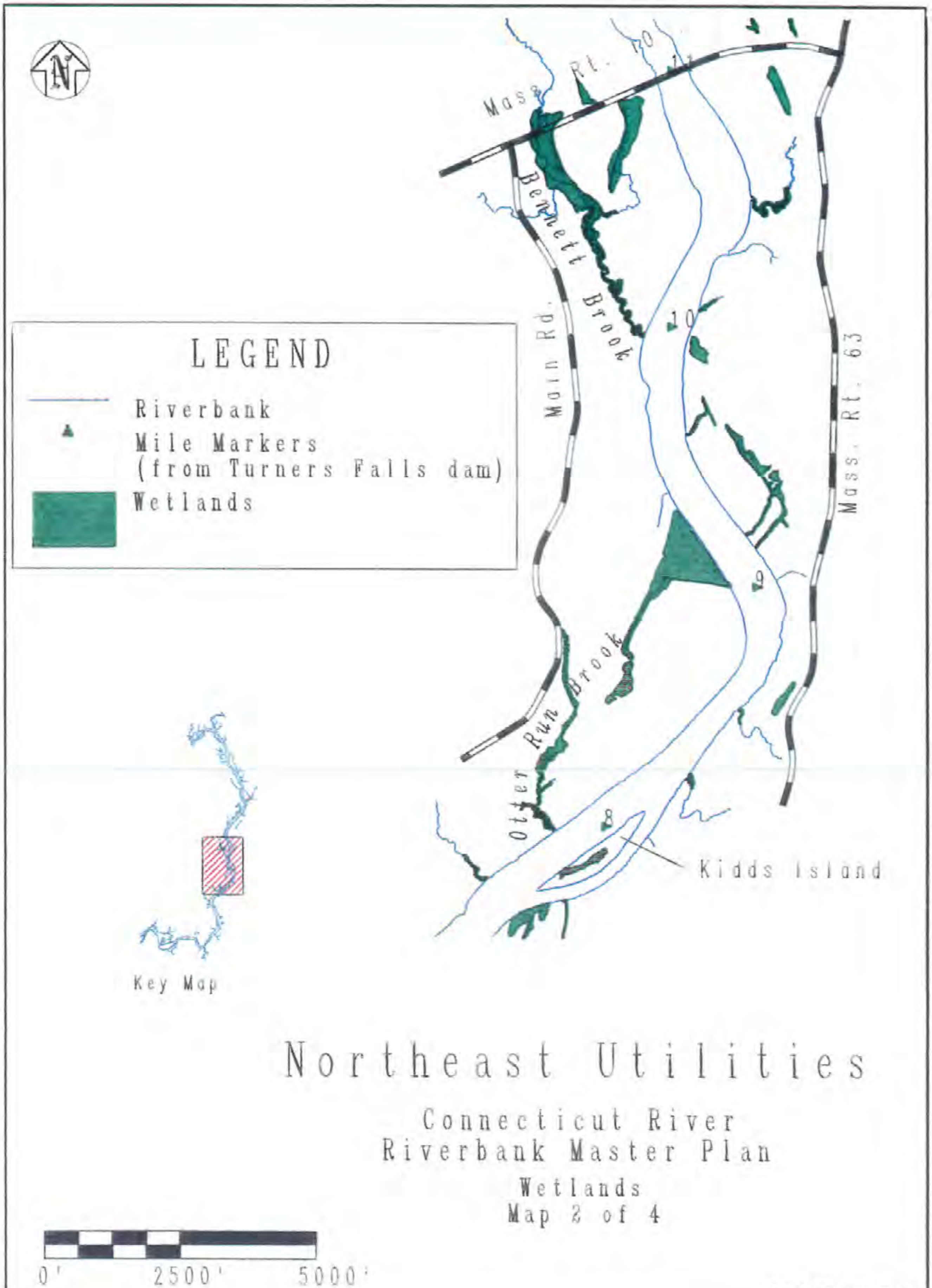
Wetlands in Vermont are divided into three classes: Class One wetlands are those selected by the Water Resources Board as "exceptional or irreplaceable in their contribution to Vermont's natural heritage". Class Two wetlands are all wetlands appearing on U.S. Fish and Wildlife Service Wetland Inventory maps and wetland continguous to such wetlands. Class Three wetlands are all other wetlands not deemed Class One or Two. Regulated buffer zones are 100 ft from Class One wetlands and 50 ft from Class Two wetlands.

NEW HAMPSHIRE (from Chapters W+100 - W+800: N.H. Code of Administrative Rules

New Hampshire has established criteria for the approval or disapproval of projects in wetlands which consider the size and location of the wetland and its freshwater area, the potential impact on plants, fish and wildlife and various interests of the general public (i.e., water quality, aesthetics). Projects are subdivided into "major, minor and minimum impact" projects. A higher degree of scrutiny is involved in permitting a major project. Major projects involve filling or dredging an area greater than 20,000 sq. ft. or impacting more than 20% of continguous wetlands. Minimum impact projects include activities that are temporary in nature (i.e., cofferdams, temporary stream crossings) or maintenance related.


Northeast Utilities
Connecticut River
Riverbank Master Plan
Wetlands
Map 1 of 4
Key Map
LEGEND
Riverbank
Mile Markers
(from Turners Falls dam)
Wetlands
Dry Brook
Pine Meadow Brook
Main Rd
Turners Falls Dam
Barton Cove
Mass. Rt. 2
Mass. Rt. 2A
Mass. Rt. 63
French King Bridge
Millers River
Northfield Mt. Pumped Storage Project Tailrace
0'
2500'
5000'
1
2
3
4
5
6
7

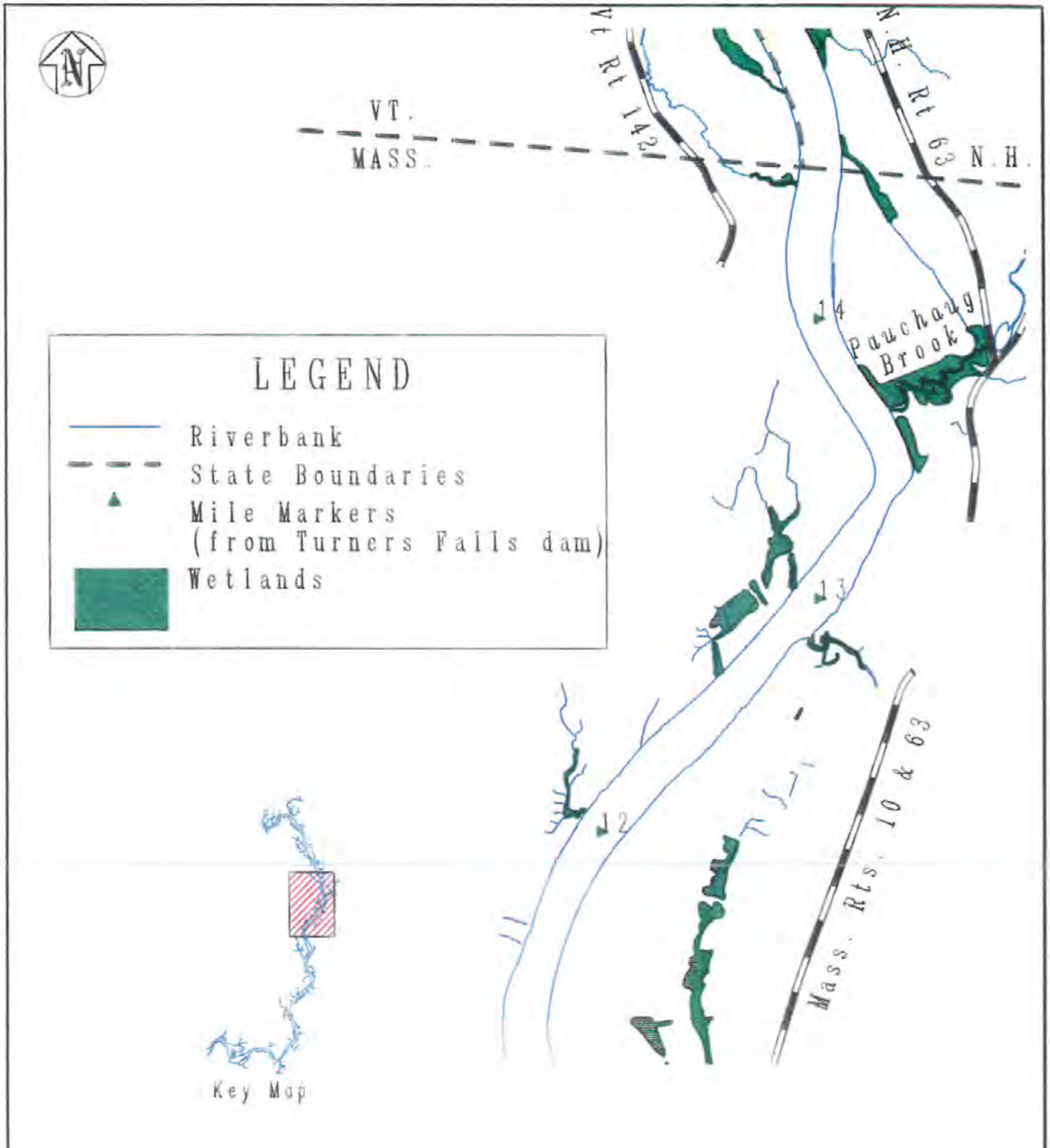
MAP III-7A



Northeast Utilities

Connecticut River
Riverbank Master Plan
Wetlands
Map 2 of 4

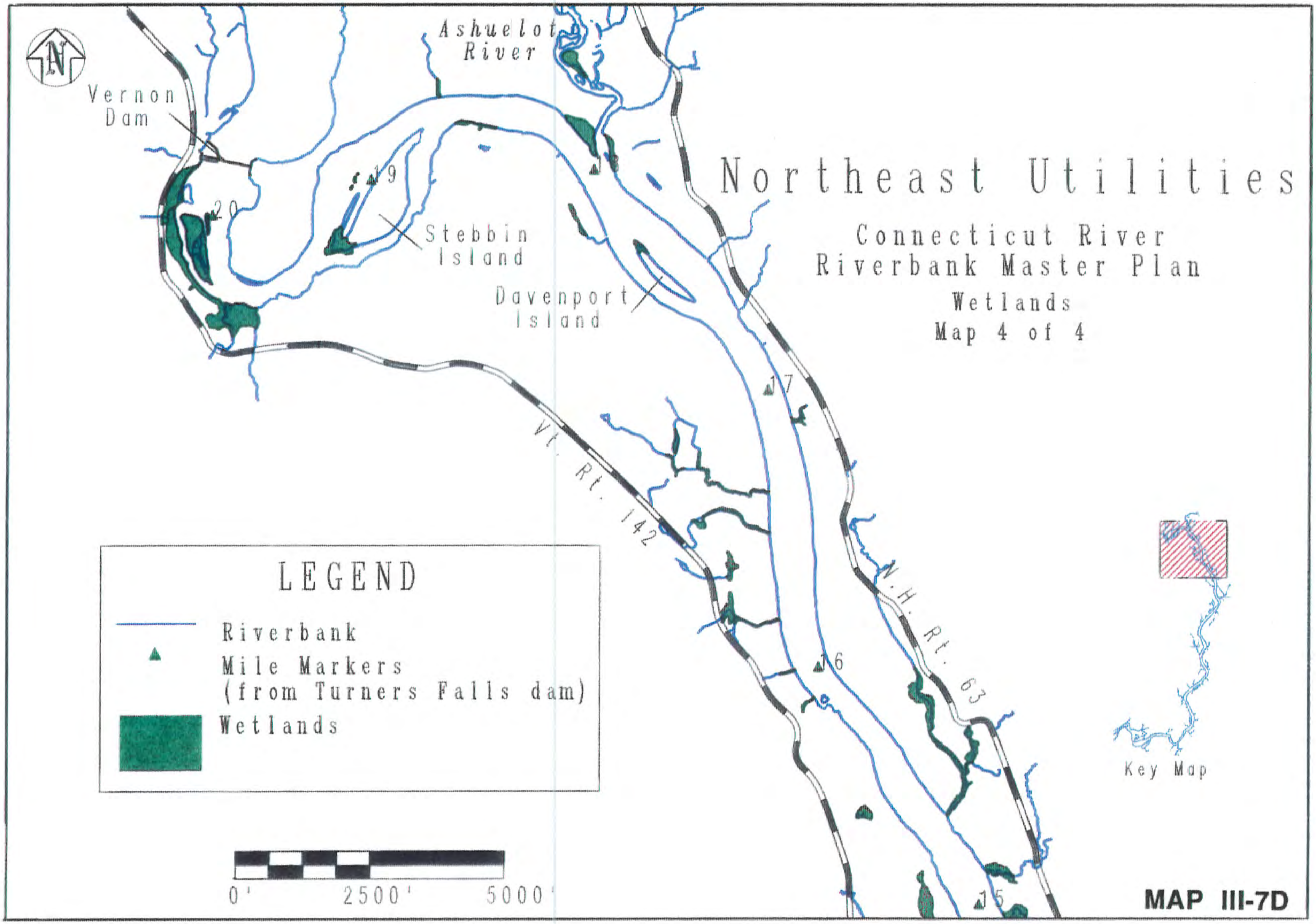
MAP III-7B



Northeast Utilities

Connecticut River
Riverbank Master Plan
Wetlands
Map 3 of 4

MAP III-7C



Ashuelot
River
Vernon
Dam
19
20
Stebbin
Island
Davenport
Island
18
17
16
15
Vt. Rt. 142
N.H. Rt. 63
Northeast Utilities
Connecticut River
Riverbank Master Plan
Wetlands
Map 4 of 4
LEGEND
Riverbank
Mile Markers
(from Turners Falls dam)
Wetlands
0'
2500'
5000'
Key Map

MAP III-7D

Typical tributary stream wetland area is highlighted by high flows in this view of Pine Meadow Brook - April 12, 1969.

Forested wetland abuts low-relief river shoreline for approximately 1,500 ft upstream of Pauchaug Brook (State-owned boat launch is on right) - May 22, 1990.

PHOTO PANEL III-5

TABLE III-4

WETLANDS ADJACENT TO
EXISTING EROSION SITES

Erosion Site No.	Total Erosion Site Length (ft)	Length of Erosion Adjacent to Wetland (ft)	Percentage of Erosion Site Adjacent to Wetland
9	54	605	8.9
10	56	184	30.6
11	392	392	100.0
12	358	782	45.9
23	353	437	80.9
24	56	2041	2.8
25	138	811	17.1
30	139	1677	8.3
52	91	1063	8.6
56	175	4125	4.3
59	193	1999	8.2
TOTALS	1975	14116	

6. Fisheries, Plant and Wildlife Habitat

ND&T has reviewed available literature concerning overall fisheries, plant and wildlife habitat within the Turners Falls Pool and has contacted Fisheries & Wildlife and Natural Heritage Program representatives in New Hampshire, Vermont and Massachusetts to determine prior evidence of any unique species within the study area. Upon review of the available literature and on the basis of field observations conducted periodically between February and November of 1990, a characterization of habitat within the Turners Falls Pool has been made.

The Turners Falls Pool of the Connecticut River primarily supports a warm-water fishery population. A detailed study of the project area's fisheries was conducted throughout the early 1970's by the Massachusetts Division of Fisheries & Game. It states that there are two primary fisheries habitats within the Turners Falls Pool - The Barton Cove pool area and the mainstem heading upstream from Barton Peninsula. The Barton Cove habitat is typified by a river bottom of clay and sand sediments and fine silt with relatively low flow velocities. The mainstem habitat is typified by a coarser bottom substrate of sand and gravel with typical river velocities.

Over a five-year study period from 1971 to 1976 the following resident fish species were identified as the primary species in each river segment. Subsequent monitoring of fish populations performed as a follow-up to this study generally re-confirms this same fish population distribution.

Barton Cove (4,188 fish/21 species):

Bluegill - 43%	Pumpkinseed - 12%
Yellow perch - 21%	Golden shiner - 6%

Mainstem (3,618 fish/19 species):

White perch - 48%	Bluegill - 9%
Spottail shiner - 12%	White sucker - 7%
Yellow perch - 9.5%	Smallmouth bass - 5%

Fish passage facilities at the Turners Falls Dam are also designed to support the use of the project area by anadromous species such as salmon and shad. NUSCO closely monitors the passage of these species at the dam. No protected species of fish have been documented in the Turners Falls Pool to date, although the shortnose sturgeon has been found downstream of the project area.

Once ND&T conducted its preliminary rating of all erosion sites, field investigations were conducted regularly between mid-August and the end of October to locate and identify all rare, threatened and endangered flora and fauna within the riverbank face and adjacent top of bank area associated with all severe and moderate-to-severe sites. This exercise included walking riverbank areas to identify plants and wildlife habitat on 18 erosion sites totaling approximately three miles. An additional five moderate erosion sites were also visited. Table III-5 lists all confirmed protected plant species discovered. Table III-6 identifies all of the confirmed or suspected state-listed unique plants discovered during field observations. Maps III-8A through 8E show the locations of the specific sites referenced in Tables III-5 and III-6. Those plants which are listed as potentially rare must be viewed again during the correct flowering season in order to clarify the exact species. Appendix G also lists a representative sample of typical flora found throughout the project area, and fauna and related habitat sites recorded during field observations.

The overall study area, as well as the entire Connecticut River valley, plays a meaningful role for wildlife propagation, especially for birds. A wide range of birds were spotted along the river, including ospreys, red-tailed hawks, turkey vultures, great blue herons and bluebirds. Resident populations of bank swallows favor steep, exposed banks where they can easily build nesting cavities. A nesting pair of bald eagles exists on Barton Island (see Photo Panel III-8 at the end of this section) and the first native eagle chick on the Connecticut River in Massachusetts in this century was hatched there in April, 1990. These federally endangered eagles were the only birds or mammals identified within the project area that are either rare, threatened or endangered. The expansive pool in Barton's Cove is favored by waterfowl, especially in the spring. The daily fluctuations in river elevation caused by the Northfield Mountain Project are most pronounced in Barton Cove and this phenomenon has promoted its use by wading birds, especially in the summer and early fall.

Many signs of small mammals, mainly chipmunks, skunks, moles, and some beaver were located during field investigations. Identifying signs included tracks, nesting cavities and in some cases the observation of a particular mammal. However, the heaviest wildlife use was by birds, with bank swallow nests evidenced as the most significant use within the riverbanks, particularly at the most eroded sites.

The majority of known rare, threatened or endangered plants located are on sites in Vermont or New Hampshire. In fact, nearly all protected species identified were discovered in a 3,500 ft stretch as shown on Map III-8E. Sites between Stebbins Island and the Massachusetts border feature the following unique plants: incurved umbrella sedge, sandbur, showy goldenrod, mild water-pepper, shore cyperus and tufted beggar-ticks. No confirmed rare, threatened or endangered plants were found on sites located in Massachusetts. Suspected unique plants located there must be visited during their respective flowering seasons to confirm their identity. The prevalence of unique plants found in Vermont and New Hampshire is partially caused by the fact that these plants are located in the southern most portion of the two states and in bioregions that are uncommon within each state. None of these unique plants are listed as protected species within Massachusetts.

Of the unique plant species spotted at or near the investigated erosion sites, the Sandbur (Cenchrus longispinus) was the most prevalent. It was sited at six locations - sites 3, 4, 5, 10, 12 and 13 - all in Vermont. A few plants were seen within the riverbank, but the vast majority were located from the top of bank, between 5 and 25 ft. away. Also of special significance are the discovery of mild water pepper (Polygonum hydropiperoides) at sites 12 and 13, and the uncovering of a single Tufted beggar ticks (Bidens comosa) plant at site 12. Both of these species possessed only one single current site within the State of Vermont prior to this Master Plan. Both species exist between five and ten feet from the river shoreline. Photo Panels III-6 and III-7 show the tufted beggar ticks, the mild water pepper and the sandbur at the sites investigated for this Master Plan.

TABLE III-5

CONFIRMED RARE, THREATENED, OR ENDANGERED PLANT SPECIES WITHIN TURNERS FALLS POOL

State & Site	Status	Plant Name	Plant Location
VT-3	S2G5	Sandbur (Cenchrus longispinus)	15 ft from top of slope
VT-4	S2G5	Sandbur (Cenchrus longispinus)	15 ft from top of slope
VT-5	S2G5	Sandbur (Cenchrus longispinus)	8 ft from shoreline
NH-7	T	Incurved umbrella sedge (Cyperus gristatus)	5 ft from shoreline
VT-10	S2G5	Sandbur (Cenchrus longispinus)	8-10 ft from shoreline
	**	Mild water pepper (Polygonum hydropiperoides)	6 ft from shoreline
VT-12	S2G5	Sandbur (Cenchrus longispinus)	20-25 ft from top of slope
	**	Mild water pepper (Cenchrus longispinus)	7 ft from shoreline
	*	Tufted beggar ticks (Bidens comosa)	5-10 ft from shoreline
VT-13	#	Whorled milkwort (Polygala verticillata)	20 ft from shoreline
	S2G5	Sandbur (Cenchrus longispinus)	6 ft from shoreline
	E	Shore cyprus (Polygonum hydropiperoides)	At shoreline
	**	Mild water pepper (Polygonum hydropiperoides)	5 ft from shoreline
VT-20	E	Shore cyprus (Cyperus diandrus)	5 ft from shoreline
NH-25	T	Hackberry (Celtis occidentalis)	5-20 ft from shoreline

S2G5 - 6-20 sites within State/globally secure species
* - Single current site
** - Single current site, several historical sites
T - Threatened
E - Endangered
- Fewer than 10 current sites

TABLE III-6

CONNECTICUT RIVER FLORA AT EROSION SITES

State & Site	Flag Location No.	Plant of Importance	No. of Plants	Status	Other Possible Common Species	Reason why plant of importance is not confirmed	When plant should be observed in flower	Plant Location
NH Site 7	7-4A	Cardamine pratensis var. palustris Cuckoo flower	1	E	Cardamine parviflora	Just basal leaves	Sp	At shoreline
NH Site 7	7-7A	Cardamine pratensis var. palustris Cuckoo flower	1	E	Cardamine parviflora	Just basal leaves	Sp	At shoreline
NH Site 7	7-8A	Cyperus aristatus Incurved Umbrella-sedge	1	T	None			5' from shoreline
NH Site 7	7-9A	Cyperus aristatus Incurved Umbrella-sedge	1	T	None			5' from shoreline
NH Site 7	7-10A	Solidago speciosa Showy Goldenrod	39	to be determined	None			25' from top of slope
NH Site 7	7-11A	Solidago speciosa Showy Goldenrod	2	to be determined	None			30' from top of slope
NH Site 7	7-12A	Solidago speciosa Showy Goldenrod	1	to be determined	None			30' from top of slope
VT Site 5	5-1B	Cenchrus longispinus Sandbur	6	S2 G5	None			8' from shoreline
VT Site 10	10-2B	Cenchrus longispinus Sandbur	10+	S2 G5	None			8' from shoreline
VT Site 10	10-3B	Cenchrus longispinus Sandbur	1	S2 G5	None			10' from shoreline
VT Site 10	10-4B	Polygonum hydropiperoides Mild Water-pepper	1	A single current site, several historical sites	None			6' from shoreline

E = endangered
T = threatened

SC = special concern
WL = watch list

S2 G5 = S2 is the state ranking, there being approximately 6-20 occurrences believed to be extant or some factors making it very vulnerable to extirpation in the state. G5 is the global ranking, stating that the species is demonstrably secure globally.

TABLE III-6 (Cont.)

State & Site	Flag Location No.	Plant of Importance	No. of Plants	Status	Other Possible Common Species	Reason why plant of importance is not confirmed	plant should be observed in flower	Plant Location
VT Sites 3, 4, 5	3-5B	Cenchrus longispinus Sandbur	200+	S2 G5	None			15' from top of slope
VT Site 12	12-1C	Bidens comosa Tufted Beggar-ticks	1	A single historical site		None		5' from shoreline
VT Site 12	12-2C	Polygonum hydropiperoides Mild Water-pepper	2	A single current site, several historical sites		None		10' from shoreline
VT Site 12	12-3C	Polygonum careyi Carey's Knotweed	1	Historic only	Polygonum amphibium	Could not relocate to final I.D.	Su, F	12' from shoreline
VT Site 12	12-4C	Ranunculus pensylvanicus Pennsylvania Crowfoot	3	WL	None			15' from shoreline, midway up slope
VT Site 12	12-5C	Bidens comosa Tufted Beggar-ticks	1	A single historical site		None		10' from shoreline
VT Site 12	12-6C	Cenchrus longispinus Sandbur	50+	S2 G5	None			Above slope, 20' from rim of slope
VT Site 12	12-7C	Cenchrus longispinus Sandbur	5	S2 G5	None			Above slope, 25' from rim of slope
VT Site 12	12-8C	Polygonum hydropiperoides Mild Water-pepper	1	A single current site, several historical sites		None		7' from shoreline
VT Site 13	13-1D	Cenchrus longispinus Sandbur	5	S2 G5	None			6' from shoreline, midway up slope
VT Site 13	13-2D	Veronica anagallis-aquatica Brook pimpernel	1	Unknown	Epilobium glandulosum	Just leaves	Su	1' from shoreline
VT Site 13	13-3D	Eleocharis ovata Ovate Spike-rush	10	3 current sites, 8 historical sites	Eleocharis obtusa	Could not relocate to	Su, F	At shoreline final I.D. due to high water

TABLE III-6 (Cont.)

State & Site	Flag Location No.	Plant of Importance	No. of Plants	Status	Other Possible Common Species	Reason why plant of importance is not confirmed	When plant should be observed in flower	Plant Location
VT Site 13	13-4D	Cyperus diandrus Shore cyperus	1	E	None			At shoreline
VT Site 13	13-5D	Cenchrus longispinus Sandbur	31	S2 C5	None			15' from shoreline, at upper slope
VT Site 13	13-6D	Polygala verticillata Whorled Milkwort	37	Fewer than 10 current sites	None			20' from shoreline, at upper slope, just below rim
VT Site 13	13-7D	Polygonum hydropiperoides Mild Water-pepper	1	A single current site, several historical sites	None			5' from shoreline
VT Site 13	13-8D	Lycopus virginicus Virginia Bugleweed	2	Unknown	Lycopus uniflorus	Should be observed in flower	Su, F	1' from shoreline
VT Site 13	13-9D	Cenchrus longispinus Sandbur	300+	S2 C5	None			Above slope, 27' from rim
VT Site 13	13-10D	Cenchrus longispinus Sandbur	50+	S2 C5	None			Above slope, 15' from rim
VT Site 20	20-1E	Lycopus virginicus Virginia Bugle weed	1	Unknown	Lycopus uniflorus	Should be observed in flower	Su, F	2'from shoreline
VT Site 20	20-2E	Cyperus diandrus Shore cyperus	2	E	None			5' from shoreline, midway up slope
VT Site 20	20-3E	Cardamine pratensis var. palustris Cuckoo flower	3	1 cur. site ca. 8 histori-cal sites	Cardamine parviflora	Just basal leaves	Sp	3' from shoreline, low to mid slope area
VT Site 20	20-4E	Cardamine pratensis var. palustris Cuckoo flower	1	1 cur. site ca. 8 histori-cal sites	Cardamine parviflora	Just basal leaves	Sp	3' from shoreline, low to middle slope area
NH/MA Site 25	25-1F	Cardamine pratensis var. palustris Cuckoo flower	1	E in NH T in MA	Cardamine parviflora	Just basal leaves	Sp	2' from shoreline

TABLE III-6 (Cont.)

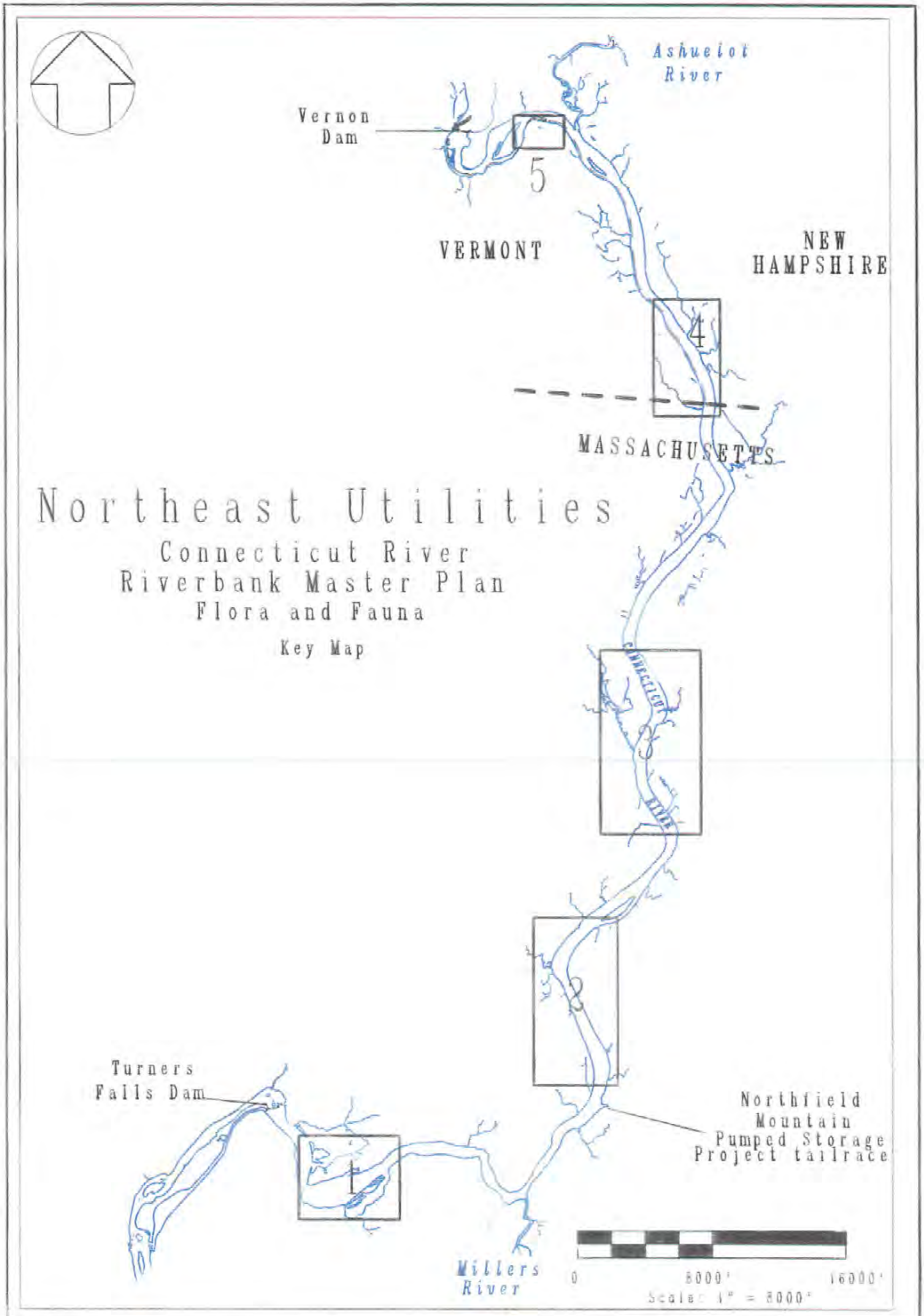
State & Site	Flag Location No.	Plant of Importance	No. of Plants	Status	Other Possible Common Species	Reason why plant of importance is not confirmed	When plant should be observed in flower	Plant Location
NH/MA Site 25	25-2F	Cardamine pratensis var. palustris Cuckoo flower	3	E in NH T in MA	Cardamine parviflora	Just basal leaves	Sp	3' from shoreline
NH/MA Site 25	25-3F	Celtis occidentalis Hackberry	1	T in NH	None			12' from shoreline, upper slope area
NH/MA Site 25	25-4F	Arabis laevigata Smooth Rock-cress	10+	T in MA	Hesperis matronalis	Just basal leaves and empty seed pods	Sp, Su	12' from shoreline, upper slope area and above slope
NH/MA Site 25	25-5F	Celtis occidentalis Hackberry	1	T in NH	None			5' from rim, located above slope
NH/MA Site 25	25-6F	Prenanthes serpentaria Lion's foot	2	E in MA	Prenanthes alba	Just basal leaves	F	15' from rim, located above slope
NH/MA Site 25	25-7F	Celtis occidentalis Hackberry	1	T in NH	None			20' from rim, located above slope
NH/MA Site 25	25-8F	Cardamine douglassii Purple Cress	1	E in MA	Brassica rapa	Just basal leaves	Sp	3' from shoreline
NH/MA Site 25	25-9F	Mimulus alatus Winged Monkey-flower	2	E in MA	Mimulus ringens	Young plant without flowers	Su	1' from shoreline
NH/MA Site 25	25-10F	Cardamine pratensis var. palustris Cuckoo flower	1	E in NH T in MA	Cardamine parviflora	Just basal leaves	Sp	1' from shoreline
MA Site 38	38-2G	Cardamine pratensis var. palustris	2	T	Cardamine parviflora	Just basal leaves	Sp	1' from shoreline
MA Site 38	38-3G	Cardamine douglassii Purple cress	1	E	Brassica rapa	Just basal leaves	Sp	3' from shoreline
MA Site 38	38-4G	Cardamine douglassii Purple cress	1	E	Brassica rapa	Just basal leaves	Sp	3' from shoreline
MA Site 44	44-2H	Cardamine douglassii Purple cress	1	E	Brassica rapa	Just basal leaves	Sp	2' from shoreline
MA Site 44	44-3H	Cardamine douglassii Purple cress	1	E	Brassica rapa	Just basal leaves	Sp	2' from shoreline
MA Site 44	44-4H	Cardamine douglassii Purple cress	1	E	Brassica rapa	Just basal leaves	Sp	2' from shoreline

TABLE III-6 (Cont.)

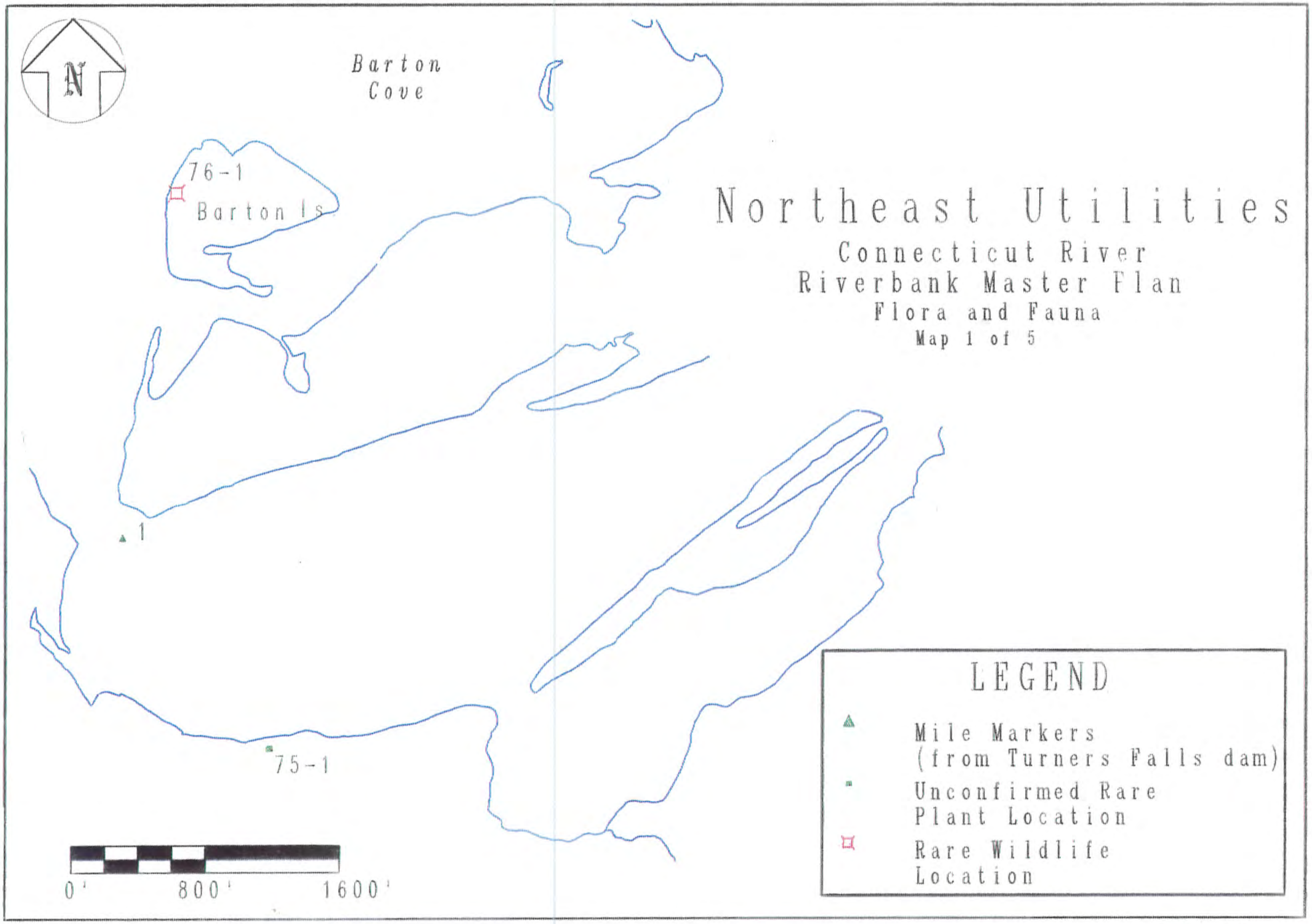
State & Site	Flag Location No.	Plant of Importance	No. of Plants	Status	Other Possible Common Species	Reason why plant of importance is not confirmed	When plant should be observed in flower	Plant Location
MA Site 44	44-5H	Cardamine pratensis var. palustris Cuckoo flower	1	T	Cardamine parviflora	Just basal leaves	Sp	1' from shoreline
MA Site 44	44-6H	Cardamine pratensis var. palustris Cuckoo flower	1	T	Cardamine parviflora	Just basal leaves	Sp	On stump in water
MA Site 44	44-7H	Cardamine douglassii Purple cress	1	E	Brassica rapa	Just basal leaves	Sp	Upper slope, just below rim
MA Site 48	48-1I	Cardamine douglassii Purple cress	4	E	Brassica rapa	Just basal leaves	Sp	3' from shoreline
MA Site 48	48-2I	Cardamine pratensis var. palustris Cuckoo flower	1	T	Cardamine parviflora	Just basal leaves	Sp	1' from shoreline
MA Site 48	48-3I	Cardamine douglassii Purple cress	1	E	Brassica rapa	Just basal leaves	Sp	6' from shoreline
MA Site 48	48-4I	Mimulus alatus Winged Monkey-flower	1	E	Mimulus ringens	Young plant without flowers	Su	1' from shoreline
MA Site 48	48-5I	Cardamine douglassii Purple cress	1	E	Brassica rapa	Just basal leaves	Sp	3' from shoreline
MA Site 51	51-1	Cardamine pratensis var. palustris Cuckoo flower	1	T	Cardamine parviflora	Just basal leaves	Sp	Lower bank
MA Site 51	51-2	Cardamine pratensis var. palustris Cuckoo flower	1	T	Cardamine parviflora	Just basal leaves	Sp	Below eroded section of upper bank
MA Site 52	52-1	Cardamine pratensis var. palustris	1	T	Cardamine parviflora	Just basal leaves	Sp	20' from upperbank edge (north of swale)
MA Site 62	62-1P	Cardamine douglassii Purple cress	3	E	Brassica rapa	Just basal leaves	Sp	Above slope, 5' from rim
MA Site 64	64-1L	Cardamine pratensis var. palustris	1	T	Cardamine parviflora	Just basal leaves	Sp	On soiled tree stump at water-line
MA Site 68	68-1M	Mimulus alatus Winged Monkey-flower	1	E	Mimulus ringens	Young plant without flowers	Su	1' from shoreline

TABLE III-6 (Cont.)

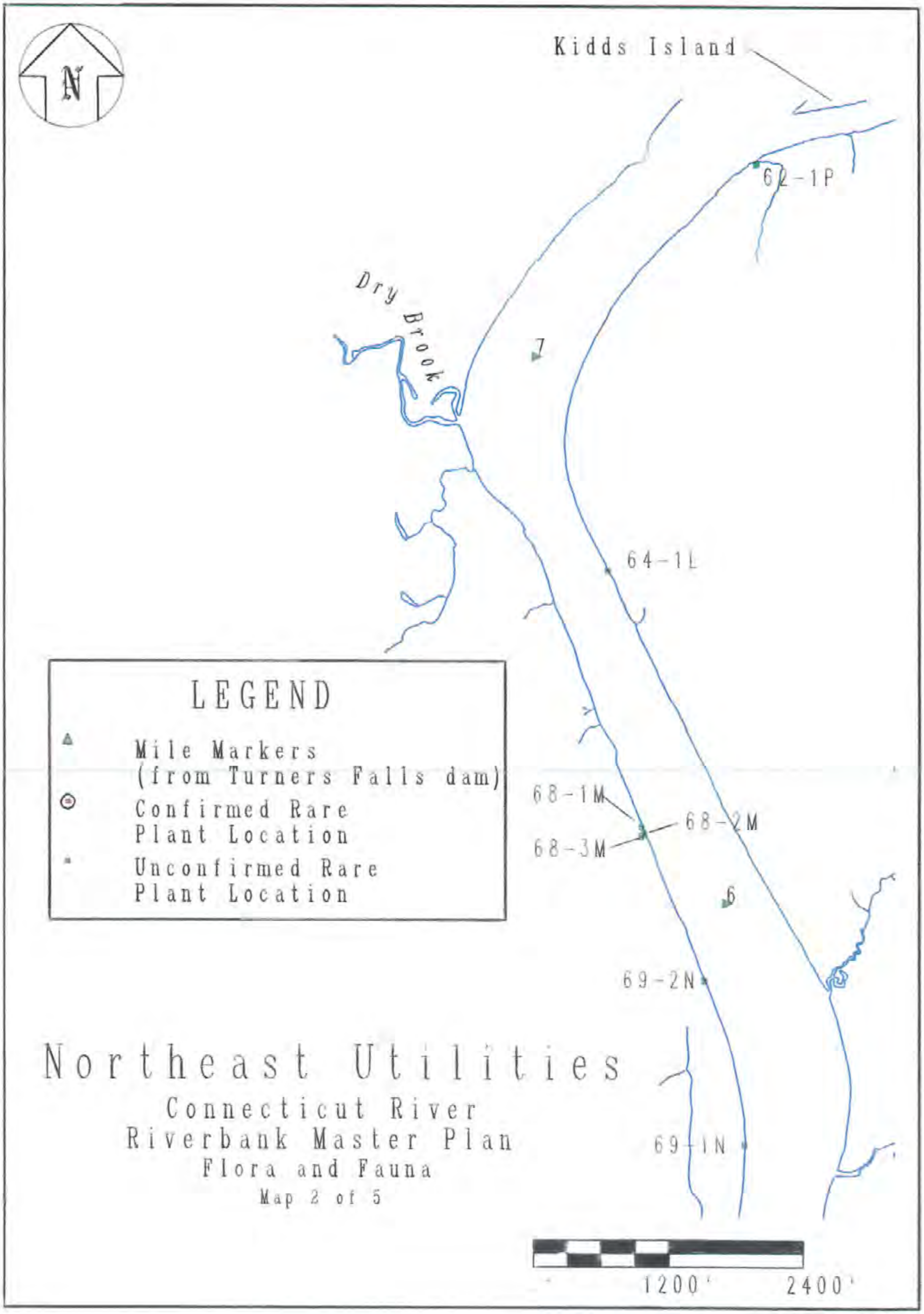
State & Site	Flag Location No.	Plant of Importance	No. of Plants	Status	Other Possible Common Species	Reason why plant of importance is not confirmed	When plant should be observed in flower	Plant Location
MA Site 68	68-2M	Cardamine douglassii Purple cress	1	E	Brassica rapa	Just basal leaves	Sp	2' from shoreline
MA Site 68	68-3M	Arabis laevigata Smooth Rock-cress	3	T	Arabis canadensis	Just dying stem with empty seed pods	Sp, Su	Above slope, 12' from rim
MA Site 69	69-1N	Cardamine pratensis var. palustris Cuckoo flower	1	T	Cardamine parviflora	Just basal leaves	Sp	1' from shoreline
MA Site 69	69-2N	Cardamine douglassii Purple cress	1	E	Brassica rapa	Just basal leaves	Sp	2' from shoreline


Ashuelot River
Vernon Dam
5
VERMONT
NEW HAMPSHIRE
4
MASSACHUSETTS
Northeast Utilities
Connecticut River
Riverbank Master Plan
Flora and Fauna
Key Map
CONNECTICUT
3
RIVER
2
Turners Falls Dam
Northfield Mountain Pumped Storage Project tailrace
1
Millers River
0
8000'
16000'
Scale: 1" = 8000'

MAP III-8

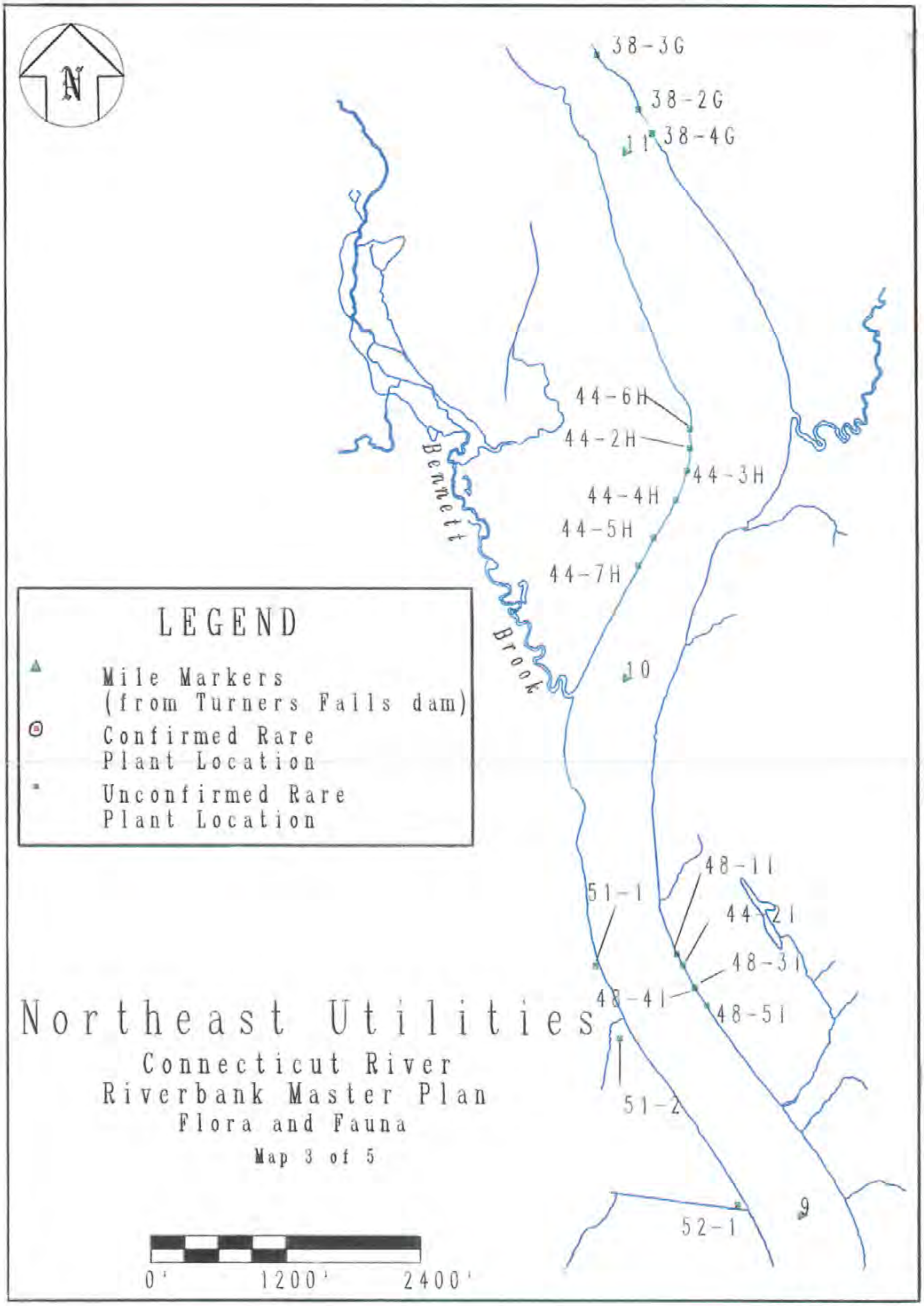

N
Barton Cove
76-1
Barton Is.
Northeast Utilities
Connecticut River
Riverbank Master Plan
Flora and Fauna
Map 1 of 5
1
75-1
LEGEND
Mile Markers
(from Turners Falls dam)
Unconfirmed Rare
Plant Location
Rare Wildlife
Location
0'
800'
1600'

MAP III-8A

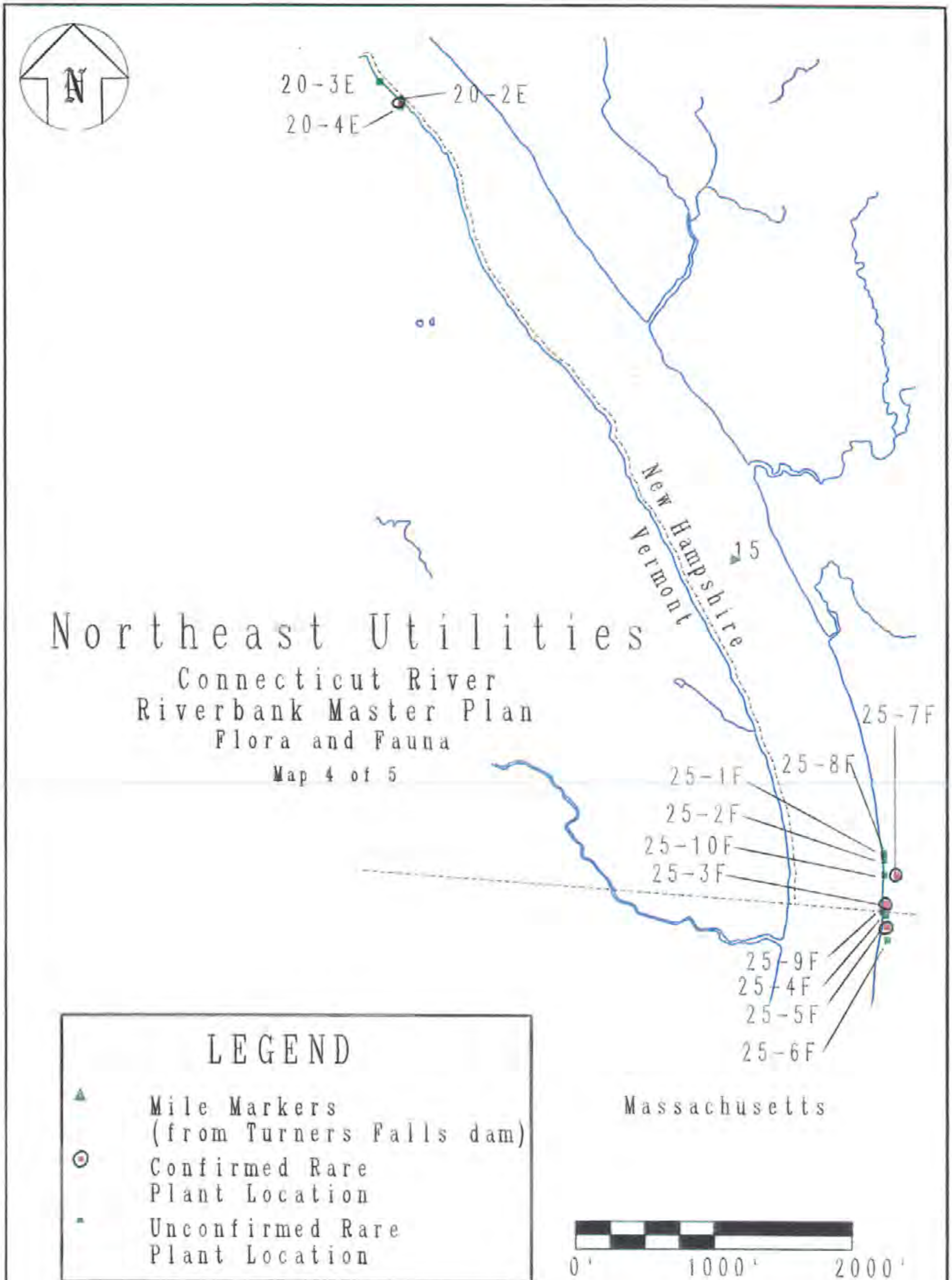


Kidds Island
Dry Brook
62-1P
7
64-1L
LEGEND
Mile Markers
(from Turners Falls dam)
Confirmed Rare
Plant Location
Unconfirmed Rare
Plant Location
68-1M
68-2M
68-3M
6
69-2N
Northeast Utilities
Connecticut River
Riverbank Master Plan
Flora and Fauna
Map 2 of 5
69-1N
1200'
2400'

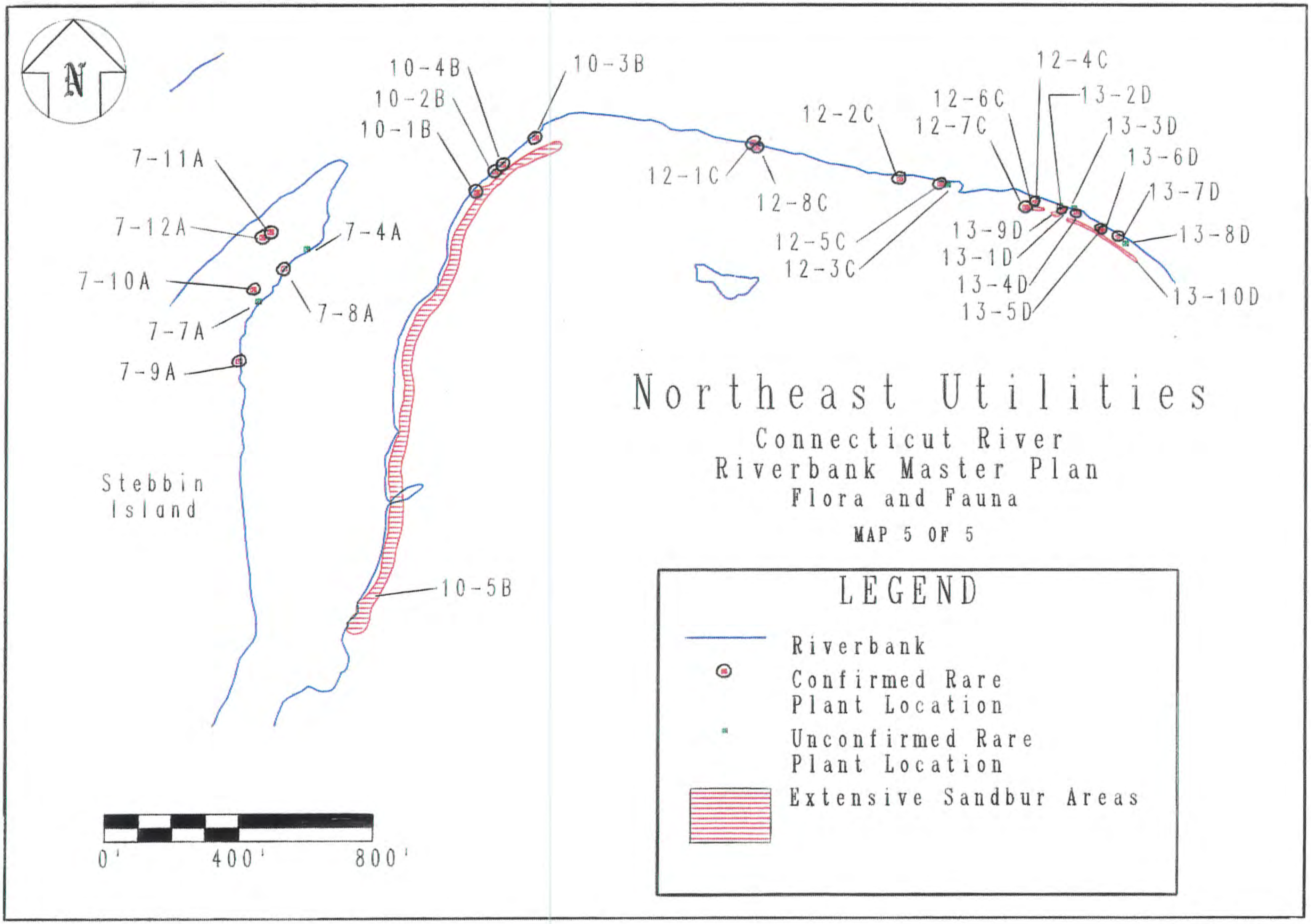
MAP III-8B


N
38-3G
38-2G
38-4G
11
44-6H
44-2H
44-3H
44-4H
44-5H
44-7H
Bennett
Brook
10
LEGEND
Mile Markers
(from Turners Falls dam)
Confirmed Rare
Plant Location
Unconfirmed Rare
Plant Location
48-11
51-1
44-21
48-31
48-41
48-51
Northeast Utilities
Connecticut River
Riverbank Master Plan
Flora and Fauna
Map 3 of 5
51-2
9
52-1
0'
1200'
2400'

MAP III-8C

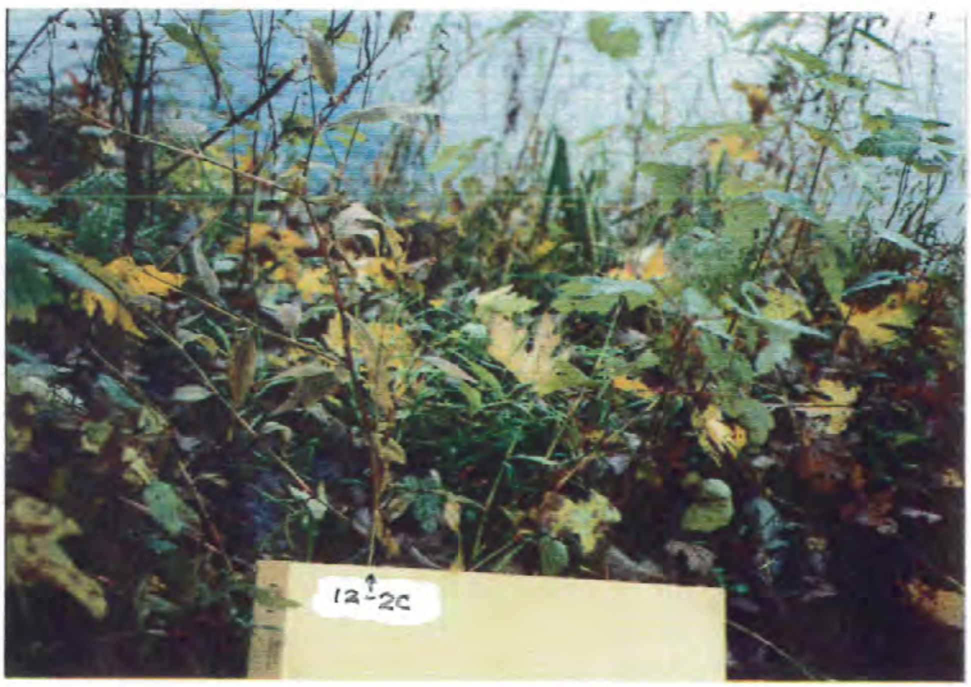

N
20-3E
20-2E
20-4E
New Hampshire
Vermont
15
Northeast Utilities
Connecticut River
Riverbank Master Plan
Flora and Fauna
Map 4 of 5
25-7F
25-8F
25-1F
25-2F
25-10F
25-3F
25-9F
25-4F
25-5F
25-6F
LEGEND
Mile Markers
(from Turners Falls dam)
Confirmed Rare
Plant Location
Unconfirmed Rare
Plant Location
Massachusetts
0'
1000'
2000'

MAP III-8D


N
10-4B
10-2B
10-1B
10-3B
7-11A
7-12A
7-4A
7-10A
7-8A
7-7A
7-9A
12-4C
12-6C
13-2D
12-2C
12-7C
13-3D
13-6D
12-1C
12-8C
13-7D
12-5C
12-3C
13-9D
13-1D
13-4D
13-5D
13-8D
13-10D
10-5B
Stebbin
Island
Northeast Utilities
Connecticut River
Riverbank Master Plan
Flora and Fauna
MAP 5 OF 5
LEGEND
Riverbank
Confirmed Rare
Plant Location
Unconfirmed Rare
Plant Location
Extensive Sandbur Areas
0'
400'
800'

MAP III-8E

Tufted Beggar Ticks - This plant is listed as having only one current site in Vermont, and was found at erosion site #12 - September, 1990.



Mild Water Pepper - Listed in Vermont as having only one current site and several historical sites. This plant was found at erosion sites #10, 12 and 13 - September, 1990.

