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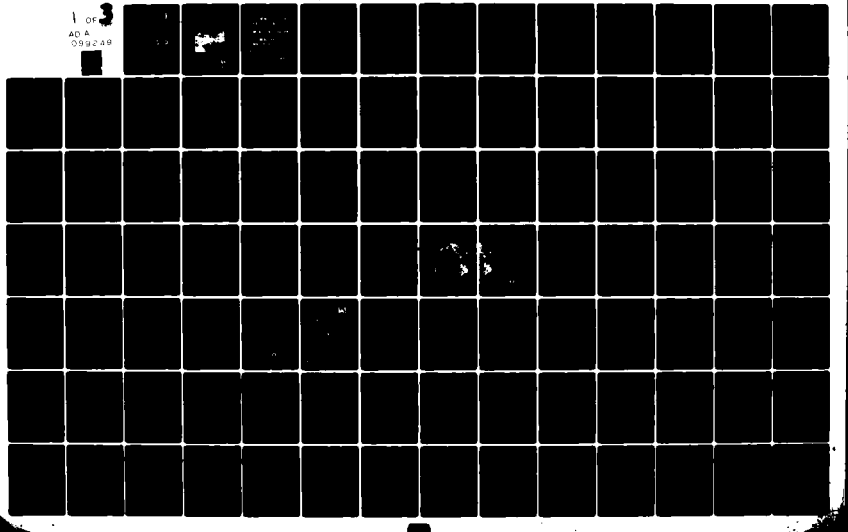

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MERRIMACK RIVER BASIN

LEOMINSTER LOCAL PROTECTION

MONOOSNOC BROOK

LEOMINSTER, MASS.

FEASIBILITY REPORT FOR WATER RESOURCES DEVELOPMENT

AUGUST 1978

U.S. ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION

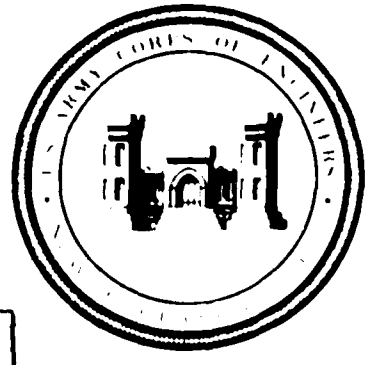
FEASIBILITY REPORT

LEOMINSTER LOCAL PROTECTION

MONOOSNOC BROOK

LEOMINSTER, MASSACHUSETTS

WATER RESOURCES DEVELOPMENT



AUGUST 1978

August 1978

SYLLABUS

The Congress of the United States authorized the Monoosnoc Brook and Lake project in the Flood Control Act of 1966, Public Law No. 789, 89th Congress. Subsequent to this authorization and because of changed conditions and priorities in the city of Leominster, the proposed dam, reservoir and channel improvements project was placed in a deferred category. Due to the continuing flood threat to the urban center of the city, a restudy of the problem area was requested by the District Congressman as well as local officials on 5 June 1972.

This report is being submitted as a result of a restudy of the original Monoosnoc Brook and Lake project and reports upon the current watershed conditions relative to flooding and associated water resource problems to ascertain the need for and feasibility of flood control and/or other improvements.

Hydrologically, the upper Monoosnoc Brook Basin can be separated into two distinct areas for flood development problems. Runoff in the extreme upper basin, west of the city, is controlled by surcharge storage in the city's existing Notown Reservoir which is used for domestic water supply purposes. The remaining upper basin, extending to Rockwell Pond, is fairly steep and conducive to rapid runoff. Runoff from this portion of the watershed downstream of Notown Reservoir to below Rockwell Pond is the principal contributor to floods in Leominster.

Major flooding occurs on approximately 70 acres of highly developed residential, commercial and industrial properties which border the Monoosnoc Brook channel within the central portion of the city of Leominster. Because of the numerous properties involved in the floodplain, structural flood control measures were found to cause the least disruption to existing developments. Programs and procedures for prevention of further encroachment of the floodplain were also considered in conjunction with structural improvements.

Improvement as reported herein provides for flood control with minor recreational facilities incorporated. The selected plan as reported herein provides for a diversion tunnel to bypass flood flows beyond the urban center of the city, and includes consideration of recreational facilities. It does not provide for other water resources activities as these are being met by other community programs. Specifically, the current and future needs for water supply have been augmented by the city joining the Metropolitan District Commission regional water supply system. Water quality improvements have been recently undertaken by the community and additional improvements are being pursued utilizing State and the Environmental Protection Agency programs.

The underground diversion tunnel with appropriate surface intake and outlet structures and appurtenant facilities has an estimated Federal first cost of $7,120,000 and annual costs of $472,400. Estimated non-Federal first and annual costs are $520,000 and $36,200, respectively. Average annual benefits derived from the tunnel diversion plan are estimated at $616,700 yielding a favorable benefit/cost ratio of 1.2 to 1.0. Selection of an underground structure for floodwater diversion has kept environmental effects such as loss of wildlife habitat and open space to a minimum. Minor detrimental effects will be offset by mitigation measures. Positive environmental gains to the city's business community by provision of flood control improvements are envisioned.

Subject to requirements of local cooperation as outlined in this report, the Division Engineer recommends that the proposed tunnel diversion plan be authorized for construction and a specific post authorization change be made concerning the existing authorized Monoosnoc Brook and Lake project.

LEOMINSTER LOCAL PROTECTION
MONOOSNOC BROOK, MASSACHUSETTS
FEASIBILITY REPORT FOR WATER RESOURCES DEVELOPMENT

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THE STUDY AND REPORT

PURPOSE AND AUTHORITY

The central business district in the city of Leominster, Massachusetts, between Pond Street and Williams Street, experiences a constant threat of recurring floods from Monoosnoc Brook. At the request of local interests, the Committee of Public Works of the U.S. House of Representatives adopted a resolution on 9 February 1961 requesting a study of the feasibility of adopting improvements for flood control and allied purposes to resolve this problem.

In partial compliance with the aforementioned authority provided by the Resolution, an Interim Report was submitted during January 1965. It provided for a plan of flood control for Monoosnoc Brook and was authorized as part of the Flood Control Act of 1966 (Senate Document 113/89/2). The authorized project which provided for an upstream reservoir and channel improvements was subsequently placed in a deferred category due to change in land use conditions both in the reservoir area and in the central business district where urban renewal plans were curtailed. During the interim period since authorization and at the request of Congressional and local interests, a restudy was initiated to determine whether alternative proposals for flood control could be found.

SCOPE OF STUDY

The restudy initiated in August 1974 forms the basis of this report and presents the studies of flooding associated water resources problems in the Monoosnoc Brook watershed together with potentials for solving such problems. Alternative plans to solve the areas water resources

problem have been investigated. Cost and corresponding benefit estimates were made for each plan studied. Selection of the most feasible plan was made after considering all factors, including views and comments expressed by concerned agencies and local interests. (A more detailed explanation of the scope of study for this report is contained in Appendix 1, Section A, "The Study and Report.")

STUDY PARTICIPATION AND COORDINATION

The Corps of Engineers having principle responsibility for conducting and coordinating the study, contacted and received information from appropriate Federal, State and local agencies. Coordination involved conferences, informal meetings and workshops to discuss problems, needs, and alternative solutions. (Comments of review and concurrence are included in Appendix 2.) A plan formulation public meeting was held on 27 January 1976. It afforded local interests the opportunity to express their ideas and comment on possible flood control measures that should be considered. Public needs and desires, expressed at this meeting, form the basis of selecting the flood control plan as reported herein.

SUMMARY OF STUDIES

Aerial topography from the U.S. Geological Survey and the Massachusetts Department of Public Works as well as municipal and other existing maps were utilized to determine basin characteristics and land use. Subsurface explorations were made along the proposed tunnel alignments. Detailed damage surveys were conducted in 1962 and updated in 1974. Damage surveys consisted of personal interviews with municipal and State officials, officers of industrial concerns and private individuals who have experienced flood losses. Office studies consisted of hydrologic and hydraulic analyses, economic studies and evaluations, and estimates of quantities and costs of the major items of construction. Real estate costs have been determined based on field reconnaissance and analysis of recent sales in the area.

THE REPORT

Results of studies for the watershed of Monoosnoc Brook a tributary of the North Nashua River, which is in turn a tributary of the Merrimack River Basin, is presented as a main report and two appendices. Appendix #1 provides technical information required for an independent evaluation of the validity of the findings and Appendix #2 contains pertinent correspondence in connection with the study. The draft environmental impact statement (EIS) is included as Attachment 1.

PRIOR STUDIES AND REPORTS

The Corps of Engineers has prepared a number of Congressionally authorized studies and reports concerning water resource development for the Merrimack River and its tributaries, including the North Nashua River and its tributary Monoosnoc Brook. These earlier Merrimack River Basin reports, some of which date back to 1938, resulted in construction of four reservoirs and five local flood protection projects. Subsequent studies recommended additional improvements for water resource development in the North Nashua and its tributary Monoosnoc Brook which became basis for project authorization. (A summary of these earlier reports is contained in Section A of Appendix 1.)

STUDIES IN PROGRESS

A flood insurance study report for the city of Leominster is being prepared by the Federal Insurance Administration (FIA). The city is presently eligible for emergency flood insurance coverage and once FIA publishes rate maps and the city officially enters the program, additional coverage will be available.

RESOURCES AND ECONOMY OF THE STUDY AREA

The Monoosnoc Brook watershed, a tributary to the North Nashua River Basin and the larger Merrimack River Basin, is located south and west of State Route 2. It lies primarily within Leominster boundaries except for a portion in the adjacent city of Fitchburg, as shown on Plate 1. From its limits in the hills west of the city proper, the watershed extends eastward approximately 5.2 miles. It has a maximum north-south width of approximately 4.2 miles and covers a drainage area of 11.2 square miles.

ENVIRONMENTAL SETTING AND NATURAL RESOURCES

Leominster and neighboring Fitchburg create the nucleus for one of 10 Standard Metropolitan Statistical Areas (SMSA) in Massachusetts. The study area is about 40 miles west of Boston, 25 miles northwest of Worcester, Massachusetts, and about 210 miles northwest of New York City.

The Monoosnoc Brook watershed is comprised of two significantly contrasting areas, the rural upper basin and an urbanized lower portion which comprises the center of the city. The two areas are separated physically by Rockwell Pond, a small pond just upstream of town. Steep, forested hills with some large rock outcropping cover most of the upper basin which also contains several reservoirs and ponds. Much of the forested area consists of virgin woods within the Leominster State Forest. Although the area is rural, steep slopes make the upper basin conducive to rapid runoff. Downstream of Rockwell Pond, the lower basin is characterized by urbanization and channel encroachment which extends back to historic times. Manufacturing, retail structures and multi-family housing crowd the brook and have dictated over time the use of conduits through parts of the city to conduct river flows.

The Monoosnoc Brook watershed is naturally steep with a total fall of 550 feet along the 8.7 mile stream. It rises in the rural forested hills in western Leominster at Notown Reservoir. Traversing other reservoirs on small tributaries, the brook flows easterly, roughly paralleling U.S. Route 2, through several small dammed impoundments to Rockwell Pond. Continuing downstream from Rockwell Pond, Monoosnoc Brook flows under one railroad and nine highway bridges in a 2.3 mile

meandering course through a heavily developed, congested urban area of the city. Much of the stream between Pond and Water Streets has been walled in. In several areas it has been confined to conduits. About one mile before its confluence with the North Nashua River, the slope of Monoosnoc Brook flattens out to form a sizable floodplain. Under normal conditions the brook meanders from Rockwell Pond in open channels or through conduits under buildings, roads and railroad tracks to an industrial site on the eastern side of the city. The streambed in this section is also cluttered with debris and vegetation. During periods of heavy rainfall, runoff from the watershed floods about 70 acres of the congested core business area between Rockwell Pond and the North Nashua River.

Water quality in the upper watershed is good, but lower watershed water quality is fair to poor due to discharges from industrial waste impacting further upon the stream. There is little or no fishing potential in the lower portions of Monoosmoc Brook, but Rockwell Pond does offer some limited fishing opportunities.

The watershed, which lies in the north-central part of Massachusetts, experiences significant variations in weather. Average annual temperature for the area is about 48°F with a summertime high of 100 degrees or more and winter lows below zero. The basin is subject to thunderstorms, tropical and extratropical weather systems and has an average rainfall of approximately 45 inches. Average snowfall amounts to about 60 inches with water contents of snow in the early spring, of 4 to 6 inches.

The Monoosnoc Brook watershed is located along the western margin of the New England upland in central Massachusetts. This is a region of moderate relief characterized by wide valleys and broad, steepsided hills that are conducive to rapid runoff. The brook runs through a rough, naturally disected upland, controlled largely by underlying crystalline bedrock that outcrops on the upper slopes of many of the hills. Remnants of glacial outwash occupy the bottoms of many of the major valleys. Variably thick deposits of glacial till lie above the outwash and along the slopes.

Bedrock in the vicinity of the proposed improvement is a gray, dense, hard unweathered phyllite at Rockwell Pond, and a similarly gray, hard schist near Water Street, with both forms intermingling between these areas. The rock lies from 7 to 70 feet below the surface. Above the bedrock lie varying quantities of overburden that consists of silty and gravelly sands.

HUMAN RESOURCES

Leominster, Massachusetts is a manufacturing city with an estimated 35,000 residents. Comprising 28.8 square miles, the city lies in the Nashua River Valley less than 3 miles from the center of its northern neighbor, Fitchburg. These two cities have a total population of 97,237 (1970 U.S. Census) and make up the core of the Leominster-Fitchburg Standard Metropolitan Statistical Area (SMSA). Leominster population has grown at an accelerating rate in the past 30 years, with increases between 1965 and 1975 from 29,729 to 35,400.

In 1970, 38.1 percent of the residents were either foreign born or second generation Americans, with the largest number coming from Canada. The migrations into Leominster are represented in the ethnic diversity of French, Italian, Polish and, most recently, Spanish speaking people. The Spanish speaking group, numbered 634 in Leominster in the 1970 census compared to 95 in Fitchburg.

The steadily increasing population growth has resulted in new demands on the cities resources, especially schools and sewering. As urban blight was identified as a problem in the older downtown areas, civic improvement activities increased and the search for new investment began. Increasing numbers of automobiles and road traffic and congestion in core areas, high accident rate, and the lack of recreational facilities are also problems mentioned by local reports. New highway construction has been initiated to link Leominster to Worcester with a limited access highway. Under such influences, the city is now preparing an updated master land use plan. Protection against flooding in the core city will be very important to any program of city revitalization.

ECONOMIC DEVELOPMENT

Leominster was established in 1940, and its initial growth depended upon an agricultural base. Aided by a good location, proximity to Boston and blessed with abundant water resources, Leominster entered manufacturing and developed into a city by 1915. Today, Leominster can be characterized as a small city whose primary economic activity is manufacturing. In 1975,

139 manufacturing firms employed an average of 6,631 persons with an annual payroll of $50,349,359. The latest listing of Massachusetts manufacturers shows the Foster Grant Co., Inc. (plastic products, sun glasses, combs, etc.) as employing more than 1,500 persons. Wholesale and retail trade is the largest nonmanufacturing employer. In 1975, 22 wholesale firms employed an average total of 454 persons and had an annual payroll of $3,546,306. An average total of 2,433 workers were employed by 193 retail firms. They had an annual payroll of $10,456,541.

Leominster is part of the Fitchburg-Leominster Labor Area representing a labor force of 51,260 in August 1975, (having increased from 50,155 in August of 1974). During 1975 the unemployment figure increased from 3,938 to 7,540 increasing the unemployment rate (seasonally adjusted) from 7.9 percent to 14.7 percent.

Although housing and population have increased in the recent past, employment and trade have grown more slowly. Approximately half of Leominster's residents are now employed outside the city. With demands for municipal services due to population growth continuing, Leominster is in part becoming a "bedroom" city.

INTERDISCIPLINARY PLANNING PROCESS

PROBLEMS AND NEEDS

The authorized North Nashua Basin Water Resources Development Plan of 1965 addressed an array of basin water resources needs and solutions. The Monoosnoc Brook and Lake project provided for flood control, water supply and limited recreational as well as channel improvements to complement a downstream urban renewal project. The water quality needs were already being met by a comprehensive program, carried out by EPA and the Commonwealth of Massachusetts, providing for modernization and expansion of treatment facilities. In addition, a concentrated effort was being made to appoint sources of pollution through the EPA's permit program.

In the 1964-1965 interim period of the authorized project, when the Corps of Engineers was requested by the local Congressman to consider resolution of the flood problems along Monoosnoc Brook, the community satisfied its immediate water supply needs by joining the Metropolitan District Commission (MDC) water supply system of Massachusetts. During the interim period, the community also rejected urban renewal proposals which would have included improvements along portions of Monoosnoc Brook.

Consequently, the loss of the Monoosnoc Dam and Reservoir brought about by land use developments in the area eliminates the opportunity for the city to acquire additional water supply and limited recreation. Nevertheless, these resource opportunities are being satisfied by alternative actions already taken by the community, in the form of joining the MDC and the permitting of a large private recreation development as part of a year round scheme operation in the area where the dam would be located. Although the urban renewal project has been shelved, a refurbishing of certain projects in the center of the city has taken place; and once needed flood control is provided, security to these properties can be assured.

At the public meeting of 27 January 1976, community leaders and citizens evidenced their primary concern as being flood control, and selected a plan of improvement which would have the least environmental impact on the community, while providing adequate flood protection at the least cost to the city. (Appendix 1, Section C - "Problems and Needs," contains a description of the principal topics of discussion at the public meetings.)

As a result of close coordination with the Leominster Planning Board and consideration of needs shown in their Community Development Plan Summary the following additional needs were noted:

1. To prevent drinking water crisis,
2. To plan, monitor and manage the growth of Leominster's population,
3. To expand economic opportunities in the community,
4. To restore the flow of commercial activity into the downstream area,
5. To provide public facilities for neighborhoods,
6. To arrest deterioration of areas,

7. To correct local flooding problems,

8. To increase the accessibility of recreation,

9. To preserve historic buildings and sites, and

10. To protect natural resources.

(A detailed analysis of these problems and needs are contained in Appendix I, Section C.)

PLANNING OBJECTIVES

Planning objectives were formulated largely on the basis of information contained in the Leominster Community Development Plan Summary. These water resource related objectives follow:

1. To plan, manage and improve Leominster water resources,

2. To provide adequate community development planning,

3. To implement an adequate, well planned economic development program,

4. To improve the downstream area,

5. To conduct a housing rehabilitation program,

6. To encourage private restoration of potentially esthetic properties,

7. To adopt and enforce rigid land use controls,

8. To adopt measures to protect natural and historic resources,

9. To adopt a program to rehabilitate properties of historic significance,

10. To provide adequate storm sewer facilities, and

11. To provide adequate recreational facilities.

Long-term Objectives Include:

1. **Adequate water supply,**
2. Growth management capability,
3. Adequate wastewater disposal capability,
4. A pleasing city appearance,
5. Protection of natural and historic resources,
6. Adequate disposal of surface water runoff, and
7. A balanced recreation program.

(A more detailed analysis of both short and long range planning objectives is contained in Appendix 1, Section F, "Formulating a Plan.")

PREVIOUS WATER RESOURCE EVALUATIONS

There are no existing flood control projects in the Monoosnoc Brook watershed. Flood protection of the central business district of Leominster was recommended by the Corps of Engineers in a January 1965 report entitled: "North Nashua River Basin Water Resource Development Plan." The improvements recommended for Monoosnoc Brook were comprised of: an upstream multipurpose dam and reservoir and channel improvements through the center of Leominster. The proposed channel improvements were separated into four zones, with two central zones to be improved by local interests as part of an urban renewal plan.

Several problems arose which hindered implementation of the proposed flood control plan. When the Leominster City Council rejected urban renewal in the central section of the city, the overall channel improvement program was no longer economically justified. Consequently, in 1967 the local protection part of the project was deferred. Water supply was then eliminated as a project purpose when Leominster subscribed to the Massachusetts Metropolitan District Commission's system. Beginning in 1965, the site for the proposed dam and reservoir underwent significant land use change from development of commercial recreation areas and

residential housing facilities. By 1969, the previously recommended upstream dam and reservoir was no longer economically justified, nor was it capable of providing a high degree of flood protection without the downstream channel improvement work. Consequently, this portion of the project was also deferred.

IMPROVEMENTS DESIRED

Flood control is the primary water resource problem within the Monoosnoc Brook watershed. Other water resource problems, including those detailed in the 1965 proposal, have either been rectified or have become unfavorable as project facets. The city of Leominster,especially its areas of high flood damage potential, should be protected against floods up to the magnitude of a Standard Project Flood. This should be done in a manner that will cause minimal disruption to the residents and make maximum contribution to environmental quality,

Although pollution is a significant problem on Monoosnoc Brook downstream of Pond Street, the best and most economical method of pollution control would be enforcement of existing pollution laws on stream abutters. Enhancement of fish and wildlife habitat would also be a desirable effect of any improved water quality as fish and wildlife habitat is virtually nonexistent from Rockwell Pond downstream.

Commercial recreational areas have recently been developed, Municipal parks in the cities of Fitchburg and Leominster accommodate limited urban type recreation. However, no areas exist in the immediate Monoosnoc Brook watershed or even in the North Nashua River Basin that offer public outdoor recreation in large open areas. Few public recreational opportunities exist within 10 miles of the Fitchburg-Leominster area. Willard Brook State Forest, located about 7 miles north of Fitchburg, has limited swimming and picnicking facilities. Mount Wachusetts Reservation and Leominster State Forest afford some land based recreational opportunities. Several lakes and reservoirs in the North Nashua River Basin provide boating and fishing, but primarily for privately owned developments. The improvements of flood control as depicted in this report will not contribute to meeting public recreation needs, but offer recreational alternatives as adjuncts to flood control improvements are unavailable.

FORMULATING A PLAN

The plan formulation portion of this study explored all potentially feasible alternative methods for water resource improvements by considering technical, economic, environmental and social factors in the analysis.

BASE CONDITION

To fully evaluate the water resource needs of the community and the region, a resources inventory of existing and most probable future conditions was conducted. Initially, an analysis was made to determine which resource categories should be inventoried. Appropriate Federal and State agencies as well as local officials and public interest groups were then contacted to determine the extent of available information and the jurisdiction for decision making. Information concerning the cultural and archaeological base condition was coordinated with the U.S. Advisory Council on Historic Preservation, the State of Massachusetts Historical Commission and the Leominster Conservation Commission.

Other facets of establishing the base condition included literature research, establishment of a systematic filing system, identification of major data deficiencies and a determination of the extent of future data collection activities. As the water resource needs and concerns of the community were established and planning objectives were more fully outlined, it was necessary to refine the data base in certain areas. Economic, social and environmental concerns were the primary inputs for the data base. In the economic category, the primary information on existing and future conditions concerned industrial and commercial activity and growth potential, labor force, employment and income. Social considerations included population density and mobility, esthetics, health and safety, housing and possible displacement of people. All established environmental concerns were fully evaluated in the required preparation and coordination of the environmental impact statement. (Details of the base condition analysis are more fully outlined in Technical Appendix 1, Section B, "Resources and Economy of the Study Area." Coordination aspects of this analysis is given in Appendix 2, "Pertinent Correspondence.")

FORMULATION AND EVALUATION CRITERIA

The formulation portion of the study involved the investigation of a range of alternatives for resolving the problems and fulfilling the needs that have been defined in the study area. Alternative plans were devised on the basis of appropriate technical engineering. Once comparable levels of flood control were obtained, each alternative was evaluated for its costs and its effects on economic development and the quality of the environment in accordance with the Principles and Standards for Water Resources Planning and Related Land Resources. The beneficial and adverse effects of the alternatives were outlined and compared and where possible, the alternatives were modified to reduce adverse effects. On the basis of the final comparisons, local participants at the formal public meeting selected the plan they judged to be most suitable for the area.

1. Technical Criteria

The following technical criteria were adopted for use in developing plans of improvements:

a. The selected water resource plans should be consistent with local and regional plans for land use and water related activities.

b. Selected plans should be flexible enough to accommodate projected future development.

c. Existing water quality standards should be enforced and future projections should insure improvement.

d. Costs for future water supply requirements should include those for required distribution systems.

e. A Standard Project Flood (SPF) is considered to be the project design flood.

f. Increased discharges into downstream areas that result from implementation of upstream flood control works should not cause additional flooding to those downstream zones.

2. Economic Criteria

The economic criteria applied in formulating plans of water resource improvements are summarized as follows:

a. Tangible benefits exceed project economic costs.

b. The scope of the project is such as to provide the maximum net benefits. However, intangible benefits are taken into consideration.

c. There are no more economical means, evaluated on a comparable basis, of accomplishing the same purpose.

d. All benefits and costs are expressed in comparable terms.

e. Annual costs include those for maintenance and operation of the project.

3. Environmental Criteria

The following environmental and social criteria were utilized in formulating plans:

a. A systematic interdisciplinary approach is used to insure the integrated use of natural and social sciences and environmental design.

b. An evaluation is made of the environmental impact of any proposed action, including adverse impact.

c. A determination of the existence of any irreversible or irretrievable commitment of resources is made.

d. Detrimental environmental effects are avoided and feasible mitigating measures are included, if necessary.

e. Measures are taken to insure public health, safety and social well-being.

FORMULATION OF ALTERNATIVE PLANS

When the various planning objectives were evalutated to determine the need for further studies, the following water resource objectives fell out of the planning process for the reasons cited.

1. Water Supply

Existing and future needs have been met by the recent inclusion of the city of Leominster in the Metropolitan District Commission (MDC) system. Because this is the least expensive method for meeting future needs, developing alternative supply sources is no longer necessary. In addition to the MDC supply, the existing water supply system includes

six impoundments in the 10.4 square mile drainage area upstream from Rockwell Pond. These are Notown, Haynes, Morse and Distributing Reservoirs and Goodfellow and Sumond Ponds.

2. Recreation

Water based recreation needs could have been met by the construction of a multipurpose dam and reservoir such as the one proposed in the 1965 study. However, since that time private development of land in the vicinity of Carter Hill has made land taking for reservoirs prohibitively expensive. Therefore, there is no longer economic justification for the construction of multipurpose reservoirs in the vicinity of Carter Hill, and other sites are nonexistent. Part of this development at Carter Hill has included recreational facilities in the form of ski slopes and golf courses.

3. Water Quality

All of the impoundments located upstream from Rockwell Pond and their tributaries are presently classified by the State of Massachusetts as Class A waters. The main stem of Monoosnoc Brook below Rockwell Pond is classified as Class B water. Because of these relatively high standards, there is no need to adopt additonal water quality standards for discharges into Monoosnoc Brook. If higher standards are implemented in the future, they will be monitored by both the State and Federal Environmental Protection Agencies.

4. Land Use Planning

"Greenbelts" or park areas along a revitalized brook channel in a dense urban setting would be of considerable value to the citizens of the community. Such a plan was proposed to the city of Leominster in 1965 as part of the overall Monoosnoc Brook and Lake study. However, the urban renewal portion of the plan was rejected in its entirety by the Leominster City Council on 30 September 1967. Because of this lack of public interest for these types of improvements, it was considered to be in the best interest of the Federal Government not to pursue this matter further. From this evaluation it became evident that flood control was the primary need of the community and that it required further study. Several alternative measures to satisfy the flood control problems and needs of the people of Leominster were investigated. Possible flood control measures included:

a. Nonstructural measures such as zoning and building code regulations, floodproofing, land acquisition, permanent evacuation of floodplain areas and purchase of subsidized flood insurance;

b. Structural measures such as dams and reservoirs and channel improvements that include widening, deepening, floodwalls, dike works, and surface or tunnel diversions or combinations of these; and

c. A combination of structural and nonstructural measures. Findings for these plans are summarized as follows:

Floodplain Relocation - A relocation plan was found to be highly impractical for this study area. It is too expensive to buy properties and too disruptive to move people, industry and businesses from the city center.

Floodplain Zoning - Zoning and building regulations should be implemented and enforced to effectively reduce the flood damage potential of the study area. Planned future development and land use program would alleviate present encroachment and preclude possible future encroachment on the floodplain lands.

Channel Improvements - The substantial development in the Leominster central district prohibits economical and practical improvements to the existing channels. Construction of necessary dikes and walls and removal and/or replacement of existing structures, to safely pass SPF levels, would be highly disruptive and costly.

Dams and Channel Improvments - Several dam locations were investigated on Monoosnoc Brook and its tributaries. Because these sites were located too far upstream, their limited storage capacities precluded control of all floodwaters to Leominster. Therefore, channel improvements would be required to supplement any flood control scheme of upstream storage. No integral dam and channel improvement scheme could satisy Corps criteria and still carry a favorable benefit/cost (B/C) ratio. In addition, dam construction and disruption associated with channel projects are generally opposed by local officials and citizens of Leominster.

Diversion Channel and Dam - A diversion channel was proposed in conjunction with an upstream dam. Floodflows would be conducted from Pierce Pond through an open channel directly to the North Nashua River. This plan was found to be economically infeasible since condominiums have been constructed along segments of the anticipated alignment.

Rockwell Pond Lowering - A plan to lower Rockwell Pond to provide a recreational pool and flood protection was investigated. Because of the limited flood storage area provided by the pond, this plan was not considered feasible.

Diversion Tunnels - Because of the meandering course of the existing channel a single, straight alignment was selected for various size underground diversion tunnels. A listing of design discharges for 8, 10 and 12 foot diameter tunnels follows:

Size	Discharge
8 foot diameter	1200 cfs
10 foot diameter	2100 cfs
12 foot diameter	3400 cfs

For a design discharge (SPF) of 4000 cfs, at Rockwell Pond the 12' tunnel would accommodate 3400 cfs and the flow on the Monoosnoc Brook channel would be controlled at 600 cfs during flood periods. Six hundred cfs is considered the nondamaging existing channel capacity.

EFFECTS ON OBJECTIVES

1. National Economic Development

First costs, annual charges and annual benefits for economic assessments were estimated for each alternative. Federal first costs include construction costs based on the June 1978 price levels, an allowance for contingencies and engineering and overhead costs. Non-Federal first costs associated with land purchase, damages, and utility relocations are to be borne by local interests. Property valuations are based on information from local officials and current sales values. Annual charges, both Federal and non-Federal, are based on an interest rate of 6-5/8 percent amortized over 100 years. Included with non-Federal annual charges are the operation and maintenance of the completed works.

Federal and non-Federal first costs and annual charges for several alternative flood control plans are summarized in the following tabulation.

TABLE I

FIRST COSTS AND ANNUAL CHARGES
FOR ALTERNATIVE PLANS
(in $1000)

Plan	First Costs		Total	Annual Charges		Total
	Federal	Non-Federal		Federal	Non-Federal	
1. Dam & Channel Project (Site 1)	$11,000	$1,850	$12,850	$703	$118	$821
2. Dam & Channel Project (Site 2)	11,300	2,300	13,600	722	147	869
3. Surface Division	7,600	2,000	9,600	487	127	614
4. 12' Tunnel By-Pass	7,120	520	7,640	472	36	508

2. Quality of the Environment

The Monoosnoc Brook watershed is divided into one upper mostly undeveloped area by Rockwell Pond, while the lower reach has a high degree of residential, commercial and industrial development. Predominant physical features of the upper area consist of a large expanse of natural forest, rock hills and a number of reservoirs. Most of the streams and ponds evidence varying degrees of pollution and degradation, and certain portions of the upland forest show signs of having been thinned. Major flooding is confined to the lower portion of the watershed which is substantially developed.

3. Effects Assessment

Impacts of the possible alternative plans on the natural, social and economic environment of the study area were assessed. It must be recognized, however, that the primary goal of each alternative is to alleviate or eliminate unpleasantness and economic losses from flooding. Each of the alternative plans investigated had some similar impacts on the environment social-well being and regional development of the project area.

The initial step of the assessment was delineating the impacts of "no action." The primary consequences of no action would be the continued economic loss, inconvenience and possible danger to human life which exists because of the inadequate channel capacity of Monoosnoc Brook in its course through the central business district of Leominster. The economic loss "without the project" is estimated at $554,200 annually under present conditions. A recurrence of the 1936 record flood would produce an estimated $3,952,500 in damages (viewed at 1977 price levels). The flood problem can be expected to intensify as runoff increases because of additional development in the upper watershed.

Leominster's vulnerability to floods would be expected to result in a continuation of depressed property values and relatively low tax assessments in the flood zone. At present, some of the property in these areas is in a deteriorated condition. Without implementation of flood control improvement there is less incentive on the part of property owners to upgrade those properties.

Environmental changes without a flood control project would be minimal. Flooding would continue to leave sediment and debris within the flood zone, requiring a cleanup after each event.

With the implementation of flood control improvements along Monoosnoc Brook most of the economic, social well-being and environmental impacts would be favorable. The following paragraphs discuss the impacts of such implementation:

a. The positive economic impacts would include a substantial increase in employment during construction, resulting in increased spending for consumer foods. Materials and supplies for the project would provide additional business for local and regional manufacturers.

b. From the municipal point of view the primary positive impact would be the reduction of flood damages at a relatively small cost to the local governments involved.

c. No business, residential or industrial relocations would be required for the tunnel bypass project. Tax revenues could be expected to increase because of revitalization of those properties that were formerly subject to flooding.

d. Due to the urban nature of the area, environmental effects include few or no impacts on existing natural resources, as fish and wildlife habitat is limited or nonexistent.

e. For a tunnel project, the long term effect on land use of easements on private property would not be great, but it would preclude future encroachment on lands around Rockwell Pond. Tunnel easements would have no effect on surface land use.

f. Since a flood control project would neither alter normal streamflow nor affect the normal pool level of Rockwell Pond, no adverse effects on future water quality are anticipated.

g. Construction of a flood control project would cause some interruption of traffic and some interruption of normal operations in the central business district of Leominster, but such inconveniences would be temporary and not of a serious nature.

h. With elimination of flooding, the value of previously flood-prone land would tend to rise.

i. Decreasing the flood threat would serve to enhance future potential for growth.

From the functional or flood control standpoint, each of the alternative plans would solve the flood problem. However, the diversion tunnel offers the highest degree of flood protection as well as the most favorable economics. Furthermore, the temporary retention of high runoffs in an upstream reservoir would not have provided as complete a plan of flood control. Complementary channel improvements through the city would also have been required to provide complete flood protection. A channel improvement project to pass design flood discharges without upstream retention would not be feasible because of extensive building relocations and new bridge construction that would be required.

Economics of the various structural alternative plans for flood control are as follows:

TABLE 2

ECONOMICS OF FLOOD CONTROL PLANS

PLAN	FIRST COST ($1,000)	ANNUAL COST ($1,000)	ANNUAL BENEFIT ($1,000)	B/C RATIO
1. Dam (Site 1) and Channel Project	12,850	821	603	0.73
2. Dam (Site 2) and Channel Project	13,600	869	610	0.70
3. Surface Diversion	9,600	614	591	0.96
4. 12' Tunnel	7,640	509	617	1.21

SELECTING A PLAN

Selection of the best plan of improvment for the study area involves the comparison and evaluation criteria previously outlined. A number of factors influenced the decision about the best method of flood control.

