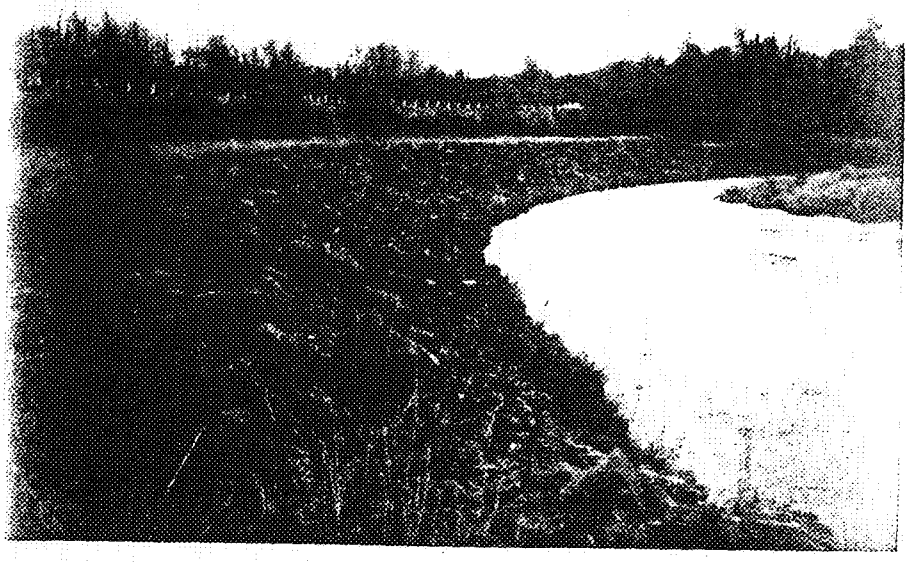
APPRAISAL REPORT
Lancaster, Massachusetts
North Nashua River

Streambank Protection Project



April 1990

US Army Corps
of Engineers
New England Division

Syllabus

This Appraisal Report was prepared for an existing Local Protection Project in the town of Lancaster, Massachusetts under the authority derived from Engineering Regulation, ER 1165-2-119.

This report assesses and documents the adequacy of the LPP at Lunenburg Road along the North Nashua River. In addition, this document reports upon the study process used in considering modifications to the LPP as reviewed from the standpoints of economics, environmental, and engineering integrity and safety considerations.

Study efforts have attempted to establish the need for modification of the LPP. It has been concluded that modification to increase the level of protection or extent of the streambank stabilization protection is not currently recommended. The town should remove any shoals in the river within the project 's limits and monitor the riverbank for any erosion that could threaten the LPP. Any further Federal Study is not recommended at this time.

APPRAISAL REPORT
LOCAL PROTECTION PROJECT
Lancaster, Massachusetts

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LOCAL PROTECTION PROJECT
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APPRAISAL REPORT
LOCAL PROTECTION PROJECT
Lancaster, Massachusetts

I. INTRODUCTION

A. Authority

This Appraisal Report concerns an existing Local Protection Project in the Town of Lancaster, Massachusetts. It was accomplished under the authority derived from Engineering Regulations, ER 1165-2-119 which provides direction to the Corps of Engineers to review the adequacy of completed LPP's. ER 1165-2-119 enables the Corps of Engineers to observe and monitor Corps' projects in order to ascertain whether they continue to function in a satisfactory manner and whether the potential exists for better serving the public interest. Development in watershed areas and new information on basin hydrology obtained since the project's construction may warrant an updated analysis of the level of protection being realized. If changes in a completed project may be desirable, further detailed investigations will be undertaken to document the need for and the feasibility of project modification. The objective of this investigation is to determine whether it is advisable to modify the project due to changes either in the area being protected, or to make changes to the existing project to improve its viability, safety and reliability.

B. Background

The Lancaster Local Protection Project (LPP) consists of 400 linear feet of stone protection along the banks of the North Nashua River on what is known as Lunenburg Road. The town of Lancaster, Worcester County, Massachusetts is located in north-central Massachusetts approximately 37 miles west of Boston and 18 miles west of Worcester, Massachusetts. The construction of this bank stabilization project was authorized by the Chief of Engineers on 23 May 1978, pursuant to the authority contained in Section 14 of the 1946 Flood Control Act, as amended.

C. Purpose and Scope

The purpose of this appraisal report is to assess and document the adequacy of the existing LPP at Lunenburg Road along the North Nashua River in Lancaster, Massachusetts, and to determine if modifications are advisable and warrant further Federal study.

This documents reports upon the study process used in considering the modifications to LPP's as reviewed from the standpoints of economic, environmental, and engineering integrity and safety considerations.

The detail of this study is at the level of an appraisal. A more detailed reconnaissance study will be required should change to the LPP be pursued.

Furthermore, if warranted, a feasibility phase effort would follow, detailing the actual modification alternatives and recommend particular courses of action. The feasibility phase will require cost sharing.

The scope of this report is of a reconnaissance nature. The objectives are:

- **Compilation of existing information.**
- **Establishing the need for modification.**
- **Identifying modification opportunities.**
- **Determining preliminary feasibility of modifications.**
- **Recommending future course(s) of action.**

D. Public Coordination

On 21 November 1989, personnel from the New England Division (NED) visited the project area. Discussions with the town's Public Works Superintendent were held regarding any future plans the town may have for the area currently.

E. Other Studies

a. Federal Emergency Management Agency, Flood Insurance Study, City of Leominster, Worcester County, Massachusetts, April 3, 1989 (revised).

b. Federal Emergency Management Agency, Flood Insurance Study, Town of Lancaster, Worcester County, Massachusetts, January 1982.

c. U.S. Army Corps of Engineers, New England Division Flood Plain Information, North Nashua River, Fitchburg and Leominster, Massachusetts, April 1977.

d. U.S. Army Corps of Engineers, New England Division, Water Resource Development Plan, North Nashua River - Merrimack River Basin, January 1965.

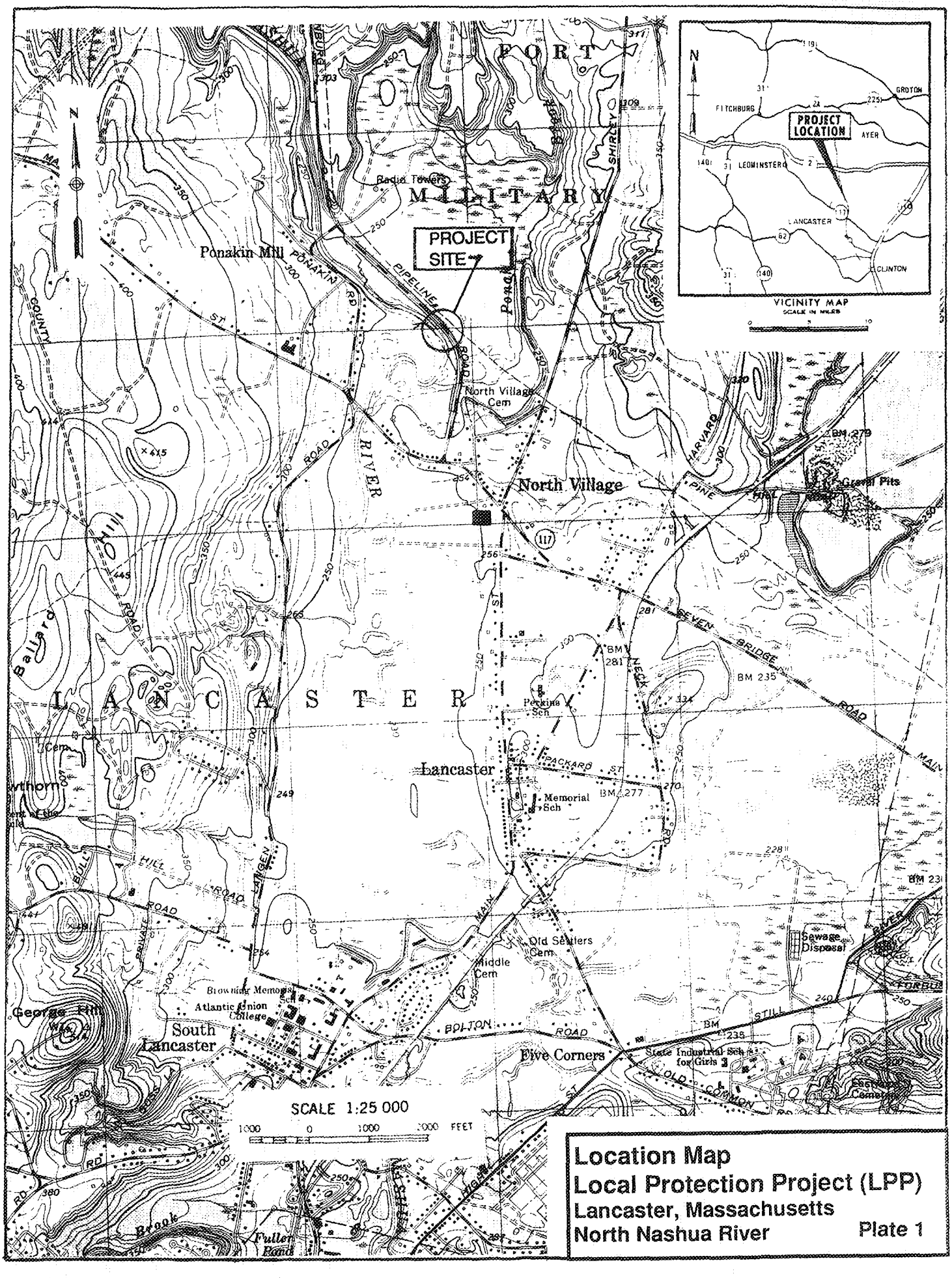
II. EXISTING CONDITIONS

A. Project Area

1. Description:

The Town of Lancaster is located in the eastern portion of Worcester County in north-central Massachusetts, approximately 37 miles northwest of the City of Boston. Lancaster is bordered by the Towns of Lunenburg and Shirley to the north, the Towns of Harvard and Bolton to the east, the Town of Clinton to the south, and the Town of Sterling and the City of Leominister to the west. A large portion of the northeastern sector of Lancaster is a part of the Fort Devens Reservation. (See Plate 1.) The area of the town consists of approximately 28 square miles. The town's topography is dominated by the flood plain and valley of the Nashua River, crossing from northeast to southeast through the town.