Sandbur - This protected species was found in abundance at erosion sites 3, 4, 5, 10, 12 and 13 Sept. 1990.

Bank swallow nest holes at erosion site #60, west of Kidds Island - Feb. 6, 1990.

PHOTO PANEL III-7

Two mature bald eagles at Barton Island - June 21, 1990.

Turkey vultures perched at northern tip of Davenport Island - June 21, 1990.

7. Scenic Resources

Scenic values were assessed along the Turners Falls Pool by seeking previously completed studies concerning the Turners Falls Pool's landscape character and scenic qualities, and then by field visiting all public access points along the riverbanks and bridge crossings in July and August, 1990. During these field visits panoramic photos were taken from each viewpoint to assess the riverbank's length and dominance within the viewing area, and the role of existing erosion sites within these views. Additional field visits were made by boat during which the role of erosion sites was assessed in relation to views from the river surface. Observations from these boat excursions were also combined with aerial photo analyses to segment the river into river-surface viewsheds. Landscape character ratings were then assigned to each segmented viewshed.

Fourteen river-surface viewsheds were categorized and landscape character was assigned to these areas based on the level of visual variety and diversity of landscape types encountered (i.e. vegetative cover, water, land use, topography). These viewshed segments were subdivided in relation to bends in the river, transition in vegetative and topographic features, the presence of cultural features (such as bridges, building clusters) and background land form scenery. Landscape character classifications listed from lowest quality to highest quality are "common," "noteworthy" and "distinctive." This rating system is in accordance with the system used by the Massachusetts Department of Environmental Management's (DEM) 1982 Natural Landscape Inventory. The definitions used in the DEM landscape inventory are as follows:

<u>Distinctive</u>:	Areas of highest visual quality
<u>Noteworthy</u>:	Areas of lesser, but nevertheless important, visual quality
<u>Common</u>:	An area that contains many smaller sections of scenic quality but lacks the consistently high levels found in distinctive and noteworthy areas

In the DEM study, the entire Turners Falls Pool is rated as a "distinctive" landscape where "the juxtaposition of open valley and wooded hills makes for outstanding scenery." Only 4 percent of the total area in the Commonwealth is classified as distinctive. Table III-7 entitled "Segmented Viewsheds Along River" presents the landscape characterizations and site descriptions at each of the 14 segments created within the study area, Maps III-9A and 9B show these segment locations. The French King Gorge Upstream segment (#5) is considered "distinctive," and the French King Gorge Downstream (#4), Kidds Island (#7) and Bennett Meadow (#9) segments are considered "noteworthy." The remaining nine segments have been rated "common."

These segment designations are based on common, noteworthy, and distinctive traits within the project area and its surrounding scenic landscape. for instance, the designation of a segment as common indicates that the landscape is common from the proximity of the river surface as one looks at the adjacent land forms. This perspective of analysis is designed to emphasize the riverbank's role within the landscape. It is a role which is limited primarily to the view of a boater. It encompasses the role of all 76 erosion sites throughout the entire project area. In contrast, there are a limited number of land-based river viewpoints which afford views of only 26 different erosion sites. These viewpoint views are deemed more significant since they are accessible to a larger number of people than boaters, although the view of a given erosion site is often obstructed or too far away to be prominent.

Thirteen publicly accessible scenic viewpoints or viewing areas were identified along the Turners Falls Pool and are identified in Table III-8. They are also shown on Maps III-9A and 9B. They consist of two bridges, two unimproved road segments adjacent to the river and nine recreational areas. The most significant viewpoint occurs at the French King Bridge where the Massachusetts Executive Office of Environmental Affairs has classified the viewpoint as a "special place" of distinct character and memorialized its proclamation with a plaque. The view looking north is truly distinctive with its transition from a narrow, steep-sided gorge to a two-tiered hill and mountain view on the horizon. There are no erosion sites within view from this point. The other bridge crossing on Route 10 presents an expansive hill/mountain view looking southeast over the southern portion of Great Meadow and is considered noteworthy given its expanse and varied terrain features.

The remaining viewpoints and viewing areas begin at the riverbank level and encompass various stretches of the opposite bank. The two viewpoints which feature prominent erosion sites are the Turners Falls Rod & Gun Club located directly across from the steep Barton Peninsula (erosion sites #74), and at NUSCO's Riverview Picnic Area which includes uniform stretches of erosion (sites #68, 69, 70) directly across and upstream along the river's west bank. The remaining viewpoints offer views of erosion sites but the dominance of these erosion sites within the landscape is generally low. Table III-9 lists the erosion sites which are visible from each viewpoint and also labels the visual dominance of each erosion site. This dominance incorporates both the visual character inherent within the erosion site and the distance between the erosion site and the viewpoint. Dominance classifications range from dominant to co-dominant to subordinate. These classifications are also utilized by the Massachusetts DEM.

Photos Panels III-9 through III-12 show the views of the riverbanks from viewpoints 2, 4, 6, 8, 11, and 12. These photos were taken in August, 1990 and are indicative of views of the riverbanks with summer and fall vegetative cover. The visual assessment was undertaken at this time of year since the great majority of views from the river and accessible riverbank viewpoints are seen by people between late spring and fall. Erosion sites are more visible during the vegetatively dormant months between November and April; however, the use of the viewpoints during these months is substantially less than in the summer months. Boater use is likewise concentrated in the May through September months, and visual impacts to boaters should be based on the views witnessed in the photos shown in this Master Plan.

Residential views of the river and its riverbank areas are concentrated in the densely-populated areas immediately upstream of the Turners Falls Dam, in the Dry Brook area in Gill and in a few isolated pockets upstream of the Route Ten Bridge. Only the Dry Brook area residences have an uninterrupted view of erosion areas - those being views of erosion sites #63 and #64 on the East bank.

TABLE III-7

TURNERS FALLS POOL SCENIC EVALUATION:

SEGMENTED VIEWSHEDS ALONG RIVER

Segment No.	Segment Name	Landscape Character*	Description
1	Barton Cove	Common	Large lake-like section of river bordered by Barton Peninsula upstream and relatively densely populated area downstream. Low relief with undeveloped view looking upstream, including nesting eagles on island; mixed development present looking downstream from peninsula.
2	Deep Hole	Common	Expansive river section with uniform, low relief along shoreline. Shoreline dominated by Rod & Gun Club and some steeply eroded banks along peninsula.
3	Horse Race	Common	Uniform river section with occasional riverfront houses and mildly sloping banks. Relatively short stretch between Deep Hole and French King gorge area.

*Landscape character indicates the level of visual variety or diversity of landscape types encountered (i.e., vegetative cover, water, land use,topography). Areas are classified as distincitive, noteworthy, or common.

TABLE III-7 (Cont.)

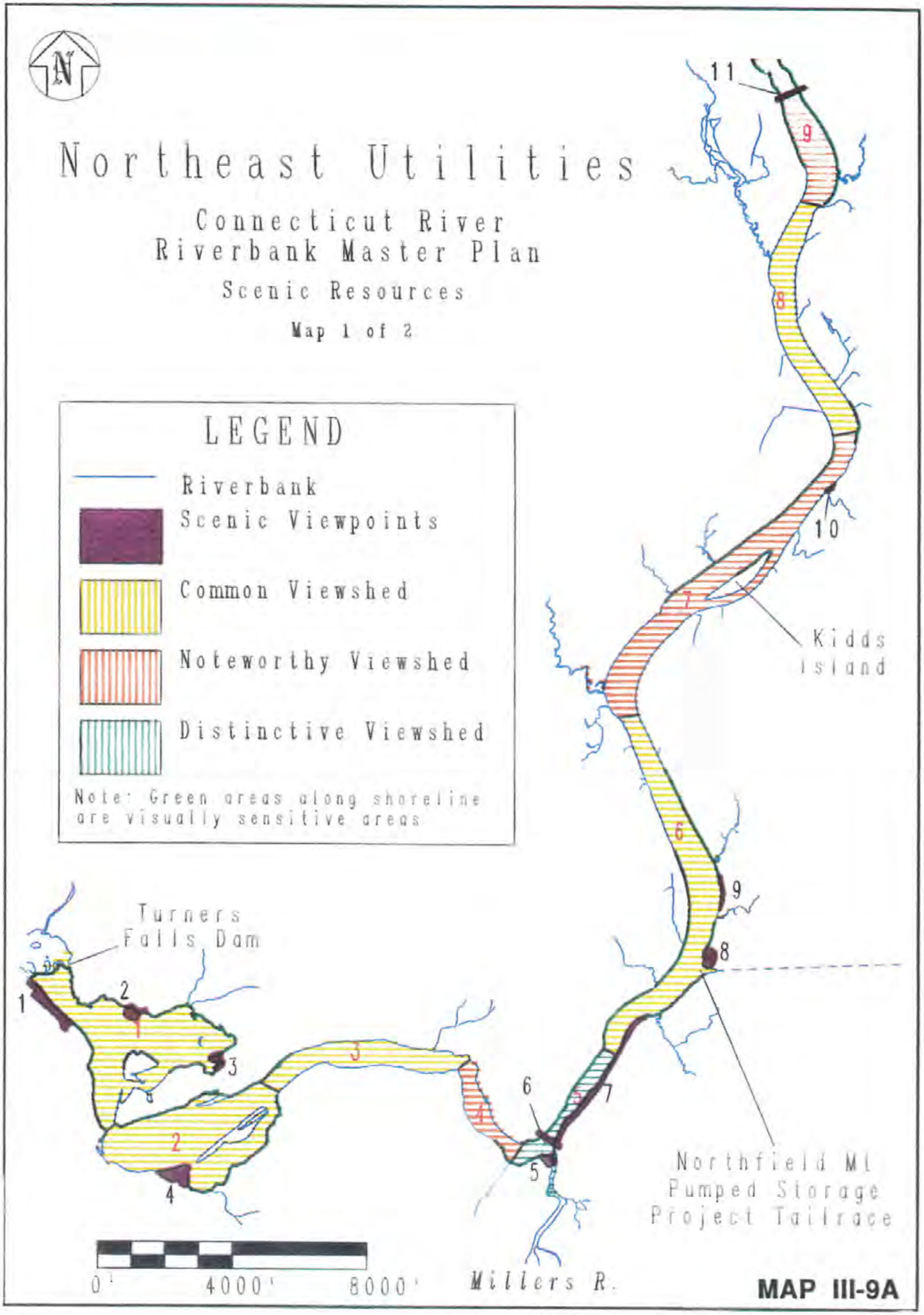
Segment No.	Segment Name	Landscape Character*	Description
4	French King Gorge Downstream	Noteworthy	Steep gorge with high relief and vertical rock faces mixed with diverse vegetation. Confined view of low duration, but unique undeveloped landscape within river valley.
5	French King Gorge Upstream	Distinctive	Limited view downstream, distinctive view upstream of steel arch bridge with transition from steep narrow gorge to background view of two-tiered hill/ mountain horizon. View from bridge has been classified by Mass. EOEA as a "special place" of distinctive character.
6	Riverview Segment	Common	Steep uniform banks giving way to flood-plain terraces supporting farms (thin rows of trees along banks). Moderately hilly beyond terraces.

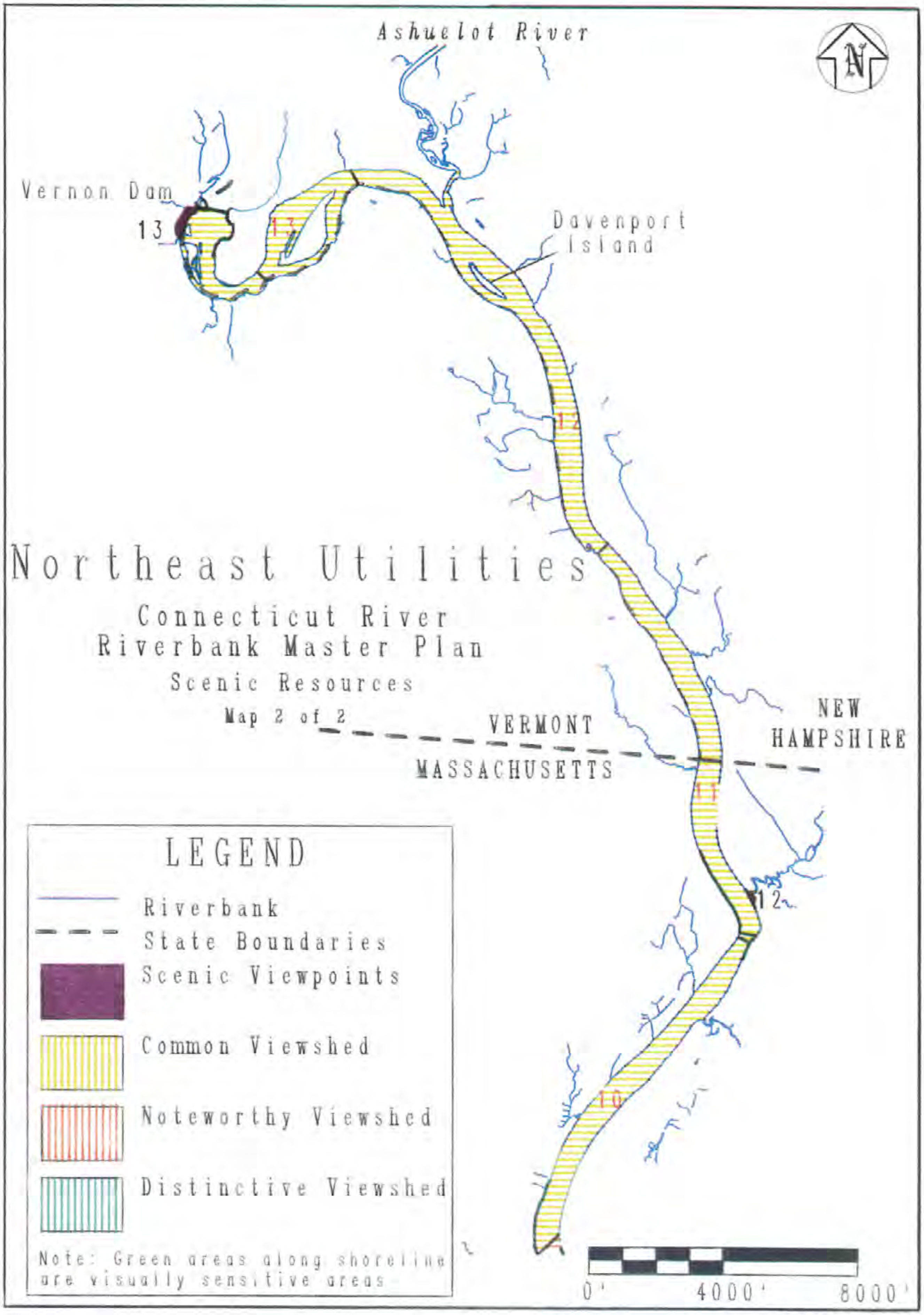
TABLE III-7 (Cont.)

Segment No.	Segment Name	Landscape Character*	Description
7	Kidds Island	Noteworthy	Relatively broad stretch of river centered by Kidds Island, with unique mountain/hill profile looking north/ northeast and isolated hills emerging from floodplain terrace to west. Approximately 2,300 ft. of steep, eroded bank bordering agricultural field near Otter Run dominates foreground view. Above average contrast between land-forms.
8	Beers Plain	Common	Uniform, vegetated bank profile with some distant hill/mountain viewing. Low contrast of landforms.
9	Bennett Meadow	Noteworthy	Broad river stretch with expansive hill/ mountain views looking southeast of Route 10 bridge over southern portion of Great Meadow. Low bank vegetation abutting Podlenski farm adds depth to view. Route 10 bridge interrupts view.
10	Great Meadow	Common	Uniform, vegetated banks with Schell Bridge and distinct mountain/hill range to north and east offering some contrast to straight river stretch.

TABLE III-7 (Cont.)

Segment No.	Segment Name	Landscape Character*	Description
11	Pauchaug Meadow	Common	Confined view of river and immediate vegetated bank areas in uniform river stretch. B & M railroad bridge offers contrast.
12	Davenport Island	Common	Confined view of river and immediate bank area. Davenport Island offers some contrast but blends in easily with horizon.
13	Stebbin Island	Common	Located between two sharp bends in river and dominated by Stebbin Island. Steep, grassy north bank with power line crossing offers contrast, as does cobbled shore on southwest portion of island.
14	Vernon Dam	Common	Narrow downstream section opens to broader pool leading to Vernon Dam. Dam and steep, unvegetated bank immediately east of dam dominate view.


N
Northeast Utilities
Connecticut River
Riverbank Master Plan
Scenic Resources
Map 1 of 2
LEGEND
Riverbank
Scenic Viewpoints
Common Viewshed
Noteworthy Viewshed
Distinctive Viewshed
Note: Green areas along shoreline are visually sensitive areas
Turners Falls Dam
Kidds Island
Northfield Mt Pumped Storage Project Tailrace
Millers R.
0'
4000'
8000'
1
2
3
4
5
6
7
8
9
10
11
MAP III-9A


Ashuelot River
N
Vernon Dam
13
13
Davenport Island
12
Northeast Utilities
Connecticut River
Riverbank Master Plan
Scenic Resources
Map 2 of 2
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
11
12
10
LEGEND
Riverbank
State Boundaries
Scenic Viewpoints
Common Viewshed
Noteworthy Viewshed
Distinctive Viewshed
Note: Green areas along shoreline are visually sensitive areas
0'
4000'
8000'

MAP III-9B

TABLE III-8

TURNERS FALLS POOL SCENIC CLASSIFICATION:

SCENIC VIEWPOINTS

I.D. No.	Viewpoints Accessible to to the Public
1	Riverside Park Area
2	Barton Cove State Boat Launch Area/Franklin County Boat Club
3	Barton Cove Picnic/ Boating Area
4	Turners Falls Rod & Gun Club
5	Millers Falls Point
6	French King Bridge
7	River Road Drive and Pull Out Areas
8	Riverview Picnic Area
9	Pine Meadow Road (from 4-Mile Brook to Pine Meadow Brook
10	Munns Ferry Campsite
11	Route 10 Bridge
12	Pauchaug Meadows Wildlife Management Area
13	Governor Hunt Recreation Area

TABLE III-9

EROSION SITES VISIBLE FROM
EACH SCENIC VIEWPOINT

Viewpoint	Erosion Site in View	Length of Erosion Site that is Visible (ft)
Viewpoint 1	76	128
Viewpoint 2	-	
Viewpoint 3	-	
Viewpoint 4	73	388
Viewpoint 4	74	595
Viewpoint 5		
Viewpoint 6	71	352
Viewpoint 6	72	60
Viewpoint 7	71	114
Viewpoint 7	72	352
Viewpoint 8	64	150
Viewpoint 8	66	2908
Viewpoint 8	69	1447
Viewpoint 8	70	382
Viewpoint 8	80	205
Viewpoint 8	72	506
Viewpoint 9	69	416
Viewpoint 9	69	1447
Viewpoint 9	70	382
Viewpoint 10	53	742
Viewpoint 10	55	911
Viewpoint 10	57	993
Viewpoint 10	58	706
Viewpoint 10	59	824
Viewpoint 10	60	1626
Viewpoint 10	61	453
Viewpoint 11	34	600
Viewpoint 11	35	537
Viewpoint 11	37	517
Viewpoint 11	38	770
Viewpoint 11	39	500
Viewpoint 11	40	667
Viewpoint 11	41	478
Viewpoint 11	42	751
Viewpoint 11	43	619

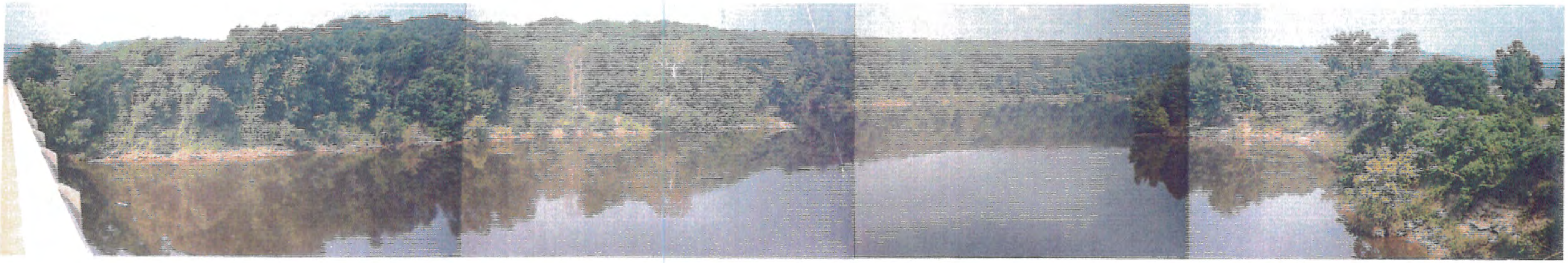
TOTAL NUMBER OF EROSION SITES - 28

TOTAL LENGTH (ft) - 19,707 (3.7 miles)

View from State Boat Ramp in Barton Cove (Viewpoint 2)
August 17, 1990

View from Pauchaug Meadow toward west bank (Viewpoint 12)
August 17, 1990

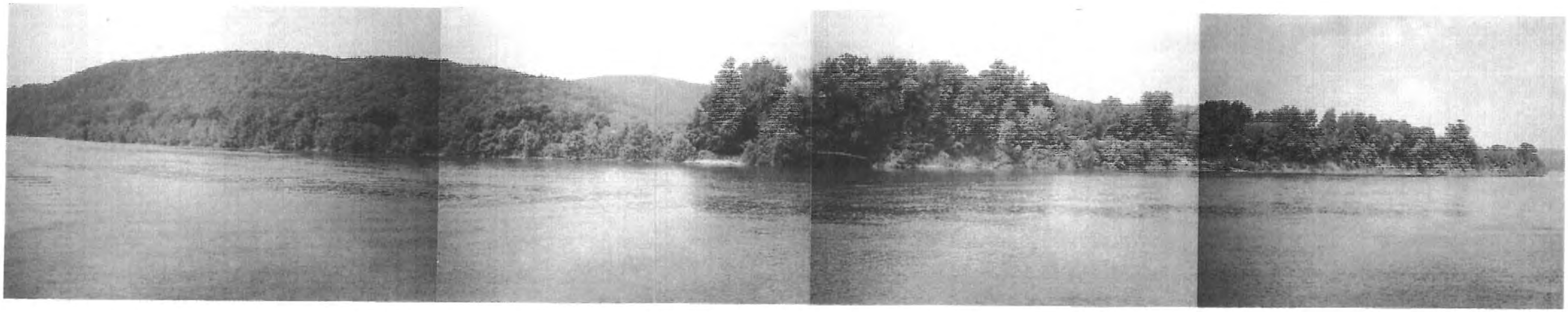
PHOTO PANEL III-9



Panoramic view looking north from the Route Ten Bridge (Viewpoint 11)
August 17, 1990

View looking south from the Route Ten Bridge (Viewpoint 11)
August 17, 1990

PHOTO PANEL III-10



View west from NUSCO Riverside Picnic Area (Viewpoint 8)
August 17, 1990

PHOTO PANEL III-11

View looking north from the French King Bridge is considered "distinctive" by the Massachusetts Executive Office of Environmental Affairs. (Viewpoint 6) - Aug. 17, 1990.

Slide erosion area across from Turners Falls Rod & Gun Club is visible looking north. (Viewpoint 4) - Aug. 17, 1990.

PHOTO PANEL III-12

8. Archaeological/Historical Resources

Dr. Mitch Mulholland, the Archaeological Director of the University of Massachusetts at Amherst was hired to inventory all known prehistoric and historic sites within the study area and to establish zones of moderate and high archaeological resource probability within and adjacent to eroded riverbanks. Dr. Mulholland also completed an archaeological investigation, complete with subsurface testing, at a 4000 ft. area of riverbank across from Kidds Island along the west bank.

The study consists of documentary research and a field walkover of probable sites. Historic research took place in each of the study area's towns and included research and interviews with historical archives, maps (1790-1990), library records, historical commissions and societies, historical librarians, local experts, historians and historical archaeologists at the University of Massachusetts. Prehistoric research consisted of a review of site archives at the Massachusetts Historical Commission, the New Hampshire Historical Commission, the New Hampshire Historic Preservation Office, the Vermont Division for Historic Preservation and the University of Massachusetts (UMASS). Professional archaeologists from UMASS, the University of Vermont, Franklin Pierce College and the University of New Hampshire at Durham were interviewed concerning site locations in the vicinity of the project area. Interviews were conducted with avocational and amateur archaeologists in the three states. Surficial and bedrock geology maps and soils maps were also consulted.

Numerous environmental attributes are considered in predicting areas of high site potential. These characteristics are identified by reviewing previous studies in localities with environments similar to that of the project area. The following is a list of the major criteria used during the investigation to assess the archaeological potential of the project area:

- The presence of known historic or prehistoric sites within or adjacent to the project area.
- Proximity to a National Register property.
- Proximity to a fresh water supply.
- Proximity to seasonal or perennial subsistence resources.
- Soils characteristics (such as drainage, texture, suitability for cultivation).
- Topographic features such as slope, aspect, elevation and barriers to prevailing winds.
- Proximity to sources of raw materials.
- Proximity to topographic features conducive to industrial development (e.g., hydrologic features).
- Proximity to areas known to have been early historic settlement clusters, or having the potential to be early settlement areas.
- Proximity to transportation routes.
- Proximity to industrial, commercial, and agricultural markets.

The project area was stratified prior to field survey in order to eliminate those areas requiring no further survey, and to delineate those with a potential for containing archaeological resources. Areas of obvious residential, highway, or other disturbance were eliminated from the survey.

Background research conducted has produced 33 recorded prehistoric sites, 18 previously unrecorded prehistoric sites, 20 areas of high potential to contain prehistoric sites, three areas of moderate potential to contain prehistoric sites and 15 historic sites. Prehistoric sites range in age from 400 to 8,000 years. The locations of these prehistoric and historic sites and probability zones are shown on Maps III-10A through III-10G. Table III-12 shows data related to each mapped site.

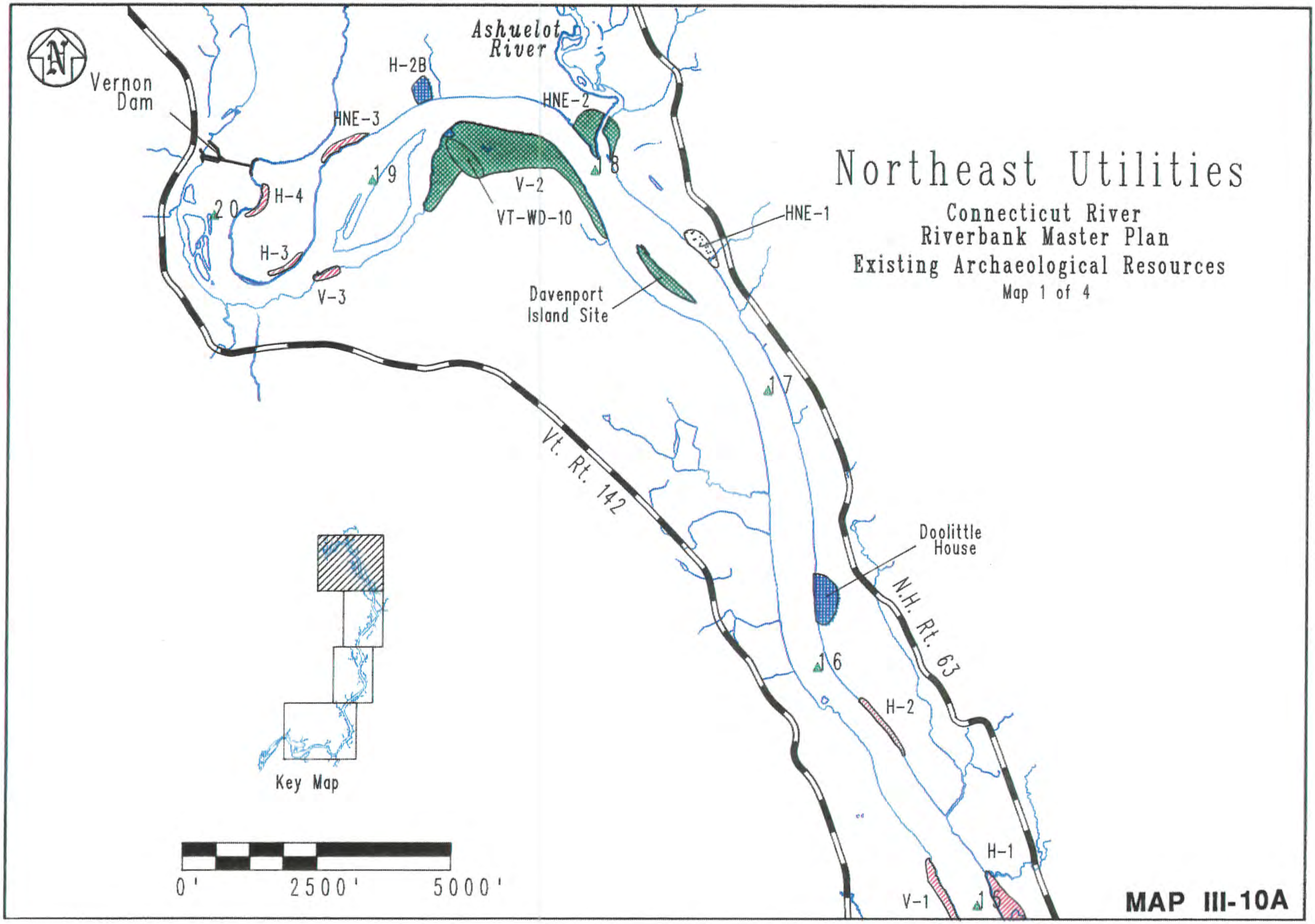
It can be concluded that any erosion stabilization projects undertaken by NUSCO will potentially require site specific field investigations, including some subsurface testing. As evidenced during the Otter Run field work completed earlier this year, the concentration of artifacts uncovered can be high. Specific study of severely eroded areas may also be warranted in order to prevent the loss of artifacts due to existing erosion.

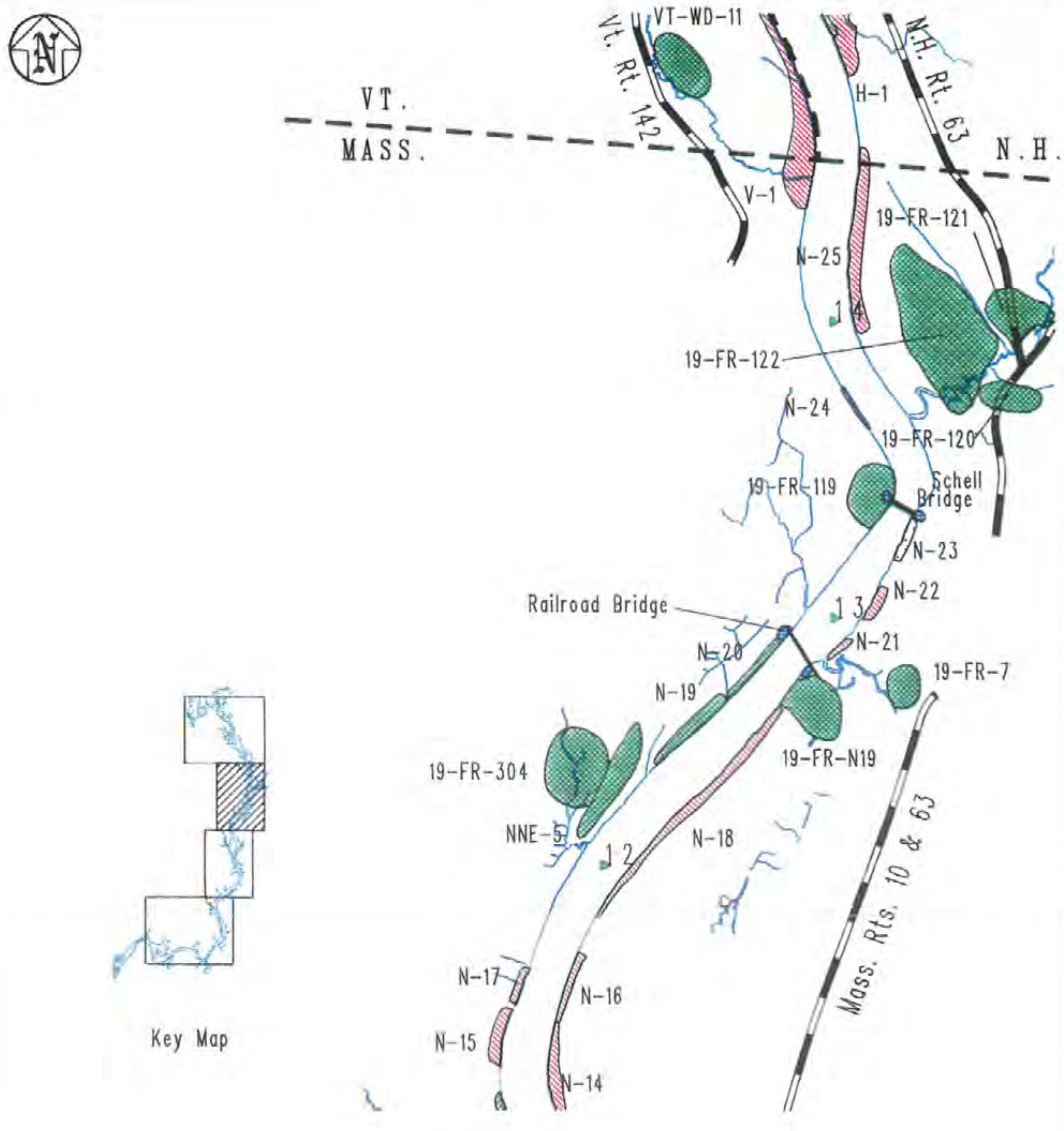
ARCHAEOLOGICAL RESOURCES

LEGEND

- Known/Reported Site
- High Probability
- Moderate Probability
- Historic Site
- Prehistoric Find

LEGEND:
ARCHAEOLOGICAL RESOURCES
MAPS III-10A TO III-10D


Vernon Dam
Ashuelot River
H-2B
HNE-2
HNE-3
19
18
H-4
20
V-2
VT-WD-10
HNE-1
H-3
V-3
Davenport Island Site
17
Vt. Rt. 142
Doolittle House
N.H. Rt. 63
16
H-2
Key Map
0'
2500'
5000'
H-1
V-1
15
Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Archaeological Resources
Map 1 of 4
MAP III-10A



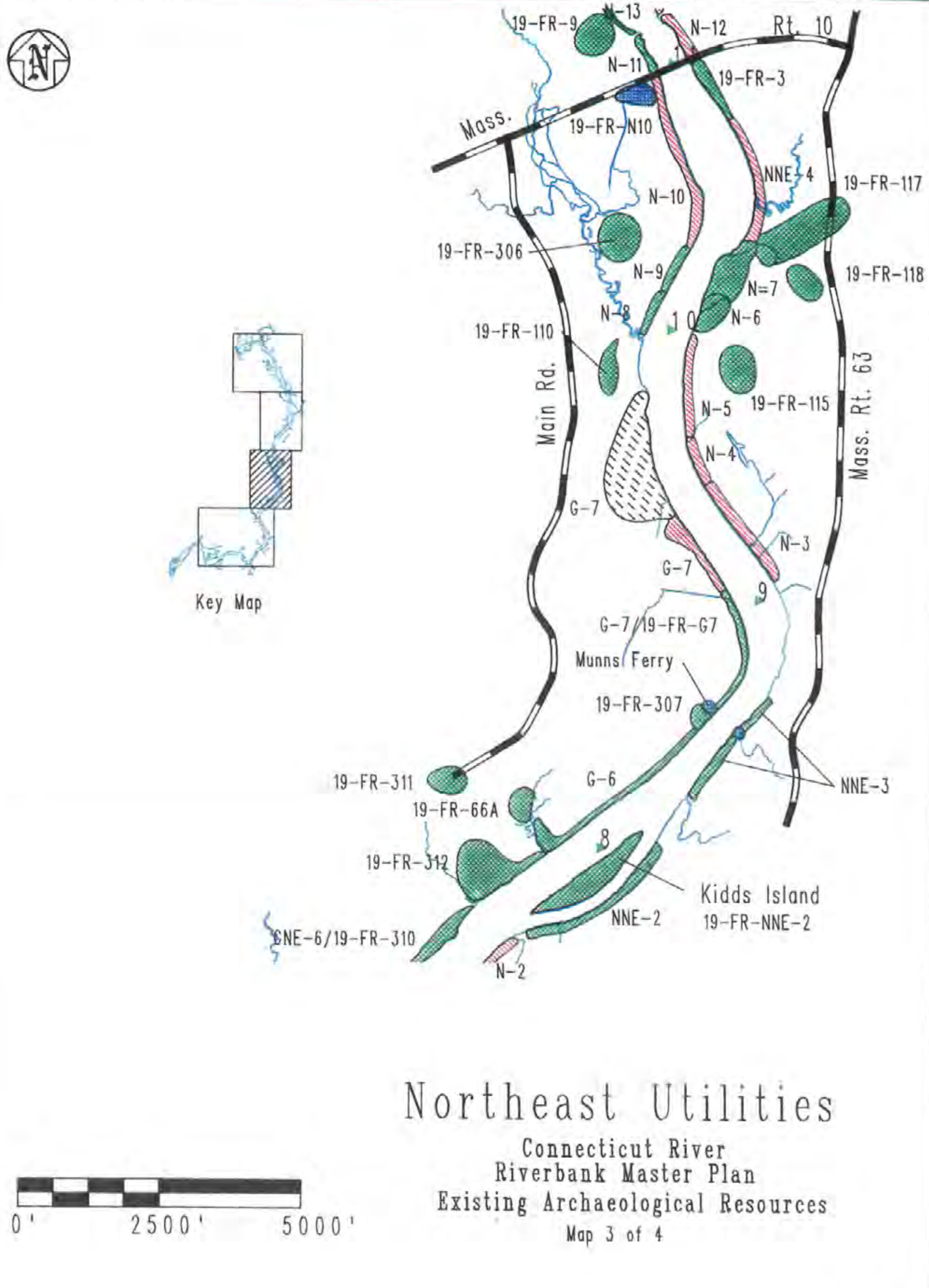
Northeast Utilities

Connecticut River
Riverbank Master Plan

Existing Archaeological Resources

Map 2 of 4

MAP III-10B



Northeast Utilities

Connecticut River
Riverbank Master Plan
Existing Archaeological Resources
Map 3 of 4

MAP III-10C

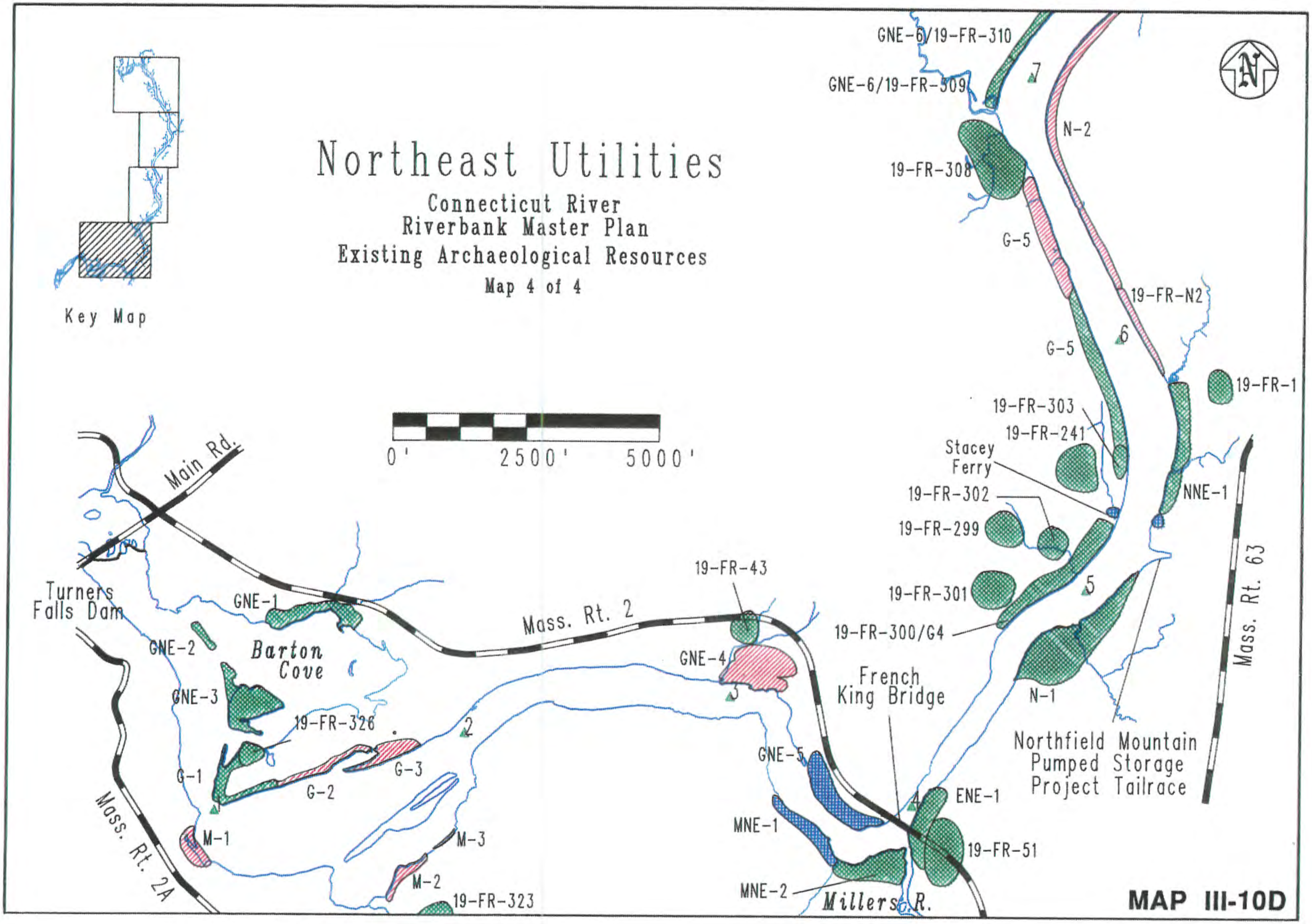

Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Archaeological Resources
Map 4 of 4
Key Map
0'
2500'
5000'
Main Rd.
Turners Falls Dam
GNE-1
GNE-2
GNE-3
Barton Cove
19-FR-326
G-1
G-2
G-3
M-1
M-2
M-3
19-FR-323
Mass. Rt. 2A
Mass. Rt. 2
19-FR-43
GNE-4
GNE-5
MNE-1
MNE-2
Millers R.
French King Bridge
ENE-1
19-FR-51
19-FR-300/G4
19-FR-301
19-FR-299
19-FR-302
Stacey Ferry
19-FR-241
19-FR-303
N-1
NNE-1
19-FR-1
Northfield Mountain Pumped Storage Project Tailrace
Mass. Rt. 63
G-5
19-FR-N2
N-2
19-FR-308
GNE-6/19-FR-309
GNE-6/19-FR-310
MAP III-10D

TABLE III-10

EXISTING EROSION SITES AND
ARCHAEOLOGICAL RESOURCES AND PROBABILITY ZONES

Erosion Site Number	Archaeological Site Name	Probability of Archaeological Find
1	H-3	High
2	H-3	High
3	V-2	Known/Reported
4	V-2	Known/Reported
5	V-2	Known/Reported
6	H-2B	Historic
5	V-2	Known/Reported
9	H-2B	Historic
10	V-2	Known/Reported
11	V-2	Known/Reported
12	V-2	Known/Reported
13	V-2	Known/Reported
14	V-2	Known/Reported
15	V-2	Known/Reported
16	Davenport Isl. Site	Known/Historic
17	Davenport Isl. Site	Known/Historic
18	H-2	High
19	H-2	High
21	V-1	High
22	V-1	High
23	H-1	High
24	V-1	High
25	N-25	High
26	N-25	High
27	N-23	Moderate
29	N-21	High
30	N-19	Known/Reported
30	N-20	Known/Reported

TABLE III-10 (CONTINUED)

Erosion Site Number	Archaeological Site Name	Probability of Archaeological Find
31	RR Bridge	Historic
31	19-FR-N19	Known/Reported
31	N-18	High
32	N-19	Known/Reported
33	N-16	High
33	N-18	High
34	N-17	High
35	N-15	High
36	N-14	High
37	N-13	Known/Reported
38	N-12	High
39	N-11	Known/Reported
40	N-10	High
41	N-10	High
42	N-10	High
43	NNE-4	High
44	N-9	Known/Reported
44	N-10	High
45	N-7	Known/Reported
46	N-5	High
47	N-5	High
48	N-3	High
48	N-4	High
49	G-7	High
49	G-7	Prehistoric Find
50	N-3	High
51	G-7	High
52	G-7	High

TABLE III-10 (CONTINUED)

Erosion Site Number	Archaeological Site Name	Probability of Archaeological Find
52	G-7/19-FR-G7	Known/Reported
53	G-7/19-FR-G7	Known/Reported
54	NNE-3	Known/Reported
55	G-6	Known/Reported
56	NNE-2	Known/Reported
56	NNE-2	Known/Reported
57	G-6	Known/Reported
58	G-6	Known/Reported
59	19-FR-NNE-2	Known/Reported
60	19-FR-312	Known/Reported
60	G-6	Known/Reported
61	19-FR-312	Known/Reported
62	N-2	High
63	N-2	High
64	N-2	High
65	G-5	High
66	N-2	High
66	19-FR-N2	High
67	G-6	High
67	G-5	Known/Reported
68	G-5	Known/Reported
69	19-FR-303	Known/Reported
69	G-5	Known/Reported
70	19-FR-303	Known/Reported
71	19-FR-300/G4	Known/Reported
72	N-1	Known/Reported
73	G-1	Known/Reported
73	G-2	High

TABLE III-10 (CONTINUED)

Erosion Site Number	Archaeological Site Name	Probability of Archaeological Find
74	G-1	Known/Reported
76	GNE-J	Known/Reported

9. Recreation

Recreational activity within the Turners Falls Pool was investigated by examining both the use of the Connecticut River and the use of its adjacent riverbank lands. Existing reports and recreational use guides were collected and reviewed to identify land-based recreational use areas. Aerial photos were also used to pinpoint specific use areas. Each recreational use site was visited either by land or by boat in order to characterize its level of development and accessibility. A total of 20 riverbank recreational use sites were identified and mapped. A list of these sites and a description of their uses is presented in Table III-11. Maps III-11A and 11B indicate the location of each recreational site.

Of the 20 sites, 11 are owned by NUSCO. NUSCO allows public use of their land at two additional locations. Three more sites are town owned, two are state owned, one is owned by New England Power Company and one is privately owned. Eight of the areas possess boat launch sites ranging from developed concrete ramps to informal shoreside beach areas. Three areas are primarily park or picnic settings. Camp sites exist on Barton Peninsula and at Munns Ferry. It should be noted that past erosion on the Barton Peninsula forced the abandonment of two campsites managed by NUSCO. Also evident are an athletic field, automobile pull-out areas on River Road, the Turners Falls Rod & Gun Club, the Bennett Meadow Wildlife Management Area and the Turners Falls Dam fish viewing facility. The natural beach area near Otter Run Brook has also been classified as a recreational use area due to its regularly used status during summer months.

In an effort to monitor recreational use during summer months, use of the river was recorded during the Memorial Day holiday weekend, June 23 - 24 and between July 3rd and 5th. Boat use was recorded in half-hour intervals at six stations along the river -

Barton Cove, French King Gorge, Kidds Island, Otter Run Brook Area, Route Ten Bridge and Pauchaug Meadow boat ramp. Boat launching was most active at the Pauchaug Meadows boat ramp, and riverbank use was most intense at the Otter Run Brook area where 35 boats passed in one thirty-minute period while 13 boats were beached on the shore and 50 people were counted along the riverbank/beach area. Photo Panels III-13 and III-14 show boat launch facilities and typical summer recreational use along the river.

Riverbank movement was also measured during these same time periods by monitoring six staked areas just before and after these recreational use periods took place. Lower bank movement was photographed and measured in order to assess the impacts of boat waves on the shoreline areas. Especially significant were long expansive lower bank cutting episodes near the Otter Run Brook area and deep 14-16" cuts in the lower bank northeast of the Route 10 Bridge area. Section VI of this report examines the impacts of recreational use on riverbank erosional activity.

It can be concluded that summer boating is a major recreational activity in the Turners Falls Pool, dominated by motorized boats but also featuring canoes. Recreational use areas are dispersed throughout the study area with the most concentrated use within Barton Cove. Local recreationalists and boat launch managers and owners have consistently stated that boat use is increasing as is the size and power of many boats.

TABLE III-11

TURNERS FALLS POOL

RECREATIONAL SITE DATA

Site No.	Recreational Site Name	Site Owner/ Manager	Recreational Activities
1	Turners Falls Dam Fish Passage Ladders	NUSCO	Fish viewing at fish ladders associated with headgates of power canal
2	Riverside Park Area	NUSCO	Riverfront open land adjacent to densely populated residential area and Montague Town Athletic Field
3	Montague Athletic Fields	Town of Montague	Athletic fields and picnic tables
4	Franklin County Boat Club Marina	Franklin County Boat Club (413) 863-3006	Marina with 92 boat slips, and car boat launch area
5	Barton Cove State Boat Launch Area	Comm. of Massachusetts	Public boat launch - parking for 42 cars with boat trailers. Has also become a popular spot for viewing eagles on Barton Island

TABLE III-11 (Cont.)

Site No.	Recreational Site Name	Site Owner/ Manager	Recreational Activities
6	Barton Cove Picnic/Boating Area	NUSCO	Year-round picnic tables, Memorial Day-Labor Day canoe and rowboat rentals. Adjacent to NUSCO camp-grounds and associated trails.
7	Barton Cove Campground	NUSCO	22 tent campsites and wooded trails along Barton peninsula
8	Turners Falls Rod & Gun Club	NUSCO-owner; Rod & Gun Club-manager	Private facility includes unimproved riverfront land with expansive view, shore fishing opportunities.
9	Millers Falls Point	NUSCO	Public access point at confluence of Millers River and Connecticut River. Used primarily for fishing and river viewing.
10	River Road Drive and pull-out areas	NUSCO, NE Power	Unimproved riverfront road between Millers River and Northfield Mountain tailrace, with various pull-out points along river. Offers scenic driving, picnicking, bicycling, hiking

TABLE III-11 (Cont.)

Site No.	Recreational Site Name	Site Owner/ Manager	Recreational Activities
11	Riverview Picnic Area	NUSCO	Picnic tables, boat dock, fishing and hiking. Pick-up/drop-off for NUSCO's Quinnetuket II riverboat tour of the Turners Falls pool (offered Memorial Day through mid-October
12	Stacey Ferry Road riverfront access point	Town of Gill	Small, unimproved riverfront access point at dead end of Stacey Ferry Road

TABLE III-11 (Cont.)

Site No.	Recreational Site Name	Site Owner/ Manager	Recreational Activities
13	Conn. River/ Otter Run beach area	NUSCO	Unmanaaged beach area receiving extensive summer weekend and holiday use by boaters, sunbathers.	Field Work Data (Recreational use was recorded over 30-minute intervals on the following days):

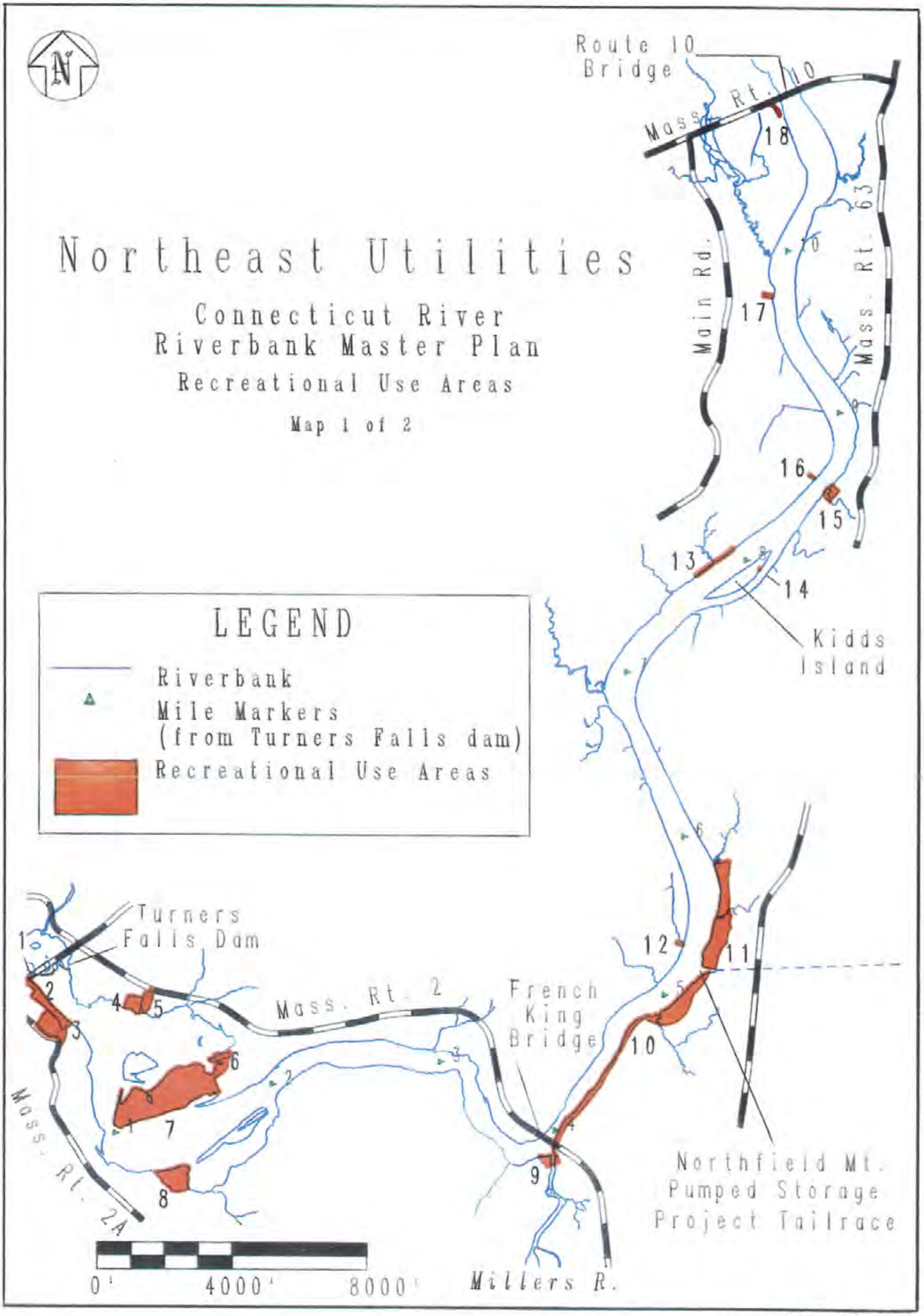
Day	Time	Boats On River	Boats On Shore	People On Shore
5/26/90	10:45-11:15 am	14	2	4
5/27/90	11:30 am-12:00 pm	9	1	0
5/28/90	2:00-2:30 pm	34	7	27
5/28/90	4:50-5:30 pm	18	4	14
6/24/90	10:10-10:30 am	26	0	2
6/24/90	2:10-2:40 pm	24	8	25
6/24/90	7:40-8:10 pm	5	1	3
7/03/90	2:00-2:30 pm	10	1	1
7/04/90	12:15-12:45 pm	39	10	31
7/04/90	3:15-3:45 pm	36	13	50
7/04/90	6:20-6:50 pm	13	6	23
7/05/90	12:00-12:30 pm	3	1	4

TABLE III-11 (Cont.)

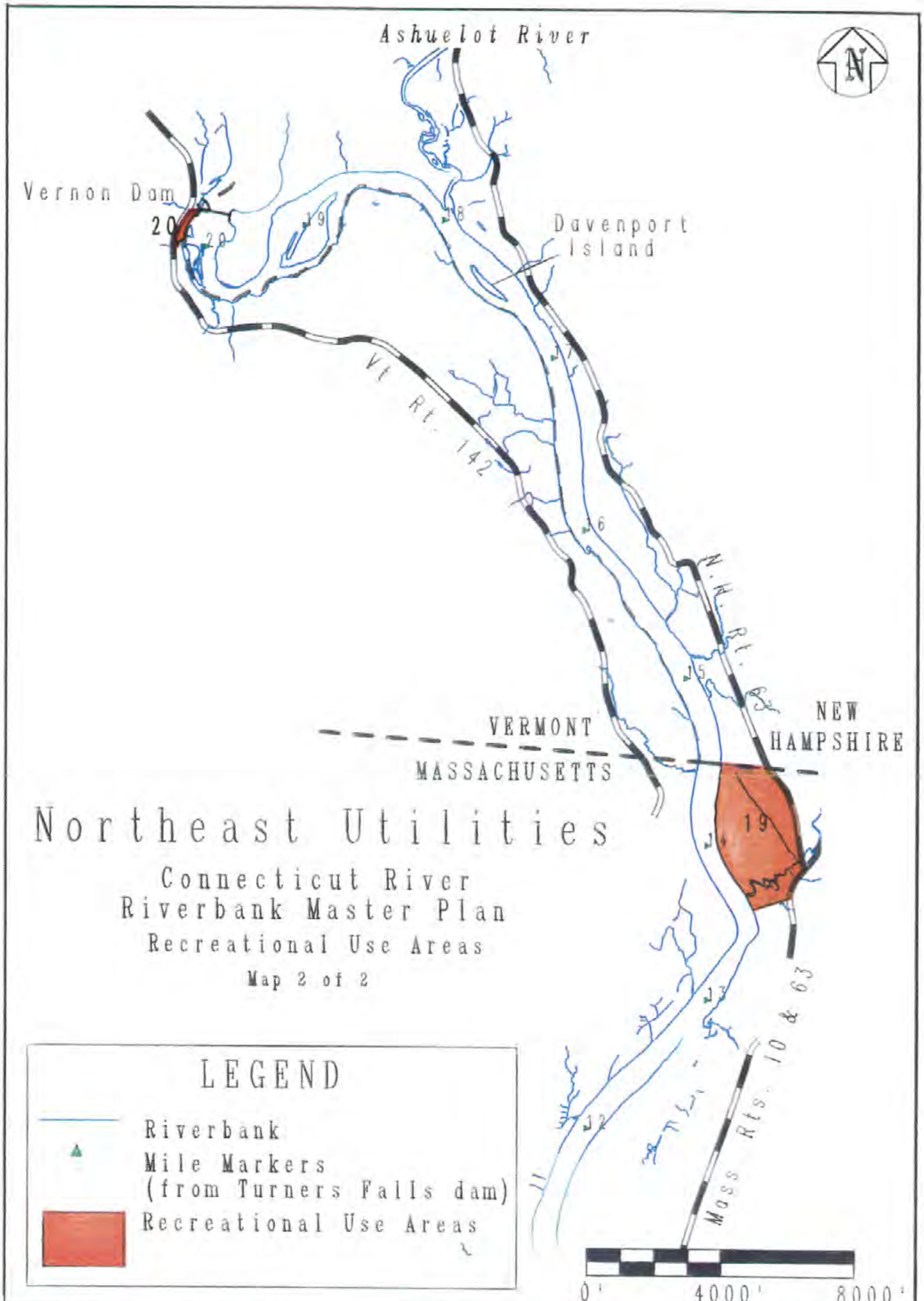
Site No.	Recreational Site Name	Site Owner/ Manager	Recreational Activities
14	Kidds Island Boat Landing	NUSCO	Unimproved boat landing spot providing access to Kidd's Island for fishing, camping
15	Munns Ferry Campsite	Hartford Light & Electric Co.	Boat launch, 3 tent campsites, restroom. Accessible only by boat or by foot
16	Munns Ferry Riverfront Access Point	Town of Gill	Riverfront access point at deadend of Munns Ferry Road with small boat dock
17	Northfield & Mt. Hermon School Boathouse and boat dock	Owner=NUSCO; Manager=Northfield and Mt. Hermon School	Private school boathouse and docking facility - Not open to the public
18	Bennett Meadow Environmental Management Area	Owner=NUSCO; Manager=Comm. of Massachusetts: Div. of Fisheries and Wildlife	Automobile access to riverbank. No trails, no improved access to river. Cooperatively managed wildlife area

TABLE III-11 (Cont.)