The plan to construct upstream dams and reservoirs was found to be costly, unpopular and somewhat ineffective. Local interest groups voiced strong opposition to any impoundments to provide SPF protection, primarily because of the high cost of extensive land acquisitions. Furthermore, impoundments would have to be supplemented with channel improvements to provide complete SPF protection.

Of several alternatives investigated in the preliminary stage, the only plan providing an excess of net benefits was the 12-foot diameter tunnel. A tunnel diversion would provide the necessary protection with minimal disruption to the community.

THE SELECTED PLAN

This section presents a description of the selected plan for flood control and includes its accomplishments and effects as well as its significant design, construction, operation and maintenance aspects.

FLOODING CONDITIONS

Monoosnoc Brook rises in the hills west of the city and flows in an easterly direction to Rockwell Pond. At this point, just upstream of the city, runoff converges from Monoosnoc Brook and its tributaries. Continuing downstream from Rockwell Pond, Monoosnoc Brook passes under

one railroad and nine highway bridges in its 2,3 mile course through a heavily congested area of the city. Much of the stream between Pond and Water Streets has been walled in, and in several areas it is confined in conduits. Local interests are concerned primarily with the inadequate capacity of the channel, which in previous flood periods has caused overtopping of the banks and inundation of the downstream business and industrial areas.

In Leominster some 580 acres of land are susceptible to flooding from the Standard Project Flood. More than 70 of these acres lie along Monoosnoc Brook in the built-up portion of the city. The remainder is a floodplain near the confluence of Monoosnoc Brook and the North Nashua River.

Records of historic floods are meager. However, local newspaper files indicate that the three worst damaging floods of recent times occurred in 1936, 1938 and 1955. The flood of record occurred in March 1936 and had two distinct peaks on the 12th and 19th. Five inches of rain between the 16th and 19th was augmented by snowmelt, producing the highest peak. (A more detailed analysis of record floods and flood development is contained in Section D on the Technical Appendis, "Hydrologic Analysis.")

The floods recorded closest to the study area were measured along the North Nashua River just downstream of the mouth of Monoosnoc Brook. Table 3 shows flood stages and discharge for the three greatest floods of record and the Standard Project Flood, as determined for the North Nashua River Basin Report dated 25 January 1965.

TABLE 3

FLOODS OF RECORD
NORTH NASHUA RIVER

FLOOD	STAGE (ft.)	U.S.G.S. Gage Leominster (D.A. 107 Sq. Mi. DISCHARGE (cfs)
March 1936	20.5	16,300
September 1938	14.6	10,300
October 1955	10.8	8,820
Standard Project Flood	25.8	24,000

PLAN DESCRIPTION

The selected plan of improvement in the Monoosnoc Brook Basin calls for construction of a subterranean bypass tunnel from Rockwell Pond at Pond Street to below Water Street Bridge.

Implementation of the plan would require acquisition of approximately 13.5 acres of permanent, flowage and temporary easements for the inlet and outlet structures and appurtenant improvements.

The main feature of the plan are as follows:

1. Diversion of floodflows from Rockwell Pond through a 12-foot diameter tunnel extending 3,200' long beneath central Leominster to the outlet of Monoosnoc Brook downstream of Water Street,

2. A morning glory type intake and spillway with a 46-foot diameter weir and a 107-foot vertical drop at Rockwell Pond,

3. A concrete outlet structure with antivandalism grate and energy dissipation structure,

4. Enlargement of the waterway under the Whitney Street Bridge by removal of a suspended sanitary sewer pipe to accommodate the anticipated peak floodflows,

5. Filling and regrading of about 3 acres of floodprone land at the Pyrotex Co., located near Williams Street, and

6. Relocation of a concrete encased sanitary sewer line across Monoosnoc Brook at the end of Williams Street.

Details of the proposed plan of improvements are shown on Plates 1 through 6 of this report.

PLAN ACCOMPLISHMENTS

The major benefits that will accrue from the plan are reduction of existing and future flood damages to about 70 acres of predominantly commercial and industrial properties adjacent to Monoosnoc Brook in

the central business area of Leominster. Average annual benefits of $616,700 are estimated from the evaluation of flood damage prevention to the area and from area redevelopment benefits. Furthermore, additional development in the area can reasonably be expected with the assured protection provided by the selected plan.

In addition to the flood damage reduction benefits that would result from the project, related conservation benefits and enhancement of the wildlife habitat would also be realized from preservation of the natural woodlands in the upper basin. Preservation of the ecology of the natural woodlands is considered as an asset along with the higher water quality that the area supplies to Leominster.

Preservation of the entire project area is also expected to increase public use of the area for fishing, nature study and birdwatching. An area free from flood threat would permit opportunities for desirable recreational development amidst the highly urbanized atmosphere.

Although the selected plan provides an opportunity for local interests to realize multiple use benefits, the project itself does not provide other major benefits. The specific effects of the project are discussed in the following paragraphs.

EFFECT OF THE PLAN ON ENVIRONMENT

The primary effect of the proposed plan would be the flood protection provided to about 70 acres of commercial, residential and industrial property in the central business district of Leominster. Removal of the flood threat would enhance the quality of the human environment and improve the local economy by substantially reducing property damage and the loss of business days due to flooding.

A secondary effect would be the tendency toward more intensive development within the protected area as well as increased real estate values throughout the project area because of retention of open space area and the improved visual impact expected to result from the project. The area would also be esthetically improved by implementing the plan.

In general, visibly disturbed areas surrounding the project would be restored to their natural scenic beauty to provide an attractive appearance for the public's enjoyment. The diversion would not alter the natural stream channel during low flow periods, but would supplement the channel capacity during flood periods. The need and justification for any temporary and permanent easements will be further reviewed during preconstruction planning, under conditions existing at that time.

In accordance with Corps guidelines, a cultural resource reconnaissance has determined that no significant resources, either historical or archaeological, are located in the vicinity of the proposed project. However, the site of the proposed tunnel outlet structure was determined to be archaeologically sensitive, and it will be more fully surveyed during advanced engineering and design phases.

The office of the Massachusetts Historical Commission was contacted to determine if any historical landmarks, points of interest, sites on the National Register of Historic Places, or sites in the process of being nominated to the Register would be affected by the project. No properties or sites would be affected. Correspondence on this matter is contained in Appendix 2, "Pertinent Correspondence."

The revised draft environmental impact statement is being submitted as Attachment I to this report. The statement includes detailed coverage of environmental considerations concerning the selected and alternative plans, as required by the National Environmental Policy Act of 1969.

AREA REDEVELOPMENT

Area redevelopment benefits, made possible by construction of the improvements described, would be realized by providing employment for people in the area during the construction period. It is estimated that 75 percent of the laborers will be locally hired for this project. No benefit has been considered for labor engaged in maintenance and operation of the completed project as the need for this work is minimal and will be handled by the public work force of the community. The average annual area redevelopment benefits for the Monoosnoc Brook tunnel diversion project are estimated to be about $76,000, based on June 1977 price levels. The recommended plan calls primarily for underground construction, with limited land acquisition and easements required, resulting in negligible loss of local tax revenue. Intangible benefits such as improved public health, reduced risk to human lives and improved morale of the areas people have not been included in the project benefit analysis.

DESIGN

The proposed diversion tunnel would carry the anticipated Standard Project Flood discharge of 4,000 cfs at Rockwell Pond, minus a maximum nondamaging capacity of 600 cfs to be discharged into the existing Monoosnoc Brook watershed. A dike and wall would not be required at the Leominster Tool Company, located downstream from the diversion tunnel outlet at Whitney Street, as the sill elevation of this building is the same as the SPF without freeboard. Project design would include filling of low-lying property adjacent to the Pyrotex Co., and building and construction of interior drainage facilities. Existing utility pipes that cross Monoosnoc Brook at the end of Williams Street and pass under the Whitney Street Bridge would be relocated to allow passage of the SPF. Borrow and spoil areas for the proposed project would be selected to provide the least disruption to the community. Visibly disturbed borrowed and spoil sites would be landscaped to restore natural esthetics and provide a suitable facility for public enjoyment.

CONSTRUCTION

Excavated material would be utilized for project construction to the maximum extent possible. Suitable embankment material,for instance, would be available from conduit excavations. If required, acceptable borrow material is available within practical hauling distance. Granular materials and rock spoil from conduit excavations would be used to provide fill at the Pyrotex Co. property. Adequate sources of other construction materials can be found locally. Temporary construction easements would be necessary for work areas and access roads at the proposed inlet and outlet sites. It is estimated that the project could be constructed within 2 years. During the construction period, protective measures cited in "Environmental Guidelines for the Civil Works Program of the Corps of Engineers" would be enforced to insure that proper methods of erosion and dust control and debris removal would be used.

OPERATION AND MAINTENANCE

No significant problems are anticipated in connection with the operation and maintenance of the selected improvement. The proposed floodwater diversion would operate automatically during periods of high runoff and, except for general surveillance, should not require maintenance during floods. Normal maintenance costs are estimated to be $1,700 annually. Routine maintenance functions necessary to assure efficient operation of local storm drains entering the existing system would also be essential to effective flood prevention. Maintenance and replacement costs associated with the subterranean conduit would be paid by the city of Leominster in accordance with Federal regulations. In addition, the city would be required to maintain the existing channel's capacity to pass a maximum discharge of 600 cfs.

ECONOMICS OF SELECTED PLAN

METHODOLOGY

The tangible economic justification of the selected plan can be ascertained by comparing equivalent average annual costs (including interest, amortization and maintenance) with an estimate of the equivalent average annual benefits that would result from the project over a 100-year period. This economic life is believed to be reasonable since the project would provide a very high degree of protection and would function indefinitely, requiring little maintenance because of the permanent nature of its components. Values of costs and benefits that would accrue to the plan were made comparable by conversion to an equivalent time basis using the current Federal interest rate. An interest rate of 6-5/8 percent was used for all features of the selected plan found to be feasible.

COSTS

Cost estimates for the diversion tunnel project are based on June 1978 price levels and include a 15-percent contingency factor. Costs for engineering and design and supervision and administration are based on costs of similar New England projects. The period of analysis for the plan was selected as 100 years. Interest and amortization charges are based on an interest rate of 6-5/8 percent. Annual expenses also include maintenance costs. Interest during construction was not charged to the plan because of its short construction period, estimated to be less than 2 years. The estimated first costs and annual charges of the project are summarized in Table 4.

BENEFITS

The primary benefit accruing to the diversion conduit plan for the Monoosnoc Brook study area would be the reduction of future damages to residential, commercial and industrial properties. The plan would provide the residents with area redevelopment and intangible benefits such as improved public health, reduced risk to human lives, potential recreation and higher morale. Future average annual flood damages that would be prevented represent the difference in average annual flood damages that would be expected without the works and residual average annual damages that would exist with the recommended plan. A determination has been made of future average annual flood damages based on the existing level of development and on the expected increase in development.

Benefits are based on a 1976 development with projections to 1990 conditions and a 100-year period of analysis. They are estimated at $540,200 annually (1978 price levels) for the flood control function, and $76,000 for area redevelopment considerations. Beneficiaries of the flood control function of the improvement plan are well distributed and are mainly the owners of residences and business establishments in the area between Rockwell Pond and Williams Street.

TABLE 4

SUMMARY OF FIRST COSTS AND ANNUAL CHARGES

First Costs

Preparation of Site	$ 20,000
Earth Excavation	45,000
Tunnel Rock Excavation	1,465,000
Open Rock Excavation	3,000
Shafts, Complete	1,314,000
Gravel Fills	20,660
Topsoil and Seeding	28,375
Concrete	1,553,140
Steel Reinforcing and Misc. Metals	449,410
Drains	16,800
Waterstops	125,120
Stone Protection	18,000
Dewatering (tunnel)	326,000
Subtotal	$5,384,505
Contingencies	815,495
Total Estimated Construction Cost	$6,200,000
Engineering and Design	400,000*
Supervision and Administration	520,000
Lands and Damages	370,000
Utility Relocations	150,000
TOTAL PROJECT COST	$7,640,000

* Does not include $210,000 for pre-authorization studies.

ANNUAL CHARGES

Interest and Amortization (.06635 x 7,640,000)	$ 506,000
Operation and Maintenance	1,700
TOTAL PROJECT ANNUAL COST	$ 508,600

JUSTIFICATION

Comparisons of average annual benefits with average costs are shown in the tabulation below for the plan of improvement. Although intangible benefits, and possibly tangible secondary benefits may accrue to the national economy, only tangible primary benefits are presented in the tabulation.

TABLE 5

AVERAGE ANNUAL COSTS AND BENEFITS

Item	Flood Control	Area Redevelopment	Total
Annual Costs	$508,600	--	$508,600
Annual Benefits	$540,700	76,000	$616,700
Benefit-Costs Ratio	1.06:1	--	1.21:1

DIVISION OF PLAN RESPONSIBILITIES

As previously discussed, although nonstructural measures such as flood proofing of individual structures and zoning and building codes are not requirements of the recommended plan, local interests should consider and adopt such nonstructural measures as necessary. The importance of flood plain zoning and related controls in preventing both encroachments on wetland areas and accelerated runoffs from loss of natural storage cannot be overemphasized. The division of responsibilities for the proposed local protection plan in Leominster is discussed in the following section.

COST APPORTIONMENT

Sharing of costs between Federal and non-Federal interests for the construction, operation, and maintenance of the Monoosnoc Brook flood control project is based on the requirements established as Federal policy for "local protection" improvements. Under this policy, the Federal Government is responsible for all flood control construction costs and non-Federal interests are required to provide, without cost to the United States, all lands, easements and rights-of-way necessary for the construction and operation of the local protection project. Non-Federal interests also bear the cost of relocating utilities and maintaining project features after construction in accordance with Federal requirements. Total project costs for the tunnel diversion are estimated at $7,640,000.

FEDERAL RESPONSIBILITIES

The presently estimated Federal share of the total first costs of the proposed flood control project is $7,120,000. This includes the total construction cost as well as engineering design supervision and administration costs.

NON-FEDERAL RESPONSIBILITIES

Non-Federal interests would provide the following:

1. Provide without cost to the United States all lands, easements, rights-of-way, utility relocation and alterations, and highway or highway bridge construction and alterations where necessary for project construction.

2. Hold and save the United States free from damages due to the construction works, except where such damages are due to the fault of the United State or its contractors.

3. Maintain and operate the project and existing channel without cost to the United States in accordance with regulations prescribed by the Secretary of the Army.

4. Prevent future encroachment which might interfere with proper flood control functioning of the project.

(The City of Leominster would be required to obtain permanent easements for properties around the perimeter of Rockwell Pond and along the existing channel from Pond Street to below Water Street. The easements at Rockwell Pond would prevent the owners from building structures in the areas subject to inundation during the SPF although they could still utilize the land for other purposes. Encroachment on the existing channel would be prohibited by local enforcement of the zoning code that established the necessary easements.) Other general responsibilities are set forth under "Recommendations." The currently estimated non-Federal share of the total first cost is $520,000 and the estimated average annual cost to non-Federal interests for maintenance and operation is $1,700.

VIEWS OF NON-FEDERAL INTERESTS

The considered plans of improvement were coordinated with the following agencies of the Commonwealth of Massachusetts: Division of Water Resources, Department of Public Works, Division of Fisheries and Wildlife, Department of Environmental Quality Engineering, Historical Commission, and the Department of Environmental Management. The Leominster Department of Public Works, Mayor John B. McLaughlin, the Leominster City Council and the Leominster Historical Commission have also reviewed the plans for the proposed improvement. Statements or resolutions by these interests expressing views and recommendations are contained in Appendix 2 and are summarized as follows:

COMMONWEALTH OF MASSACHUSETTS

Initially, the Division of Water Resources, Water Resources Commission, coordinated the review of the general plan for a flood control project on Monoosnoc Brook with other departments and commissions within the State. Conclusions reached and comments made by various agencies during the initial review and the recent EIS review are quoted or summarized below:

· Under the Massachusetts General Laws, the Department of Public Works is expressly authorized to consummate agreements with the Federal Government by providing formal assurances of local cooperation. Their review indicates no conflict with any Department of Public Works projects in the area.

· Department of Environmental Quality Engineering

This office has reviewed the scope of the proposed construction activity for local flood protection and is in favor of the project.

· Massachusetts Historical Commission

The final report of a Phase I survey from the Institute for Conservation Archaeology has been reviewed by the State archaeologist, and he is satisfied with the field survey as conducted. The survey of the proposed site did not reveal any known archaeological areas. Therefore, the proposed project will not result in any archaeological impact. No properties within the project boundaries are listed on the National Register of Historic Places.

CITY OF LEOMINSTER

· *Office of the Mayor*

The mayor has expressed his concern about Leominster's designated flood zone, its adverse economic impact on the city, and the effects of the flood damage potential on residents and other downtown property

owners. His primary interests were the city's share of the project costs and the economic impact to the downstream area, in conjunction with the ongoing I-190 highway construction. He has endorsed floodflow diversion as advantageous and feasible, and he hopes that all pertinent problems are carefully evaluated before decisions are made final.

· Leominster City Council

By a vote of 8 to 1, the city council has approved a continuation of studies of the proposed tunnel beneath downtown Leominster.

· Leominster Department of Public Works

The public works department fully supports the proposed project, but it suggests that two surface sewer lines crossing downstream from the proposed tunnel outlet be relocated or appropriately considered as to capacity and efficiency in conjunction with the project structures.

· Leominster Historical Commission

The chairman was particularly concerned that the diversion may, in effect, eliminate waterflow to the brook. He required assurance that the tunnel design will take only excess floodwaters and will not interrupt normal flow onto the brook.

REVIEW BY OTHER FEDERAL AGENCIES

The considered plans of improvement were coordinated with the following Federal agencies:

Department of Interior
Department of Housing and Urban Development
Department of Health, Education, and Welfare
Environmental Protection Agency
Fish and Wildlife Service
Department of Agriculture, Soil Conservation Service
Advisory Council on Historic Preservation Service
Economic Development Administration

Letters received from those agencies expressing views and recommendations are contained in Appendix 2 and are summarized below.

· Department of Interior - Bureau of Mines

Expressed concern over disposition of excavated materials and its effect on local crushed stone producers. The proposed project would have no impact on other mineral resources.

· Department of Interior - Geological Survey

Wanted additional information concerning water supply wells and the location of aquifers in relation to the tunnel alignment.

· Department of the Interior - National Park Service

Suggested that additional archaeological surveys be conducted.

· Department of Interior - Bureau of Outdoor Recreation

No comment at this time.

· Department of Housing and Urban Development

Found no conflict with the objectives of the proposed local protection project.

· Environmental Protection Agnecy

Was concerned that water stored in inverted syphon might become anoxic.

· Department of Agriculture - Soil Conservation Service

Replied that there are no existing or planned SCS projects that would be affected by the tunnel project.

· Advisory Council on Historic Preservation

Determined that EIS was procedurally adequate, but requested further coordination with the State Historic Preservation Office.

PLAN IMPLEMENTATION

Construction of the proposed improvement can begin after the following procedure is completed:

- Higher Corps of Engineers authorities such as the Board of Engineers must review and approve this report.

- The Chief of Engineers then requests a formal review and comments from the Governor of Massachusetts and interested Federal agencies.

- Following the State and interagency review and subsequent to seeking comments from the Office of Management and Budget regarding the relationship of the project to the program of the President, the final report to the Chief of Engineers is forwarded by the Secretary of the Army to the Congress.

- Congressional authorization of the flood control project is then required. This includes appropriate review and hearings by the Public Works Committees.

- When the project is authorized, the Chief of Engineers then includes funds, when appropriate, in his budget requests for design and construction of the project.

- When the Congress appropriates the necessary initial funds, formal assurances of local cooperation are requested from non-Federal interests.

- Advance engineering and design studies are initiated, project formulation is reviewed, and the plan is reaffirmed or modified to meet existing conditions.

- Surveys, materials investigations and preparations of design criteria, plans, specifications, and an engineering estimate of cost are then accomplished by the New England Division. Bids are invited and a contract is awarded. At this time, the necessary local actions are required.

- Following completion of certain sections of the project, local interests assume the responsibility of operation and maintenance of project.

SUMMARY

Following a comprehensive study of the Monoosnoc Brook area's problems and needs and a thorough consideration of beneficial and adverse project effects, the tunnel diversion was determined to be the alternative that best solved the flood problem and satisfied the previously outlined criteria.

The selected project which is sized at the optimum economic capacity, is functionally able to provide a high degree of flood protection (SPF) for the flood-prone areas of urban Leominster, and is economically justified. Project-related conservation benefits and preservation of the existing environment will be realized from the successful implementation of the proposed project.

As designed, a concrete spillway inlet at Rockwell Pond would carry anticipated flood flows through a 3,200-foot long diversion tunnel under central Leominster to an outlet structure downstream from Water Street. The tunnel would divert excess floodwaters and would not impair normal flow in the existing Monoosnoc Brook channel.

Improvements to the existing brook channel system would be required to insure natural unobstructed flow. Improvements would include enlargement of one bridge by relocating a utility pipe and relocation of a sewer line spanning the brook. Filling and regrading of certain areas to control interior runoff and temporary and permanent easements would be necessary to discourage encroachment on the flood plain. Any disturbance of the surrounding natural environment would be restored accordingly.

Total cost of this improvement plan would be $7,640,000 with annual charges and benefits equal to $508,600 and $616,700, respectively. The overall benefit cost ratio is 1.21 to 1.

The existing surroundings in central Leominster afford few natural areas for recreation and natural wildlife habitation. The proposed plan of local flood control suggests an improved social and environmental climate in the area with minimal adverse effects. Effective losses are associated mainly with easement rights necessary for efficient flood control and small land acquisitions required for the above ground project structures.

Non-Federal interests will furnish all lands, easements and rights-of-way, as not to indemnify the United States. They will be required to prevent encroachments on existing channels and will maintain and operate all project features. Operation and maintenance costs are currently estimated at $1,700 annually.

STATEMENT OF FINDINGS

All plan formulation data concerning the proposed action and the stated views of other interested agencies and individuals have been reviewed and evaluated. In accordance with interdisciplinary planning within the multi-objective framework of Principles and Standards, various practicable alternatives for providing the needed flood control and related water resource needs for Leominster were investigated. Alternatives have been viewed for environmental, social well-being and economic effects, including regional and national development and engineering feasibility. During plan formulation the following points were considered pertinent:

- The project will provide standard project flood protection for the central business district of Leominster and adjacent areas.

- The project is sized at the optimum economic capacity, is functionally adequate and economically justified.

- Care was taken to minimize adverse environmental effects.

The proposed action as developed in the "Formulating a Plan" and "The Selected Plan" sections is based on thorough analysis and evaluation of various practicable alternative courses of actior for achieving the stated objective. The selected plan meets the nine evaluation criteria, i.e., acceptability, completeness, effectiveness, efficiency, certainty, geographic scope, NED benefit cost ratio, reversibility and stability. The selected plan is consonant with national policy, statutes and administrative directives, and the total public interest would best be served by implementation of the selected plan.

RECOMMENDATIONS

It is recommended that the tunnel diversion project for the Monoosnoc Brook watershed in the City of Leominster, described as the selected plan in this report and shown on Plates 1 thru 6, be authorized for Federal construction, with such modifications as the Chief of Engineers may find advisable, at an estimated Federal cost of $7,120,000 and an estimated non-Federal cost of $520,000 provided that Non-Federal interests will:

a. Provide without cost to the United States all lands, easements and rights-of-way necessary for the construction and maintenance of the project.

b. Hold and save the United States free from damages due to construction works except damages due to fault or negligence of the United States or its contractors.

c. Maintain and operate all project works as well as the existing channel after completion on accordance with regulations prescribed by the Secretary of the Army.

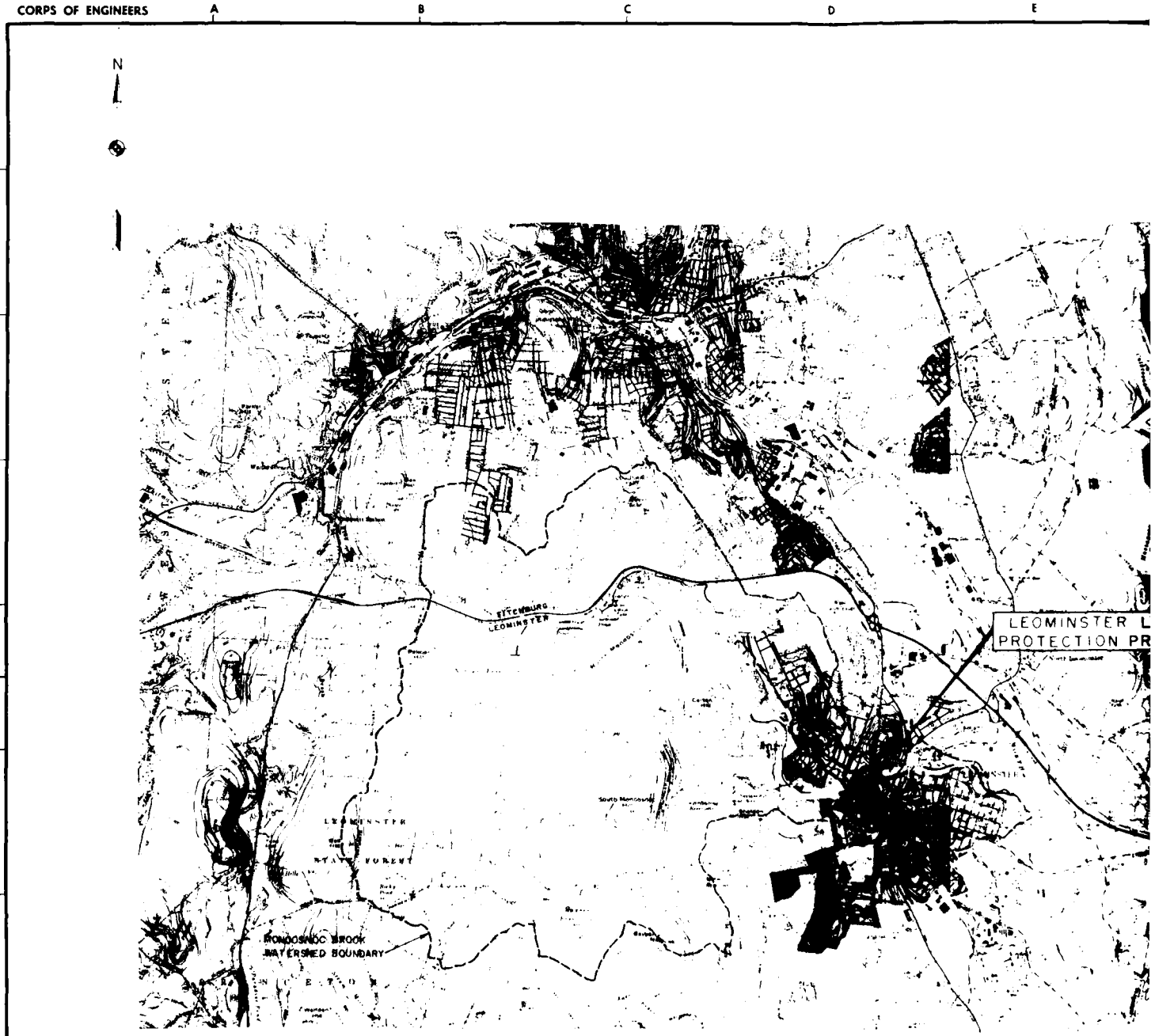
d. Provide without cost to the United States all alterations and replacements of existing utilities.

e. Prescribe and enforce regulations to prevent encroachment on both the improved and unimproved channels, and manage all project related channels to preserve capacities for local drainage as well as for project functions.

f. Comply with the provisions under Section 210 and 305 on Public Law 91-646, 91st Congress, approved 2 January 1971 entitled "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970."

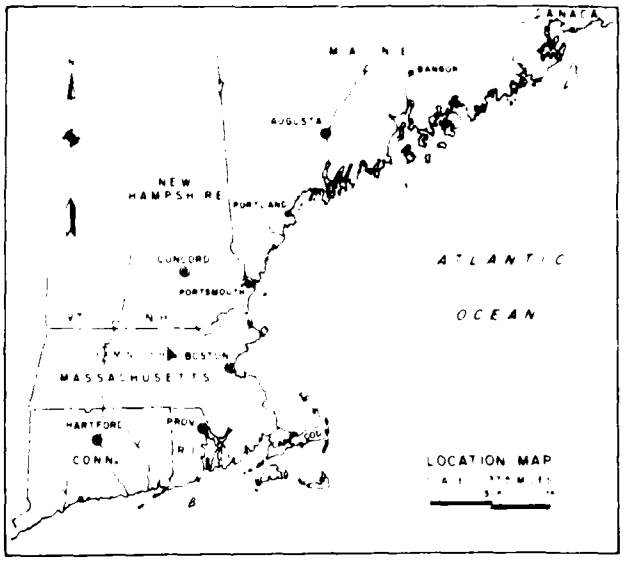
John P. Chandler
Colonel, Corps of Engineers
Division Engineer

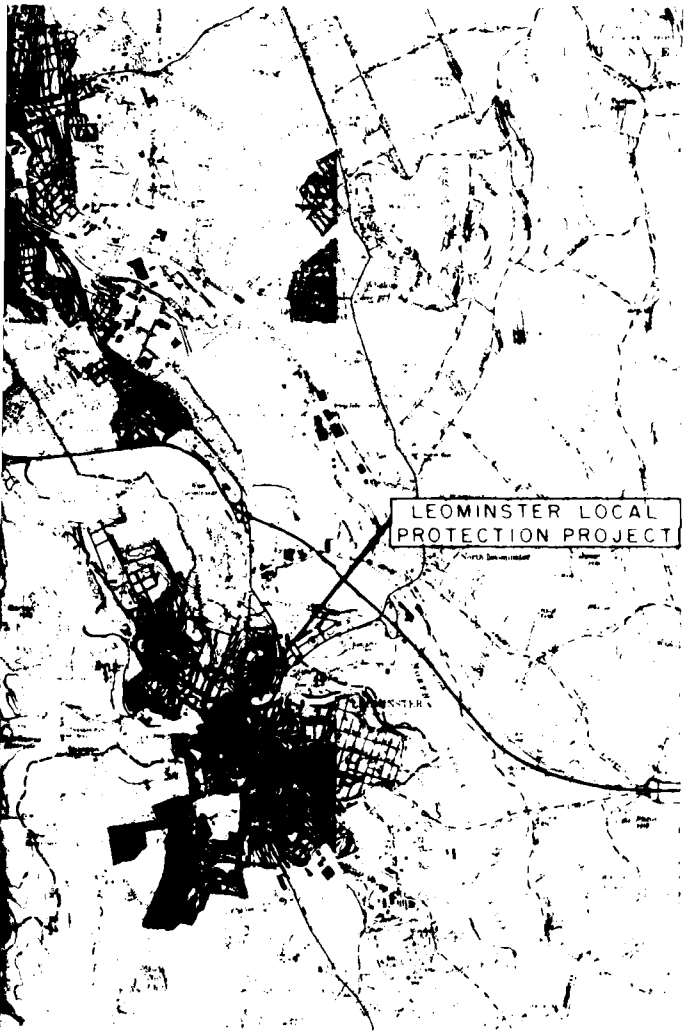
CORPS OF ENGINEERS



BASIN MAP

D E F G H U S ARMY





MAP

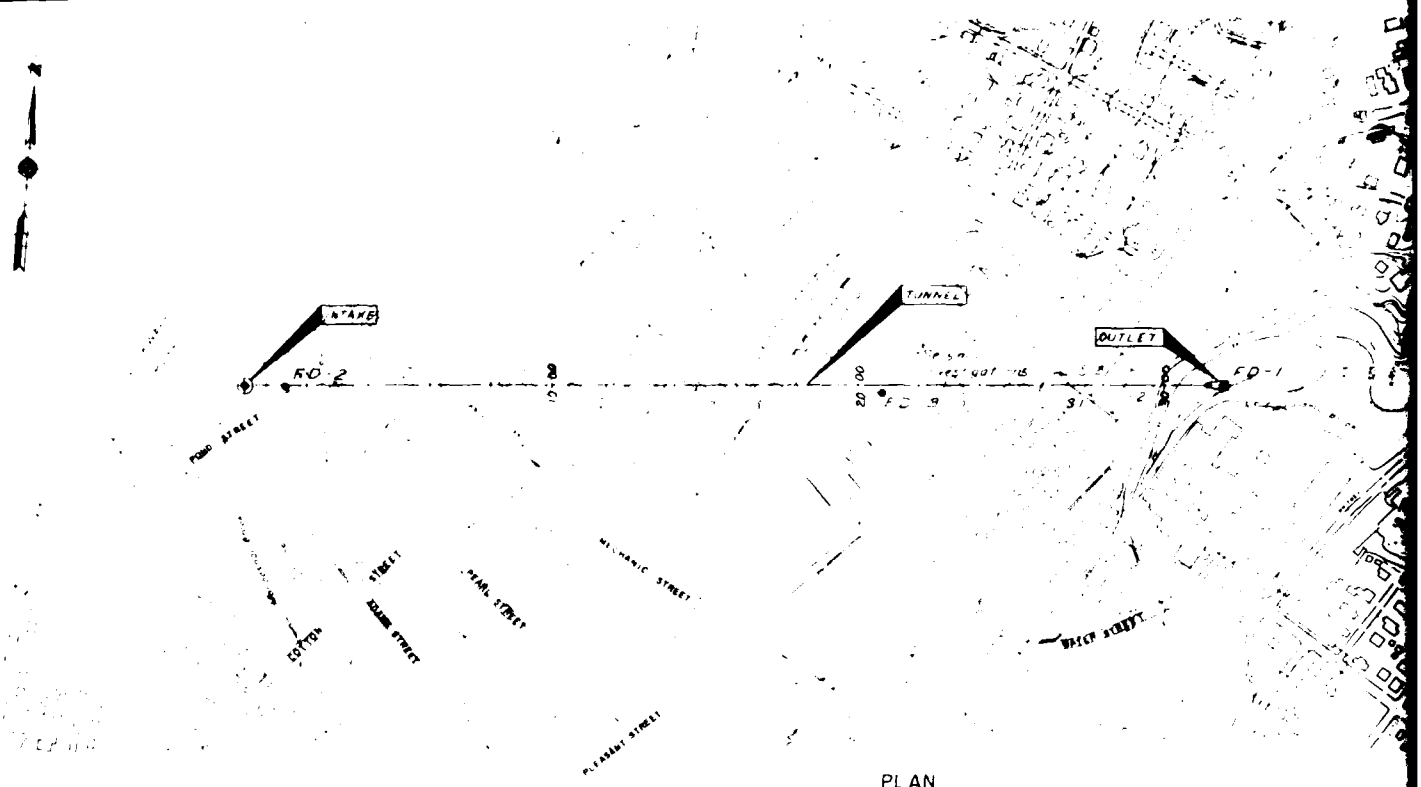
SAFETY PAYS

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

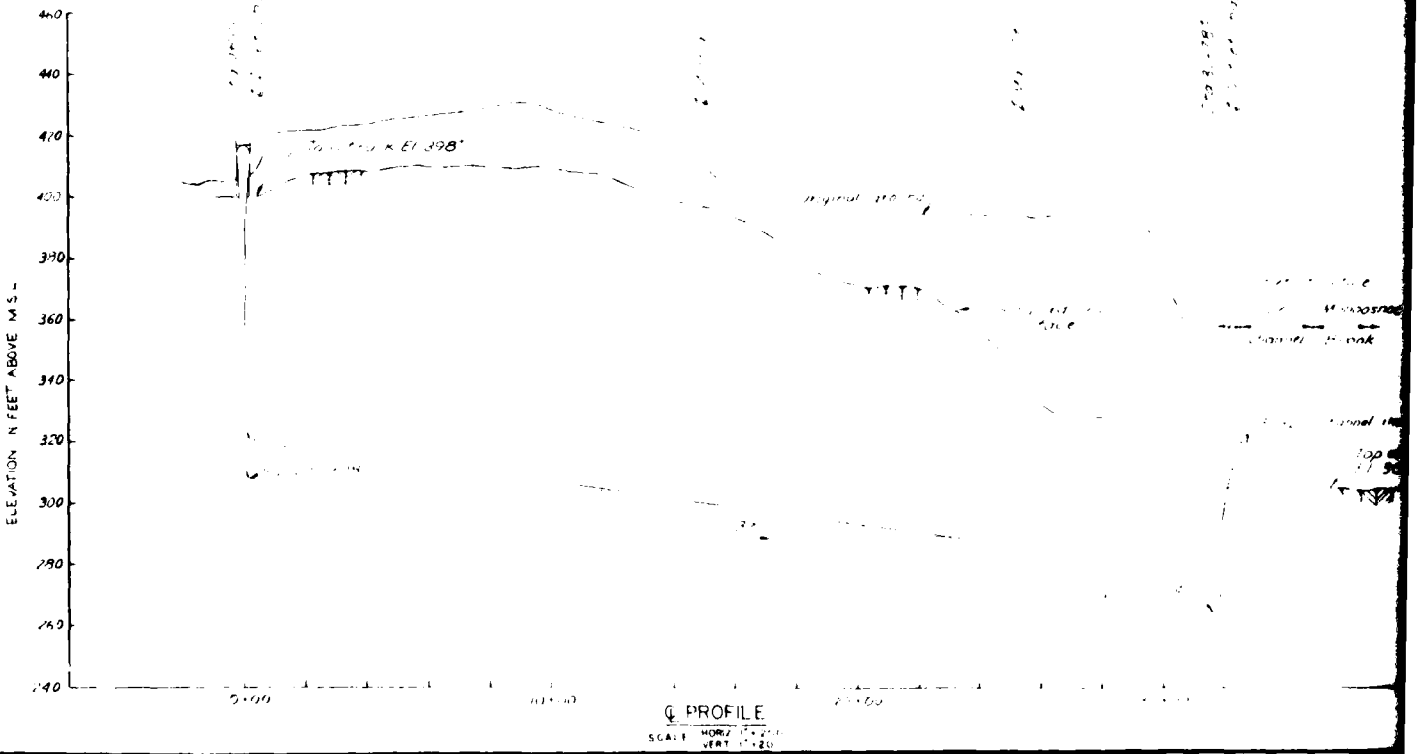
WATER RESOURCES FEASIBILITY REPORT
LEOMINSTER, MASS
LOCAL PROTECTION PROJECT
BASIN MAP
MONOOSNOC BROOK MASSACHUSETTS
DATE NOV. 1976