According to the 1980 U.S. Bureau of the Census, the population of Lancaster was 6,334. The town of Lancaster is a rural residential town, primarily a bedroom community, with workers commuting to any of the very large number of employers located in the Boston, Worcester, and Lowell metropolitan areas. Employment in Lancaster itself is in service industries, government and agriculture.



Location Map
Local Protection Project (LPP)
Lancaster, Massachusetts
North Nashua River

Plate 1

2. Current Land Use:

The project area has not experienced significant development since the construction of the project in 1978. The project protects Lunenburg Road from being threatened by erosion to the river banks of the North Nashua River. There is no other development in the immediate area of the project. The project is bordered by wetlands immediately adjacent to it and privately owned farmland south of the project as well as undeveloped land owned by the Fort Devens Army Installation north of the project.

Lunenburg Road is a well-traveled commuter route. Since the 1980's, Lancaster has experienced a boom in residential development resulting in more traffic carried on Lunenburg Road. Lunenburg Road is used as a short-cut for commuters traveling east on Route 2 and south on Route 495.
According to a traffic study conducted by the town of Lancaster, the average daily traffic volume on Lunenburg Road was 5080 in 1972. Currently, road usage is at about 5400 vehicles per day.

3. Hydrology and Hydraulics:

The North Nashua River watershed is hilly and contains numerous reservoirs which modifies the effect of flooding upon the floodplain and adjacent development. The North Nashua River is also subject to flow regulation by upstream mills as well as diversion for municipal supplies. A watershed map is shown on Plate 2.

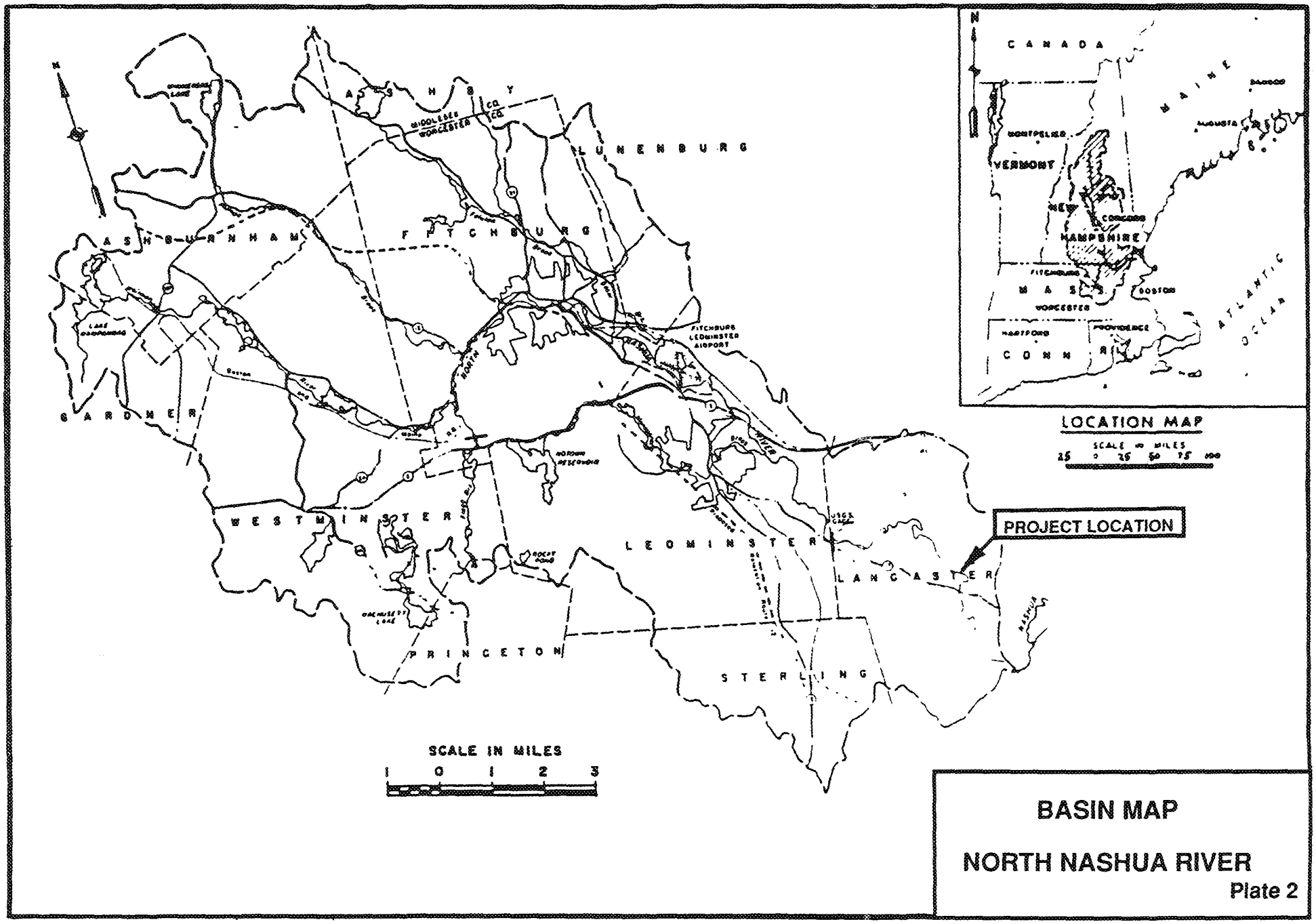
The North Nashua River originates at the confluence of the Whitman River and Flagg Brook in Fitchburg, Massachusetts and flows through the cities of Fitchburg and Leominster to its confluence with the Nashua River in Lancaster, Massachusetts. The drainage area of the North Nashua River, at the USGS gage near the Leominster- Lancaster town line, is approximately 110 square miles. In its 18.2 mile length, the North Nashua River has a fall of about 365 feet. Tributaries of the river are the Whitman River and Flagg, Phillips, Baker and Monoosnoc Brooks.

A summary of Peak Annual Discharges of the North Nashua River at the USGS gage in Leominster, Massachusetts is shown in **Appendix A**, Table 1.

4. History of Floods:

The flood history of the Merrimack River Basin, of which the Nashua and North Nashua Rivers are tributaries, demonstrates that floods may be expected to occur during any season of the year. Flooding may result from intense rainfall, snow melting, ice jams or any combinations thereof. Low-lying areas of Lancaster are subject to periodic flooding caused by the overflow of the Nashua and North Nashua Rivers. Within the past 50 years, the basin has experienced major floods during March 1936, September 1938, October 1955, and May 1984. During the March 1936 flood, the Leominster gage on the North Nashua River had the greatest flow recorded at 16,300 cfs.

In March 1936, Lancaster experienced the most severe flooding on the rivers, resulting from a succession of meteorological events. Above average snowfall with accompanying cold weather and frozen ground, followed by mild temperatures and repeated days of rain in the early spring, saturated the ground and caused extensive runoff and massive flooding. Roads were awash, bridges collapsed, and factories and homes were inundated. In addition to the 1936 event, repeated structure damage has occurred in the Nashua River flood plain as a result of the floods



BASIN MAP

NORTH NASHUA RIVER

Plate 2

of May 1850, December 1878, July 1879, February 1900, March 1900 and March 1968.

B. Project Description

1. History:

The primary streambank erosion area is located along the left bank of the North Nashua River in Lancaster, Massachusetts along Lunenburg Road. By letter dated 24 May 1976, the Lancaster Board of Selectmen requested Federal assistance to eliminate the erosion that was threatening the roadway embankment. Under the authority contained in Section 14 of the 1946 Flood Control Act, as amended, a study determined that Federal interest in providing streambank protection was warranted. The study recommended that stone riprap slope protection would eliminate future bank erosion, and that it would be in the Federal interest to pursue.

The Lancaster LPP was designed to provide streambank protection to prevent further erosion of the riverbank along the North Nashua River and thereby prevent the undermining of Lunenburg Road, also known as State Route 70. Construction of this bank stabilization project was completed in December 1978.

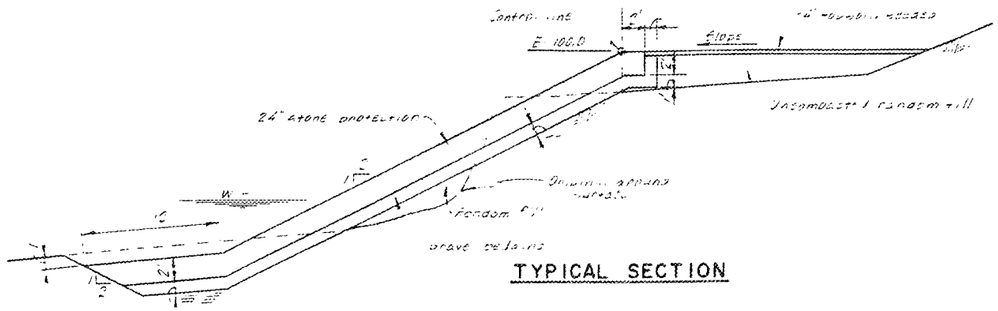
The project consists of a two-foot layer of stone protection placed upon a one-foot thick layer of gravel filter material. A layer of stone naturally sloping to the base (Slope: 1 Vertical on 2 Horizontal) provides protection for 400 linear feet of river bank for a height of 18 feet. Four inches of seeded topsoil has been placed on the top of the slope. An existing 12-inch storm drain was also extended down the slope (See Plate 3). The Lancaster LPP's first cost in 1978 was $81,671, of which the Federal cost was $56,500. In 1989 dollars, this would represent a total cost of $140,000 and a federal cost of $96,600, based on the average of the construction cost index and the implicit price deflator from 1978 to 1989.