Site No.	Recreational Site Name	Site Owner/ Manager	Recreational Activities
19	Pauchaug Meadows Wildlife Management Area and Boat Launch	Comm. of Massachusetts; Div. of Fisheries and Wildlife	Picnic area, hiking, improved boat launch
20	Governor Hunt Recreation Area	New England Power Company	Boat launch area, shore fishing


Northeast Utilities
Connecticut River
Riverbank Master Plan
Recreational Use Areas
Map 1 of 2
LEGEND
Riverbank
Mile Markers
(from Turners Falls dam)
Recreational Use Areas
Route 10 Bridge
Mass. Rt. 10
Main Rd.
Mass. Rt. 63
Kidds Island
Turners Falls Dam
Mass. Rt. 2
French King Bridge
Northfield Mt. Pumped Storage Project Tailrace
Mass. Rt. 2A
Millers R.
0'
4000'
8000'

MAP III-11A


Ashuelot River
Vernon Dam
Davenport Island
Vt Rt. 142
N.H. Rt. 63
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
Mass Rts. 10 & 63
Northeast Utilities
Connecticut River
Riverbank Master Plan
Recreational Use Areas
Map 2 of 2
LEGEND
Riverbank
Mile Markers
(from Turners Falls dam)
Recreational Use Areas
0'
4000'
8000'

MAP III-11B

This boat launch facility is owned and operated by the Northfield - Mt. Hermon School - May 22, 1990.

This dock in Barton Cove is one of nine sites along the Turners Falls Pool used to launch or dock boats - Aug. 18, 1990.

PHOTO PANEL III-13

Power boating, including water skiing, is a growing recreational activity along the river - July 4, 1990.

The long, exposed beach west of Kidds Island is a popular summer recreational spot for boaters - July 4, 1990.

PHOTO PANEL III-14

10. Land Use

The entire project area was analyzed for land use by conducting a two-phase inventory process. The study area was defined at a minimum to include all riverbank land ownership parcels and those privately-owned parcels adjacent to NUSCO riverbank property. First, all local town halls were visited to review municipal tax maps and update NUSCO's "Exhibit K" maps (filed during project licensing) in terms of property ownership boundaries and owner names. The resultant revisions were then digitized into ND&T's ARC INFO computer base for a total of 289 parcels. Secondly, analysis of April, 1990 1"=100' aerial photo enlargements was made to identify land use activity within the 289-parcel study area. Where parcels contained more than one type of land use, each land use type was recorded. A 5,860 acre area comprises this total study area.

Land use types within the study area were divided into nine categories, as follows:

1. Agricultural
2. Residential
3. Commercial/Industrial
4. Publicly owned land (Town/State)
5. Active utility or transportation use
6. Undeveloped woodlands (utility company owned)
7. Undeveloped open land (utility company owned)
8. Undeveloped woodlands (privately owned)
9. Undeveloped open land (privately owned)

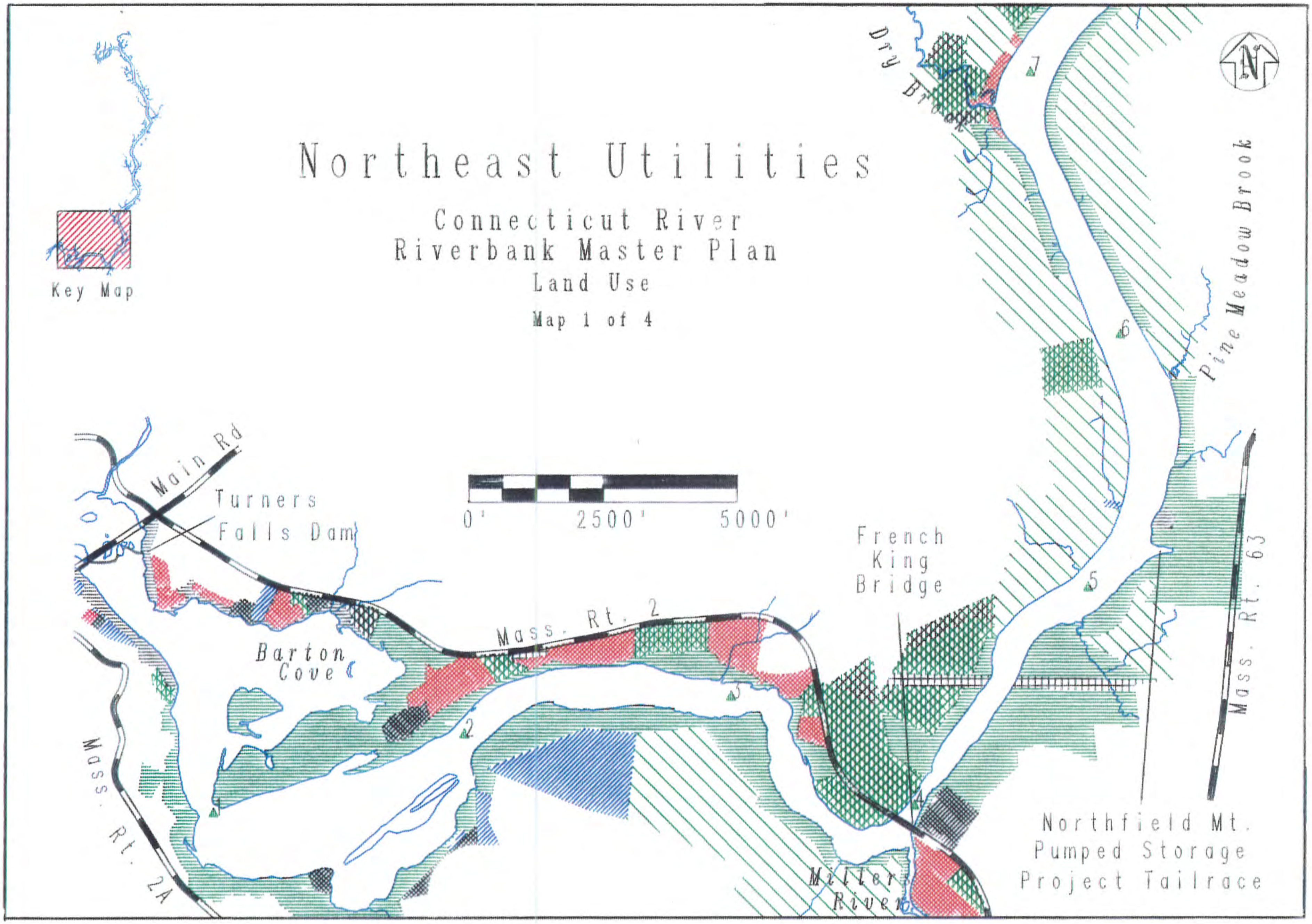
Each of these categories are coded and appear on Maps III-12A through 12D. Land use changes gradually from fairly dense residential properties in Barton Cove to undeveloped woodlands through the French King Gorge. As the river valley terraces appear near the Northfield Mountain tailrace and continue to

LAND USE MAP

LEGEND

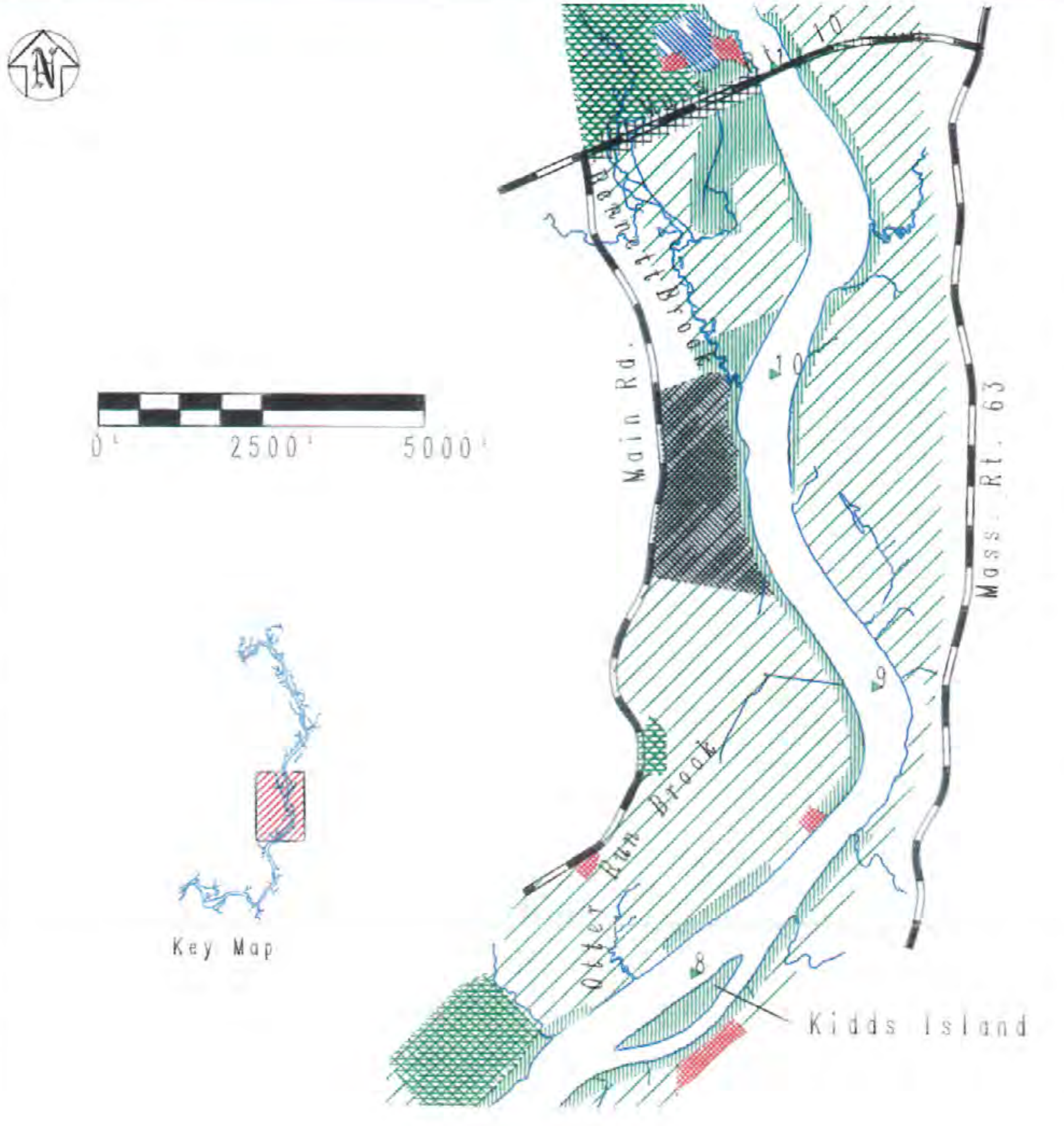
Symbol	Description
(line)	Riverbank
▲	Mile Markers (from Turners Falls dam)
(pattern)	Agricultural
(pattern)	Residential
(pattern)	Commercial/Industrial
(pattern)	Public Land (town/state)
(pattern)	Active Utility/Transportation
(pattern)	Woodlands (utility owned)
(pattern)	Open Lands (utility owned)
(pattern)	Undeveloped Woodlands (privately owned)
(pattern)	Undeveloped Open Land (privately owned)

LEGEND:
LAND USE
MAPS III-12A TO III-12D



Northeast Utilities
Connecticut River
Riverbank Master Plan
Land Use
Map 1 of 4
Key Map
0'
2500'
5000'
Main Rd
Turners Falls Dam
Barton Cove
Mass. Rt. 2
French King Bridge
Dry Brook
Pine Meadow Brook
Mass. Rt. 63
Mass. Rt. 2A
Millers River
Northfield Mt. Pumped Storage Project Tailrace
1
2
3
4
5
6
7

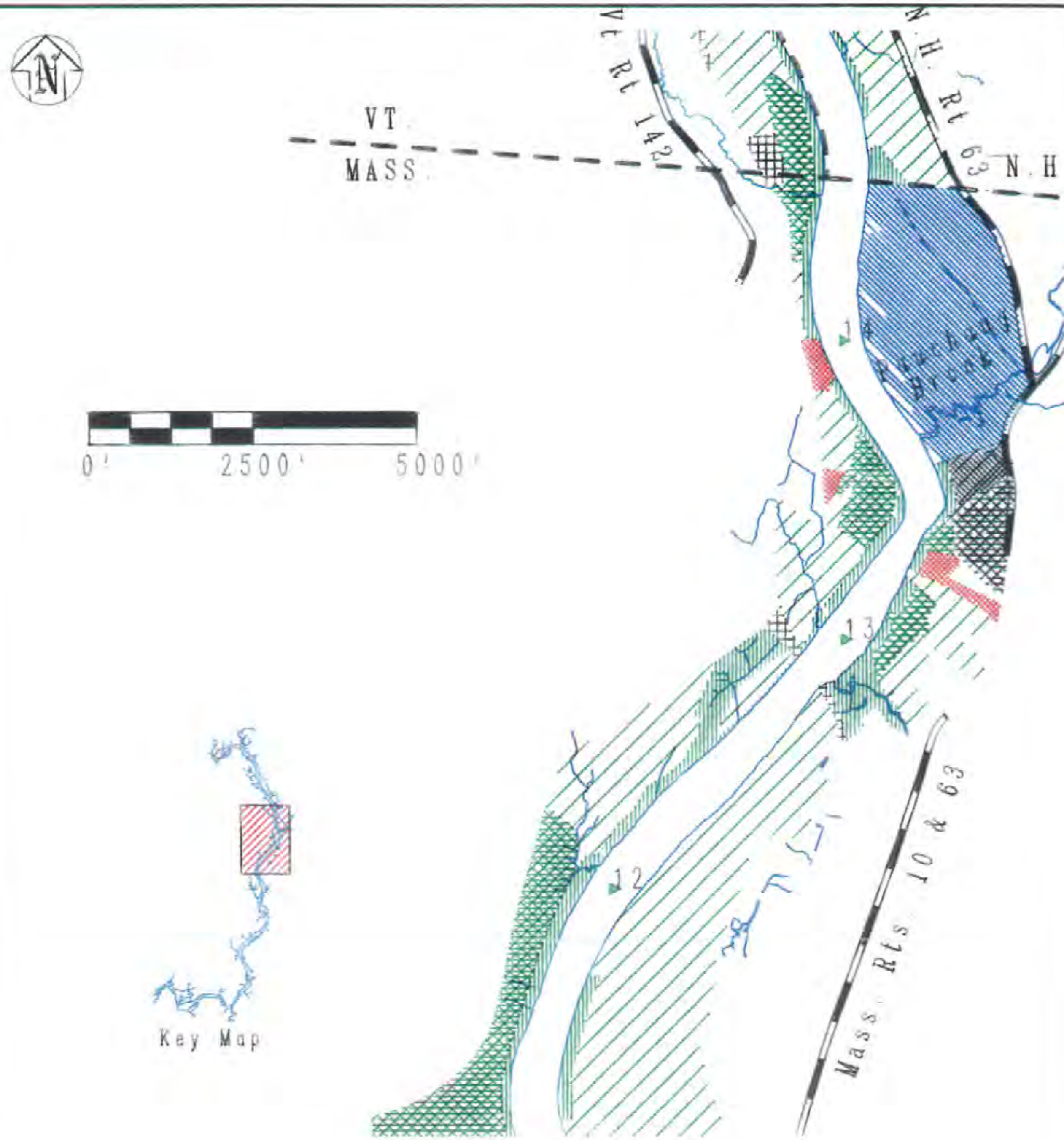
MAP III-12A



Northeast Utilities

Connecticut River
Riverbank Master Plan
Land Use
Map 2 of 4

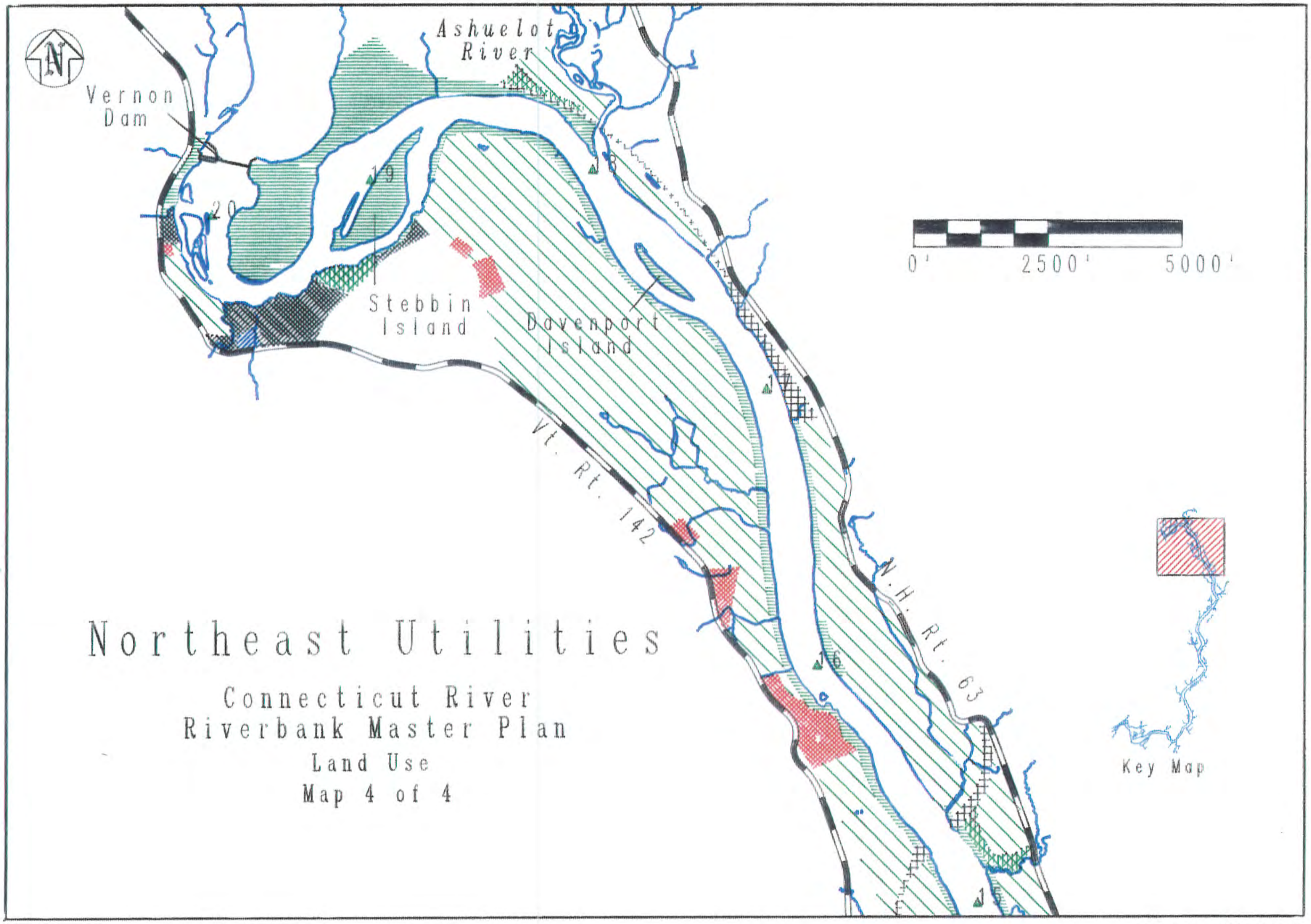
MAP III-12B



Northeast Utilities

Connecticut River
Riverbank Master Plan
Land Use
Map 3 of 4

MAP III-12C


N
Vernon Dam
Ashuelot River
20
19
18
16
Stebbin Island
Davenport Island
Vt. Rt. 142
N.H. Rt. 63
0'
2500'
5000'
Key Map
Northeast Utilities
Connecticut River
Riverbank Master Plan
Land Use
Map 4 of 4

MAP III-12D

predominate upstream to the Ashuelot River, agricultural land use is the primary feature with corn fields, pasture lands and dairy farms patching the landscape. In addition, NUSCO owns long strips of riverbank land throughout the project area. This is consistent with FERC's requirement that the utility company either own or control flowage rights within the 50-year floodplain of the river. These long strips are mainly undeveloped wooded riverbank property, although in certain cases adjacent landowners use NUSCO property for agricultural purposes almost down to the riverbank.

Population density is relatively light within the project area and average parcel size is large. The primary land use factor that must be considered when addressing riverbank erosional issues is the amount of vegetative cover that exists just up from the top of the riverbank and on to the adjacent land. There is a clear relationship between erosional activity and agricultural property that is cleared close to the river's top of bank. Land use coverage can be overlayed with erosion severity and/or soils type to ascertain where overclearing may be problematic. It must also be noted that in some cases, the absence of top of bank vegetation is due to erosion activity and not intentional clearing. These two instances must be separated when assessing erosional cause at a given site.

Table III-12 lists the land use evidenced within the project area by type. Agricultural use dominates the area with 53.4% of the total coverage and 31% of the project area is undeveloped woodlands. Only 3.7% is considered residential property. Table III-13 lists the type of land use adjacent to each riverbank erosion site. Woodlands border 73.1% of the eroded riverbank sites and agricultural property abuts 24.7% of the sites. Photo Panel III-15 shows agricultural and woodland land use along the Connecticut River within the Turners Falls Pool.

TABLE III-12

LAND USE WITHIN
PROJECT AREA

Land Use Type	Total Acreage	Percent of Total
Agriculture	3,130	53.4
Residential	214	3.7
Commercial/Industrial	195	3.3
Public Land (town/state)	333	5.7
Active Utility/Transportation	106	1.8
Utility-Owned Woodlands	1,265	21.6
Utility-Owned Open Land	32	0.6
Private Woodlands	550	9.4
Private Open Land	35	0.6
TOTAL LAND USE	5,860	100.0

TABLE III-13

LAND USE RELATED TO
EROSION SITES

Land Use Type	Length of Bordering Erosion Sites	Percentage of Total Land Use
Agricultural	3.36 miles	24.7
Public Lands (Town/State)	0.27 miles	2.0
Active Utility or Transportation	0.02 miles	0.1
Woodlands	9.95 miles	73.1
TOTAL	13.6 miles	100.0

Agricultural land use comprises 53 percent of the project area upland from the river - Aug. 17, 1990.

Typical undeveloped woodlands, such as this area upstream of the Schell Bridge, grow adjacent to nearly 80 percent of the Turners Falls Pool's riverbanks. Aug. 17, 1990

PHOTO PANEL III-15

C. Assessment of Existing Riverbank Conditions

1. Identification of Existing Erosion Sites

In order to establish a precise description of existing erosion conditions along the Connecticut River, ND&T conducted several site visits and collected field data, photographs, measurements, and soil samples along the reach between Turner's Falls and Vernon Dam. Detailed site visits were conducted on May 22 and 23, 1990; June 11th through the 13th, 1990; July 2 and 3, 1990; and August 4, 1990. Field studies included review of the river bank from land, from the water and, for a greater part of the reach, by foot along the base of the bank. A detailed study of existing river bank conditions was performed during these site visits. While the general condition of the bank was observed, attention was focused on soil exposure, vegetative cover, bank geometry, and apparent signs of bank erosion, movement, or failure.

Existing bank conditions along the river have been documented in field notes, video recordings, and still photography. The extent and general severity of the erosion was observed and recorded in field notes and on maps.

a. Site Classification System

Once sufficient data had been gathered, a "classification system", or method of classifying existing erosion, had to be developed. Both the U.S. Corp of Engineers and the Department of Agriculture-Soil Conservation Service were contacted regarding the existence of erosion classification systems. Neither agency knew of any system, but suggested criteria from which a system could be developed. Criteria included: bank height, slope, soil exposure, and soil movement. ND&T developed a method of classifying existing erosion which incorporated soil exposure and amount of movement of the vegetated areas of any particular erosion site. Bank height and slope were eliminated from the system because it was felt that these criteria were more indicative of the susceptibility or rate of erosion at a site rather than the present degree of erosion.

Each erosion site has been evaluated based on summer conditions, when vegetation and its coverage was more apparent. Winter and early spring evaluations are considered misleading since bank vegetation is not easily observed and snow cover and freezing conditions precluded observation of tension cracks or signs of recent movement.

The existing erosion classification system bases an erosion site's severity on the percentage of soil exposure and the percentage of area which displays signs of bank or soil movement. Soil exposure and amount of bank or soil movement criteria have been assigned five ranges of values (see Table III-14, Existing Erosion Classification System). In each criteria, a higher ranking value indicates a more severe erosion condition.

Erosion conditions have been divided into five levels of severity: none to low, low to moderate, moderate, moderate to severe, and severe. Each level of erosion severity has been assigned a "composite value" or range of composite values. The composite value of any erosion site is the sum of the ranking values assigned to the percentage of soil exposure and percentage of activity or movement.

Numerical values have been applied to the ranking values and the composite values in an attempt to develop a system which accurately evaluated erosion sites. Several trial systems were developed, and eventually discarded, due to inconsistent evaluation of "test sites". The determination of an inconsistent ranking system was based on the comparison of the degree of severity indicated by the classification method versus the physically observed severity when compared to all sites visually inspected. Field verification of the system was performed in order to determine the accuracy of site classification. Measurements of erosional area height and length, as well as measurements of areas of exposed soil or moving areas of vegetated soil, were used to determine the classification of five sites. The classification system used to evaluate the existing erosion conditions weighs the percentage of soil exposure twice as heavily as it does the level of activity or movement. Exposed soil has been considered completely susceptible to erosion while vegetated areas, even though moving, failing, or sloughing are still substantially more resistant to erosion because of the root mass and binding action of the vegetative cover.

b. Existing Erosion Sites

Field notes, mapping, and video recordings have been used to review erosion sites between Turner's Falls and Vernon Dam. While the entire reach was investigated and reviewed for classification, seventy-six sites have been classified under the system. Sites have been numbered according to their location along the river. The first site is located at the northern end of the reach, at Vernon Dam, and the 76th site is located at the southern end at Turners Falls. Shown on Maps A1-1 through A1-7 in Attachment A are the seventy-six sites which have a composite value of 20 (low to moderate) or greater. The severity of the remaining area has been classified "none to low" and not designated as a numbered site or series of sites. The existing erosion sites account for approximately 13 miles of riverbank, or approximately 30 percent of the riverbank between Vernon Dam and Turner's Falls. Table III-15 indicates the number of sites in each of the four levels of severity and length of bank involved. Table III-16 is a summary of the Erosion Classification and site evaluation and lists the 76 sites consecutively. Photo Panels III-16 through III-19 show examples of low-to-moderate, moderate, moderate-to-severe, and severe erosion sites.

TABLE III-14

EXISITING EROSION CLASSIFICATION SYSTEM

PERCENT SOIL EXPOSURE	RANKING VALUE
0 - 10%	10
10 - 25%	20
25 - 50%	30
50 - 75%	40
75 - 100%	50

LEVEL OF ACTIVITY / MOVEMENT	RANKING VALUE
0 - 10%	5
10 - 25%	10
25 - 50%	15
50 - 75%	20
75 - 100%	25

EROSION CONDITION	COMPOSITE VALUE
NONE TO LOW	15
LOW TO MODERATE	20,25
MODERATE	30,35
MODERATE TO SEVERE	40,45
SEVERE	> 50

TABLE III-15

SITE DISTRIBUTION AND RIVERBANK LENGTH

CLASSIFICATION	NUMBER OF SITES	TOTAL LENGTH OF SITES (mi.)
LOW TO MODERATE	22	4.6
MODERATE	32	5.2
MODERATE TO SEVERE	20	3.3
SEVERE	2	0.5
TOTAL	76	13.6

TABLE III - 16

EROSION CLASSIFICATION SUMMARY

SITE #	LENGTH (ft)	EROSION CLASSIFICATION RATING	
		NUMERICAL RATING	CONDITION
1	218	35	MODERATE
2	496	30	MODERATE
3	298	25	LOW-MODERATE
4	395	35	MODERATE
5	533	25	LOW-MODERATE
6	623	25	LOW-MODERATE
7	407	40	MODERATE-SEVERE
8	830	40	MODERATE-SEVERE
9	605	25	LOW-MODERATE
10	184	40	MODERATE-SEVERE
11	392	25	LOW-MODERATE
12	782	35	MODERATE
13	949	40	MODERATE-SEVERE
14	1024	20	LOW-MODERATE
15	1177	25	LOW-MODERATE
16	476	35	MODERATE
17	316	40	MODERATE-SEVERE
18	406	25	LOW-MODERATE
19	706	25	LOW-MODERATE
20	270	35	MODERATE
21	1235	40	MODERATE-SEVERE
22	615	30	MODERATE
23	437	40	MODERATE-SEVERE
24	2042	25	LOW-MODERATE
25	812	40	MODERATE-SEVERE
26	1023	35	MODERATE
27	589	25	LOW-MODERATE
28	991	45	MODERATE-SEVERE

TABLE III-16 (Cont.)

EROSION CLASSIFICATION SUMMARY

#	SITE LENGTH (ft)	EROSION CLASSIFICATION RATING NUMERICAL RATING	CONDITION
29	540	35	MODERATE
30	1677	30	MODERATE
31	2449	35	MODERATE
32	304	40	MODERATE-SEVERE
33	4069	35	MODERATE
34	601	30	MODERATE
35	537	35	MODERATE
36	444	35	MODERATE
37	517	25	LOW-MODERATE
38	770	60	SEVERE
39	500	30	MODERATE
40	667	25	LOW-MODERATE
41	478	40	MODERATE-SEVERE
42	751	35	MODERATE
43	619	35	MODERATE
44	1267	40	MODERATE-SEVERE
45	248	35	MODERATE
46	1231	30	MODERATE
47	505	40	MODERATE-SEVERE
48	1026	35	MODERATE
49	573	30	MODERATE
50	1079	25	LOW-MODERATE
51	1111	40	MODERATE-SEVERE
52	1063	35	MODERATE
53	1342	25	LOW-MODERATE
54	510	30	MODERATE
55	911	20	LOW-MODERATE
56	4126	25	LOW-MODERATE
57	993	30	MODERATE
58	706	45	MODERATE-SEVERE

TABLE III- 16 (Cont.)

EROSION CLASSIFICATION SUMMARY

# SITE	LENGTH	EROSION CLASSIFICATION RATING	
	(ft)	NUMERICAL RATING	CONDITION
59	2000	25	LOW-MODERATE
60	1627	60	SEVERE
61	454	30	MODERATE
62	642	35	MODERATE
63	3015	40	MODERATE-SEVERE
64	1969	30	MODERATE
65	723	25	LOW-MODERATE
66	2909	25	LOW-MODERATE
67	758	25	LOW-MODERATE
68	645	30	MODERATE
69	2335	40	MODERATE-SEVERE
70	588	30	MODERATE
71	555	30	MODERATE
72	1012	25	LOW-MODERATE
73	389	30	MODERATE
74	596	40	MODERATE-SEVERE
75	860	40	MODERATE-SEVERE
76	128	40	MODERATE-SEVERE

TOTAL	71650	FT
	13.57	MI

Site 53 - Low to moderate erosion - Aug. 17, 1990.

Site 53 - Upstream of Munn's Ferry; west bank - Aug. 17, 1990.

PHOTO PANEL III-16

Site 57 - Moderate erosion. Across from the upstream end of Kidds Island; west bank - Aug. 16, 1990.

Site 42 - Moderate erosion. Downstream of the Rt. 10 bridge; west bank - May 22, 1990.

Site 63 - Moderate to severe erosion - May 22, 1990.

Site 63 - Downstream of Kidds Island, east bank - May 22, 1990.

PHOTO PANEL III-18

Site 60 - Severe erosion - Aug. 18, 1990

Site 60 - Across from Kidds Island, west bank - Aug. 3, 1990.

PHOTO PANEL III-19

2. Previously Stabilized Erosion Sites

Of the nearly 45 miles of riverbank shoreline within the Turners Falls Pool, 11.5 miles have already been stabilized using structural reinforcement or hydroseeding. In addition, 21.1 miles of riverbank were selectively cleared of trees near the shoreline. Table III-17 presents summary information regarding 41 individual stabilization sites and two episodes of tree clearing. Table III-18 details the work involved at each site. The riverbank repair areas referred to in these tables have been mapped and are shown by number on Maps III-13A through 13D.

The great majority of bank stabilization work has occurred in the past 21 years with NUSCO installing riprap along 2.9 miles of shoreline and hydroseeding 7.2 miles of shoreline. NUSCO has also implemented all of the tree clearing conducted within the Turners Falls Pool by selectively clearing 14.1 miles of shoreline downstream of the Route 10 Bridge in 1976 and clearing 7 miles of shoreline upstream of the same bridge in 1977.

An additional eight sites comprising 4400 feet of shoreline have been riprapped by non-NUSCO parties. The dates and costs of these installations are unknown. In 1981 the US Army Corps of Engineers spent federal funds to repair 2000 feet of riverbank southeast of the Route 10 Bridge. The repairs were made as part of a demonstration program in which experimental stabilization techniques were employed. A precast cellular concrete block mattress was used to stabilize 600 feet of riverbank. Immediately adjacent to this site, used automobile tires were utilized to stabilize 1400 feet of riverbank. Approximately half of this site was reinforced by installing a filter fabric, while the other half was not. Figure III-7 and Table III-19 show the detailed plan for this site, including plant selection for the upper bank.

Upon field inspection of these previously stabilized sites, it can be discerned that the structurally reinforced stabilization areas have all performed well. The Corps demonstration project and the riprapped areas adequately reinforce the bank at the toe of the slope and have prevented further slope failure. Areas where tree clearing was conducted initially relieved certain riverbank locations of the stress associated with large trees falling into the river. Falling trees also brought adjoining riverbank material down with them. However, over time, many of these cleared shorelines have succumb to erosion due to the loss of tree roots which formerly served to buttress the toe slope during high flows. Hydroseeding conducted by NUSCO followed the tree clearing episodes and was performed at 15 sites between the Route 10 Bridge and the area just downstream of the Northfield Mountain tailrace. The shallow roots of the hydroseeded banks served to reinforce the surface layer of soil, but failed to offer long-term protection from erosion. Photo Panel III-20 and III-21 show stabilized banks at Dry Brook (site 125), Munn's Ferry (site 119) and the Corps demonstration project (site 113).

TABLE III-17

SUMMARY OF PREVIOUS RIVERBANK STABILIZATION WORK PERFORMED AT TURNERS FALLS POOL EROSION SITES

Stabilization Method Initiated by NUSCO	Length of Riverbank Repaired by NUSCO	NUSCO Cost
RipRap (15 sites)	15,490 ft (2.9 miles)	$173,421[1]
Hydroseeding (15 sites)	38,150 ft (7.2 miles)	$ 35,842
Grade and Plant (3 sites)	500 ft	------
TOTAL (Non-tree clearing)	54,140 ft (10.3 miles)	$209,263
Selective Tree Clearing	21.1 miles	$358,300
TOTAL NUSCO COST:		$567,563

Stabilization Method (non-NUSCO)	Length of Riverbank Repaired	Cost
RipRap (8 sites)	4,400 ft	Unknown
Concrete block mattress	600 ft	$411,614[2]
Used Autotire wall	1,400 ft	
TOTAL	6,400 ft (1.2 miles)	

Total Number of Previous Riverbank Stabilization Sites: 41 (non-tree clearing)

Total Length of Stabilization Sites (non-tree clearing): 11.5 mi.

Total Length of Shoreline with Selective Tree Clearing: 21.1 mi.

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[1]Cost does not include 2,400 ft of riprap associated with Turners Falls Dam reconstruction and Northfield Mountain Station tailrace construction

[2]Constructed by US Army Corps of Engineers

TABLE III-18

PREVIOUS RIVERBANK STABILIZATION WORK PERFORMED AT TURNERS FALLS POOL EROSION SITES

Erosion Repair Site	Area Length	Repair Date	Repair Technique	Repair Cost	Reference
101	300′	N/A	Railroad Bridge abutment and stone placement	N/A	
102	300′	N/A	Railroad Bridge abutment and stone placement	N/A	
103	7 miles	1977	Selective aerial tree clearing with helicopter	$160,000 ($22,857/mile)	
104	1000′	N/A	Rip Rap	N/A	
105	400′	N/A	Rip Rap	N/A	
106	250′	N/A	RR Bridge abutment reinforcement	N/A	
107	250′	N/A	RR Bridge abutment reinforcement	N/A	
108	500′	N/A	Rip Rap		
109A	300′	1979	Rte. 10 bridge abutment rip rap }	$5,360	
109B	300′	1979	Rte. 10 bridge abutment rip rap }		

N/A - Not Applicable

TABLE III-18 (Cont.)

Erosion Repair Site	Area Length	Repair Date	Repair Technique	Repair Cost	Reference
110	14.1 mi.	1976	Selective aerial tree clearing by helicopter	$198,300 ($14,000/mile)	
111	3900'	1977	Hydroseed		
112	3000'	1977	Hydroseed		
113	2000'	Nov. 1981	a) Precast cellular concrete block mattress - 600'	$411,634	(See "Conn. River at Northfield, MA-Demonstration Project Performance Report" Section 32 Program Streambank Erosion Control Evaluation and Demonstration Act of 1974, U.S. Army Corps of Engineers, pp. G-55-1 to G-55-25.
			b) Used Autotire wall with filter fabric - 725'		
			c) Used autotire wall without filter fabric - 675'		
114	2100'	1977	Hydroseed		
115	600'	1977	Hydroseed		

TABLE III-18 (Cont.)

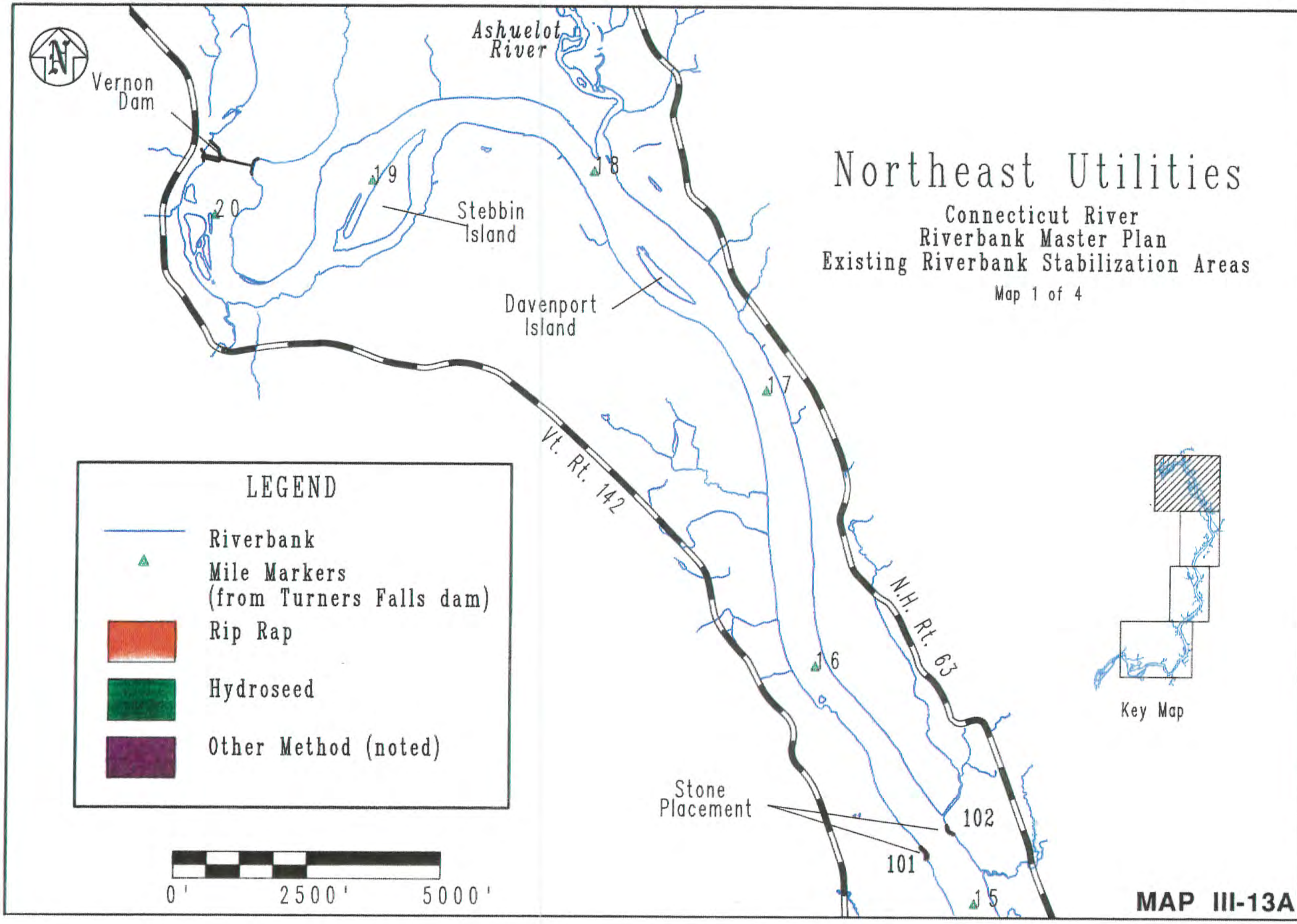
Erosion Repair Site	Area Length	Repair Date	Repair Technique	Repair Cost	Reference
116	1400′	1977	Hydroseed		
117	200′	1984	Dump 2000 yds^3 of rip rap; grade and loam (100 yd^3)	$17,400	
118	100′	1976	Dump rip rap	$1,500	
119	330′	1977	Fill and grade, dump 2,548 yd^3 of rip rap	$6,208	
120	9700′	1977	Hydroseed		
121	4100′	1977	Hydroseed		
122	500′	1977	Hydroseed		
123	750′	1977	Hydroseed		
124	1700′	1977	Hydroseed		
125	1400′	1978	Dump 14,642 yd^3 of rip rap; grade and loam (15 yd^3)	$40,765	
126	1000′	1976	Compacted rip rap - 4594 yd^3	$32,970	
127	4600′	1977	Hydroseed		
128	1900′	1977	Hydroseed		

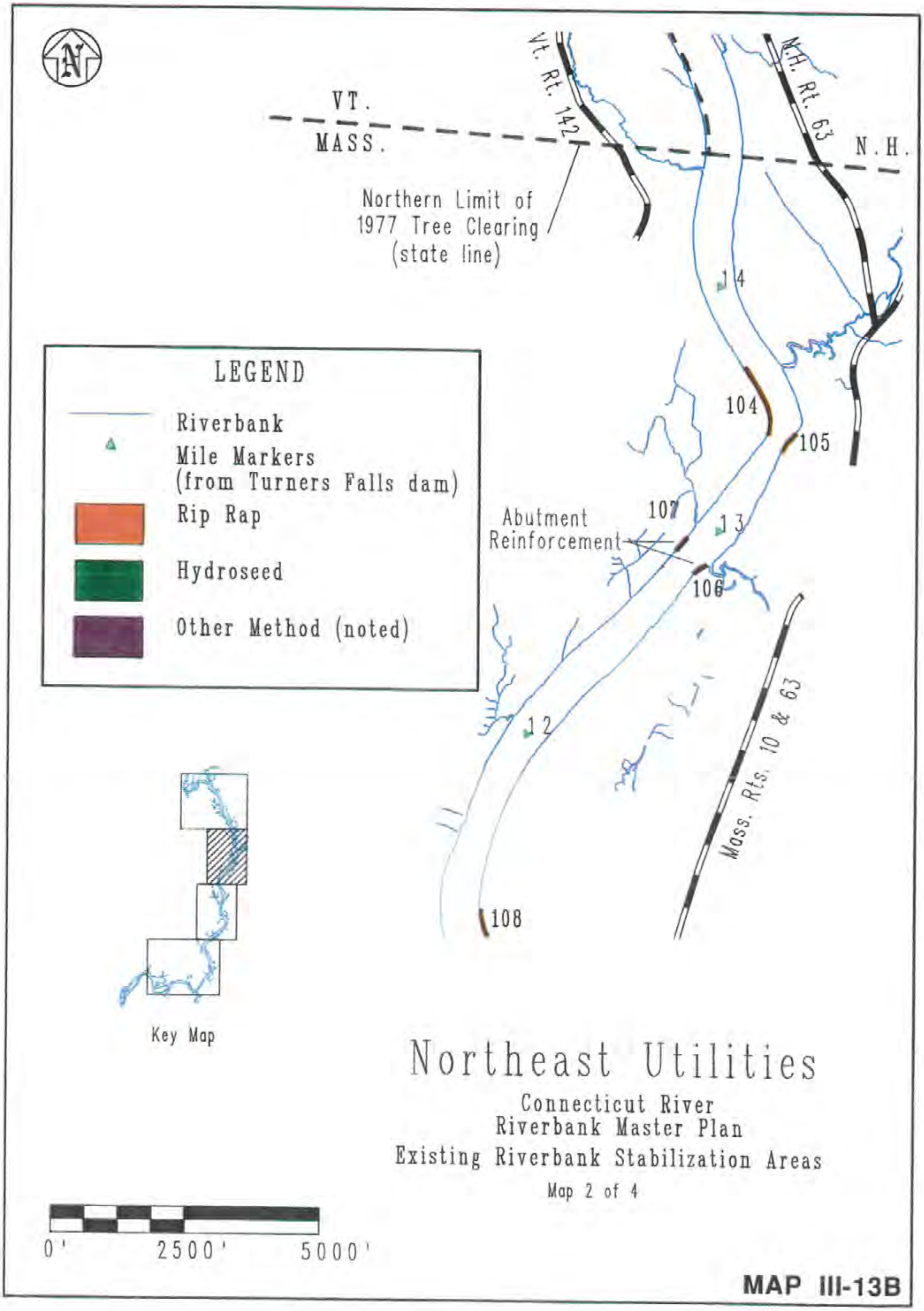
TABLE III- 18 (Cont.)

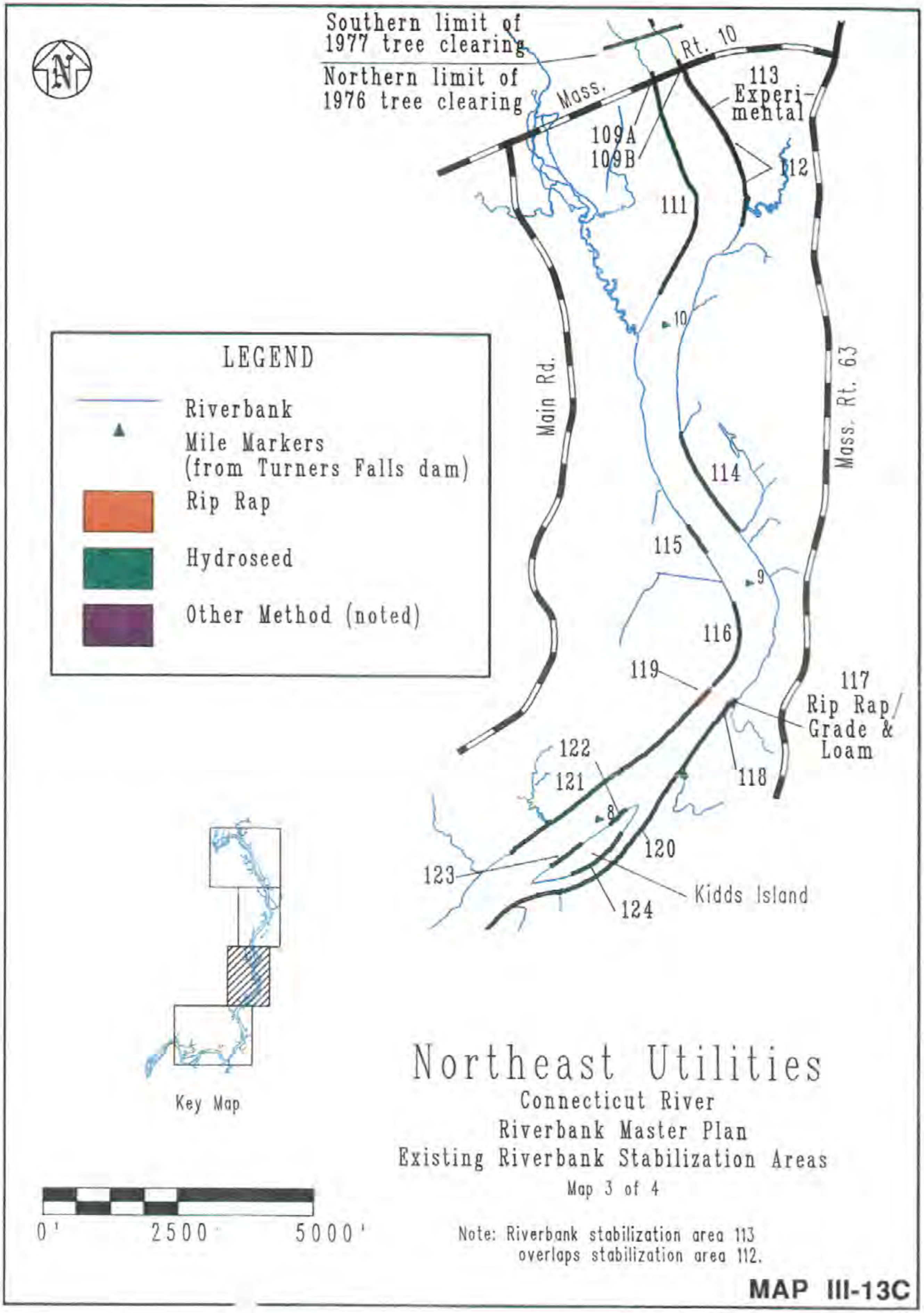
Erosion Repair Site	Area Length	Repair Date	Repair Technique	Repair Cost	Reference
129	1400′	N/A	Rip Rap (unknown origin/age)	N/A	
130	460′	1977	Tree stump burial fill and grade Dump 2055 yd^3 of rip rap	$4,625	
131	800′	1981	Dump 3034 yd^3 Rip Rap and Grade	$9,413	
132	1200′	1970	Rip Rap, Grade (part of Northfield Mtn. construction)	N/A	
133	1000′	1977	Hydroseed		
134	1600′	1976	Tree clear		
	1600′	1977	Tree stump burial, fill and grade, dump 2511 yd^3 of rip rap	$8,880	
	1600′	1978	Hydroseed	$1,250	
135	150′	1977	Grade and plant		
136	1300′	1977	Hydroseed		
137	150′	1977	Grade and plant		
138	200′	1977	Grade and plant		

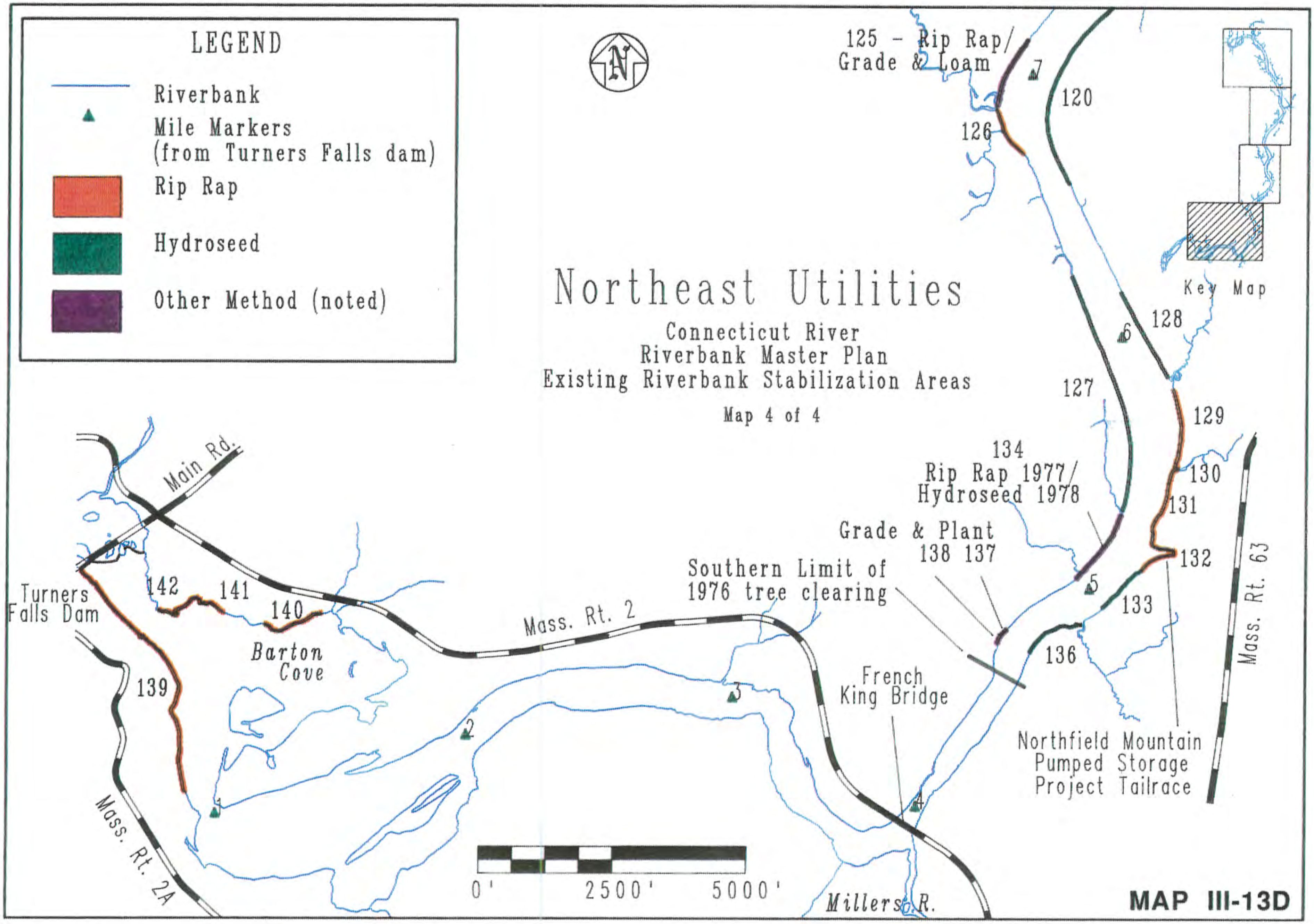
TABLE III-18 (Cont.)

Erosion Repair Site	Area Length	Repair Date	Repair Technique	Repair Cost	Reference
139	5000′	1969	Build up bank, Dump rip rap	$10,000	
140	1200′	1969	Rip rap and storm water drains (done during dam reconstruction)		
141	800′	1986	Transplant vegetation; Dump 4000 yd^3 of rip rap; grade and plant	$18,300	
142	800′	1986	Dump rip rap	$18,000	


Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Riverbank Stabilization Areas
Map 1 of 4
N
Vernon Dam
Ashuelot River
Stebbin Island
Davenport Island
Vt. Rt. 142
N.H. Rt. 63
Stone Placement
102
101
20
19
18
17
16
15
Key Map
LEGEND
Riverbank
Mile Markers (from Turners Falls dam)
Rip Rap
Hydroseed
Other Method (noted)
0'
2500'
5000'
MAP III-13A


VT.
MASS.
N.H.
Vt. Rt. 142
N.H. Rt. 63
Northern Limit of
1977 Tree Clearing
(state line)
LEGEND
Riverbank
Mile Markers
(from Turners Falls dam)
Rip Rap
Hydroseed
Other Method (noted)
14
104
105
107
13
106
Abutment
Reinforcement
12
108
Mass. Rts. 10 & 63
Key Map
Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Riverbank Stabilization Areas
Map 2 of 4
0'
2500'
5000'
MAP III-13B


Southern limit of
1977 tree clearing
Northern limit of
1976 tree clearing
Mass. Rt. 10
113
Experi-
mental
109A
109B
112
111
10
LEGEND
Riverbank
Mile Markers
(from Turners Falls dam)
Rip Rap
Hydroseed
Other Method (noted)
Main Rd.
Mass. Rt. 63
114
115
9
116
119
117
Rip Rap/
Grade &
Loam
122
121
118
8
120
123
124
Kidds Island
Key Map
0'
2500'
5000'
Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Riverbank Stabilization Areas
Map 3 of 4
Note: Riverbank stabilization area 113
overlaps stabilization area 112.
MAP III-13C


LEGEND
Riverbank
Mile Markers
(from Turners Falls dam)
Rip Rap
Hydroseed
Other Method (noted)
Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Riverbank Stabilization Areas
Map 4 of 4
125 - Rip Rap/
Grade & Loam
126
120
128
127
129
130
131
132
133
136
134
Rip Rap 1977/
Hydroseed 1978
Grade & Plant
138 137
Southern Limit of
1976 tree clearing
French
King Bridge
Northfield Mountain
Pumped Storage
Project Tailrace
Key Map
Main Rd.
Mass. Rt. 2
Mass. Rt. 2A
Mass. Rt. 63
Turners
Falls Dam
142
141
140
139
Barton
Cove
Millers R.
0'
2500'
5000'
MAP III-13D

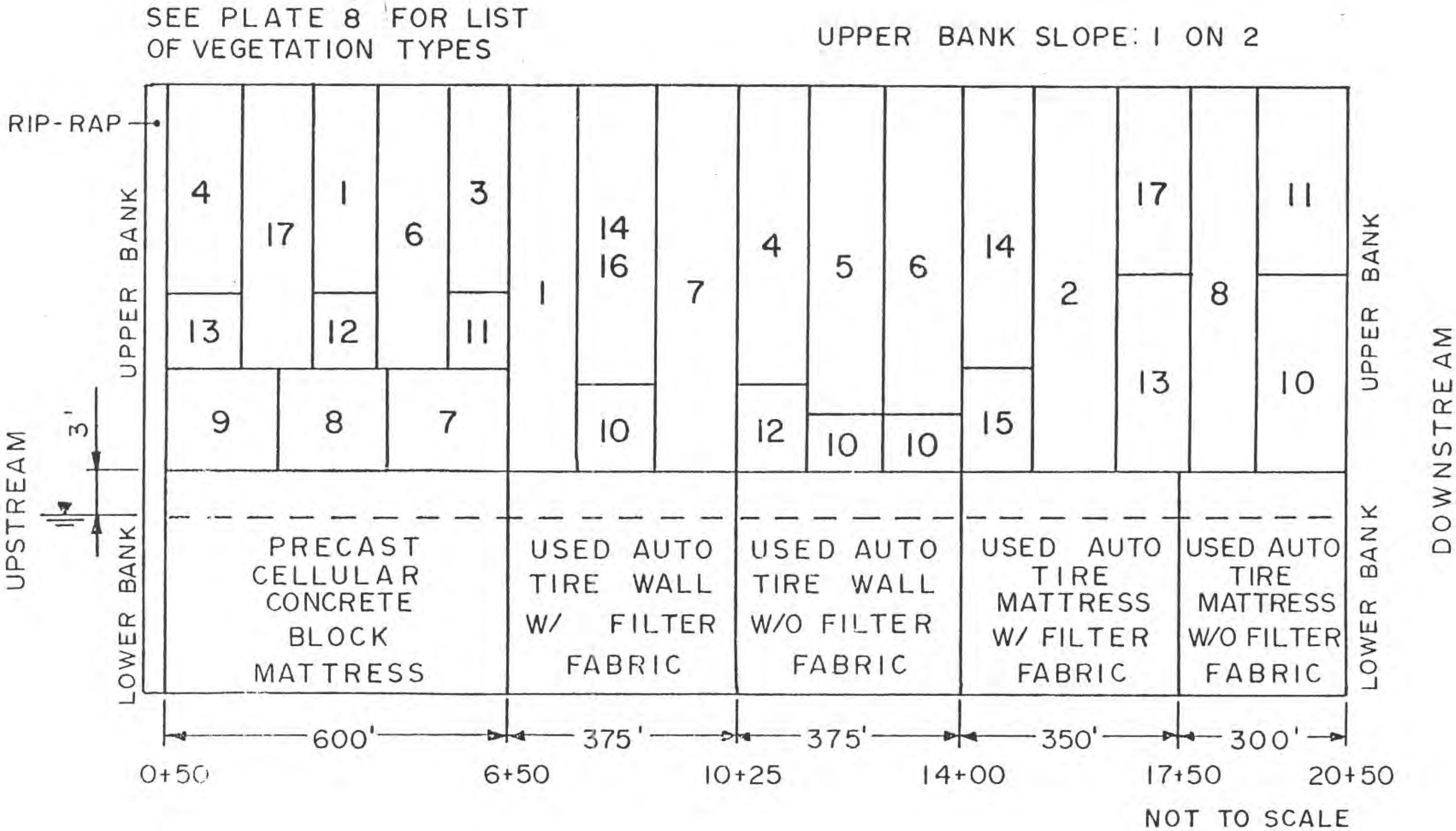


FIGURE III-7
NORTHFIELD DEMONSTRATION PROJECT
PROTECTIVE MEASURES

Table III- 19
Upper Bank Vegetation
Northfield Demonstration Project

SEED MIXTURES

1 REED CANARYGRASS
CREEPING RED FESCUE
REDTOP

2 REED CANARYGRASS
KENTUCKY 31 FESCUE
BIRDSFOOT TREFOIL

3 CROWNVETCH
KENTUCKY 31 FESCUE
CREEPING RED FESCUE

4 FLAT PEA
KENTUCKY 31 FESCUE
CREEPING RED FESCUE

5 CROWNVETCH
FLAT PEA
KENTUCKY 31 FESCUE

6 BIRDSFOOT TREFOIL
CREEPING RED FESCUE

7 KENTUCKY 31 FESCUE
CREEPING RED FESCUE
REED CANARYGRASS
REDTOP

8 KENTUCKY 31 FESCUE
CREEPING RED RESCUE
REDTOP

9 PERENNIAL RYEGRASS
REDTOP

SHRUBS AND VINES

10 PURPLE-OSIER WILLOW

11 SIBERIAN DOGWOOD

12 REDOSIER DOGWOOD

13 SUMMERSWEET

14 AMERICAN BITTERSWEET

15 VIRGINIA CREEPER

16 HALL'S HONEYSUCKLE

17 SWEETFERN

NOTE: NUMBERS ARE
KEYED TO PANELS
ON FIGURE III-7

NUSCO installed 330 ft of riprap at this site
across from Munn's Ferry in 1977 - May 22, 1990.