PLATE 1

CORPS OF ENGINEERS

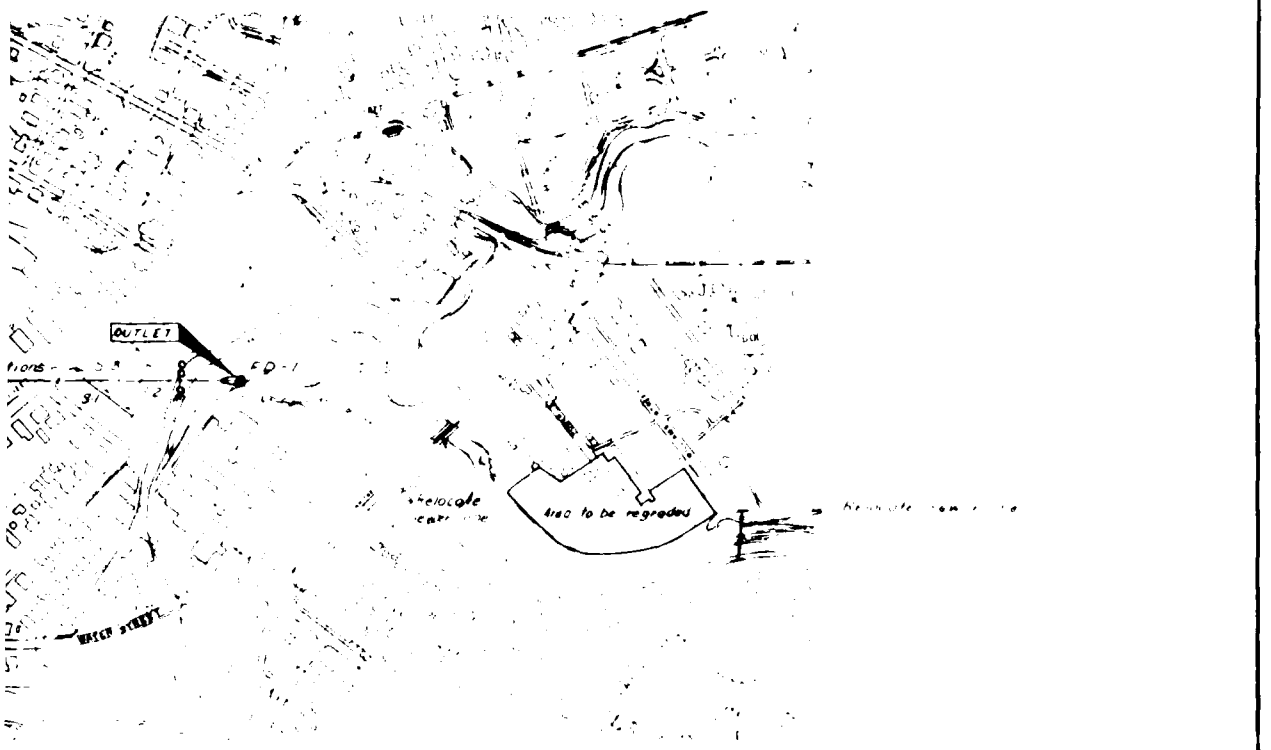


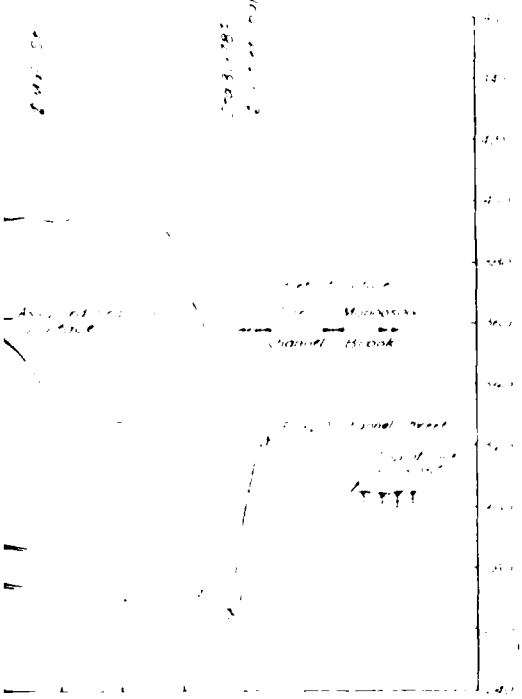
PLAN
SCALE 1" = 200' ±



℄ PROFILE
SCALE HORIZ 1" = 200'
VERT 1" = 20'

U S ARMY





GRAPHIC SCALE

1" = 20'

1" = 200'

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

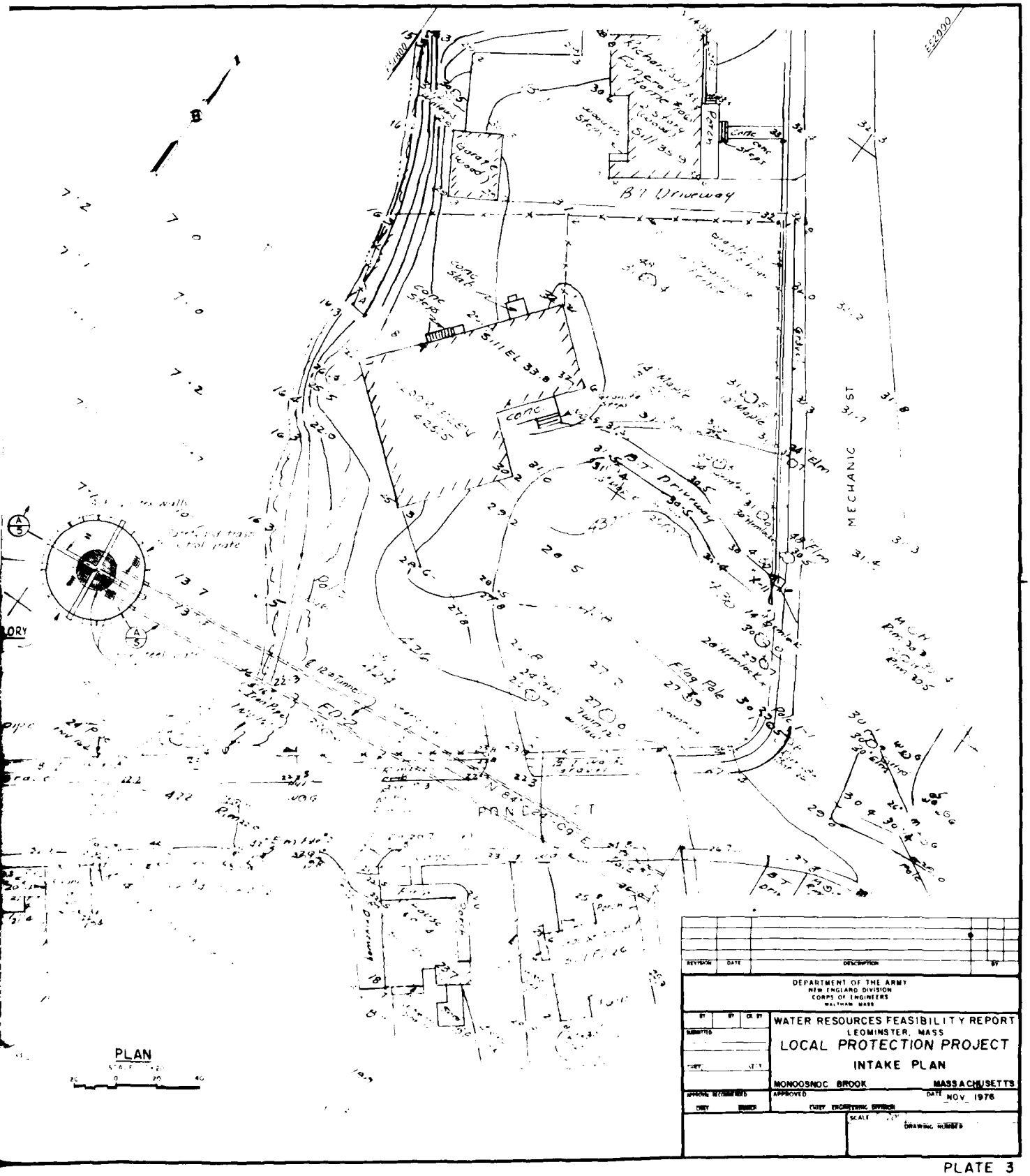
WATER RESOURCES FEASIBILITY REPORT
LEOMINSTER MASS
LOCAL PROTECTION PROJECT
GENERAL PLAN & PROFILE
MONOOSNOC BROOK MASSACHUSETTS
DATE NOV 1975

SHEET

PLATE 2


B
Granite Conc. Spillway
POND
PLAN

U. S. ARMY



PLAN

REVISION	DATE	DESCRIPTION	BY

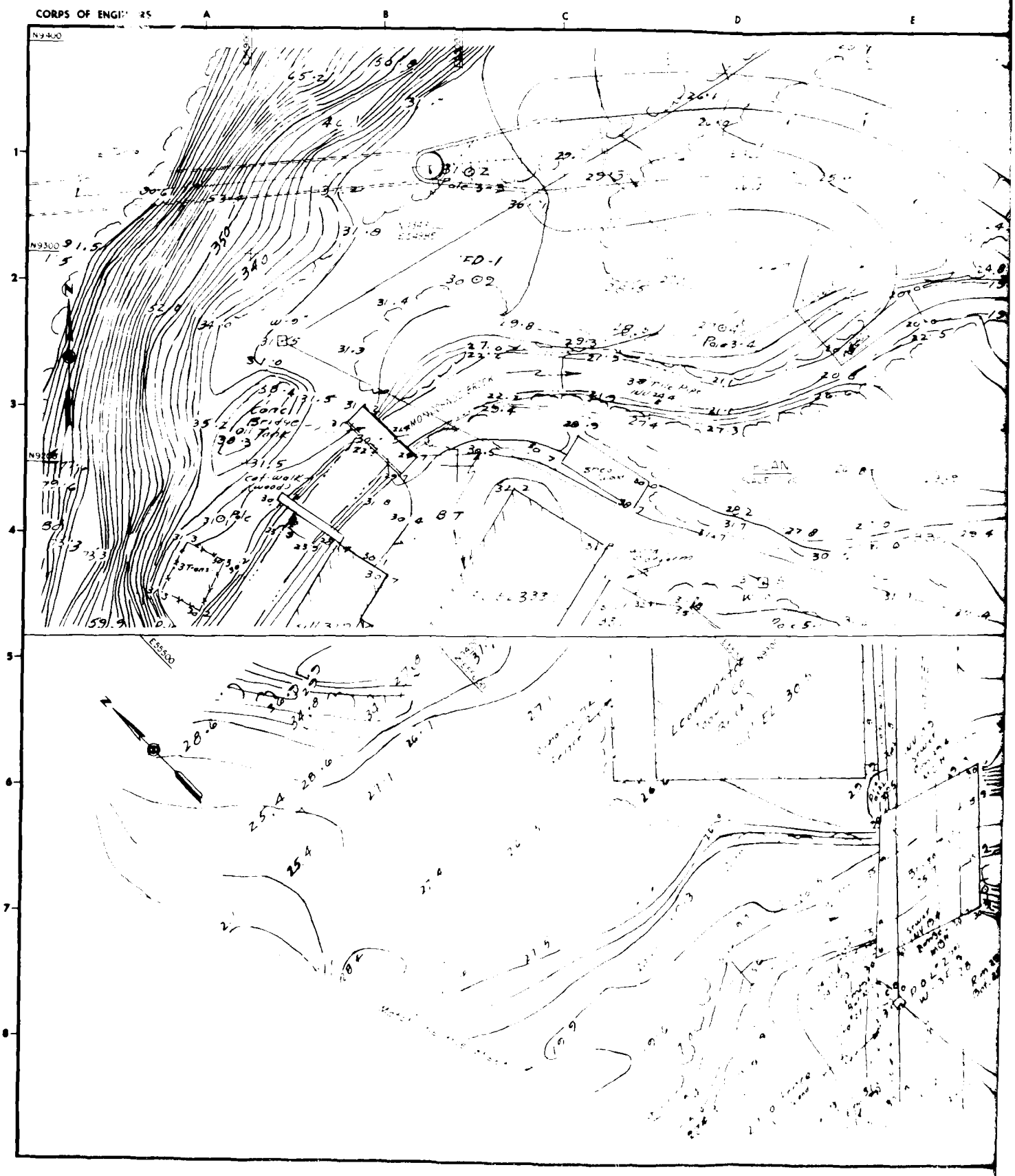
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

WATER RESOURCES FEASIBILITY REPORT
LEOMINSTER, MASS
LOCAL PROTECTION PROJECT
INTAKE PLAN
NONOOSNOC BROOK MASSACHUSETTS

APPROVED DATE NOV. 1976
CHIEF ENGINEERING DIVISION

SCALE
DRAWING NUMBER

PLATE 3


CORPS OF ENGI
A
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D
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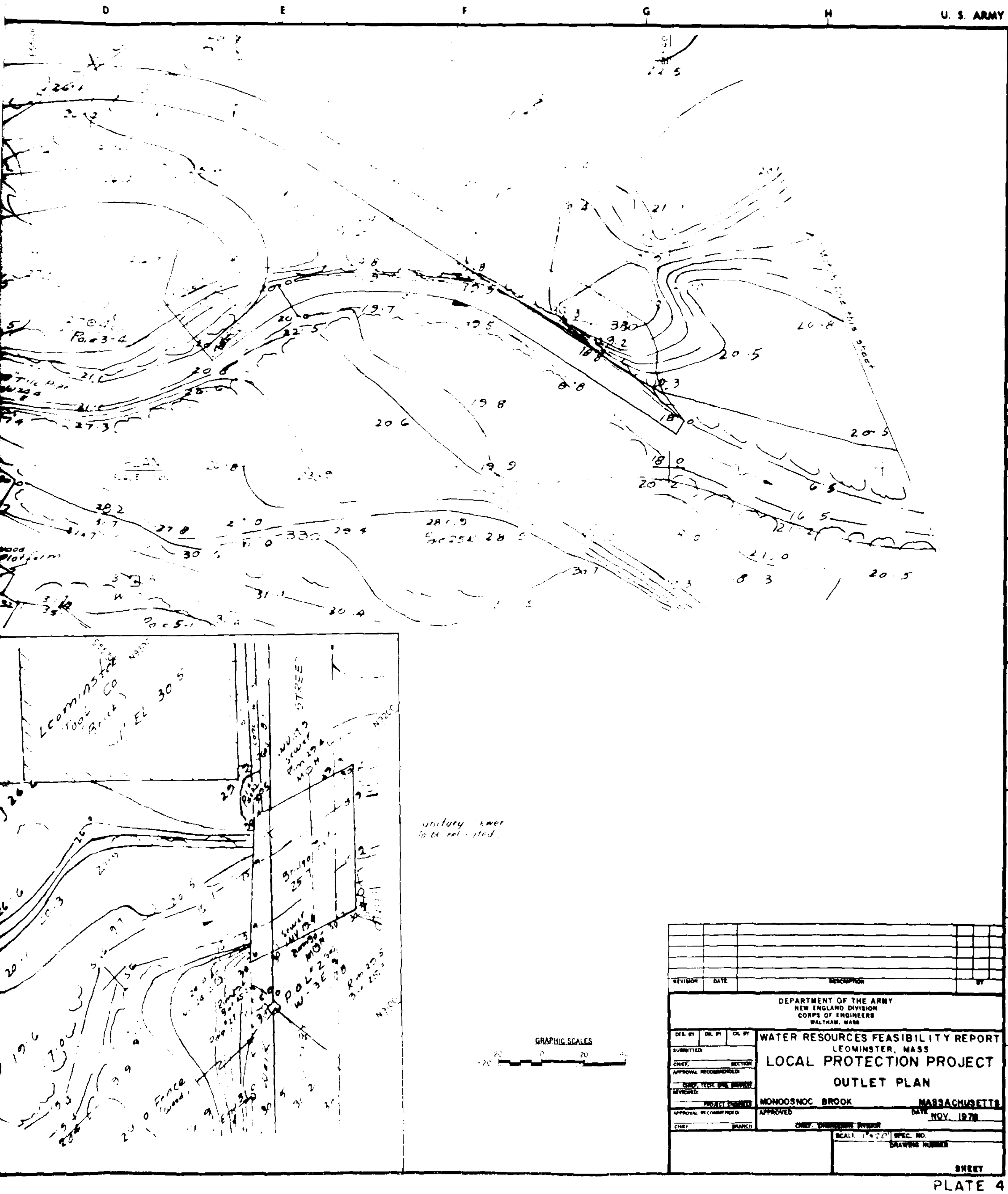
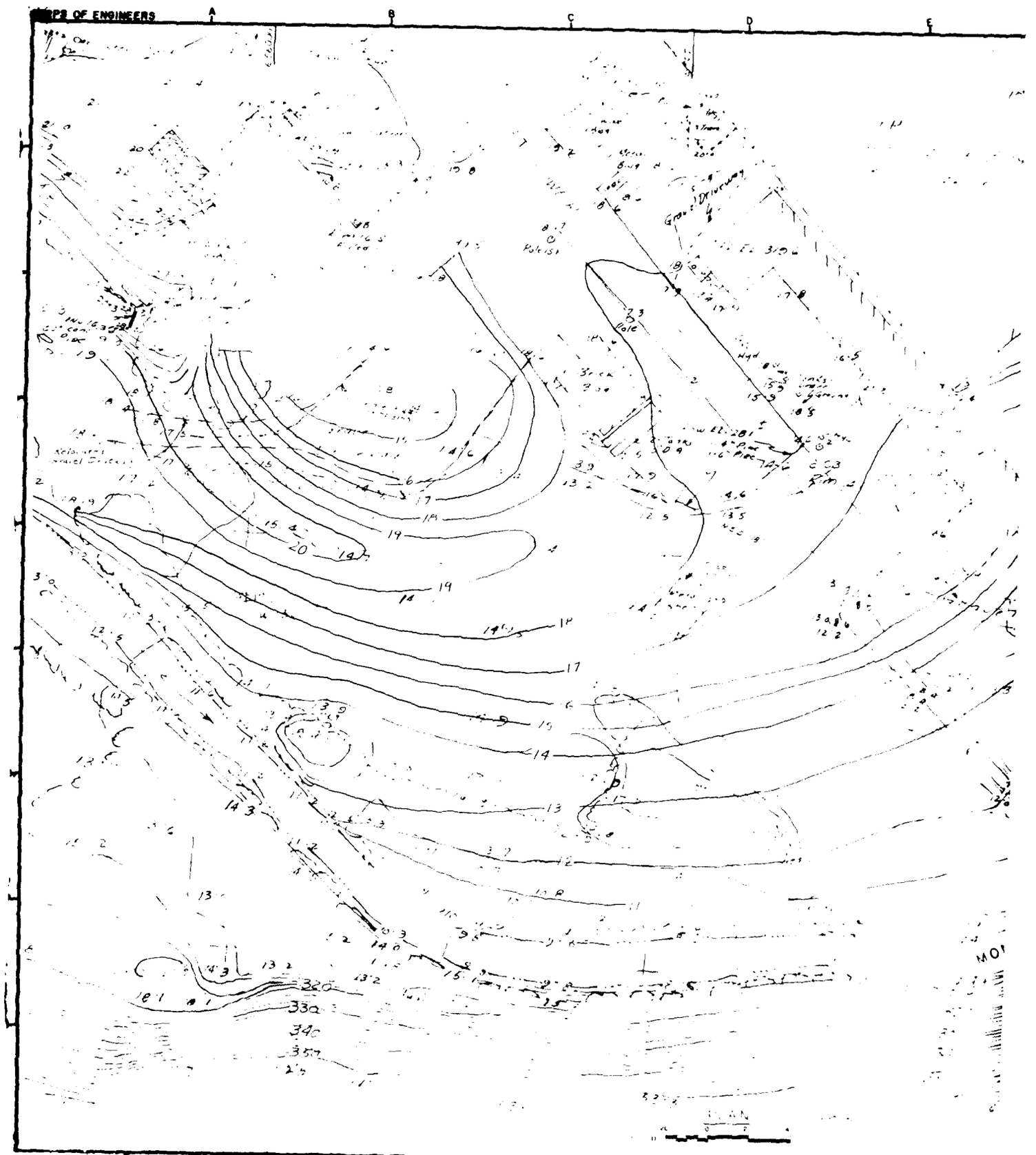
2
3
4
5
6
7
8
N9400
N9300
E5500
FD-1
Tantalli Bridge
Cat walk (wood)
3 Trans
PLAN



U. S. ARMY
GRAPHIC SCALES
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS
WATER RESOURCES FEASIBILITY REPORT
LEOMINSTER, MASS
LOCAL PROTECTION PROJECT
OUTLET PLAN
MONOOSNOC BROOK
MASSACHUSETTS
APPROVED
DATE NOV. 1978
SCALE 1" = 20'
SPEC. NO.
DRAWING NUMBER
SHEET

PLATE 4


CORPS OF ENGINEERS
A
B
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D
E
Reservoir Control Center
Hole
Gravel Driveway
Pole
Hydr
Elec
Gas
Water
Sewer
Storm
Phone
Overhead
Fence
Bldg
Concrete
Asphalt
Gravel
Dirt
Grass
Trees
Brush
Rock
Wall
Curb
Edge
Top
Bottom
Toe
Slope
Ditch
Culvert
Manhole
Valve
Meter
Box
Pipe
Conduit
Wire
Cable
Guy
Anchor
Light
Sign
Mailbox
Bench
Table
Chair
Umbrella
Flag
Pole
Tree
Shrub
Bush
Rock
Boulder
Stone
Gravel
Sand
Dirt
Grass
Lawn
Garden
Flower
Vine
Leaf
Branch
Trunk
Root
Bark
Seed
Fruit
Nut
Berry
Cone
Needle
Twig
Bud
Flower
Petal
Stem
Leaf
Vein
Edge
Tip
Base
Apex
Margin
Surface
Underside
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North
South
East
West
Northeast
Northwest
Southeast
Southwest
Inside
Outside
Above
Below
Between
Among
Around
Through
Over
Under
Beside
Next
Near
Far
Close
Distance
Scale
Feet
Meters
Miles
Kilometers
Inches
Centimeters
Millimeters
Yards
Rods
Chains
Links
Degrees
Minutes
Seconds
Latitude
Longitude
Elevation
Depth
Height
Width
Length
Area
Volume
Weight
Mass
Density
Pressure
Temperature
Time
Date
Year
Month
Day
Hour
Minute
Second
Clock
Watch
Calendar
Schedule
Plan
Map
Chart
Graph
Table
Figure
Diagram
Sketch
Drawing
Picture
Photo
Image
Print
Copy
Original
Draft
Final
Revision
Version
Edition
Publication
Author
Editor
Publisher
Printer
Binder
Cover
Page
Chapter
Section
Paragraph
Sentence
Word
Letter
Number
Symbol
Mark
Line
Curve
Point
Angle
Circle
Square
Rectangle
Triangle
Polygon
Solid
Hollow
Filled
Empty
Full
Half
Quarter
Third
Fifth
Sixth
Seventh
Eighth
Ninth
Tenth
Hundredth
Thousandth
Millionth
Billionth
Trillionth
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Billion
Trillion
Quadrillion
Quintillion
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Septillion
Octillion
Nonillion
Decillion
Undecillion
Duodecillion
Tredecillion
Quattuordecillion
Quindecillion
Sexdecillion
Septendecillion
Octodecillion
Novemdecillion
Vigintillion
Centillion
Googol
Googolplex
Infinity
Zero
One
Two
Three
Four
Five
Six
Seven
Eight
Nine
Ten
Eleven
Twelve
Thirteen
Fourteen
Fifteen
Sixteen
Seventeen
Eighteen
Nineteen
Twenty
Thirty
Forty
Fifty
Sixty
Seventy
Eighty
Ninety
Hundred
Thousand
Million
Billion
Trillion
Quadrillion
Quintillion
Sextillion
Septillion
Octillion
Nonillion
Decillion
Undecillion
Duodecillion
Tredecillion
Quattuordecillion
Quindecillion
Sexdecillion
Septendecillion
Octodecillion
Novemdecillion
Vigintillion
Centillion
Googol
Googolplex
Infinity

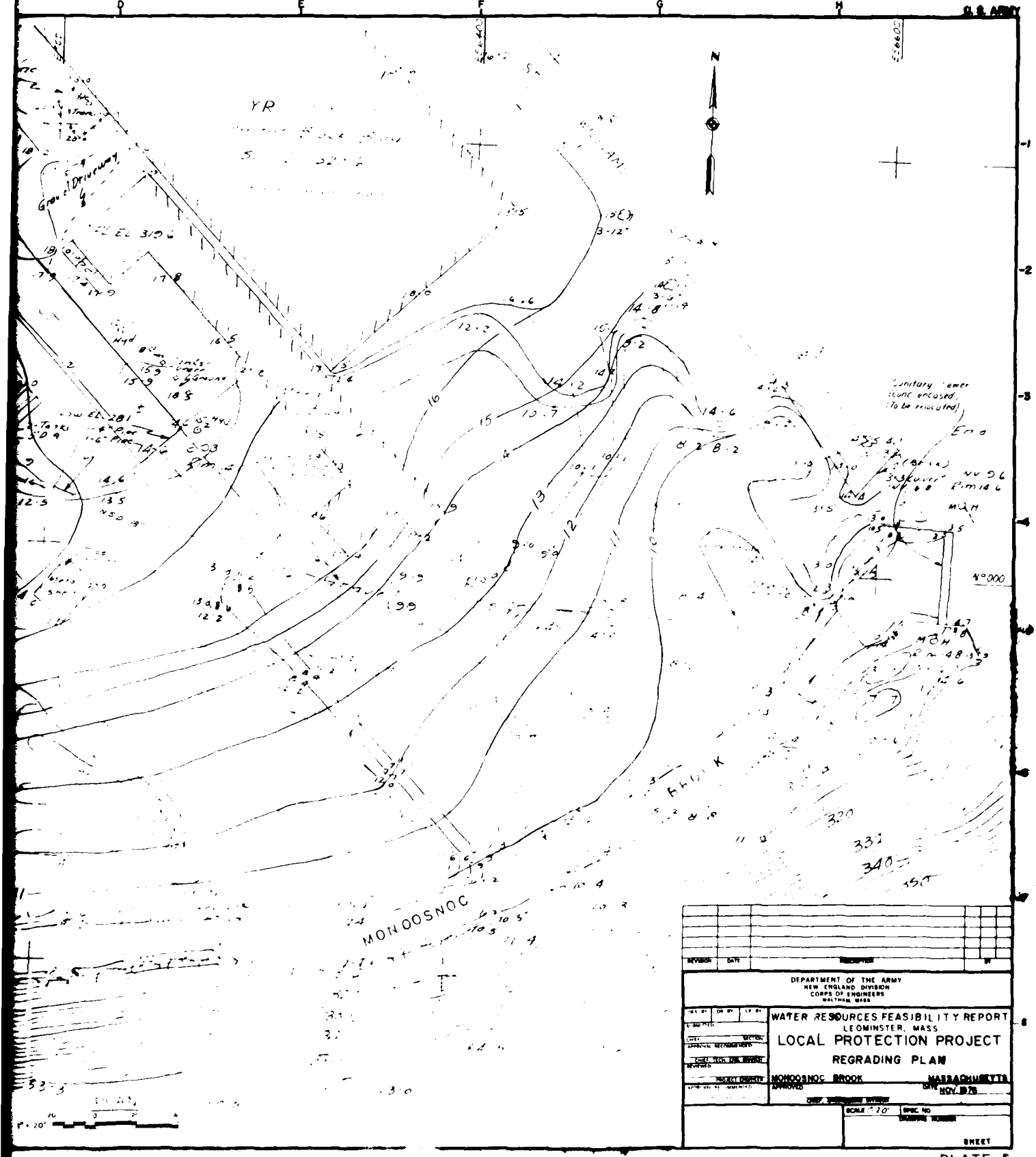
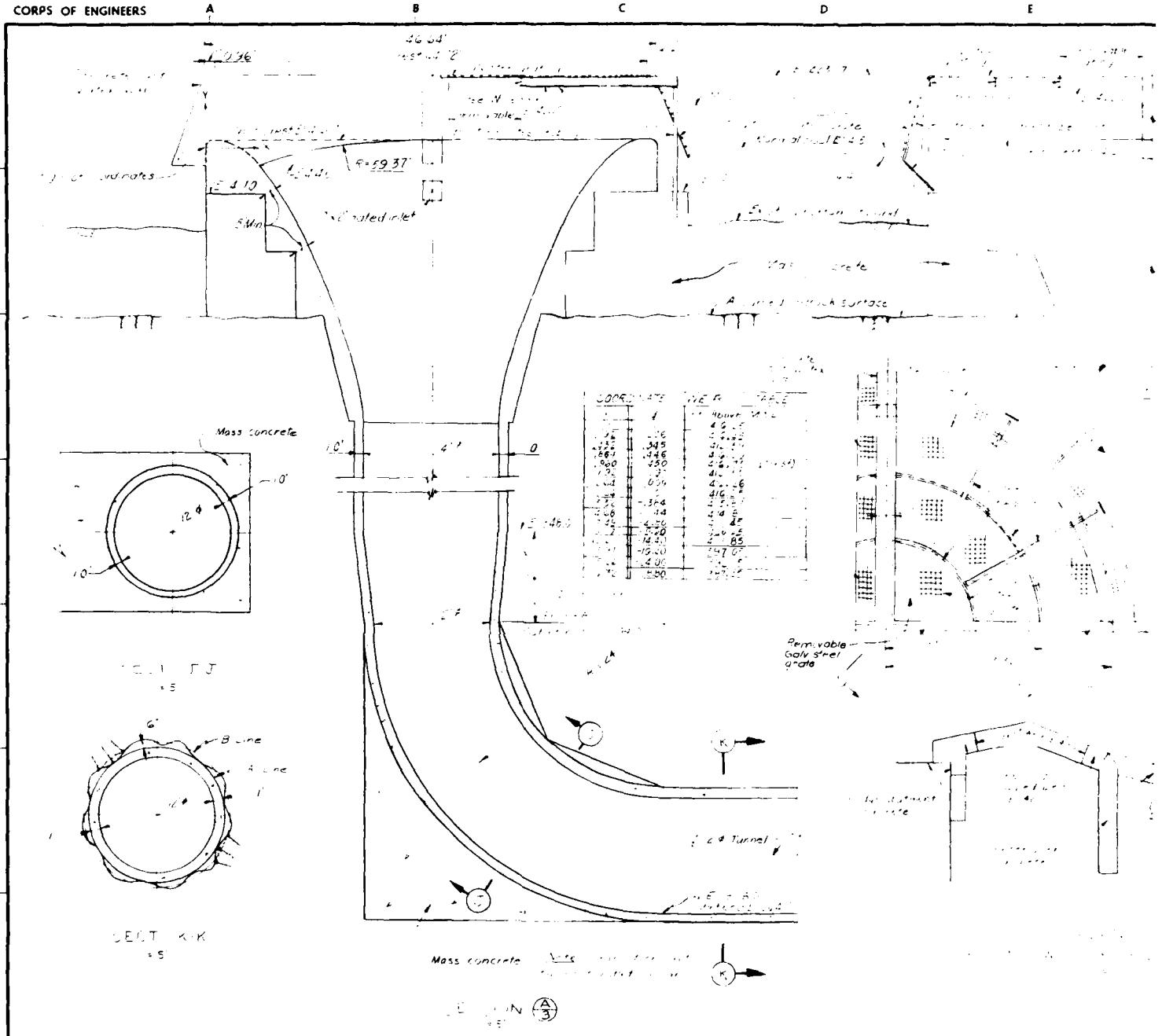
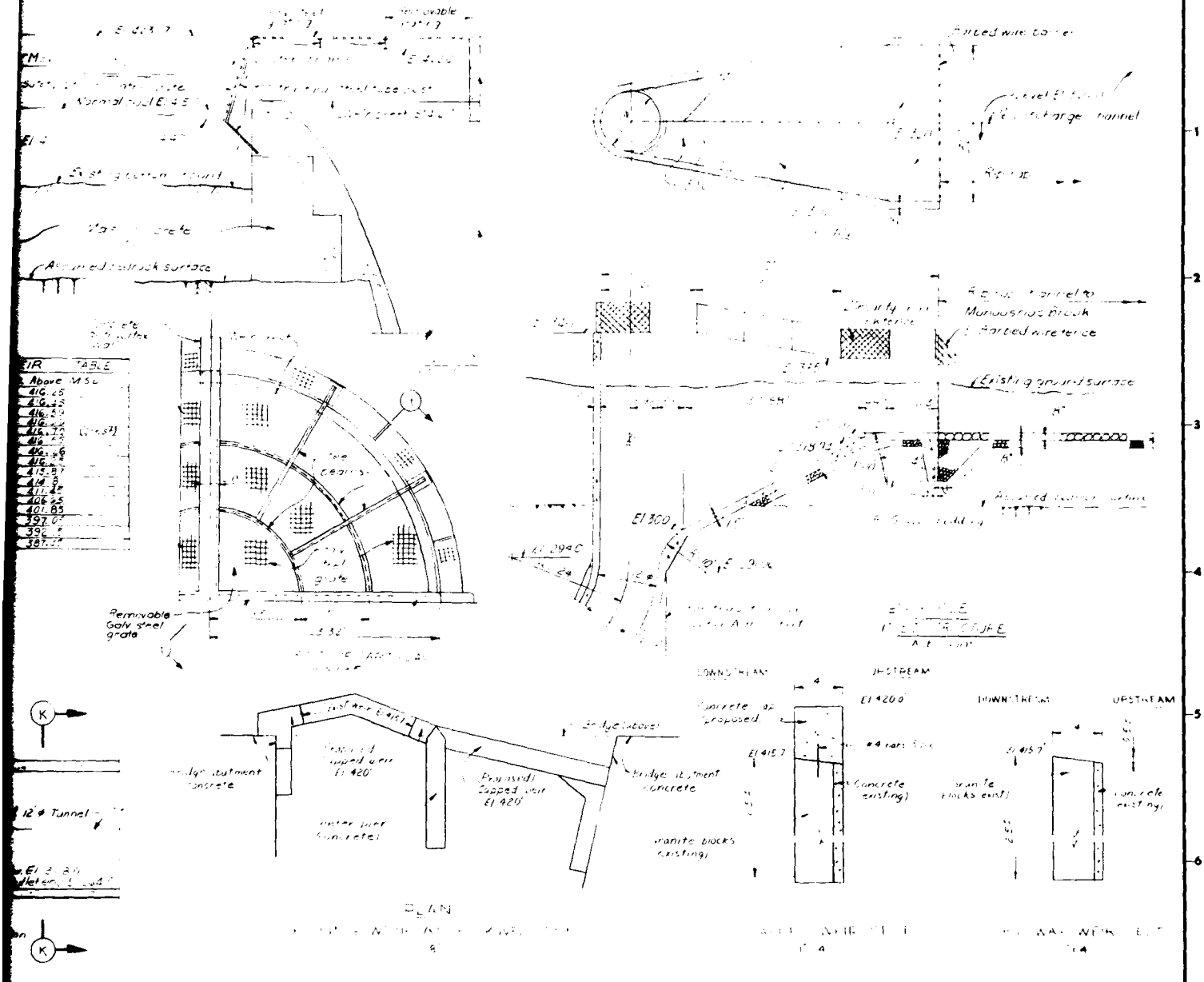