2. Damages Prevented:

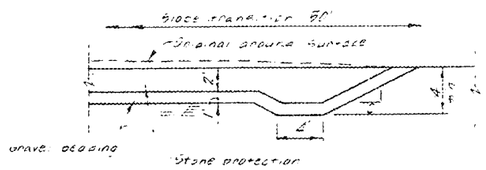
The Lancaster LPP was constructed to prevent the washout of Lunenburg Road and the resulting traffic detour and road repair costs which would be incurred. The economic benefits attributable to the LPP were based upon the cost savings attained from traffic detours and road repair costs not having to be spent. In 1978, project benefits were estimated at $107,000 with annual benefits of $8,560 (both in 1978 dollars). These annual benefits compared to annual costs of $6,800 yielded a project benefits to cost ratio for the LPP of 1.3.

3. Level of Protection:

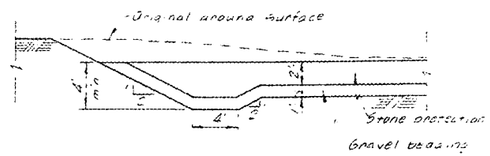
The streambank stabilization project in Lancaster was designed for the March 1936 flood of record along the North Nashua River. This flood has been estimated to be a 1 percent (100-Year) chance flood event. This flood event produced the greatest recorded flow (16,300 cfs) on the North Nashua River at the upstream Leominster, Massachusetts gage. Since the completion of the Lancaster streambank protection project in 1978, the most recent flood event of April 1987 on the North Nashua River had a peak flow of approximately 7,400 cfs at the Leominster gage. This flow had an estimated occurrence frequency of about a 5 percent (20-Year) chance flood event.



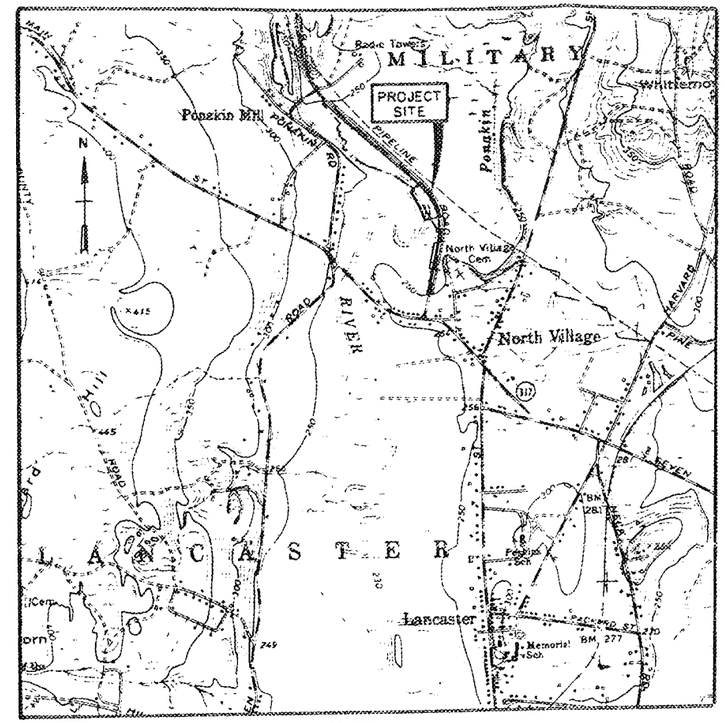
TYPICAL SECTION



SECTION B-B

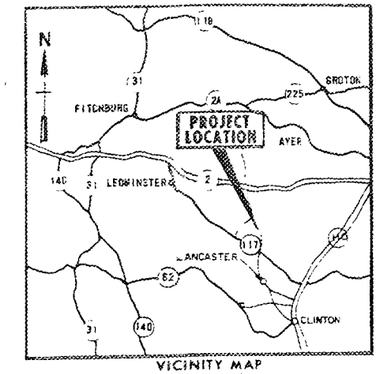


SECTION A-A



LOCATION MAP

1" = 1000'

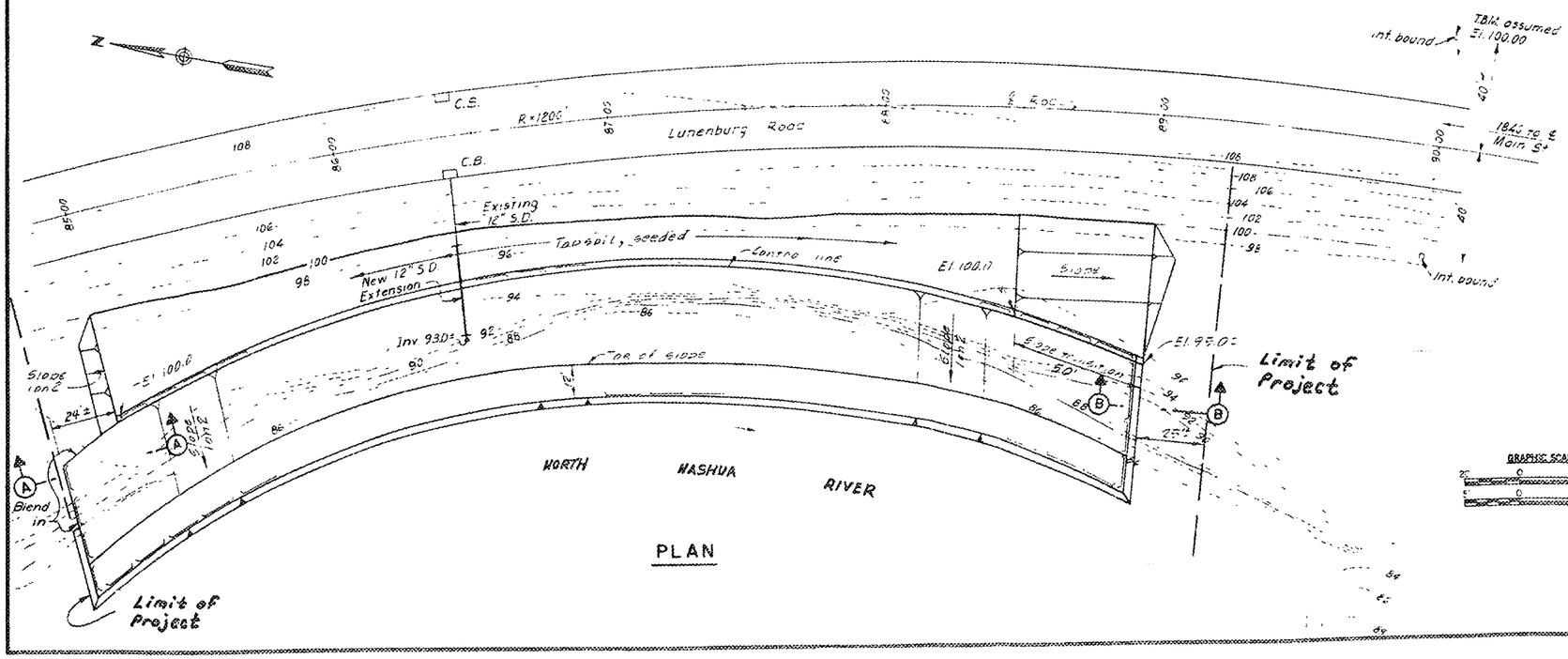


VICINITY MAP

SCALE IN MILES

DISTANCE ℄ LUNENBURG ROAD TO CONTROL LINE

89+00	90'
88+50	76'
88+00	65'
87+50	58'
87+00	54'
86+50	55'
86+00	59'
85+50	66'
85+00	[illegible]



PLAN

GRAPHIC SCALES

Local Protection Project (LPP)
Lancaster, Massachusetts
North Nashua River

Dated July 1978 **Plate 3**

4. Recent Inspection:

The most recent annual inspection of the Lancaster LPP by the Corps was conducted on 18 April 1989. The project was found to be good condition, however, the inspection noted a large shoal which constricts the channel and which may contribute to downstream erosion. In addition, an upstream erosion area has not developed since the inspection of 1985. This upstream erosion area does not pose an immediate threat to the LPP or Lunenburg Road (See Plate 4 & 5). The Corps inspection concluded that the town should remove the shoal and stabilize the downstream bank. The town was asked to continue to monitor and record the rate of erosion and to alert the Corps if the erosion accelerates significantly. The most recent inspection report is shown as **Exhibit A**.