NUSCO installed 2,400 ft of riprap adjacent to
Dry Brook between 1976 and 1978 - Nov. 19, 1990.

PHOTO PANEL III-20

U.S. Army Corps of Engineers Demonstration Project - 6 years after completion (1987).

Close-up of Gobi matting at shoreline of Corps' Demonstration Project - Feb. 6, 1990.

PHOTO PANEL III-21

IV. ASSESSMENT OF METHODS OF RIVERBANK STABILIZATION

ND&T compiled information and case studies on existing streambank erosion control projects in order to develop a list of appropriate riverbank stabilization techniques. Alternative methods of stabilization selected for consideration at erosion sites were based upon three general criteria: site conditions and accessibility, extent and cause of erosion, and resource values to be protected at each erosion site.

A. Bank Stabilization Techniques

The three general bank stabilization concepts considered for use along the Turners Falls reservoir were vegetative stabilization, slope reinforcement, and structural stabilization. These concepts, when used separately or in combination with each other, form the individual, detailed erosion site stabilization techniques considered for use at each site. Erosion site stabilization was very site-dependent and required a detailed outline of the work required; an evaluation of several combinations of stabilization techniques applicable to the erosion site; and identification of the construction impacts to environmental, archaeological, and recreational resources of the particular riverbank.

Several factors play a part in developing the most appropriate combination of stabilization methods chosen for an erosion site. Engineering and environmental factors are examined on a site-by-site basis in order to determine stabilization techniques or combinations of techniques which are best suited for a particular erosion site. Certain aspects of the environmental, archaeological, and recreational resources may preclude one or several types of stabilization from being used at a particular site. A site-by-site analysis allowed selection of the appropriate stabilization techniques to minimize temporary construction impacts and reduce permanent environmental impacts.

1. Vegetative Stabilization

Potential vegetative stabilization methods include plantings of grass, willow and dogwood cuttings, rushes, and sedges. The use of a particular planting is dependent upon the relationship of the area to be planted to the normal high and normal low water elevations. Vegetative stabilization techniques are most effective along riverbanks which are not affected by erosion and undercutting at the toe of the bank.

2. Slope Reinforcement

Several slope reinforcement techniques are also applicable to the banks of the Connecticut River. Natural fiber matting made of jute or burlap help to stabilize fill areas or disturbed soil, and assist in establishing vegetation on a bank. Synthetic slope reinforcement or geotextile fabrics can be used to stabilize larger fill areas or banks of a steeper slope.

3. Structural Toe Protection

Along the lower riverbank, where tractive forces and wave effect may advance erosion, a more substantial protection method must be utilized. Structural stabilization techniques such as fieldstone, stone-filled log cribs, gabions, and concrete retaining walls prevent bank erosion and allow "upper bank" methods of stabilization to be implemented. In some cases, toe protection along an eroding bank may be essential to preventing further bank degradation. Toe protection must be capable of retaining bank soil and preventing further removal and deterioration of the bank at the water line.

B. Evaluation of Methods of Bank Stabilization

1. Vegetative Options

a. Hydroseeding

Hydroseeding of land and slopes consists of the spraying of a mixture of seed, water, and fertilizer on bare soil. A protective layer of mulch is applied on top of the seed mixture to maintain a moist environment and prevent surface runoff from carrying away seed and soil.

Hydroseeding is effective in upland areas along roadways and embankments unaffected by water and wave action. Within river courses, hydroseeding is limited to terrace zones well above normal high water elevation. Hydroseeding along shoreline and riverbank areas (below normal high water elevations) provide little protection against the influence of water. When used in conjunction with a suitable method of lower bank protection, hydroseeding becomes an effective means of controlling upper bank erosion.

Following NUSCO's mid-1970s tree clearing work, extensive areas of riverbank were hydroseeded. Detailed monitoring of the short-term and long-term effectiveness of the hydroseeding was not undertaken, other than indirectly during annual or routine inspections. In general, the hydroseeding was not effective because no lower bank protection was completed nor were the riverbank slopes flattened to a stable level prior to hydroseeding. The location of hydroseeded banks can be found in Section III-C.

b. Tree Clearing

Tree clearing is not a widely-used method for directly controlling erosion. However, it may be effective where trees are being lost due to inundation, and wash-out and uprooting of trees cause exposure of erodible soils. At the same time, however, the protection afforded the bank against direct impingement of flowing water, floating debris, and ice may be lost by tree removal. In addition, an active root mass is more effective at retaining soil than an inactive root system. Therefore, tree clearing will be effective where tree uprooting is the major cause of erosion. Where it is not, tree clearing may retard or accelerate the rate of erosion depending on the site-specific bank characteristics.

Tree clearing is quite often necessary to allow installation of various bank stabilization techniques. Both selective and clear-cut methods of tree clearing can be employed in preparation for construction of erosion control measures. Selective cutting of trees is generally used for purposes of thinning a tree stand or for preparing a specific area for construction. Clear-cutting is the removal of all trees, and often all vegetation, from an area surrounding a construction site.

Tree clearing techniques may be used in any situation requiring cleared land prior to construction. Tree line integrity can be preserved through the use of selective tree clearing methods, while still allowing standard construction practices to be used.

Between 1976 and 1977, Northeast Utilities performed extensive tree clearing along approximately 21.1 miles of the riverbank. Banks were cleared of trees which were in the process of falling or overturning, and those potentially capable of removing large quantities of bank material if they were to fall. Photo Panel IV-2 shows the tree clearing performed at the Rt. 10 bridge. Maps III-14A through 14D in Section III show the extent of the tree clearing performed by NUSCO between Turners Falls and Vernon Dam. In general, the tree clearing was probably effective in reducing the

Riprap bank protection installed in 1984 (left of bridge) and 1976 (right of bridge) at Munns Ferry Campground - Aug. 17, 1990.

Riprap bank protection installed by NUSCO in 1986 at Barton's Cove-1986.

PHOTO PANEL IV-1

rate of erosion at most sites. However, because tree overturning was not the major cause of erosion, the tree clearing was not a final solution to the erosion.

c. Shallow/Deep Rooted Plants and Vegetation

The use of vegetation to control erosion and stabilize slopes consists of planting, under highly controlled conditions, special combinations of grasses, sedges, woody plants, and cuttings. The appropriate combination depends on the site conditions and the cause of erosion.

On the ground surface, vegetation resists the erosive force of rainwater by buffering the impact of rain as it strikes the ground and by reducing the velocity of runoff as it travels across the ground surface. Below the ground surface, roots act to bind the soil particles and add shear strength to the soil layers.

The grass types recommended for use on the Connecticut River include Tall Fescue, Rye, Crown Vetch, Red Fescue, and Birdsfoot Trefoil. Generally, these grasses prefer upland areas of dry to wet soils in areas which are some distance above the maximum high water line.

Use of more woody cuttings such as purple-osier willow and red-osier dogwood provide resistance to bank erosion in areas influenced by spring or flood flows. Although not adaptable to areas of standing water, the purple willow and red dogwood can provide erosion control at, or above, the normal high water line on a streambank. The purple-osier willow is well suited for areas above the normal high water line, and its resilient nature provides added resistance to injury by floating debris or ice. Its growth is rapid in favorable conditions and its size rarely exceeds 1" in diameter when mature. Purple willow forms a more dense, erosion resistant coverage than that of the tree-forming varieties of willow. Red-osier dogwood, best situated at or immediately above the normal high water line, is even more flexible than purple willow and resists and recovers from damage well. Plantings of red dogwood, which are flattened down by debris or ice, provide abundant new growth and thickening of the stand.

Areas below the normal high water line, which are generally under water, require sedge and rush species such as three-square, swordgrass, and great or soft-stem bullrush. These varieties can prosper in habitats of standing water, where the water elevations tend to fluctuate. Seeding potential of these plants is high, and they tend to spread well by rhizomes. The extensive root system and thickening of the stand by rhizomes reduces the erosional effect of waves, while at the same time strengthening and reinforcing the soil.

In general, submergent vegetation such as sedge and rush grow quite readily in bank areas which are underwater for a greater part of the time, while willow and dogwood prefer conditions which are wet but not inundated. A representative bank stabilization concept for the Turners Falls pool using vegetative options is shown in Figure IV-1.

The feasibility of using vegetation to control erosion along riverbanks is highly dependent on the cause of erosion. If the cause is primarily a result of channel downcutting or shear forces along the toe of the bank, vegetative solutions to erosion are not likely to be effective. So while it is possible to maintain a stable slope through the use of vegetation, lower bank areas which come under repeated inundation and the influence of significant waves and river currents may require a more substantial method of

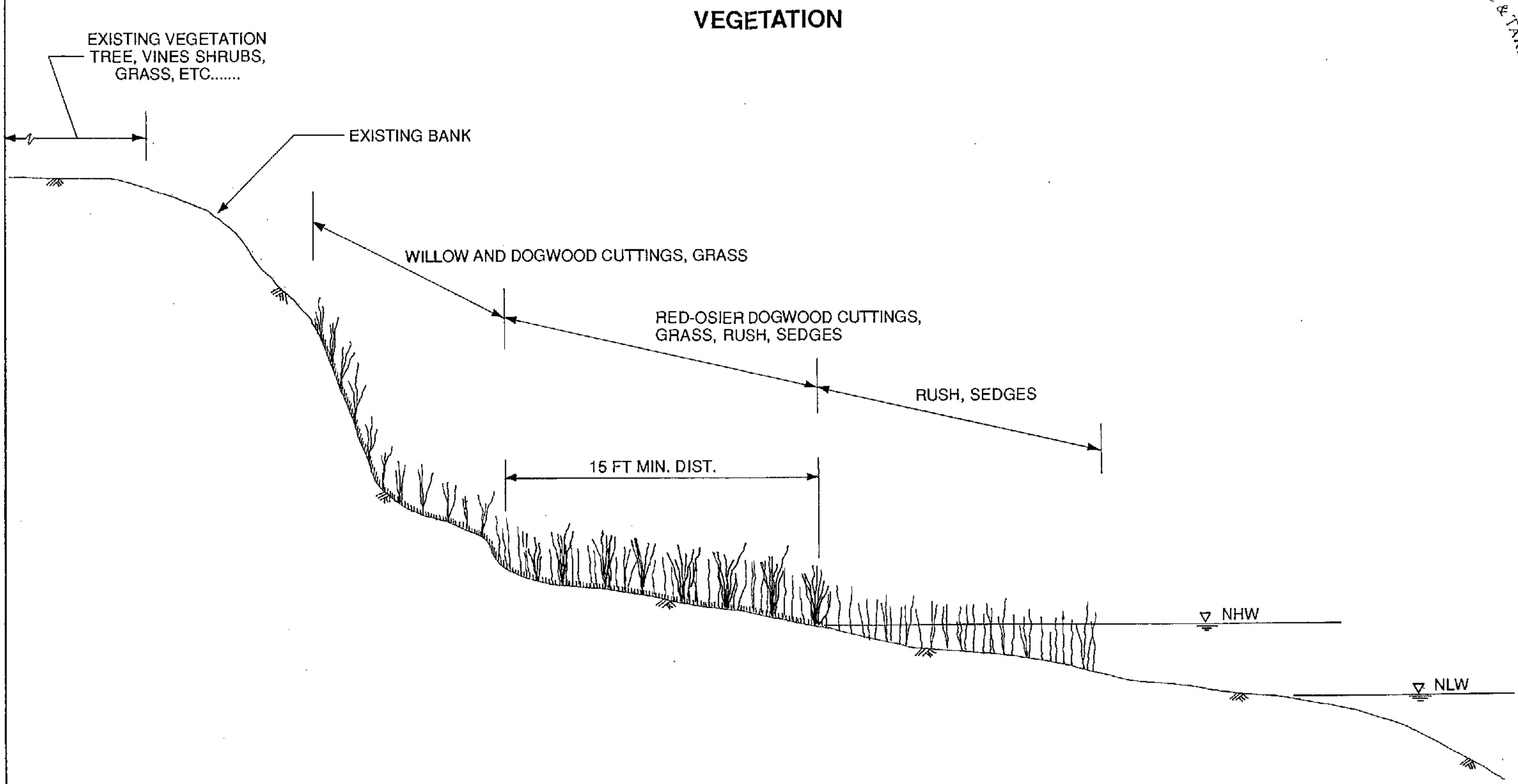


FIGURE IV-1
CONNECTICUT RIVER
RIVERBANK MANAGEMENT MASTER PLAN

90-200

stabilization than is provided by vegetation. If vegetative means of stabilization are expected to maintain bank integrity, a distance of between 10 to 15 ft is generally required between the point at which the normal high water elevation intersects the beach area of a streambank and the toe of bank above the water (see Figure IV-1). In situations where the horizontal distance between the toe of bank and normal high water elevation is less than 10 to 15 ft, additional slope protection will be required to prevent the movement of soil, erosion and bank undercutting.

2. Slope Reinforcement

a. Soil Reinforcement and Geotextiles

Soil or slope reinforcement consists of natural or man-made fabrics designed to strengthen embankments and slopes. Reinforcement reduces the potential for soil movement and provides tensile strength to soil layers. The ability of reinforcement to prevent soil particle transportation is minimal, and is dependent upon the spacing of fabric and grid patterns. Closely spaced fabric grids can retain soil particles and resist the erosive forces of water and runoff; however, reinforcement is primarily designed to strengthen and stabilize slopes internally.

Slope reinforcement is generally used on embankments or slopes which are unable to stand on their own or require additional strength to be stable at steeper grades. Roadways and highway embankments employ reinforcement allowing steeper slopes to be constructed. Along streams and shorelines, slope reinforcement is used to stabilize banks and provide additional support for erosion control devices such as fieldstone, gabions, or vegetation. Figures IV-2 and IV-3 shows the general configuration of slope reinforcement as it applies to streambanks.

NATURAL FIBER MATTING

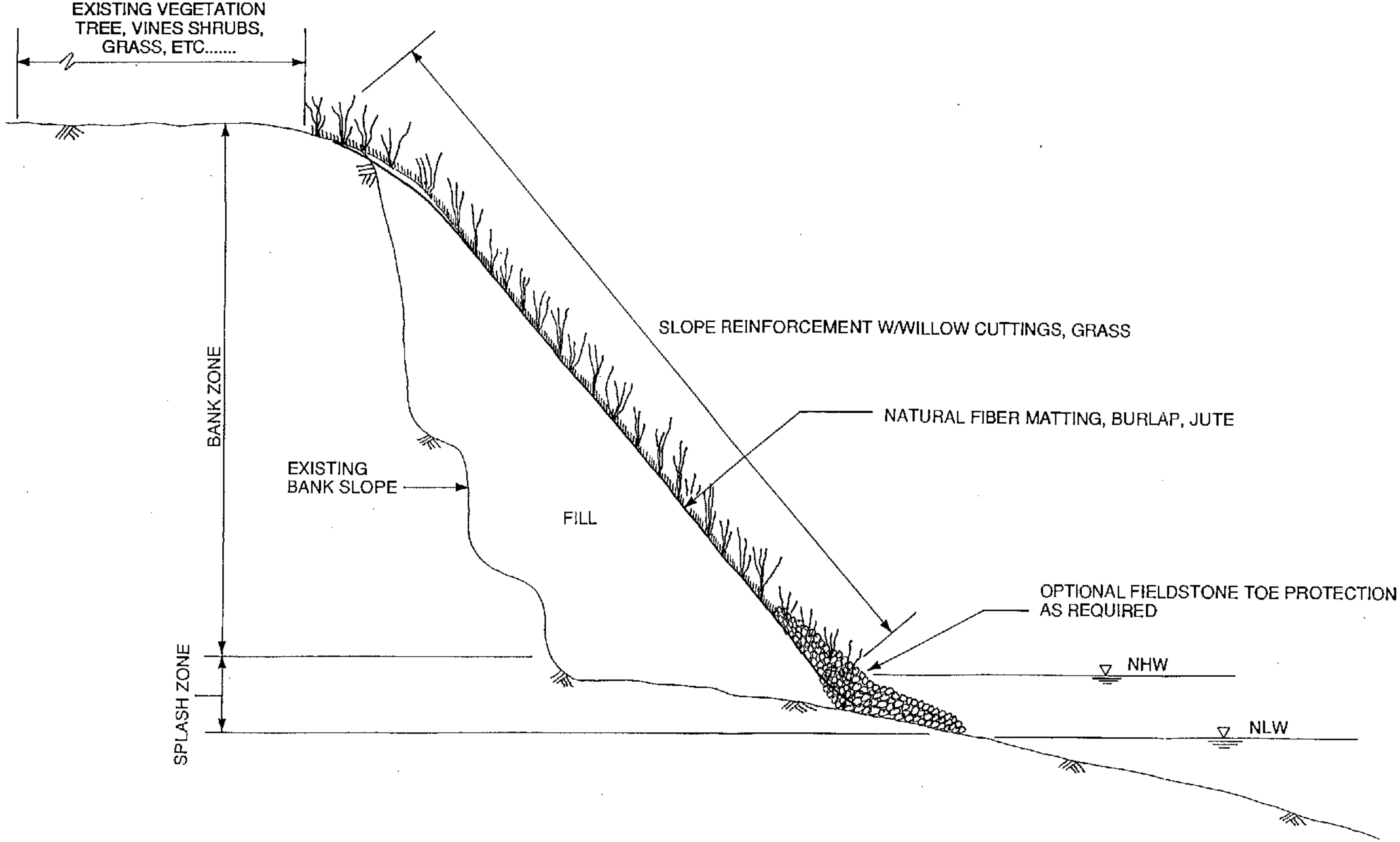


FIGURE IV-2
CONNECTICUT RIVER
RIVERBANK MANAGEMENT MASTER PLAN

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GEOTEXTILE REINFORCEMENT

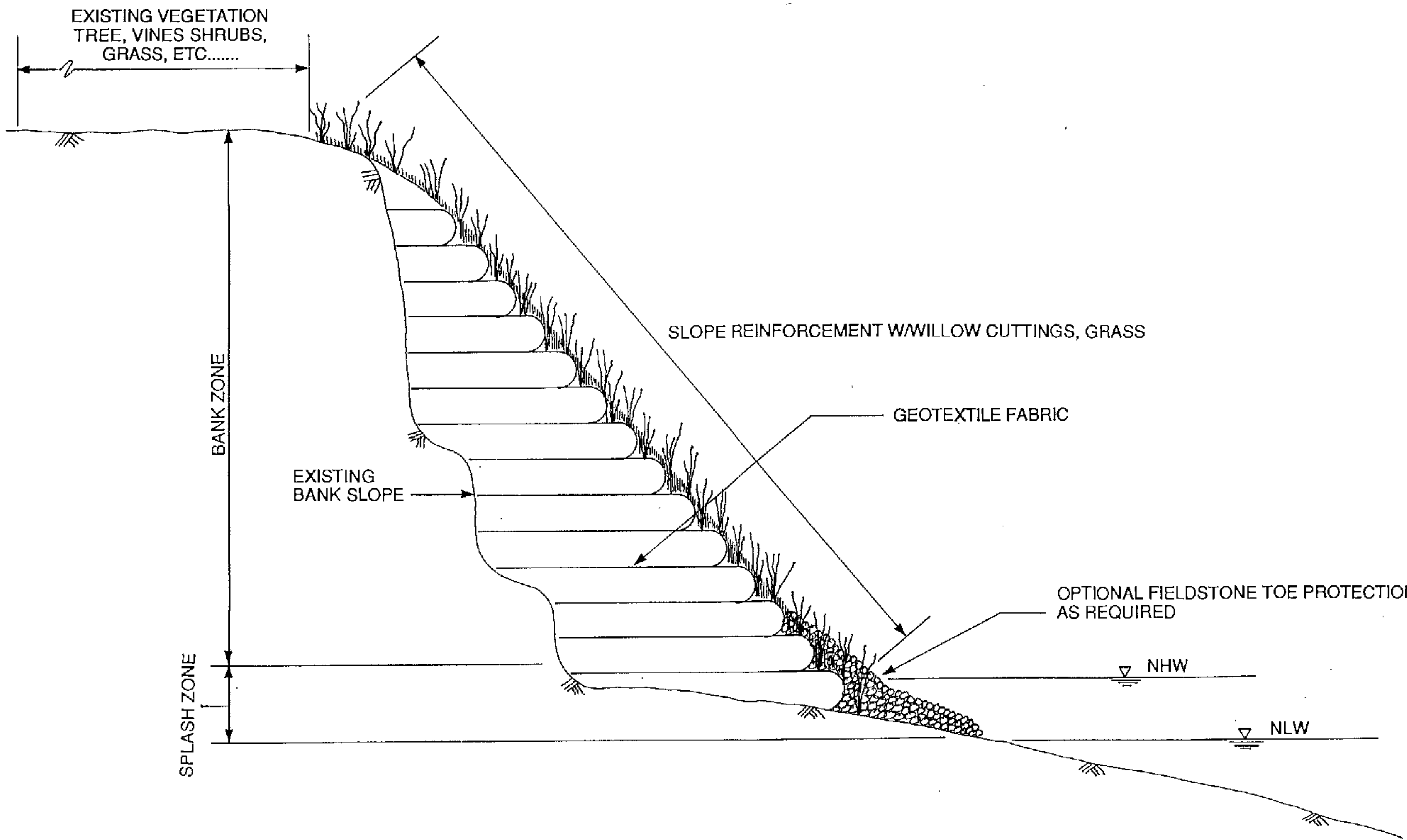

FIGURE IV-3
CONNECTICUT RIVER
RIVERBANK MANAGEMENT MASTER PLAN

In addition to slope reinforcement, geotextile fabric grids have been designed to effectively resist erosion by water and wave action. This system of reinforcement is a surficial treatment of a riverbank, while the soil reinforcement method mentioned above is designed to be internal to the slope. Specially engineered cells and mattresses have been developed to reduce the erosive nature of water on slopes or embankments. Revetment of pre-formed fabric grids vary in shape and design as well as method of installation; however, each is effective at preventing soil loss at the toe of slopes and reducing the erosive action of waves and water. An example of a mattress revetment as it applies to riverbank stabilization is shown in Figure IV-4.

The addition of geotextile fabrics to a slope allows banks to be constructed more steeply, reducing the quantity of fill material required. Synthetic slope reinforcement includes tubular gabions and mattress revetments. Though not internally reinforcing the soil, both tubular gabions and mattress revetments prevent the erosive action of water currents and wave action upon a bank. Use of these synthetic structures is most effective at the toe of a bank under the influence of wave and water action. Figure IV-3 shows the general configuration of geotextile revetment as it applies to riverbank stabilization.

Natural fiber matting provides plants and vegetation an opportunity to become established and stabilize sections of banks which are not directly influenced by water elevation or wave action. Several types of natural fiber matting are produced, some with a life expectancy of 5 to 10 years. While not capable of reinforcing the soil directly, natural fiber matting combines longevity and strength, enabling vegetation to develop root systems which strengthen and reinforce the soil. Use of natural matting is limited to

MATTRESS REVETMENT

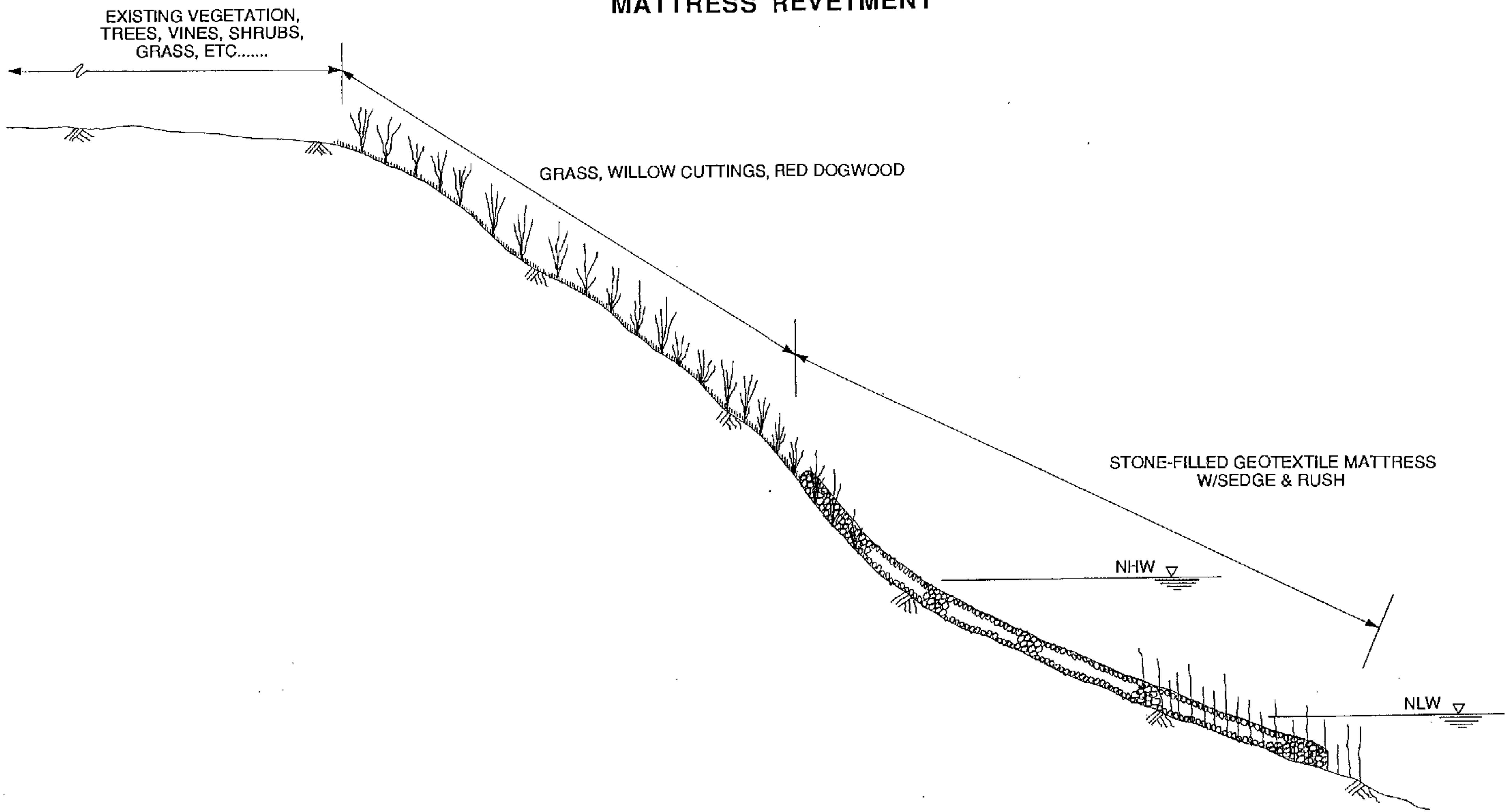

FIGURE IV-4
CONNECTICUT RIVER
RIVERBANK MANAGEMENT MASTER PLAN

those areas of the bank which are not directly influenced by eroding action of the water. Either method of slope reinforcement or protection provides a strong, stable base for vegetation and plantings. Depending upon the type of protection installed, vegetation could aide in strengthening the bank. Photo Panel IV-1 shows slope reinforcement used on the Connecticut River.

The U.S. Corps of Engineers conducted riverbank stabilization experiments within the Turners Falls pool in 1980 as part of the Streambank Erosion Control Evaluation and Demonstration Act of 1974. Five different techniques of bank protection, totaling approximately 2,000 ft, were installed. Stabilization methods included a precast cellular concrete block mattress, an auto tire wall assembled in layers, installed with and without filter fabric, and an auto tire mattress also installed with and without filter fabric. Some grading of the riverbank was performed to accommodate installation of stabilization techniques. Above the normal high water elevation vegetation was used to stabilize the bank. While some small areas of headcutting occur above the stabilization techniques, due to flood flows, these areas quickly revegetate after flood waters recede. Each method of stabilization has proven to be an effective means of preventing riverbank erosion. Figure IV-5 shows the five methods of stabilization used by the Army Corps of Engineers within the Turners Falls pool. Photo Panel IV-2 shows the precast cellular concrete block mattress used on the Connecticut River.

3. Structural Options

a. Fieldstone

Fieldstone bank protection consists of a layer of stone placed on top of a slope or embankment to prevent movement of upland soils by rain and surface runoff and movement of riverbanks due to current and wave action. Fieldstone

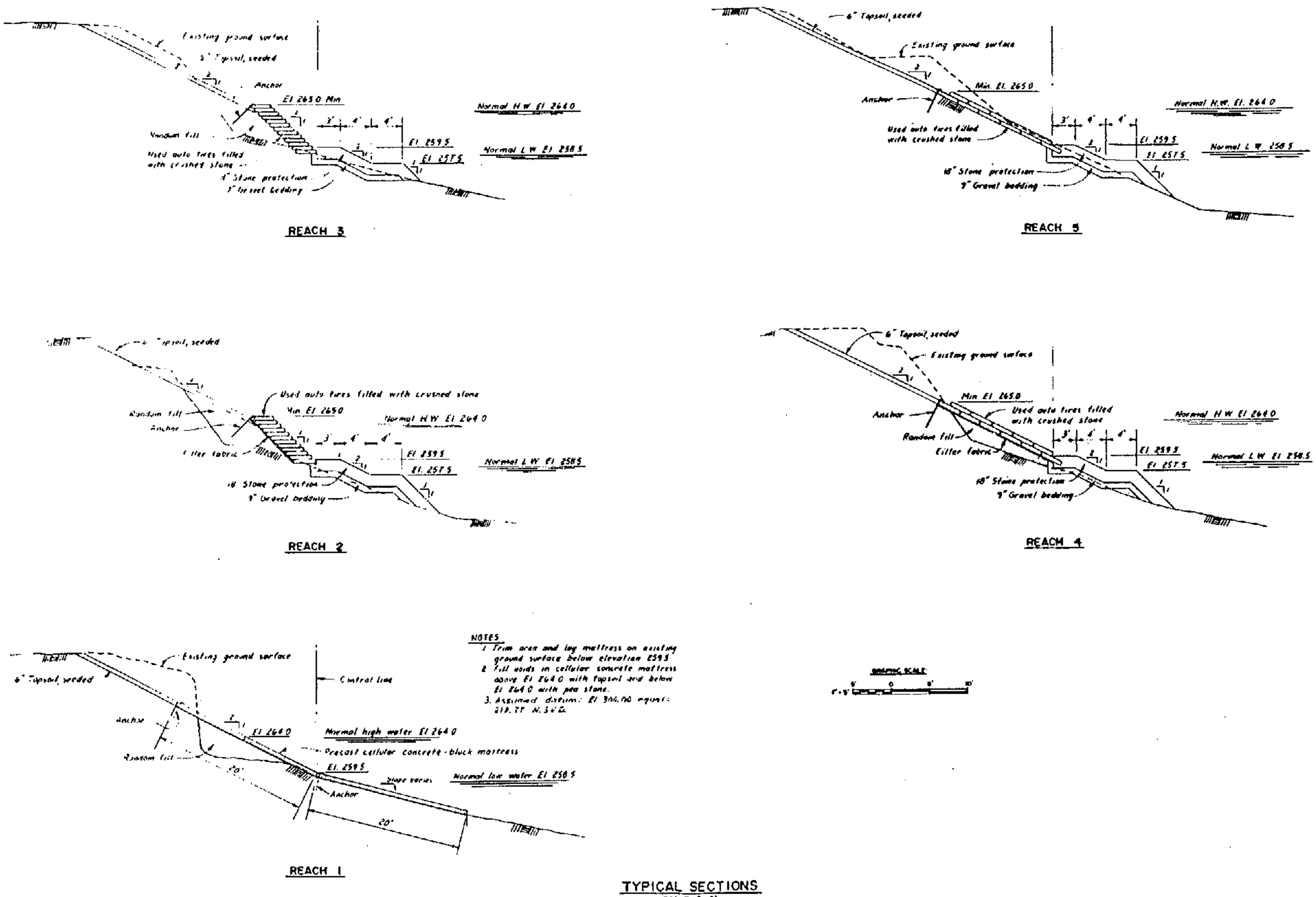

FIGURE IV-5
PROTECTION SCHEMES
CONNECTICUT RIVER
RIVERBANK MANAGEMENT MASTER PLAN

Source: U.S. Army Corps of Engineers

varies in size and weight depending upon the particular application, and can be selectively placed or randomly dumped.

Fieldstone bank protection is applicable under several different conditions. Steep highway embankments can be stabilized by the use of fieldstone and, at the same time, combat the effects of surface runoff. Along coastal shorelines, stone is used to prevent deterioration of banks by wave action. In streams and rivers, fieldstone stabilizes the bank, prevents river currents and wave action from removing soil and vegetation, and prevents erosion at the toe of the bank.

Fieldstone is effective in various situations and site conditions, and is capable of withstanding the erosive forces of water, surface runoff, and wave action. Fieldstone toe protection consists of quarried stone graded according to size and weight requirements needed to prevent disturbance under high velocities of flood flows and erosive wave action. Figure IV-6 shows the general configuration of stone situated on a riverbank. Photo Panel IV-1 shows stone placed along the banks of the Connecticut River at Munn's Ferry Campground and Barton Cove to prevent bank erosion. Repair and stabilization work was performed in 1976, 1984, and 1986, respectively.

Stone has been successfully used along the bank of Buffalo Creek in western New York. Its effectiveness was increased when used in conjunction with other stabilization techniques. The use of stone along the banks of the Winooski River in Vermont was "especially effective where the banks were subject to undercutting." Failure of this method of stabilization generally occurs when an undersized, insufficient, or irregular layer of stone is used. But, when

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FIELDSTONE TOE PROTECTION

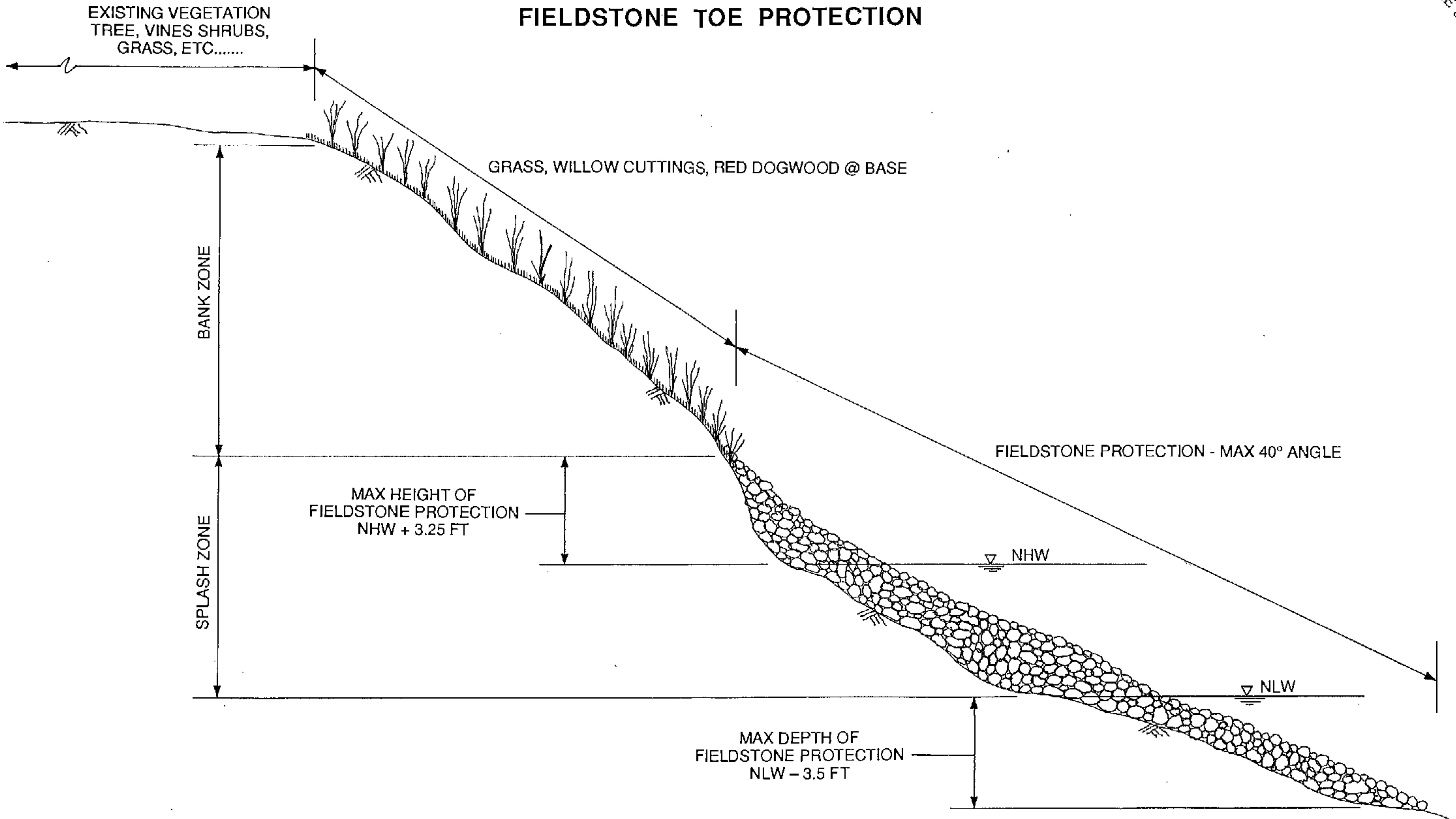
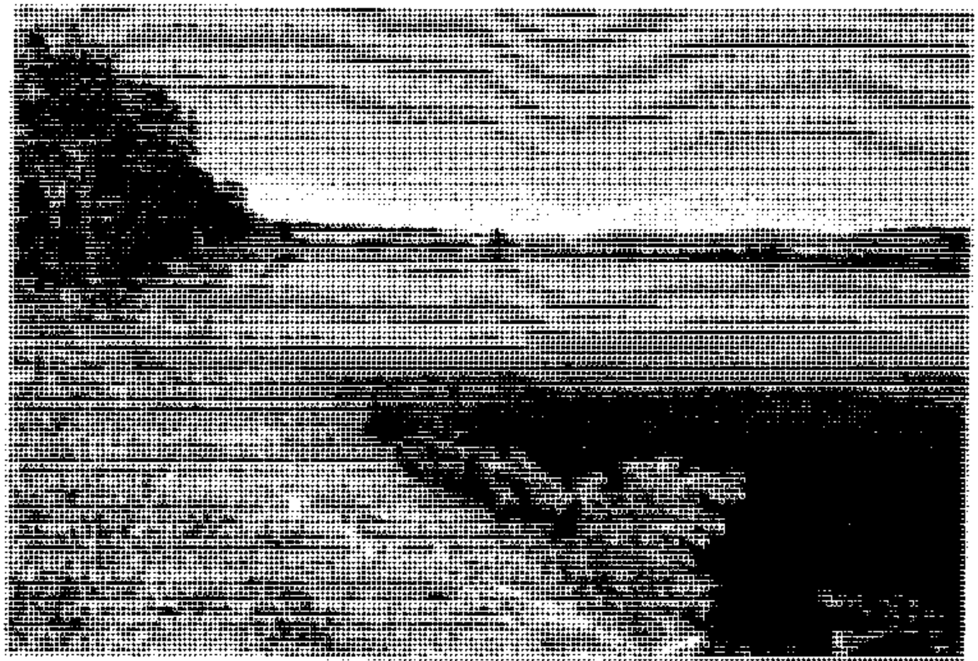


FIGURE IV-6
CONNECTICUT RIVER
RIVERBANK MANAGEMENT MASTER PLAN



Tree clearing - downstream of Rt. 10 bridge in late 1976.

Geotextile slope reinforcement installed in 1981 - downstream of Rt. 10 bridge - Sept. 1990.

properly engineered, fieldstone can be an effective and efficient method of stabilizing an eroding bank.

The placement of stone along the Turners Falls headpond has been quite successful in preventing erosion. Examples of this type of protection on the headpond date back to at least 1930. Locations of stone protection are described in section III.C.2. The stone need only be placed to a height just above normal high water to be effective. It is usually associated with some grading and vegetative stabilization above normal high water where needed. Although some headcutting above the stone is possible, these areas quickly revegetate after flood waters recede.

b. Jetties

Jetties are projections of stone, stone-filled cribs, or rock-filled piles used to deflect water currents away from shores or banks. Jetties are useful where velocities along a bank are great enough to remove soil and cause erosion at the toe. The use of jetties can increase soil deposition and enhance stabilization by reducing water velocities on curved sections of a river, or by preventing the erosive tendencies of river currents or waves.

The materials needed to construct jetties are very similar to those required for fieldstone and gabion wall methods of stabilization. While the fieldstone and gabion method require continuous protection along an eroding bank, jetties are spaced according to streambank curvature. The use of jetties in areas where water is deep adjacent to the toe of the bank, and curvature of the bank is not excessive, reduces the quantity of materials required to stabilize the bank, when compared to stabilization with gabions or fieldstone.

Pile jetties were used along the Winooski River in Vermont as part of a bank stabilization program performed in the mid- 1940s. The effectiveness of the jetties was limited because of annual fluctuations in river elevation, leading to overtopping of the jetties. In the correct situation, and when properly installed, jetties can provide an effective means of controlling erosion. The advantage of reduced material use is limited and based on bank curvature, with a continuous stabilization method becoming more economical on curves of a radius of less than 200 ft.[1]

c. Stone-filled Timber Cribbing and Live Cribs

Stone-filled timber cribs are composed of interlocking layers of timber, partially embedded on a slope or bank, and filled with stones or cobbles. Timber cribbing generally projects out of the bank slightly, and is inclined back into the bank in order to increase stability. Cribbing is effective in both dry upland slopes as well as along stream or riverbanks. Timber cribs are located at the toe of slopes to prevent soil movement and erosion, and to provide a means of support for steeper slopes which require re-grading.

Timber cribbing is useful along embankments or slopes which require reinforcement of the toe and stabilization of bank material. Timber cribs reduce the quantity of soil cut from a bank and the amount of bank affected by regrading. At the toe of a riverbank, cribs retain bank material and prevent the loss of soil and erosion by water and wave action. Stones are placed directly upon foundation bank material and allowed to settle as needed. A secondary benefit of timber

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1. Streambank Erosion Control in the Winooski River, Vermont. Frank C. Edminster.

cribs is the ability of the stone fill to form a cut-off wall by settling below the timber cribbing if excessive undercutting should occur.

Figure IV-7 shows the general configuration of a stone-filled timber crib situated on a riverbank.

d. Gabions

Gabion walls are stone-filled wire baskets placed on slopes or embankments to resist soil movement. Gabion walls retain bank material and are used in circumstances similar to those which require other forms of retaining walls. They are capable of retaining bank material and preventing bank deterioration and erosion.

Gabion walls can be used in situations similar to those of concrete retaining walls. On land, gabions are useful in retaining soil and supporting embankments which might otherwise require regrading or a change in slope. Along riverbanks, gabions provide structural support for banks, resist erosion from surface runoff, and prevent erosion at the toe of a bank. The open, porous nature of a gabion creates a suitable environment for plantings and vegetation. While not directly reinforcing the soil retained by a gabion, vegetation can be used to enhance a wall aesthetically.

Figure IV-8 shows the general configuration of a gabion retaining wall situated on a riverbank.

e. Concrete Retaining Walls

Concrete retaining walls consist of steel reinforced concrete structures placed on an embankment or slope to prevent movement of soil. Generally, retaining walls allow vertical cuts to be made at some distance into a bank without requiring a change to existing bank slopes above.

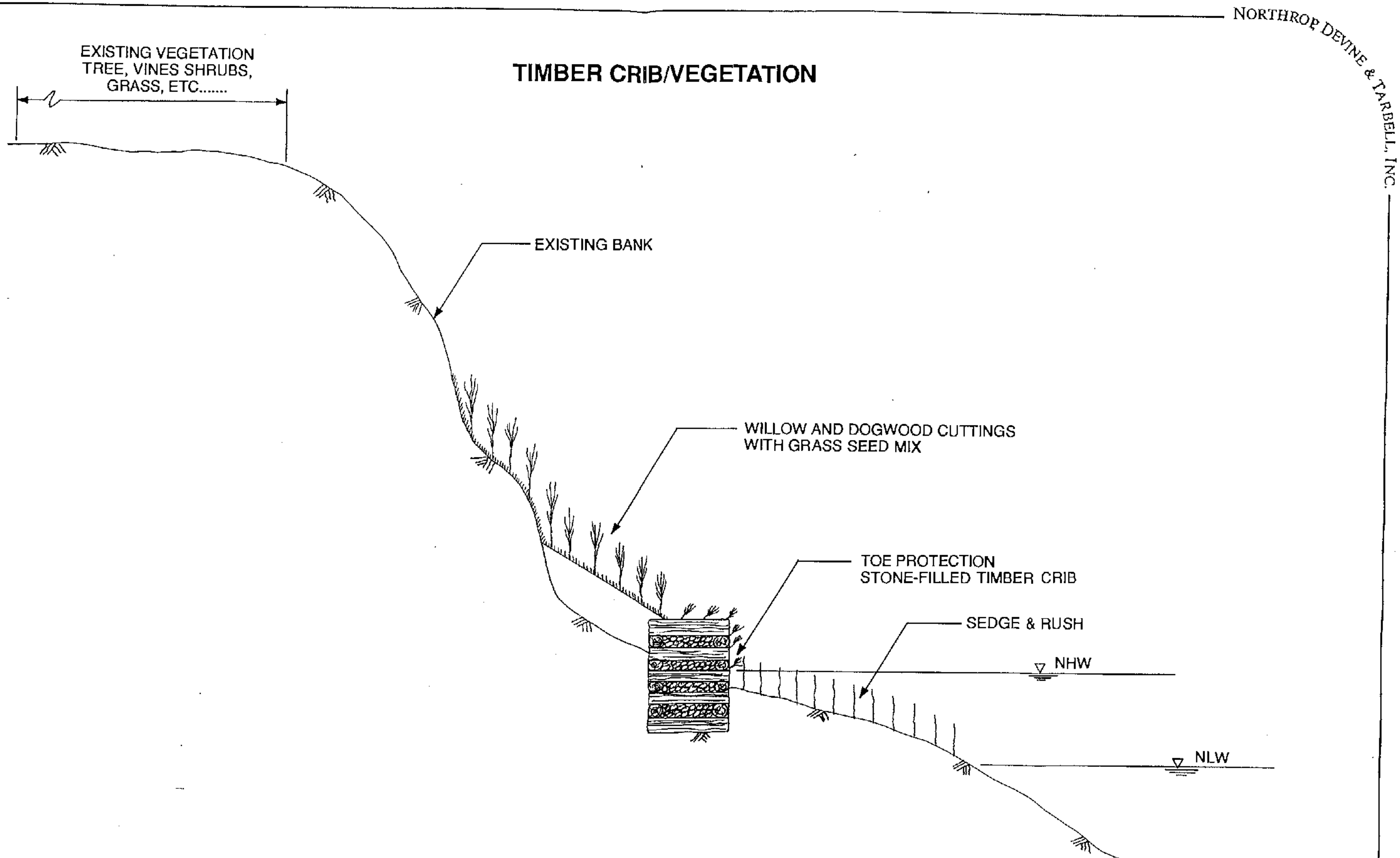

FIGURE IV-7
CONNECTICUT RIVER
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GABION WALL TOE STABILIZATION

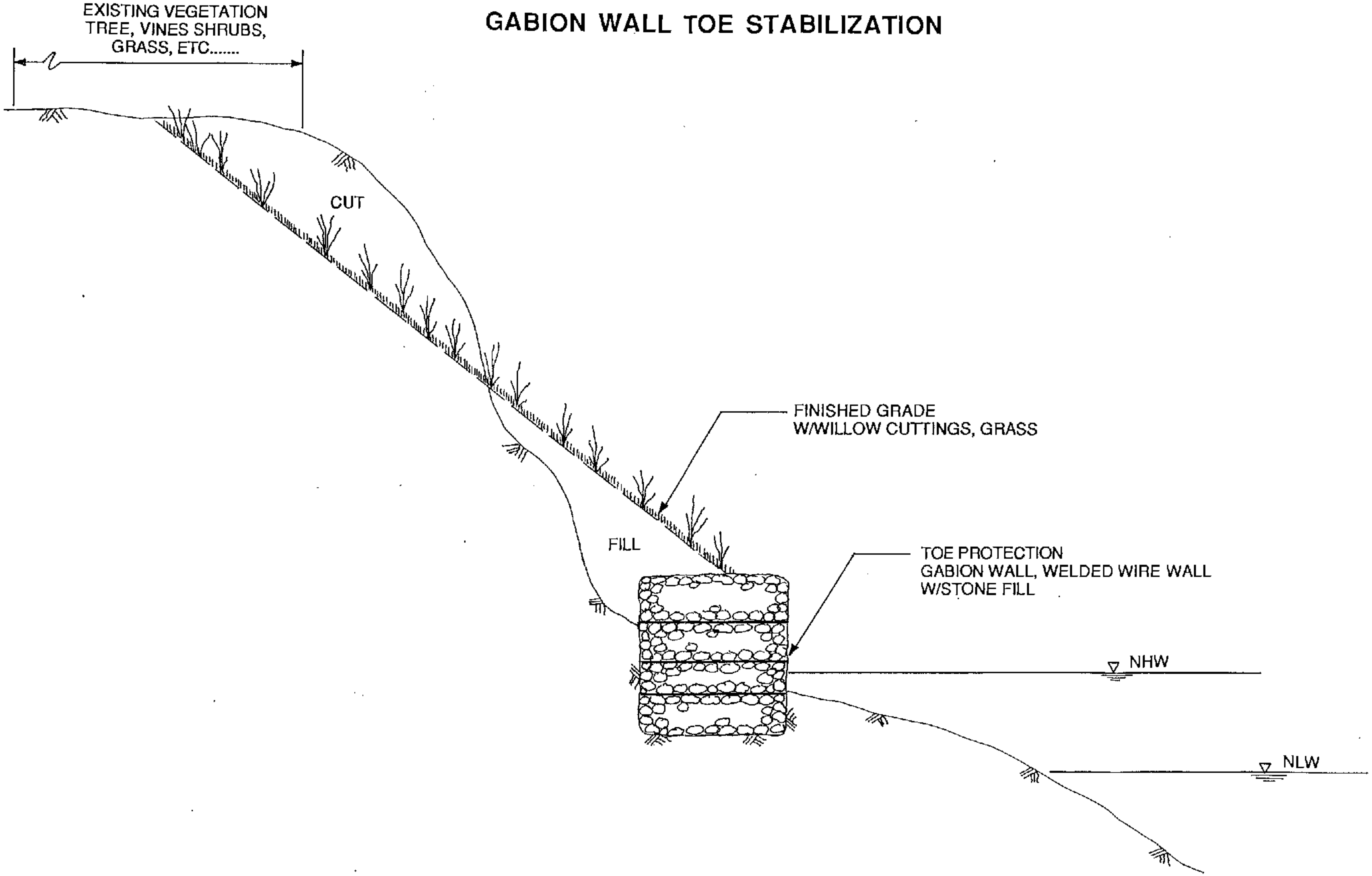

FIGURE IV-8
CONNECTICUT RIVER
RIVERBANK MANAGEMENT MASTER PLAN

Retaining walls also prevent the transportation of soil through permeable layers within a bank, and protect exposed vertical banks from the erosive action of water and surface runoff.

Concrete retaining walls are applicable under several different circumstances. Roads and highways bounded by steep banks often require retaining walls to stabilize the bank without dramatically changing its slope. During the widening of roadways, embankments are often cut creating vertical faces at the toe which require reinforcement, stabilization, and the use of retaining walls. Retaining walls are also suitable along coastal shores as breakwaters and soil-retaining structures. Along riverbanks, concrete retaining walls protect banks from the erosive action of water and waves, while also retaining soil and preventing the removal of material from the toe of the bank or at the water line.

Figure IV-9 shows the general configuration of a concrete retaining wall situated on a riverbank.

When properly designed and engineered, concrete retaining walls can be a very effective and reliable means of protecting riverbanks from erosion, and can be utilized under a broad range of site conditions.

4. Combined Option

a. Geotextiles and Vegetation

Soil reinforcement and geotextile slope stabilization methods not only strengthen soil layers, but provide a stable environment for vegetation and plantings. Plants can more easily establish root systems, develop new growth, and naturally strengthen soil when used in conjunction with some

RETAINING WALL TOE STABILIZATION

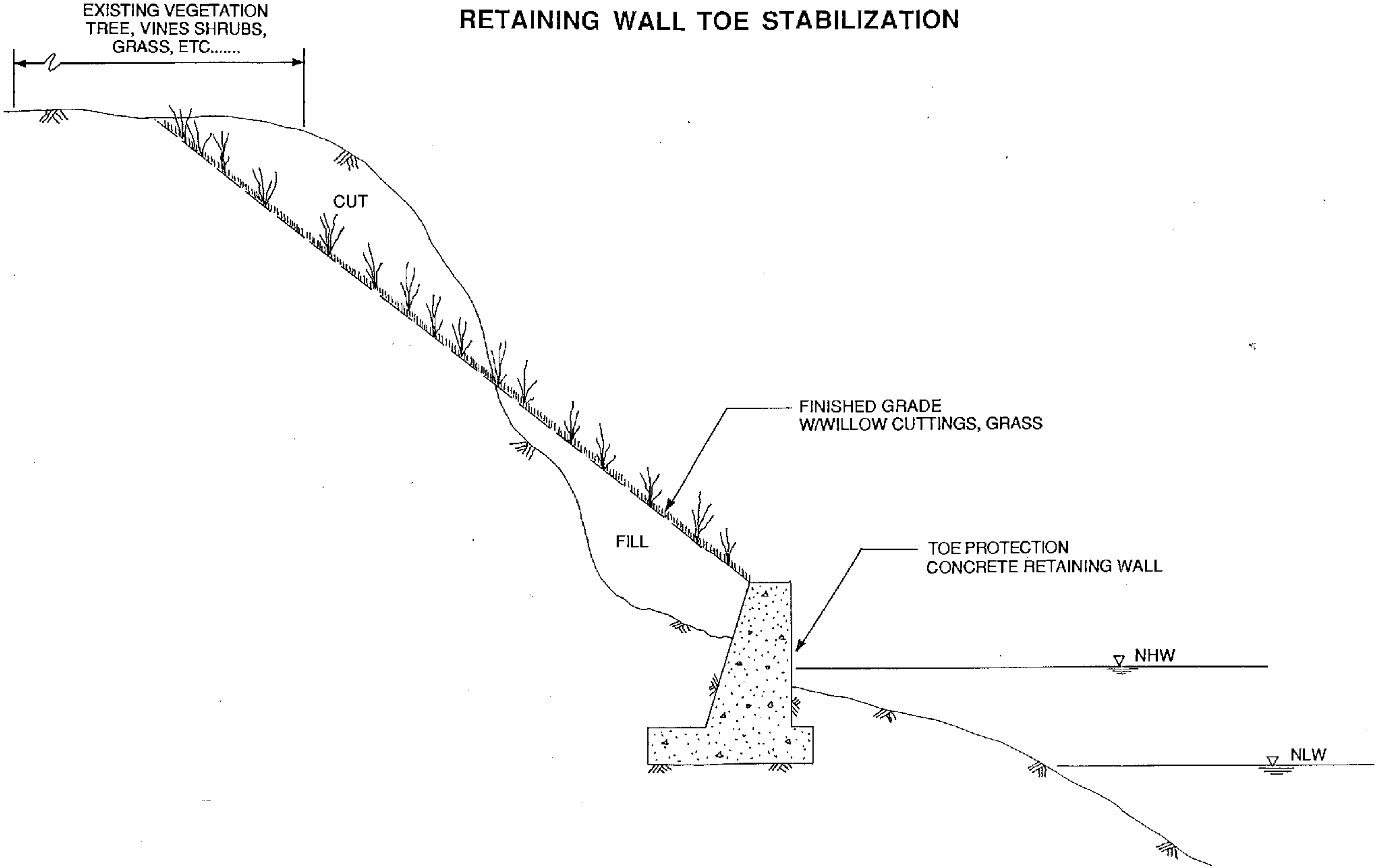

FIGURE IV-9
CONNECTICUT RIVER
RIVERBANK MANAGEMENT MASTER PLAN

form of soil reinforcement. Vegetation can be used without reducing geotextile fabric strength or impairing its performance.

Soil reinforcement and geotextile fabrics can be used at any point along a streambank, allowing vegetation to become established within any zone of the bank. On upper bank areas, geotextiles protect seed and plantings from rainwater and runoff as they develop root systems. In the bank zone and splash zone (from normal low water to flood elevation) geotextile fabrics protect the toe of slopes , prevent soil loss and undercutting, and allow submergent vegetation to root. Geotextile and vegetation combinations provide a means of bank support, prevent erosion, and visually enhance a stabilized slope.

b. Structural and Vegetation

The introduction of vegetation to structural stabilization options improves the appearance of the stabilization method and, in some cases, increases the stabilizing effect of the slope protection. Fieldstone, stone-filled cribs, and gabions protect the toe of slope along a river from the erosive forces associated with waves and currents, while vegetation prevents erosion from occurring in bank areas above the normal high water elevation. Use of vegetation within the structural option develops vegetative continuity from the top of bank to areas below the normal low water elevation. Plantings are capable of rooting within fieldstone, and penetrate soil below, creating a tightly bound stabilization system. Stone-filled timber cribs easily accommodate vegetation as a method of enhancing the cribs appearance. Gabions draped with vegetation buffer the structural appearance of the wire baskets and rock fill.

5. Site Specific - Stabilization Options

Methods of stabilization best suited for erosion sites within the Turners Falls pool have been based upon the various individual stabilization techniques discussed above, adjusted to suit site conditions and the site-specific causes of erosion, to the extent these are known. Individual stabilization techniques and combinations of techniques believed most appropriate for erosion sites are shown in Figures IV-1 through IV-4, and Figures IV-6 through IV-9, and form the basis for erosion site stabilization options. The combination of techniques depicted in Figures IV-1 through IV-4 and Figures IV-6 through IV-9 have been used as the baseline from which cost estimates were developed.

V. RATING AND RANKING OF EROSION SITES

A. Erosion Site Rating Method Overview

In order to compare the physical and environmental resource values and erosion severity evident at sites within the Turners Falls Pool from a common baseline, ND&T developed a rating system designed to allow the ranking of identified sites. The system consists of two overall categories - existing erosion condition and environmental resource value.

The erosion condition category consists of evaluating two factors - the percentage of exposed or unvegetated soil evident at a given site, and the percentage of remaining vegetated bank which shows signs of bank movement. The total numerical value assigned to each site for erosion condition results in a site characterization ranging from none-to-low erosion to severe erosion.

The environmental resource value rating system considered six factors - wetlands, scenic value, unique plant and wildlife habitat, recreational value, archaeological/historical value, and land use adjacent to the riverbank. Figures V-1 and V-2 highlight the components of the rating system and include the numerical range used for rating these factors and the weighting values assigned within each category. Table V-1 provides greater detail regarding the rating of each environmental resource value.