D
E
F
G
H
U.S. ARMY
N
MONOOSNOC
Sanitary sewer (conc encased) (To be relocated)
N°000
MH
REVISION
DATE
DESCRIPTION
BY
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
WATER RESOURCES FEASIBILITY REPORT
LEOMINSTER, MASS
LOCAL PROTECTION PROJECT
REGRADING PLAN
MONOOSNOC BROOK
MASSACHUSETTS
NOV. 1975
SCALE 1" = 20'
SHEET

PLATE 5

CORPS OF ENGINEERS



D E F G H U S ARMY



WEIR TABLE	
	Above MSL
Elev. 25	
Elev. 25	
Elev. 54	
Elev. 54	
Elev. 54	(crest)
Elev. 54	
Elev. 54	
Elev. 54	
Elev. 54	
Elev. 54	
Elev. 54	
Elev. 54	
Elev. 54	
Elev. 54	
Elev. 54	

GRAPHIC SCALES

1" = 4'	0	4	8	
1" = 5	0	5	10	
1" = 8	0	8	16	
1" = 10	0	10	20	

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

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

WATER RESOURCES FEASIBILITY REPORT
LEOMINSTER, MASS
LOCAL PROTECTION PROJECT
SECTIONS AND DETAILS
MONOOSNOC BROOK MASSACHUSETTS

APPROVED DATE NOV 1976
CHIEF ENGINEERING DIVISION

SCALE AS SHOWN SPEC NO
DRAWING NUMBER
SHEET

PLATE 6

NEW ENGLAND DIVISION

LEOMINSTER
LOCAL PROTECTION
MONOOSNOC BROOK
Leominster, Massachusetts

APPENDICES

Feasibility Report for WATER RESOURCES DEVELOPMENT

LEOMINSTER LOCAL PROTECTION
MONOOSNOC BROOK
LEOMINSTER, MASSACHUSETTS

FEASIBILITY REPORT FOR
WATER RESOURCES DEVELOPMENT

Technical Report

APPENDIX 1

PREPARED BY THE
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

SECTION A

THE STUDY AND REPORT

THE STUDY AND REPORT

TABLE OF CONTENTS

SECTION A

THE STUDY AND REPORT

Background information concerning the authorization of this study and a description of the nature of the study are presented here as an introduction to the contents and findings of this report.

Purpose and Authority

The purpose of this study, the results of which are presented in this technical appendix, is to investigate the flood and associated water resources problems in the watershed of Monoosnoc Brook and to develop the most suitable plan that would solve these problems. Economic feasibility was one of the major factors considered in selecting a plan and was, therefore, investigated in detail. Recommendations of this study are presented in the main report.

This report is submitted in partial compliance with authority provided in the Resolution by the Committee on Public Works of the United States Senate adopted 9 February 1961. The Resolution reads as follows:

> "That the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbor Act, approved 13 June 1902, be, and is hereby requested to review the reports of the Chief of Engineers on the Merrimack River, New Hampshire and Massachusetts, published as House Document Numbered 689, Seventy-fifth Congress, third session, and other reports, with a view to determining the need for modification of the recommendations contained in such reports, and the advisability of adopting further improvements for flood control and allied purposes in view of the heavy damages and loss of life caused by recent severe storms in the Merrimack River Basin."

An Interim Report in partial compliance with the authority provided by the Resolution was submitted during January 1965. This report recommended a plan of flood control for Monoosnoc Brook. The plan was authorized as part of the Flood Control Act of 1966 (Senate Document 113/89/2). However, the proposed project was subsequently placed in a deferred category because of changing local interest requirements. At the request of Congressional and local interests, the restudy was initiated during August 1974.

Scope of Study

This report includes a study of water resources problems in the watershed of Monoosnoc Brook in Leominster, Massachusetts. Its purpose was determining the advisability of improvements in the interest of flood control and allied purposes. The inter-disciplinary planning approach of Principles and Standards (P&S) was utilized throughout this study. The P&S planning process requires a systematic approach to the development of plans to satisfy the water resource needs and problems of the community. Although the current study of Monoosnoc Brook directly evolved from a reevaluation of flood control measures authorized by the 1966 Flood Control Act, as requested by Congressman Robert F. Drinan, the procedures of P&S were utilized in the public involvement and agency coordination programs. This is more fully detailed in Appendix 1, Section C - Problems and Needs, Section F - Formulating a Plan, and Appendix 2, Pertinent Correspondence.

All reasonable alternative plans to solve the areas water resources problems were considered. Several plans were studied in detail that included computing cost and benefit estimates. Selection of the most feasible plan was made after considering all factors, including comments expressed by concerned agencies and local interests. The studies were developed to the depth and detail needed to determine the feasibility of the alternatives and to permit plan selection. To ensure the most useful information base, information developed during prior and ongoing study programs was utilized.

Study Participants and Coordination

The Corps of Engineers has the principal responsibility for conducting and coordinating the study and the plan formulation, consolidating information from studies of other agencies and preparing this report.

All studies for this report were coordinated with appropriate Federal, State and local agencies including the U.S. Fish and Wildlife Service, U.S. Department of Housing and Urban Development, U.S. Economic Development Administration, USDA Soil Conservation Service, U.S. Environmental Protection Agency, New England River Basins Commission and various resource agencies of the Commonwealth of Massachusetts and the city of Leominster. The coordination was achieved through informal meetings to discuss the alternative plans, review of and comments on the preliminary draft environmental statement for the selected plan, and participation in the formal public meetings.

During the investigation, several informal meetings were held with various Federal, State and local interests. Correspondence with interested citizens has also furthered the progress of the studies. Pertinent letters of comment and concurrence are contained in Appendix E of this report.

A public meeting was held on 27 January 1976 to present all alternatives studied during the investigation and to incorporate public needs and desires in the final plan formulation and selection. The plan of flood control improvements selected at this meeting is the plan recommended in this report.

Summary of Studies

U.S. Geological Survey, Massachusetts Dept. of Public Works, aerial topography, municipal and other existing maps were utilized to determine basin characteristics and land use. Subsurface explorations by means of drive sample bore holes and geological reconnaissance were accomplished after the final plan of improvements was chosen based on the needs and desires of the community.

Surveys of flood damages were made following the floods of 1938 and 1955, and detailed damage surveys were conducted in 1962 and again in 1974. The surveys consisted of personal interviews with municipal and State officials, officers of industrial concerns and private individuals subject to flood losses.

The Report

In the interest of clarity of presentation and reference, this report has been arranged into a main report and two appendices.

The main report is a nontechnical presentation of the studies of flood and associated water resources problems in the watershed of Monoosnoc Brook. It is the basic document that presents a broad view of the overall study for the benefit of both general and technical readers. Included in the main report is a description of the study area, including existing improvements; the problems being experienced and the need for additional improvements; a summary of the project economics giving the benefits, costs and justification; the division of plan responsibilities between Federal and non-Federal interests; and recommendations for implementing the selected plan.

Appendix 1 is a technical report following the same general outline as the formulation and evaluation part of the main report but presented in greater detail for the technical reviewer. Descriptions of the problems and solutions are presented in the same order as in the main report. Appendix 2 contains pertinent correspondence from local officials as well as Federal and State agencies. The Draft Environmental Impact Statement (EIS) is also included as Attachment 1.

Prior Reports

Several reports have been prepared by the Corps of Engineers concerning water resource improvements in the Merrimack River and its tributaries, including the North Nashua River and Monoosnoc Brook.

These earlier reports resulted in the construction of four reservoirs and five local flood protection projects at five locations in the Merrimack River Basin. More recently authorized studies recommended additional improvements for water resource development in the North Nashua River and Monoosnoc Brook watersheds. A summary of these reports follows.

"308" Report

The Merrimack River in New Hampshire and Massachusetts was studied by the Corps of Engineers under provisions of House Document No. 308, 69th Congress, 1st Session, which was enacted into law with modifications in Section 1 of the River and Harbor Act of 21 January 1927. The reports that followed became known as "308" Reports. The Merrimack River "308" report was published as House Document No. 649, 71st Congress, 3rd Session. It determined that navigation, flood control, power development and irrigation improvements were not warranted at that time.

Survey Reports for Flood Control

Following the flood of 1936, a report for the Merrimack River Basin dated 18 May 1938 was submitted and published as House Document 689, 75th Congress. The report recommended the construction of a system of flood control reservoirs and related flood control works. The present system constructed under this authority included four reservoirs and local flood protection projects at five locations. The reservoirs include Franklin Falls, Blackwater, Hopkinton-Everett and Edward McDowell while the local protection projects are located at Nashua and Wilton, New Hampshire and Lowell, Saxonville and Haverhill, Massachusetts.

NENYIAC Report

The report of the New England-New York Inter-Agency Committee (NENYIAC) considered all aspects of the land and water resources of the area. The report was published as Senate Document No. 19, 85th Congress, 1st Session. Chapter XV of Part Two of the report covers the problem of flood control in the Merrimack River Basin. It determined that additional flood control measures were needed in the basin.

Interim Report

In compliance with authority provided in a Resolution by the House Committee on Public Works of the United States adopted 9 February 1961, a survey was made to determine "the advisability of adopting further improvements for flood control and allied purposes in view of the heavy damages and loss of life caused by recent severe

storms in the Merrimack River Basin." An interim report dealing with the Water Resources Development Plan, North Nashua River Basin, was prepared in 1965. Based on the findings of the interim report, the 89th Congress (Public Law 89-789) authorized the construction of the Monoosnoc Brook Channel Improvement and Monoosnoc Dam and Lake.

NAR Report

The North Atlantic Regional Water Resources Study was one of 20 regionwide comprehensive water and related land resources studies conducted throughout the United States under guidelines established by the 1965 Flood Control Act (Section 209, Public Law 89-298). The study's objective was the establishment of a broad master plan or framework to serve as a basis for future regional water resources development and management plans. The requirements of the residents were considered in analyzing needs such as water quality control, flood control, municipal and industrial water supply, irrigation and rural water supply, navigation, hydroelectric power, recreation, fish and wildlife and other environmental resources. These needs are projected through the year 2020. The study began in 1966 and was completed in June 1972.

Northeastern United States Water Supply Study (NEWS)

The unprecedented drought that started in 1960 over the northeastern seaboard of the Nation led Congress to authorize the Secretary of the Army, in October 1965, to cooperate with Federal, State and local agencies in preparing plans to meet the long-range water requirements of the northeastern United States. Congress anticipated that such plans could include major reservoirs, major conveyance facilities to transfer water between river basins and major purification facilities to be constructed under Federal auspices with appropriate non-Federal financial participation. The NEWS Study was initiated in 1966 and was completed in 1974.

Merrimack River Basin Survey Report

A study of Survey Report scope was completed in August 1972, the last in a series of reports authorized by the Congressional resolutions of 1938, 1961 and 1964. Although the 1972 report covered the entire Merrimack River Basin, solutions to water resource problems involving the North Nashua and Sudbury Rivers had been suggested in the earlier interim reports. The final report recommended no additional flood control or navigation improvements in the Merrimack River Basin.

Merrimack River Wastewater Management Study

A wastewater management study of the Massachusetts portion of the Merrimack River Basin was published in June 1975. The study was a joint effort by the Commonwealth of Massachusetts and five regional planning agencies in the Environmental Protection Agency and the Nashua River Program. The study investigated point and nonpoint sources of pollution, including municipal, industrial and stormwater wastes, and proposed system alternatives that varied from decentralized to large centralized or regional facilities. The study team investigated the possibility of utilizing land application methods as well as water-oriented treatment plants to purify wastewaters. The study was conducted to meet the criteria of the Federal Water Pollution Control Act Amendment of 1972.

Floodplain Information Report

A Floodplain Information study report for the city of Leominster, prepared by the New England Division, was published in October 1976. The city of Leominster is now eligible for flood insurance under the emergency flood insurance program.

Studies in Progress

Flood Insurance Report

A flood insurance study report for the city of Leominster is being prepared by the Federal Insurance Administration (FIA). As previously noted, the city of Leominster is now eligible for flood insurance under the emergency flood insurance program. Residential homes can obtain flood insurance coverage of up to $35,000 for $0.25 per $100 (a subsidized rate). Additional subsidized coverage for contents, up to $10,000, is also available. When rate maps are published by FIA and the city officially enters the program, property owners will be able to get additional coverage up to $185,000 for structural damages, plus an additional $50,000 coverage for contents.

SECTION B

RESOURCES AND ECONOMY OF THE STUDY AREA

RESOURCES AND ECONOMY OF STUDY AREA

TABLE OF CONTENTS

TABLES

SECTION B

RESOURCES AND ECONOMY OF STUDY AREA

This section of the Technical Appendices presents an analysis of natural and human resources for the Leominster area, as well as environmental, climatology and archaelogical data. Economic development information also is furnished along with tables of population, income and employment.

Environmental Setting and Natural Resources

A general understanding of the resources and economy affected by the proposed project is helpful in identifying the problems of the area and in selecting appropriate solutions. The resources and economy of the study area were analyzed on two levels. First, the cities of Leominster and Fitchburg, which form the economic base study area, were analyzed to determine the broad economic setting of the project. Secondly, the area immediately surrounding the project, referred to as the study area, was analyzed to determine the project's specific impacts on the adjacent land.

TERRAIN AND LAND USE

Monoosnoc Brook rises in Rocky Pond in the hills west of Leominster and flows in an easterly direction for 8.7 miles, through the commercial center of Leominster to its confluence with the North Nashua River.

The Monoosnoc Brook watershed totals 11.2 square miles and is located along the eastern margin of the New England upland in central Massachusetts. It is a region of moderate relief, characterized by wide valleys and broad, steep-sided hills that are conducive to rapid runoff. The brook flows through the Massachusetts western highland, a rough, naturally disected upland, controlled largely by the underlying crystalline bedrocks that outcrop on the upper slopes and tops of many of the hills.

Remnants of the glacial outwash occupy the bottoms of many of the major valleys. Variably thick deposits of glacial till lie above the outwash and along the upper slopes of the region.

Bedrock in the vicinity of the proposed improvement is a gray, dense, hard, unweathered phyllite at the intake end and a similarly gray, hard schist at the outlet site; both forms intermingle between. The rock lies from 7 to 70 feet below the surface. Covering the bedrock are varying quantities of overburden, consisting of silty and gravely sands and till.

The Monoosnoc Brook Basin comprises two significantly contrasting areas. The rural upper basin and the urbanized lower area are separated by Rockwell Pond, a small pond, located just upstream of the urban center of Leominster.

The upper basin is primarily steep forested hills with some large rock outcropping. The area contains several reservoirs and ponds along Monoosnoc Brook and its tributaries. Much of the forested area is virgin woods within the Leominster State Forest. Although the area is rural, steep slopes make the upper basin conducive to rapid runoff.

Downstream of Rockwell Pond, the lower basin is characterized by urbanization and channelization. Manufacturing, retail structures and multifamily housing have encroached on the brook resulting in channelization, bridges and conduits through the city. In the past central Leominster has had major flooding problems, due to these restrictions.

HISTORICAL AND ARCHAEOLOGICAL RESOURCES

In accordance with the Corps guidelines 33 CFR Part 305.16 (a), New England Division engaged a professional archaeologist to conduct a cultural resource reconnaissance. This preliminary study was made to

identify, locate and record any cultural resources within the proposed project area. The archaeologist's report did not cite any significant resources, either historical or archaeological, which would be disturbed by the proposed project. The report did state that areas adjacent to the outlet structure are archaeologically sensitive because similar sites in New England have produced archaeological finds. Since no archaeological reconnaissance can be expected to locate all possible sites, the sensitive areas will be surveyed further during subsequent authorized studies. The Office of the Massachusetts Historical Commission (State Historic Preservation Officer) was contacted to determine whether any State Historic Landmarks, State Points of Interest, sites on the National Register of Historic Places, or sites in the process of being nominated to the National Register would be affected by this project. None were listed.

CLIMATE

The Monoosnoc Brook watershed, situated within the North Nashua River watershed, has a variable climate. It frequently experiences periods of heavy precipitation produced by local thunderstorms and larger weather systems of tropical and extra-tropical origin. The basin lies in the path of the prevailing "westerlies" that traverse the country in an easterly or northeasterly direction and produce frequent weather changes. Temperature extremes within the basin range from summertime highs of about 100°F to subzero temperatures in the minus teens occurring for short periods in the winter.

The mean annual temperature in the North Nashua River watershed is about 48°F. Recorded temperature extremes at representative stations within or adjacent to the watershed have varied from a maximum of 103°F at Fitchburg to a minimum of -22°F at Clinton, Massachusetts. Freezing temperatures may be expected from the later part of September until late in April.

The average annual precipitation over the North Nashua River Basin is approximately 45 inches, uniformly distributed throughout the year. The maximum and minimum annual precipitation at Fitchburg are 60.23 and 27.45 inches, respectively. Annual snowfall in the basin averages about 60 inches at Fitchburg which is located at about elevation 400 feet msl.

A more detailed description of climatology, including tables of temperature and precipitation, is included in Appendix 1, Section D-Hydrologic Analysis.

NATURAL RESOURCES

The Monoosnoc Brook watershed is an area of contrasts. In the upper basin, the stream flows through a series of reservoirs and small impoundments. This area is surrounded primarily by State or municipal forests which are dominated by oaks, hickories, hemlocks and maples. These forests are considered a transitional zone between the northern pines and hardwoods and the southern black birches, sweet gums, tulip trees and dogwoods.

The upper basin is primarily a small animal habitat. Animals such as gray squirrels, chipmunks, raccoons, foxes and field mice are present. Occasional deer can also be found in this area. A few species of minnows and suckers live in the brook, but for the most part the summer flows cannot maintain cold water species.

The brook is impounded at the outskirts of the city by Rockwell Pond, a warm water habitat. Species from the sunfish, catfish and sucker families are present. In the summer the pond has substantial growths of algae, indicating that the pond is in an advanced state of eutrophication.

Water leaving the pond goes through the city's center which is typical of industrial cities in New England, with its many factories and multipurpose dwellings lining the brook. For all intents and purposes, there is no mammal habitat present and only the heartiest of fish are found in this portion of the brook.

Beyond the city center, the land reverts to a small animal habitat with forest similar to the upper basin, although less dense.

Human Resources

The approximately 70 acres subject to flooding is located in Leominster, Massachusetts, a small manufacturing city with an estimated 35,000 residents. Comprising 28.8 square miles, the city lies in the Nashua River Valley less than 3 miles from the center of its northern

neighbor, Fitchburg. These two cities make up the core of the Leominster-Fitchburg Standard Metropolitan Statistical Area (SMSA) with a total population of 97,237 (1970 U.S. Census). Located approximately 40 miles from Boston and 200 miles from New York City, the area is accessible via highway routes 2, 12 and 117.

With new construction and other factors, the city's population has grown at an accelerating rate in the past 30 years. During the decade of 1955 to 1965, the population increased by 20.0 percent. Between 1965 and 1975 the population grew from 29,729 to 35,400 with a 7.5 percent increase in the last half of that period.

The city's share of the SMSA also increased from 33 percent in 1950 to 34 percent in 1970. The population density of Leominster increased from 836 persons per square mile in 1950 to 1,143 persons per square mile in 1970.

In 1970, 38.1 percent of the residents were either foreign born or first generation Americans. The largest number came from Canada. The migrations into Leominster are reflected in the ethnic diversity of the project area, namely French, Italian, Polish and, most recently, Spanish speaking persons. The Spanish speaking group numbered 634 in Leominster in the 1970 census as compared to 95 in Fitchburg.

In 1970 nearly 60 percent of Leominster families had school age children. In 27 percent of those families, the children were under the age of six. In the same year, 24 percent of the elementary school children were in private schools, principally parochial.

In 1960, 2.2 percent of the 8,099 housing units in Leominster were vacant and available for occupancy, while in 1972, 8.2 percent of the estimated 11,540 housing units in Leominster were vacant and available for occupancy. For reasons which have not been explored, Leominster experienced a sudden growth in housing construction beginning in 1970. The growth was principally in apartment complexes outside of the core area. Continued expansion is planned to attract a broad regional market.

The continuing growth in population has resulted in new demands on city resources, schools and sewerage in particular. After urban blight was identified as a problem in downtown areas, civic improvement activities increased and the search for new investment continued. The increasing numbers of automobiles and traffic in core areas and the high accident rate and lack of recreational facilities in town are also problems mentioned in local official reports. New highway construction is underway that will link Leominster to Worcester by a limited access highway. Under these pressures the city is updating its master plan, but protection against flooding in the core city is a continuing constraint to the revitalization program.

TABLE 1

POPULATION

	SMSA	LEOMINSTER	% OF SMSA
1950	73,120	24,075	33
1960	82,486	27,929	34
1970	97,237	32,939	34
1975		35,400	

POPULATION GROWTH IN LEOMINSTER

1950 — 1975

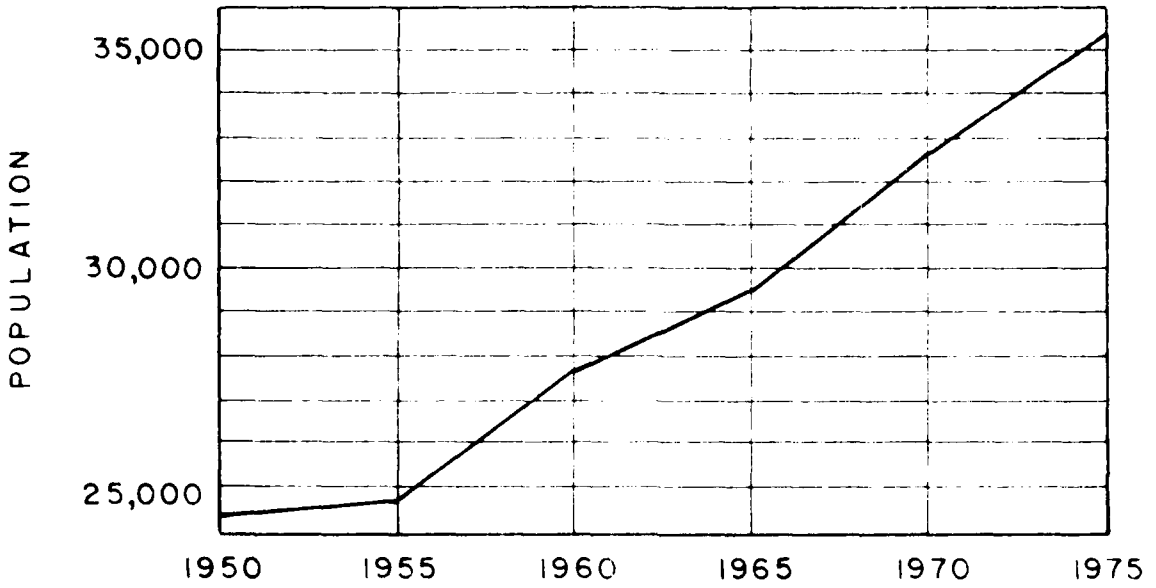
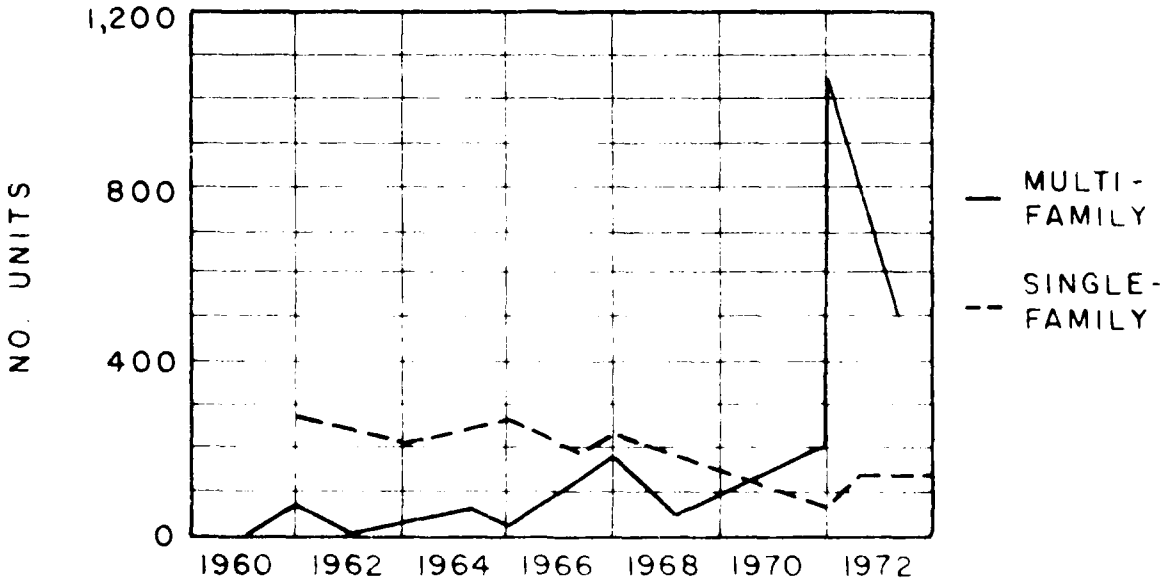


FIG. 2

BUILDING ACTIVITY IN LEOMINSTER

1960 — 1972



Economic Development

Leominster was established in 1740, and its initial growth depended on an agricultural base. Aided by a good location, its proximity to Boston and the abundance of water resources, Leominster was initially a manufacturing town and then became a city in 1915. Leominster repeatedly adapted itself to the manufacture of new products. The city shifted from comb making around 1845 to the production of piano cases, to the tanning of leather to the manufacture of baby carriages and even to dressmaking.

Today, Leominster can be characterized as a small city whose primary economic activity is manufacturing. In 1970, 650 Leominster firms reported to the Massachusetts Division of Employment Security. These firms employed 62.5 percent of the working population, or 11,455 persons for an annual payroll of $74,515,041.

In 1970, 140 manufacturing firms employed a total of 7,160 persons and had an annual payroll of $51,594,814. The five largest manufacturing groups, in order of importance as employers, were plastic products, apparel and other finished goods, machinery (except electrical), furniture and paper.

In 1971, 139 manufacturing firms employed a total of 6,631 persons and had an annual payroll of $50,349,359. The latest listing of Massachusetts manufacturers shows the Foster Grant Co., Inc. which makes plastic products, sun glasses, combs, etc. to be employing more than 1,500 persons.

Wholesale and retail trade is the city's largest nonmanufacturing employer. In 1970, 20 wholesale firms employed a total of 503 persons and had an annual payroll of $3,538,896 while 197 retail firms had an average of 2,273 employees with an annual payroll of $9,560,664.

In 1971, 22 wholesale firms employed an average total of 454 persons and had an annual payroll of $3,546,306, while 193 retail firms had a total of 2,433 employees with an annual payroll of $10,456,541.

The 1960 Census of Population, which reported information on the basis of residence rather than place of employment, listed 9,525 private wage and salary workers, 916 Government workers, 869 self-employed and 36 unpaid family workers living in Leominster. By 1970 census, these categories had increased to 11,527 private wage and salary workers, 1,397 Government workers, 787 self-employed and 52 unpaid family workers.

Leominster is part of the Fitchburg-Leominster Labor Area. This Labor Area had a labor force of 51,260 in August 1975, a gain of 1,105 in one year. The Labor Area's total employment figure of 43,720 in August 1975 was down from the 46,217 of August 1974, a decrease of 3,938. The unemployment rate (seasonally unadjusted) in this one year increased from 7.9 percent to 14.7 percent. The unadjusted State unemployment rate was 13 percent in August 1975.

TABLE 2

INCOME AND EMPLOYMENT

INCOME (1970)

	Leominster	SMSA	State
Total Personal	$108,039,920	$306,491,024	
Median Family	10,390	10,177	$10,835
Per Capita	3,280	3,152	3,425

EMPLOYMENT (1970)

	Leominster	Fitchburg-Leominster SMSA
Total employed 16 yrs. and over	13,578	39,210
Percent of population employed (16 yrs. and older)	41%	40%

Fitchburg-Leominster Labor Area

	August 1975	August 1974
Labor Force	51,260	50,155
Total Employment	43,720	46,217
% of Labor Force Employed	86%	92%
Total Unemployment	7,540	3,938
Unemployment Rate (Unadjusted)	14.7	7.9

TABLE 3

EMPLOYMENT AND PAYROLLS
(Prepared by Mass. Dept. of Commerce and Development)

ALL INDUSTRY

Industry	No. of Firms	Annual Payroll, 1970	Employees Aug. 1970	Distribution by Employees
1. Agriculture & Mining	4	$ 29,209	12	0.1%
2. Construction	105	3,930,439	443	3.9
3. Manufacturing	140	51,594,814	7,160	62.5
4. Trans., Comm., & Utilities	19	2,116,161	256	2.2
5. Wholesale & Retail Trade	207	13,099,560	2,776	24.2
6. Finance, Ins. & Real Estate	35	1,217,726	168	1.5
7. Service Ind.	140	2,527,132	640	5.6
TOTALS	640	$74,515,041	11,455	100.0

NOTE: The 1970 figures are based on the revised Standard Industrial Classification Code-1957. These figures are not comparable to tabulations of years prior to 1958.

MANUFACTURING (62.5% of the Average Employed Population)

Group	No. of Firms	Annual Payroll, 1970	Employees Aug. 1970
1. Ordnance and Accessories			
2. Food & Kindred Prod.	6	$ 559,198	104
3. Tobacco Mfg.			
4. Textile Mill Prod.	1)	3,281,623)	689)
5. Apparel & Other Fin. Goods	3)	)	)
6. Lumber & Wood Prod.	3	55,050	13
7. Furniture & Fixtures	8	2,556,936	314
8. Paper & Allied Prod.	3	1,892,213	273
9. Printing, Publishing & Allied	8	1,161,064	150
10. Chemicals & Allied	7	6,284,894	735
11. Prod. of Petroleum & Coal			
12. Rubber Products	49	26,372,576	3746
13. Leather & Leather Prod.			
14. Stone Clay & Glass Prod.	3	168,946	35
15. Primary Metal Industries	1)	12,171,134)	161)
16. Fabr. Metal Products	5)	)	)
17. Machinery (Ex. Electrical)	30	5,765,662	573
18. Electrical Machinery			
19. Transportation Equipment			
20. Prof., Scient. & Controlling Inst. Photo. & Optical Goods Watches & Clocks	1 firm included in Misc. Mfg. Ind.		
21. Miscellaneous Mfg. Ind.	13	2,279,518	367
TOTALS	140	51,594,814	7,160

According to the 1970 Census, Leominster had a per capita income of $3,280. This is lower than the State's $3,425 but higher than the SMSA's $3,152. The same relationship is apparent in comparing city, SMSA and State by median family income; $10,390, $10,177 and $10,835 respectively.

In summary, although housing and population have increased in the recent past, employment and trade have grown more slowly. Manufacturing has dropped. It appears that approximately half of Leominster residents are now employed outside the city and that the demand for municipal services due to population growth will continue.