III. FUTURE CONDITIONS

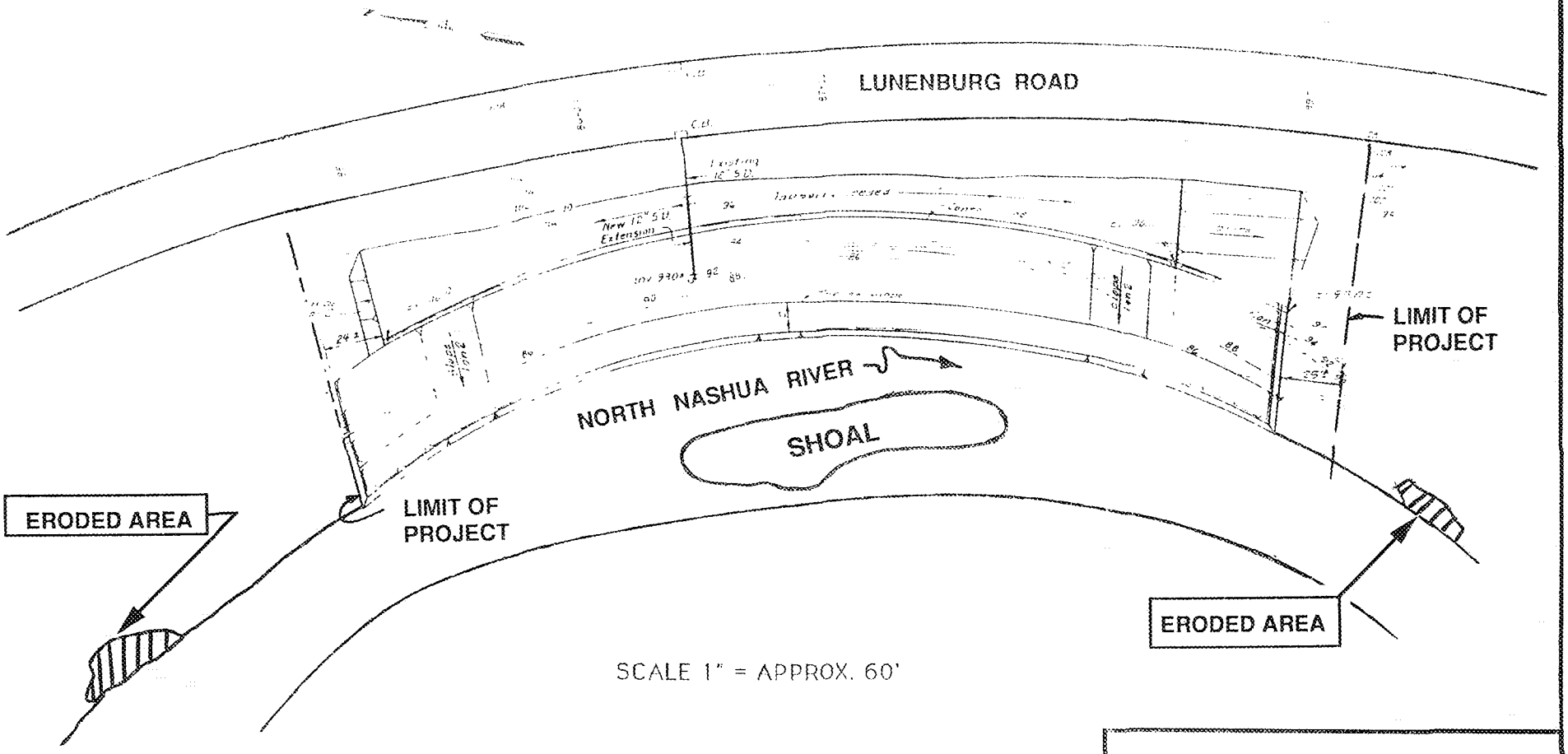
A. Projected Future Land Use:

With respect to the area that is protected by the LPP, we find no significant change in development over the past 11 years. Officials of the Town of Lancaster predict that there will be little change in land use in the project area over the next decade or so. The lands on both sides of Lunenburg Road at the project site are wetlands, on which development is restricted by regulatory control. The Fort Devens Reservation land, north of the LPP, will likely remain undeveloped, and the farmland south of the project will likely remain as farmland. Town officials believe that Lunenburg Road will continue to experience its current level of usage and that the protection as provided by the LPP is necessary. Future road usage on Lunenburg Road in the next decade is predicted to be about 5500 vehicles per day.

B. Project Integrity:

The existing Lancaster LPP is performing its intended purpose. The project currently provides adequate protection against erosion for Lunenburg Road and the left bank of the North Nashua River. There is the presence of streambank erosion both upstream and downstream of the project limits. The upstream and downstream erosion sites are about 100 feet and 50 feet, respectively, away from the project limits. Both sites are eroding back toward Lunenburg Road and toward the project. If erosion continues and reaches behind the LPP, the integrity of the project could be threatened. Local officials are aware of the erosion problem and are concerned. Town officials estimated that within two years the erosion will reach the LPP, stating that at least 2 feet of riverbank have eroded at the spot upstream of the project during the past year. However, they noted that there has been an unusually large amount of rainfall in 1989 and thus the erosion this year has been especially significant.

A further problem in the project area is the large shoal in the middle of the river channel directly across from the project. The mid-channel bar or shoal formation is caused by low stream velocities that cannot carry sediments. As the shoal forms, the river's current may be shifted against the river bank causing downstream erosion. The shoal constricts the channel and contributes to the downstream erosion as noted in the most recent Corps Inspection report. Photographs of these fluvial characteristics are presented in **Appendix A.**



MID-CHANNEL SHOAL & ERODED AREAS

Lancaster, Massachusetts
North Nashua River

Plate 4

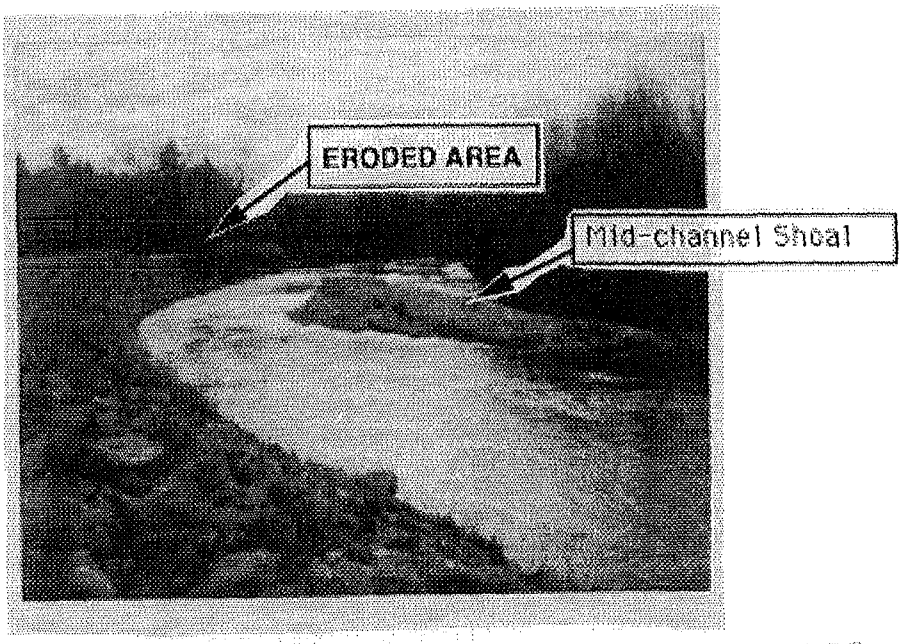


Figure 1. N. Nashua River, looking downstream of the LPP at the mid-channel shoal.

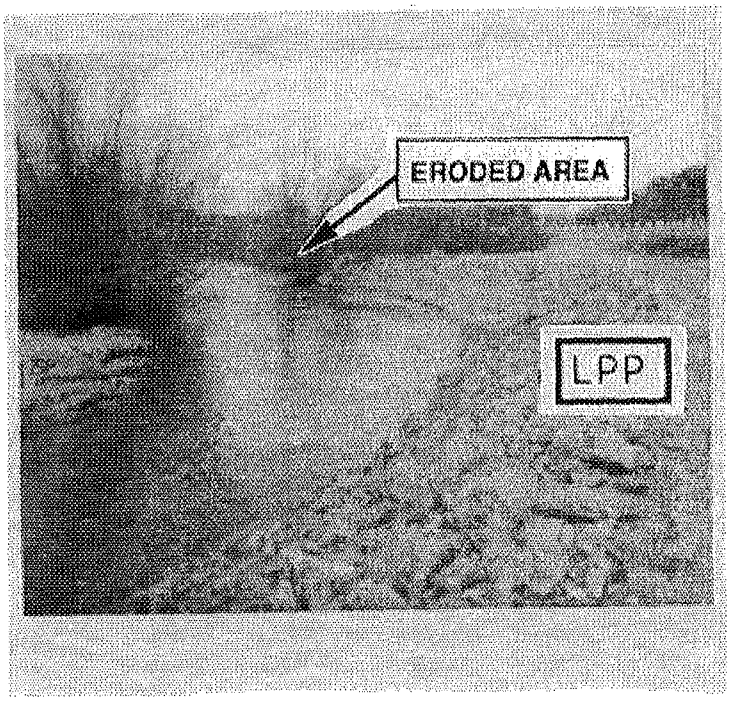


Figure 2. N. Nashua River, looking upstream at the LPP.

Photographs of
Local Protection Project
Lancaster, Massachusetts
North Nashua River

Dated November 1989

Plate 5

April 24, 1989

Operations Division,
Project Operations Branch

Board of Selectmen
Town Hall
Lancaster, Massachusetts 01523

Dear Sirs:

My representatives conducted the annual inspection of the federally built local flood protection project in Lancaster on April 18, 1989. I have enclosed a detailed inspection report for your review.

The project continues to be maintained in good condition, however, a large shoal still constricts the channel and contributes to downstream erosion. We suggest the town accurately monitor and record the rate of erosion and alert the Corps if it accelerates significantly. Also, we continue to urge the town to investigate any funding mechanisms that may be available to remove the shoal and stabilize the downstream bank.

I want to thank Mr. Johnson and Mr. Sonia for their cooperation during the inspection. If you require any technical assistance in the operation and maintenance of your project, please call me at (617) 647-8411 or Mr. Joseph Faloretti, Lower Connecticut River Basin Manager at (508) 249-2547.