The rating system as it appears in this report is the result of review and discussion from portions of three workshop meetings. In June, 1990 the framework for the rating scheme was presented to the workshop group and the factors to be rated were agreed to. In July a detailed rating method was presented to the workshop members which included all variables and numerical values to be assigned to the rating factors. In August an entire workshop meeting was held to systematically review and refine the environmental resource value rating system. ND&T felt that it was imperative to clearly present and debate the rating method

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EXISTING EROSION CONDITIONS RATING SYSTEM

RANKING VALUE	PERCENT SOIL EXPOSURE	RANKING VALUE	LEVEL OF ACTIVITY/MOVEMENT WITHIN VEGETATED BANK
10	FROM 0 TO 10%	5	FROM 0 TO 10%
20	FROM 10 TO 25%	10	FROM 10 TO 25%
30	FROM 25 TO 50%	15	FROM 25 TO 50%
40	FROM 50 TO 75%	20	FROM 50 TO 75%
50	FROM 75 TO 100%	25	FROM 75 TO 100%

COMPOSITE VALUE	EROSION SITE CHARACTERIZATION
15	NONE TO LOW
20/25	LOW TO MODERATE
30/35	MODERATE
40/45	MODERATE TO SEVERE
>50	SEVERE

FIGURE V-1

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

ENVIRONMENTAL RESOURCE VALUE RATING SYSTEM FOR EROSION SITES
(All variables rated from 0 to 100%)

WETLANDS - 15%

- WETLAND SITE IDENTIFICATION/PROXIMITY 100%

SCENIC/VISUAL - 15%

- WITHIN SIGHT OF RESIDENCE/VIEWPOINT 50%
- LANDSCAPE CHARACTER 25%
- DOMINANCE OF EROSION SITE 25%

HABITAT VALUE - 15%

- RIVERINE HABITAT 25%
- UPLAND HABITAT 25%
- BIRDS/WATERFOWL HABITAT 25%
- PLANTS/FLORA 25%

RECREATION - 15%

- RIVERBANK RECREATION SITE 100%

ARCHAEOLOGICAL/HISTORICAL - 15%

- DOCUMENTED PRESENCE OF RESOURCES OR PROBABILITY OF FINDING RESOURCES 100%

LAND USE - 25%*

- AGRICULTURAL
- RESIDENTIAL
- COMMERCIAL/ INDUSTRIAL
- UNDEVELOPED LAND
- UTILITY, ROAD, RR

*IF ONE LAND USE, MULTIPLY RATING BY 1.0
IF TWO LAND USES, MULTIPLY TOTAL FIGURE BY 0.6
IF THREE LAND USES, MULTIPLY TOTAL FIGURE BY 0.5
IF FOUR LAND USES, MULTIPLY TOTAL FIGURE BY 0.4

FIGURE V-2

TABLE V-1

DETAILED EROSION SITE RATING METHOD FOR ENVIRONMENTAL RESOURCE VALUES

WETLANDS

A. WETLAND SITE IDENTIFICATION	RATING	MULTIPL. FACTOR
No vegetated wetlands exist beyond riverbank and river.	50	
Isolated vegetated wetlands located upland from site, but wetland values not threatened by erosion.	50	
Bordering vegetated wetlands and associated wetland values are slightly threatened by erosion.	75	RATING VALUE x 1.0
Bordering vegetated wetlands and associated wetland values are significantly threatened by erosion.	100	

The total score for wetland value is based solely on the wetland site identification score. This score addresses only the presence of biological wetlands. A minimum score of 50 reflects the presence of submerged areas and the riverbank at each site. The resultant score will range from 50 to 100. This total score will then be multiplied by 0.15 to produce a final value for use in rating the erosion site.

TABLE V-1 (Cont.)

VISUAL/SCENIC VALUE

A. WITHIN SIGHT OF RESIDENCE OR PUBLIC VIEWING POINT	RATING	MULTIPL. FACTOR
Not within sight of residence or public viewing point	0	
Obstructed view from public viewpoint	20	
Within sight of public property with no stationary viewpoint (i.e., road, bridge)	40	RATING VALUE x 0.50
Within sight of public viewpoint or residence	70	
Within sight of residence and public viewpoint	100	

B. CLASSIFICATION OF VIEWSHED'S LANDSCAPE CHARACTER	RATING	MULTIPL. FACTOR
Not Applicable	0	
Common	30	RATING VALUE x 0.25
Noteworthy	70	
Distinctive	100	

C. DOMINANCE OF EROSION SITE WITHIN LANDSCAPE	RATING	MULTIPL. FACTOR
Not Applicable	0	
Subordinate	30	RATING VALUE x 0.25
Co-Dominant	70	
Dominant	100	

The total rating score for visual/scenic value is based on the addition of landscape character (x 0.25), dominance of erosion site (x 0.25), and visibility from residence or viewpoint (x 0.50). The resultant score will range from 0 to 100. This total score will then be multiplied by 0.15 to produce a final value for use in rating the overall erosion site.

TABLE V-1 (Cont.)

UNIQUE HABITAT VALUE

A. RIVERINE HABITAT	RATING	MULTIPL. FACTOR
Common habitat for fish, invertebrates	50	RATING VALUE x 0.25
Above average cover and bottom characteristics for fish, invertebrates	75	
Rare species present	100	

B. UPLAND HABITAT	RATING	MULTIPL. FACTOR
Below average habitat conditions (little to no evidence of mammals, reptiles)	25	RATING VALUE x 0.25
Common upland animal habitat within or adjacent to bank	50	
Above average habitat within or adjacent to bank (i.e., near tributary streams, protected wooded areas)	75	
Rare, endangered animal exists on bank or on land adjacent to bank	100	

C. BIRDS/WATERFOWL HABITAT	RATING	MULTIPL. FACTOR
Poor habitat for use by birds, waterfowl	25	RATING VALUE x 0.25
Common habitat within project area for use by birds/waterfowl	50	
Resident nesting and/or breeding bird habitat in riverbank	75	
Rare species nesting at site	100	

TABLE V-1 (Cont.)

UNIQUE HABITAT VALUE (cont.)

D. PLANTS/FLORA (On bank, top of bank)	RATING	MULTIPL. FACTOR
No plants evident	0	
Less than 50% plant cover on bank	25	
Over 50% plant cover on bank with common species diversity	50	RATING VALUE x 0.25
Confirmed rare plant(s) evident	100	

The total rating score for unique habitat value is based on the addition of riverine habitat (x 0.25), upland habitat (x 0.25), birds/waterfowl habitat (x 0.25) and the value of plants/flora (x 0.25). The resultant score will range from 0 to 100. This total score will then be multiplied by 0.15 to produce a final value for use in rating the overall erosion site. However, any incidence of a rare, threatened or endangered species that is on a published list and is impacted by erosion will automatically cause that site to receive a 100 rating for unique habitat value. These sites may be evaluated separately regarding repair priority because of their unique environmental value.

TABLE V-1 (Cont.)

RECREATION

A. PRESENCE OF RIVERBANK RECREATION OR PUBLIC ACCESS SITE	RATING	MULTIPL. FACTOR
No riverbank public access point exists; or existing recreational use is not adversely affected by erosion.	0	
Site is under consideration for recreational use by landowner or within a recreational plan	25	
Recreational use of land adjacent to riverbank, but not to top of bank	50	RATING VALUE x 1.0
Recreational use on upland to top of bank, or on riverbank	75	
Waterfront recreational use facility exists and is adversely affected by erosion, or waterfront recreational use has been abandoned due to prior erosion activity	100	

The total rating score for an erosion site's recreational value is based solely on the rating for the presence of a riverbank recreational site or public access point. The score will range from 0 to 100. This total score will then be multiplied by 0.15 to produce a final value for use in rating the overall erosion site.

ARCHAEOLOGICAL/HISTORICAL VALUE

A1.	DOCUMENTED PRESENCE OF ARCHAEOLOGICAL RESOURCES	RATING	MULTIPL. FACTOR
	*(If no test pits exist, proceed to 1B)		
	No archaeological resources present	0	
	No riverbank findings, but adjacent sites found on upland	50	
	Archaeological sites evident on less than 100 ft of riverbank shoreline	80	RATING VALUE x 1.0
	Riverbank sites evident on over 100 ft of riverbank shoreline	100	

A2.	RATED PROBABILITY OF FINDING ARCHAEOLOGICAL RESOURCES	RATING	MULTIPL. FACTOR
	*(If subsurface site investigation has been performed at site, proceed to A1.)		
	Low probability (poorly drained or disturbed areas)	20	
	Moderate probability (near water, well drained soils)	50	RATING VALUE x 1.0
	High probability (near water, level, dry, well drained soils)	80	

The total rating score for archaeological/historic value is based solely on the rating of either the value of documented resources (x 1.0) or the probability of finding resources (x 1.0) (whichever one applies, but not both). The resultant score will range from 0 to 100. This total score will then be multiplied by 0.15 to produce a final value for use in rating the overall erosion site.

TABLE V-1 (Cont.)

LAND USE VALUE

A. AGRICULTURAL USE	RATING	MULTIPL. FACTOR
No agricultural use	0	SEE SUMMARY DISCUSSION
Productive agricultural land; cultivated over 100 ft from riverbank	50	
Productive agricultural land; cultivated within less than 100 ft of riverbank	75	

B. RESIDENTIAL USE	RATING	MULTIPL. FACTOR
No residential use	0	SEE SUMMARY DISCUSSION
Residence exists; set back more than 101 ft from riverbank	50	
Residential structure is between 50 ft and 100 ft from riverbank	80	
Residential structure is within 50 ft of riverbank	100	

C. COMMERCIAL/INDUSTRIAL	RATING	MULTIPL. FACTOR
No commercial/industrial use	0	
Riverfront property controlled or owned by commercial/industrial user but not currently utilized	50	
Associated facility exists and is 101 to 200 ft from river	60	SEE SUMMARY DISCUSSION
Associated facility exists and is 50 to 100 ft from river	80	
Associated facility is less than 50 ft from river	100	

TABLE V-1 (Cont.)

LAND USE VALUE (cont.)

D. UNDEVELOPED OPEN OR WOODED LAND	RATING	MULTIPL. FACTOR
Not Applicable	0	SEE SUMMARY DISCUSSION
Undeveloped private land present	50	
Publically accessible undeveloped land present	75	

E. UTILITY, ROAD, RAILROAD	RATING	MULTIPL. FACTOR
No facilities near erosion site	0	
Facility is set back from site, or adequate structural reinforcement exists to counter potential impacts from erosion	20	SEE SUMMARY DISCUSSION
Erosion is within 50 ft of facility; no present indication of damage	60	
Erosion is within 50 ft of facility and could endanger structural integrity	80	
Erosion is presently damaging structural integrity of facility	100	

The total rated score for determining land use value is based on the following method. If only one land use type is evidenced near the erosion site, then the rated score is multiplied by 1.0. If two land use types are evidenced and rated, then the total rated score is equal to the sum of the two land use scores multiplied by 0.6. If three land use types are evidenced, then the total rated score is equal to the sum of the three land use scores multiplied by 0.5. If four land use types are evidenced, then the total rated score is equal to the sum of the four land use scores multiplied by 0.4.

This method is designed to recognize the increased value of sites where multiple land use values exist. This total score will then be multiplied by 0.25 to produce a final value for use in rating the overall erosion site.

being used in this master plan and incorporate the comments and suggestions of participating local and state officials and landowners. This component of the master planning process represents a coordinated effort at striving to fairly assess what is deemed important to both the residents and local users of the river, as well as agencies responsible for regulating resources within the river.

Both the US Army Corps of Engineers and the US Soil Conservation Service were initially contacted regarding the existence of an erosion classification system. Neither agency knew of any system, but they suggested criteria from which a system could be developed. Recommended criteria included riverbank height, slope, soil exposure and soil movement. After analyzing the importance of these criteria as they relate to the project area, and testing several different rating systems, ND&T developed a method of classifying existing erosion which incorporates soil exposure and the amount of movement within the vegetated riverbank area at a given erosion site. Bank height and slope were deemed more indicative of the susceptibility or rate of erosion at a site rather than the present degree of erosion.

Each erosion site has been evaluated based on summer conditions, when vegetation and its coverage are more apparent. Winter and early spring evaluations are considered misleading since bank vegetation is not easily observed and snow cover and freezing conditions preclude observation of tension cracks or signs of recent movement.

The chosen erosion conditions classification system bases an erosion site's severity on the percentage of soil exposure and the percentage of remaining vegetated area which displays signs of bank or soil movement. Each rating component has been assigned five value ranges. The higher the rated value, the more severe the erosion condition. As seen in Figure V-1, the value range for percentage of soil exposure is from 10 to 50, while the value range for bank or soil movement is 5 to 25. A higher weighting has been given to the percentage of soil exposure since exposed soil is considered completely susceptible to erosion. Vegetated areas, meanwhile, even though moving, failing, or sloughing are still substantially more resistant to erosion because of the root mass and binding action of the vegetative cover. The composite value which results from adding the two rated values together is then used to characterize each erosion site.

Once each erosion site was defined, an inventory of the environmental resource values present or influenced by a particular site was completed. In order to equitably compare these values between sites, an environmental resource value rating system was developed. After reviewing the available types of rating systems in existence, a method was developed which rated wetlands, scenic values, flora and fauna habitat values, recreational value, archaeological/historical value and land use value at each site.

No previously used comprehensive environmental rating system specifically designed for use within riverbank areas was uncovered. Other wetland rating methods have been formulated and were analyzed, and scenic value guidelines created by the Commonwealth of Massachusetts were incorporated into the rating system. Ratings related to habitat value acknowledge the presence of rare, threatened and endangered species documented by Vermont, New Hampshire and Massachusetts. Likewise, known archaeological resources registered with each of the three states are given major emphasis. Recreational use and various land use types are rated according to their proximity to an erosion site. Table V-1 indicates how each variable within the environmental resource value rating system was rated and gives the range of numerical values available for assignment.

As stated above, the final method chosen represents a collective effort between ND&T and Workshop participants. As shown on Figure V-2, the method rates each variable on a 0-100 basis and weights land use value slightly higher than the other five variables. Land use either at or adjacent to a riverbank erosion site was given more value because it represents a constant use of the riverbank area and its immediate environs.

This system allows the ranking of erosion sites both comprehensively or for individual erosion characteristics or resource values. For instance, all sites can be ranked separately for their unique habitat value and then compared to the overall rating for existing erosion condition. Or, all sites can be ranked in terms of the percentage of remaining vegetated bank which show signs of bank movement and then cross-reference highly rated sites with soil types that are highly susceptible to erosion. The flexibility built into the system is designed to allow any combination of features to be compared and analyzed. Combined with the coverage overlay capability inherent in the GIS computer data management system, rating numbers assigned to each erosion site can be compared to any of the 20 informational layers added to the data base.

It is also important to remember that this document is a master plan and, as such, should be prepared in a format which easily allows for the updating of existing data and the addition of new data layers as they become available. The GIS data base is tailor-made to suit this objective. The rating method, likewise, was designed to create a consistent and comprehensive method for future periodic ratings to be compared with the initial ratings provided in this report. The success or failure of riverbank management initiatives implemented through this report can be consistently tracked using this rating method.

B. Erosion Site Rating Results

1. Existing Erosion Conditions

As explained above, the rating numbers for existing erosion condition reflect the physical conditions encountered in 1990 in terms of the percentage of soil exposure at a given riverbank site and the level of noticeable movement within the vegetated section of the riverbank. Section III-C of this Master Plan specifies the location, length and characterization of all 76 identified erosion sites. These 76 sites comprise 13.6 miles of riverbank and are shown on Maps A1-1 through A1-7 in Attachment A. A summary table restating these rating numbers is provided in Table V-2. These rating numbers will be merged with the environmental resource rating numbers in Part C of this section to generate a comprehensive rating for each erosion site.

2. Environmental Resource Value Rating

This section will display rating values for each of the six environmental values analyzed and will then show the overall environmental values assigned to each erosion site. Maps A2-1 through A2-7 in Attachment A show the environmental resources being analyzed as they relate to one another throughout the project area. They are helpful in showing not only where resources intersect the riverbank, but also where resources are situated away from riverbank areas. Tables V-3 through V-9 display environmental rating numbers for each of the six environmental resource categories investigated. Tables V-10 and V-11 display the overall environmental ratings for each site.

TABLE V-2

EROSION CLASSIFICATION SUMMARY

#	SITE LENGTH (ft)	EROSION CLASSIFICATION RATING NUMERICAL RATING	CONDITION
1	218	35	MODERATE
2	496	30	MODERATE
3	298	25	LOW-MODERATE
4	395	35	MODERATE
5	533	25	LOW-MODERATE
6	623	25	LOW-MODERATE
7	407	40	MODERATE-SEVERE
8	830	40	MODERATE-SEVERE
9	605	25	LOW-MODERATE
10	184	40	MODERATE-SEVERE
11	392	25	LOW-MODERATE
12	782	35	MODERATE
13	949	40	MODERATE-SEVERE
14	1024	20	LOW-MODERATE
15	1177	25	LOW-MODERATE
16	476	35	MODERATE
17	316	40	MODERATE-SEVERE
18	406	25	LOW-MODERATE
19	706	25	LOW-MODERATE
20	270	35	MODERATE
21	1235	40	MODERATE-SEVERE
22	615	30	MODERATE
23	437	40	MODERATE-SEVERE
24	2042	25	LOW-MODERATE
25	812	40	MODERATE-SEVERE
26	1023	35	MODERATE
27	589	25	LOW-MODERATE
28	991	45	MODERATE-SEVERE

TABLE V-2 - continued

EROSION CLASSIFICATION SUMMARY

SITE #	LENGTH (ft)	EROSION CLASSIFICATION RATING NUMERICAL RATING	CONDITION
29	540	35	MODERATE
30	1677	30	MODERATE
31	2449	35	MODERATE
32	304	40	MODERATE-SEVERE
33	4069	35	MODERATE
34	601	30	MODERATE
35	537	35	MODERATE
36	444	35	MODERATE
37	517	25	LOW-MODERATE
38	770	60	SEVERE
39	500	30	MODERATE
40	667	25	LOW-MODERATE
41	478	40	MODERATE-SEVERE
42	751	35	MODERATE
43	619	35	MODERATE
44	1267	40	MODERATE-SEVERE
45	248	35	MODERATE
46	1231	30	MODERATE
47	505	40	MODERATE-SEVERE
48	1026	35	MODERATE
49	573	30	MODERATE
50	1079	25	LOW-MODERATE
51	1111	40	MODERATE-SEVERE
52	1063	35	MODERATE
53	1342	25	LOW-MODERATE
54	510	30	MODERATE
55	911	20	LOW-MODERATE
56	4126	25	LOW-MODERATE
57	993	30	MODERATE
58	706	45	MODERATE-SEVERE

TABLE V-2 - continued

EROSION CLASSIFICATION SUMMARY

#	SITE LENGTH (ft)	EROSION CLASSIFICATION RATING NUMERICAL RATING	CONDITION
59	2000	25	LOW-MODERATE
60	1627	60	SEVERE
61	454	30	MODERATE
62	642	35	MODERATE
63	3015	40	MODERATE-SEVERE
64	1969	30	MODERATE
65	723	25	LOW-MODERATE
66	2909	25	LOW-MODERATE
67	758	25	LOW-MODERATE
68	645	30	MODERATE
69	2335	40	MODERATE-SEVERE
70	588	30	MODERATE
71	555	30	MODERATE
72	1012	25	LOW-MODERATE
73	389	30	MODERATE
74	596	40	MODERATE-SEVERE
75	860	40	MODERATE-SEVERE
76	128	40	MODERATE-SEVERE

TOTAL 71650 FT
13.57 MI

a. Wetland Value

Wetland values for each erosion site are shown on Table V-3, which lists each erosion site consecutively. The resultant scores reflect the proximity of a given erosion site to any adjacent wetlands that may abut the riverbank. Section III-B.5 of the Master Plan describes the overall wetland values within the Project Area, including their relationship to riverbank areas. Only three erosion sites (11, 51 and 23) are deemed to possess wetlands that are significantly threatened by future erosion. Another 11 sites are adjacent to wetlands that may be slightly threatened by future erosion; simply due to the fact that a small portion of the wetland abuts an erosion site. The remaining 62 sites are not adjacent to any bordering vegetated wetlands. The vast majority of the Project Area's 336 wetlands are situated upland from the riverbanks and are thus unimpacted by riverbank erosion. It can be concluded that the present impact of erosion on existing wetlands is negligible.

TABLE V-3

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

WETLAND RESOURCE RATING

#	SITE LENGTH (ft)	WETLAND NUMERICAL RATING
1	218	7.5
2	496	7.5
3	298	7.5
4	395	7.5
5	533	7.5
6	623	7.5
7	407	7.5
8	830	7.5
9	605	7.5
10	184	7.5
11	392	15.0
12	782	11.3
13	949	7.5
14	1024	7.5
15	1177	7.5
16	476	7.5
17	316	7.5
18	406	7.5
19	706	7.5
20	270	7.5
21	1235	7.5
22	615	7.5
23	437	15.0
24	2042	11.3
25	812	7.5
26	1023	7.5
27	589	7.5
28	991	7.5
29	540	11.3

TABLE V-3 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

WETLAND RESOURCE RATING

SITE #	LENGTH (ft)	WETLAND NUMERICAL RATING
30	1677	11.3
31	2449	7.5
32	304	7.5
33	4069	7.5
34	601	7.5
35	537	7.5
36	444	7.5
37	517	7.5
38	770	7.5
39	500	7.5
40	667	7.5
41	478	7.5
42	751	7.5
43	619	11.3
44	1267	7.5
45	248	7.5
46	1231	11.3
47	505	7.5
48	1026	7.5
49	573	11.3
50	1079	7.5
51	1111	15.0
52	1063	11.3
53	1342	7.5
54	510	7.5
55	911	7.5
56	4126	7.5
57	993	7.5
58	706	7.5

TABLE V-3 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

WETLAND RESOURCE RATING

#	SITE LENGTH (ft)	WETLAND NUMERICAL RATING
59	2000	7.5
60	1627	11.3
61	454	7.5
62	642	11.3
63	3015	7.5
64	1969	7.5
65	723	7.5
66	2909	7.5
67	758	7.5
68	645	7.5
69	2335	7.5
70	588	7.5
71	555	11.3
72	1012	7.5
73	389	7.5
74	596	7.5
75	860	7.5
76	128	7.5

b. Unique Habitat Rating

Table V-4 lists each erosion site consecutively in terms of associated riverbank habitat value. The resultant scores reflect the characterization of a given erosion site's habitat for fisheries, wildlife or protected plant species. Section III-B.6 of the Master Plan describes the overall habitat values within the Project Area, including their relationship to riverbank areas.

It was decided that all riverbank areas inherently possess a habitat value that is important, given their proximity to the river and the associated "edge" habitat that exists within any riverbank. As such, the lowest score assigned to any erosion site was a 7.5 (or 50%). Any site possessing a legislatively protected species was automatically rated 15.0 - the highest rating possible. Ten different sites contain protected species - nine sites possessing rare plants and one site (#76) adjacent to a Bald Eagle nest. Other sites with a wide variety of common species habitat or a relatively large habitat area received above average ratings (i.e., bank swallow nesting cavities, waterfowl nest sites). A total of 26 sites received a rating above 7.5, but below the 15.0 reserved for protected species habitat. The remaining 40 erosion sites were considered average or below average habitat areas.

It should be noted that in some instances, the eroded banks **aid** habitat conditions within a riverbank area. For instance, bank swallows favor unvegetated cliffs near the river and certain rare plants tend to favor frequently flooded areas that are relatively open. This factor must be considered when deciding whether to stabilize a given erosion site. If the completed riverbank repair work does not protect the existing environmental resource value that makes a given site important, then the stabilization work is going to directly conflict with the objective of protecting a valued resource. These rating values dictate the relative importance of riverbank habitat areas, and do not necessarily reflect the urgency attributed to stabilizing that site. A case-by-case assessment of each erosion site's existing environmental value must be weighed against the consequences of altering that site.

Existing erosion conditions do not appear to be negatively impacting the integrity of the Turners Falls Pool's wildlife community. In fact, the loss of vegetation at certain eroded sites tends to create alternative habitat conditions that expand diversity. Riverbank stabilization work may cause a greater negative impact to significant wildlife and plant communities than allowing erosion to gradually advance and retreat.

TABLE V-4

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

UNIQUE HABITAT RESOURCE RATING

SITE #	LENGTH (ft)	UNIQUE HABITAT NUMERICAL RATING
1	218	7.5
2	496	7.5
3	298	15.0
4	395	15.0
5	533	15.0
6	623	7.5
7	407	15.0
8	830	7.5
9	605	8.4
10	184	15.0
11	392	7.5
12	782	15.0
13	949	15.0
14	1024	7.5
15	1177	8.4
16	476	7.5
17	316	7.5
18	406	7.5
19	706	7.5
20	270	15.0
21	1235	7.5
22	615	7.5
23	437	8.4
24	2042	8.4
25	812	15.0
26	1023	8.4
27	589	7.5
28	991	7.5
29	540	8.4

TABLE V-4 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

UNIQUE HABITAT RESOURCE RATING

SITE #	LENGTH (ft)	UNIQUE HABITAT NUMERICAL RATING
30	1677	8.4
31	2449	7.5
32	304	8.4
33	4069	7.5
34	601	8.4
35	537	7.5
36	444	7.5
37	517	7.5
38	770	7.5
39	500	7.5
40	667	8.4
41	478	8.4
42	751	8.4
43	619	8.4
44	1267	9.5
45	248	7.5
46	1231	7.5
47	505	7.5
48	1026	7.5
49	573	8.4
50	1079	8.4
51	1111	7.5
52	1063	7.5
53	1342	7.5
54	510	7.5
55	911	7.5
56	4126	8.4
57	993	7.5
58	706	8.4

TABLE V-4 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

UNIQUE HABITAT RESOURCE RATING

SITE #	LENGTH (ft)	UNIQUE HABITAT NUMERICAL RATING
59	2000	7.5
60	1627	8.4
61	454	7.5
62	642	8.4
63	3015	7.5
64	1969	7.5
65	723	8.4
66	2909	7.5
67	758	7.5
68	645	8.4
69	2335	8.4
70	588	7.5
71	555	7.5
72	1012	7.5
73	389	8.4
74	596	8.4
75	860	8.4
76	128	15.0

c. Scenic Resources

Table V-5 lists each erosion site consecutively in terms of its associated scenic value. The resultant scores reflect the visibility of a given erosion site as it relates to any public viewpoints or residences, the dominance of that erosion site within the local landscape and the overall landscape character of the scenic viewshed that contains the erosion site. Section III-B.7 of the Master Plan describes the overall scenic values within the Project Area, including their relationship to certain erosion sites.

Only 11 erosion sites received a rated score above 7.5 (or 50 percent). The top two rated sites are sites 58 and 63, each scoring a 10.5. Both sites are in a "noteworthy" landscape viewshed within the river, and are co-dominant features within the immediate landscape. Site 58 is visible from a public viewpoint and site 63 is directly across from the Dry Brook riverfront residential community. Seven sites receive a 9.0 rating, primarily due to their location within sight of a public viewpoint and either the dominance of the erosion site or the noteworthy character of the erosion site's local landscape. Site 69 is particularly dominant when viewed from the from the NUSCO Riverview Picnic Area, which receives a fairly high degree of use. Fifty-nine erosion sites scored below 7.5, indicating that the vast majority of erosion sites are simply not visible, except by boaters for relatively brief periods. Hence, the average viewer is relatively unimpacted by any erosion conditions that occur presently.

TABLE V-5

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

SCENIC/VISUAL RESOURCE RATING

#	SITE LENGTH (ft)	SCENIC/VISUAL NUMERICAL RATING
1	218	3.8
2	496	3.8
3	298	2.3
4	395	2.3
5	533	2.3
6	623	2.3
7	407	3.8
8	830	3.8
9	605	5.0
10	184	3.8
11	392	3.8
12	782	3.8
13	949	3.8
14	1024	2.3
15	1177	2.3
16	476	2.3
17	316	3.8
18	406	2.3
19	706	2.3
20	270	2.3
21	1235	3.8
22	615	3.8
23	437	2.3
24	2042	2.3
25	812	3.8
26	1023	2.3
27	589	7.5
28	991	3.8
29	540	2.3

TABLE V-5 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

SCENIC/VISUAL RESOURCE RATING

SITE #	LENGTH (ft)	SCENIC/VISUAL NUMERICAL RATING
30	1677	2.3
31	2449	2.3
32	304	3.8
33	4069	2.3
34	601	5.3
35	537	5.3
36	444	2.3
37	517	5.3
38	770	6.8
39	500	5.3
40	667	8.3
41	478	6.8
42	751	6.8
43	619	6.8
44	1267	5.3
45	248	2.3
46	1231	2.3
47	505	2.3
48	1026	2.3
49	573	2.3
50	1079	2.3
51	1111	3.8
52	1063	2.3
53	1342	9.0
54	510	7.5
55	911	9.0
56	4126	7.5
57	993	9.0
58	706	10.5

TABLE V-5 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

SCENIC/VISUAL RESOURCE RATING

#	SITE LENGTH (ft)	SCENIC/VISUAL NUMERICAL RATING
59	2000	5.3
60	1627	8.0
61	454	5.3
62	642	3.8
63	3015	10.5
64	1969	3.8
65	723	2.3
66	2909	7.5
67	758	3.8
68	645	2.3
69	2335	9.0
70	588	9.0
71	555	7.5
72	1012	7.5
73	389	9.0
74	596	9.0
75	860	2.3
76	128	3.8

d. Archaeological/Historical Value

Table V-6 lists each erosion site consecutively in terms of associated archaeological value. The resultant scores reflect the proximity of a given erosion site to any adjacent riverbank archaeological site, or the probability associated with discovering an archaeological resource at the erosion site. Section III-B.8 of the Master Plan describes the overall archaeological and historical values within the Project Area, including their relationship to riverbank areas. Information used for this rating exercise is based on an investigation conducted in 1990 by the University of Massachusetts Archaeology Department.

The Connecticut River valley is well established as an important historic and prehistoric area. The study conducted by the University of Massachusetts pointed out a significant number of known archaeological sites, as well as extensive riverbank zones possessing a high probability for the discovery of artifacts. Thirty-four erosion sites abut existing archaeological sites and another 34 are immediately adjacent to zones of high probability or are near a known upland site that does not abut the riverbank. Only seven erosion sites were found to have a low probability of containing archaeological resources and one site was rated moderate probability. These findings are not surprising, given the favorability of river valleys and flat river terraces for settlement by Native Americans between 500 and 3000 years ago.

Given the incidence of these known archaeological sites and the probability of discovering additional sites, most planned riverbank stabilization work will require some amount of subsurface testing. Once confirmation of the exact location of artifacts is made, these resources can either be protected through riverbank armoring or retrieved.

Of all environmental resources inventoried along the Turners Falls Pool, archaeological resources cover the broadest zone in relation to erosion sites. It is difficult to assess the precise impact of existing erosion where the location of artifacts, or even the existence of artifacts, is unknown. Monitoring of erosion sites with known resources abutting the riverbank may be necessary in order to prevent the loss of artifacts.

TABLE V-6

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

ARCHAEOLOGICAL/HISTORICAL RESOURCE RATING

#	SITE LENGTH (ft)	ARCHAEOLOGICAL/HISTORICAL NUMERICAL RATING
1	218	12.0
2	496	12.0
3	298	15.0
4	395	15.0
5	533	15.0
6	623	3.0
7	407	3.0
8	830	3.0
9	605	3.0
10	184	15.0
11	392	15.0
12	782	15.0
13	949	15.0
14	1024	15.0
15	1177	15.0
16	476	15.0
17	316	15.0
18	406	12.0
19	706	12.0
20	270	3.0
21	1235	12.0
22	615	12.0
23	437	12.0
24	2042	12.0
25	812	12.0
26	1023	12.0
27	589	7.5
28	991	3.0
29	540	12.0

TABLE V-6 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

ARCHAEOLOGICAL/HISTORICAL RESOURCE RATING

#	SITE LENGTH (ft)	ARCHAEOLOGICAL/HISTORICAL NUMERICAL RATING
30	1677	15.0
31	2449	12.0
32	304	12.0
33	4069	12.0
34	601	12.0
35	537	12.0
36	444	12.0
37	517	15.0
38	770	12.0
39	500	15.0
40	667	12.0
41	478	12.0
42	751	12.0
43	619	12.0
44	1267	12.0
45	248	15.0
46	1231	12.0
47	505	12.0
48	1026	12.0
49	573	15.0
50	1079	12.0
51	1111	12.0
52	1063	15.0
53	1342	15.0
54	510	15.0
55	911	15.0
56	4126	15.0
57	993	15.0
58	706	15.0

TABLE V-6 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

ARCHAEOLOGICAL/HISTORICAL RESOURCE RATING

SITE #	LENGTH (ft)	ARCHAEOLOGICAL/HISTORICAL NUMERICAL RATING
59	2000	15.0
60	1627	15.0
61	454	15.0
62	642	12.0
63	3015	12.0
64	1969	12.0
65	723	12.0
66	2909	12.0
67	758	15.0
68	645	15.0
69	2335	15.0
70	588	15.0
71	555	15.0
72	1012	15.0
73	389	12.0
74	596	15.0
75	860	3.0
76	128	15.0

e. Recreational Resources

Table V-7 lists each erosion site consecutively that possesses or is adjacent to a riverbank recreational site. Section III-B.9 of the Master Plan describes the overall recreational values within the Project Area.

Only five erosion sites were rated above zero. Of these, only site 74 received a 15.0 rating (or 100%). This site is a slide area located on Barton Peninsula with campsites located above the erosion site. Its high rating was assigned because the existing erosion has already caused the abandonment of two campsites. Site 39 is rated relatively high because of its proximity to publicly accessible town property near the riverbank. There are no other instances where recreational sites intersect existing erosion sites. Consequently, riverbank erosion's impact on existing riverbank recreational resources is extremely minimal.

It was determined that riverbank erosion on its own did not interfere with existing recreational activity taking place on the river surface (i.e., boating, water skiing). Views of erosion sites which may impact recreational users are addressed within the scenic resource rating section of the rating method.

TABLE V-7

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

RECREATIONAL RESOURCE RATING

#	SITE LENGTH (ft)	RECREATIONAL NUMERICAL RATING
1	218	0.0
2	496	0.0
3	298	0.0
4	395	0.0
5	533	0.0
6	623	0.0
7	407	0.0
8	830	0.0
9	605	0.0
10	184	0.0
11	392	0.0
12	782	0.0
13	949	0.0
14	1024	0.0
15	1177	0.0
16	476	0.0
17	316	0.0
18	406	0.0
19	706	0.0
20	270	0.0
21	1235	0.0
22	615	0.0
23	437	0.0
24	2042	0.0
25	812	0.0
26	1023	7.5
27	589	0.0
28	991	0.0
29	540	0.0

TABLE V-7 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

RECREATIONAL RESOURCE RATING

SITE #	LENGTH (ft)	RECREATIONAL NUMERICAL RATING
30	1677	0.0
31	2449	0.0
32	304	0.0
33	4069	0.0
34	601	0.0
35	537	0.0
36	444	0.0
37	517	0.0
38	770	0.0
39	500	11.3
40	667	0.0
41	478	0.0
42	751	0.0
43	619	0.0
44	1267	0.0
45	248	0.0
46	1231	0.0
47	505	0.0
48	1026	0.0
49	573	0.0
50	1079	0.0
51	1111	0.0
52	1063	0.0
53	1342	0.0
54	510	0.0
55	911	0.0
56	4126	0.0
57	993	0.0
58	706	0.0

TABLE V-7 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

RECREATIONAL RESOURCE RATING

#	SITE LENGTH (ft)	RECREATIONAL NUMERICAL RATING
59	2000	0.0
60	1627	0.0
61	454	0.0
62	642	0.0
63	3015	0.0
64	1969	0.0
65	723	0.0
66	2909	0.0
67	758	0.0
68	645	0.0
69	2335	0.0
70	588	0.0
71	555	0.0
72	1012	7.5
73	389	7.5
74	596	15.0
75	860	0.0
76	128	0.0

f. Land Use

Table V-8 lists each erosion site consecutively in terms of its adjacent land use value. The resultant scores reflect both the proximity of a given erosion site to any adjacent land use as well as the rated value of that land use. By design, land use values were weighted higher than the other five environmental resource values rated in this Master Plan. They are based on a 0 to 25 score, rather than the 0 to 15 score attributed to the remaining variables. Section III-B.10 of the Master Plan describes the overall land use types existing within the Project Area.

The highest land use rating was a 23.3 (or 93%) assigned to site 38, immediately northeast of the Route Ten Bridge. This erosion site is presently adjacent to the supporting infrastructure of the bridge and may impact the integrity of the structure if erosion continues. NUSCO has contacted the Massachusetts Department of Transportation regarding this situation. Site 38 is also within 100 feet of existing agricultural land. Thirty-eight different erosion sites received a rating of 18.8 (or 75%). The vast majority of these sites are within 100 feet of an adjacent agricultural field. Only one erosion site rated below a 12.5 (or 50%) in land use value.

Over 73% of the 13.6 miles of erosion sites abut wooded property. The land use often changes within 100 feet of the top of bank, however, and that relationship is reflected in these rating values. By weighting land use values higher than the other environmental resources, the resultant score is meant to emphasize the ongoing importance of the resources adjacent to the riverbank which are constantly utilized by a given landowner.

The overall impact to land use associated with existing erosion conditions can be characterized as minimal. The loss of agricultural land has been evidenced at sites, and efforts were made in this Master Plan to quantify land losses at impacted areas. No buildings, roads, railroads, or utility structures are presently endangered by erosion. As discussed in Section VI, riverbank loss has occurred in isolated areas, but has not generated a significant impact on present land uses. It should be noted that NUSCO owns 81% of the riverbank lands along the Turners Falls Pool, and is the impacted landowner in most cases.

TABLE V-8

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

LAND USE RESOURCE RATING

#	SITE LENGTH (ft)	LAND USE NUMERICAL RATING
1	218	15.0
2	496	12.5
3	298	18.8
4	395	18.8
5	533	18.8
6	623	12.5
7	407	12.5
8	830	12.5
9	605	12.5
10	184	18.8
11	392	12.5
12	782	18.8
13	949	18.8
14	1024	18.8
15	1177	12.5
16	476	12.5
17	316	12.5
18	406	18.8
19	706	11.3
20	270	12.5
21	1235	18.8
22	615	18.8
23	437	12.5
24	2042	18.8
25	812	18.8
26	1023	18.8
27	589	15.0
28	991	18.8
29	540	12.5

TABLE V-8 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

LAND USE RESOURCE RATING

#	SITE LENGTH (ft)	LAND USE NUMERICAL RATING
30	1677	18.8
31	2449	18.8
32	304	12.5
33	4069	18.8
34	601	12.5
35	537	12.5
36	444	18.8
37	517	18.8
38	770	23.3
39	500	15.0
40	667	18.8
41	478	18.8
42	751	12.5
43	619	18.8
44	1267	18.8
45	248	12.5
46	1231	18.8
47	505	12.5
48	1026	18.8
49	573	15.0
50	1079	18.8
51	1111	12.5
52	1063	15.0
53	1342	12.5
54	510	12.5
55	911	12.5
56	4126	15.0
57	993	18.8
58	706	18.8

TABLE V-8 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

LAND USE RESOURCE RATING

#	SITE LENGTH (ft)	LAND USE NUMERICAL RATING
59	2000	18.8
60	1627	18.8
61	454	12.5
62	642	12.5
63	3015	18.8
64	1969	18.8
65	723	12.5
66	2909	18.8
67	758	18.8
68	645	18.8
69	2335	18.8
70	588	18.8
71	555	18.8
72	1012	12.5
73	389	12.5
74	596	12.5
75	860	12.5
76	128	12.5

g. Overall Environmental Resource Value

Table V-9 lists each erosion site consecutively in terms of its cumulative environmental resource value. These scores will then be merged with the existing erosion condition values to generate a comprehensive erosion site rating value.

The highest rated sites are those which possess a relatively high incidence of environmental value either within the riverbank site or adjacent to it. The top ten sites are scattered throughout the Turners Falls Pool. The top ranked site is on Barton Peninsula, four sites are located near Stebbins Island and possess rare plants, two sites are on the west riverbank across from Kidds Island and two sites are located near the Northfield Mountain Pumped Storage Facility tailrace.

The scores range from 32.8 to 67.4, based on a 0 to 100 scale. The median score is 51.0. These quantified evaluations of the environmental resources associated with existing erosion sites are meant to be used as a gauge for determining the relative importance of each erosion site's environmental value. They are not meant to indicate a definitive value, but instead are designed to act as a barometer for comparative purposes. This should be kept in mind when using these numbers for decision-making purposes.

TABLE V-9

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

ENVIRONMENTAL RESOURCE RATING

#	SITE LENGTH (ft)	ENVIRONMENTAL RESOURCE RATING NUMERICAL RATING
1	218	45.8
2	496	43.3
3	298	58.6
4	395	58.6
5	533	58.6
6	623	32.8
7	407	41.8
8	830	34.3
9	605	36.4
10	184	60.1
11	392	53.8
12	782	63.9
13	949	60.1
14	1024	51.1
15	1177	45.7
16	476	44.8
17	316	46.3
18	406	48.1
19	706	40.6
20	270	40.3
21	1235	49.6
22	615	49.6
23	437	50.2
24	2042	52.8
25	812	57.1
26	1023	56.5
27	589	45.0
28	991	40.6
29	540	46.5

TABLE V-9 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

ENVIRONMENTAL RESOURCE RATING

#	SITE LENGTH	ENVIRONMENTAL RESOURCE RATING
	(ft)	NUMERICAL RATING
30	1677	55.8
31	2449	48.1
32	304	44.2
33	4069	48.1
34	601	45.7
35	537	44.8
36	444	48.1
37	517	54.1
38	770	57.1
39	500	61.6
40	667	55.0
41	478	53.5
42	751	47.2
43	619	57.3
44	1267	53.1
45	248	44.8
46	1231	51.9
47	505	41.8
48	1026	48.1
49	573	52.0
50	1079	49.0
51	1111	50.8
52	1063	51.1
53	1342	51.5
54	510	50.0
55	911	51.5
56	4126	53.4
57	993	57.8
58	706	60.2

TABLE V-9 (continued)

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

ENVIRONMENTAL RESOURCE RATING

#	SITE LENGTH	ENVIRONMENTAL RESOURCE RATING
	(ft)	NUMERICAL RATING
59	2000	54.1
60	1627	61.5
61	454	47.8
62	642	48.0
63	3015	56.3
64	1969	49.6
65	723	42.7
66	2909	53.3
67	758	52.6
68	645	52.0
69	2335	58.7
70	588	57.8
71	555	60.1
72	1012	57.5
73	389	56.9
74	596	67.4
75	860	33.7
76	128	53.8

C. Comprehensive Rating and Ranking of Erosion Sites

Tables V-10 and V-11 list the comprehensive ratings and rankings of the 76 erosion sites identified by ND&T within the Turners Falls Pool of the Connecticut River. These comprehensive ratings combine the numbers assigned to each site for existing erosion condition and overall environmental resource value. The assigned ratings and rankings are to be used to assist in the selection of erosion sites which will require either full-scale riverbank stabilization, short-term remedial stabilization measures, future monitoring of conditions or no further action.

The comprehensive rating combines the erosion site characterization score with the environmental resource rating score on a 50%-50% basis. The resultant combined scores were then ranked in order to determine the relative importance of each of the 76 erosion sites. It is an attempt to combine and quantify the findings of the erosion site identification exercise and the environmental resource inventory.

The highest rated site is site 60, on the west bank across from Kidds Island, with a comprehensive score of 61. Site 6 received the lowest score with a 29. The median score among all sites is 41. The two highest ranked sites are also the only two sites classified as "severe" in terms of erosion.

This erosion site ranking will serve as the primary basis for determining an equitable action plan designed to protect environmental resource values where erosion is negatively impacting them. Depending on the status of the erosion at a given site and the nature of the associated environmental values which are subject to degradation, an appropriate implementation strategy will be devised. Section VII of the Master Plan will recommend a comprehensive plan with various initiatives designed to address conditions at the highest ranked sites first.

When overlaying 13.5 miles of erosion sites with the variety of environmental resource values characterized within the Master

Plan, the amount of identified resources which are not adjacent to an erosion site is significant. As shown throughout Section V, the relationship between the resources identified in Section III and existing erosion is such that the most significant resources are not impacted by erosion.

Wetlands are generally not abutting erosion. Scenic viewpoints such as the French King Bridge or Barton Cove vantage points are not influenced by erosion. Protected plant and wildlife resources are more influenced by the overall setting of the Turners Falls Pool and, in fact, are sometimes aided by erosion. Recreational, residential, and industrial facilities are not endangered by erosion. The primary resources presently impacted by erosion are agricultural land use and archaeological resources. Agricultural land loss can be quantified over time, and attempts have been made to determine bank movement in Section III of this plan. Archaeological resources are more difficult to identify, but the high incidence of known and highly probable resource areas causes this resource to be most potentially impacted by existing and future erosion.

TABLE V-10

COMPREHENSIVE RATING OF EROSION SITES

SITE #	APPROXIMATE LENGTH (ft)	EROSION CLASSIFICATION RATING	ENVIRONMENTAL RESOURCE RATING	COMPREHENSIVE SITE RATING
		NUMERICAL RATING	NUMERICAL RATING	
1	218	35	45.8	40
2	496	30	43.3	37
3	298	25	58.6	42
4	395	35	58.6	47
5	533	25	58.6	42
6	623	25	32.8	29
7	407	40	41.8	41
8	830	40	34.3	37
9	605	25	36.4	31
10	184	40	60.1	50
11	392	25	53.8	39
12	782	35	63.9	49
13	949	40	60.1	50
14	1024	20	51.1	36
15	1177	25	45.7	35
16	476	35	44.8	40
17	316	40	46.3	43
18	406	25	48.1	37
19	706	25	40.6	33
20	270	35	40.3	38
21	1235	40	49.6	45
22	615	30	49.6	40
23	437	40	50.2	45
24	2042	25	52.8	39
25	812	40	57.1	49
26	1023	35	56.5	46
27	589	25	45.0	35
28	991	45	40.6	43
29	540	35	46.5	41
30	1677	30	55.8	43

TABLE V-10 (continued)

COMPREHENSIVE RATING OF EROSION SITES

SITE #	APPROXIMATE LENGTH (ft)	EROSION CLASSIFICATION RATING	ENVIRONMENTAL RESOURCE RATING	COMPREHENSIVE SITE RATING
		NUMERICAL RATING	NUMERICAL RATING	
31	2449	35	48.1	42
32	304	40	44.2	42
33	4069	35	48.1	42
34	601	30	45.7	38
35	537	35	44.8	40
36	444	35	48.1	42
37	517	25	54.1	40
38	770	60	57.1	59
39	500	30	61.6	46
40	667	25	55.0	40
41	478	40	53.5	47
42	751	35	47.2	41
43	619	35	57.3	46
44	1267	40	53.1	47
45	248	35	44.8	40
46	1231	30	51.9	41
47	505	40	41.8	41
48	1026	35	48.1	42
49	573	30	52.0	41
50	1079	25	49.0	37
51	1111	40	50.8	45
52	1063	35	51.1	43
53	1342	25	51.5	38
54	510	30	50.0	40
55	911	20	51.5	36
56	4126	25	53.4	39
57	993	30	57.8	44
58	706	45	60.2	53
59	2000	25	54.1	40
60	1627	60	61.5	61

TABLE V-10 (continued)

COMPREHENSIVE RATING OF EROSION SITES

SITE #	APPROXIMATE LENGTH (ft)	EROSION CLASSIFICATION RATING	ENVIRONMENTAL RESOURCE RATING	COMPREHENSIVE SITE RATING
		NUMERICAL RATING	NUMERICAL RATING	
61	454	30	47.8	39
62	642	35	48.0	42
63	3015	40	56.3	48
64	1969	30	49.6	40
65	723	25	42.7	34
66	2909	25	53.3	39
67	758	25	52.6	39
68	645	30	52.0	41
69	2335	40	58.7	49
70	588	30	57.8	44
71	555	30	60.1	45
72	1012	25	57.5	41
73	389	30	56.9	43
74	596	40	67.4	54
75	860	40	33.7	37
76	128	40	53.8	47
AVERAGE		33	51	42
	71650 FT 13.57 MI			

TABLE V-11

COMPREHENSIVE RANKING OF EROSION SITES

SITE #	APPROXIMATE LENGTH (FT)	EROSION CLASSIFICATION RATING	ENVIRONMENTAL RESOURCE RATING	COMPREHENSIVE SITE RATING *	OVERALL RANKING
		NUMERICAL RATING	NUMERICAL RATING		
60	1627	60	61.5	61	1
38	770	60	57.1	59	2
74	596	40	67.4	54	3
58	706	45	60.2	53	4
13	949	40	60.1	50	5
10	184	40	60.1	50	6
12	782	35	63.9	49	7
69	2335	40	58.7	49	8
25	812	40	57.1	49	9
63	3015	40	56.3	48	10
76	128	40	53.8	47	11
4	395	35	58.6	47	12
41	478	40	53.5	47	13
44	1267	40	53.1	47	14
43	619	35	57.3	46	15
39	500	30	61.6	46	16
26	1023	35	56.5	46	17
51	1111	40	50.8	45	18
23	437	40	50.2	45	19
71	555	30	60.1	45	20
21	1235	40	49.6	45	21
57	993	30	57.8	44	22
70	588	30	57.8	44	23
73	389	30	56.9	43	24
17	316	40	46.3	43	25
52	1063	35	51.1	43	26
30	1677	30	55.8	43	27
28	991	45	40.6	43	28
32	304	40	44.2	42	29
5	533	25	58.6	42	30
3	298	25	58.6	42	31
33	4069	35	48.1	42	32
31	2449	35	48.1	42	33
48	1026	35	48.1	42	34
36	444	35	48.1	42	35
62	642	35	48.0	42	36
72	1012	25	57.5	41	37
42	751	35	47.2	41	38
68	645	30	52.0	41	39
49	573	30	52.0	41	40
46	1231	30	51.9	41	41
47	505	40	41.8	41	42

**Comp. Site Rating = 0.5x(Eros. Class. Rating) + 0.5x(Environ. Res. Rating)*

TABLE V-11 (Continued)

COMPREHENSIVE RANKING OF EROSION SITES

SITE #	APPROXIMATE LENGTH (FT)	EROSION CLASSIFICATION RATING	ENVIRONMENTAL RESOURCE RATING	COMPREHENSIVE SITE RATING *	OVERALL RANKING
		NUMERICAL RATING	NUMERICAL RATING		
7	407	40	41.8	41	43
29	540	35	46.5	41	44
1	218	35	45.8	40	45
40	667	25	55.0	40	46
54	510	30	50.0	40	47
35	537	35	44.8	40	48
16	476	35	44.8	40	49
45	248	35	44.8	40	50
64	1969	30	49.6	40	51
22	615	30	49.6	40	52
59	2000	25	54.1	40	53
37	517	25	54.1	40	54
11	392	25	53.8	39	55
56	4126	25	53.4	39	56
66	2909	25	53.3	39	57
24	2042	25	52.8	39	58
61	454	30	47.8	39	59
67	758	25	52.6	39	60
53	1342	25	51.5	38	61
34	601	30	45.7	38	62
20	270	35	40.3	38	63
8	830	40	34.3	37	64
50	1079	25	49.0	37	65
75	860	40	33.7	37	66
2	496	30	43.3	37	67
18	406	25	48.1	37	68
55	911	20	51.5	36	69
14	1024	20	51.1	36	70
15	1177	25	45.7	35	71
27	589	25	45.0	35	72
65	723	25	42.7	34	73
19	706	25	40.6	33	74
9	605	25	36.4	31	75
6	623	25	32.8	29	76
AVERAGE		33	51	42	

71650 FT
13.57 MI

VI. DISCUSSION OF THE CAUSES OF EROSION

Depending on one's point of view, a river can be characterized in many different ways. Recreationists will view a river as potential for leisure time activity, biologists will view it in terms of the uniqueness of the ecosystems it supports, industry will consider its ability to do work or assist in a process, hydrologists consider its variation in flow rate and potential for flood and drought, and the geomorphologist will inquire about its channel geometry and spatial pattern.

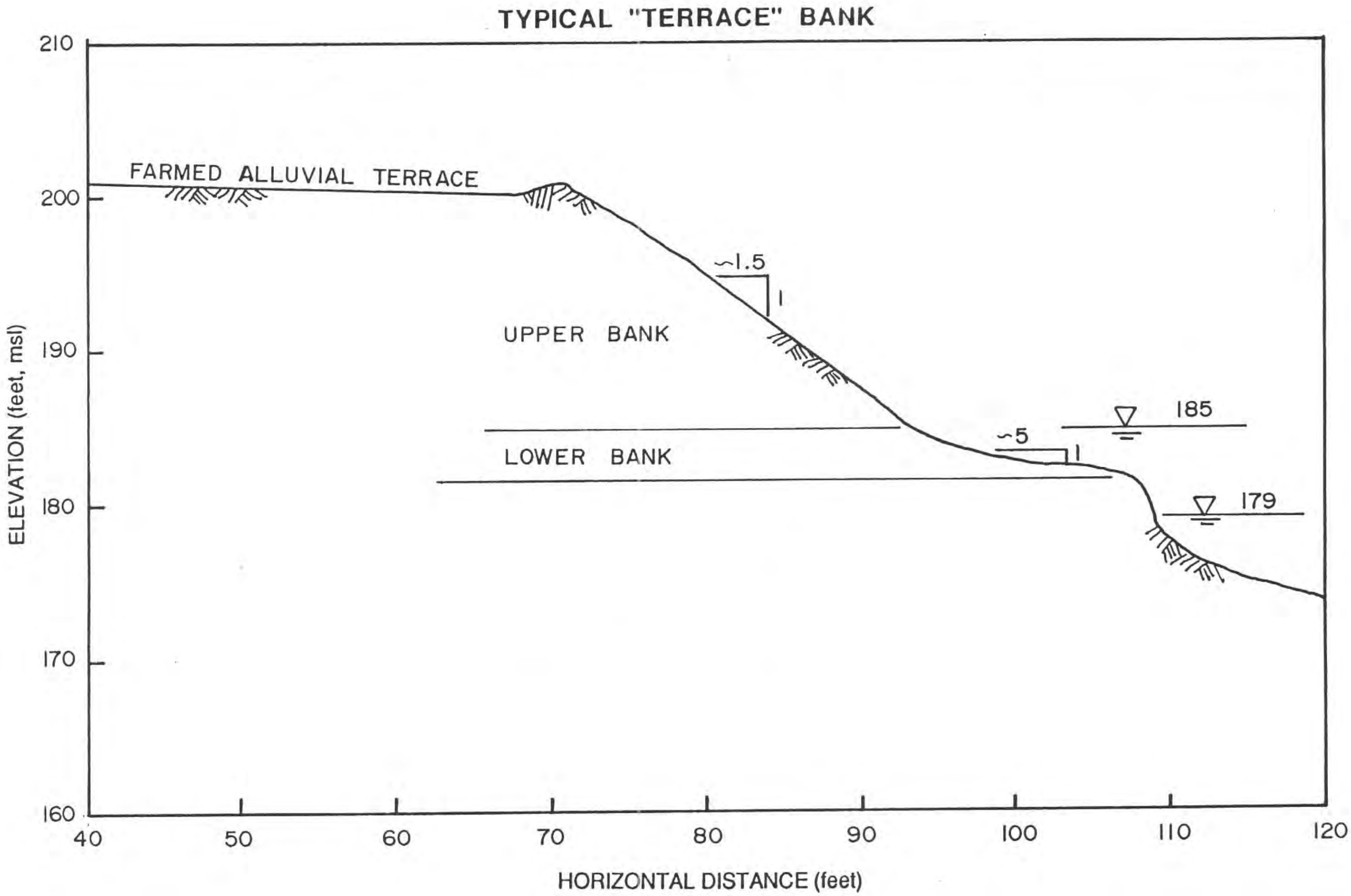
As part of the Master Plan, the river was considered with respect to its ability to transform its channel. The modification of a river channel occurs by the simultaneous processes of erosion and sedimentation. These processes can affect recreation, flora and fauna habitats, hydraulics, associated riverbank land use, and other characteristics of the river and riverbank resources.

Rivers are dynamic systems and river geometry can be the result of complex cause-effect relationships. The most visible evidence of a river's natural tendency to change is erosion of its banks. The forces contributing to erosion can be greatly influenced by man, and can result in either the acceleration or inhibition of erosion. The forces causing erosion tend to vary considerably from one river to another, between reaches of the same river, and at opposite banks at the same river section. Developing a clear idea of the dominant forces at work in a specific river area is the key to understanding the causes of erosion.

The Connecticut River between Turners Falls Dam and Vernon Dam can be classified as an alluvial river with a relatively stable channel. Notwithstanding such a classification, there is evidence of significant channel movement in the Study Area which is apparent from a close examination of available aerial photographs. Ground and aerial photographs obtained from a variety of sources dating back to 1929 show that riverbank erosion has long been a part of this reach of the Connecticut River. Photos obtained in May, 1990 clearly show the boundaries of old river channels in what is now active farmland. As recently as 1938, a major channel shift occurred when the flood flows of March overtopped the banks and rerouted the river around the Shell Bridge. If not for the restoration efforts of man, the channel may have been permanently rerouted. Further, the terrace on the west bank across from Stebbins Island displays evidence of being deeply eroded by past flood events. The alluvial nature of the Connecticut River guarantees that erosion will always be a phenomenon along this stretch of the river.

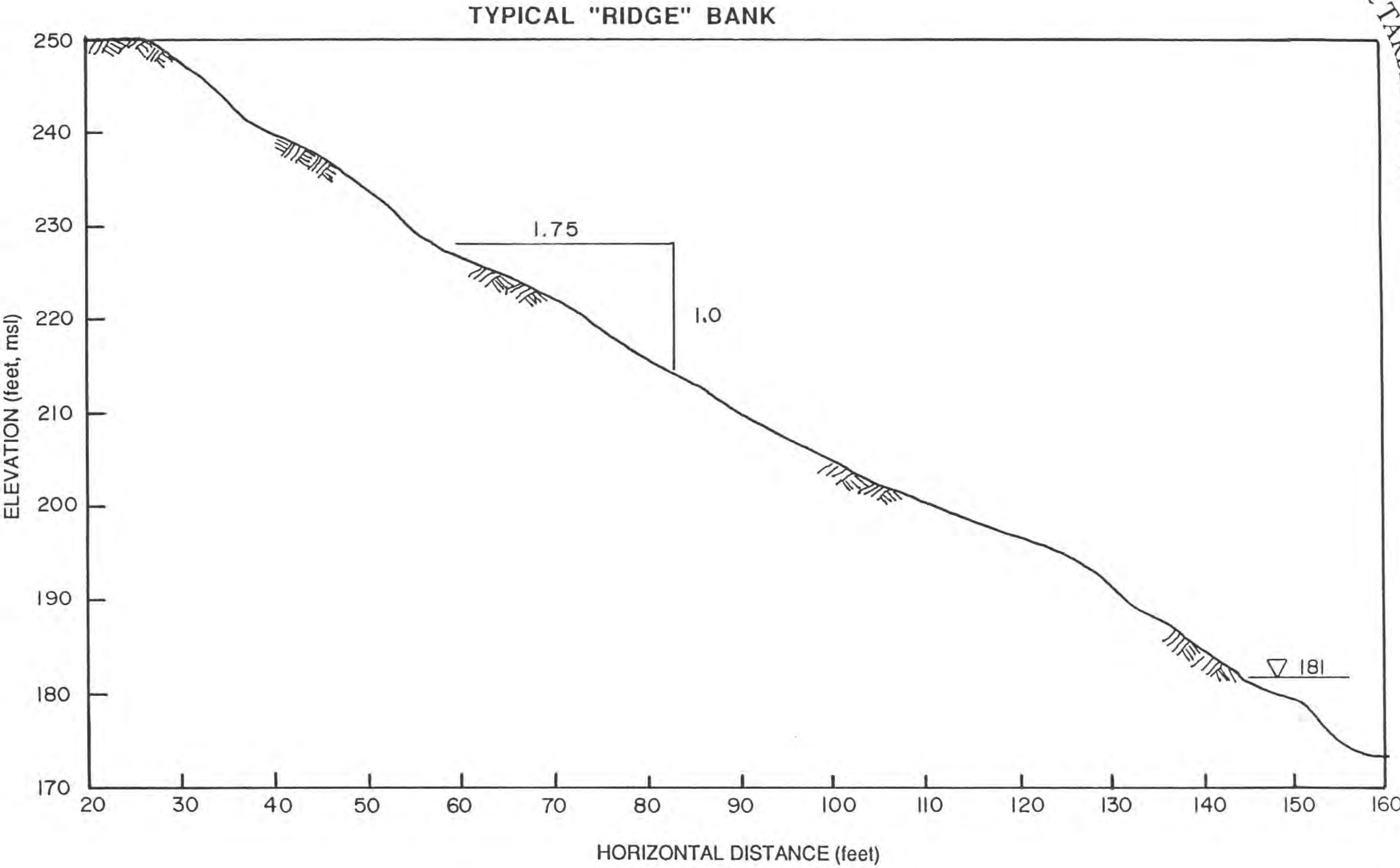
As part of the Master Plan, ND&T initiated an investigation into the causes of erosion along the Turners Falls headpond. The work included extensive field reconnaissance of existing erosion conditions, documentation of bank characteristics at erosion sites, obtaining baseline river and bank cross-sections, documenting affects of recreational activities, obtaining data on impoundment fluctuations, conducting soil borings, documenting land use and vegetative cover, analysis of aerial photographs, and performing various hydraulic analyses. Appendix O contains a more in-depth description of the work performed and the field findings.

While actual conditions along the riverbanks were shown to be highly variable with respect to soil type, bank slope, vegetative cover, and bank height, certain typical conditions became apparent for both the alluvial terraces ("terraces") and the higher-banked, wooded slopes ("ridges"). Figures VI-1 and VI-2 provide the general geometry of the two types of riverbank which are frequently encountered along the headpond.