SECTION C

PROBLEMS AND NEEDS

PROBLEMS AND NEEDS

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SECTION C

PROBLEMS AND NEEDS

The problems and needs of the city of Leominster and the region, concerning water and land related resources, are considerable, but they are not totally different from those of many similar urban areas of the United States. During 1963-65 a plan for flood control improvements along Monoosnoc Brook was developed as part of the authorized North Nashua River Basin Water Resources Development Plan. It is noted that, although the 1965 study did address water resources needs other than flood control (i.e., proposed multipurpose reservoir construction) a larger investment of funds would have been necessary at that time to ascertain the magnitude of all other problems and needs.

Meetings with city officials and concerned citizens were held at least annually from 1963 to 1971 to determine the extent of changing water resource needs and problems. The entire Monoosnoc Brook and Lake project was placed in a deferred status in 1971 when it was ascertained that additional water supply was no longer a need of the community and that a proposed urban renewal project had been rejected by the Leominster City Council.

A typical meeting was held with local officials on 11 September 1967. At this meeting the need for funds to construct channel improvements along Monoosnoc Brook in the vicinity of a proposed municipal parking lot was discussed. City officials had been under the impression that partial funding would be transferred from design monies for the proposed Whitmanville Reservoir. This need was not met as such a transfer was not within the pruview of existing corps authorizations.

A public meeting to determine the problems and needs of the community was held on 27 January 1976. Although a feasible proposal to prevent flooding on Monoosnoc Brook was presented, the meeting was held as an open forum for the public to express their problems and needs on any aspect of water resource development. The following views and questions were discussed:

1. Construction of flood control improvements would have a beneficial impact on the Leominster tax rate.

2. The Leominster Historical Commission stated that any plan for tunnel construction should insure that normal flows will continue to pass through the existing channel.

3. The Leominster Conservation Commission would require additional meetings to make sure that the provisions of the Massachusetts Wetlands Protection Act are being implemented.

4. A resident felt that flood control is a fine endeavor but that the construction monies should be spent to improve the school system.

5. Care should be taken to include safety measures in any proposed plan of flood control.

6. The Leominster Sportsmen's Club would like to see old properties in the center of Leominster replaced with a park along the brook.

7. Floodproofing should be considered as an alternative to tunnel construction.

8. Flood insurance and floodplain management studies should be investigated.

9. Would the city of Leominster be legally bound to maintain the existing channel if a tunnel diversion bypass is constructed?

10. Citizens were concerned that continued development in the watershed as well as interstate highway construction will worsen the flood problem.

Another method to determine the problems and needs of the community involved close coordination with the Leominster Planning Board and consideration of needs described in their Community Development Plan Summary. Areas of concern related to water resources development are summarized below:

1. To prevent drinking water crises. Leominster's sources of drinking water are wells and reservoirs. In 1974 the pollution of a major reservoir resulted in the deposit of fine silt into the drinking water of a large part of the community. Between 1963 and 1965 a severe drought threatened the community with a water shortage. It is evident that Leominster has a need to protect its water supply. Drinking water protection involves the maintenance of adequate watersheds, an adequate distribution system and adequate emergency supplies.

2. To plan, monitor and manage the growth of Leominster's population and the development of its land areas so the population will not exceed Leominster's capability to provide vital city services. Between 1972 and 1974 a large number of apartment units were constructed in Leominster. This, combined with the development of single family homes, resulted in population growth which exceeded the city's ability to provide services. Two ramifications of this problem are overloading of the sewerage treatment plant and overcrowding in the schools.

3. To expand economic opportunities in the community in a well planned manner to maximize long-range benefits to the people of Leominster and minimize associated problems. Many of the residents are unemployed. It is important that economic opportunities be provided for these people. This can be accomplished by implementing a well planned economic development program.

4. To restore the flow of commercial activity into the downtown area. New shopping malls have been built in the past 5 years in outlying parts of the community. Because of easy access, unlimited parking, new construction and other factors, they have attracted a considerable volume of commerce from the downtown area. Retail establishments have moved from downtown to the shopping centers and commerce has flowed away from the older downtown buildings. Congestion and inadequate parking have also resulted in a relative decline in vitality of the downtown. An important need of the city of Leominster is to restore the flow of commercial activity into the downtown and to restore the downtown as the central marketplace of the city.

5. To provide public facilities for neighborhoods which would result in a better living environment for low income persons. Part of the crime and vandalism problem results from the lack of adequate public facilities, especially in the more densely settled parts of the community. Many of the low and moderate income people live in these areas, and many urban problems are located there. Providing public facilities will often give younger people outlets for their energies and should help reduce crime and vandalism. They will also improve the living environment.

6. To arrest deterioration of areas in the community. Part of the deterioration problem is related to housing. Part is due to the number of older factory buildings dispersed throughout the community, many of which are inadequate for modern industrial needs. Parking facilities are inadequate. Deterioration causes health, safety and blight problems in the city.

7. To correct local flooding problems caused by surface runoff. Poor storm sewer systems or, in some cases, no storm sewer systems have caused severe flooding in many areas of the community. Before subdivision regulations were established, privately built roads utilized poor drainage techniques. Leominster's hilly terrain compounds the problem. Areas that have been affected by flooding include basements, yards, sidewalks and streets.

8. To increase the accessibility of recreation to elderly and handicapped people, to provide more passive recreation areas and to improve recreation facilities. Recreation is a major need of the city of Leominster. To develop into a viable urban community with a suitable living environment for low and moderate income people, it is necessary that Leominster develop adequate recreation facilities. This includes facilities for organized sports as well as facilities for passive recreation for young and old.

9. To preserve historic buildings and sites. Leominster has no sites or buildings on the National Register of Historic Places. It is difficult to preserve buildings of historic value because of cost and other factors. It is important, however, for future generations to know the history of their community. A community which has preserved historic buildings has preserved its identity and culture.

10. To protect natural resources. Leominster has a large acreage of forested land and several mountains and lakes. The North Nashua River is used for canoeing and other recreational purposes. Vital to achieving a more rational utilization of land and other natural resources in Leominster is the protection of natural resources for future use.

From the information obtained at the public meeting and from the Community Development Plan it was ascertained that the primary water resource needs of the community are as follows:

1. Implementation of flood control measures.

2. Restoration of the central business district.

3. Maintenance of adequate water supply.

4. Preservation of historical and natural resources.

5. Provision of areas for public recreation.

Because flooding is the primary concern of the community this section of the technical report includes data on storm characteristics, streamflows, hydrologic analysis, areas subject to flooding, floods of record, and flood damages as they relate to the Monoosnoc Brook study area. More detailed information concerning basin hydrology and the coverage of specific solutions to flood problems is covered in subsequent sections. Also discussed here are the needs for conservation, recreation, fish and wildlife preservation and water quality improvement; the status of existing plans and improvements, and improvements desired, as expressed by local interests.

Status of Existing Improvements

The existing Monoosnoc Brook consists of a system of open channels, bridges and conduits under buildings and railroad tracks. These structures extend a distance of 2.3 miles from Rockwell Pond through Leominster center to an industrial site on the eastern side of the city at Williams Street. The streambed is cluttered with debris and overgrown vegetation which severely hampers the capability of the stream to carry floodflows. Encroachment on the stream by industrial, commercial and residential buildings is typical throughout its length in the city. Little or no protection is afforded to these buildings against flooding conditions. During periods of heavy rainfall, runoff from the Monoosnoc Brook watershed results in periodic flooding in the congested core business district of Leominster. This flooding occurs because of insufficient flood storage upstream, increased runoff from accelerated urban development, filling and encroachment on natural floodplain storage area and insufficient channel capacities.

An existing granite block dam at Rockwell Pond withstood the record flood of 1936. However, several properties around the pond experienced flooding. After completion of the proposed flood control improvement the design flood stage would be 3 feet lower than the 1936 flood stage at Rockwell Pond. Although a stability analysis was not performed, field investigations indicate that the dam is structurally sound. The normal pool level of Rockwell Pond is about El. 416 msl.

Flood Problems

In Leominster about 580 acres are susceptible to flooding from the standard project flood. About 70 acres of this land is along Monoosnoc Brook in the urban center of Leominster, while the remainder is the floodplain at the confluence of the N. Nashua River and Monoosnoc Brook. Much of the existing stream through the commercial center of Leominster has been confined by walls and building foundations. Bridges and conduits further restrict the stream in this downtown area.

Floods have caused damage to the city of Leominster in March 1936, September 1938, June 1944 and October 1955. During any appreciable storm, the limited surcharge storage capacity of Rockwell Pond cannot significantly reduce peak rates of runoff through the pond. Since the maximum nondamaging channel capacity of the Monoosnoc Brook channel and conduit system through the center of the city is only 600 cfs, storm discharge rates of up to 4,000 cfs cannot be accommodated and discharged. Backup occurs and subsequent flooding of the Leominster core business area takes place. The problem is compounded by seasonal storms and by runoff contributions from urban expansion in Leominster. Runoff from undeveloped areas would cause further flooding if they are built on in the future.

STORM CHARACTERISTICS

The Monoosnoc Brook watershed located within the North Nashua River watershed has a variable climate. Major storms producing flooding on Monoosnoc Brook have generally been associated with local thunderstorms and larger weather systems of tropical and extratropical origin. Four general types of these storms occur in the North Nashua River Basin.

1. Extratropical continental storms which move across the basin under the influence of the prevailing "westerlies".

2. Extratropical maritime (coastal) storms which originate and move northward, often called "northeasters".

3. Storms of tropical origin, some of which attain hurricane magnitude.

4. Thunderstorms produced by local convective activity or more general frontal action.

FLOOD HISTORY

The four most significant floods in Leominster occurred on 19 March 1936, 21 September 1938, 25 June 1944 and 15 October 1955. The 1936 event was the flood of record along Monoosnoc Brook. A description of rainfall and runoff associated with these storms is contained in Section A (Hydrologic Analysis) of the Technical Appendices.

Damage records of the four floods indicate the primary flood-prone area in Leominster is along Monoosnoc Brook which runs through the center of Leominster. The Monoosnoc Brook watershed of 11.2 square miles may be divided into two subareas for flood analysis: the 4.7 square miles of headwater controlled by Notown Dam and Reservoir and the 6.5 square miles below the dam. The surcharge storage in the reservoir effectively reduces and delays peak flows from the upper basin.

Runoff from the area below the reservoir is uncontrolled and the hilly topography and steep gradient of the brook is highly conducive to rapid runoff. Approximately 85 percent of the flood peaks affecting the flood-prone section of Leominster originate from the ineffective drainage area below the Notown Reservoir.

The limits of SPF flooding in the Monoosnoc Brook watershed are shown on Plate 9 of Section D of Appendix I. The flood limits cover approximately 70 acres extending from Rockwell Pond through the Leominster core business area to the industrial complex at Williams Street.

Stage-frequency curves depicting flood stages of Monoosnoc Brook under present conditions of development, without additional improvements on the brook, are shown in Section H of Appendix 1.

EXTENT AND CHARACTER OF FLOODED AREA

The flood problem area as indicated on Plate 9 - Section D, Appendix 1, shows the potential limits of flooding which may be experienced. This comprises an approximate area of 70 acres of highly urbanized residential, commercial and industrial properties. Area residents have low to mid-income near the business and civic center which is closely mixed with manufacturing industries from Whitney Street to Water Street. Based on damage surveys conducted in 1974 and selected field checks in 1976, it is estimated that a flood with a recurrence interval of 40 years, comparable to 1936 event, would cause losses in the study area of $3,252,300 at 1974 price levels. Some 38 percent of losses would be industrial; 45 percent would be commercial and the remaining percentage would be divided between residential and public.

Recurring losses at various stages of flooding were combined with stage-frequency data to determine annual losses amounting to $541,000, taken at 1977 price levels.

Trends of Development

Hydrologic: Continuing urbanization of a small watershed increases the frequency and damage of each flood. Section D (Hydrologic Analysis) of Appendix 1 discusses this effect in detail.

Economics: The potentially floodable area in Leominster is centered around a commercial and industrial zone. It is substantially developed with 94 business establishments and 10 factories, although there are some vacancies. These buildings are clustered together, surrounded by 65 residential structures that are subject to flooding. In 1970 manufacturing was Leominster's primary economic activity. Second in importance was wholesale and retail trade.

The city's population has grown at a high steady rate in the past 30 years. Between 1965 and 1975, the population increased by 19.1 percent. While Leominster housing and population have increased in the recent past, employment and trade have grown more slowly. In Leominster's current economic climate, local restrictions have a negative effect on business activity and on land and property values. Therefore, any effective flood control plan would be advantageous, both socially and economically, to the area.

Other Needs

The Monoosnoc Brook input area appears to be valuable from a social point of view since it constitutes an area of potential open space within the continuing urbanization of Leominster. Past land use practices of residents and industry have deteriorated the watershed ecology. Sections of the Monoosnoc channels are strewn with debris and other industrial deposits which contribute unfavorably to the pollution and contamination of the water quality in the brook. As a result of the overall deterioration of the natural environment, the area does not at this time provide a high quality habitat for fish and wildlife nor does it provide an adequate recreational area for residents.

A general environmental awareness as well as primary flood control improvements is greatly desired by local interests, whether in conjunction with State and Federal agencies or in separate actions. To achieve such a preserved area and its maximum utilization the need for improved water quality is an important consideration. The immediate sources of water pollution must be eliminated. Proper oxygen levels in the water must be maintained to improve the wildlife habitat. Such

benefits to human and animal life are needed in the impact area, where increasing urbanization is slowly stifling valuable space. A flood protection project provides an excellent opportunity for initiating and coordinating these social improvements as well as initially protecting the affected area.

Improvements Desired

Flood control is the primary water resource problem within the Monoosnoc Brook Basin. Other water resource problems, including those detailed in the 1965 report, have either been rectified or have become unfavorable as project facets. The city of Leominster, especially its areas of high potential damage, should be protected against flooding from events up to the magnitude of a Standard Project Flood. This should be done in a manner which would cause minimal disruption and maximum contribution to environmental quality.

There are several environmental considerations for this project. Pollution is a significant problem on Monoosnoc Brook downstream of Pond Street. However, water quality improvement by low flow augmentation or other methods is not economically justifiable. The best and most economical method of pollution control would be enforcement of existing pollution laws on stream abutters. Enhancement of fish and wildlife habitat would also be a desirable result of any proposed work. Present conditions are such that fish and wildlife habitat is virtually nonexistent from Rockwell Pond downstream.

Recreation would be a welcome benefit, if possible. No areas exist in the immediate Monoosnoc Brook watershed or even in the North Nashua River Basin which offer public outdoor recreation in large open areas. Little public recreational opportunity exists within 10 miles of the Fitchburg-Leominster area. Municipal parks in the cities of Fitchburg and Leominster accommodate limited urban type recreation. Willard Brook State Forest has limited swimming and picnicking facilities and is located about six miles north of Fitchburg. Mount Wachusetts Reservation and Leominster State Forest offer some land based recreational opportunities. Several lakes and reservoirs in the North Nashua River Basin provide boating and fishing, but they are primarily restricted to privately owned developments.

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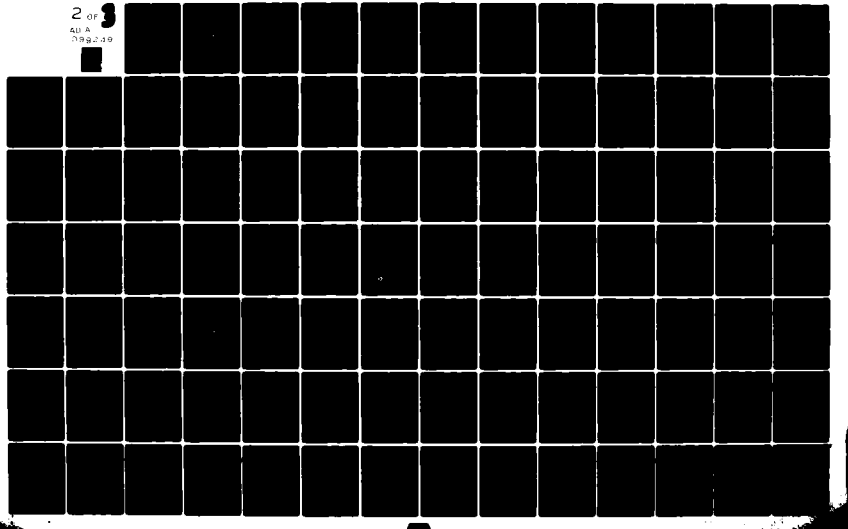

Therefore, in the selection of a final plan effects compatible with community, social and environmental objectives should be considered along with the primary goal of flood control in the study area.

At two public meetings, during damage survey interviews and at other meetings, concerned citizens and public officials have expressed the opinion that structural measures would be required to eliminate flooding from the Monoosnoc Brook floodplain.

The public meetings were held on 27 January 1976 and 2 March 1976 in Leominster, Massachusetts. The first was scheduled to hear the problems, needs and desires of the public and Federal, State, and local interest if favorable to participation in proposed flood control improvements.

The primary purpose of the meeting on 2 March 1976 was to discuss non-Federal costs in more detail. Corps of Engineers representatives explained to Mayor McLaughlin of Leominster and others in attendance the items of local cooperation required, including the acquisition of lands and easements and the local cost-share. The mayor and City Council endorsed a plan for alleviating future flooding in the urban center at Leominster. Such a plan would coincide with current plans for the future development of Leominster.

SECTION D

HYDROLOGIC ANALYSIS

HYDROLOGIC ANALYSIS

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SECTION D

HYDROLOGIC ANALYSIS

Introduction

This report presents the hydrologic analysis pertinent to the revised flood control plans for Monoosnoc Brook in Leominster, Massachusetts. Included are sections on watershed description, climatology, flood history, flood frequencies, standard project flood development and hydrologic features of the proposed improvements.

Monoosnoc Brook, a tributary to the North Nashua River, was included in studies reported in "Water Resource Development Plan, North Nashua River Basin," dated January 1965. At that time a flood control reservoir was recommended on Monoosnoc Brook together with channel improvements in combination with a proposed urban renewal project. This plan was subsequently authorized by Congress. However, escalating real estate costs and development in the reservoir site plus the rejection of the proposed urban renewal project by the city council resulted in the city's requesting a flood control restudy of the brook in 1972. The restudy was funded by the Public Works Appropriation Act of 1975 (Public Law 93-393, dated 28 August 1974) under the general investigations provisions.

The current restudy has determined that the reservoir is no longer feasible but that a deep rock tunnel bypass of the brook through the center of Leominster is a practical alternative. Therefore, the new recommended plan for flood control on Monoosnoc Brook in the city of Leominster consists of a 12-foot diameter tunnel extending from Rockwell Pond to an outlet downstream of Water Street Dam a distance of 3,200 feet.

Watershed Description

Monoosnoc Brook originates at Rocky Pond in the hills west of the city of Leominster and flows in an easterly direction for 8.7 miles through the business center of Leominster to its confluence

with the North Nashua River, about nine miles upstream of the junction of the North Nashua and Nashua Rivers. The Nashua River in turn enters the Merrimack River in Nashua, New Hampshire. A watershed map of Monoosnoc Brook is shown on Plate 1.

Monoosnoc Brook has a total drainage area of 11.2 square miles. Flood runoff from the upper 4.7 square miles of the watershed is largely controlled by surcharge storage in Notown Reservoir, a large domestic water supply lake. The intervening 5.7 square miles between Notown Reservoir and the city of Leominster is very hilly and conducive to rapid runoff. The remaining 0.8 square miles of watershed, mostly within the city of Leominster, is flatter in slope but quite heavily urbanized. New development taking place in the watershed is mostly upstream of Leominster and along Route 2, a limited access highway passing through the northern portion of the watershed.

Further discussion of the Monoosnoc Brook watershed and the larger North Nashua basin is contained in the 1965 "Water Resources Development Plan, North Nashua River Basin."

Climatology

a. General. The Monoosnoc Brook watershed has a variable climate and frequently experiences periods of heavy precipitation produced by local thunderstorms and larger weather systems of tropical and extratropical origin. The basin lies in the path of the prevailing "westerlies" which traverse the country in an easterly or northeasterly direction and produce frequent weather changes. Temperature extremes within the basin range from summertime highs of about 100° F to subzero temperatures in the minus teens occurring for short periods in the winter.

b. Temperature. The mean annual temperature in the North Nashua River watershed is about 48° F. Recorded temperature extremes at representative stations within or adjacent to the watershed have varied from a maximum of 105° F at Fitchburg to a minimum of -22° F at Clinton, Massachusetts. Freezing temperatures may be expected from the latter part of September until late in April. Table 1 shows the mean, maximum and minimum monthly and annual temperatures at Fitchburg for 89 years of record through 1975.

TABLE 1

MONTHLY TEMPERATURES AT
FITCHBURG, MASSACHUSETTS
(Degrees Fahrenheit)

Month	Average	Maximum	Minimum
January	24.8	68	-21
February	25.0	68	-21
March	34.5	86	-8
April	46.0	92	6
May	57.7	97	26
June	66.4	100	35
July	71.6	103	40
August	69.3	105	35
September	62.1	101	27
October	51.3	91	16
November	39.9	81	-2
December	28.6	71	-16
Annual	48.1		

c. Precipitation. The average annual precipitation over the North Nashua River basin is approximately 43 inches, uniformly distributed throughout the year. The maximum and minimum annual precipitation at Fitchburg is 60.23 (1954) and 27.45 (1883) inches, respectively. Table 2 shows the mean, maximum and minimum monthly and annual precipitation at Fitchburg for 111 years of record through 1975.

TABLE 2

MONTHLY PRECIPITATION AT
FITCHBURG, MASSACHUSETTS
(In Inches)

Month	Mean	Maximum	Minimum
January	3.44	7.78	0.84
February	3.28	8.33	0.34
March	3.67	12.15	Trace
April	3.42	9.91	0.57
May	3.57	8.25	0.57
June	3.66	11.56	0.09
July	3.67	12.68	0.46
August	3.66	10.72	0.17
September	3.64	14.04	0.19
October	3.43	13.01	Trace
November	3.84	7.79	0.38
December	3.51	9.33	0.58
Annual	32.77	60.23	27.45

d. Snowfall. The annual snowfall in the basin averages about 60 inches at Fitchburg located at about elevation 400 feet msl. Table 3 shows the mean monthly and annual snowfall at Fitchburg for 90 years of record through 1975.

TABLE 3

SNOWFALL DATA AT
FITCHBURG, MASSACHUSETTS
(Depth in Inches)

Month	Mean
January	15.6
February	17.6
March	11.3
April	2 5
May	Trace
June	-
July	-
August	-
September	-
October	Trace
November	3.5
December	11.7
Annual	62.2

e. Snow Cover. Snow surveys have been taken by the Corps of Engineers in or adjacent to the North Nashua River watershed since 1950. These surveys indicate that the water content of the snow normally reaches a maximum about mid-March. The mean, maximum and minimum water content of the snow cover measured in the nearby Millers River watershed for 27 years of record through 1976 is shown in Table 4.

TABLE 4

WATER EQUIVALENT IN SNOW COVER
MILLERS RIVER WATERSHED
1950-1976
(Inches)

	Mean	Maximum	Minimum
1 February	2.1	4.2	0.3
15 February	2.7	5.6	0.0
1 March	3.1	7.6	0.0
15 March	3.2	7.7	0.0
1 April	2.0	8.2	0.0
15 April	0.3	4.9	0.0

Streamflow

There are no streamflow records for Monoosnoc Brook; however, average annual flow is believed to be about 15 cfs based on records of other streams in the region. Minimum flows approach zero quite frequently during the summer months, and the maximum flow of the stream occurred in March 1936 when the peak approximated 2,000 cfs based on high watermarks at the Water Street dam (10.8 square miles) and computation of flow over the crest.

A U.S. Geological Survey (USGS) gaging station is located on the North Nashua River at Leominster. Drainage area above this gage is 107 square miles and includes Monoosnoc Brook. Average annual runoff for 39 years of record through water year 1974 has varied from 307 cfs in 1956 to 81.2 in 1965, with a mean of 192.8. Records at the gage

indicate that several periods of sustained low flow have occurred in the North Nashua River. The longest and most severe drought, 1961-1966, resulted in a cumulative runoff deficiency of 31.75 inches, which is 135 percent of the average annual runoff (24.6 inches) at the Leominster gage. The maximum and minimum instantaneous flows recorded at the gate were 16,300 cfs on 18 March 1936 and 11 cfs on 29 August 1948, respectively. Table 5 lists pertinent data for the five largest events of record at the gage, while Table 6 summarizes the mean, maximum and minimum monthly and annual runoff in cfs and inches for the period of record at the Leominster USGS gage.

TABLE 5

PEAK DISCHARGE
USGS GAGE, NORTH NASHUA RIVER
LEOMINSTER, MASSACHUSETTS

Date	Average Rainfall (Inches)	Peak Discharge (cfs)	Peak Discharge (csm)	Runoff (Inches)
18 Mar 1936	5.5	16,300	152	4.0
21 Sep 1938	7.5	10,300	96	4.7
15 Oct 1955	7.5	8,870	83	5.0
25 Jun 1944	5.5	8,100	76	-
12 Mar 1936	3.0	5,500	51	-

TABLE 6

MONTHLY RUNOFF
NORTH NASHUA RIVER
DA = 107 Square Miles
Oct 1935 - Sep 1974

Month	Average		Maximum		Minimum	
	CFS	Inches	CFS	Inches	CFS	Inches
January	205.2	2.2	465	5.1	50.9	0.6
February	215.7	2.1	534	5.2	88.8	0.9
March	372.7	4.0	1289	14.0	140.0	1.5
April	422.5	4.4	868	9.1	154.0	1.6
May	292.7	2.6	450	4.9	85.4	0.9
June	155.5	1.6	393	4.3	64.3	0.7
July	91.1	1.0	392	4.3	42.9	0.5
August	75.1	0.8	286	3.1	38.1	0.4
September	90.6	0.9	595	6.3	38.9	0.4
October	95.8	1.0	606	6.6	39.4	0.4
November	155.6	1.6	485	5.1	44.4	0.5
December	190.8	2.0	429	4.6	58.6	0.6
Water Year	192.8	24.6	307*	39.4	81.2**	10.4

*1950
**1965

Flood Development

a. General. The 11.2 square mile Monoosnoc Brook watershed may be divided into two subareas with respect to flood development: (1) the 4.7 square mile headwater area controlled by Notown Reservoir, and (2) the 6.5 square mile area below Notown Dam. The reservoir

is normally filled to spillway crest, forming a 250-acre pool; however, the surcharge storage above spillway crest effectively reduces and delays peak flows originating in the upper watershed. Runoff from the area below the reservoir is uncontrolled, and its hilly topography is conducive to rapid rainfall runoff. Runoff from the portion of the watershed downstream of the reservoir is the main producer of floods in Leominster.

b. March 1936 Flood. The greatest known flood on Monoosnoc Brook occurred as the result of the second storm of March 1936. Intermittent periods of moderate to heavy rainfall during the month combined with considerable snowmelt to produce two floods. The first rise, occurring on the 12th, resulted largely from runoff from melting snow with some contribution from moderate rainfall that averaged about three inches over the basin during the period from 9 to 13 March. A second storm period, lasting from the 16th to the 19th produced the brook's record flood of the 18th. This second flood peak resulted from intense rainfall that averaged about 5.5 inches with only minor contribution from snowmelt. The resulting peak flow on Monoosnoc Brook was about 2,000 cfs and Plate 2 graphically illustrates the development of the computed 1936 flood hydrograph and its contribution to the North Nashua River at Leominster. The estimated plan and flood profile, based on limited high water marks and the developed rating curves are shown on Plates 9 and 8 respectively. A comparison of associated 1936 rainfall amounts are listed in Table 7.

c. September 1938 Flood. Another flood producing event occurred as a result of rainfall associated with the September 1938 hurricane that passed up the Connecticut River Valley. The Monoosnoc Brook watershed just narrowly missed the brunt of this storm with 14 inches of rain falling a short distance to the west. However, basin rainfall averaged about 7 inches during 18 to 21 September, with about 4 inches falling in a 24-hour period on the 20th. The peak resulting flow on Monoosnoc Brook has been estimated at about 1,400 cfs based on rainfall runoff computations. September 1938 rainfall amounts recorded at Worcester, Massachusetts, compared with other storms, are listed in Table 7.

d. October 1955 Flood. The Monoosnoc Brook watershed escaped the widespread torrential hurricane rainfalls of August 1955 but did experience flood producing rainfall in October 1955. The October storm resulted from the interaction of a west to east frontal weather system with a coastal low pressure system moving northward. Rainfall in the watershed amounted to about 5 inches in 24 hours on the 15th, based on rainfall records at Sterling, Massachusetts.

TABLE 7

MAXIMUM RAINFALL - DURATION DATA
(In Inches)

Storm	1 Hr.	2 Hr.	3 Hr.	6 Hr.	12 Hr.	24 Hr.
10-Year Frequency	1.8	2.3	2.6	3.3	3.9	4.7
100-Year Frequency	2.6	3.4	3.7	4.6	5.4	6.3
Standard Project	3.3	4.6	5.8	8.7	10.2	11.9
March 1936 (at Worcester)	0.8	1.0	1.4	2.3	4.1	5.3
September 1938 (at Worcester)	0.7	1.0	1.3	2.1	2.6	3.8
October 1955 (at Sterling)	0.5	0.8	1.0	1.7	3.1	4.6

Flood Frequencies

An adopted peak discharge frequency curve for Monoosnoc Brook is shown on Plate 3. The curve was developed by relating the computed frequency statistics of the flow records for the North Nashua River at Leominster to Monoosnoc Brook through comparison of common flood events at the two locations. Statistical analysis was made in accordance with Water Resources Bulletin 17 and consideration was given to: (a) regional frequency analyses, i.e., analysis of the North Nashua record, (b) the estimated magnitude and plotting position of the three historic floods on Monoosnoc Brook and, (c) the computed 100- and 10-year storm runoff based on a rainfall-unit hydrograph analysis.

Studies in the New England Division area of responsibility indicate that standard deviations have no relationship to drainage area and that skews are most sensitive to length of record, being the highest where major floods have occurred. Regional studies indicate a skew of 0.5 for streams in Massachusetts most nearly approximates conditions on ungaged streams. Studies have also shown that within a given watershed there is a close relationship between drainage area and mean log, i.e., the ratio of mean log varies in proportion to the ratio of the respective drainage area to an exponential power, generally 0.7 to 0.8. In computing the mean log for Monoosnoc Brook this relationship was used and an exponent of 0.7 was adopted. The computed mean log, standard deviation and adopted skew for the North Nashua River at Leominster, with a drainage area of 107 square miles was 3.3634, 0.3033 and 0.8, respectively. The adopted parameters for Monoosnoc Brook with a drainage area of 11.2 square miles were: mean log = 2.669, standard deviation = 0.2924 and adopted skew = 0.50. It was considered that the adopted frequency curve was sufficiently high to be representative of runoff conditions under present and near future levels of development in the watershed.

Standard Project Flood

a. General. A standard project flood (SPF) was developed for Monoosnoc Brook by applying standard project rainfall to synthetically developed unit hydrographs for various subwatersheds and then routing and combining the resulting component hydrographs at selected index points. The SPF represents the flood discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the region, excluding extremely rare combinations.

b. Rainfall. Standard project storm rainfall was determined in accordance with Civil Engineer Bulletin 52-8 and EM 1110-2-1411. The 24-hour index rainfall for 200 square miles was 10.0 inches. This amount was increased 19 percent for the 11.2 square mile Monoosnoc watershed, resulting in an adjusted index rainfall of 11.9 inches. Losses were assumed to be 0.1 inch per hour and the resulting 24-hour rainfall excess was 9.5 inches. Hourly rainfall amounts are listed in Table 8.

c. Unit Hydrographs. A synthetic 1-hour unit hydrograph shown on Plate 4 was developed for the 6.5 square mile Monoosnoc Brook watershed downstream of Notown Reservoir. The adopted unit graph had a peak of 506 cfs, equivalent to 78 cfs per square mile, and a lag time of 4.5 hours. Snyder's coefficients used in developing the unit graph and other pertinent data are listed on Plate 4.

The unit graph was tested by determining the degree to which the 1936 flood peak could be reproduced. Representative runoff hydrographs for Nowtown Reservoir were first computed and then routed through surcharge storage to determine outflow. The outflow was then routed downstream and combined with the lower watershed runoff to establish the total 1936 flood hydrograph. Development of the 1936 flood is graphically illustrated on Plate 2.

d. Standard Project Flood. The standard project flood for Monoosnoc Brook was developed as follows: (1) the standard project inflow to Notown Reservoir was computed and routed through surcharge storage, (2) the outflow was lagged to Rockwell Pond and combined with the computed runoff from the intervening 5.7 square miles of watershed, and (3) the Rockwell Pond hydrograph was lagged to the mouth of the brook and combined with the local runoff from the 0.8 square mile of urban watershed in Leominster. The resulting peak discharges at Notown Reservoir, Rockwell Pond and the mouth of the brook were 1,410, 4,000 and 4,600 cfs, respectively. The component hydrographs at Notown Reservoir Rockwell Pond and the mouth of the brook are shown on Plates 5, 6 and 7.

Inflow to Notown Reservoir had a peak of 2,750 cfs. After routing through surcharge storage the peak outflow was 1,410 cfs, which was delayed five hours after time of peak inflow. Although the peak outflow from Notown Reservoir was 1,410 cfs, due to desynchronization, it is noted that its contribution to the peak downstream discharge was only 400 cfs.

TABLE 8

STANDARD PROJECT
STORM RAINFALL

Time (Hrs)	Rainfall (Inches)	Loss (Inches)	Excess (Inches)
1	0.2	0.1	0.1
2	0.2	0.1	0.1
3	0.2	0.1	0.1
4	0.2	0.1	0.1
5	0.3	0.1	0.2
6	0.3	0.1	0.2
7	0.9	0.1	0.8
8	1.2	0.1	1.1
9	3.3	0.1	3.2
10	1.3	0.1	1.2
11	1.0	0.1	0.9
12	0.9	0.1	0.8
13	0.3	0.1	0.2
14	0.2	0.1	0.1
15	0.2	0.1	0.1
16	0.2	0.1	0.1
17	0.2	0.1	0.1
18	0.2	0.1	0.1
19	0.1	0.1	0.0
20	0.1	0.1	0.0
21	0.1	0.1	0.0
22	0.1	0.1	0.0
23	0.1	0.1	0.0
24	0.1	0.1	0.0
	11.9	2.4	9.5

Flood Profiles

Monoosnoc Brook flood profiles were computed utilizing the computer program, HEC-2, developed by the Hydrologic Engineering Center in Davis, California. Cross section data was taken from recent Corps of Engineers surveys from the mouth upstream to Water Street dam. From the dam upstream to Rockwell Pond, cross section information was taken from a flood control plan completed for the city of Leominster by Mr. William P. Ray, C.E., in 1938. The 1938 data was verified by field investigation. Backwater computations were made for both natural and modified conditions using a Manning's "n" of 0.035 for the channel and 0.06 for overbank areas. Assumed contraction and expansion loss coefficients for all bridges were 0.3 and 0.5, respectively. The computed standard project flood profile, both natural and as modified by the proposed bypass tunnel, is shown on Plate 8. Limits of flooding are shown on Plate 9.