Sincerely,

B. C. Manor
Chief, Project Operations Branch

Enclosure

Copies Furnished:

Mr. John Sonia
Highway Superintendent
Lancaster, MA 01523

Dept. of Env. Quality Engrg.
1 Winter St.
Boston, MA 02108

Mr. Richard Thibedeau
Director & Chief Engineer
Div. of Water Resources
Dept. of Env. Mgmt.
100 Cambridge St.
Boston, MA 02202

EXHIBIT 'A'

LOCAL FLOOD PROTECTION PROJECT INSPECTION REPORT

Project: LANCASTER, MA LPP

Maintaining Agency: TOWN OF LANCASTER DPW

Type Inspection: x Semi-Annual Staff ____ 90 Day Interim

River Basin: NASHUA Date of Inspection 18 APRIL 89

Feature	Sat	Unsat	Deficiencies
PUMPING STATIONS - STRUCTURES N/A			
INTERIOR			
EXTERIOR			
PUMPS - MOTORS - ENGINES N/A			
TRIAL OPERATED			
GENERAL CONDITION			
POWER SOURCE			
INSULATION TESTS			
METAL INTAKES/OUTLETS			
GATE VALVES			
GATES - DRAINAGE STRUCTURES N/A			
TRIAL OPERATED			
GENERAL CONDITION			
LUBRICATION			
DIKES - DAMS N/A			
GENERAL CONDITION			
SLOPES/EROSION			
SAND BOILS/CAVING			
TRESPASSING			
SLOPE PROTECTION			
DRAINS			
STOP-LOGS - LOG BOOM N/A			
CONDITION OF LOGS			
AVAILABILITY OF LOGS			
HIGHWAY SLOTS			
STORAGE FACILITIES			
CHANNELS - OUTLET WORKS CHANNEL			
BANKS	x		
OBSTRUCTION CONTROL		x	LARGE SHOAL AT LOWER END OF PROJECT

NED FORM JAN 66 513

EXHIBIT 'A'

Feature	Sat	Unsat	Deficiencies
CONCRETE STRUCTURES N/A			
SURFACE			
SETTLEMENT			
JOINTS			
DRAINS			
MISCELLANEOUS			
EMERGENCY OPER. PLAN			N/A
EMERGENCY EQUIPMENT			N/A
SEMI-ANNUAL REPORT			

Inspection Party: RAYMOND JOHNSON - FOREMAN, DPW - LANCASTER, MA
JACK SONIA - HIGHWAY SUPERINTENDENT, LANCASTER, MA
JIM BACON - PROJECT MANAGER, BIRCH HILL DAM, COE

Photographs Taken: NONE

Remarks & Additional Comments:

(Indicate Here Observations, Discussions, Specific Feature Deficiencies, Recommendations and any other pertinent information. Use Continuation Sheet if necessary.)

SHOAL STILL THERE WITH NO OBVIOUS CHANGES

X ALL APPLICABLE ITEMS. IF UNSAT INDICATE SPECIFIC DEFICIENCIES. INDICATE IF NOT APPLICABLE.

DATE	INSPECTED BY: TYPED NAME & TITLE	SIGNATURE
18 APRIL 1989	for JAMES H. BACON, PROJECT MANAGER	Joseph J. Fabretti

EXHIBIT 'A'

IV. CURRENT PLANNING & DESIGN CRITERIA

Requirements:

The design criteria for the LPP stone revetment was based on the smallest (D_{50}) stone size that would resist displacement by water forces from the North Nashua River. During the planning and design of the LPP, it was determined that a D_{50} stone size of (1 foot diameter) would be the most cost effective size to resist displacement.

V. MODIFICATION OPPORTUNITIES

A. Level of Protection:

Based on a recent site investigation, it was determined that increasing the level of protection of the Lancaster LPP is not warranted at this time. The 400' long streambank stabilization project is providing adequate protection to Lunenburg Road. Since development has not changed significantly and traffic volume remains at about 5500 vehicles per day, extending the LPP is not required at this time.

B. Protected Area:

Inspection of the areas downstream and upstream of the existing LPP indicates that extending the length of protection is not needed at this time, but we find there are areas both downstream and upstream of the project's limits, approximately 50 feet and 100 feet respectively, which are eroding away. The Corps of Engineers was made aware of these two erosion areas by the town in April 1985. A site investigation at that time determined that there wasn't an immediate threat to any public facilities. A recent site investigation of the LPP, of the two erosion areas just outside of the project limits, reconfirmed past findings. In addition, there is a large shoal present mid-stream of the LPP.

In 1985, the town's D.P.W. superintendent notified the Corps that they would remove the shoal. However, due to local funding constraints, the shoal has not been removed. If and when the shoal is removed, the method employed should not upset the habitat, or cause river sedimentation. This mid-channel shoal may contribute to the erosion downstream of the LPP, however it is not currently affecting the existing project.

C. Project Features:

Deficiencies noted in the recent inspections require attention by the Town of Lancaster in order to assure that the existing LPP continues to perform at its expected level of protection.

VI. CONCLUSIONS

An increased level of protection or extension of the protected area is not warranted at this time. The LPP was found to be in good condition. Changes in the watershed conditions may have shifted river currents such that a point bar and shoal formation in the river channel as well as erosion of river banks may be a concern in the future. If the downstream and upstream erosion is allowed to encroach upon the project, it could effect the LPP. The shoal can contribute to downstream erosion and should be removed before it degrades the level of protection provided by the LPP.

VII. RECOMMENDATIONS

Modification to increase the level of protection or extent of the streambank stabilization protection is not recommended at this time, however the Town of Lancaster should remove the shoal and stabilize the downstream and upstream erosion areas before the LPP is threatened. The proper operation and maintenance of the LPP is the responsibility of the town. The Operation and Maintenance manual for the LPP stipulates that the town is required to remove any shoal areas as part of the maintenance procedures/regulations. In the interim, the town should continue to monitor the shoal and notify the Corps of Engineers of any significant changes that may occur which could endanger the integrity of the LPP.

APPENDIX A: HYDRAULIC AND HYDROLOGIC ANALYSIS

REVIEW OF BANK STABILIZATION PROJECT ON NORTH NASHUA RIVER AT LANCASTER, MASSACHUSETTS

BY
HYDROLOGIC ENGINEERING BRANCH
WATER CONTROL DIVISION
DIRECTORATE OF ENGINEERING

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

APRIL 1990

REVIEW OF BANK STABILIZATION PROJECT ON NORTH NASHUA RIVER AT LANCASTER, MASSACHUSETTS

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REVIEW OF BANK STABILIZATION PROJECT ON NORTH NASHUA RIVER AT LANCASTER, MASSACHUSETTS

1. PURPOSE

This report presents a cursory hydrologic review of the streambank stabilization project at Lancaster, Massachusetts. The review was performed as part of an overall project assessment by the Planning Directorate at the request of Operations Directorate. The purpose of the investigation is to assess and document the adequacy of the project and determine if modifications are advisable and warrant further Federal study. Included are sections on project description, flood history, and watershed description.

2. PROJECT BACKGROUND AND DESCRIPTION

The project consists of bank stabilization works on the North Nashua River in Lancaster, MA. The project was authorized by the Chief of Engineers on 23 May 1978 pursuant to authority contained in Section 14 of the 1946 Flood Control Act, as amended. The project was completed in November 1978. A project location map, plan and profile are shown on plate 1.

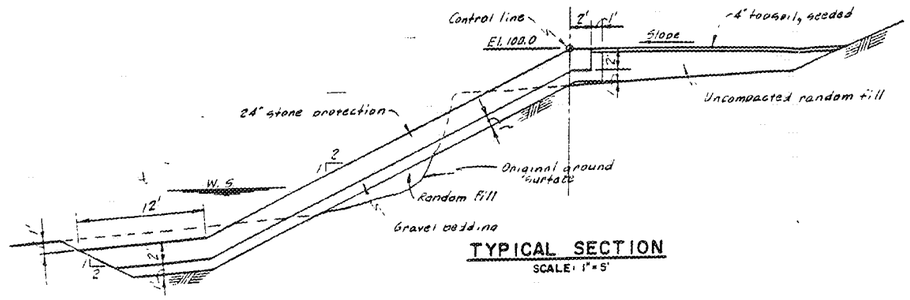
The bank stabilization project is a two-foot layer of stone protection on a one-foot thick layer of gravel filter material. The protection for this 400 feet of riverbank is a layer of stone naturally sloping to the base. The 18-foot high protection in general has a slope of 1 vertical on 2 horizontal. Four inches of seeded topsoil has been placed on top of the slope back to existing grade. An existing 12-inch storm drain was extended down the slope.

The project's function is to mitigate erosion of the riverbank from changing river discharges and/or ice flows. Prior to construction of this project, significant erosion of the river's banks and uprooting of trees had threatened Lunenburg Road which runs along the northeast bank.

3. WATERSHED DESCRIPTION

The North Nashua River originates at the confluence of the Whitman River and Flag Brook in Fitchburg, Massachusetts, and flows through the cities of Fitchburg and Leominster to its confluence with the Nashua River in Lancaster, Massachusetts. The drainage area of the North Nashua River at the USGS gage, near the Leominster-Lancaster line, is approximately 110 square miles; drainage areas above the project and Nashua River confluence are approximately 120 and 130.5 square miles, respectively.

CORPS OF ENGINEERS — U. S. ARMY



TYPICAL SECTION
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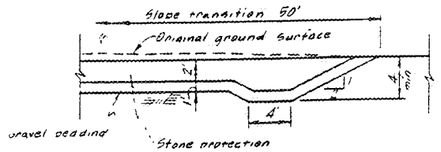

SECTION B-B
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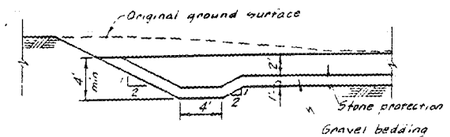

SECTION A-A
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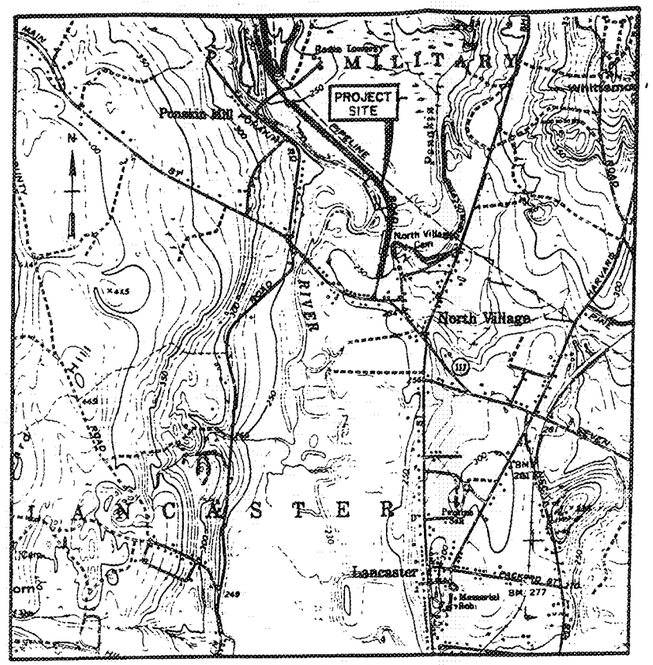
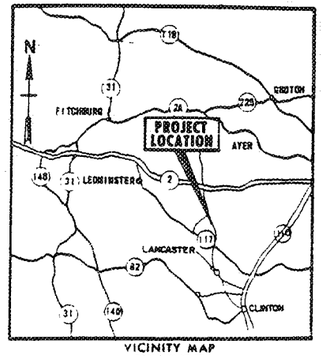