BASED ON 1990 FIELD SURVEY
LOOKING UPSTREAM

FIGURE VI-1
SECTION THROUGH UNERODED WEST BANK UPSTREAM OF PINE MEADOW BROOK IN TERRACE AREA



BASED ON 1966 FIELD SURVEY
LOOKING UPSTREAM

FIGURE VI-2
TYPICAL SECTION THROUGH UNERODED RIDGE AREA

A few observations about these bank conditions are worth noting. First, at the terraces, the slope of the upper bank (above elevation 185±) is quite steep, being either near or exceeding the angle of repose of the soil (about 1.7H:1V). Therefore, the soils of the upper bank are being kept in place by the vegetative cover and by the buttressing effect of the lower bank which was flatter (about 5H:1V).

Second, in the "terrace" areas, the erosional condition of the bank appeared to be related to the height of the terrace. As a general rule, more erosional activity was apparent on the higher-banked, terrace soils (20 to 25 ft) than on the lower-banked, terrace soils (10 to 15 ft), although bank height was generally less significant a factor than vegetative cover.

Third, the "ridges" are uniformly covered by dense stands of brush and hardwood trees above the normal high water line (≈El 184). In contrast, the vegetative cover on the terraces varies widely from grass to brush to some hardwood to dense hardwood. It was apparent that where the terraces have been cleared either to the edge of bank or close to the edge of bank, erosion is more evident. Where a wide vegetative buffer has been left in place between the top of bank and cleared land, the erosion is much less apparent.

Based on the field work and review of historic data, five potential causes of erosion were identified as summarized below.

Cause A: Due to soil conditions, it was considered likely that the terrace soils, if exposed, would be readily erodible due to the action of flowing water. This theory of cause-effect has been well documented on other rivers and was identified as a major contributor to erosion in the Corps of Engineers 1979 report on the Connecticut River. The forces involved can be analyzed by the "Tractive Force" technique. This potential cause has therefore been labeled the Tractive Force concept.

Cause B: Pool fluctuations induced by the operation of the Northfield Mountain Pumped Storage Project have been identified as a possible cause of erosion. This theory is based on the concept that seepage forces developed by the alternate raising and lowering of the pool are sufficient to dislodge soil particles, thereby causing the banks to be undercut at the waters edge. Fluctuations are also suspected of preventing the establishment of emergent or submergent vegetation within an impacted zone. This concept is referred to as the Pool Fluctuation concept.

Cause C: As indicated previously, field observations noted an apparent relationship between the soil type, bank vegetation, and erosion characteristics. This concept is referred to as the Soil-Cover concept.

Cause D: Several people have pointed out the possibility that wave action caused by recreational power boating was a potentially significant contributor to erosion of the bank. ND&T made field observations of the impact of boating activity on erosion. This theory is referred to as the Wave Action concept.

Cause E: Professor John Reid, Jr. of Hampshire College introduced the concept that the erosion process on the Connecticut River is primarily a result of the river's natural tendency to meander within the constraints imposed by the variation in riverbank material. This theory is referred to as the River Meander concept.

Identifying the potential causes individually is not intended to indicate that they are independent. More likely, there is a high degree of interdependence between the various causes.

Each of the causes was considered with respect to its potential to transform the riverbanks from their apparent historic configuration to their present conditions. Data collection, analysis, and findings with respect to each of the causes of erosion are summarized below in this section and appear in greater detail in Appendix O.

As provided in Appendix O, ND&T prepared both qualitative and quantitative analyses of the various potential causes of erosion. Qualitatively describing the erosion mechanisms is relatively simple compared to mathematically evaluating the factors involved in causing erosion. Some of the quantitative analyses were hindered by a lack of well-developed numerical methods. For example, quantitatively evaluating the impact of loss of vegetation or partial loss of vegetation on either bank stability or the rate of erosion is difficult, at best.

For purposes of the Master Plan, ND&T developed a method for quantifying the percent contribution of the individual causes of erosion by combining a qualitative evaluation of the cause of erosion at each site with quantitative measurements of the amount and timing of erosional activity. The objective of the analysis was to identify the major factor(s) contributing to erosion and the likelihood that the construction and operation of the Northfield Mountain Pumped Storage Project affected erosion rates. Therefore, the quantitative analyses were made by comparing the type, amount, and apparent rate of erosional activity before 1970 with the type, amount, and apparent rate since 1970 using aerial photographic coverage of the river. ND&T employed aerial photographs from 1952 (1 in=200 ft), 1971 (1 in=200 ft), 1980 (1 in=200 ft), and 1990 (1 in=100 ft) for analysis, supplemented by other photographic evidence when needed.

Erosion during the 1952 to 1971 period establishes a baseline for assessing the amount and rate of erosional activity without the influence of the Northfield Project.

Photographs from the 1971 to 1990 period provide evidence of the influence of the Northfield Project, assuming other factors remained relatively constant. A more detailed description of this analysis and its results are contained in Appendix O.

Based on the various analyses conducted of the potential causes of erosion, ND&T has developed certain conclusions regarding erosion occurring along the Turners Falls impoundment. Because of the limited amount of data collected and inherent inaccuracies in some of the data sources, these conclusions must be considered preliminary and, as such, are in need of further data collection and subsequent analysis in order to confirm and refine the accuracy of the results.

Subject to such confirmation studies, it can be concluded that:

- The causes of erosion are varied and highly site-specific;
- The alluvial soils of the "terraces" are much more susceptible to erosion than the "ridges" as a result of the distinct differences in soil conditions;
- The erosion susceptibility of the alluvial terraces are readily influenced by the activities of man, such that any activity which changes the balance of erosional forces between the river and its channel/banks can impact erosion susceptibility;
- Maintaining the stability of the alluvial soils is particularly sensitive to the type and quality of the vegetative cover;
- If exposed, the soils of the alluvial terraces are prone to extensive erosion during higher flows;
- The raising of the Turners Falls reservoir associated with the construction of the Northfield Mountain Pumped Storage Project inundated part of the lower vegetated bank that existed along the alluvial terraces, causing

bank that existed along the alluvial terraces, causing a loss of vegetative cover, resulting in a subsequent exposure of the highly erodible soils to tractive forces, and as such caused an acceleration of erosion at certain sites. The contribution to erosion at any particular bank site caused by the raising of the impoundment can vary anywhere from near zero percent to approaching 100 percent, depending on site location and site conditions;

- Fluctuation of the impoundment does not appear to contribute significantly to the erosional activity along the river. The apparent inability of vegetation to develop within the fluctuating zone is attributed much more to erodability of the beach soils, steepness of the upper slope, and to high river velocities than to fluctuation. The riverbanks between the French King Bridge and the Turners Falls Dam experience some of the greatest fluctuations, yet where the slopes are relatively flat and velocities are low, even during normal spring flows, emergent and submergent vegetation grow in abundance. In contrast, the fluctuating zone in the more riverine areas between the Route 10 Bridge and the Northfield Mountain tailrace possess little vegetation. This is primarily due to the adverse influence of high velocities associated with normal spring flows and summer freshets, the lack of stable riverbank soils necessary to support germination and growth, and the likelihood that the eroded beaches contain nutrient-poor soils.
- Recreational power boating is a contributor to erosion, but primarily as a secondary factor, because it can accelerate the erosion of exposed soils.

As an overview, it is important to remember that the erosion caused by one major flood event may result in greater overall loss of soils, sediment deposition, and changes in bank geometry than the erosion activity presently underway.

VII. RIVERBANK MANAGEMENT OPTIONS AND RECOMMENDATIONS

The objective of the Master Plan was to evaluate the erosion occurring along the Turners Falls Pool and identify the damage to environmental resources being caused by erosion. Based on the FERC license, NUSCO must "minimize erosion" along the Turners Falls Pool. This condition was interpreted to mean that NUSCO is required to minimize the adverse environmental impacts of erosion caused by the Northfield Project. This interpretation is based on current environmental regulations. The Master Plan, therefore, was to establish the present level of environmental impact, determine the need for immediate action, and define a longer-term management program to protect valuable environmental resources that may, in the future, be adversely affected by erosion. The management program was to provide the framework for making future decisions about the need for and timing of bank stabilization efforts. All of these objectives were to be met through extensive data collection, data analysis, and public discussion of the findings. A series of meetings with a Workshop Committee provided the forum for input and debate on the Master Plan.

During the development of the Master Plan, a variety of riverbank management options were identified. Both structural and non-structural means of riverbank stabilization and resource management methods for stabilizing eroding riverbank sites and protecting environmental resources along the banks of the Turners Falls Pool were considered. As part of the Master Plan, an overall assessment of the present effects of erosion on environmental resources was made. By combining the environmental assessment with the means and cost of stabilization, the benefits derived from different riverbank management actions were compared to the costs associated with these actions. With cost-effectiveness and equity as goals, NUSCO sought to commit resources in proportion to the amount of environmental damage.

Riverbank management options are presented and discussed below. The overall environmental assessment of the present erosion is also summarized below and, in the final part of this section, the recommendations of the Master Plan are put forward. In essence, the Master Plan represents the beginning of, and sets the framework for, a program of long-term management action along the Turners Falls Pool.

A. Riverbank Management Options

Riverbank management options considered during the Master Plan development process included both riverbank stabilization and resource management methods for structural and non-structural means of addressing any significant adverse effects of present and future erosion. The structural options comprise riverbank stabilization methods designed to repair existing erosion sites relying on engineering and biological technologies which tend to be oriented towards construction. These have been discussed and presented in Section IV. Non-structural management options include plans ranging from "no action along the entire Study Area" to very site-specific concepts (such as mitigation of archaeological impacts) to management plans which encompass the entire Study Area.

1. Riverbank Stabilization Options

ND&T selected the top 12 ranked erosion sites to evaluate potential stabilization techniques and their associated capital costs. In addition, these 12 sites were evaluated to provide representative examples of the construction requirements and construction impacts associated with different stabilization options. Use of these 12 sites for study purposes was not intended to imply a recommendation for repair. These 12 sites represent those riverbank segments within the Project area which are more severely eroded and at the same time possess significant environmental resource value. The 12 sites, in numerical order, are site 4, 10, 12, 13, 21, 25, 38, 58, 60, 63, 69 and 74. ND&T has evaluated appropriate riverbank stabilization techniques and formulated cost estimates for repairing the erosion at the sites. These methods range from sheetpiling in front of the riverbank to a totally vegetative solution for controlling erosion. The environmental impacts associated with the construction and installation of erosion protection at each site have also been evaluated.

Table VII-1 presents a summary of the costs associated with stabilizing each site. These costs are based on the unit quantities of material and labor needed to complete the work. Site dimensions and the unit costs at each site are also provided in the table. Appendix N of the Master Plan provides detailed cost estimates for each stabilization option and also indicates the anticipated environmental impacts associated with the stabilization construction. Figures within the Appendix show the location of each stabilization site and provide a cross-section view of the proposed repair work. Maps VII-1 through VII-7 are computer-generated maps displaying each proposed repair site in relation to its environmental resource values.

In general, the environmental impacts associated with construction need to be considered and compared to the present level of impacts occurring at an eroding bank. For example, sites possessing protected plant species may require transplanting off-site to ensure no damage during construction. However, such transplanting may destroy the plants, or if feasible to transplant, may represent a more cost-effective solution than construction. It became apparent during the Master Plan process that prior to any

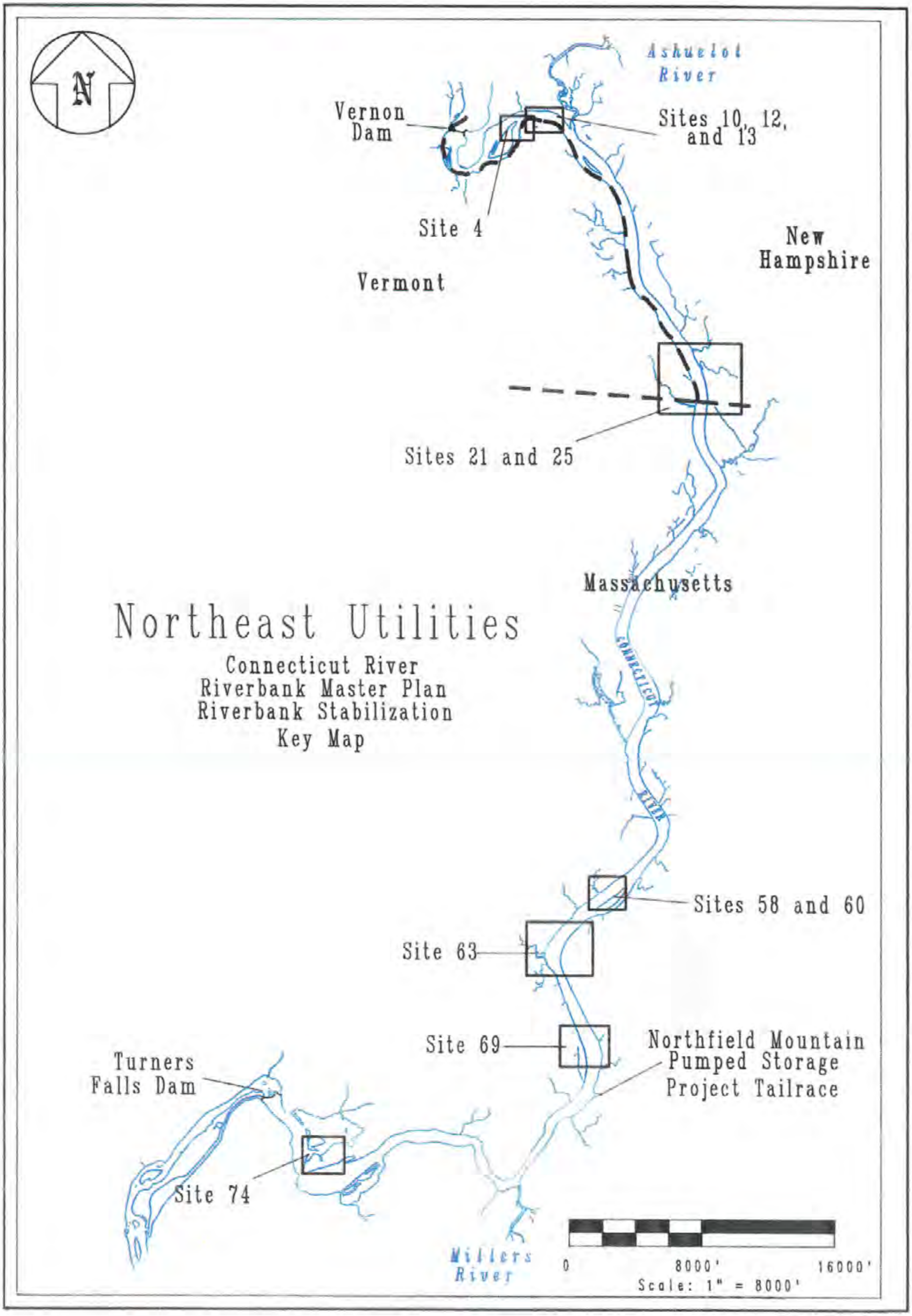
TABLE VII-1

SUMMARY OF COST ESTIMATES

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

Site No	Stabilization Method Option A	Stabilization Method Option B	Estimate of Cost Option A (1990$)	Estimate of Cost Option B (1990$)	Overall Site Dimensions Length (ft)	Overall Site Dimensions Bank Width (ft)	Area of Site (SY)	Unit Cost (1990$/SY) Option A	Unit Cost (1990$/SY) Option B
4	Vegetation	Fieldstone	60,000	60,000	395	37	1,624	37	37
10	Vegetation	Fieldstone	50,000	50,000	184	34	695	72	72
12	Mattress	Fieldstone	100,000	120,000	782	90	7,820	13	15
13	Fieldstone	Mattress	130,000	90,000	950	36	3,800	34	24
21	Mattress	Fieldstone	160,000	190,000	1,235	42	5,763	28	33
25	Timber Crib	Mattress	270,000	90,000	812	19	1,714	158	53
38	Sheet Piles	Fieldstone	1,210,000	410,000	770	38	3,251	372	126
58	Fieldstone	Mattress	250,000	220,000	706	71	5,570	45	39
60	Timber Crib	Mattress	660,000	580,000	1,627	66	11,931	55	49
63	Fieldstone	Timber Crib	690,000	960,000	3,000	44	14,667	47	65
69	Timber Crib	Fieldstone	1,160,000	720,000	2,335	40	10,378	112	69
74	Vegetation	----------	120,000	-------	596	113	7,483	16	--

Item	Avg $1990/SY
Vegetation	42
Mattress	34
Fieldstone	53
Timber Crib	98


N
Ashuelot River
Vernon Dam
Sites 10, 12, and 13
Site 4
New Hampshire
Vermont
Sites 21 and 25
Massachusetts
CONNECTICUT RIVER
Northeast Utilities
Connecticut River
Riverbank Master Plan
Riverbank Stabilization
Key Map
Sites 58 and 60
Site 63
Site 69
Northfield Mountain Pumped Storage Project Tailrace
Turners Falls Dam
Site 74
Millers River
0
8000'
16000'
Scale: 1" = 8000'

MAP VII-1

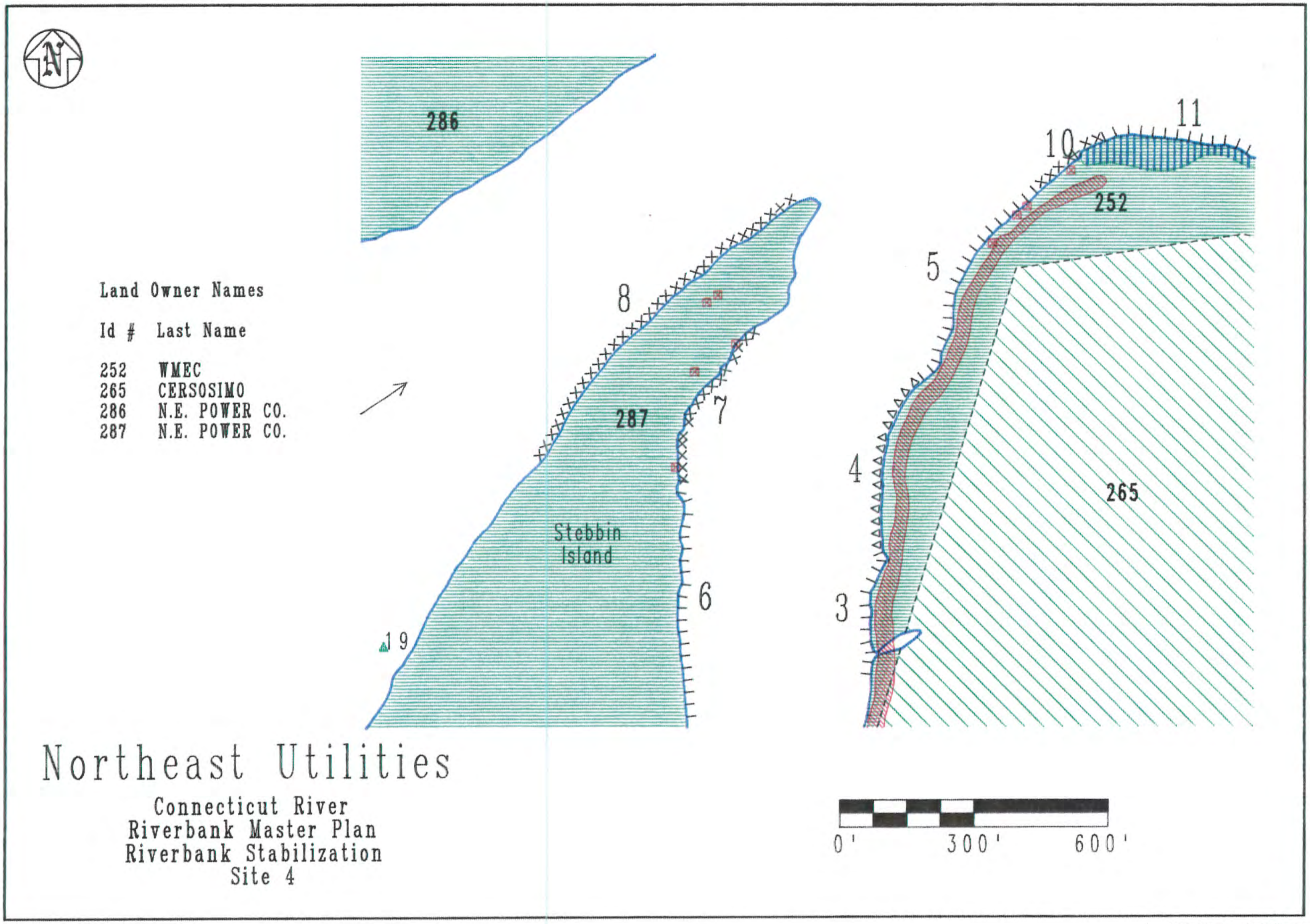
LEGEND

Riverbank
Low-Moderate Erosion
Moderate Erosion
Moderate-Severe Erosion
Severe Erosion

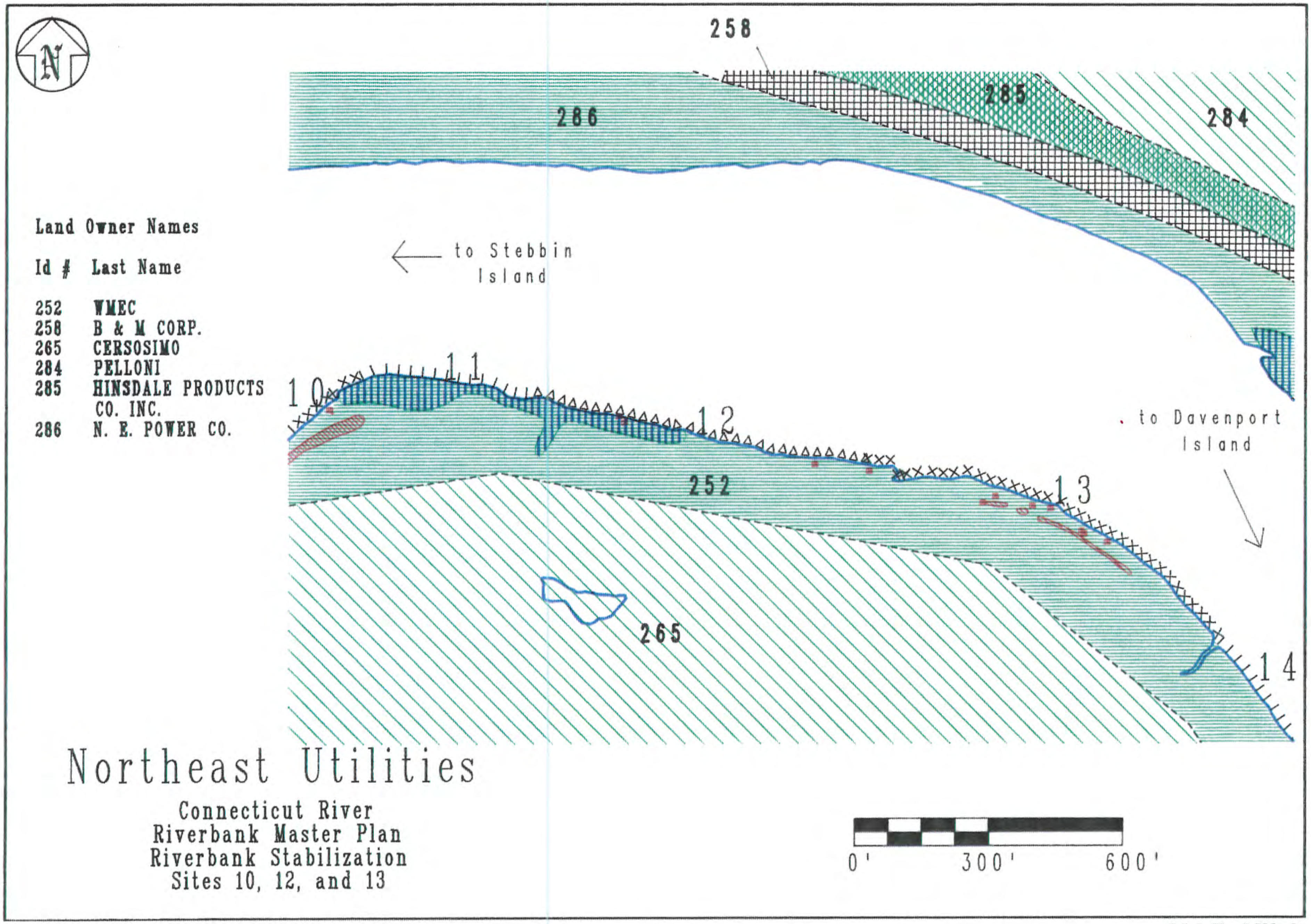
Mile Markers (from Turners Falls dam)
Confirmed Rare Plant Location
Rare Wildlife Location

Extensive Rare Plant (Sandbur) Areas
Agricultural
Residential
Commercial/Industrial
Public Land (town/state)
Active Utility/Transportation
Woodlands (utility owned)
Open Lands (utility owned)
Undeveloped Woodlands (privately owned)
Undeveloped Open Land (privately owned)
Recreational Use Areas
Wetlands
Scenic Viewpoints
Visually Sensitive Areas

LEGEND: MAPS VII-2 – VII-8


N
286
Land Owner Names
Id # Last Name
252 WMEC
265 CERSOSIMO
286 N.E. POWER CO.
287 N.E. POWER CO.
8
287
7
Stebbin Island
6
1 9
10
11
252
5
4
265
3
Northeast Utilities
Connecticut River
Riverbank Master Plan
Riverbank Stabilization
Site 4
0' 300' 600'

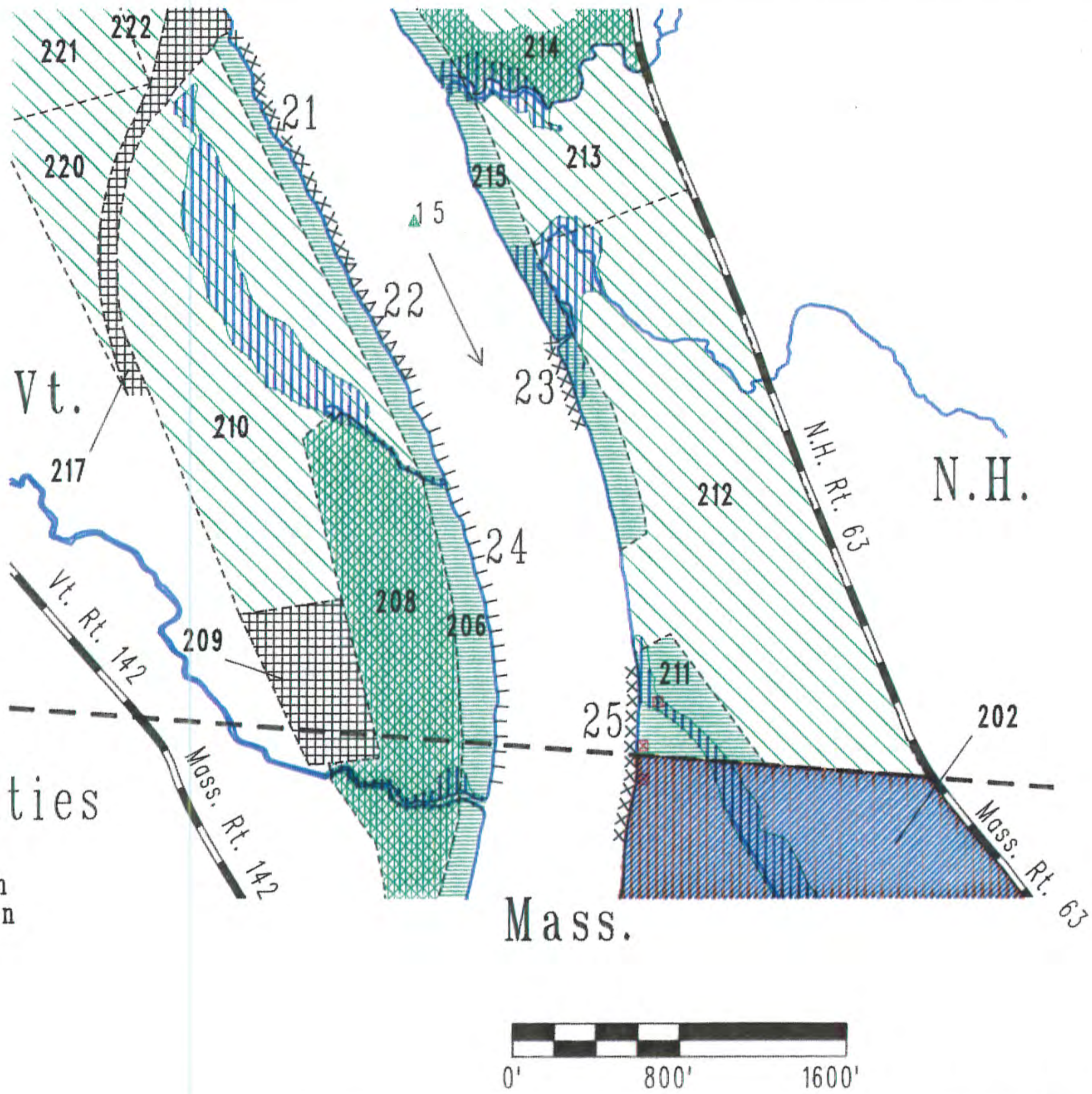
MAP VII-2


N
258
286
285
284
Land Owner Names
Id # Last Name
252 WMEC
258 B & M CORP.
265 CERSOSIMO
284 PELLONI
285 HINSDALE PRODUCTS CO. INC.
286 N. E. POWER CO.
to Stebbin Island
10
11
12
252
13
to Davenport Island
265
14
Northeast Utilities
Connecticut River
Riverbank Master Plan
Riverbank Stabilization
Sites 10, 12, and 13
0'
300'
600'

MAP VII-3

Land Owner Names

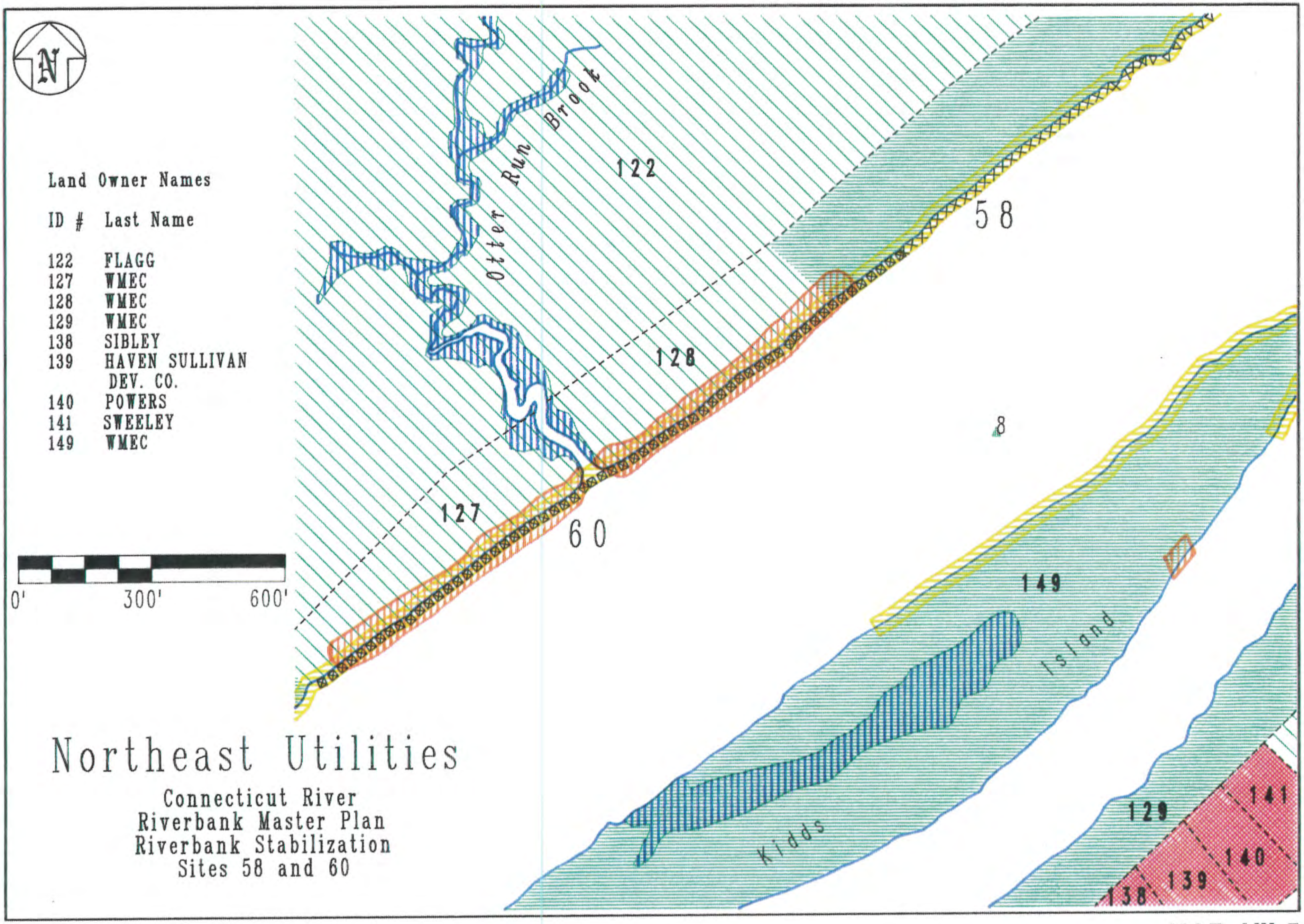
Id #	Last Name
202	COMMONWEALTH OF MASS.
206	WMEC
208	NOKES
209	B & M RAILROAD
210	KENDALL
211	WMEC
212	HOLBROOK
213	BEAMON
214	PERHAM
215	WMEC
217	B & M CORP.
220	KENDALL
221	DUNKLEE
222	KENDALL



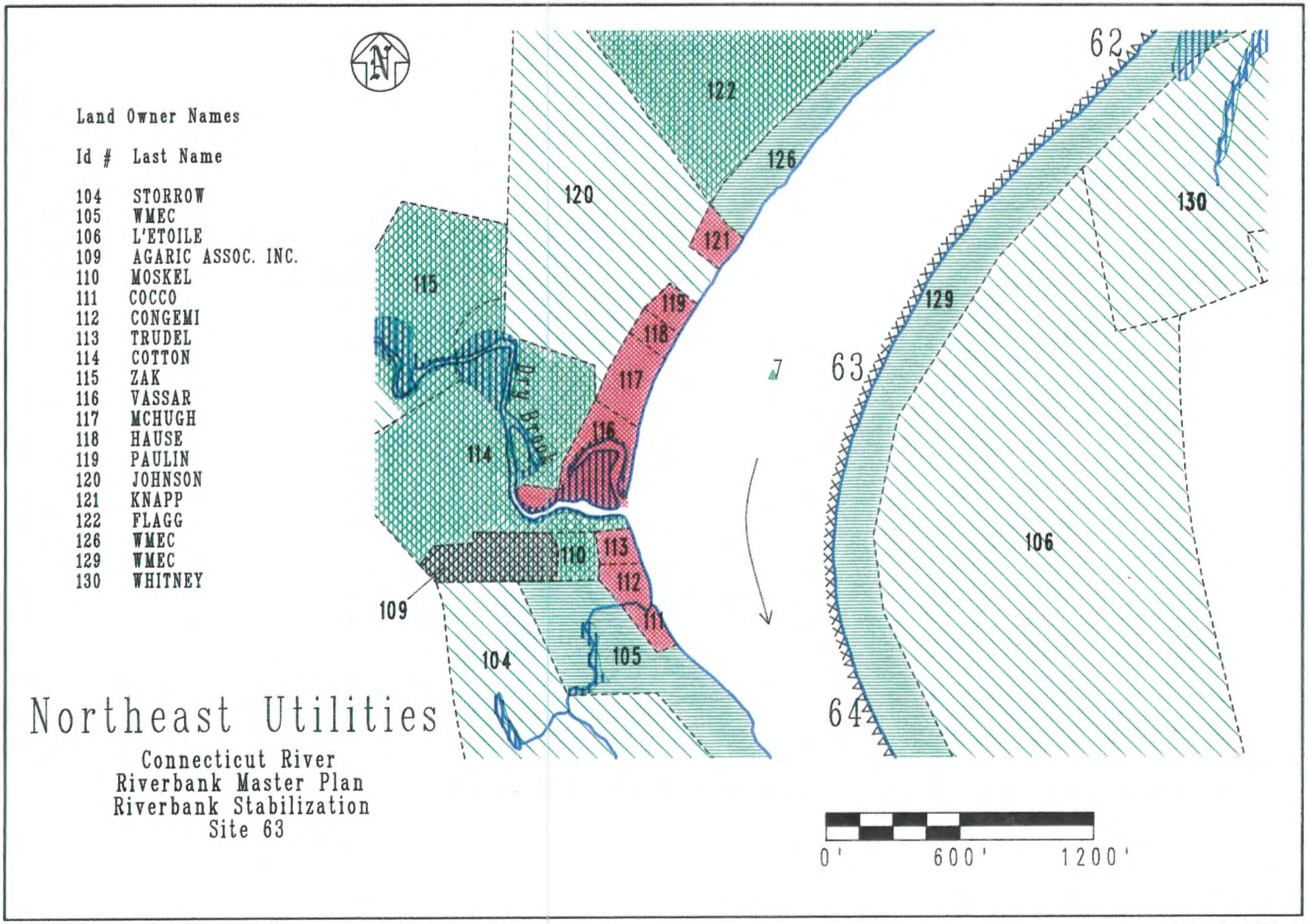
Northeast Utilities

Connecticut River
Riverbank Master Plan
Riverbank Stabilization
Sites 21 and 25

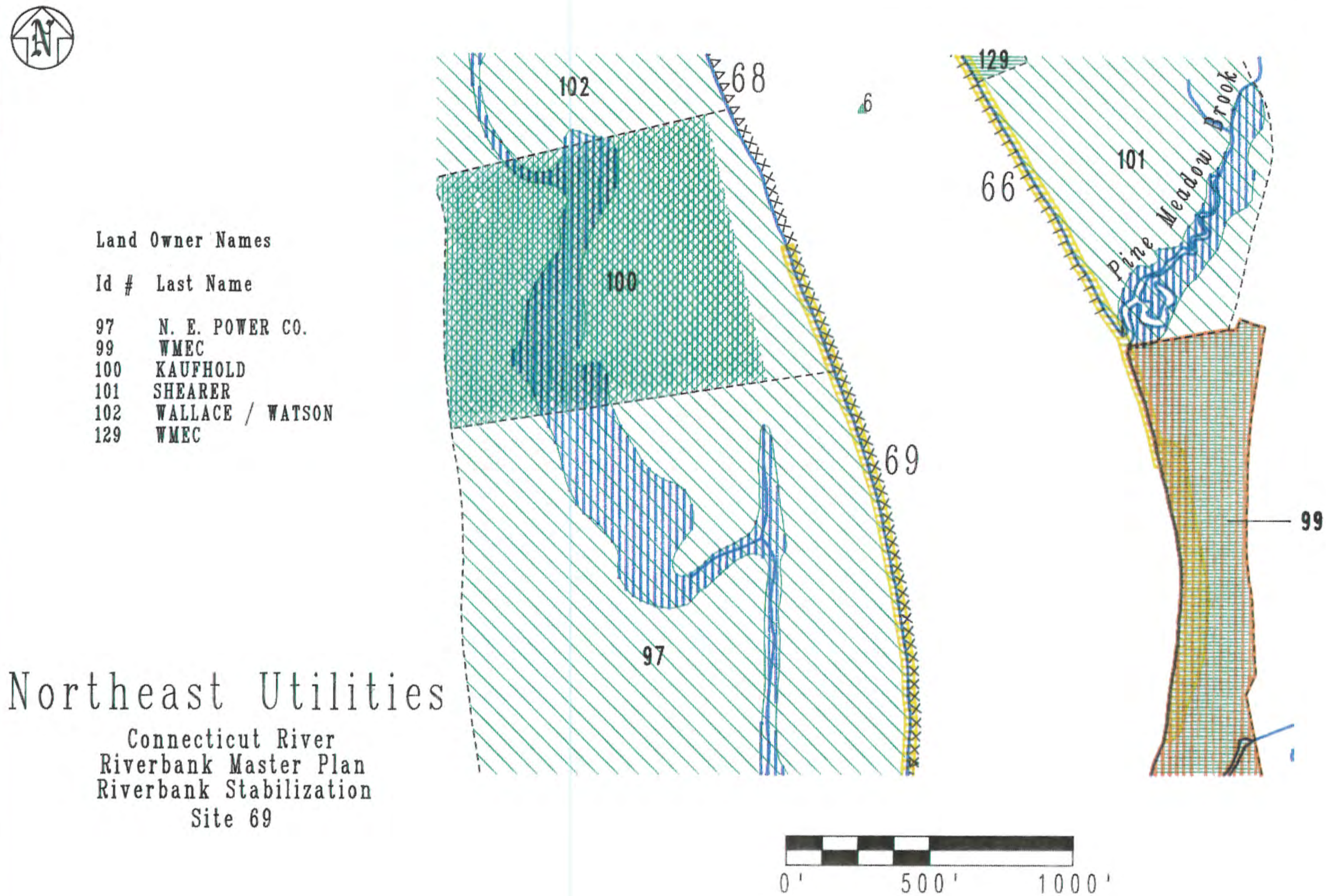
MAP VII-4


N
Land Owner Names
ID # Last Name
122 FLAGG
127 WMEC
128 WMEC
129 WMEC
138 SIBLEY
139 HAVEN SULLIVAN DEV. CO.
140 POWERS
141 SWEELEY
149 WMEC
0'
300'
600'
Northeast Utilities
Connecticut River
Riverbank Master Plan
Riverbank Stabilization
Sites 58 and 60
Otter Run Brook
122
58
128
8
127
60
149
Island
Kidds
129
141
140
139
138

MAP VII-5


N
Land Owner Names
Id # Last Name
104 STORROW
105 WMEC
106 L'ETOILE
109 AGARIC ASSOC. INC.
110 MOSKEL
111 COCCO
112 CONGEMI
113 TRUDEL
114 COTTON
115 ZAK
116 VASSAR
117 MCHUGH
118 HAUSE
119 PAULIN
120 JOHNSON
121 KNAPP
122 FLAGG
126 WMEC
129 WMEC
130 WHITNEY
Northeast Utilities
Connecticut River
Riverbank Master Plan
Riverbank Stabilization
Site 63
122
126
120
121
115
119
118
117
116
114
Dry Brook
110
113
112
111
109
104
105
62
63
64
7
129
130
106
0'
600'
1200'

MAP VII-6



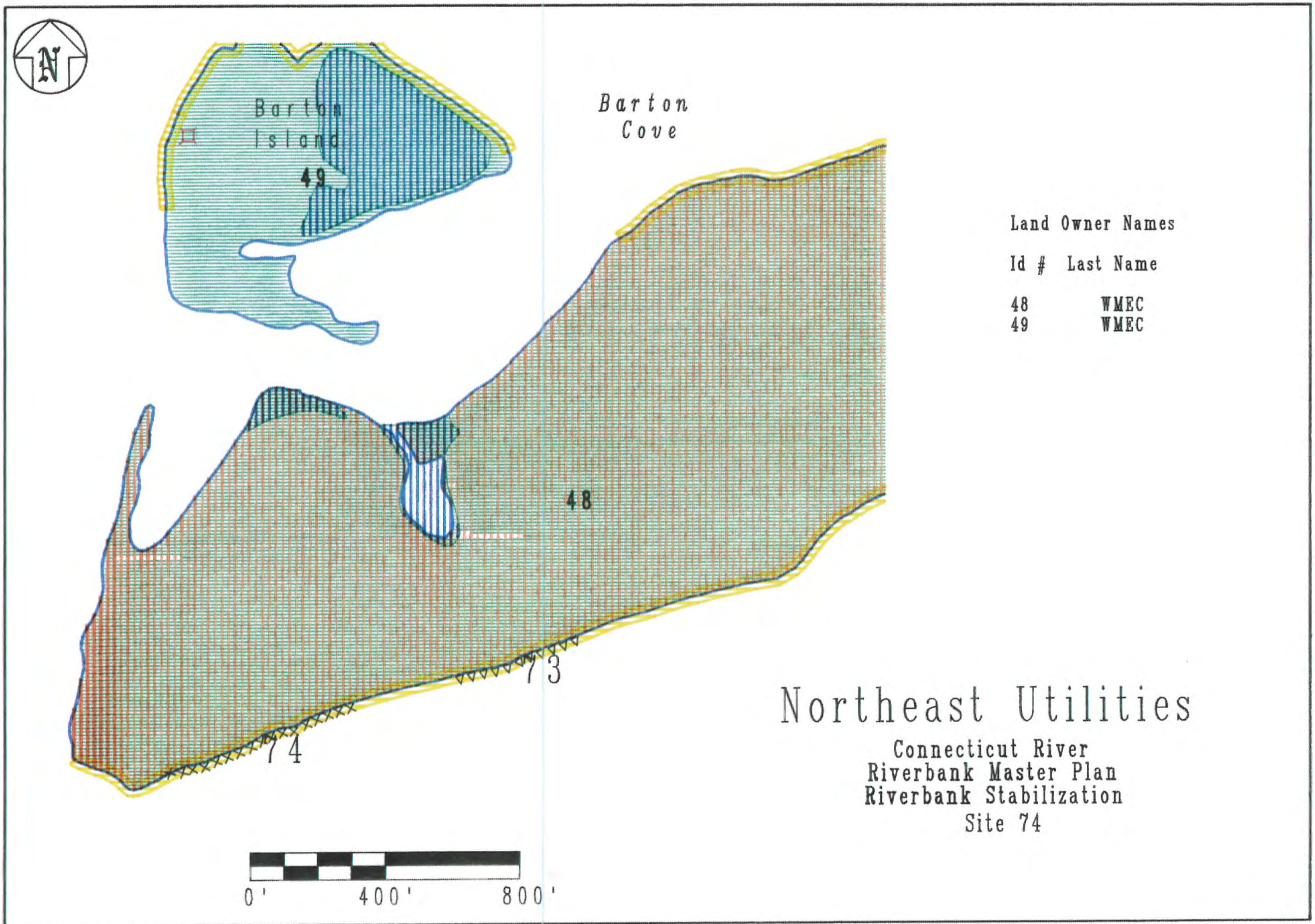
Land Owner Names

Id #	Last Name
97	N. E. POWER CO.
99	WMEC
100	KAUFHOLD
101	SHEARER
102	WALLACE / WATSON
129	WMEC

Northeast Utilities

Connecticut River
Riverbank Master Plan
Riverbank Stabilization
Site 69

MAP VII-7


N
Barton Island
49
Barton Cove
48
73
74
Land Owner Names
Id # Last Name
48 WMEC
49 WMEC
Northeast Utilities
Connecticut River
Riverbank Master Plan
Riverbank Stabilization
Site 74
0'
400'
800'

MAP VII-8

construction, or as part of any future management program, these site-specific issues must be addressed at <u>each</u> erosion site.

2. Riverbank Resource Management Options

In addition to riverbank stabilization initiatives, a variety of non-structural riverbank management options and resource enhancement measures were identified for consideration both in the development of the Master Plan and for the implementation of the Master Plan. Some of these options were evaluated as part of the Master Plan and others are more appropriate to consider when determining the necessity for future site-specific action within the framework of riverbank management. Specifically, these non-structural options are:

- To the extent that the erosional process is a natural phenomenon and to the extent that construction impacts may be greater than the impacts of erosion, do nothing to inhibit the process; at least until the erosion threatens important structures or residential housing.
- Setting of limitations on use, size, and/or speed of power boats.
- Adjustment or limitation to the fluctuation of the Turners Falls Pool due to hydroelectric facility operations.
- Regulating or restricting recreational use of certain beach areas.
- Revegetation of selected NUSCO property adjacent to selected riverbank erosion sites.
- Acquisition of riverbank development rights beyond the limits of the FERC Project boundary where it may enhance adjacent land uses.

- Preservation of agricultural land use by purchasing agricultural preservation restrictions (APR), possibly in concert with the Massachusetts Department of Food and Agriculture's APR Program.
- Funding of further archaeological investigations at those sites where known resources may be subject to impact by existing or anticipated erosion activity.
- Establishment of a management program to include comprehensive riverbank erosion monitoring and a framework for future decision making on bank stabilization.

B. Master Plan Findings and Conclusions

The development of the Master Plan to address the issue of bank erosion along the Turners Falls Pool started with an extensive program of both field and library data collection and technical analysis to establish a solid foundation for identifying and evaluating alternative courses of action. Consultation with public entities and individual land owners was extremely valuable to both an understanding of the issues and development of the recommendations.

In a general sense, structural options to address erosion are considered feasible if two conditions are met:

1. Erosion has advanced to the stage that it is adversely affecting significant environmental resources, <u>and</u>

2. The capital cost and environmental impacts of bank stabilization are roughly equivalent to the value of the resource to be protected, i.e., could the resource impact be mitigated at substantially less cost than repair and without incurring other environmental damage.

As presented in other sections of this Plan, a unique and highly site-specific methodology was developed to assess erosion conditions and environmental resources along the Turners Falls Pool and to develop an objective ranking of the relative need for action at each erosion site. This relative ranking method was chosen as the best means of producing a quantifiable value for a given site, while acknowledging the difficulty of assigning cost values to environmental resources, such as rare plants, scenery and wildlife habitat.

The analyses conducted as part of the Master Plan, as previously reported in this document, indicated that about 30% of the banks are undergoing some erosion; however, only about 8% are experiencing moderate-to-severe or severe erosion. The environmental assessment found that the highly-ranked sites for overall environmental resource value did not coincide with the more severely eroded sites, with but a few exceptions. Therefore, overall, with the exceptions identified, the present erosion was not adversely affecting significant environmental resources. In addition, the cost of bank stabilization was shown to be substantial and the construction required to ensure bank stability has some associated environmental impacts. Therefore, structural options were not considered highly desirable at this time. However, at the same time, it was recognized that if the erosion being experienced along the pool is advancing, future conditions will be different and significant resources may be threatened. Further, it was recognized that the costs and effectiveness of the bioengineering technologies considered are not well known, because these concepts have only recently been advanced as solutions to erosion on major rivers.

Non-structural (or resource management) options are considered viable as long as they are effective in protecting resources, do not result in programs that have greater negative consequences, and can be cost-effectively implemented. Each of the options that were identified in the Master Plan, as listed in subsection A, is briefly discussed below.

Maintain Status Quo

As in any environmental assessment, maintaining the status quo is a consideration. There is validity in allowing the erosional process to continue without intervention, because of the finding that the present erosion is not unduly affecting significant environmental resources and the cost of stabilization is substantial. This option would ignore the findings of the Master Plan - that future erosion (if it advances) may adversely affect these resources. Further, it was acknowledged in the Master Plan that the actual cost of bioengineering solutions was not well known.

Establishing Limitations on Power Boating

While data collected during the Master Plan showed that wave action caused by power boating results in erosion of the lower bank area, this activity appears to be a secondary factor in erosion along the pool. Sufficient data does not exist to establish definitive restrictions on size, speed, or off-limit locations, that would prevent or reduce erosion. It is likely that localized restrictions would be required near any areas undergoing stabilization by vegetative methods. Further, it is apparent that certain erosion sites are more vulnerable to damage by wave action. These vulnerable sites are those which have reached a moderate-to-severe and severe stage of erosion. However, sufficient data still does not exist to establish restrictions even at these sites. To begin to address this issue, it may be beneficial to initiate an "awareness" program through the local boating clubs, marinas, or state licensing process.

Establishing Limitations on the Operation of Hydroelectric Facilities

It has been suggested that guidelines could be established to limit the fluctuations caused by the operation of NUSCO's Northfield Mountain Project. The data collected and analyzed to date as part of the Master Plan, while limited, does not in any way support the conclusion that pool fluctuations are a significant cause of erosion (see Section VI). It has been suggested that pond fluctuations may inhibit the recolonization of the newly inundated fluctuating zone by wetland vegetation. While sufficient data does not yet exist to definitively address this possibility, it is noted that large areas exist where this revegetation is taking place.

The apparent inability of vegetation to develop within a given fluctuating zone is attributed much more to the erodability of beach soils, steepness of the slope and to high river velocity than to fluctuation. Where the slopes are relatively flat and velocities are low, even during normal spring flows, emergent and submergent vegetation thrive despite fluctuations. Where slopes are steep, subjected to high velocities associated with normal spring flows and lacking stable riverbank soils, vegetation can have great difficulty establishing itself regardless of any fluctuation.

Further, and most importantly, the operation of the hydroelectric facilities associated with the Northfield Project represents a resource of regional significance and value. This includes environmental value as well as economic value. In light of the findings of the Master Plan concerning the causes of erosion and the present lack of significant adverse environmental effects caused by erosion, consideration of limiting the operation appears to be without real merit.

Restricting Recreational Use of Beach Areas

While the Master Plan documented that heavy recreational use of certain beach areas resulted in erosion at these areas, this use appears to be a secondary cause of erosion. The discussion regarding the establishment of limitations on power boating also applies when considering restricting recreational use of beach areas. In addition, bank stabilization efforts, if not carefully planned, may remove heavily used recreational areas from future use by turning beach areas into heavily vegetated banks. This is an example of the fact that structural stabilization efforts may be associated with significant environmental impacts.

Mitigation Efforts

Revegetation of selected NUSCO property, acquisition of additional development rights, preservation of agricultural lands, and performance of additional archaeological investigations all fall within a category of action that can be described as mitigation efforts. These activities do not, in and of themselves, protect resources from erosion. These actions would compensate for loss of certain resources. Based on the overall assessment contained in the Master Plan, the present adverse effects of erosion would not justify extensive expenditures in mitigation. Therefore, broad programs of mitigation are unlikely to be cost-effectively implemented. However, if the erosion activity continues, these mitigation options (or others that are similar) may be viable. To this end, ND&T recommends that consideration of options for mitigation be an integral part of the framework of future decision making.

Establishment of Long-Term Management Program and Framework for Future Decision Making

Based on the investigations, analyses, and consultation conducted throughout the Management Plan process, it was established that the extent of the present erosion and its adverse affects on the environmental resources of the riverbanks had not progressed to the point where capital and construction intensive solutions were justified, with but two sites being possible exceptions. These two sites represent about 1% of the length of the riverbank considered eroded. Erosion is not presently adversely impacting the great majority of wetlands, habitat areas, key scenic resources, recreational resources, and existing land uses. Some potential archaeological resources may be threatened. In addition, eroded riverbanks have diversified wildlife habitat within the study area as evidenced by the use of many unvegetated banks by bank swallows. Recreational boaters favor eroded areas for beach use and boat landing.

The Master Plan process also recognized that the erosion may be advancing and progressing and that, in the future, significant environmental resources may be threatened. Therefore, a course of action was needed which would both monitor and update on-going erosional activity and provide a reasonable framework for decision making using the information developed as part of the Master Plan's foundation. This management program is presented in detail in the following subsection.

C. Master Plan Recommendations

Considering the evaluation of the structural and management options summarized above, the recommendations of the Master Plan are presented herein. The recommendations represent an objective framework from which to consistently evaluate and update the status of erosion activity and environmental resource values present within the Turners Falls Pool. A program has been developed which utilizes the erosion rating method of Section V to trigger various management actions. The higher the rating numbers, the more immediate the response required regarding the selection of an appropriate means of protecting riverbank resources which may be endangered by erosion. The triggering mechanism established to justify possible bank stabilization action is based directly upon the findings within this Master Plan.

In summary, the Master Plan recommendations consist of four interrelated components as follows:

(a) Establishment of a process for determining when an erosion site should be considered for bank stabilization and the framework for deciding the proper action at that site when under consideration.

(b) Maintenance of a comprehensive erosion site monitoring program as initiated by the Master Plan.

(c) Design and installation of a bank stabilization demonstration project testing three variations of bioengineering solutions and the eventual implementation of a stabilization solution at site 60.

(d) NUSCO sponsorship of boater awareness meetings, designed to foster discussion of recreational boating interests and riverbank management concerns.

Each of these components is presented in detail below along with an implementation schedule. In addition, NUSCO commits to providing a progress report on the Master Plan's implementation in 1996, providing follow-up data and findings and a revised implementation plan.

ESTABLISHMENT OF A PROCESS FOR SELECTING CANDIDATE SITES FOR RIVERBANK STABILIZATION AND A FRAMEWORK FOR FUTURE DECISION MAKING.

This recommendation is the backbone of the Master Plan. It represents the primary method to be utilized by NUSCO in the future for evaluating both erosion and environmental conditions within the Turners Falls Pool, and selecting appropriate responses where environmental resource degradation may be occurring. It uses the rating method developed during the master planning process as the basis for updating conditions at each erosion site. The method selected for rating erosion conditions is described in detail in Section III.C, and the environmental resources rating method is described in Section V.

The degree of attention afforded a particular site, either now or after future monitoring, is based directly upon the rating it receives. Sites achieving a certain threshold rating will receive analysis of both potential stabilization options and riverbank management options to select the appropriate action which will best minimize negative environmental impacts and foster the protection of existing environmental resources. Figure VII-1 is a flow diagram showing this method, which is described in detail below.

The process acts as a triggering mechanism which initially proposes further site specific resource analysis at sites with a comprehensive rating over 55. It has been determined that sites rated at this value possess a significant environmental resource value which is either presently impacted or is in danger of being impacted by erosion activity. Once a more detailed site analysis is performed concerning the nature and location of threatened environmental resources, appropriate bank stabilization options will be developed at a given site and detailed cost estimates will be generated (using the results of the demonstration

NORTHROP, DEVINE & TARBELL, INC.

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN

PROPOSED ND&T PROCESS FOR SELECTING RIVERBANK STABILIZATION CANDIDATE

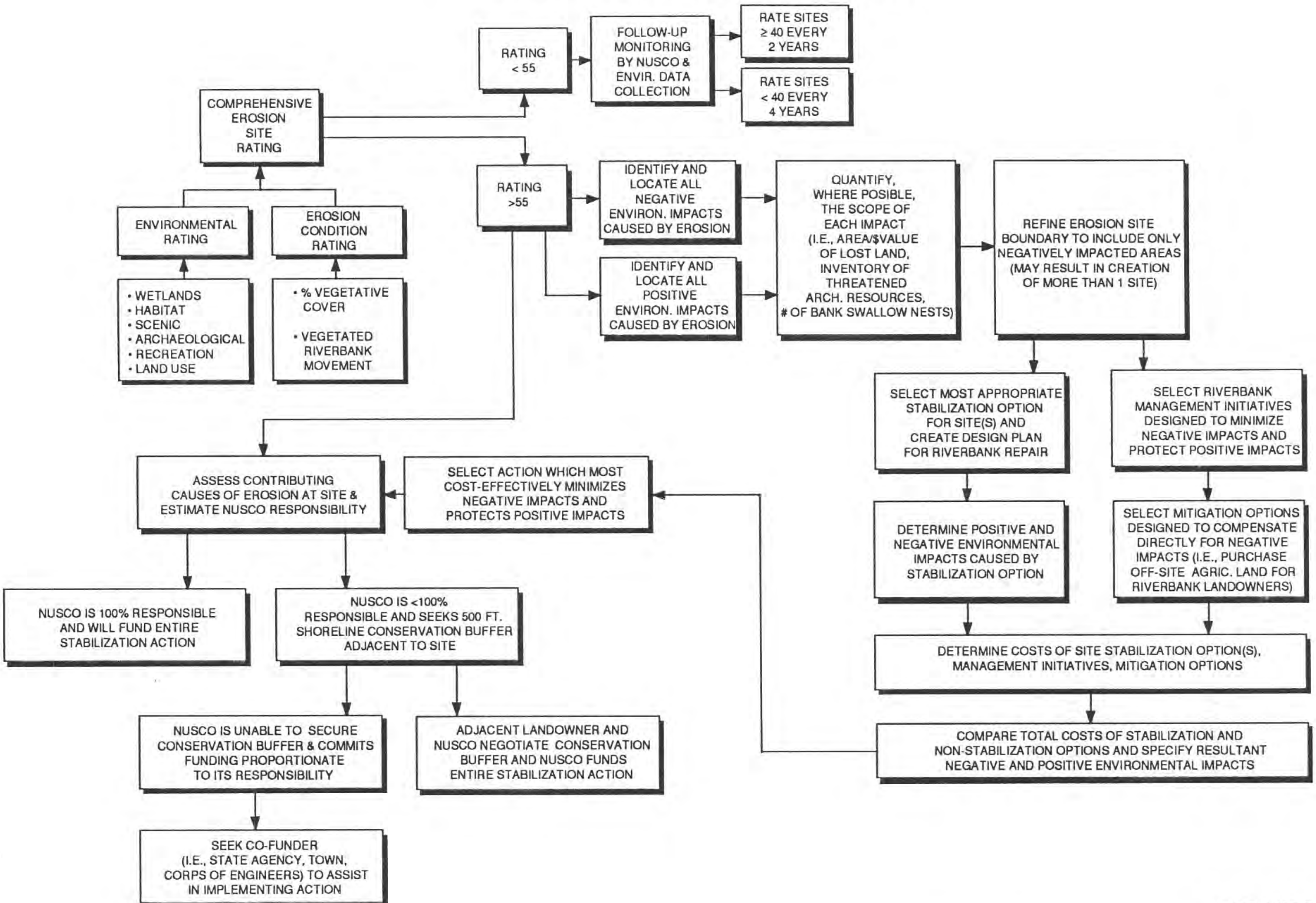


FIGURE VII-1

project). At the same time, mitigation concepts will be formulated which would compensate for impacts to environmental resources. A cost comparison will be performed to determine which type of initiative will most prudently and effectively meet the goal of environmental resources protection.