Monoosnoc Brook Bypass

a. General. The proposed deep rock tunnel will serve to bypass floodflows from the existing Rockwell Pond, located just upstream of the Leominster business district, to a point approximately 900 feet downstream of the Water Street dam, a distance of 3,200 feet.

Hydrologic engineering features of the various components of the proposed diversion are shown on Plates 10 through 13 and discussed in the following paragraphs. Hydraulic analyses made during plan formulation were general in scope. More detailed analysis, probably including model studies of some of the more complex hydraulic structures, will be required in final design.

b. Design Capacity. The tunnel bypass, in combination with the existing channel capacity, will be designed to safely convey the standard project flood through the urban center of Leominster. The SPF discharge at Rockwell Pond is 4,000 cfs, of which 3,400 will be conveyed in the bypass tunnel while the remaining 600 cfs will be discharged into the existing channel. Designing to the level of the SPF was found feasible in project formulation studies and was considered advisable due to the high damage potential in the city. It is noted that in the event of flows greater than the SPF, the bypass will still serve to reduce flows by an amount equal to its capacity of approximately 3,500 cfs.

c. Required Assurances. The ability of the proposed improvements to safely convey the SPF will be dependent on the maintenance of both the integrity of the existing Rockwell Pond dam and the existing safe channel capacity through Leominster. Therefore, as part of local assurances it will be necessary to stipulate that the dam and channel be appropriately maintained.

d. Bypass Tunnel. The 12-foot diameter tunnel will be concrete-lined and approximately 3,200 feet in length. The invert of the tunnel at the upstream end will be 308 feet msl and will slope at 0.0137 ft/ft to elevation 264 feet msl at the outlet. With the design discharge of 3,400 cfs, the velocity of the flow in the tunnel will be about 30 feet per second. The hydraulic capacity of the tunnel was computed using a Manning's "n" of 0.014. A profile of the tunnel, including the design hydraulic gradient, is shown on Plate 10.

e. Bypass Inlet. The inlet to the tunnel, shown on Plate 11, is of the "morning glory" type atop a 14-foot diameter vertical shaft. The 14-foot diameter transitions to a 12-foot diameter before entering the tunnel. The transition starts at elevation 343 feet msl, which is the hydraulic gradient of the tunnel for a flow of only about 1,400 cfs. The larger 14-foot shaft was selected to insure free aeration of the flow, thereby minimizing the possibility of "burping" or "gulping" as has been experienced with minimum sized morning glory spillways. The inlet will also be equipped with "splitter walls" to minimize potential vortex action. Trash racks are provided for the collection of debris and personal safety. The inlet crest was shaped for a design "Hs" of 4.8 feet, thereby insuring complete support of the nappe up to the actual design head of 3.5 feet. Crest shape data was taken from: "Design of Small Dams," U.S. Department of Interior, Bureau of Reclamation, 1960 edition.

Operation of the bypass for flood control will be automatic through the proper selection of elevation and length of the two overflow weirs. The level at Rockwell Pond is presently maintained by a granite block dam about 13 feet high with crest elevation at 415.7 feet msl and an effective length of about 68 feet. With the proposed plan of improvement, the effective length of the existing spillway will be reduced to 22.5 feet while maintaining the same crest elevation. Elevation of the bypass crest will be one foot higher at elevation 416.7 feet msl and will have an effective crest length of 138 feet. The original dam crest, being one foot lower than the bypass, will allow passage of normal riverflows downstream through Leominster in the old Monoosnoc Brook channel. During flood periods the lip of the morning glory inlet will be the hydraulic control for bypass flows up to approximately 3,400 cfs, with a required head pool elevation at the inlet of about 420.2 feet msl. This maximum water surface elevation was determined by physical constraints to properties around the edge of Rockwell Pond and the elevation of Pond Street near the right abutment of the dam. Pond Street with a low roadway elevation of about 421.5± feet msl provides slightly in excess of 1-foot of freeboard above the adopted maximum water surface elevation. With flows greater than 3,400 cfs the inlet will become submerged by tunnel backwater ahd the hydraulic control will switch to the tunnel outlet. With the head pool at elevation 420.2 feet msl, the system will be capable of discharging the SPF discharge of 4,000 cfs with 3,400 going through the bypass and 600 being discharged into the existing Monoosnoc channel. The 600 cfs corresponds to the maximum nondamaging channel capacity of Rockwell Pond. The channel capacity increases to 800 cfs at the Water Street Dam. Outlet rating curves for Rockwell Pond are shown on Plate 14.

f. Bypass Outlet. The outlet of the bypass tunnel will consist of a 12-foot diameter vertical shaft transitioning to a 32-foot wide horizontal apron with an invert elevation at elevation 320 feet msl. A plan and profile of the outlet is shown on Plate 13.

An apron of riprap will be placed at the outlet exit to prevent excessive scour. With a design flow of 3,400 cfs in the bypass, the velocity in the vertical shaft will be approximately 30 feet per second. Water level at the top of the shaft would rise to near the energy gradient of 334 feet msl and then drop to about 332 feet msl as it passes over the apron end sill. Velocities of flows exiting the outlet structure will be about 8 feet per second. Design tailwater at the outlet structure is elevation 333 feet msl based on backwater computations.

A breakaway fence will be placed across the outlet to prevent a person from unknowingly entering the outlet.

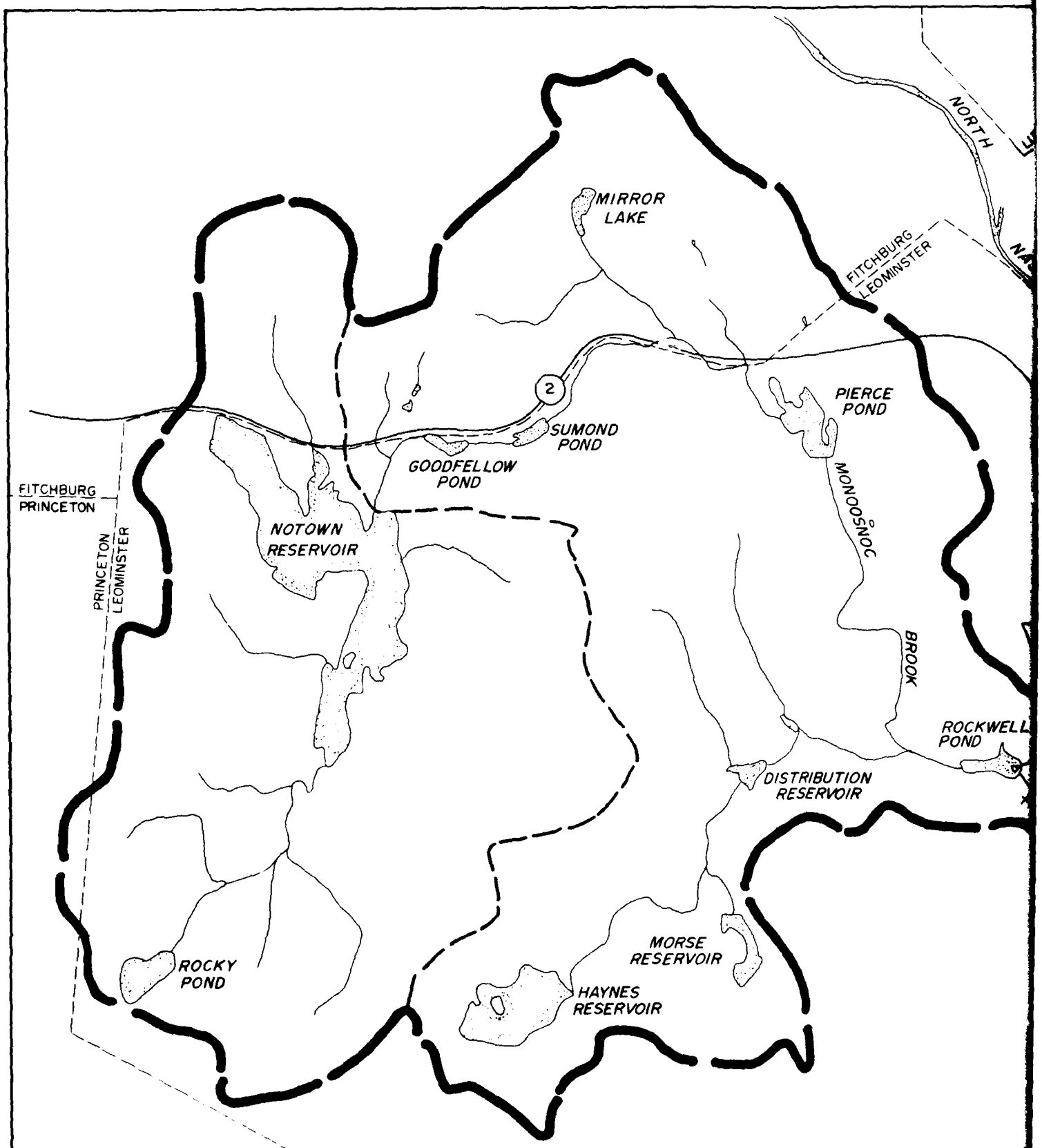
g. Effects of Bypass. The effects of the proposed bypass tunnel on flows and stages as computed for the standard project and March 1936 floods is summarized in Table 9.

Due to the shorter travel time of flows from Rockwell Pond there will be minor increases in flows downstream of the tunnel outlet, generally considered less than 5 percent. The increase in stage for a standard project flood would be less than 5 inches. The tunnel will not affect the total volume of runoff and due to the natural desynchronization of flows on Monoosnoc Brook and the main stem of the North Nashua River, it is considered the proposed diversion would not have any measurable effect on stages on the North Nashua River below the mouth of Monoosnoc Brook.

TABLE 9

EFFECTS OF MONOOSNOC BROOK BYPASS

Location	Drainage Area (Sq. Mi.)	Standard Project Flood				1936 Flood			
		Natural		Modified		Natural		Modified	
		Q	Elev.	Q	Elev.	Q	Elev.	Q	Elev.
Notown Reservoir	4.7	1410	-	1410	-	700	-	700	-
Rockwell Pond	10.4	4000	422.4	600	420.2	1885	419.7	360	418.5
Adams Street	10.6	4150	403.8	800	394.2	1940	399.8	410	391.5
Mechanic Street	10.6	4150	395.0	800	389.3	1940	391.9	410	387.8
Water Street Dam	10.8	4300	355.4	1000	351.5	1990	353.0	480	350.5
Monoosnoc Brook	11.2	4600	-	4800	-	2050	-	2100	-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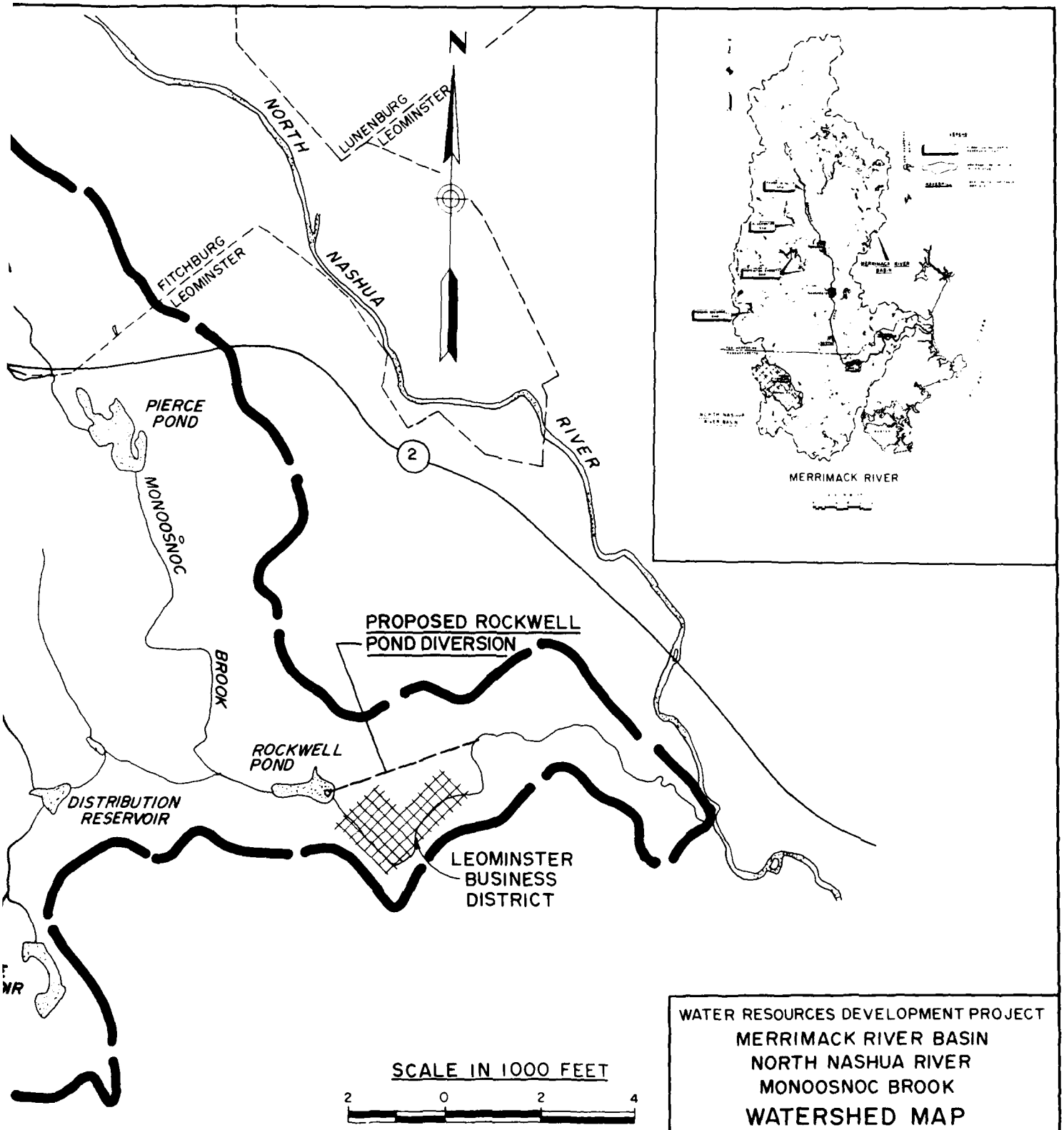
FITCHBURG
LEOMINSTER
2
PIERCE POND
SUMOND POND
GOODFELLOW POND
FITCHBURG
PRINCETON
PRINCETON
LEOMINSTER
NOTOWN RESERVOIR
MONOSONOC
BROOK
ROCKWELL POND
DISTRIBUTION RESERVOIR
ROCKY POND
MORSE RESERVOIR
HAYNES RESERVOIR



WATER RESOURCES DEVELOPMENT PROJECT

MERRIMACK RIVER BASIN

NORTH NASHUA RIVER

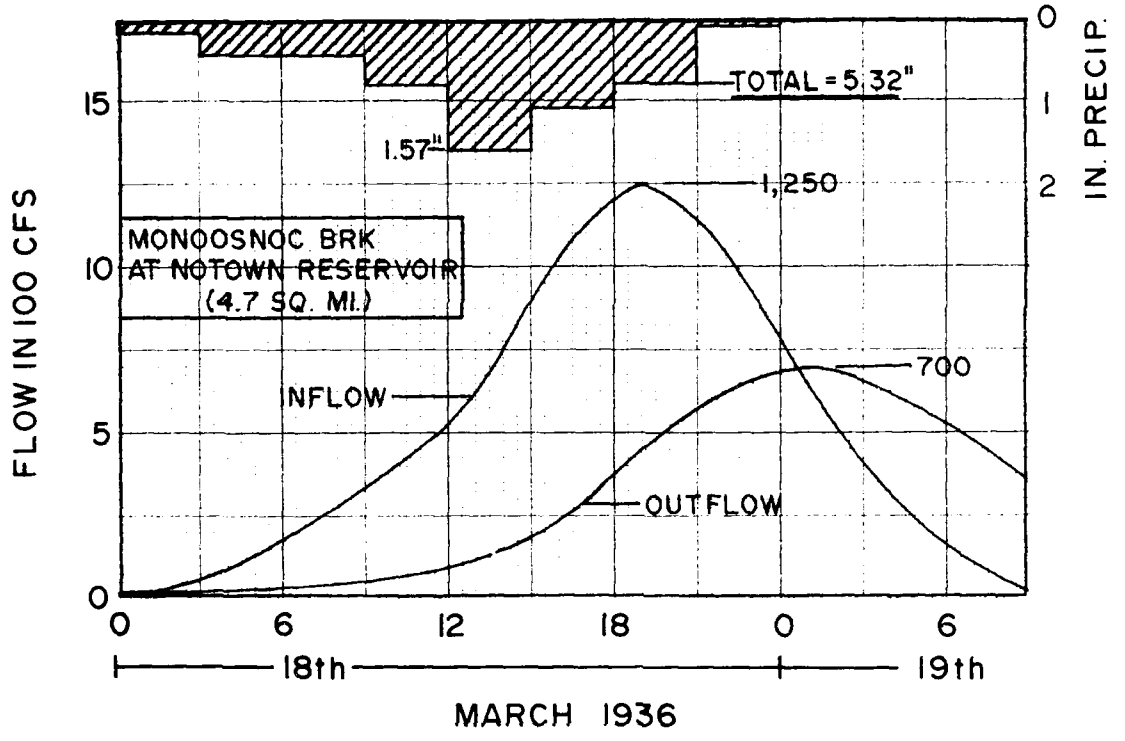
MONOOSNOC BROOK

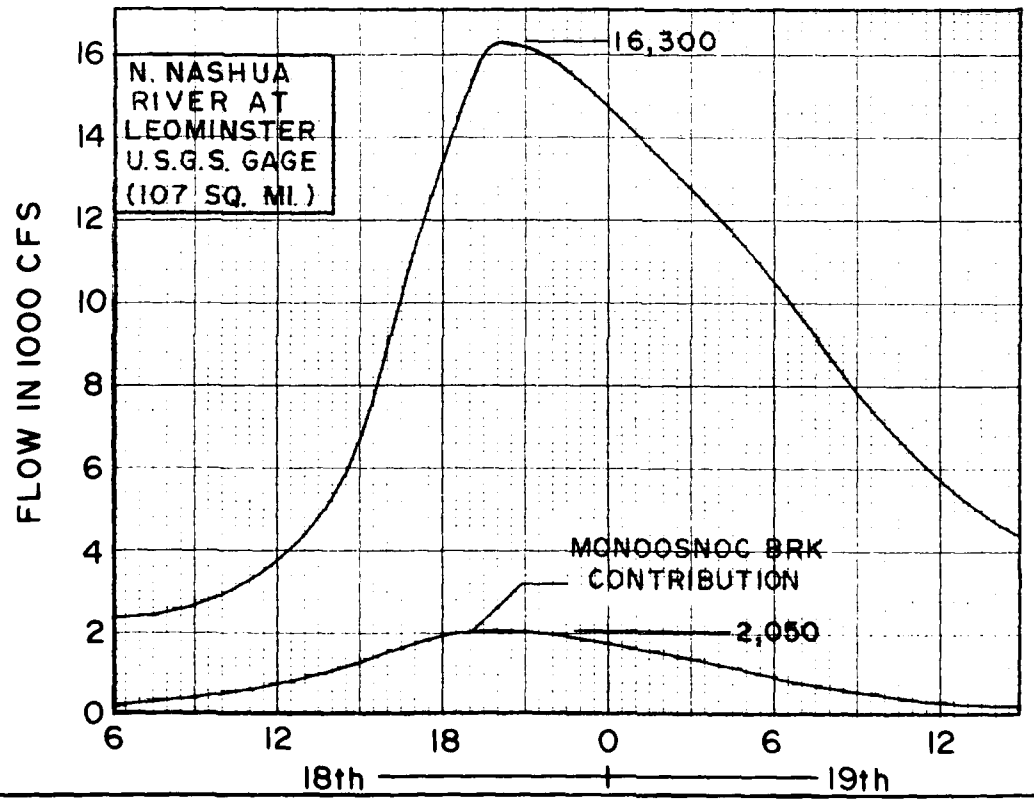
WATERSHED MAP

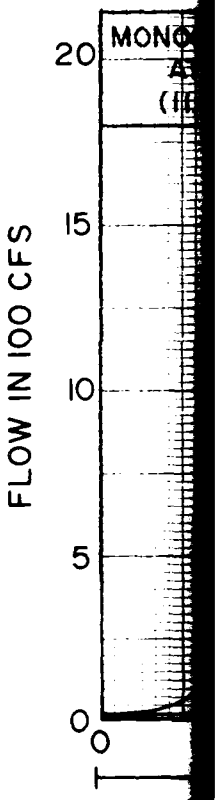
NEW ENGLAND DIVISION, WALTHAM, MASS

OCTOBER 1976

PLATE-1







NOTES

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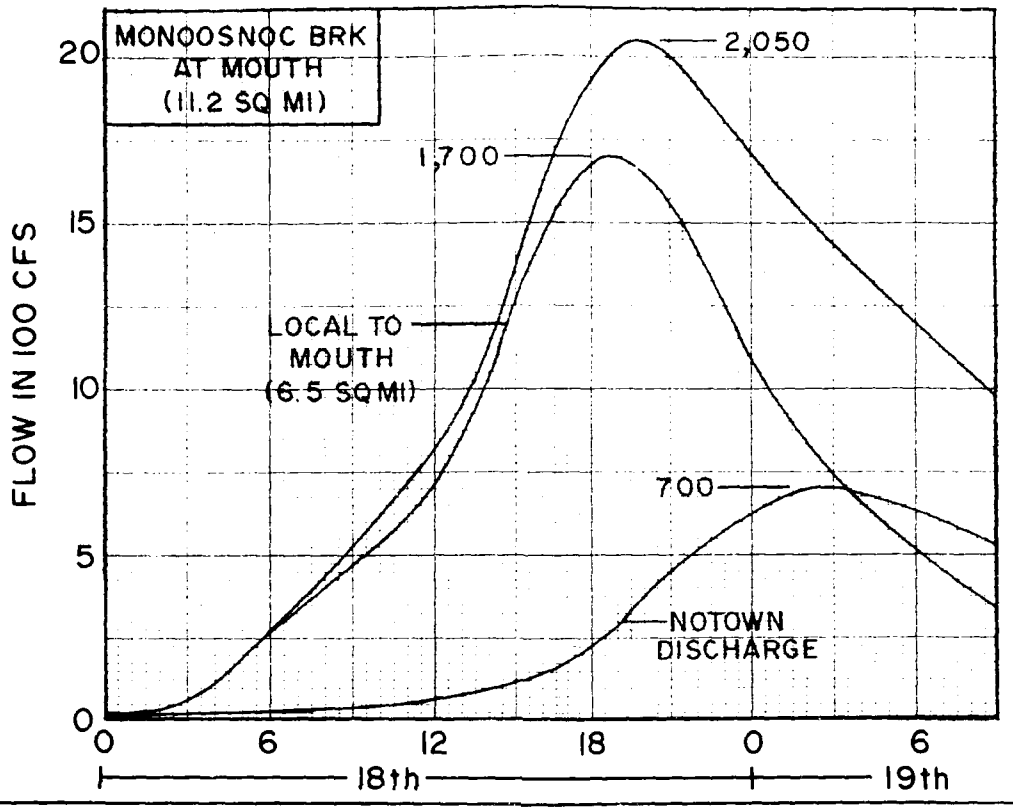
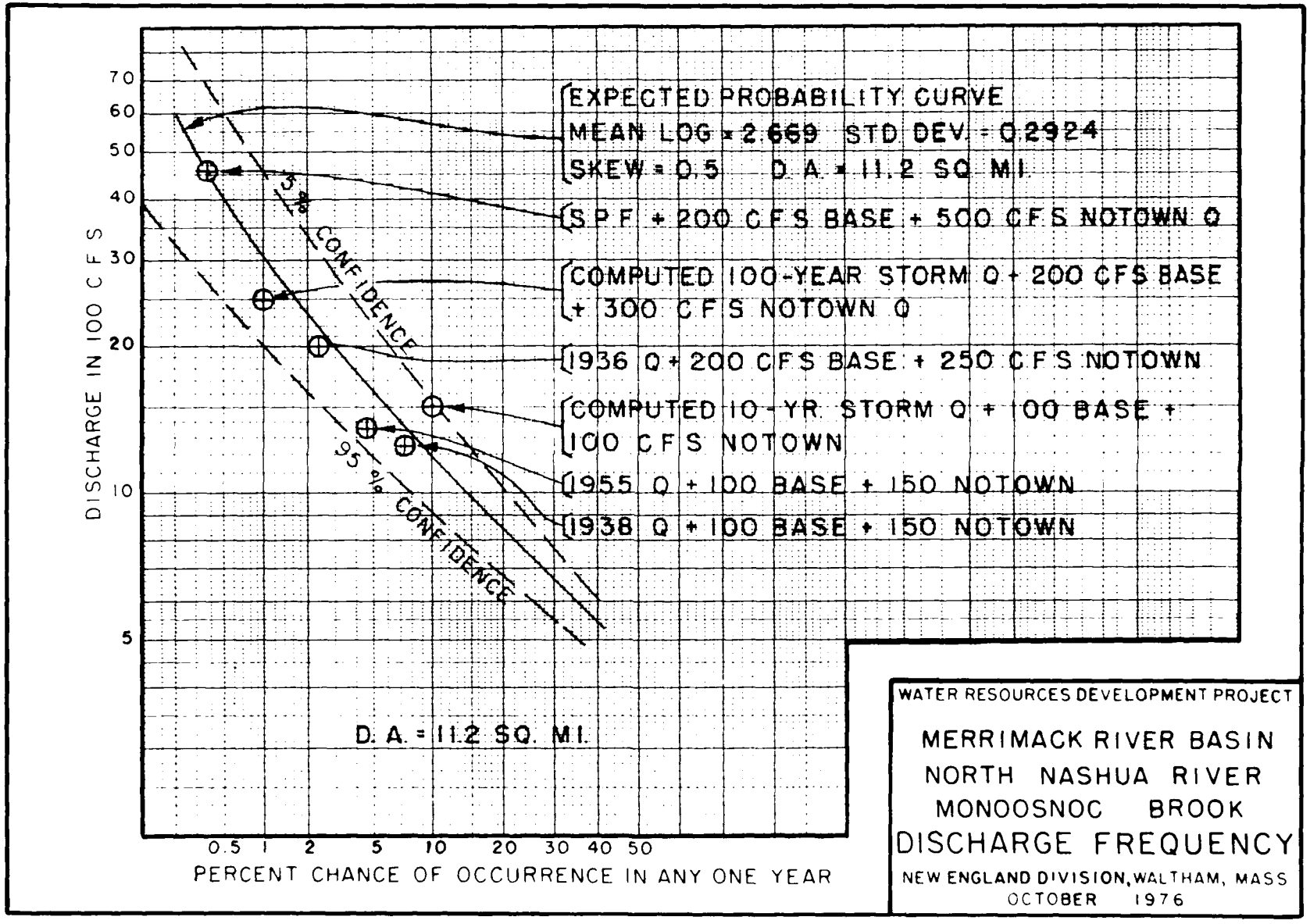


NOTES

1. ALL HYDROGRAPHS ON MONOOSNOC BROOK ARE COMPUTED BASED ON ADOPTED UNIT HYDROGRAPHS AND WORCESTER, MASSACHUSETTS, HOURLY RAIN FALL.
2. LOSSES ARE ASSUMED NEGLIGIBLE DUE TO ACCOMPANYING SNOWMELT AND SATURATED SOIL CONDITIONS.
3. PEAK FLOW WAS SUBSTANTIATED BASED ON HIGH WATER MARK AT WATER ST. DAM.

WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK
MARCH 1936 FLOOD ANALYSIS
NEW ENGLAND DIVISION, WALTHAM, MASS
OCTOBER 1976

PLATE-2



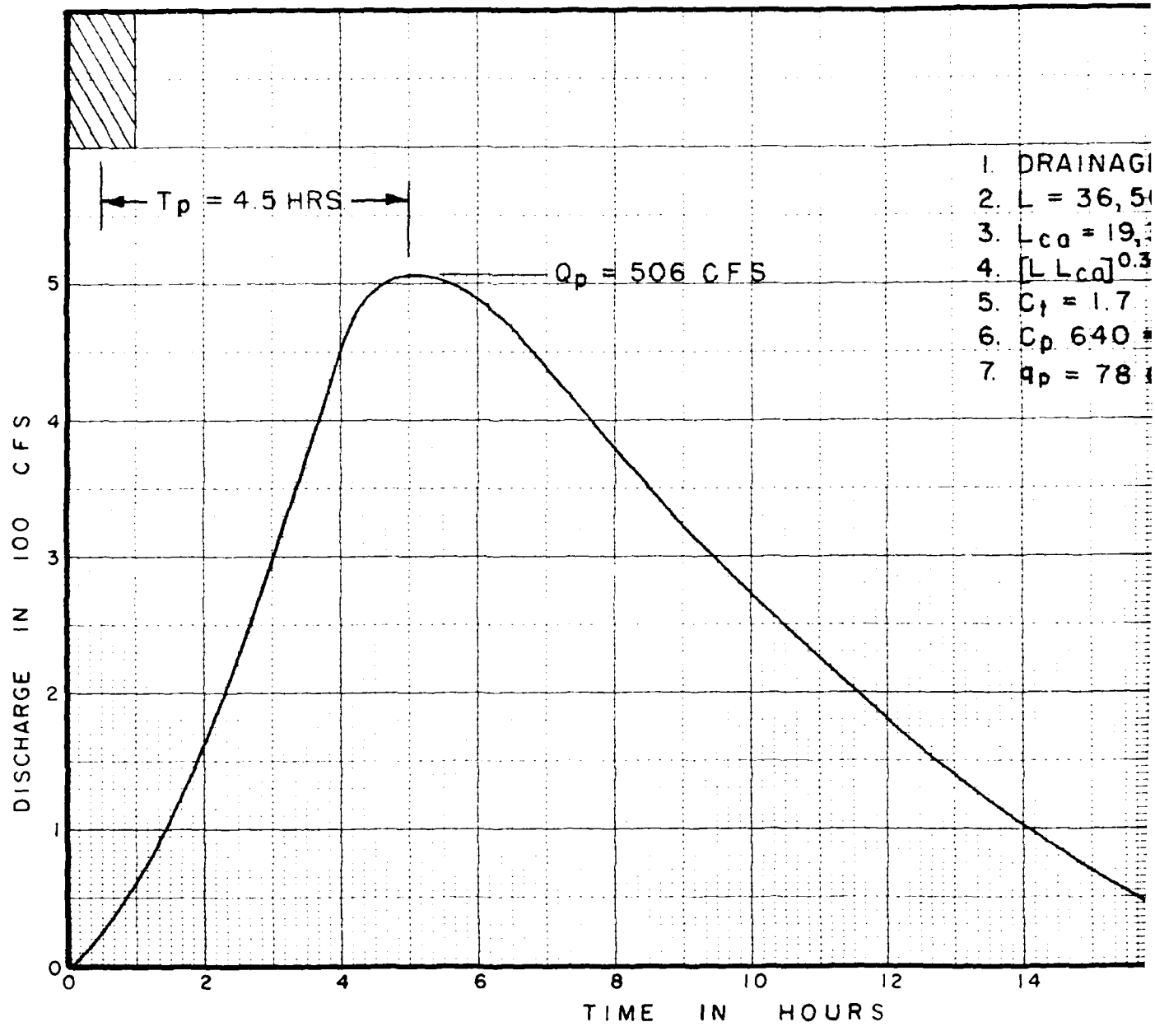
WATER RESOURCES DEVELOPMENT PROJECT

MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK

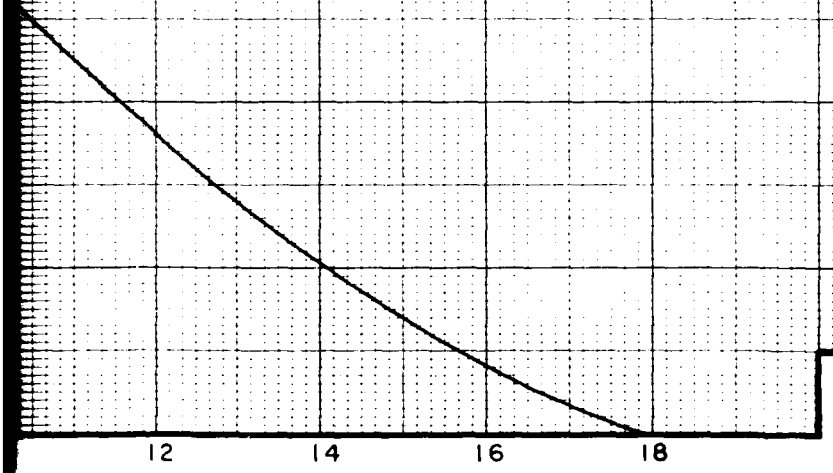
DISCHARGE FREQUENCY

NEW ENGLAND DIVISION, WALTHAM, MASS
OCTOBER 1976

PLATE 3

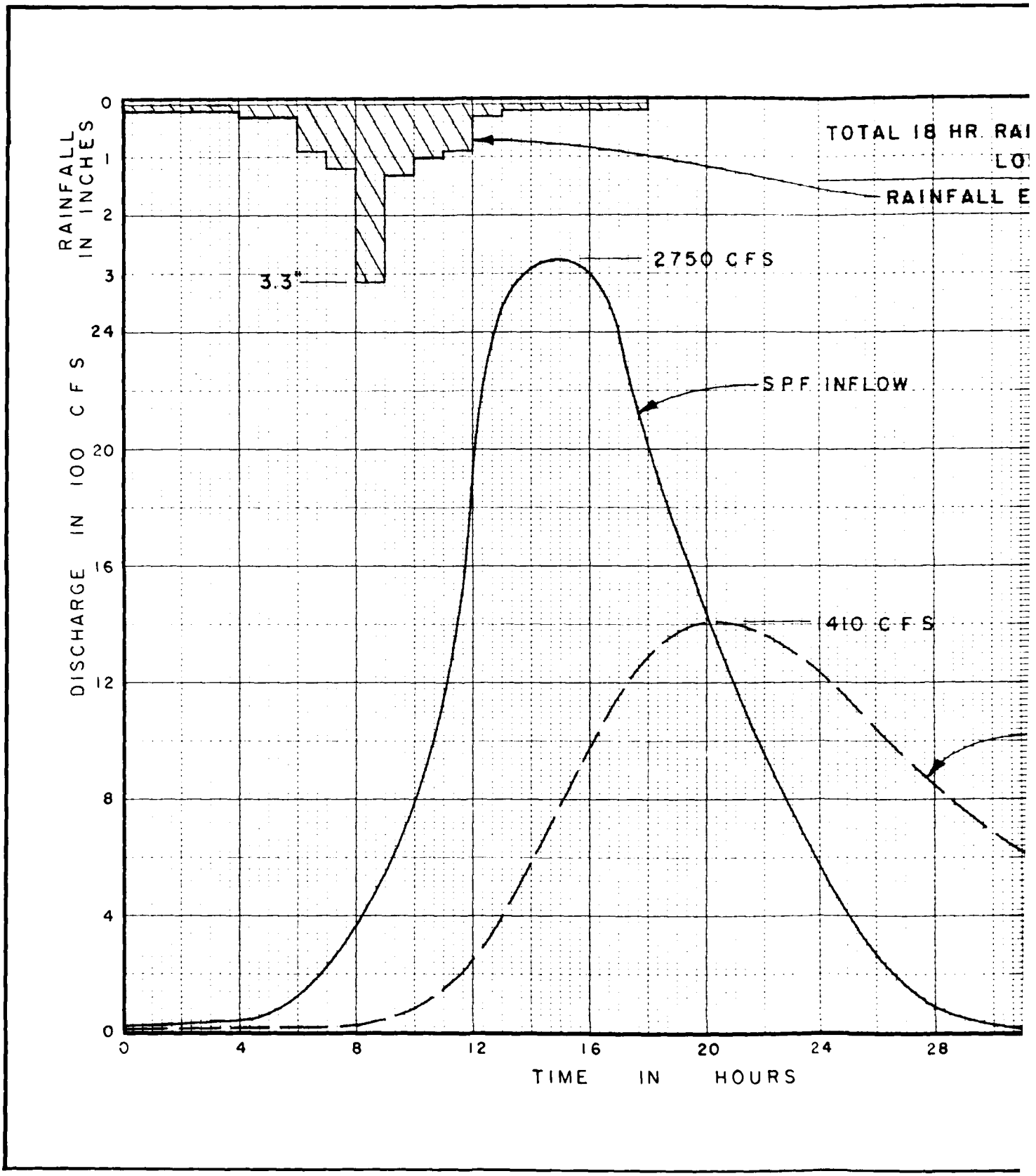

Tp = 4.5 HRS
Qp = 506 CFS
1. DRAINAGI
2. L = 36, 5
3. Lca = 19,
4. [L Lca]0.3
5. Ct = 1.7
6. Cp 640
7. qp = 78
DISCHARGE IN 100 CFS
0
1
2
3
4
5
0
2
4
6
8
10
12
14
TIME IN HOURS