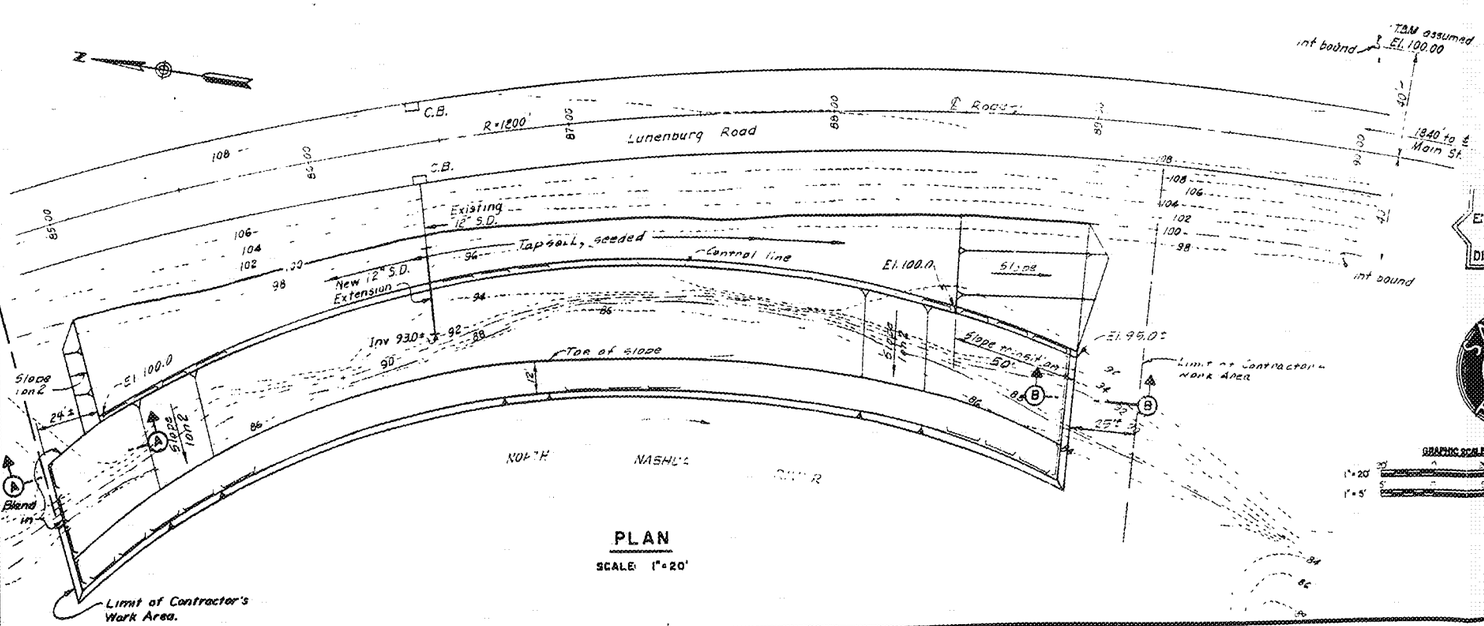
LOCATION MAP
1"=1000'



VICINITY MAP
SCALE IN MILES

DISTANCE
℄ LUNENBURG ROAD
TO CONTROL LINE

89+00	90'
88+50	76'
88+00	65'
87+50	58'
87+00	54'
86+50	55'
86+00	59'
85+50	66'
85+00	[illegible]



PLAN
SCALE: 1"=20'

VALUE ENGINEERING PAYS DIVIDENDS

SAFETY PAYS

W33-78-C-0380

GRAPHIC SCALES
1"=20' 1"=5'

REVISION	DATE	DESCRIPTION
	1-29-79	Final field corrections

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
LANCASTER, MASS.
STABILIZATION OF RIVER BANK
LOCATION MAPS, PLAN AND SECTION
NORTH NASHUA RIVER — MASSACHUSETTS

DESIGN: J.H. GOBEL, R.L. — DRAWN: R.T.C.
CHIEF, CIVIL & MAR. SECTION
CHIEF, PROJECT DESIGN
APPROVED: JULY 1979

SCALE AS SHOWN — SPEC. NO. DACW 33-78-B-0329

MER-37
SHEET 1 OF 1

PLATE 1

The North Nashua River watershed is hilly and contains numerous reservoirs which have a modifying effect on flood development. The North Nashua River is subject to flow regulation by upstream mills and diversion for municipal supplies. A watershed map is shown on plate 2.

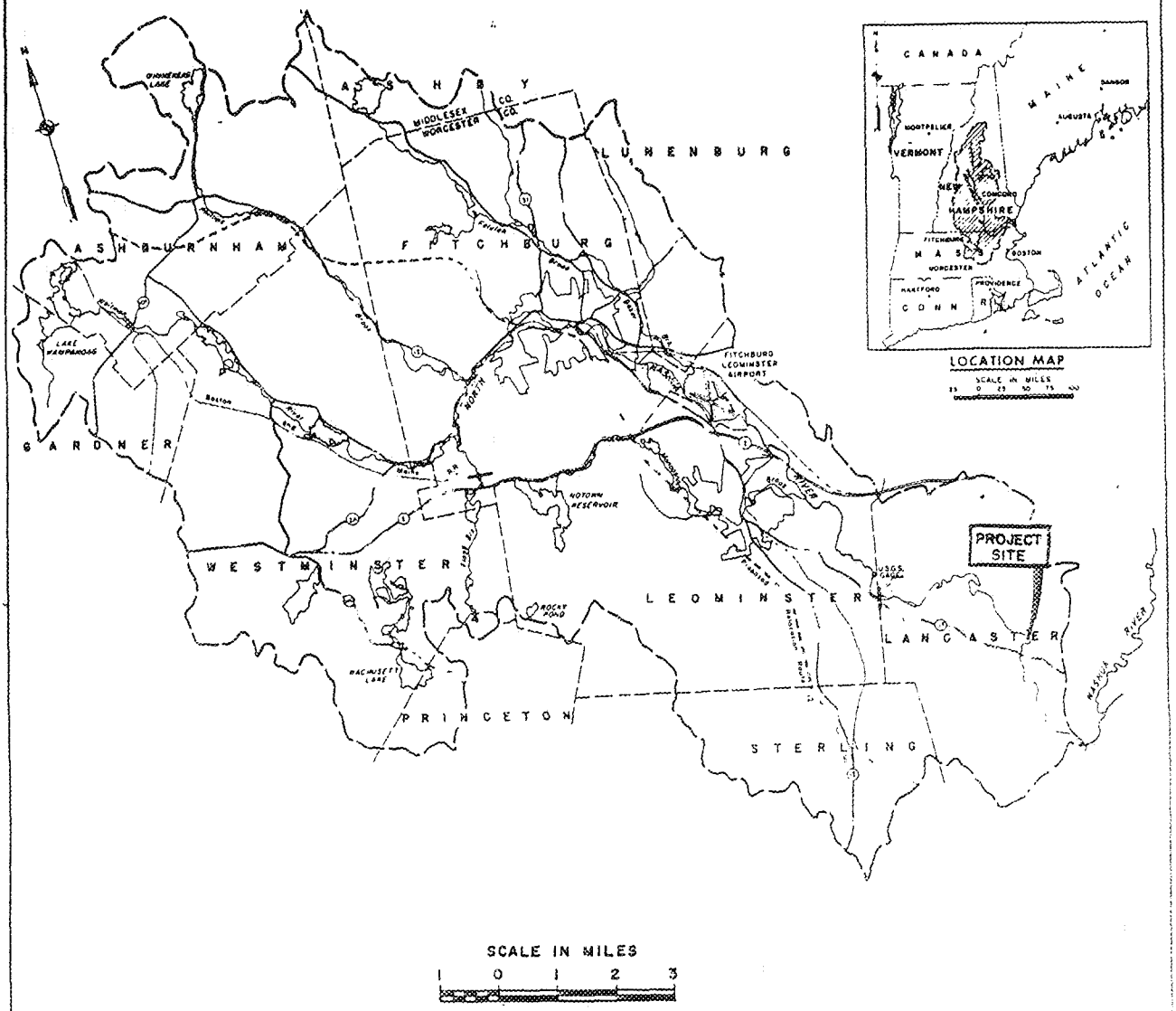
4. FLOOD HISTORY

a. General. The flood history of the Merrimack River Basin demonstrates that floods can occur during any season of the year. Flooding may result from intense rainfall, melting snow, ice jams or any combination thereof. Within the past 50 years, major floods within the basin were experienced during March 1936, September 1938, October 1955, and April/May/June 1984. The greatest flow recorded on the North Nashua River at the Leominster gage was 16,300 cfs in March 1936. Annual peak flows measured at Leominster are listed in table 1.

b. March 1936. The greatest recorded flow on the North Nashua River at the Leominster, Massachusetts gage (DA = 110 square miles) was 16,300 cfs and was caused by a combination of heavy rainfall, deep snow cover and above-average temperatures for the season. During the period 9-19 March, floods resulted from two storms, 9-13 and 16-19 March. The first flood event occurring on the 12th, was largely the result of runoff from melting snow with some contribution from moderate rainfall which averaged about 3 inches over the basin. The second storm period produced the record flow on the North Nashua River. This second peak resulted from intense rainfall, which averaged about 5.5 inches, with minor contribution from snowmelt.

c. September 1938. The storm which produced this flood occurred as a result of rainfall associated with the September 1938 hurricane that passed up the Connecticut River valley. Rainfall averaged about 7 inches on 18-21 September in the North Nashua basin, with about 4 inches falling in a 24-hour period on the 20th. The resulting peak flow at the Leominster gage was 10,300 cfs.

d. October 1955. The North Nashua watershed escaped the widespread torrential hurricane rainfall of August 1955, but did experience high flow producing rainfall in October 1955. Rainfall in the watershed amounted to 7 inches over the period 14-17 October with about 5 inches occurring in a 24-hour period on the 15th. The peak flow of the North Nashua River at Leominster, as recorded at the gage, was 8,870 cfs, on the 15th.