Parallel to this investigation, a determination of the contributing influences causing erosion at a given erosion site can be finalized. Based on the determination of these causes, a decision will be made regarding responsibility for funding the remedial action needed to protect any environmental resources impacted by erosion. If NUSCO is considered 100% responsible for causing the erosion at a given site, it will fund the stabilization action. If NUSCO is considered less than 100% responsible, it will fund the entire stabilization action only if a 500 foot shoreline conservation buffer can be established adjacent to the site. The buffer zone constitutes a designated area within 500 feet of the river and adjacent to a given erosion site where all future development by either NUSCO or adjacent landowners will be prohibited. Securing this buffer zone will be attempted by NUSCO prior to all future stabilization actions as a way to protect the long-term integrity of the environmental resources which prompt a given erosion site to be considered for stabilization. If an agreement to secure this buffer zone can not be reached with an adjacent landowner, then NUSCO will either seek co-funding for the stabilization action, based on their percentage of responsibility, or the site may be dropped from consideration for stabilization. If adjacent landowners will not commit to protecting existing environmental resources through this mechanism, then NUSCO could be expending funds to protect resources which could be degraded or removed by future actions. This will prevent NUSCO from protecting an environmental resource by its actions, only to have that resource value vulnerable to future elimination.

In addition to those sites qualifying for possible stabilization, all other existing erosion sites will be rated periodically regarding their erosion conditions and environmental resource values. If a rating between 41 and 55 exists, the erosion site will be rated again in two years. If a comprehensive site rating of less than 40 exists, the erosion site will be rated again in four years. This monitoring program is designed to ensure that all erosion sites will be assessed with a common criteria so that erosional activity can be well-documented and riverbank movement can be better quantified over time. All sites receiving future ratings over 55 will then become candidates for possible stabilization.

NUSCO feels that this planning framework will allow for an objective and equitable evaluation of the effects of erosion in the Turners Falls Pool and a continual vigilance of riverbank resources. It promotes action where action is warranted and promotes reevaluation of erosion conditions and associated riverbank resources at all sites on a periodic basis. It also offers a comprehensive and quantifiable method for evaluating changes in erosional activity as described below.

<u>MAINTAIN A COMPREHENSIVE EROSION SITE MONITORING PROGRAM AS INITIATED IN THE MASTER PLAN.</u>

Through an erosion site monitoring program, NUSCO would periodically reevaluate both the erosion conditions and associated environmental resource values at a given erosion site.

The frequency of monitoring will be based on the rating score assigned to a given site in this Master Plan (see Section V). All 76 sites will be investigated and rated again in 1994 and every following four years. Erosion sites with a rating of 40 or above will be rated again in two years and will continue to be rated every two years as long as the value remains above 40.

The rating method will be the same one utilized in 1990 for the formulation of the Master Plan. In this way, a common basis of evaluation will be used in future years and comparisons of conditions over time will be meaningful. As sites are rated again, any site scoring a value over 55 will immediately be considered as a candidate for possible stabilization. NUSCO will be able to ascertain whether a particular erosion site is experiencing accelerating or decelerating erosion conditions. This information will also fortify the baseline knowledge available to continue assessing the probable causes of erosion within the Turners Falls Pool.

Whenever a site is reevaluated the following steps will be taken:

a. Site visit during summer months to determine the length of erosion site, percent of exposed soil within riverbank and the degree of vegetated riverbank movement since the last rating period. Using the rating method described in the Master Plan, determine the erosion condition rating. This site visit should involve the same level of investigation conducted in 1990, including photographing and videotaping all erosion sites.

b. Review existing environmental resource value rating and revise if any values have changed since the last rating period. This should incorporate field conditions, new research data and changes in applicable environmental regulations.

c. Combine erosion condition rating value and environmental resource value to determine comprehensive erosion site rating value. If a site is rated above 55 it will immediately become a candidate for considering stabilization and follow up actions will begin.

d. Individual erosion site ratings will be compared with all previous ratings at a particular site to determine whether erosion activity is accelerating or decelerating. Likewise, all environmental resource values will be compared with previous ratings to assess the degree of change occurring.

e. All severe and moderate-to-severe erosion sites will be field surveyed every two years at an identical location. Secure and permanent benchmarks would be used to relate survey data collected at different periods to a common baseline. This data will be compared over time, in conjunction with erosion site rating information, to provide detailed information on the quantity of riverbank movement evident at a given site. This analysis will also be invaluable for reliably determining the rate of erosion evident at a particular site, and can aid NUSCO's efforts to fine tune its findings concerning the contributing causes of erosion.

f. Conduct low-level aerial flyovers of the Turners Falls Pool every two years in order to photo document conditions during each erosion site rating period. River elevation and flow data should also be recorded at the time of each flyover.

DESIGN AND INSTALL A BANK STABILIZATION DEMONSTRATION PROJECT AT SITE 60 TO TEST BIOENGINEERING SOLUTIONS AND SELECT STABILIZATION ACTION FOR IMPLEMENTATION AT SITE 60 IN 1993-1994.

In order to establish the type, actual unit cost, and maintenance associated with biotechnical riverbank stabilization, NUSCO proposes to install a demonstration stabilization project at Site 60, on the west bank of the river downstream of Otter Run Brook.

This site was chosen since it exhibits the most severe erosion condition identified within the project area and possesses significant environmental resources which are presently threatened. This demonstration project will involve three of the proposed stabilization techniques outlined in Section IV, and provides the opportunity to evaluate erosion protection techniques which have not been previously tested within the Turners Falls Pool and which offer the most hope for cost-effective bank stabilization.

Site 60, west of Kidds Island, has been chosen as the location for demonstration of proposed stabilization techniques. Site 60 has been classified as severe erosion under the erosion classification system, and tops the list of candidate sites in the comprehensive ranking. Since it received a rating of 61, the 1,627 ft. site also qualifies for consideration as a stabilization candidate. Based on the results of the demonstration project, NUSCO commits to implementing a site-wide stabilization action by 1994.

ND&T recommends approximately 180 feet of Site 60 be used as a demonstration stabilization project. The demonstration project has been proposed for an area downstream of Otter Run Brook, which exhibits signs of active erosion. Three variations of bio-technical stabilization methods will be installed - each approximately 60 feet in length. None have been applied to the banks of the Turner's Falls Pool, but each technique is considered appropriate for bank stabilization.

Reach 1 consists of a combination of vegetation and rock-filled timber cribbing and is shown on Figure VII-2. A rock-filled timber crib will be placed for the entire 60 feet of Reach 1. It is anticipated that timber crib sections will be constructed off site prior to the commencement of bank stabilization efforts, and brought on site as needed. The exposed top face of the crib will

NORTHROP, DEVINE & TARBELL, INC.

TIMBER CRIB/VEGETATION

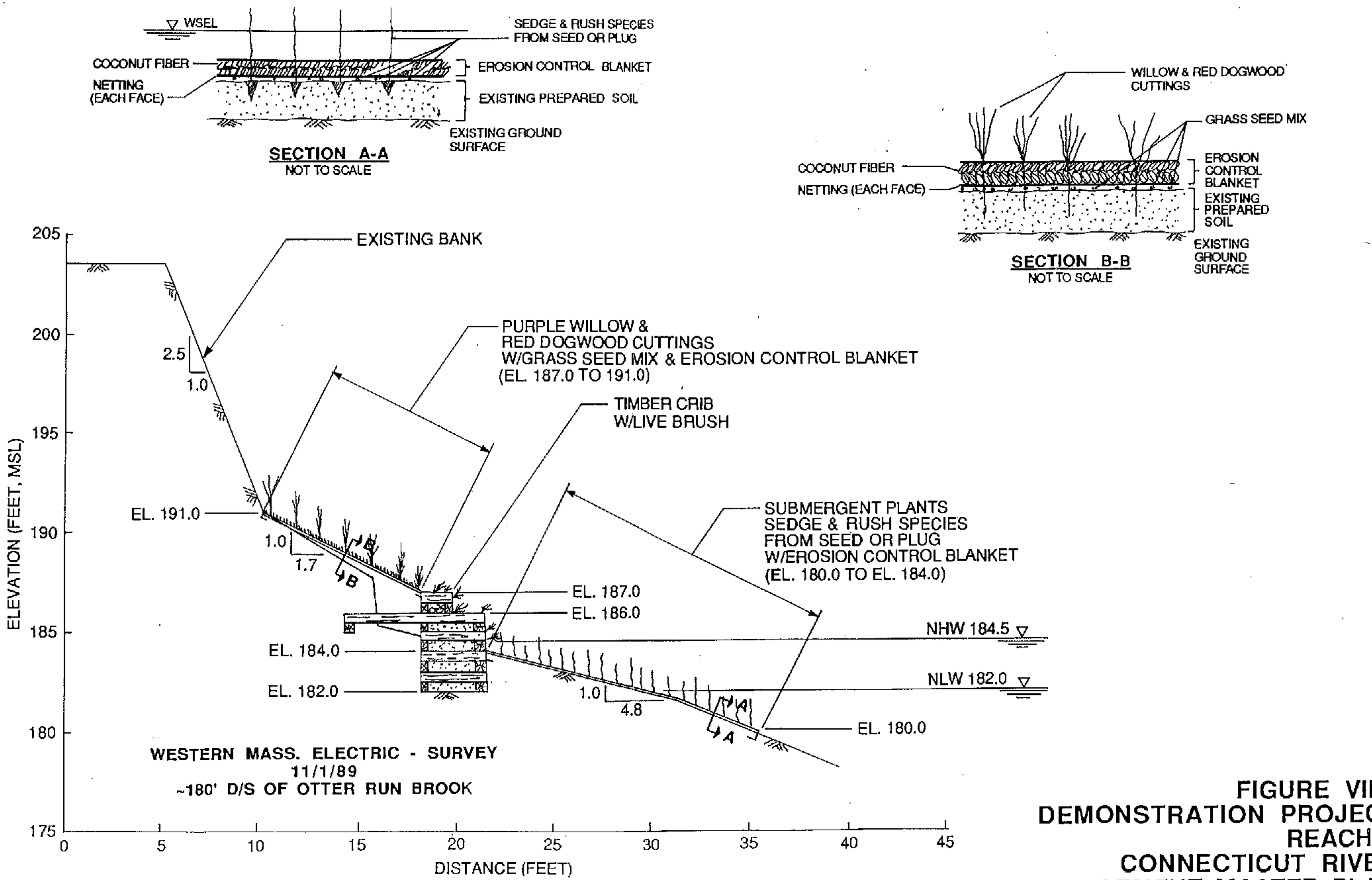


FIGURE VII-2
DEMONSTRATION PROJECT
REACH 1
CONNECTICUT RIVER
RIVERBANK MANAGEMENT MASTER PLAN

be "stepped" with the front half of the crib at EL 186 and the back half at EL 187. The timber crib will be positioned approximately 5 ft. from the toe of the bank. Approximately 35 cy of stone will be required in the placement of the timber crib.

All but the top three feet of the timber cribbing will be covered by existing bank material. Proposed vegetation includes sedge and rush species between EL 180.0 and EL 184.0, willow and dogwood cuttings, and a grass seed mixture above the normal high water elevation. Stabilization of the bank will also include the use of natural fiber blankets which resist the erosive forces of the water, prevent soil transportation and loss, and provide seedlings the opportunity to establish root systems. This particular combination of techniques provides an opportunity to evaluate the ability of a purely vegetative stabilization method and a second means of protecting the bank if the vegetative method should prove less than adequate.

Construction time is anticipated to be of a short duration, given the relatively small work area and the time-sensitive nature of plantings being used. Major work items in the construction sequence consist of, access roadway extension to the toe of the bank, excavation for, and placement of, timber crib sections, placement of stone, placement of excavated material behind cribbing, and placement of erosion control blankets and vegetation.

Reach 2 consists of vegetative methods of stabilization and is shown on Figure VII-3. Proposed vegetation includes sedge and rush species between normal low and normal high water elevation, and willow and dogwood cuttings with a grass seed mixture above the normal high water elevation. Sedge and rush species such as three-square, swordgrass, and great or soft-stem bullrush are recommended for areas below the normal highwater line. Willow

VEGETATION

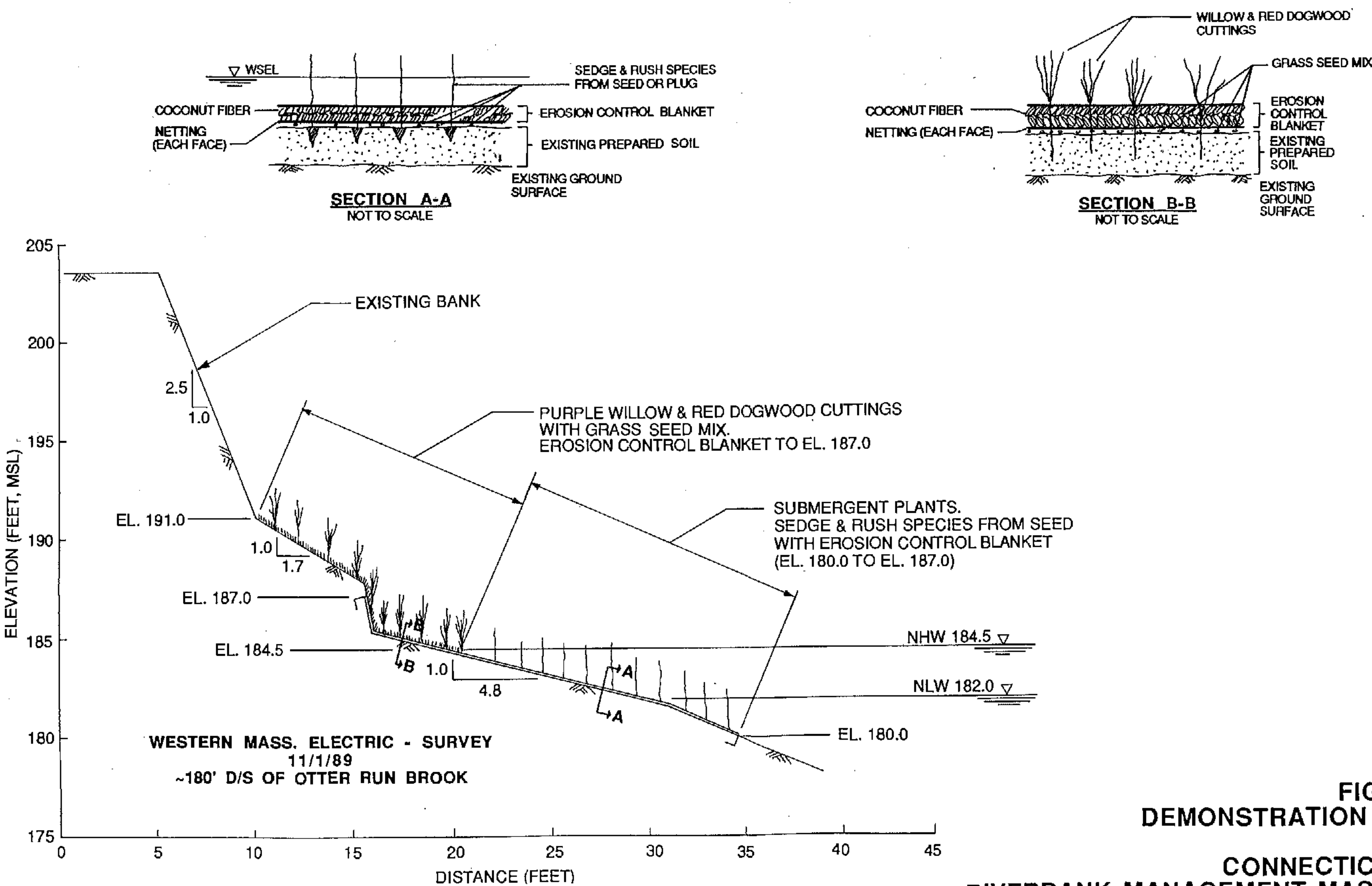


FIGURE VII-3
DEMONSTRATION PROJECT
REACH 2
CONNECTICUT RIVER
RIVERBANK MANAGEMENT MASTER PLAN

and dogwood cuttings, freshly cut branch stems, develop and root when placed in soil. Grass seed mixtures will be composed of several seed types including; Tall Fescue, Rye Crown Vetch, Red Fescue and Birdsfoot Trefoil. The upper portion of the existing bank will remain undisturbed in both stabilization scenarios to minimize disturbance of wildlife habitat.

The riverbank and erosion site will be reached by an existing farm access roadway. Extension of the roadway as well as some grading will be required to maintain the roadway during construction. A small laydown area will also be maintained during construction to provide a storage area for equipment and materials. The temporary roadway will be constructed in a manner which avoids damage to identified environmental resources present at the site. A temporary roadway will traverse the top of the bank and continue down to the toe of the bank near the Otter Run Brook. Access along the toe of the slope will ease placement of timber cribbing and vegetative stabilization materials. Upon completion of the stabilization work, all roadways and storage areas will be removed in such a manner as to minimize or completely avoid disturbance of existing soil and return the land to its pre-construction condition.

Major work items in the construction sequence of Reach 2 consist of access roadway extension to the toe of the bank and placement of erosion control blankets, plantings and vegetation.

Reach 3 of the demonstration project will consist of a 60 foot stretch of geotextile slope reinforcement. In this portion of the project, a synthetic geotextile material, such as Tensar, will be utilized to secure the toe of the slope to an elevation of approximately 187.0 feet. Similar to the technique used in Reach 1, plantings will be added between the geotextile fabric and an elevation of approximately 191.0 feet. The remaining face of the bank above this elevation will remain untreated.

The specific use of this product is dependent upon a site visit and consultation with the manufacturer. Consequently, the amount of material and specific type of geotextile fabric to be used is currently unknown. Further investigation in the summer of 1991 will allow a detailed plan for Reach 3 to appear in the Final version of the Master Plan.

Construction and access needs for the demonstration project are described below. During construction, machinery such as a small loader or bulldozer, backhoe, and dump truck may access the site by the temporary roadway. Placement of timber cribbing, excavated material, and stone will be performed from the toe of the bank with a backhoe or a small loader. Areas of the bank inaccessible by heavy equipment will require hand labor to complete the work. Final grading and compaction of the slope, placement of erosion control blankets and natural fiber matting, and planting of cuttings and grass seed will be performed by hand and with the assistance of small, hand-operated machinery.

With substantial pre-stabilization construction and preparation of materials off site prior to the start of field work, and coordination of construction sequencing and timing with the operation of Northfield Mountain Pumped Storage Facility, bank stabilization construction is anticipated to be completed within a relatively short time.

Placement of timber cribs will require excavation at the toe of the bank to an elevation of approximately 182.0. Excavated material will be relocated behind the timber crib prior to the placement of vegetation.

Timber cribbing will be brought onto site and placed as needed. A loader or backhoe may be necessary to place sections timber crib into place. Stone will be carried to the toe of the bank by dump truck and placed with a small loader. Final positioning of stone will be completed by hand.

Existing environmental resources at Site 60 are shown on Map VII-2. Site 60 contains no rare or endangered plant species. Otter Run Brook and its adjacent 100-year floodplain exist just upstream from the site and represent the only wetland that may be temporarily affected during construction. Archaeological resources were identified adjacent to the bank during an April, 1990 subsurface investigation. Bank swallow nesting cavities are clustered throughout the upper bank face of Site 60. The beach area at Site 60 is frequently used by recreational boaters in the summer months.

Provisions for minimizing construction impacts to these resource areas have been considered in the techniques used to access the site and stabilize the bank as well as through the timing of the construction. Stabilization of bank areas near wetlands will be done primarily by hand with heavy equipment remaining on the top of the bank and some distance from the wetland area. Construction impacts to the bank swallow habitat along the top of the bank will be avoided by eliminating any construction activity in the area, and allowing the bank to remain in its present condition. All planting and construction will take place between late October and April in order to maximize the rooting and development of installed vegetation. This timing will also minimize any potential wetland impacts and will be the least disruptive to bank swallows and recreational users of the beach. Known archaeological resources upland of the site, will be avoided. Resources within the riverbank will be removed by a professional archaeologist in any area where the removal of bank material will expose resources identified in April, 1990. Areas where fill will be added will not require artifact removal.

Plantings will be placed by hand in the water and along the bank, with grass mixtures broadcast hydraulically in order to minimize the impact of heavy machinery on the riverbank. Upland erosion and sedimentation control will consist of haybales, silt fencing, and earth berms. In general, these techniques will be used where soil is disturbed and in areas where construction equipment is stored or used.

The methods of construction and procedures involved in stabilizing the portion of Site 60 involved in the demonstration project are typical of those anticipated at any erosion site within the Turner's Falls Pool. While actual erosion site stabilization methods are site-specific, the general approach to site access, roadway placement, bank access, use of heavy machinery, and minimizing impact to environmental resources will closely follow those outlined for the demonstration project.

a. Demonstration Project Permitting Requirements

Permits will be required for this demonstration project from local, state and federal government agencies. The following listing itemizes the permits, or approvals, which NUSCO will need to possess prior to construction.

1. Local Order of Conditions

Required with the Massachusetts Wetlands Act, the Gill Conservation Commission is charged with reviewing the project as it related to impacts on the land under water, bordering vegetated wetlands and their 100 ft. buffer zone, and any land within a 100 year flood plain. NUSCO must file a "Notice of Intent" with the Town of Gill and the Western Regional Office of the Massachusetts Department of Environmental Protection (DEP).

2. Rare Species Review

An "Appendix A", which itemizes any state or federal protected plant or animal species within the project area, must be submitted to the Massachusetts Division of Fish and Wildlife. Appendix A must also be filed with the Notice of Intent.

3. Massachusetts State Historical Commission Approval

This entails an archaeological review of the project area and documentation of the location of any prehistoric or historic material. Subsurface testing was performed in the vicinity of the demonstration project and a report was generated in April, 1990. Information from this investigation can be used when seeking approval.

4. U.S. Army Corps of Engineers Permit

To meet the requirements of Section 10 of the U.S. Rivers and Harbors Act and Section 404 of the Clean Water Act, NUSCO must file for a U.S. Army Corps of Engineers Permit. An individual permit will be sought regarding the placement of fill in a navigable water of the U.S. Riverbank stabilization projects less than 500 ft. in length are pre-approved via the Nationwide Permit Program if the activity is necessary for erosion protection and less than an average of one cubic yard per running foot is constructed. Since the demonstration project includes four to five cubic yards per running foot an individual permit will be required.

5. Chapter 91 Permit

A "Chapter 91" permit, in accordance with the Massachusetts Tidelands and Waterways Act, will not be needed for the project. The regulations administered by the Massachusetts DEP for dredging and filling were revised on October 4, 1990. Upon consultation with DEP's staff, it was determined that the demonstration project described in this section meets the provisions for non-applicability as dictated in 310 CMR 9.05 of the Code of Massachusetts Regulations, as recently revised. A letter acknowledging this non-applicability would be sent to the DEP by NUSCO.

In addition, MEPA approval is not required since the project area is less than 500 linear feet. However, through the Master Plan's filing with MEPA, the demonstration project may be commented on as part of the entire submitted plan. The approvals and permits stipulated above will be applied for by NUSCO in order to allow for construction of the demonstration project during the winter of 1991-1992. Project construction during this time is desired both for environmental protection considerations and for the successful establishment of the vegetative materials to be used in the demonstration project.

b. Stabilization Action for Site 60

Depending upon the outcome of the demonstration project, NUSCO will select an appropriate stabilization technique to implement throughout Site 60 in 1993-1994. It has been concluded by NUSCO that the present erosion conditions at this site and its associated environmental resource values warrant stabilization action. The access and construction considerations mentioned in context with the demonstration project should also apply to the stabilization of the entire site. Permitting considerations will change given the 1,627 feet length of the site and will also be influenced by the stabilization technique utilized. The same permitting agencies mentioned above will be consulted prior to stabilizing Site 60, to discuss the applicability of permits.

NUSCO WILL SPONSOR A BOATER AWARENESS PROGRAM

As mentioned previously, existing data on boat waves and their effects on erosion does not warrant the restriction of boating activity. Nonetheless, wave action is a secondary contributor to erosion in lower bank areas where conditions are already moderate-to-severe or severe and soils are highly erodable. Recreational boating use has been increasing steadily over the last decade in the Turners Falls Pool, and the size and power of boats has also been increasing. As such, NUSCO feels that it is warranted to sponsor an awareness program designed to alert boaters that their actions may add to the erosion of Turners Falls Pool riverbanks. Information can be disseminated through local boating clubs, marinas, towns and state agency regional offices. In addition, NUSCO advocates sponsoring meetings between boating enthusiasts, local officials and state resource management agencies to discuss issues of concern and, perhaps, adopt a series of initiatives to accommodate the varied interests of Turners Falls Pool users.

D. Master Plan Implementation Schedule

To follow through on the recommendations listed in this Master Plan, NUSCO has developed an implementation schedule. Figure VII-4 shows the anticipated sequence of events necessary to implement the Master Plan through 1996. Five years from now a comprehensive review of the implementation program will be presented in a progress report and a revised series of recommendations for the next five year period will be put forward. NUSCO firmly believes that the implementation of the Master Plan is dependent on follow-up monitoring and review of its initiatives. This will ensure that the Master Plan will periodically be updated and will become a dynamic tool for managing Turners Falls Pool riverbank resources.

CONNECTICUT RIVER RIVERBANK MANAGEMENT MASTER PLAN
MASTER PLAN IMPLEMENTATION SCHEDULE 1991-1996

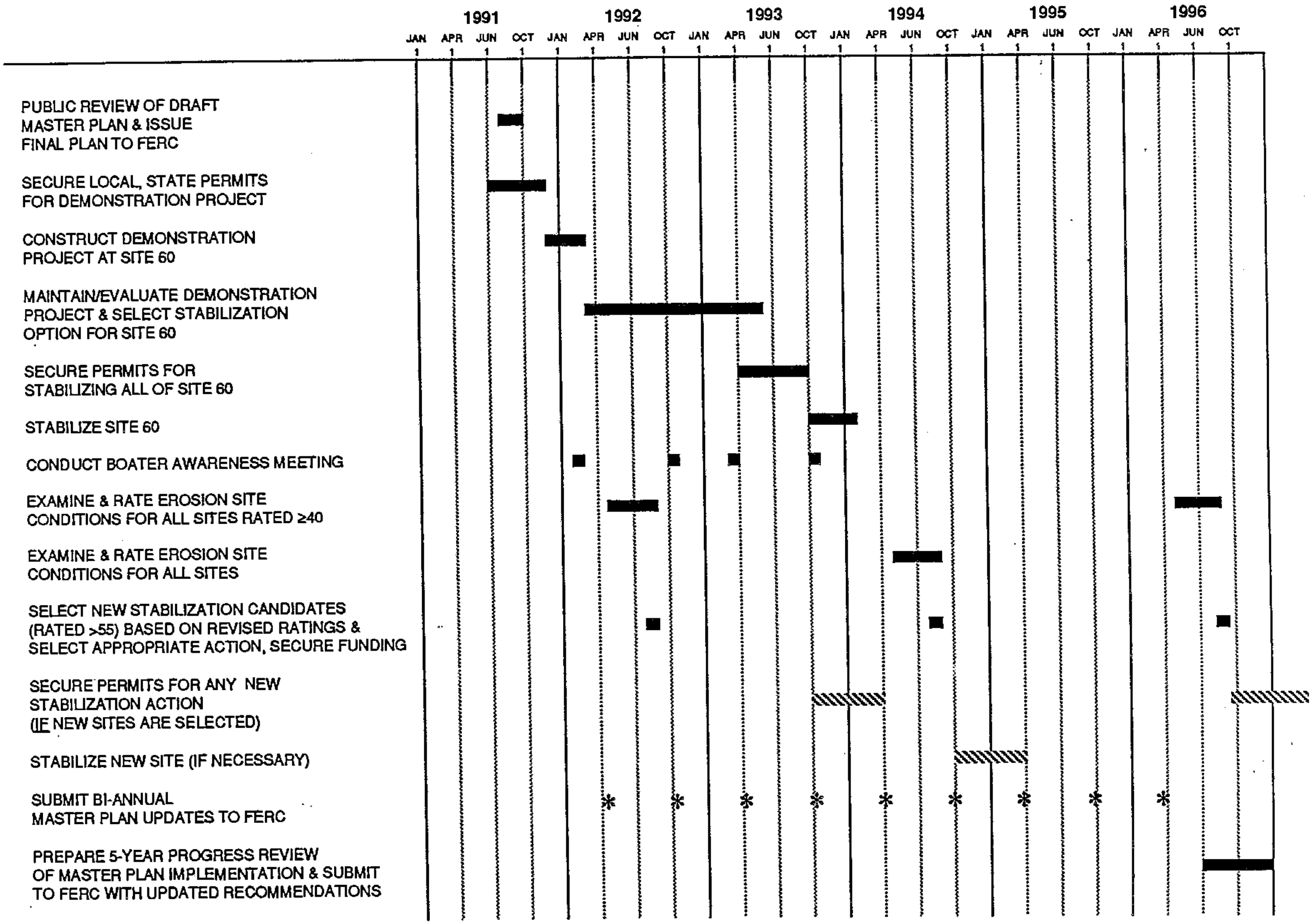
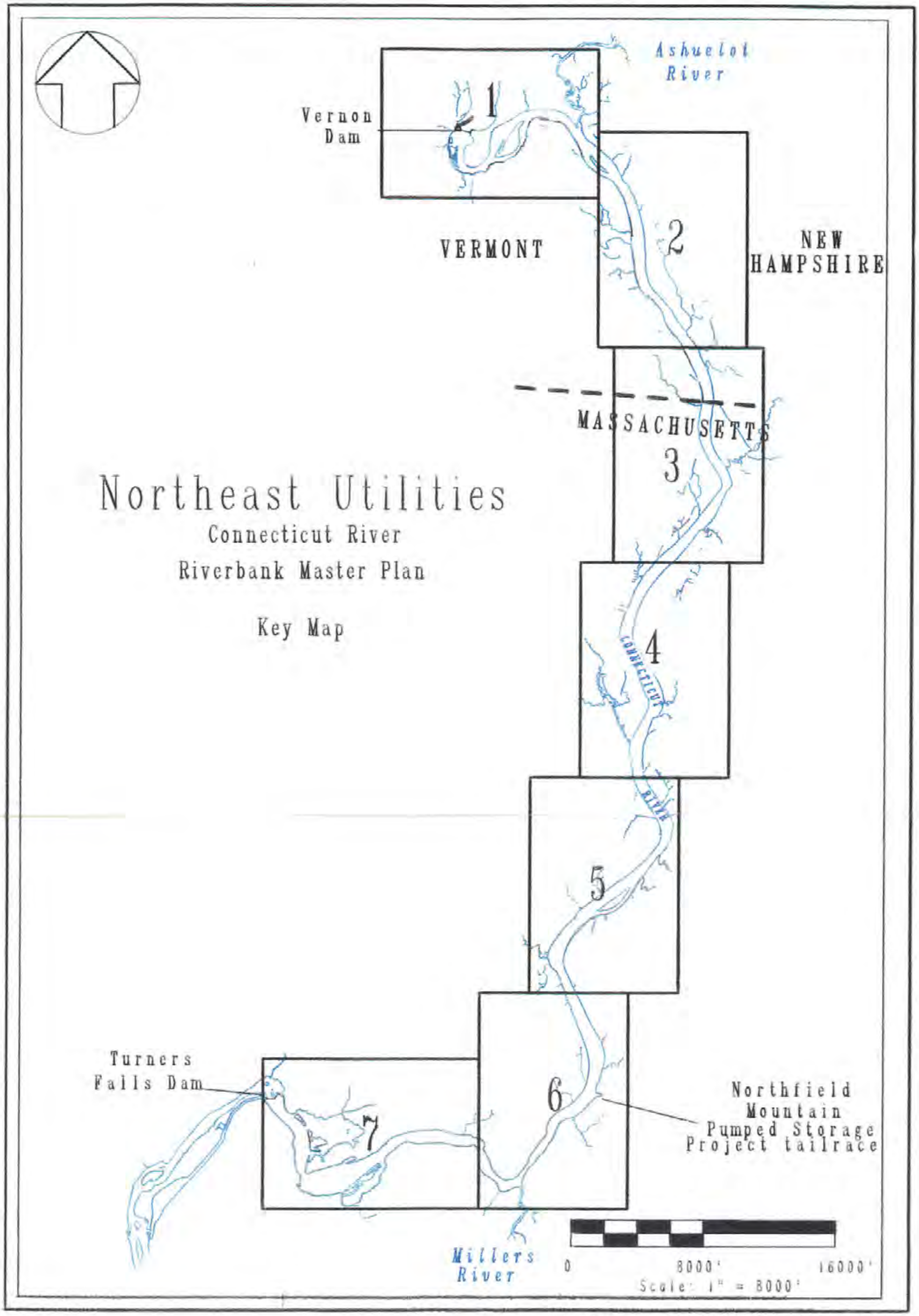
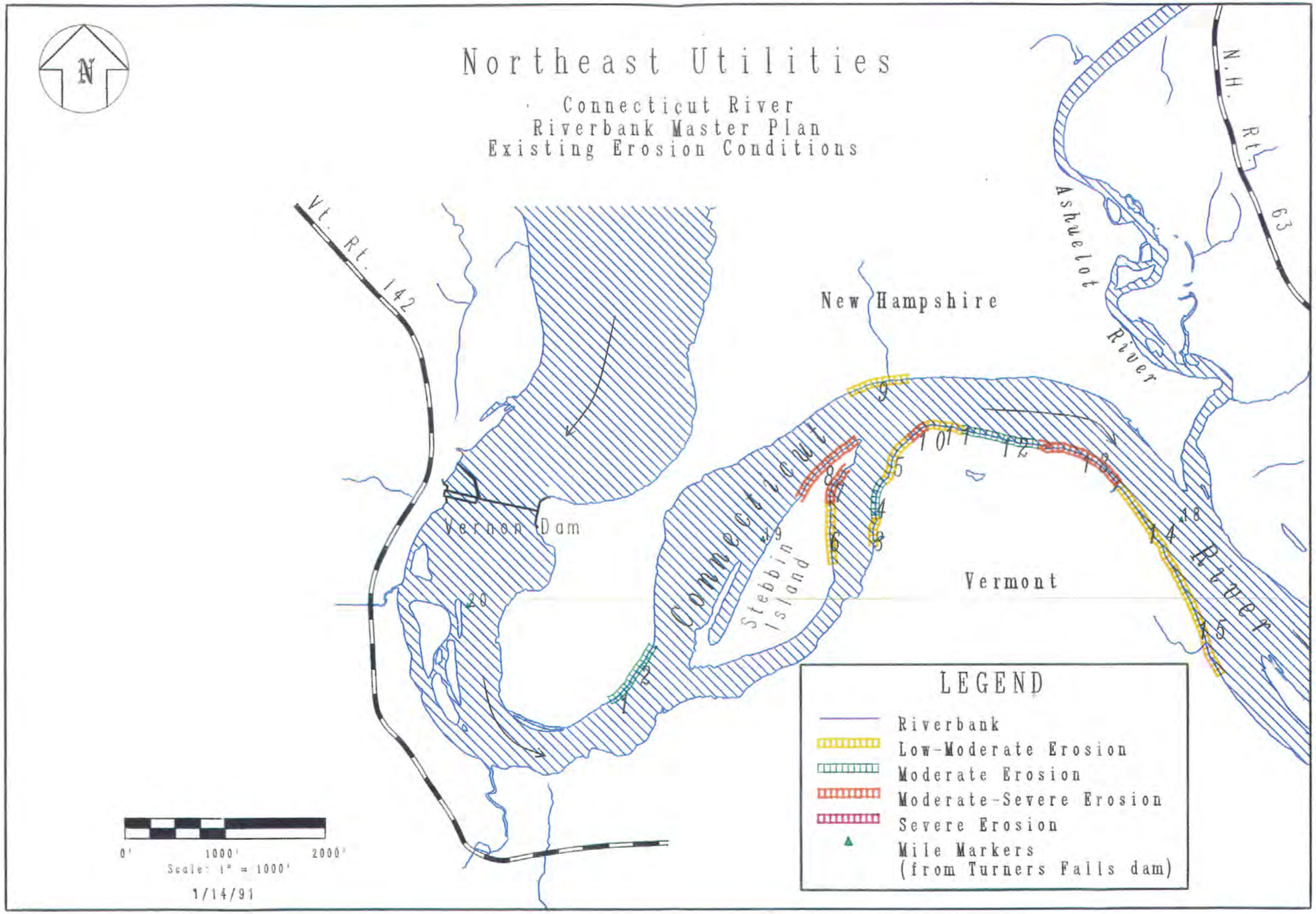


FIGURE VII-4

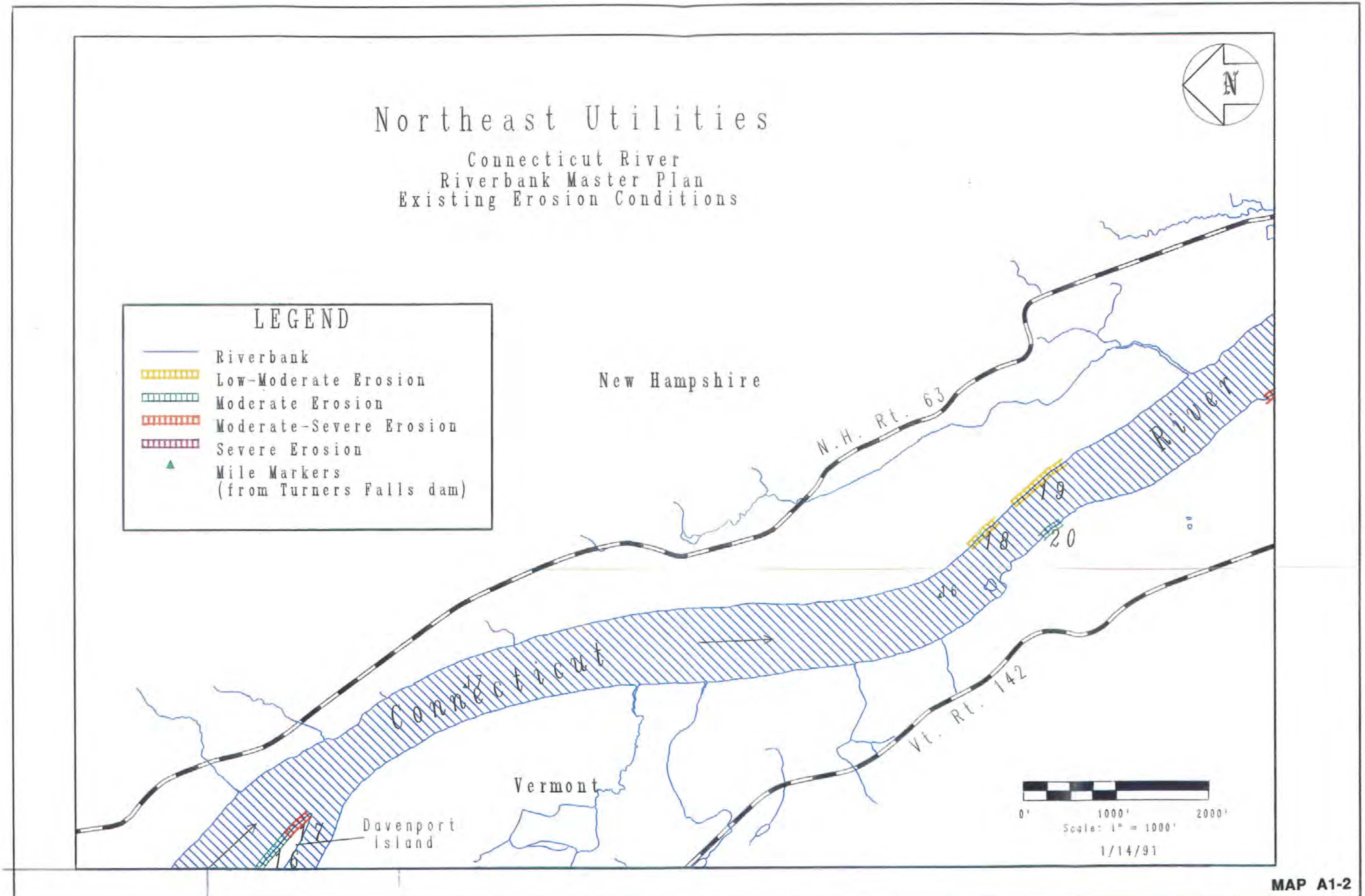
ATTACHMENT A



ATTACHMENT "A" KEY MAP


Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Erosion Conditions
N
Vt. Rt. 142
N.H. Rt. 63
New Hampshire
Ashuelot River
Vermont
Vernon Dam
Connecticut River
Stebbins Island
LEGEND
Riverbank
Low-Moderate Erosion
Moderate Erosion
Moderate-Severe Erosion
Severe Erosion
Mile Markers
(from Turners Falls dam)
0'
1000'
2000'
Scale: 1" = 1000'
1/14/91

MAP A1-1



Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Erosion Conditions
LEGEND
Riverbank
Low-Moderate Erosion
Moderate Erosion
Moderate-Severe Erosion
Severe Erosion
Mile Markers
(from Turners Falls dam)
New Hampshire
N.H. Rt. 63
Connecticut
River
Vermont
Vt. Rt. 142
Davenport Island
17
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2000'
Scale: 1" = 1000'
1/14/91
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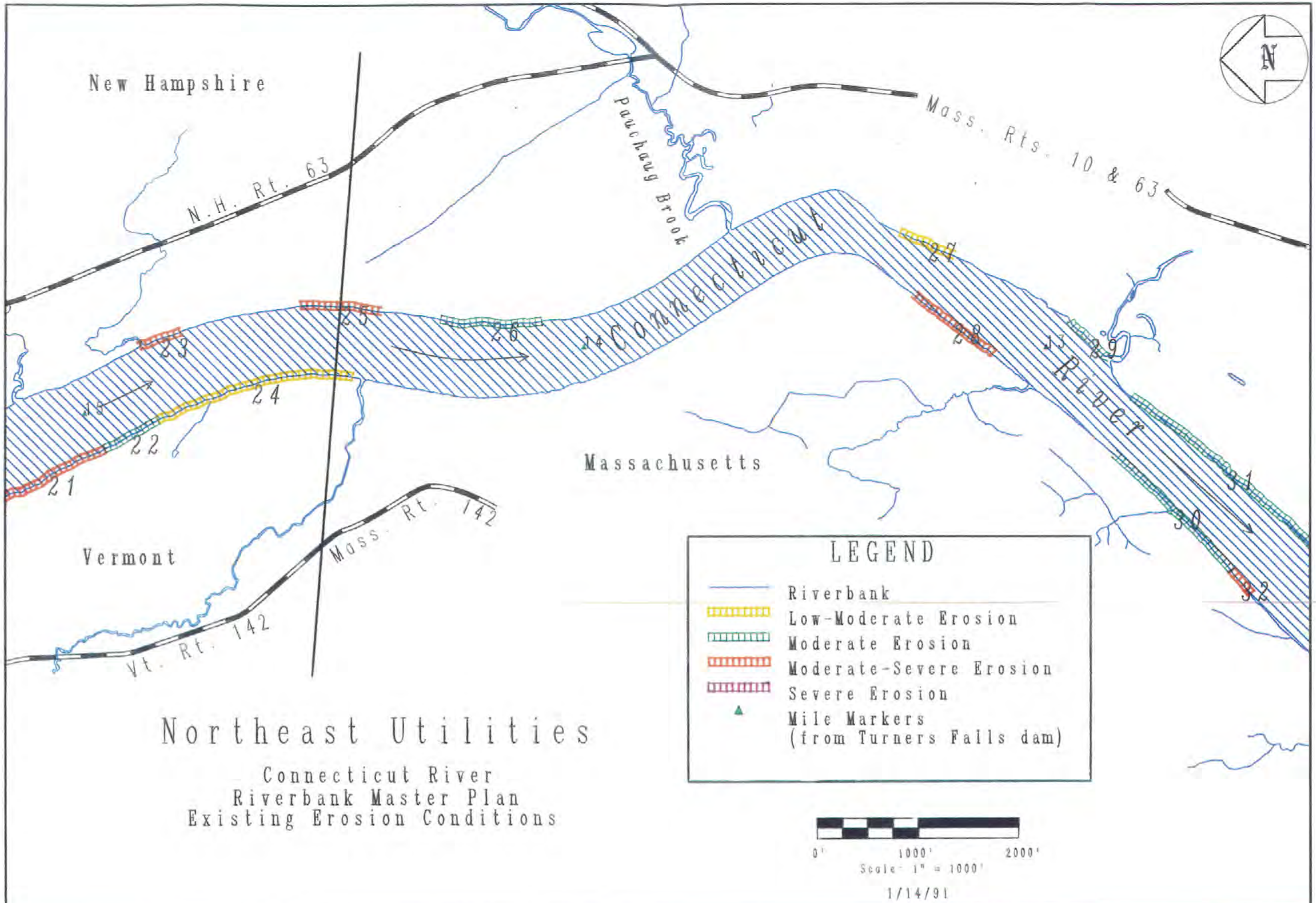
MAP A1-2


New Hampshire
N.H. Rt. 63
Pauchaug Brook
Mass. Rts. 10 & 63
Connecticut River
Massachusetts
Vermont
Mass. Rt. 142
Vt. Rt. 142
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LEGEND
Riverbank
Low-Moderate Erosion
Moderate Erosion
Moderate-Severe Erosion
Severe Erosion
Mile Markers
(from Turners Falls dam)
Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Erosion Conditions
0'
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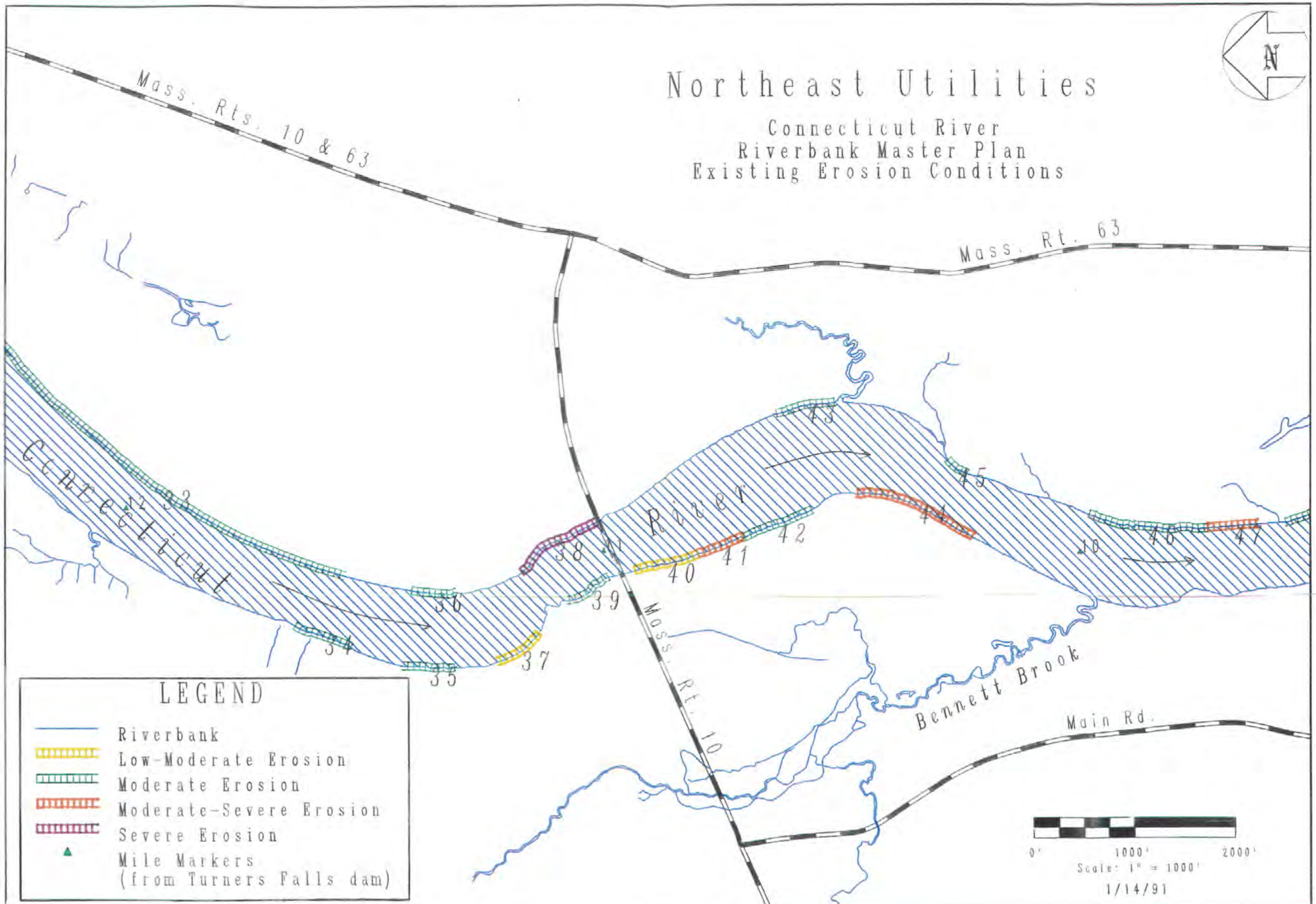
Scale: 1" = 1000'
1/14/91

MAP A1-3


Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Erosion Conditions
Mass. Rts. 10 & 63
Mass. Rt. 63
Mass. Rt. 10
Main Rd.
Connecticut
River
Bennett Brook
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LEGEND
Riverbank
Low-Moderate Erosion
Moderate Erosion
Moderate-Severe Erosion
Severe Erosion
Mile Markers
(from Turners Falls dam)
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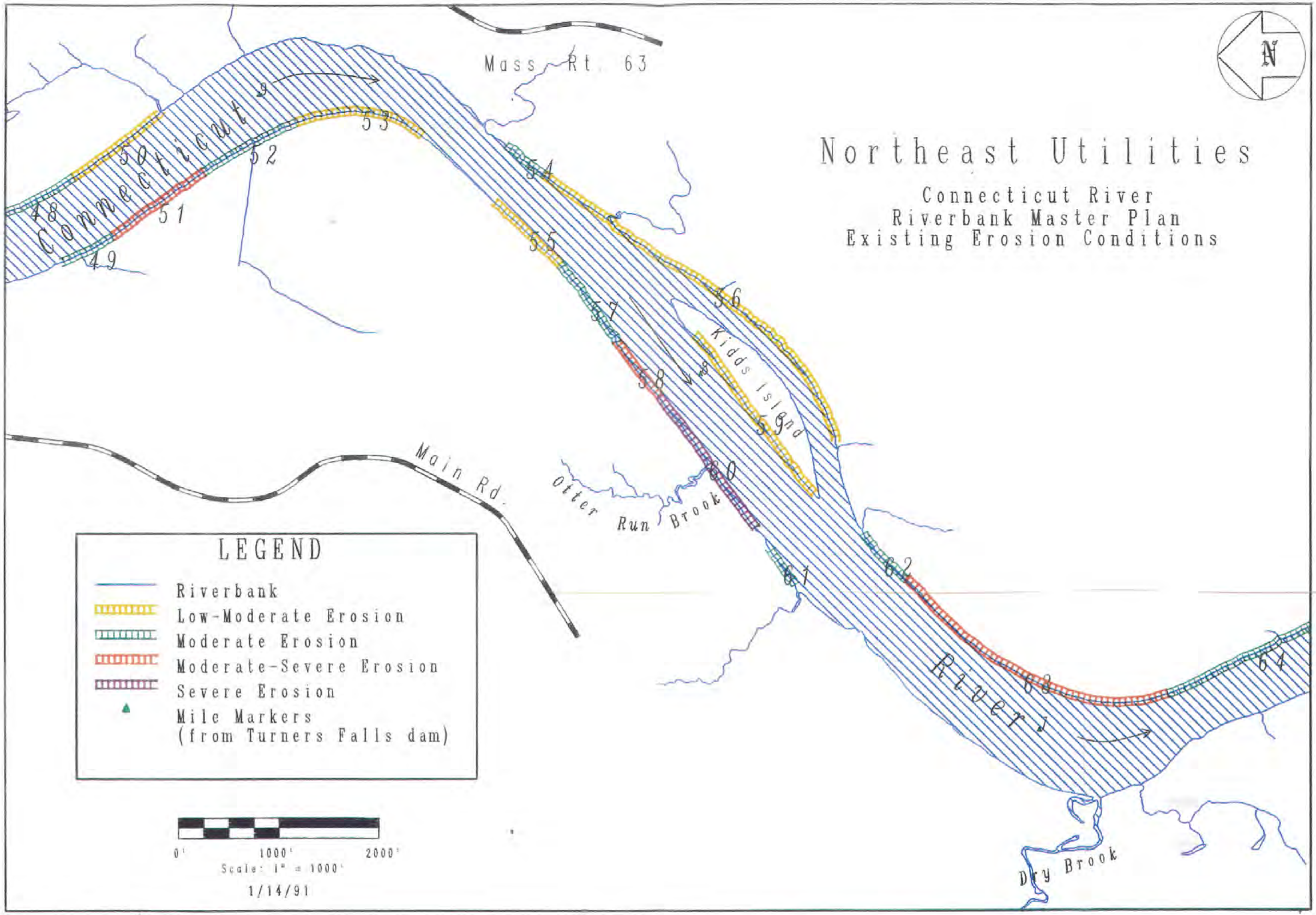
Scale: 1" = 1000'
1/14/91

MAP A1-4


Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Erosion Conditions
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Mass Rt. 63
Main Rd.
Connecticut
River
Kidds Island
Otter Run Brook
Dry Brook
48
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61
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63
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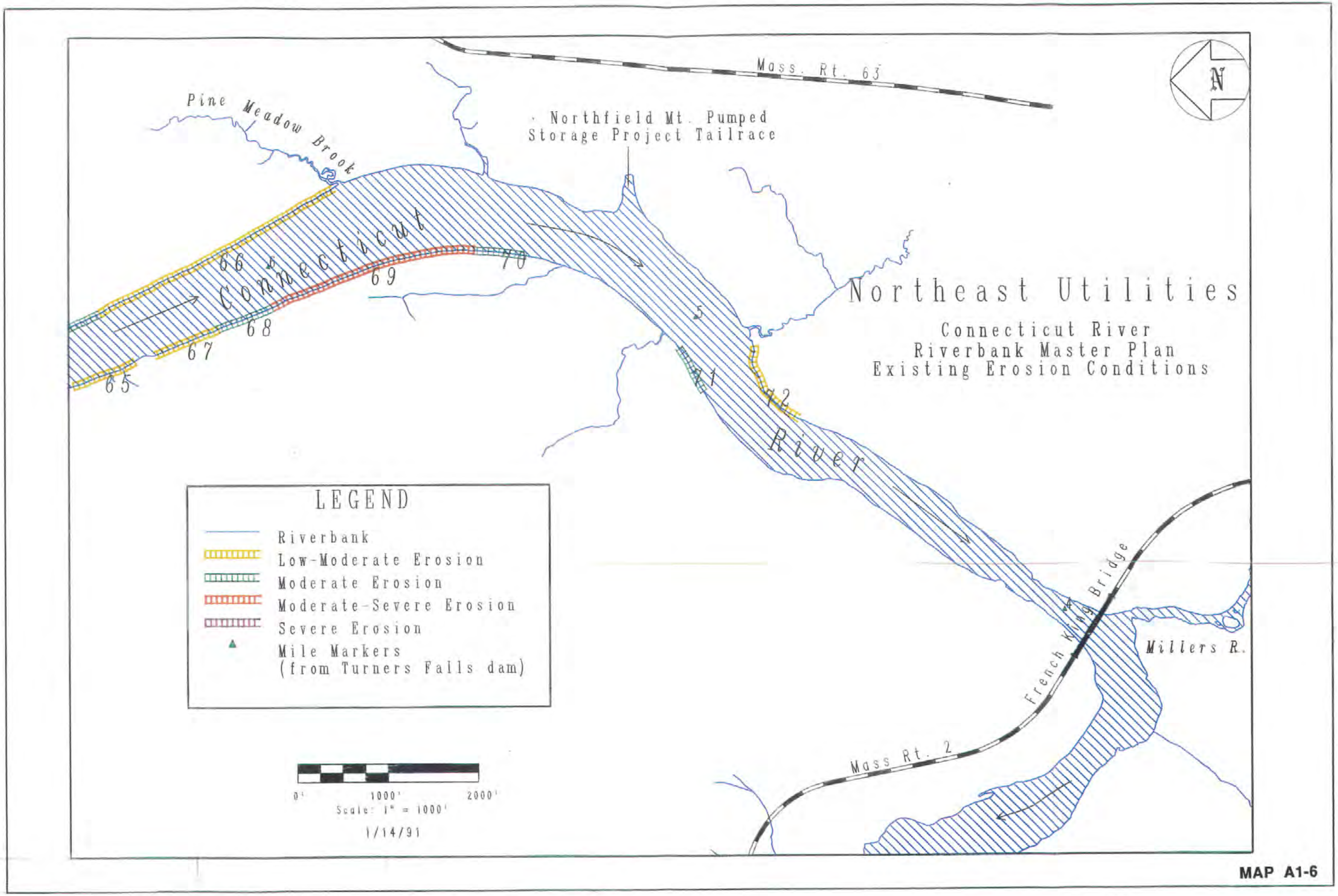
LEGEND
Riverbank
Low-Moderate Erosion
Moderate Erosion
Moderate-Severe Erosion
Severe Erosion
Mile Markers
(from Turners Falls dam)
0'
1000'
2000'
Scale: 1" = 1000'
1/14/91

MAP A1-5


Mass. Rt. 63
N
Pine Meadow Brook
Northfield Mt. Pumped
Storage Project Tailrace
Connecticut
River
65
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74
Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Erosion Conditions
LEGEND
Riverbank
Low-Moderate Erosion
Moderate Erosion
Moderate-Severe Erosion
Severe Erosion
Mile Markers
(from Turners Falls dam)
0'
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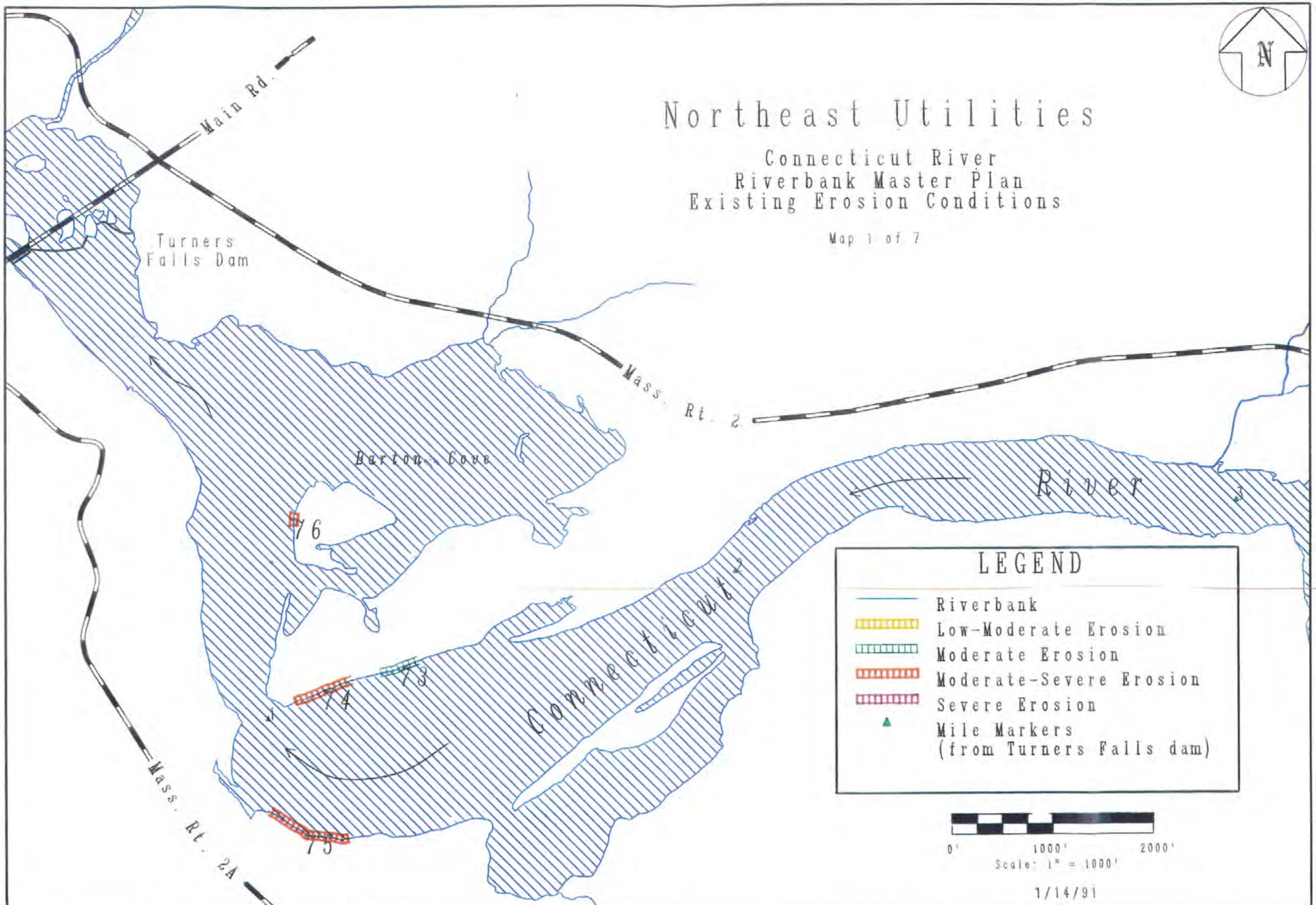
Scale: 1" = 1000'
1/14/91
French King Bridge
Millers R.
Mass Rt. 2