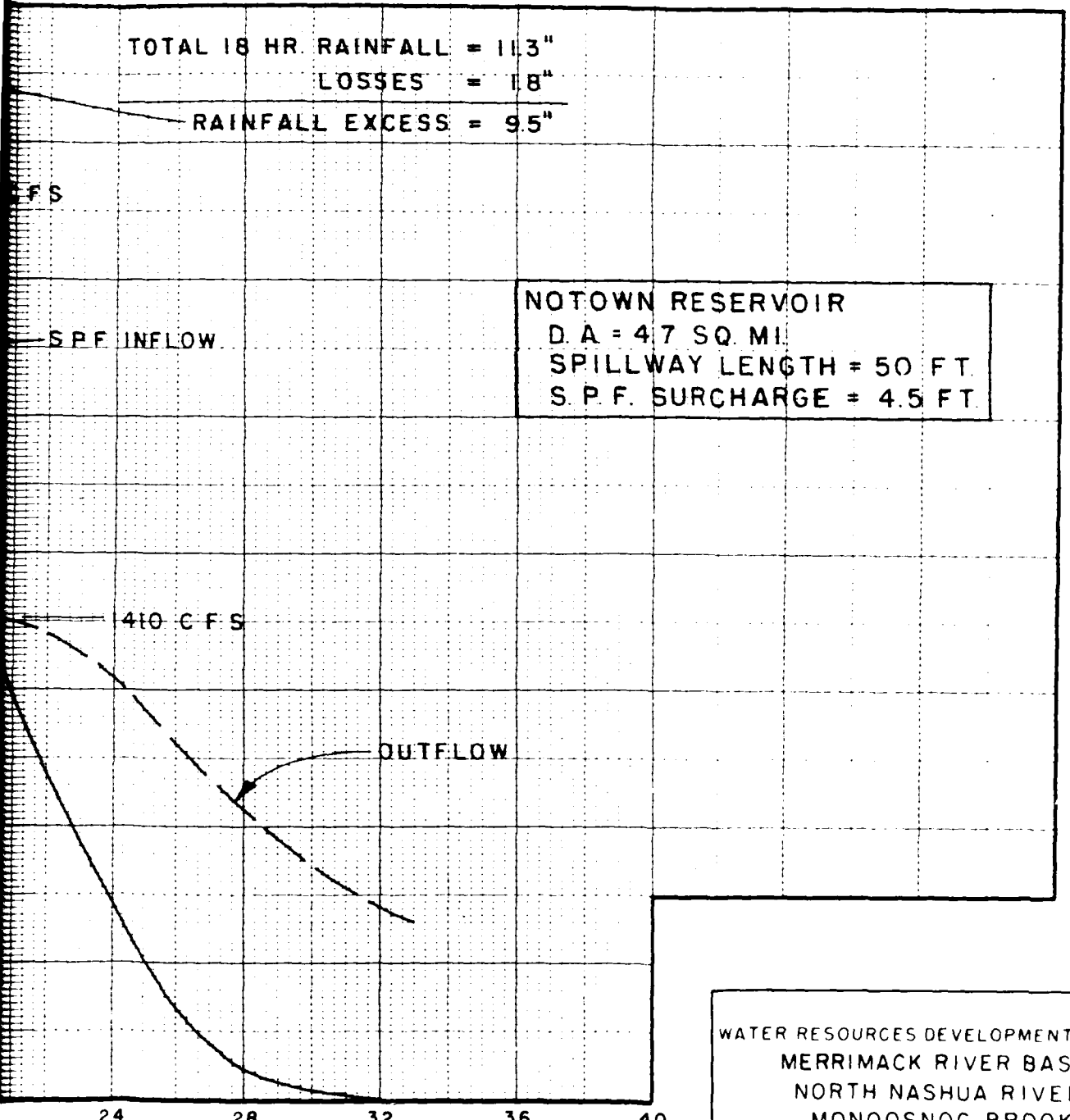
1. DRAINAGE AREA = 6.5 SQ. MI.
2. L = 36,500 FT.
3. L_{ca} = 19,300 FT.
4. $[L L_{ca}]^{0.3}$ = 2.6
5. C_t = 1.7
6. C_p 640 = 350
7. q_p = 78 C F S/SQ. MI.



WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK
BELOW NOTOWN RESERVOIR
ONE HOUR UNIT-GRAPH
NEW ENGLAND DIVISION, WALTHAM, MASS
OCTOBER 1976

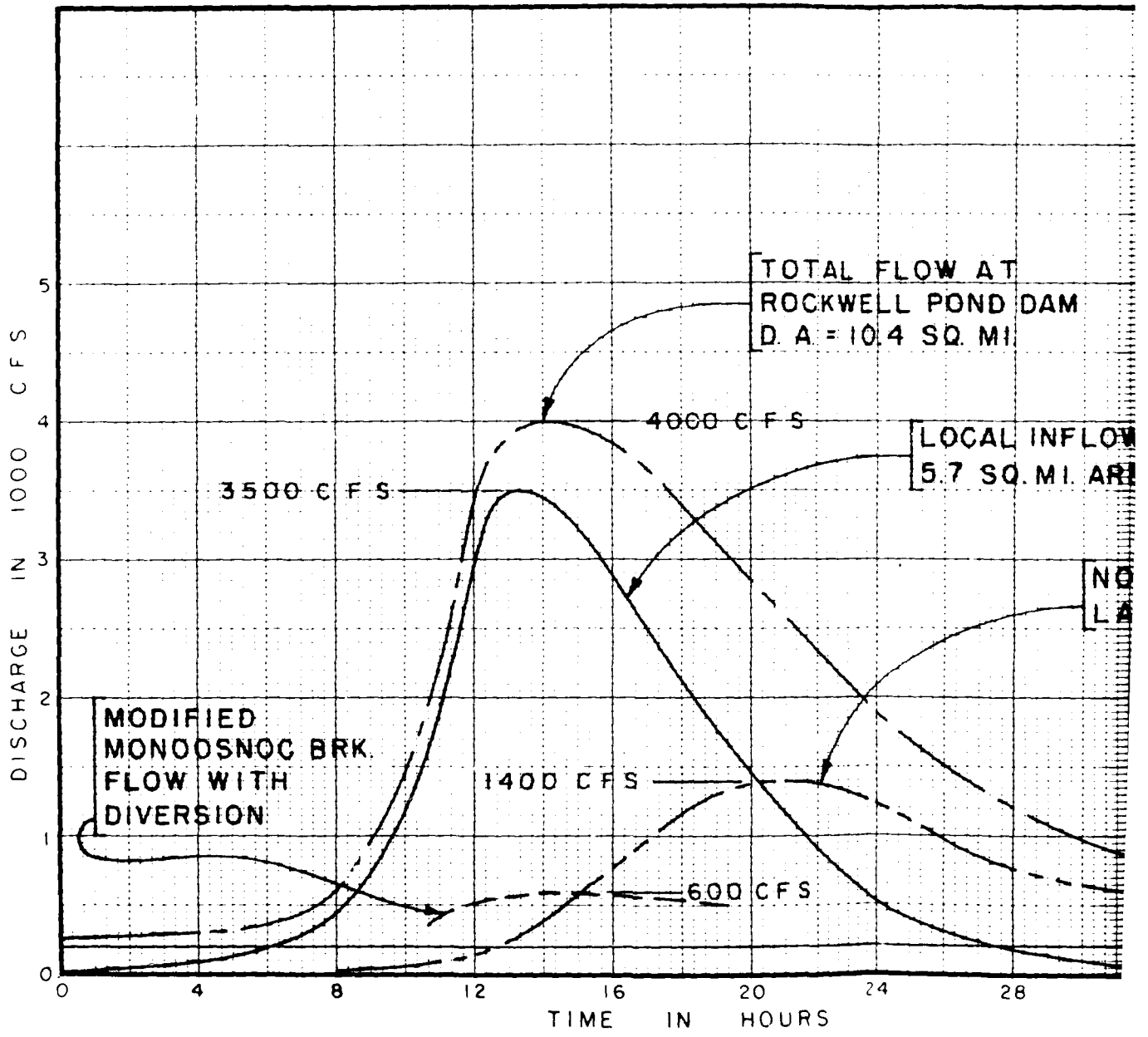
PLATE 4

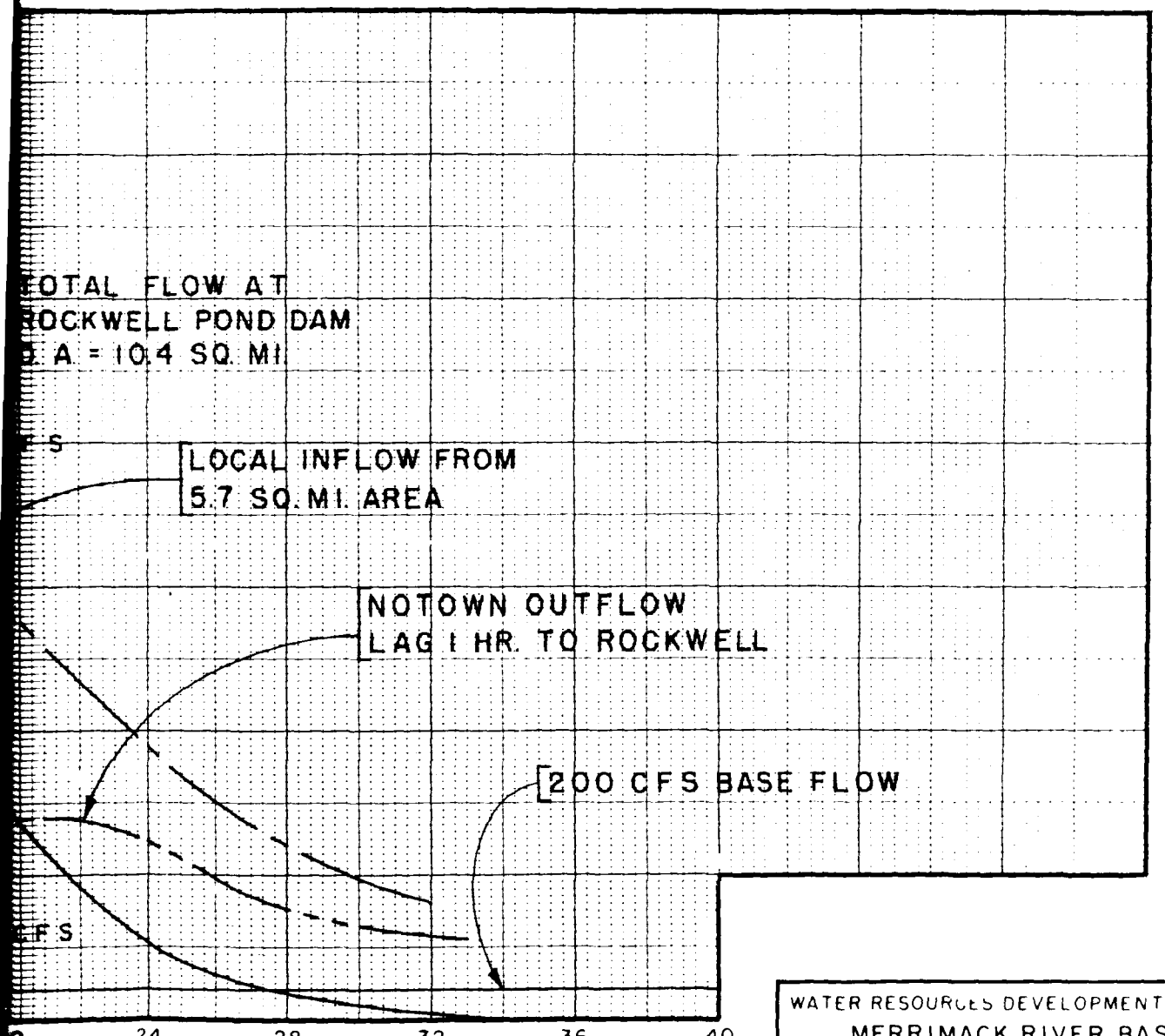

RAINFALL IN INCHES
0
1
2
3
TOTAL 18 HR RAI
LO
RAINFALL E
3.3"
2750 CFS
DISCHARGE IN 100 CFS
24
20
16
12
8
4
0
SPF INFLOW
410 CFS
0
4
8
12
16
20
24
28
TIME IN HOURS



WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK
NOTOWN RESERVOIR
STANDARD PROJECT FLOOD
NEW ENGLAND DIVISION, WALTHAM, MASS
OCTOBER 1976

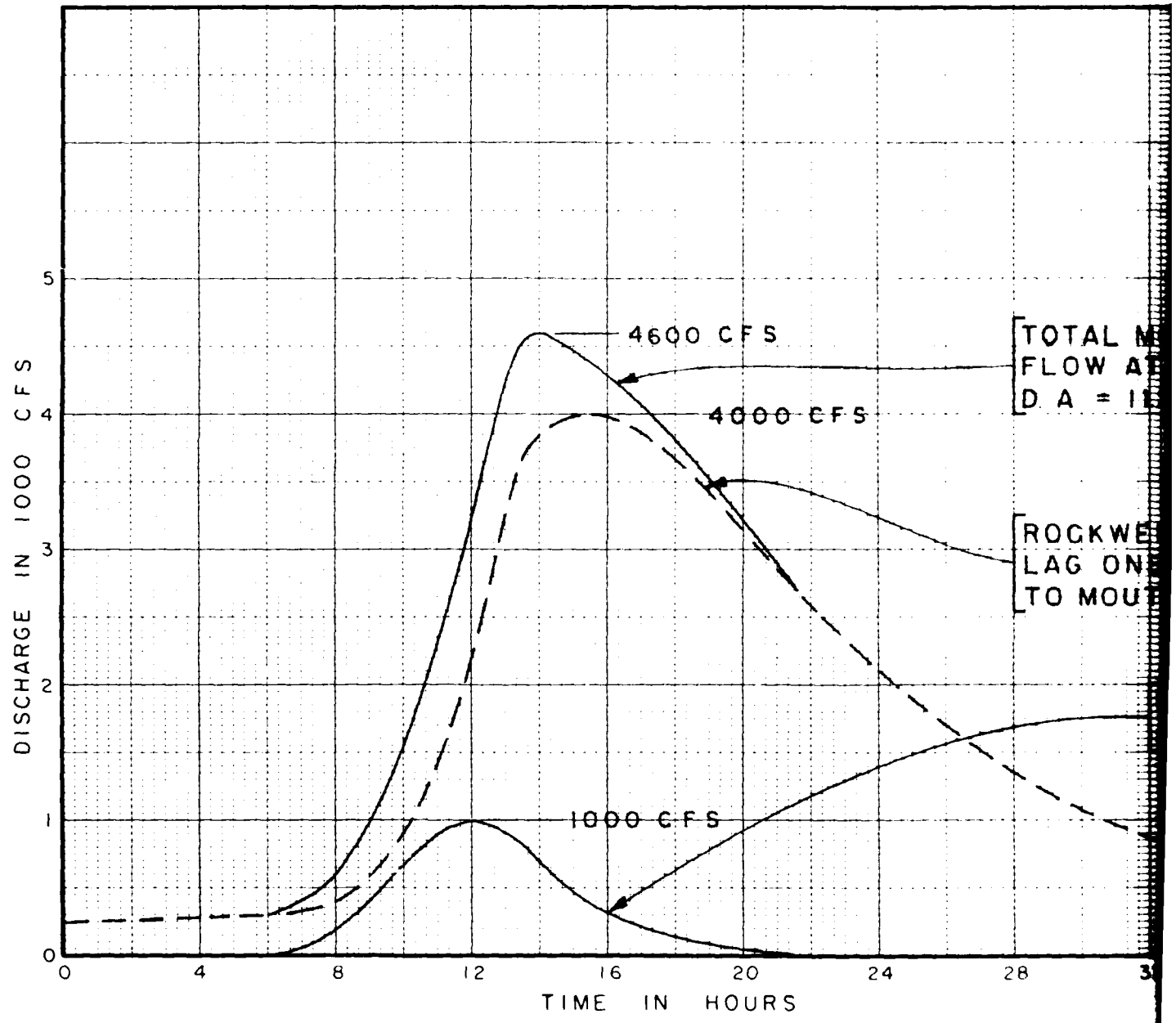
PLATE 5

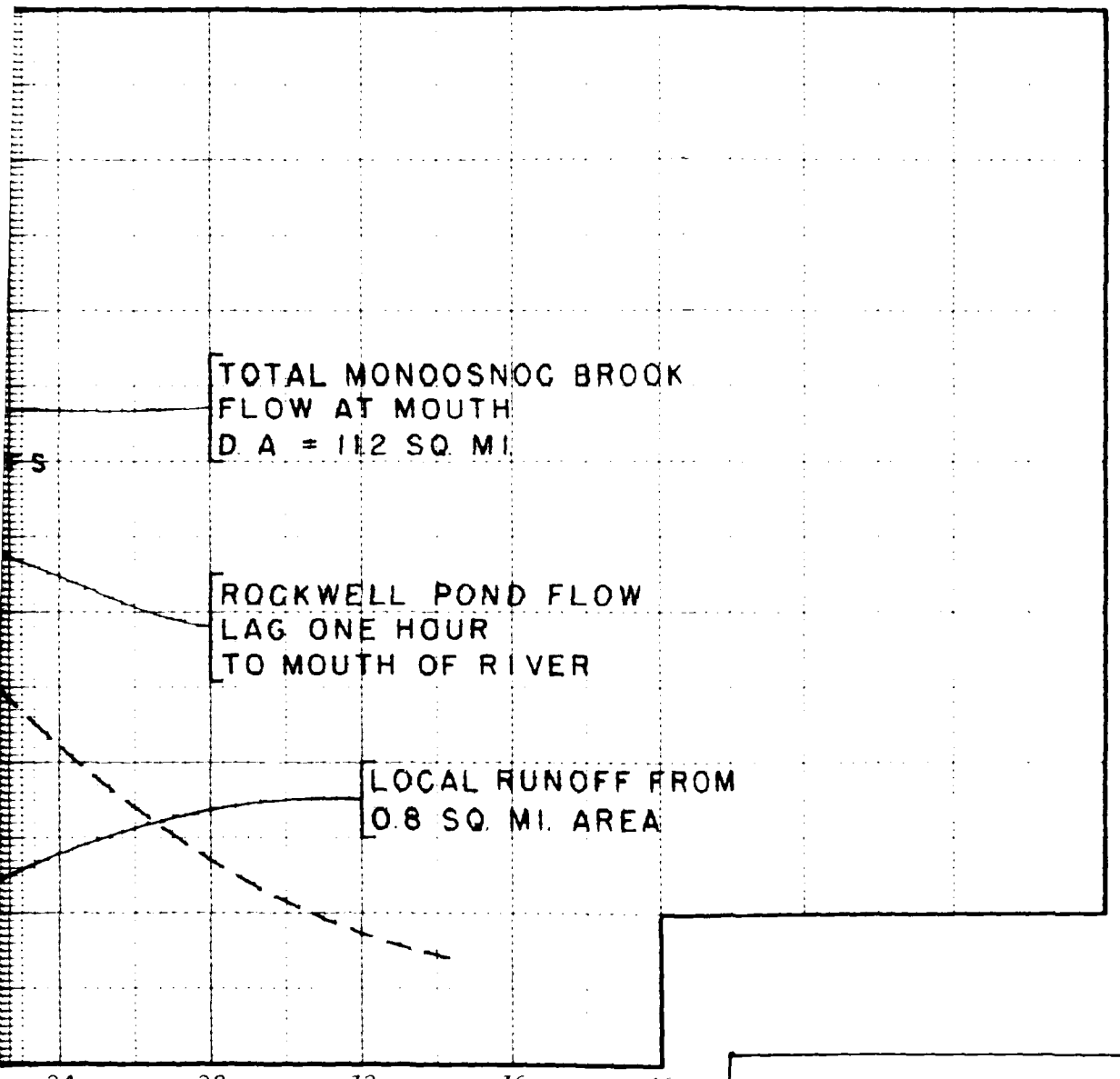

TOTAL FLOW AT
ROCKWELL POND DAM
D. A = 10.4 SQ. MI.
4000 C F S
LOCAL INFLOW
5.7 SQ. MI. AR
3500 C F S
NO
LA
MODIFIED
MONODSNOC BRK.
FLOW WITH
DIVERSION
1400 C F S
600 CFS
DISCHARGE IN 1000 C F S
0
1
2
3
4
5
0
4
8
12
16
20
24
28
TIME IN HOURS



WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK
ROCKWELL POND
STANDARD PROJECT FLOOD
HYDROGRAPHS
NEW ENGLAND DIVISION, WALTHAM, MASS
OCTOBER 1976

PLATE 6


DISCHARGE IN 1000 CFS
0
1
2
3
4
5
0
4
8
12
16
20
24
28
TIME IN HOURS
4600 CFS
4000 CFS
1000 CFS
TOTAL M
FLOW AT
D A = 1
ROCKWE
LAG ON
TO MOU



WATER RESOURCES DEVELOPMENT PROJECT

MERRIMACK RIVER BASIN

NORTH NASHUA RIVER

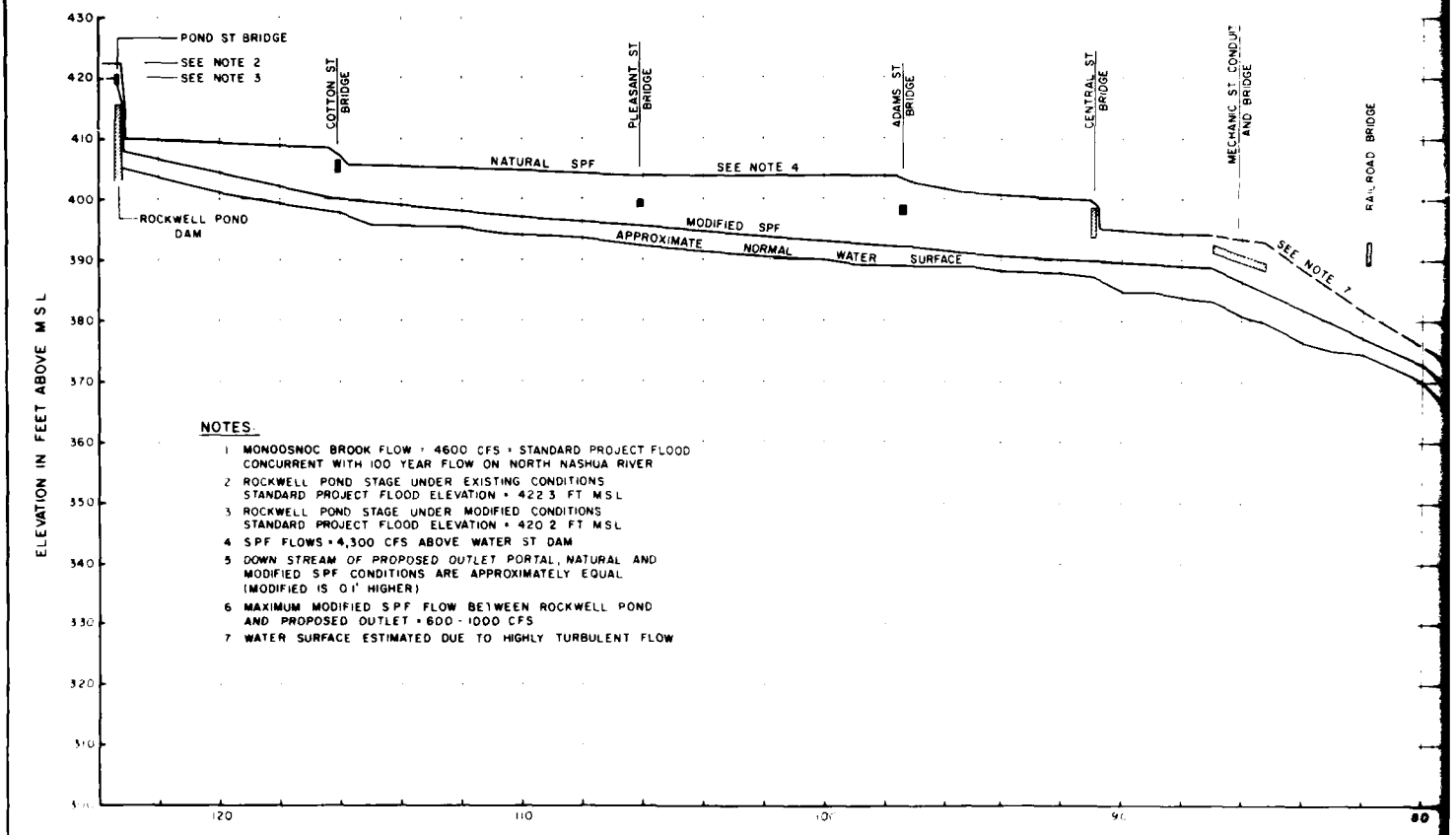
MONOOSNOC BROOK

STANDARD PROJECT FLOOD HYDROGRAPHS

NEW ENGLAND DIVISION, WALTHAM, MASS.

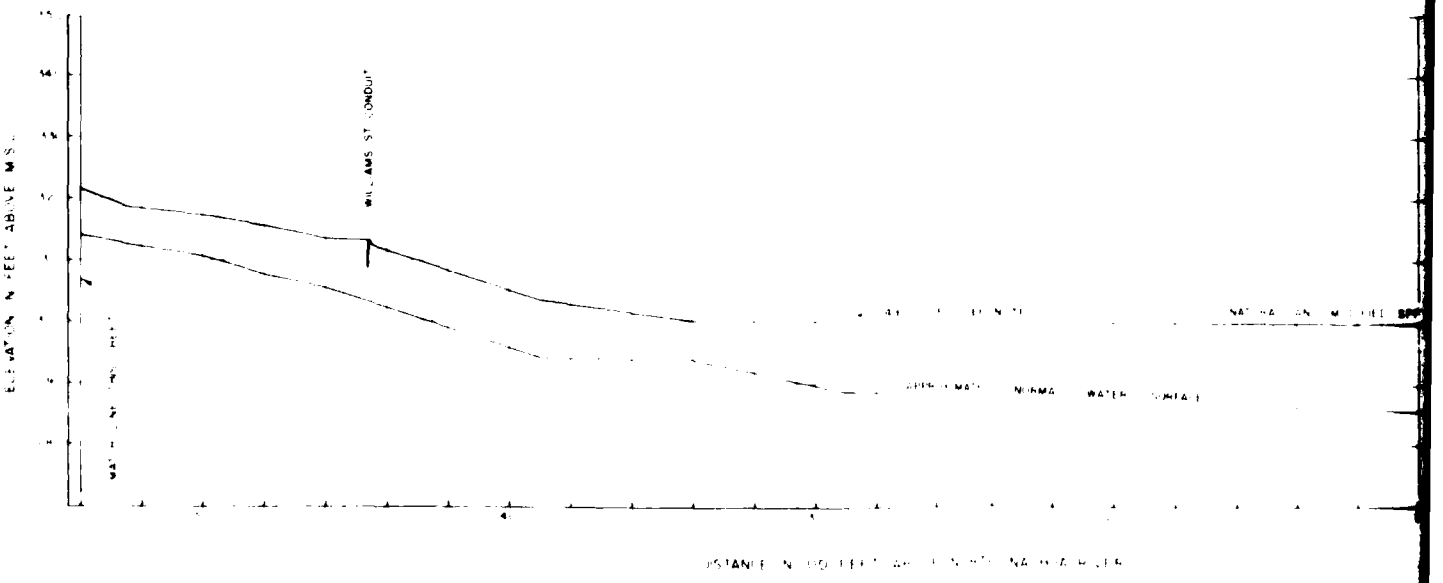
OCTOBER 1976

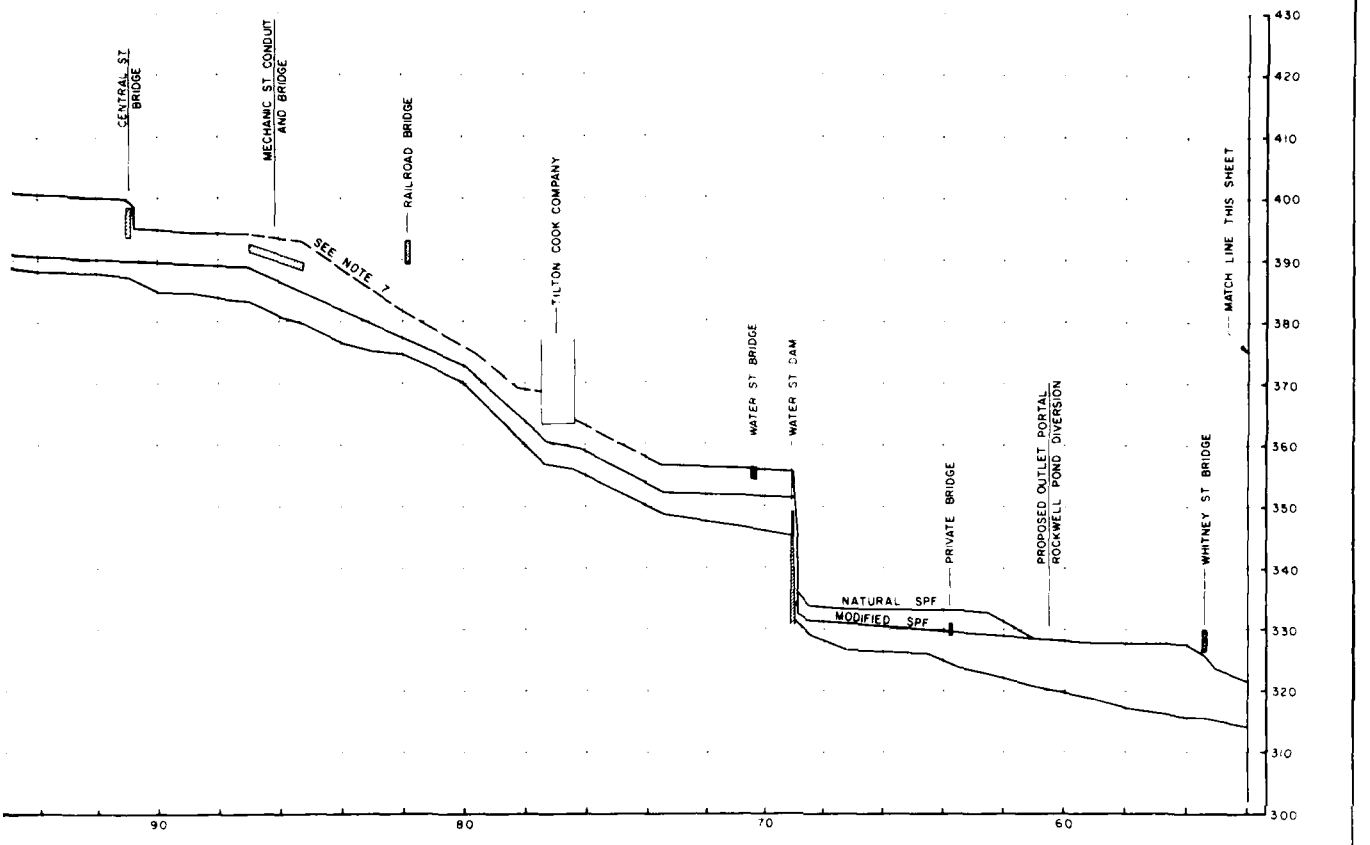
PLATE 7



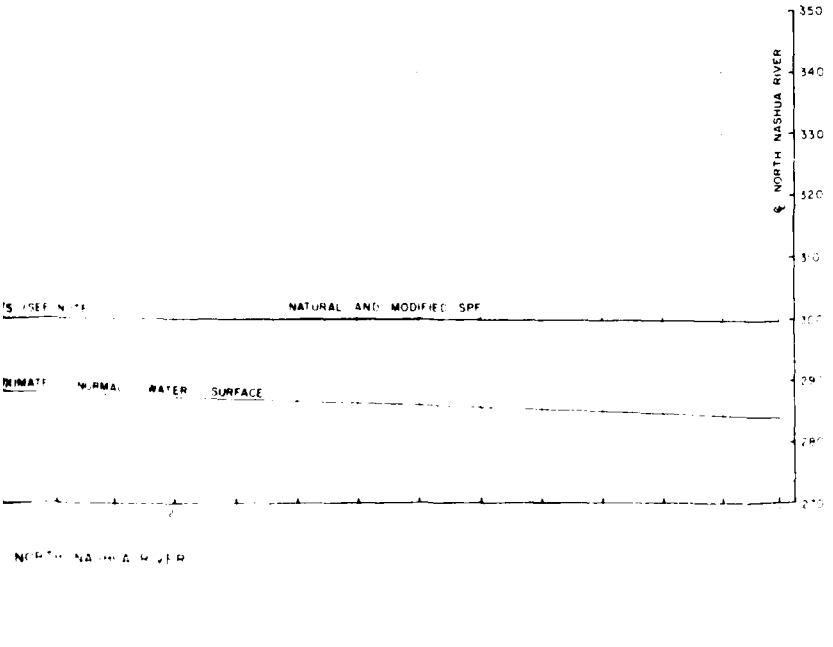
NOTES.