FLOOD PLAIN INFORMATION
NORTH NASHUA RIVER

MASSACHUSETTS

GENERAL MAP

APRIL 1977

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

PLATE 2

Table 1

Peak Annual Discharges of
North Nashua River at Leominster, Massachusetts
D.A. = 110 Square Miles

Date	Annual Peak Discharges* (cfs)	Date	Annual Peak Discharges (cfs)
18 Mar 1936	16,300	17 Apr 1961	1,660
20 Dec 1936	2,570	01 Apr 1962	3,560
21 Sep 1938	10,300	06 Dec 1962	2,230
06 Dec 1938	1,180	06 Mar 1964	1,300
13 Apr 1940	2,380	25 Feb 1965	1,260
08 Feb 1941	1,180	13 Feb 1966	741
09 Mar 1942	2,960	26 May 1967	1,550
02 Dec 1942	1,240	19 Mar 1968	4,070
25 Jun 1944	8,100	25 Mar 1969	2,140
22 Mar 1945	1,010	11 Feb 1970	3,410
09 Mar 1946	1,600	03 Apr 1971	1,140
15 Mar 1947	1,080	23 Mar 1972	1,420
20 Mar 1948	1,800	02 Apr 1973	1,940
06 Jan 1949	1,120	21 Dec 1973	2,610
23 Mar 1950	1,070	04 Apr 1975	2,190
08 Feb 1951	4,390	28 Jan 1976	1,800
03 Nov 1951	2,140	14 Mar 1977	3,160
16 Mar 1953	3,220	26 Jan 1978	1,970
11 Sep 1954	5,800	07 Mar 1979	3,140
15 Dec 1954	2,510	22 Mar 1980	2,390
15 Oct 1955	8,870	25 Feb 1981	1,840
23 Jan 1957	1,730	06 Jun 1982	4,240
07 Apr 1958	2,230	19 Mar 1983	4,250
03 Apr 1959	3,560	06 Apr 1984	5,900
05 Apr 1960	3,260	12 Mar 1985	1,280
		27 Jan 1986	3,590
		05 Apr 1987	7,400
		1988	1,920

* Water year Oct. 1 - Sept. 30

e. April/May/June 1984. Two significant flood events occurred in the North Nashua River watershed in 1984. A fast-moving storm deposited 1.5-2 inches, beginning late on 4 April through 5 April, which produced a peak flow of 5,900 cfs at the USGS streamflow gage at Leominster, MA. The second flood resulted from a large slow-moving storm system that passed through New England during the last week of May 1984. The storm produced a 28 May to 2 June total rainfall of about 7.5 inches, with about 3 inches occurring on the 30th, as measured at the Ashburnham, Massachusetts rainfall station located just northwest of Fitchburg. Peak flow on the North Nashua River at Leominster was recorded to be 4,060 cfs on 31 May.

f. April 1987. During a one-week period beginning at the end of March 1987, two intense rainstorms hit most of New England. The extensive runoff created widespread flooding conditions, particularly within the middle and lower reaches of the Connecticut and Merrimack River basins. Peak flow on the North Nashua River measured at the Leominster gage was 7,400 cfs on 5 April 1987.

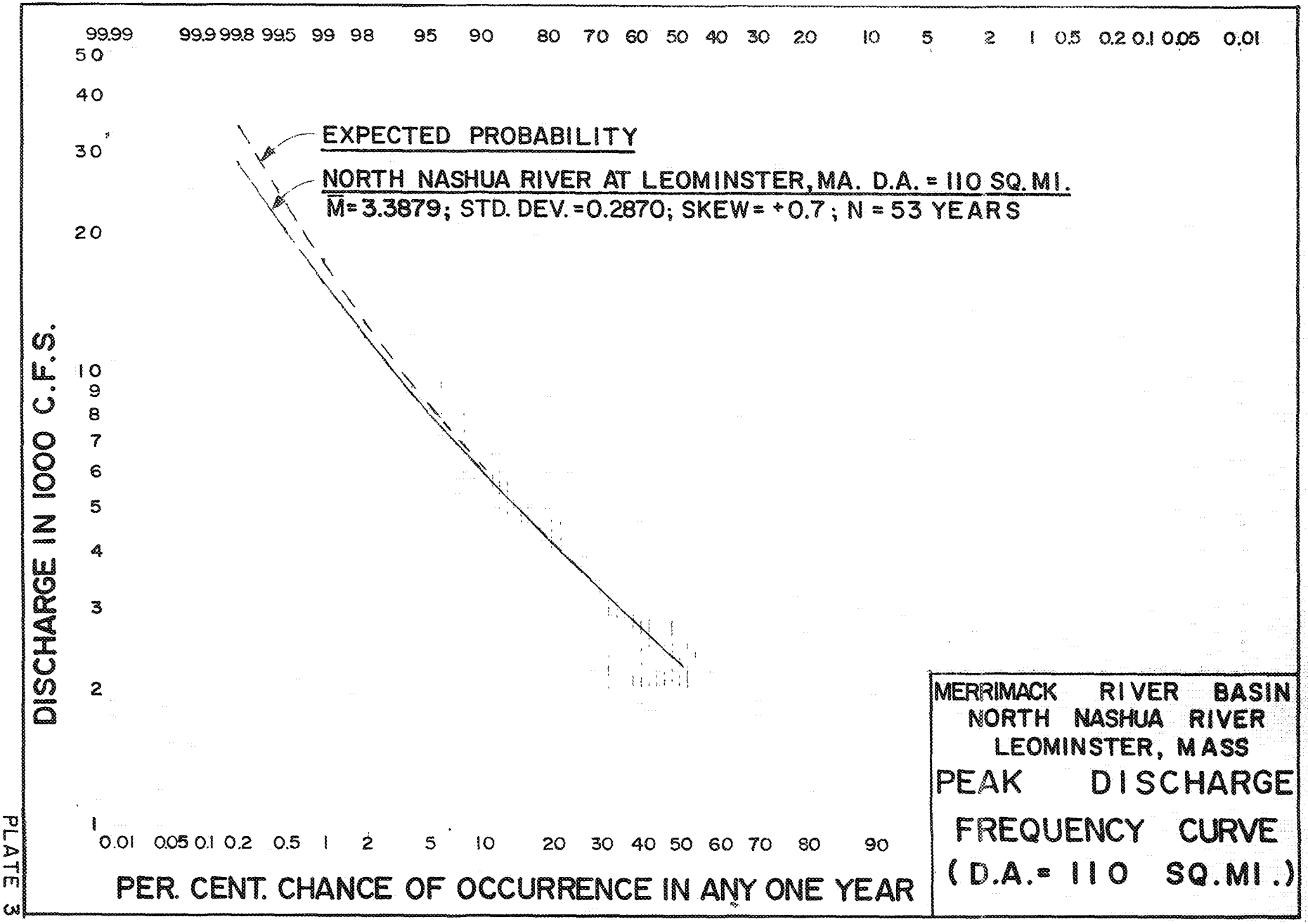
5. DISCHARGE FREQUENCIES AND RATING CURVE

Peak discharge-frequency relations were developed for the North Nashua River at the USGS gage in Leominster, MA.

The USGS gage is located 6.1 miles upstream of the confluence with the Nashua River and approximately 3.1 upstream of the project. A frequency analysis of annual peak flow data obtained at the gage was performed which required fitting the data to a Log Pearson Type III distribution by transforming peak flow values to logarithms and finding the mean, standard deviation and skew coefficient. A Corps' computerized program which follows Appendix 13, Guidelines for Determining Flood Flow Frequencies, Water Resources Council Bulletin 17B, March 1982, facilitated the analysis; this peak discharge frequency curve is shown on plate 3. The developed discharge-frequency curve compared favorably with 10, 50, 100 and 500-year peak discharges in the 1982 Lancaster Flood Insurance Study. A stage-discharge curve was developed at the project from the Lancaster Flood Insurance Study information and is shown on plate 4.