MAP A1-6

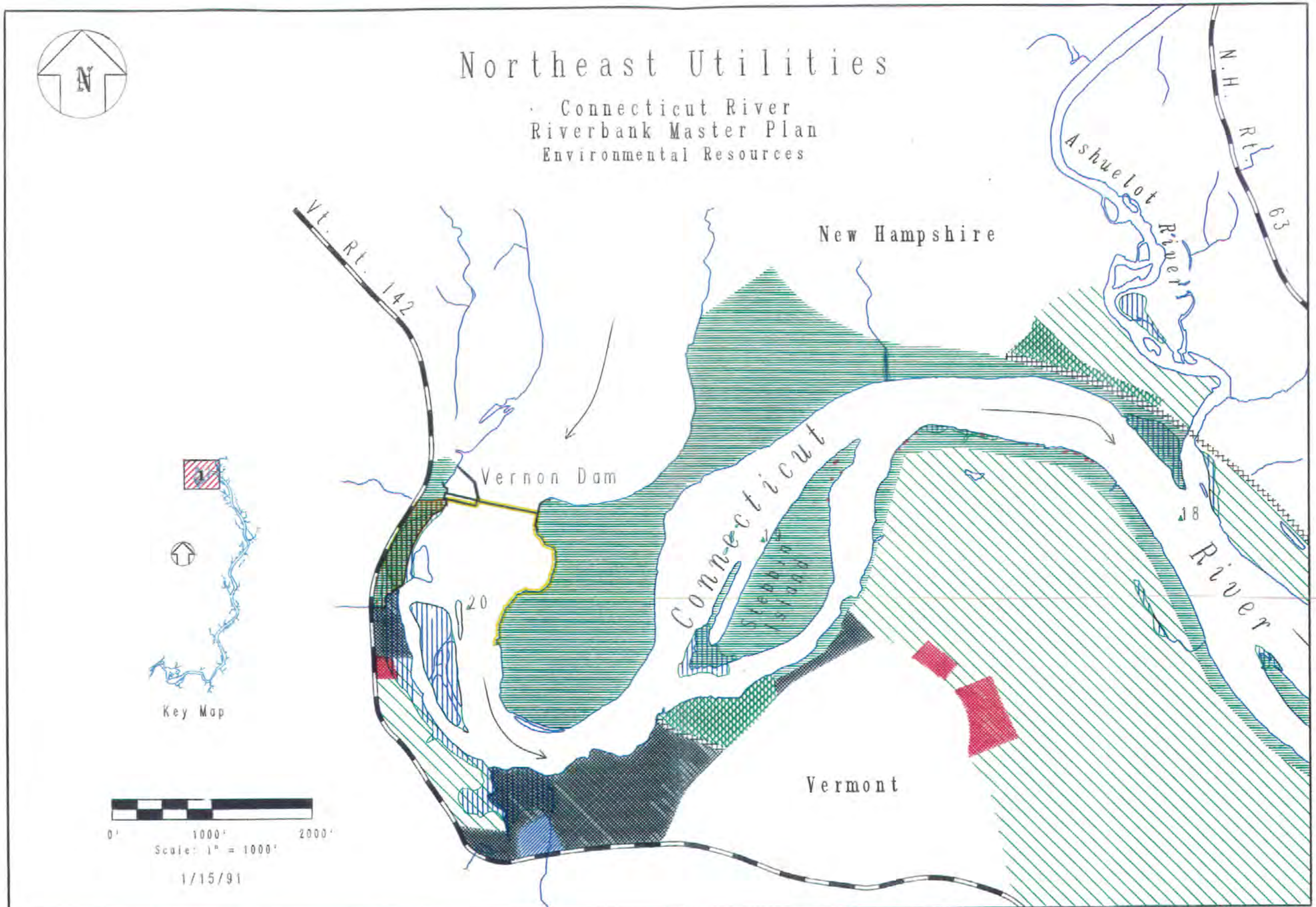

Northeast Utilities
Connecticut River
Riverbank Master Plan
Existing Erosion Conditions
Map 1 of 7
N
Main Rd.
Turners
Falls Dam
Mass. Rt. 2
Barton Cove
River
Connecticut
Mass. Rt. 2A
76
74
73
75
2
3
LEGEND
Riverbank
Low-Moderate Erosion
Moderate Erosion
Moderate-Severe Erosion
Severe Erosion
Mile Markers
(from Turners Falls dam)
0'
1000'
2000'
Scale: 1" = 1000'
1/14/91

MAP A1-7

LEGEND

- Riverbank
- Mile Markers (from Turners Falls dam)
- Confirmed Rare Plant Location
- Agricultural
- Residential
- Commercial/Industrial
- Public Land (town/state)
- Active Utility/Transportation
- Woodlands (utility owned)
- Open Lands (utility owned)
- Undeveloped Woodlands (privately owned)
- Undeveloped Open Land (privately owned)
- Wetlands
- Visually Sensitive Areas
- Scenic Viewpoints
- Recreation Sites

LEGEND:
ENVIRONMENTAL RESOURCES
MAPS A2-1 TO A2-7



Northeast Utilities
Connecticut River
Riverbank Master Plan
Environmental Resources
Vt. Rt. 142
N.H. Rt. 63
Ashuelot River
New Hampshire
Vernon Dam
Connecticut River
Stebbins Island
Vermont
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Key Map
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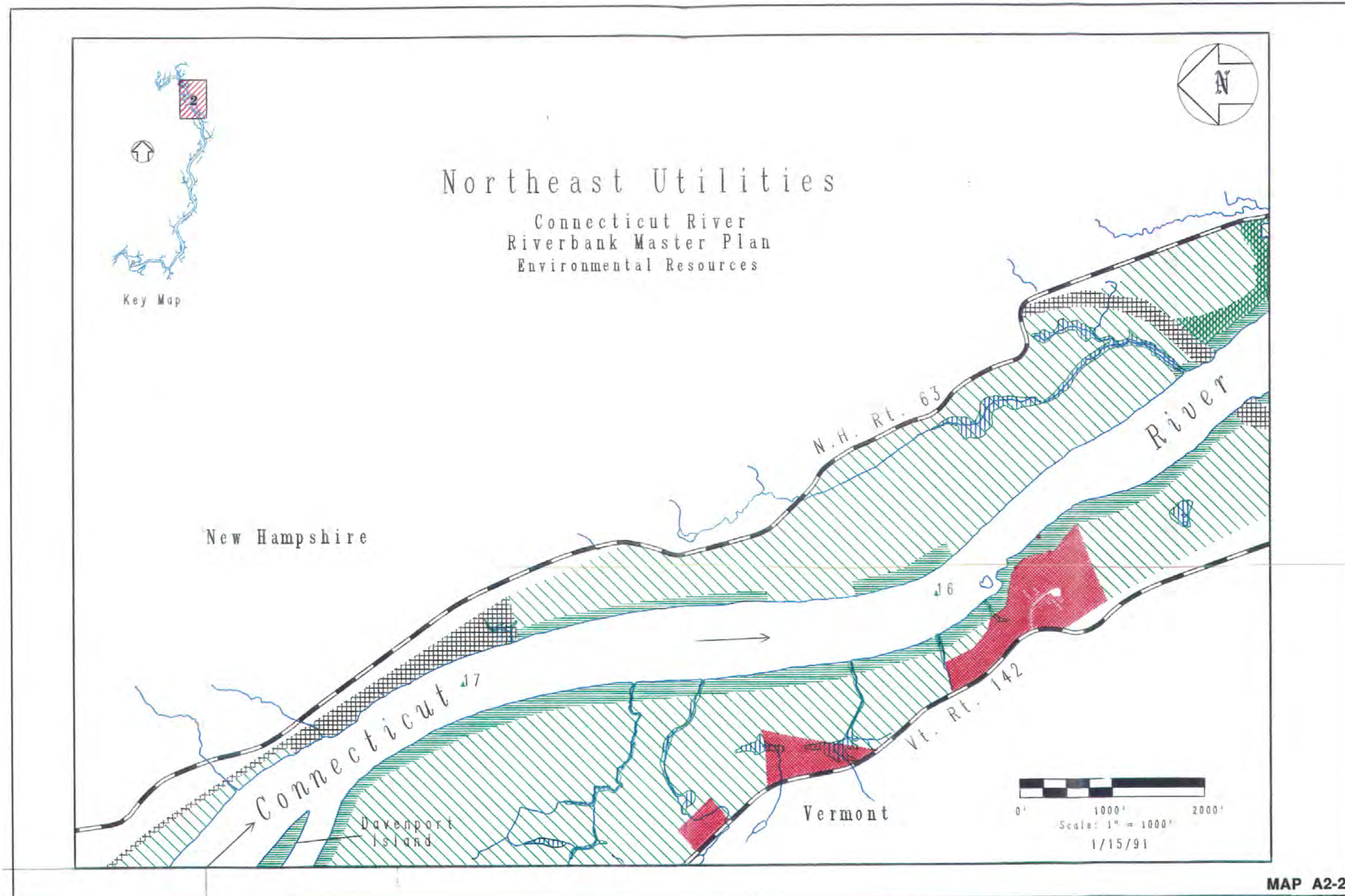
Scale: 1" = 1000'
1/15/91

MAP A2-1


Northeast Utilities
Connecticut River
Riverbank Master Plan
Environmental Resources
Key Map
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New Hampshire
N.H. Rt. 63
River
Connecticut
17
16
Davenport
Island
Vt. Rt. 142
Vermont
0'
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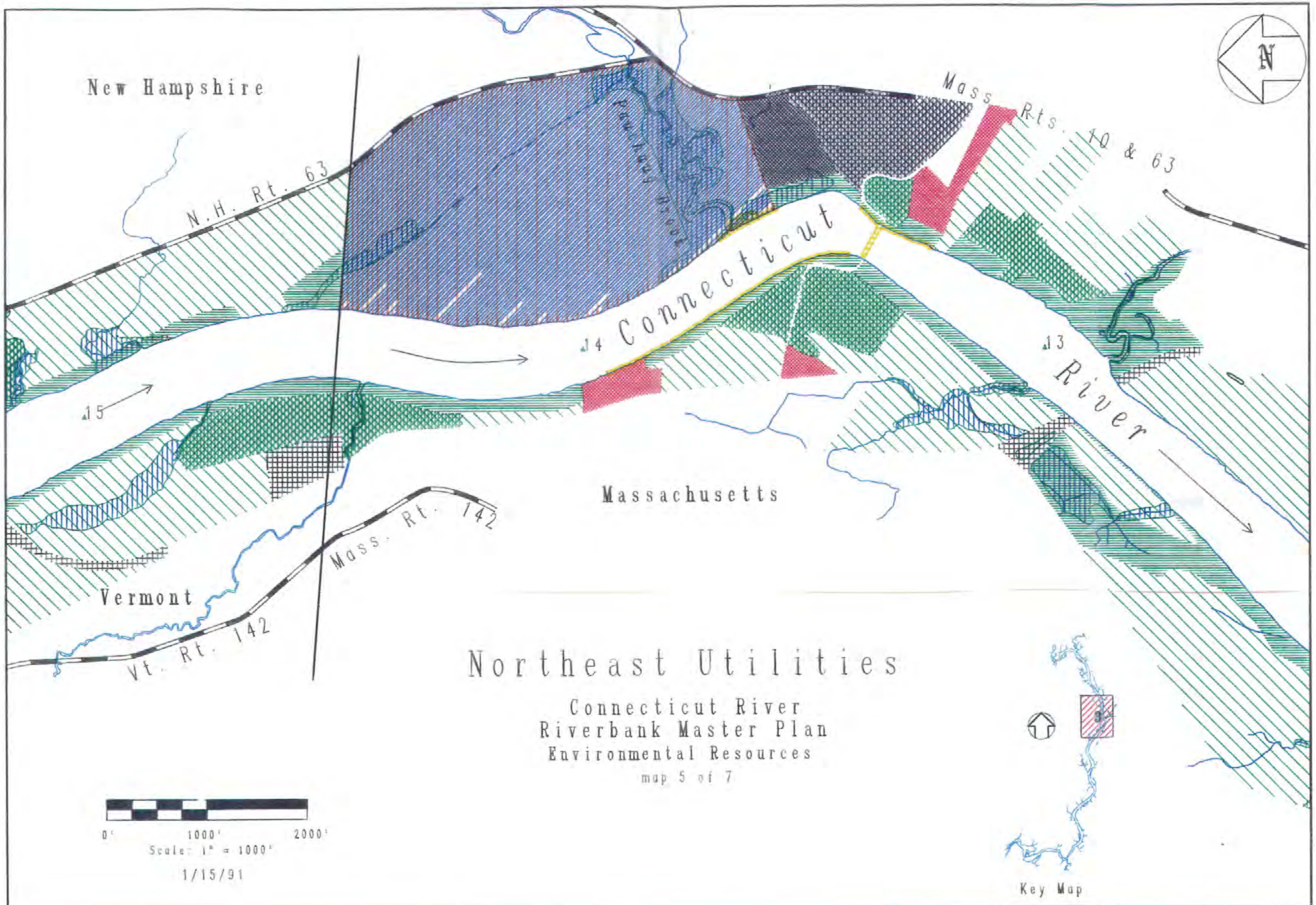
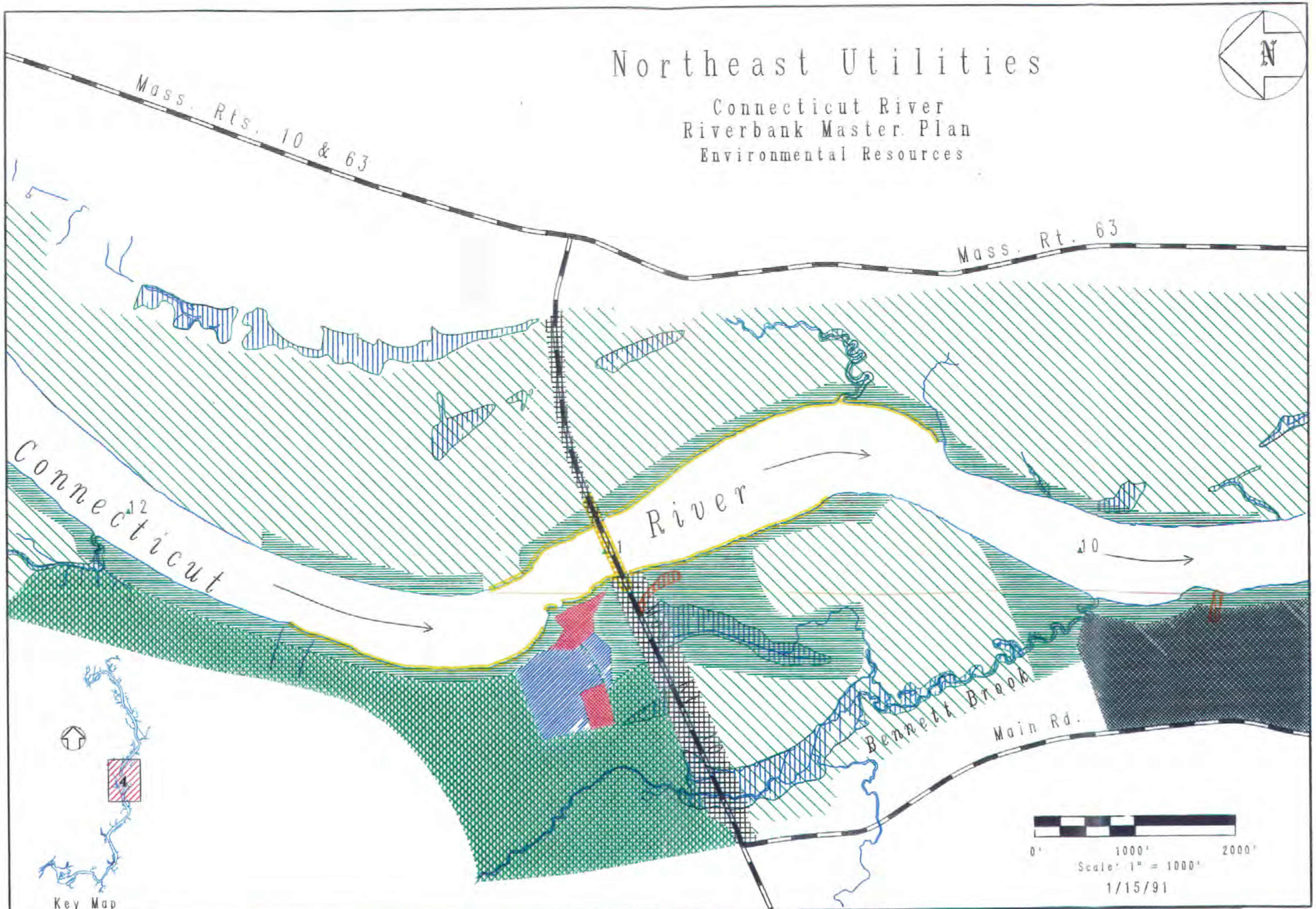
2000'
Scale: 1" = 1000'
1/15/91

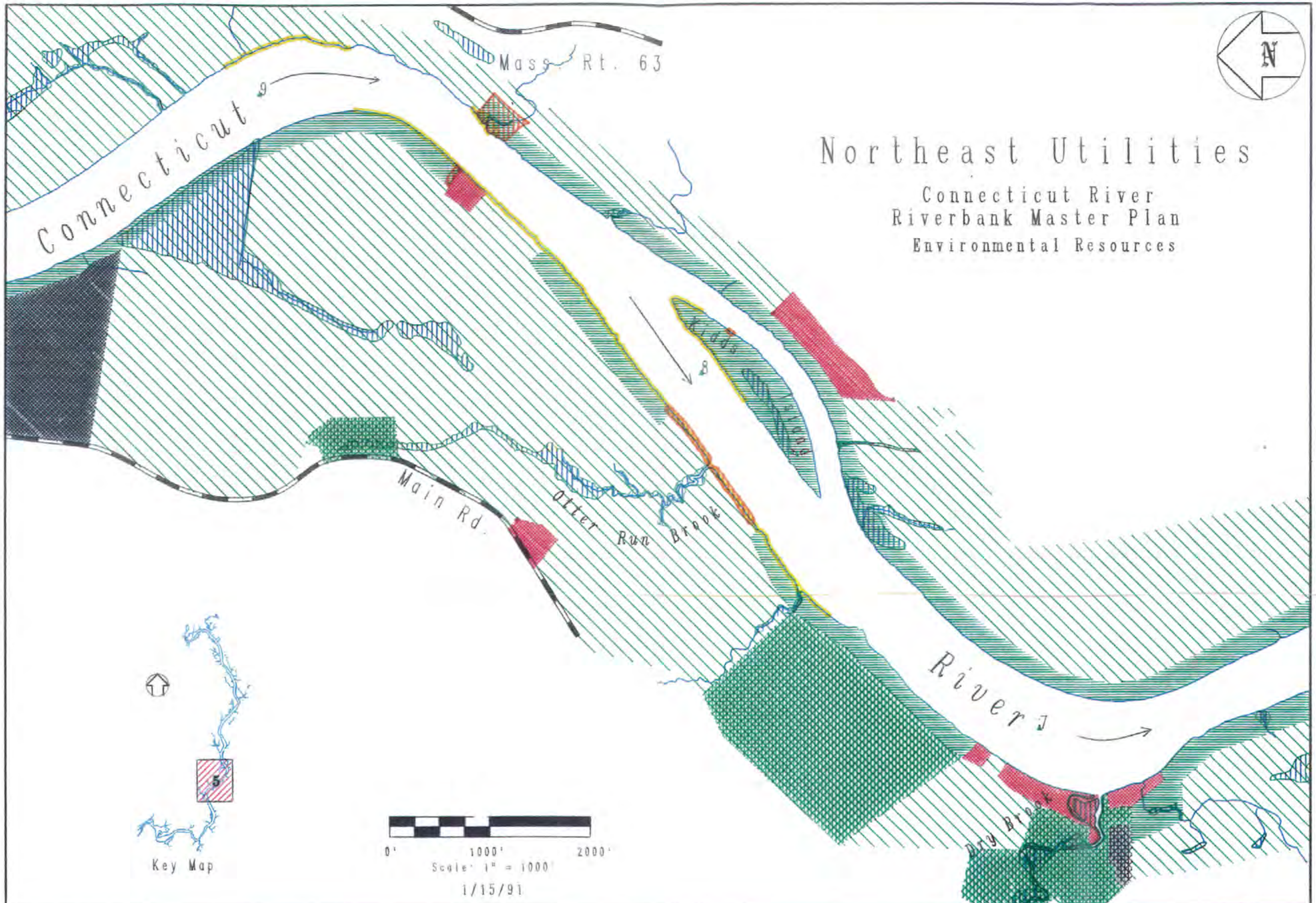
MAP A2-2


New Hampshire
N.H. Rt. 63
Pauchaug Brook
Mass. Rts. 10 & 63
N
Connecticut River
14
13
15
Massachusetts
Vermont
Mass. Rt. 142
Vt. Rt. 142
Northeast Utilities
Connecticut River
Riverbank Master Plan
Environmental Resources
map 5 of 7
0'
1000'
2000'
Scale: 1" = 1000'
1/15/91
Key Map

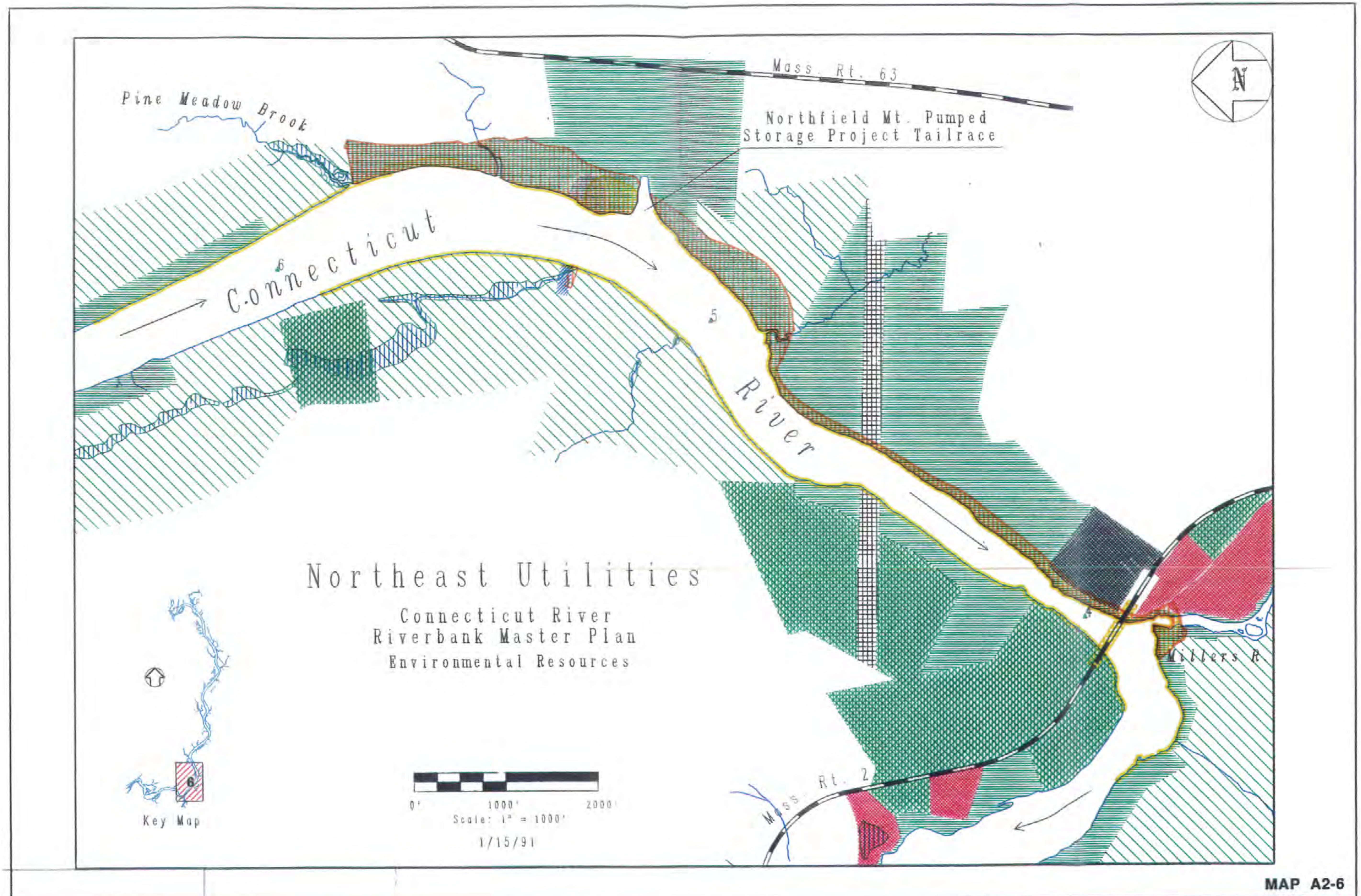
MAP A2-3


Northeast Utilities
Connecticut River
Riverbank Master Plan
Environmental Resources
Mass. Rts. 10 & 63
Mass. Rt. 63
Connecticut
River
Bennett Brook
Main Rd.
12
1
10
0'
1000'
2000'
Scale: 1" = 1000'
1/15/91
Key Map
4
N

MAP A2-4

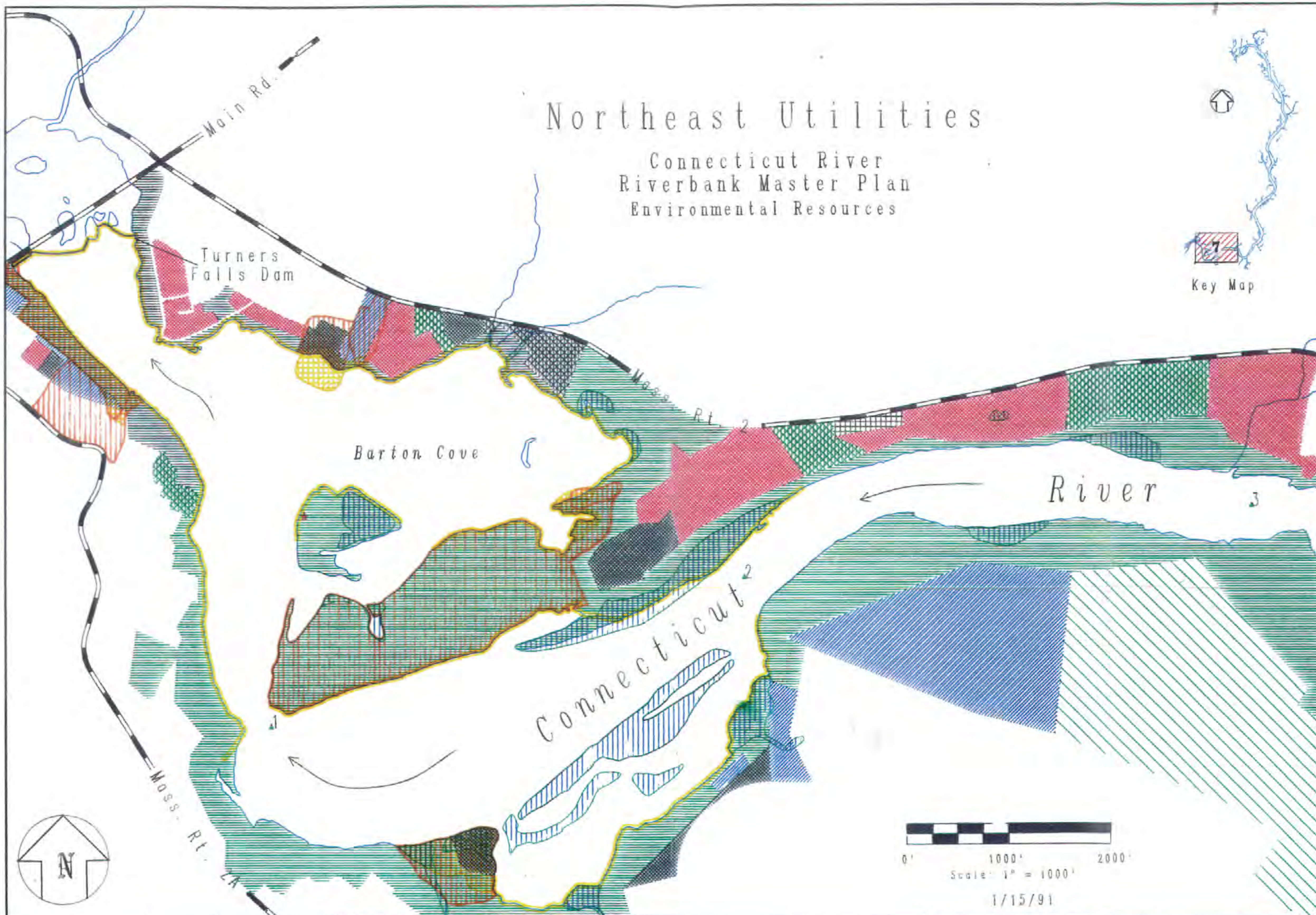

Northeast Utilities
Connecticut River
Riverbank Master Plan
Environmental Resources
Connecticut
River
Mass. Rt. 63
Main Rd.
Otter Run Brook
Kidds Island
Dry Brook
Key Map
5
0'
1000'
2000'
Scale: 1" = 1000'
1/15/91

MAP A2-5



Mass. Rt. 63
Pine Meadow Brook
Northfield Mt. Pumped
Storage Project Tailrace
Connecticut
River
Millers R.
Mass. Rt. 2
Northeast Utilities
Connecticut River
Riverbank Master Plan
Environmental Resources
Key Map
0'
1000'
2000'
Scale: 1" = 1000'
1/15/91

MAP A2-6



Northeast Utilities
Connecticut River
Riverbank Master Plan
Environmental Resources
Key Map
Main Rd.
Turners Falls Dam
Barton Cove
Mass. Rt. 2
River
Connecticut
Mass. Rt. 2A
N
0' 1000' 2000'
Scale: 1" = 1000'
1/15/91

MAP A2-7

LEGEND

Riverbank

5 ft. Contours

25 ft. Contours

Low-Moderate Erosion

Moderate Erosion

Moderate-Severe Erosion

Severe Erosion

Soil Boring Locations

Alluvial Soils (Qal)

Lake Hitchcock Soils (Qhl)

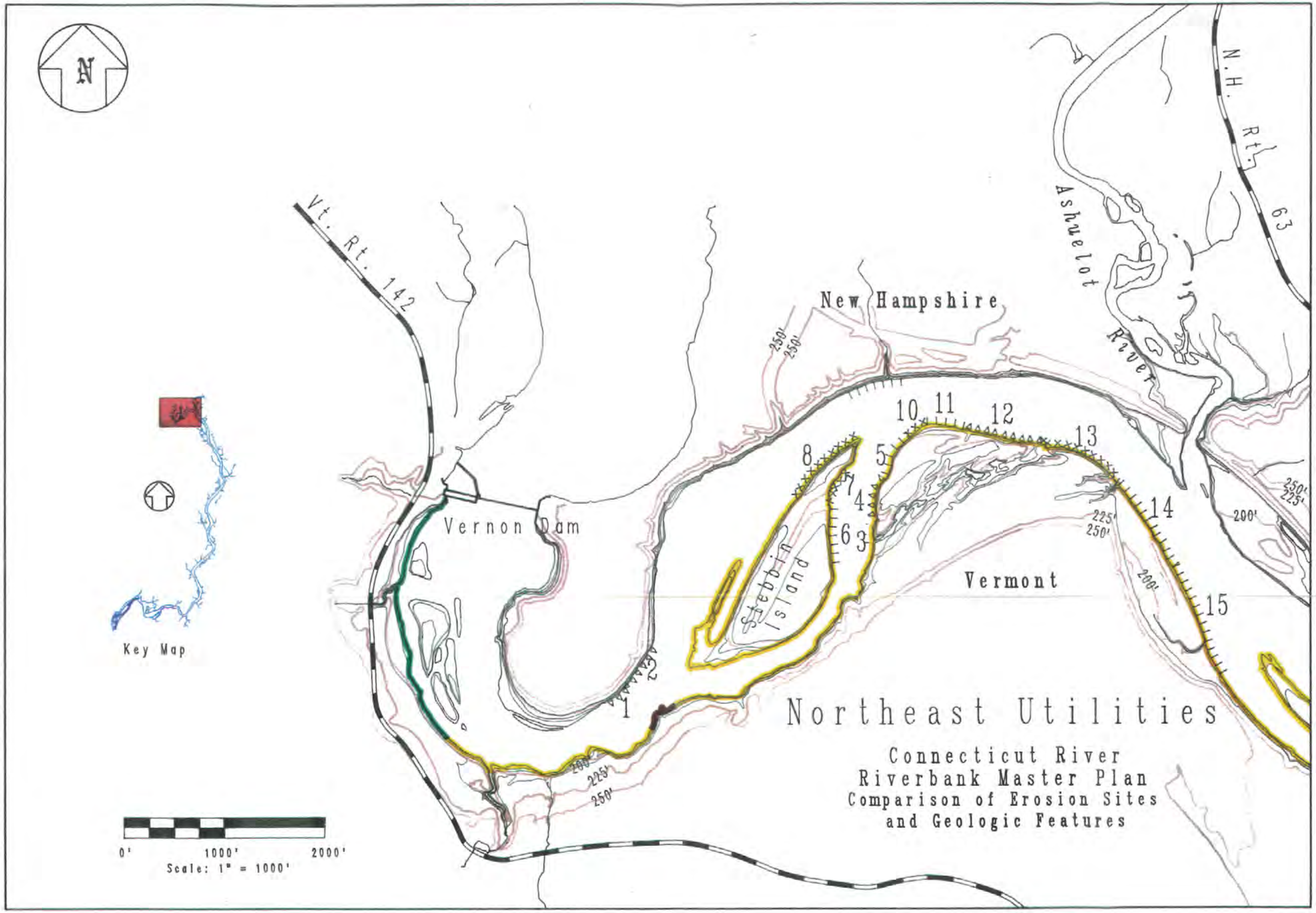
Other Soils

Hard Points/Rock Outcrop

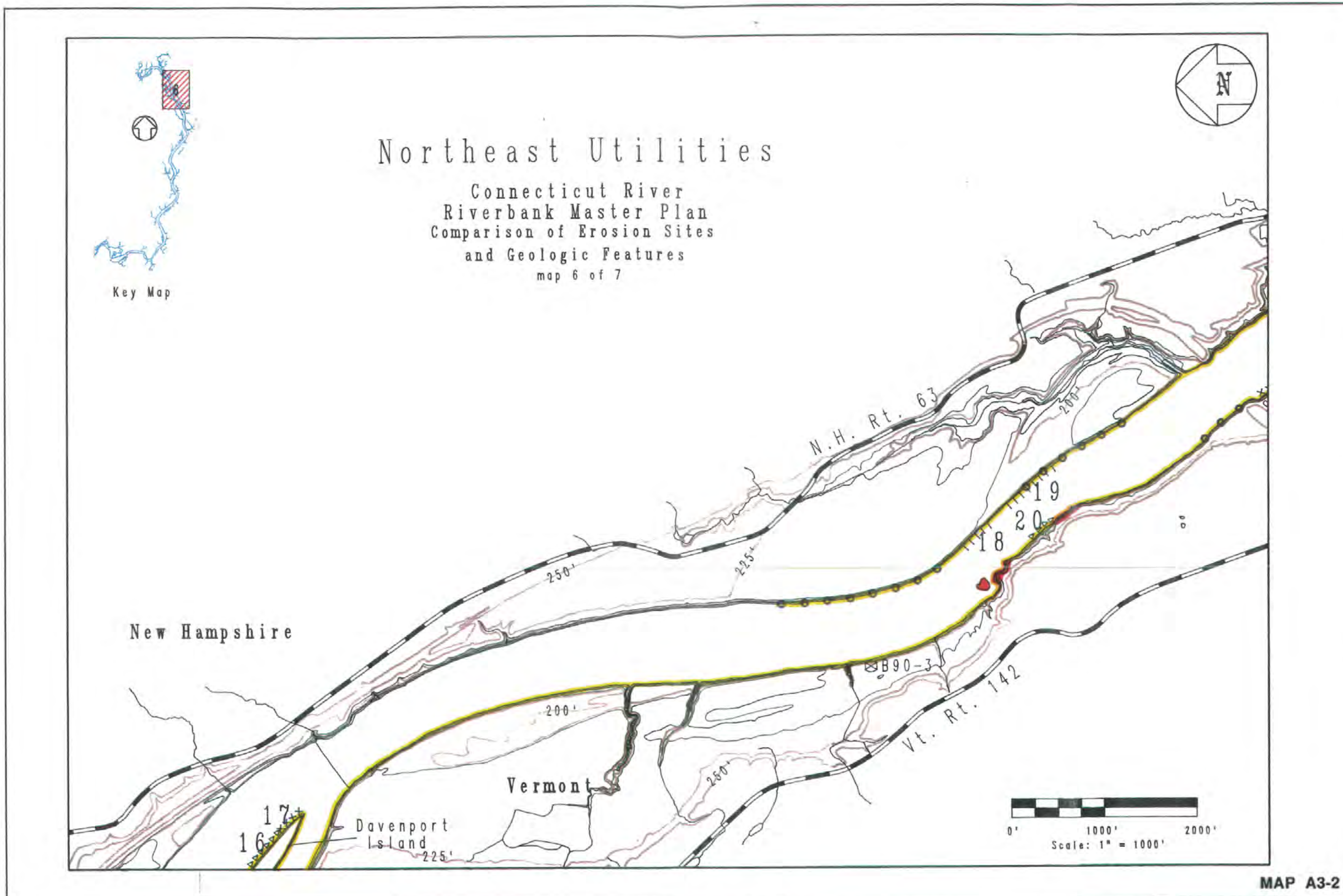
LEGEND:

MAPS A3-1 TO A3-7

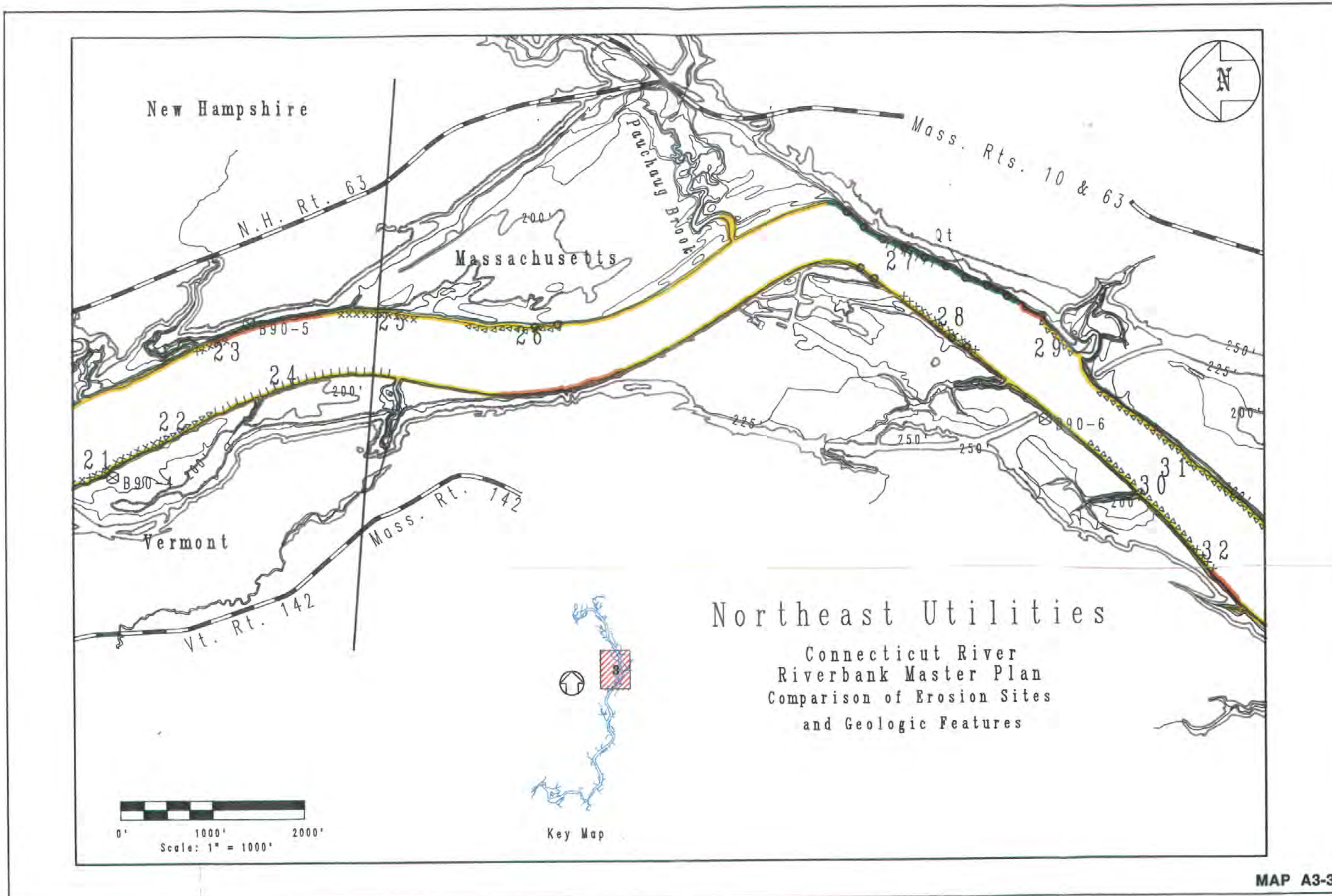
EROSION SITES AND GEOLOGIC FEATURES


N
Vt. Rt. 142
N.H. Rt. 63
Ashuelot River
New Hampshire
Vermont
Vernon Dam
Stebbin Island
Key Map
0'
1000'
2000'
Scale: 1" = 1000'
Northeast Utilities
Connecticut River
Riverbank Master Plan
Comparison of Erosion Sites
and Geologic Features

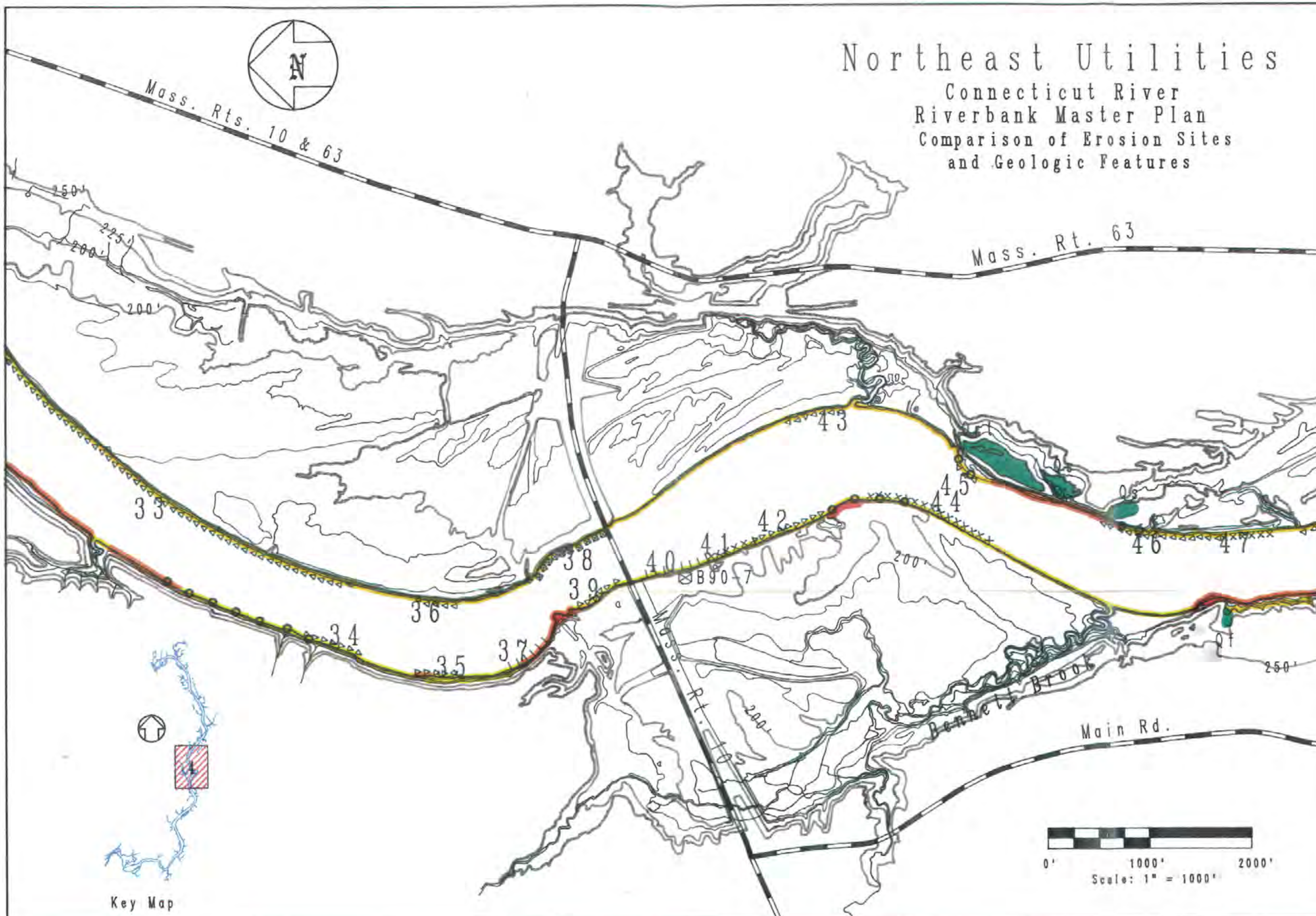
MAP A3-1


Northeast Utilities
Connecticut River
Riverbank Master Plan
Comparison of Erosion Sites
and Geologic Features
map 6 of 7
Key Map
N
New Hampshire
Vermont
N.H. Rt. 63
Vt. Rt. 142
250'
225'
200'
250'
225'
200'
16
17
18
19
20
B90-3
Davenport
Island
0'
1000'
2000'
Scale: 1" = 1000'

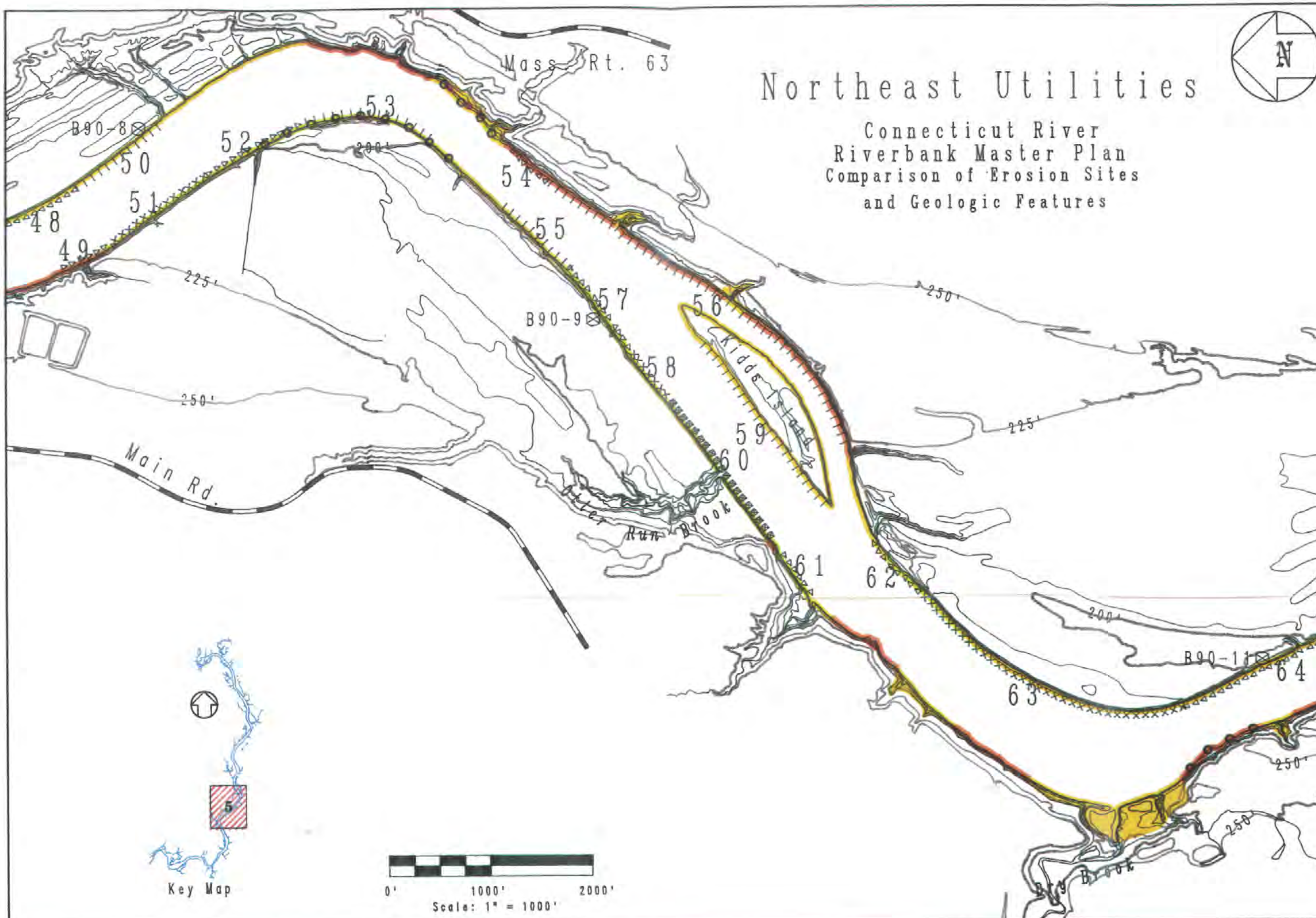
MAP A3-2


New Hampshire
N.H. Rt. 63
Massachusetts
Pauchaug Brook
Mass. Rts. 10 & 63
Vermont
Mass. Rt. 142
Vt. Rt. 142
B90-5
B90-4
B90-6
Qt
200'
225'
250'
21
22
23
24
25
26
27
28
29
30
31
32
N
Northeast Utilities
Connecticut River
Riverbank Master Plan
Comparison of Erosion Sites
and Geologic Features
Key Map
0'
1000'
2000'
Scale: 1" = 1000'

MAP A3-3

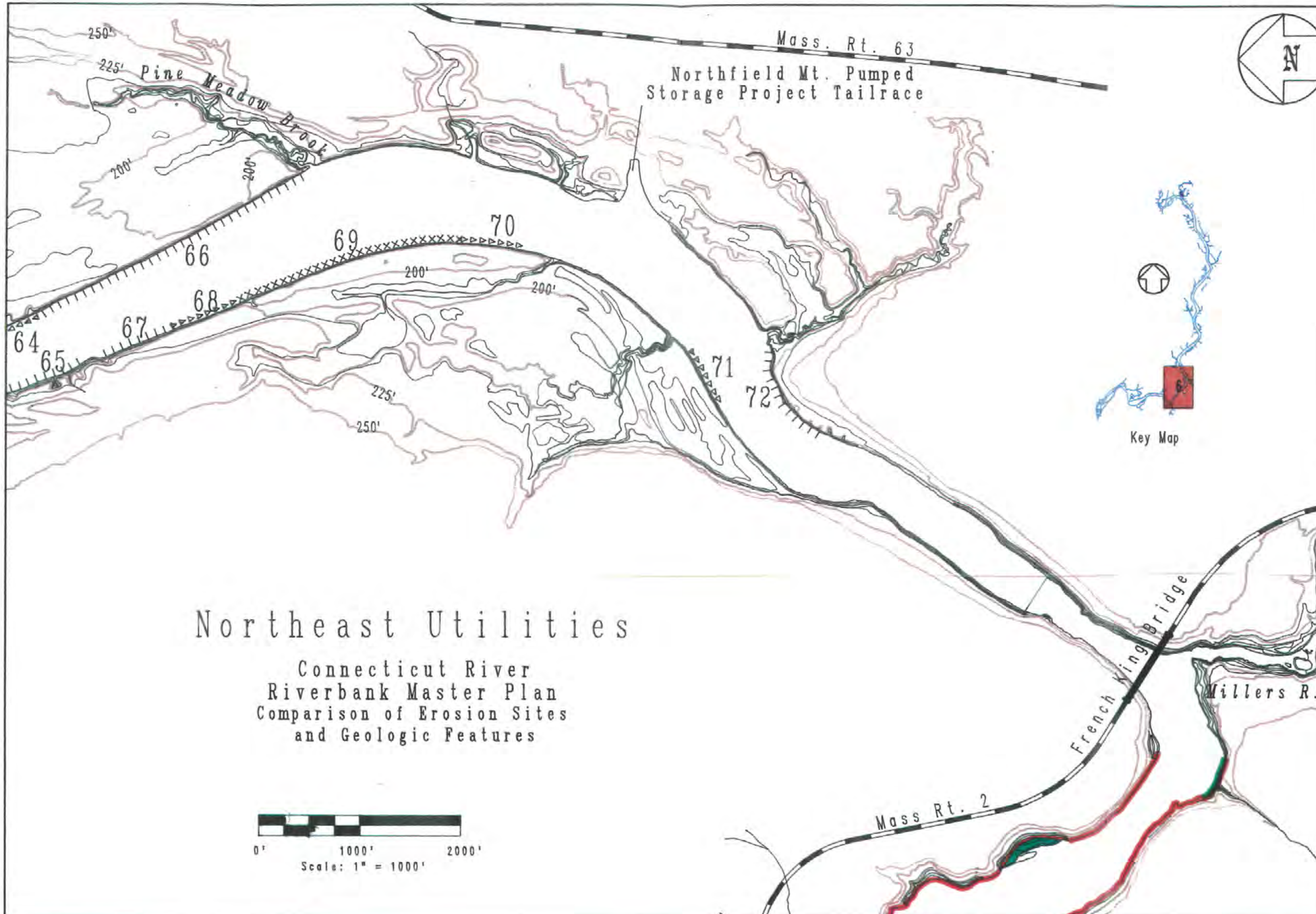

Northeast Utilities
Connecticut River
Riverbank Master Plan
Comparison of Erosion Sites
and Geologic Features
Mass. Rts. 10 & 63
Mass. Rt. 63
Mass. Rt. 10
Main Rd.
Bennett Brook
B90-7
250'
225'
200'
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
0'
1000'
2000'
Scale: 1" = 1000'
Key Map

MAP A3-4

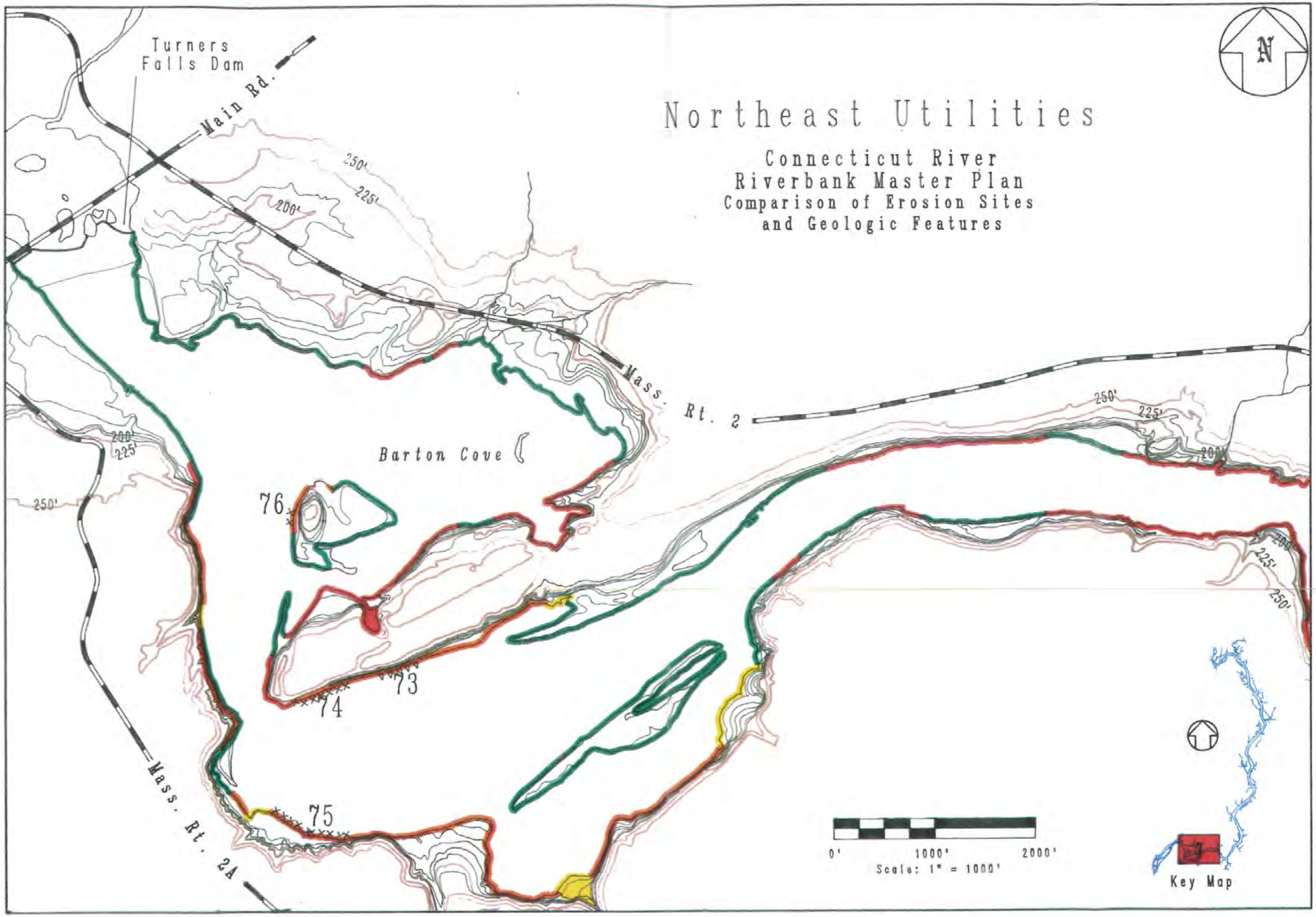


Northeast Utilities
Connecticut River
Riverbank Master Plan
Comparison of Erosion Sites
and Geologic Features
N
Mass Rt. 63
Main Rd.
Otter Run Brook
Kidds Island
Big Brook
B90-8
B90-9
B90-11
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
200'
225'
250'
Key Map
5
0'
1000'
2000'
Scale: 1" = 1000'

MAP A3-5


Mass. Rt. 63
Northfield Mt. Pumped
Storage Project Tailrace
N
Pine Meadow Brook
250'
225'
200'
200'
66
64
65
67
68
69
70
200'
200'
71
72
225'
250'
Key Map
French King Bridge
Millers R.
Mass Rt. 2
Northeast Utilities
Connecticut River
Riverbank Master Plan
Comparison of Erosion Sites
and Geologic Features
0'
1000'
2000'
Scale: 1" = 1000'

MAP A3-6



Northeast Utilities
Connecticut River
Riverbank Master Plan
Comparison of Erosion Sites
and Geologic Features
Turners
Falls Dam
Main Rd.
Mass. Rt. 2
Barton Cove
Mass. Rt. 2A
250'
225'
200'
73
74
75
76
0'
1000'
2000'
Scale: 1" = 1000'
Key Map

MAP A3-7