6. OBSERVATIONS

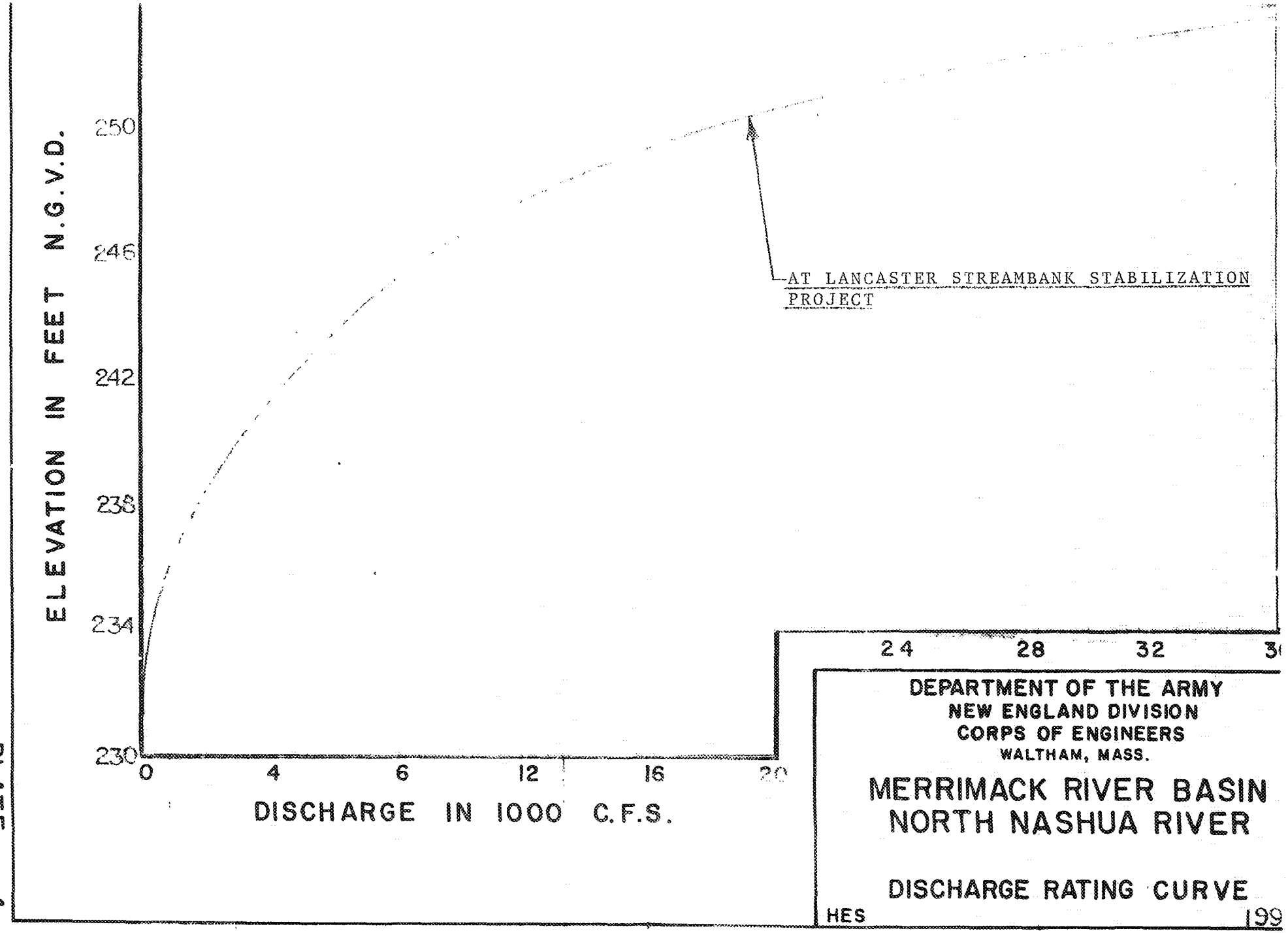
The Lancaster bank stabilization project site was inspected on 8 December 1989 by a staff engineer from the Water Control Division, Hydrologic Engineering Branch. The streambank stabilization structure was observed to be in good



MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
LEOMINSTER, MASS

PEAK DISCHARGE FREQUENCY CURVE
(D.A. = 110 SQ. MI.)

PLATE 3



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CORPS OF ENGINEERS
WALTHAM, MASS.

MERRIMACK RIVER BASIN
NORTH NASHUA RIVER

DISCHARGE RATING CURVE

HES 199

PLATE 4

condition. However, erosion of banks upstream and downstream of the project was noticed in addition to shoal and point bar formation in the river channel opposite the project and extending beyond the project limits. Photographs of these fluvial characteristics are presented in Appendix A of this report.

7. SUMMARY AND CONCLUSIONS

The riverbank stabilization project was evaluated and found to be in good condition. However, point bar and shoal formation in the river channel and erosion of riverbanks may be a concern in the future. Continued shoal buildup in the channel could increase river velocities and exacerbate erosion on the downstream left bank; however, erosion is presently occurring on private property and the streambank stabilization project is not threatened. Further, minor erosion is occurring on the upstream left bank with shoaling in the upstream right channel.

In conclusion, the North Nashua River streambank stabilization project in Lancaster, MA, adjacent to Lunenburg Road, is protecting the roadway embankment from erosion. Erosion is occurring on private land immediately downstream of the project; however, there is no immediate threat to a public facility, including the road or the existing bank stabilization project. The town of Lancaster could implement measures to remove the river channel shoals and bars if the distressed banks erode further. The Corps should conduct another inspection, in approximately 5 years, to survey channel aggradation and streambank erosion but additional Federal study is not warranted at this time. Photographs of the stream channel and banks are provided in Appendix A.

8. REFERENCES

a. Federal Emergency Management Agency, Flood Insurance Study, City of Leominster, Worcester County, Massachusetts, April 3, 1989 (revised).

b. Federal Emergency Management Agency, Flood Insurance Study, Town of Lancaster, Worcester County, Massachusetts, January 1982.

c. U.S. Army Corps of Engineers, New England Division Flood Plain Information, North Nashua River, Fitchburg and Leominster, Massachusetts, April 1977.

d. U.S. Army Corps of Engineers, New England Division, Operation and Maintenance Manual for Stabilization of River Banks, North Nashua River, Lancaster, Massachusetts, February 1977.

e. U.S. Army Corps of Engineers, New England Division, Water Resource Development Plan, North Nashua River - Merrimack River Basin, January 1965.

f. U.S. Army Corps of Engineers, New England Division, Miscellaneous Files and Records - Nashua River Basin.

g. U.S. Geological Survey, National Water Data Storage and Retrieval System, User's Guide.

h. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Generalized Computer Program - Flood Flow Frequency Analysis, User's Manual, June 1976.

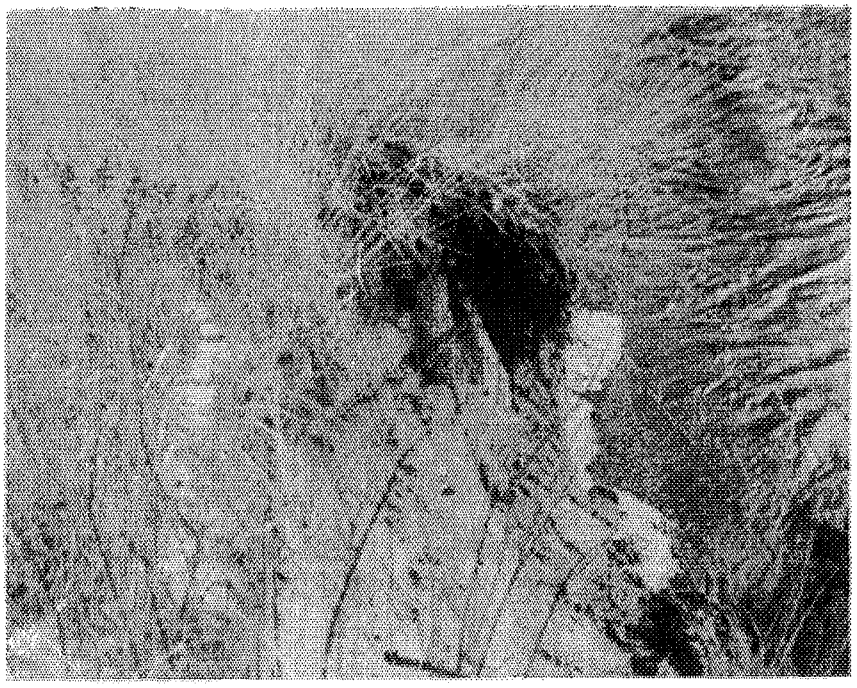
APPENDIX A - PHOTOGRAPHS

December 8, 1989

Photo 1 - North branch Nashua River looking downstream. Note shoal formation in center, across from local protection project.

December 8, 1989

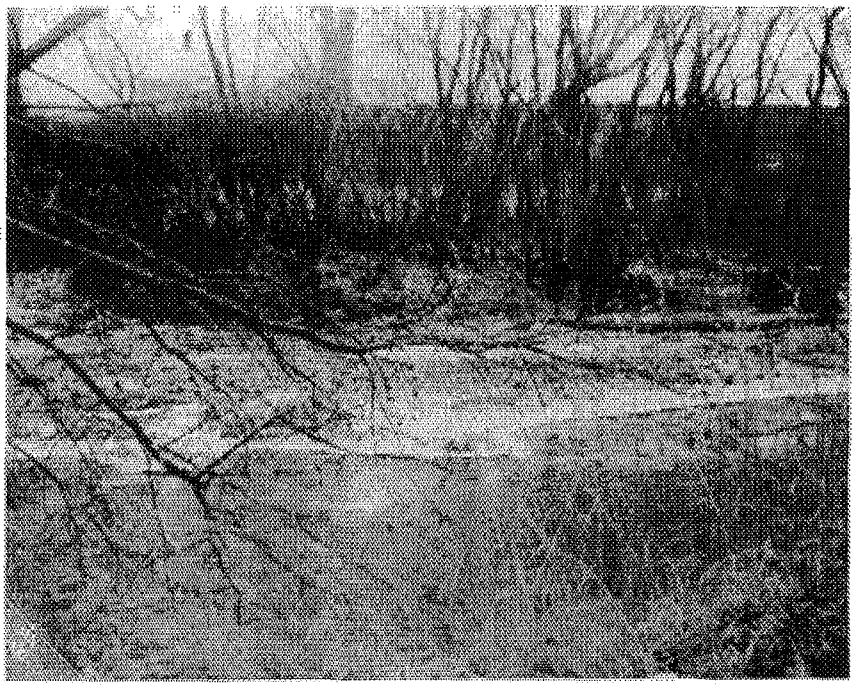
Photo 2 - Another downstream view of river. Note erosion on concave (left) bank.



December 8, 1989
Photo 3 - Closeup view of streambank erosion on left channel bank downstream of project.

December 8, 1989
Photo 4 - Wide view of left bank erosion downstream of project.

December 8, 1989
Photo 5 - Left bank erosion upstream of local protection project looking downstream.



December 8, 1989
Photo 6 - Shoal formation on convex (right) bank upstream of local protection project looking northeast to southwest.