1. MONOOSNOC BROOK FLOW = 4600 CFS = STANDARD PROJECT FLOOD CONCURRENT WITH 100 YEAR FLOW ON NORTH NASHUA RIVER
2. ROCKWELL POND STAGE UNDER EXISTING CONDITIONS STANDARD PROJECT FLOOD ELEVATION = 422.3 FT MSL
3. ROCKWELL POND STAGE UNDER MODIFIED CONDITIONS STANDARD PROJECT FLOOD ELEVATION = 420.2 FT MSL
4. SPF FLOWS = 4,300 CFS ABOVE WATER ST DAM
5. DOWN STREAM OF PROPOSED OUTLET PORTAL, NATURAL AND MODIFIED SPF CONDITIONS ARE APPROXIMATELY EQUAL (MODIFIED IS 0.1' HIGHER)
6. MAXIMUM MODIFIED SPF FLOW BETWEEN ROCKWELL POND AND PROPOSED OUTLET = 600 - 1000 CFS
7. WATER SURFACE ESTIMATED DUE TO HIGHLY TURBULENT FLOW





DISTANCE IN 100 FEET ABOVE NORTH NASHUA RIVER



WATER RESOURCES DEVELOPMENT PROJECT

MERRIMACK RIVER BASIN

NORTH NASHUA RIVER

MONOOSNOC BROOK

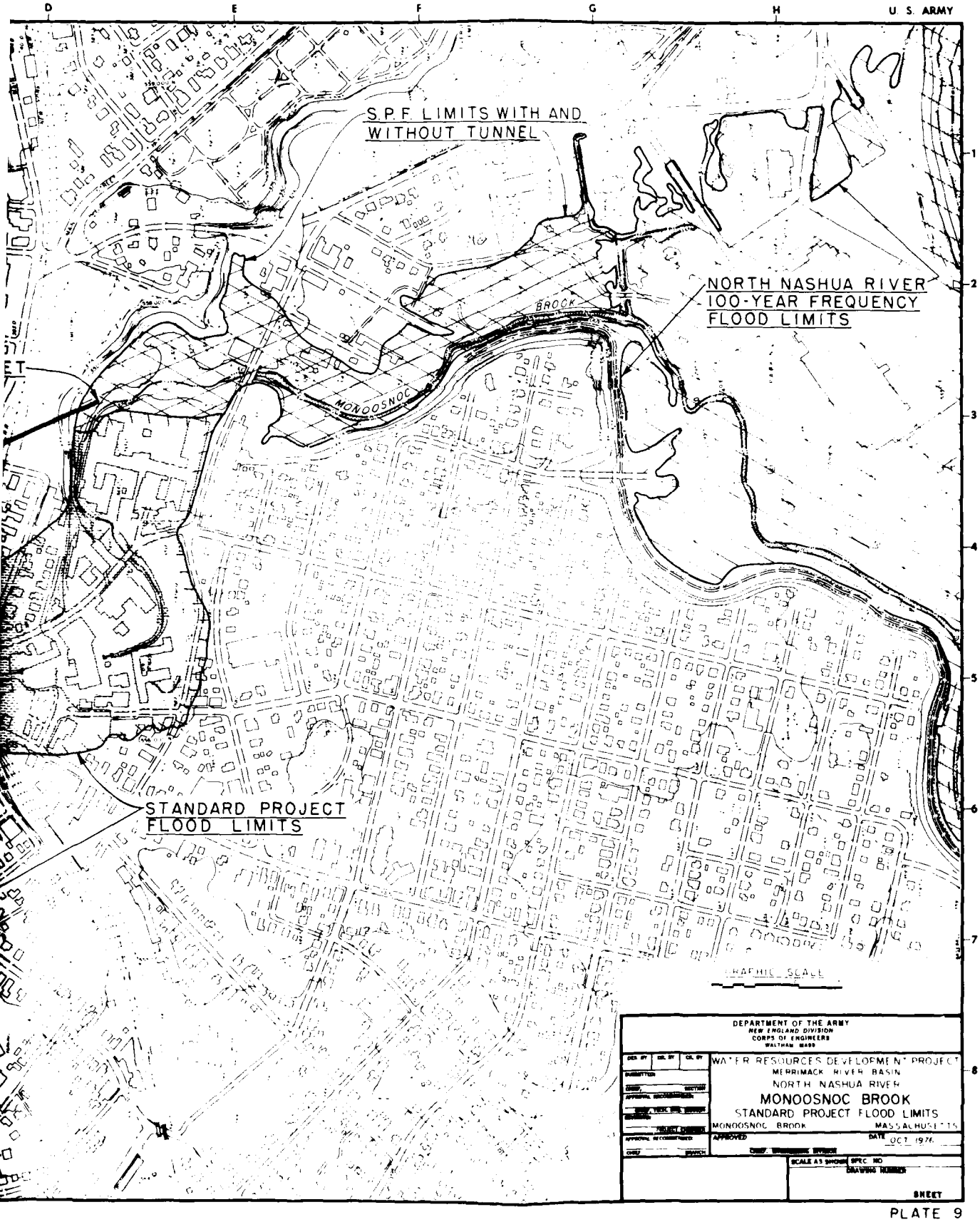
FLOOD PROFILES

NEW ENGLAND DIVISION, WALTHAM, MASS.

OCTOBER 1956

PLATE 8


CORPS OF ENGINEERS
A
B
C
D
1
2
3
4
5
6
7
8
LEOMINS
S.W.
OUTLET
TUNNEL
INLET
S.P.F. LIMITS
WITHOUT
TUNNEL
ROCKWELL POND
STANDARD PROJECT
FLOOD LIMITS
BROOK
MONGOSNOC



GRAPHIC SCALE

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

WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK
STANDARD PROJECT FLOOD LIMITS
MONOOSNOC BROOK MASSACHUSETTS

APPROVED DATE OCT. 1974

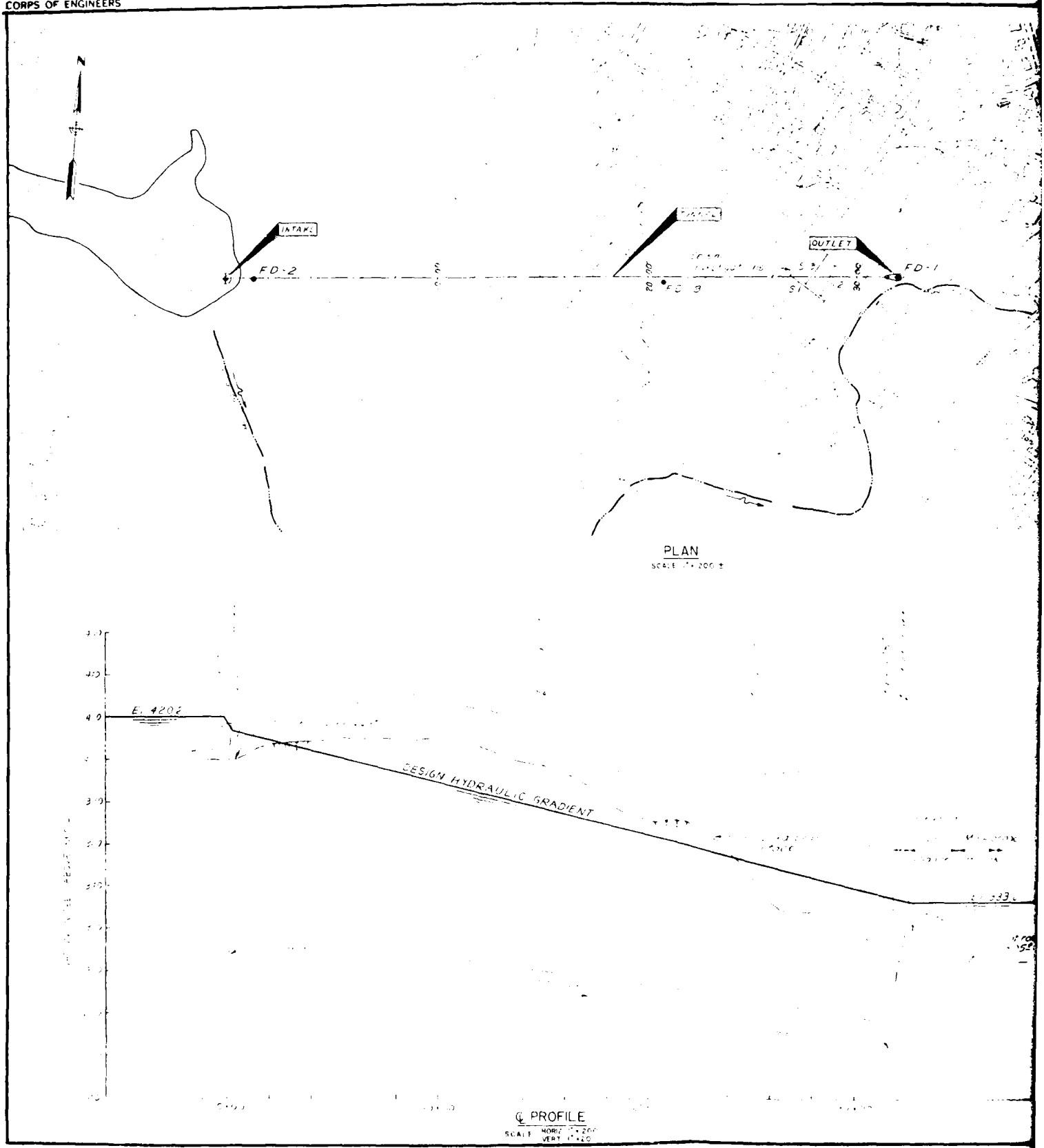
CHIEF ENGINEERING DIVISION

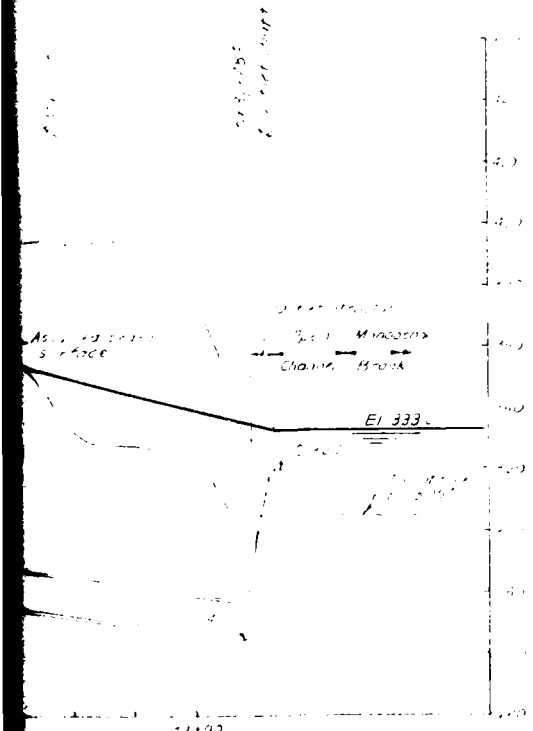
SCALE AS SHOWN SPEC. NO.
DRAWING NUMBER

SHEET

PLATE 9

CORPS OF ENGINEERS





REVISION	DATE	DESCRIPTION

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

DES. BY | DR. BY | CK. BY

SUBMITTED
CHIEF, SECTION
APPROVAL RECOMMENDED
CHIEF, TECH. ENG. BRANCH
REVIEWED
PROJECT ENGINEER
APPROVAL RECOMMENDED
CHIEF, BRANCH

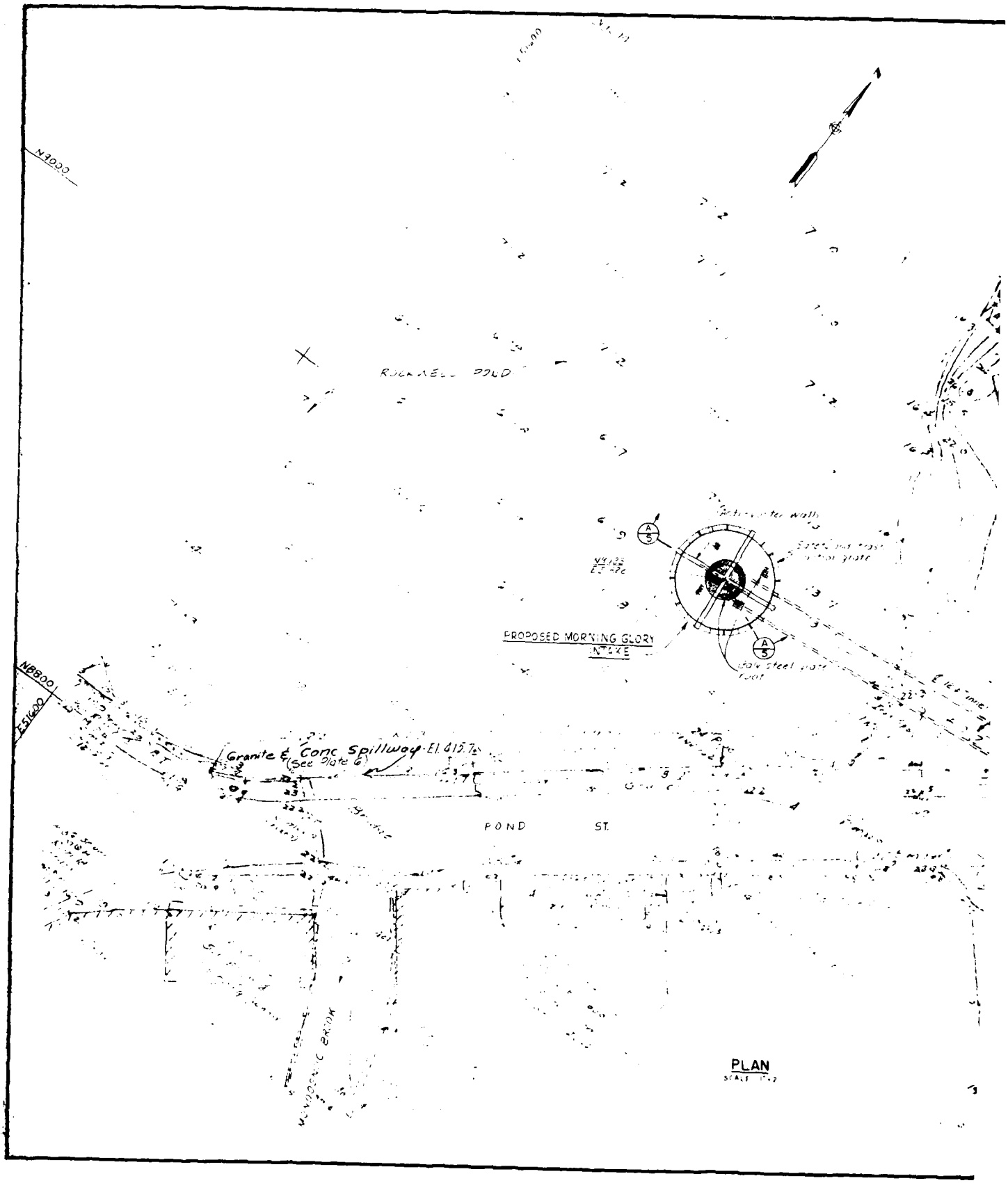
WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK BYPASS
PLAN AND PROFILE
MONOOSNOC BROOK MASSACHUSETTS

APPROVED
DATE OCT 1976
CHIEF, ENGINEERING BRANCH

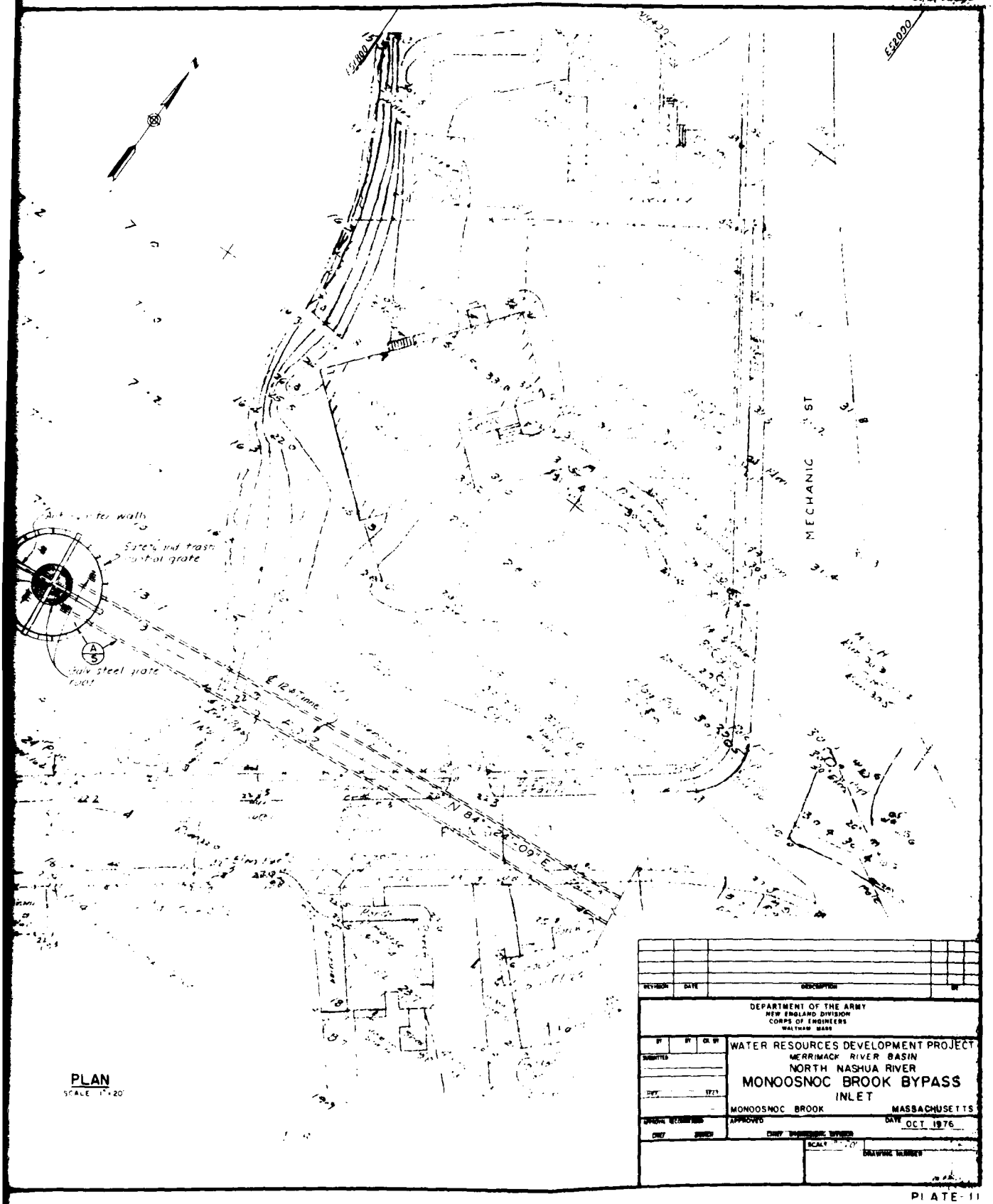
SCALE AS SHOWN | SPEC. NO.
DRAWING NUMBER

PLATE 10

CORPS OF ENGINEERS



U. S. ARMY



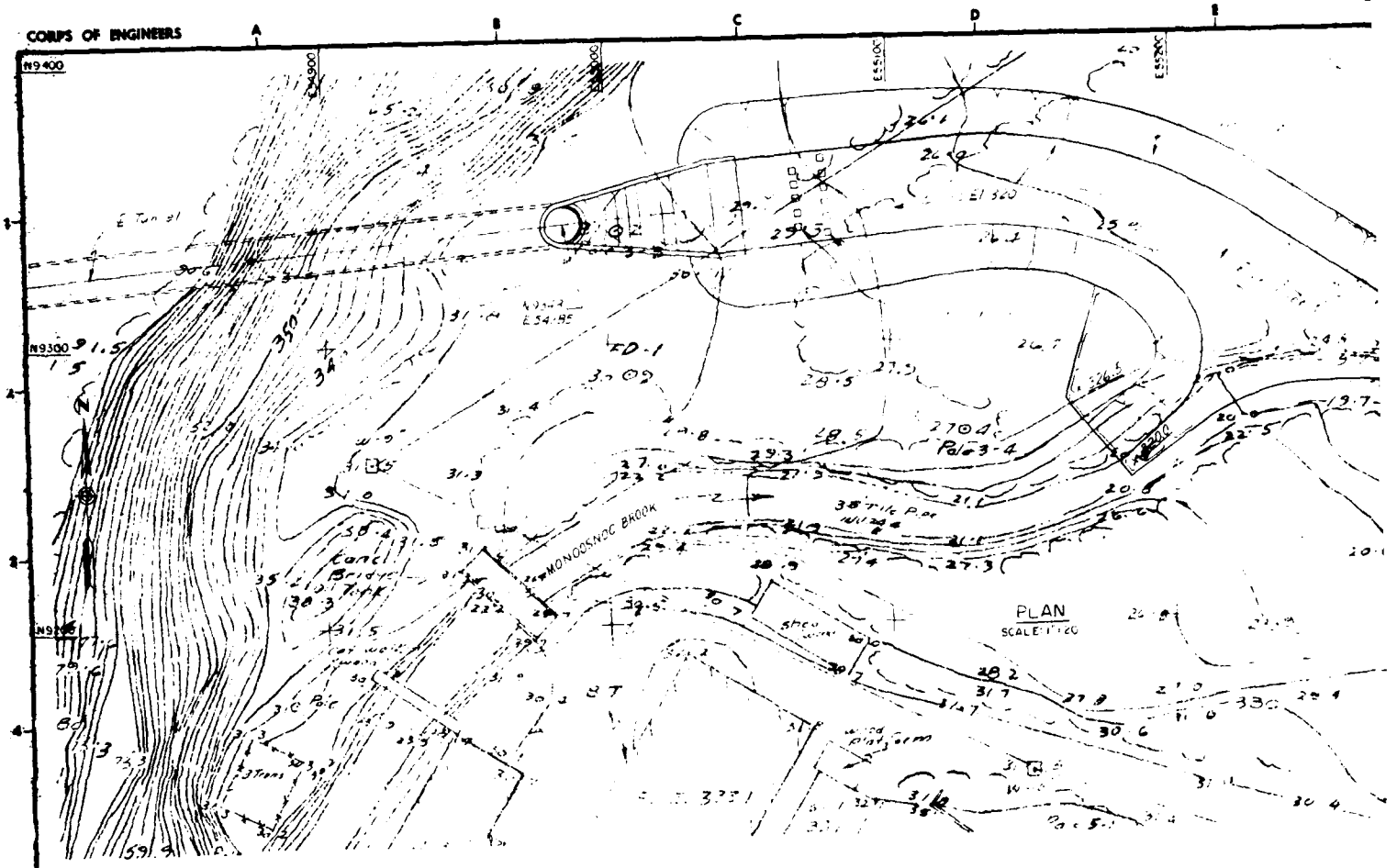
PLAN
SCALE 1" = 20'

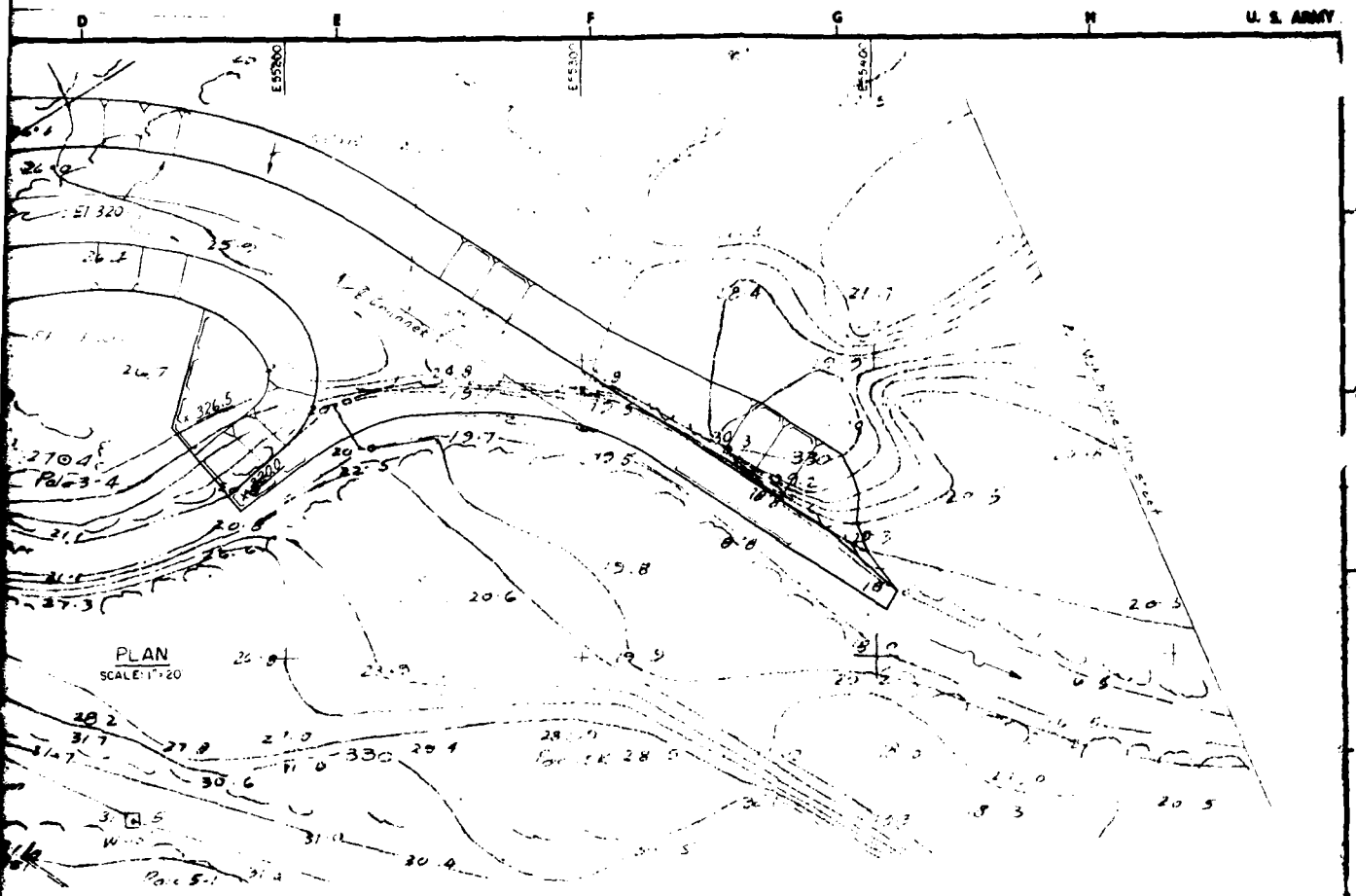
REVISION	DATE	DESCRIPTION	BY

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

WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK BYPASS
INLET
MONOOSNOC BROOK MASSACHUSETTS
APPROVED DATE OCT 1976

PLATE-11


CORPS OF ENGINEERS
A
B
C
D
E
N9400
N9300
E5400
E5500
MONOOSNOC BROOK
PLAN
SCALE 1"=20'

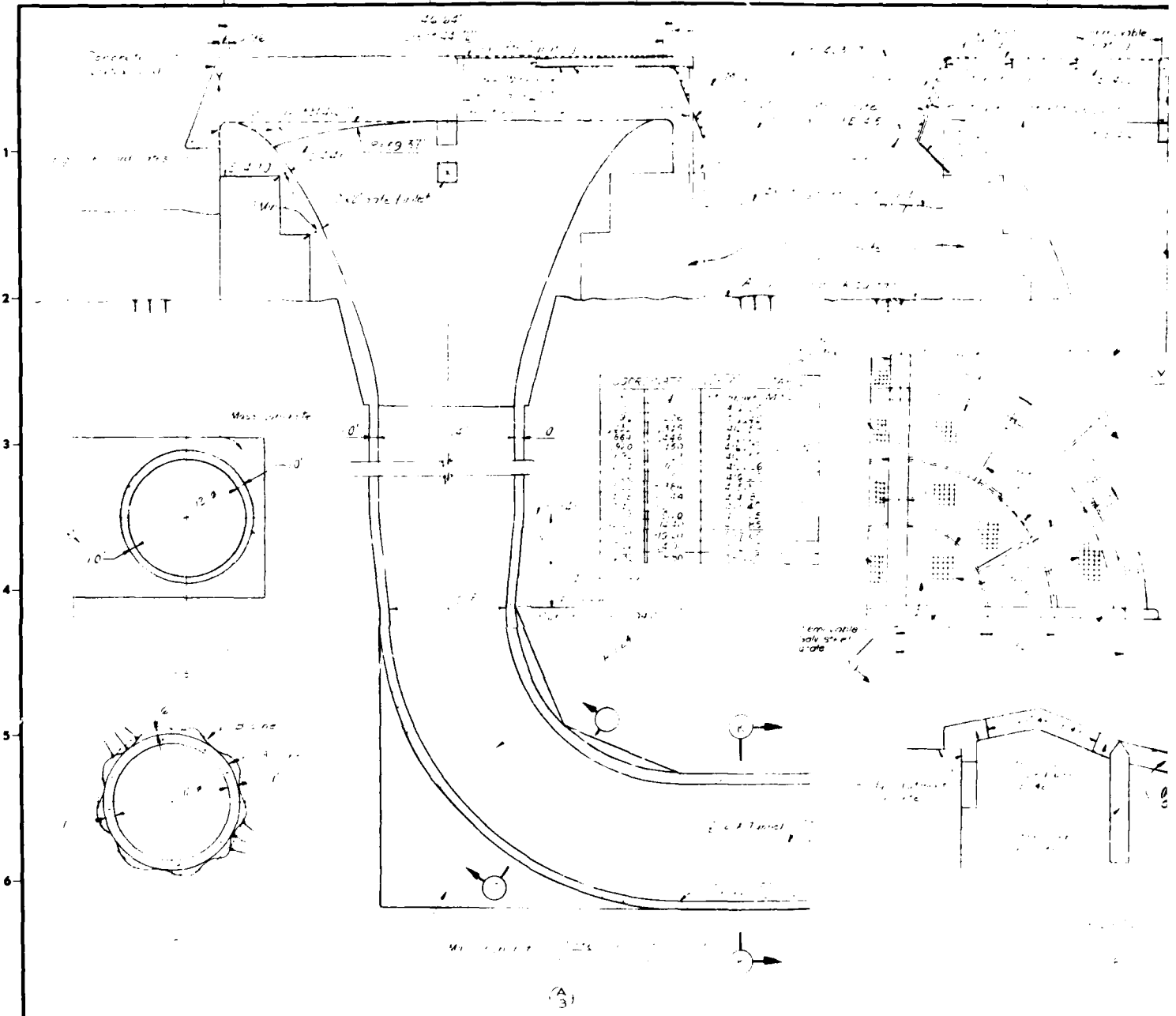


DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

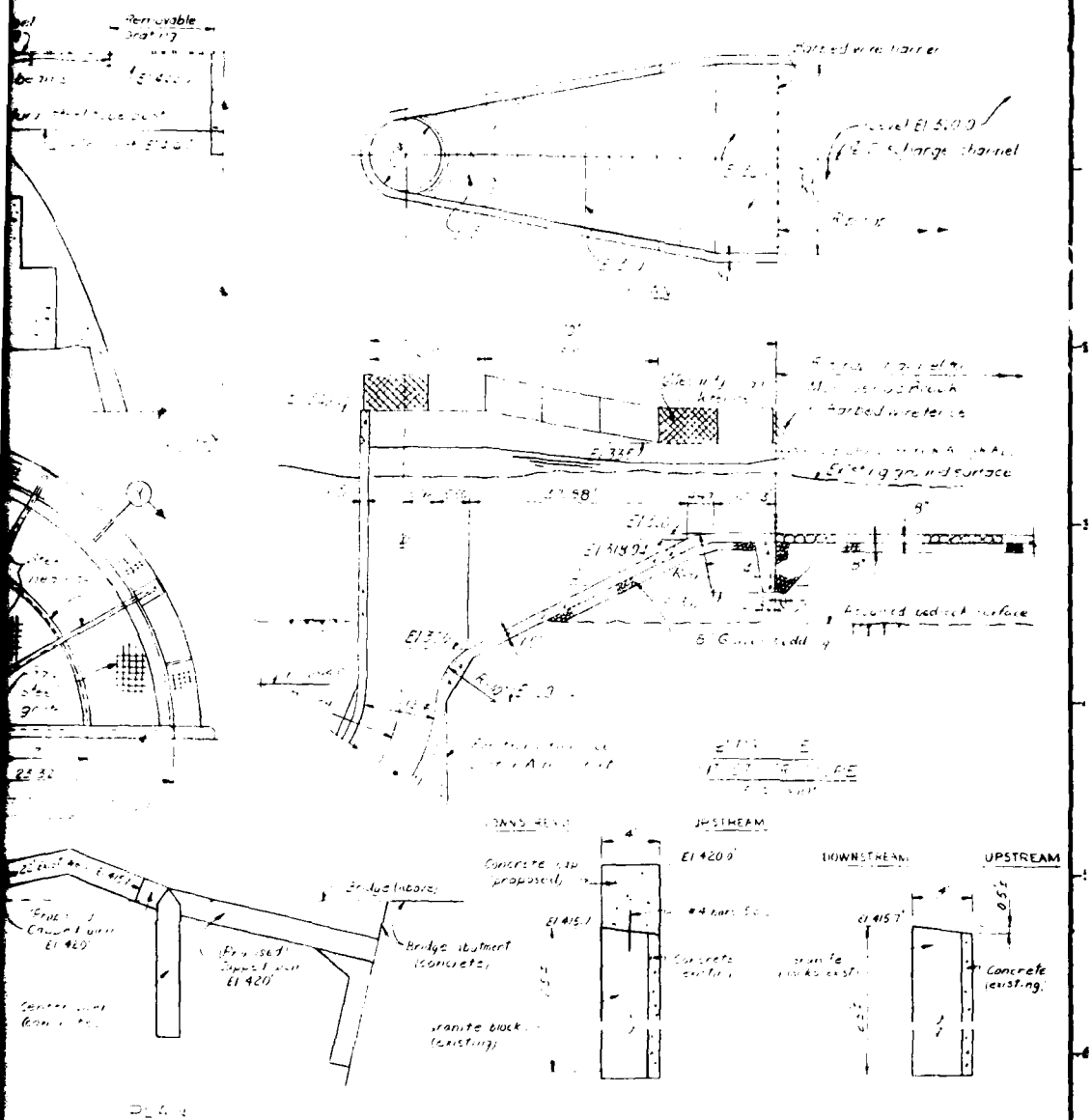
WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK BYPASS
OUTLET
MONOOSNOC BROOK MASSACHUSETTS
APPROVED OCT. 1976
SCALE 1"=20'

PLATE 12

CORPS OF ENGINEERS



E F G H U. S. ARMY



SAFETY PAYS

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY

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

DES. BY	DR. BY	CK. BY

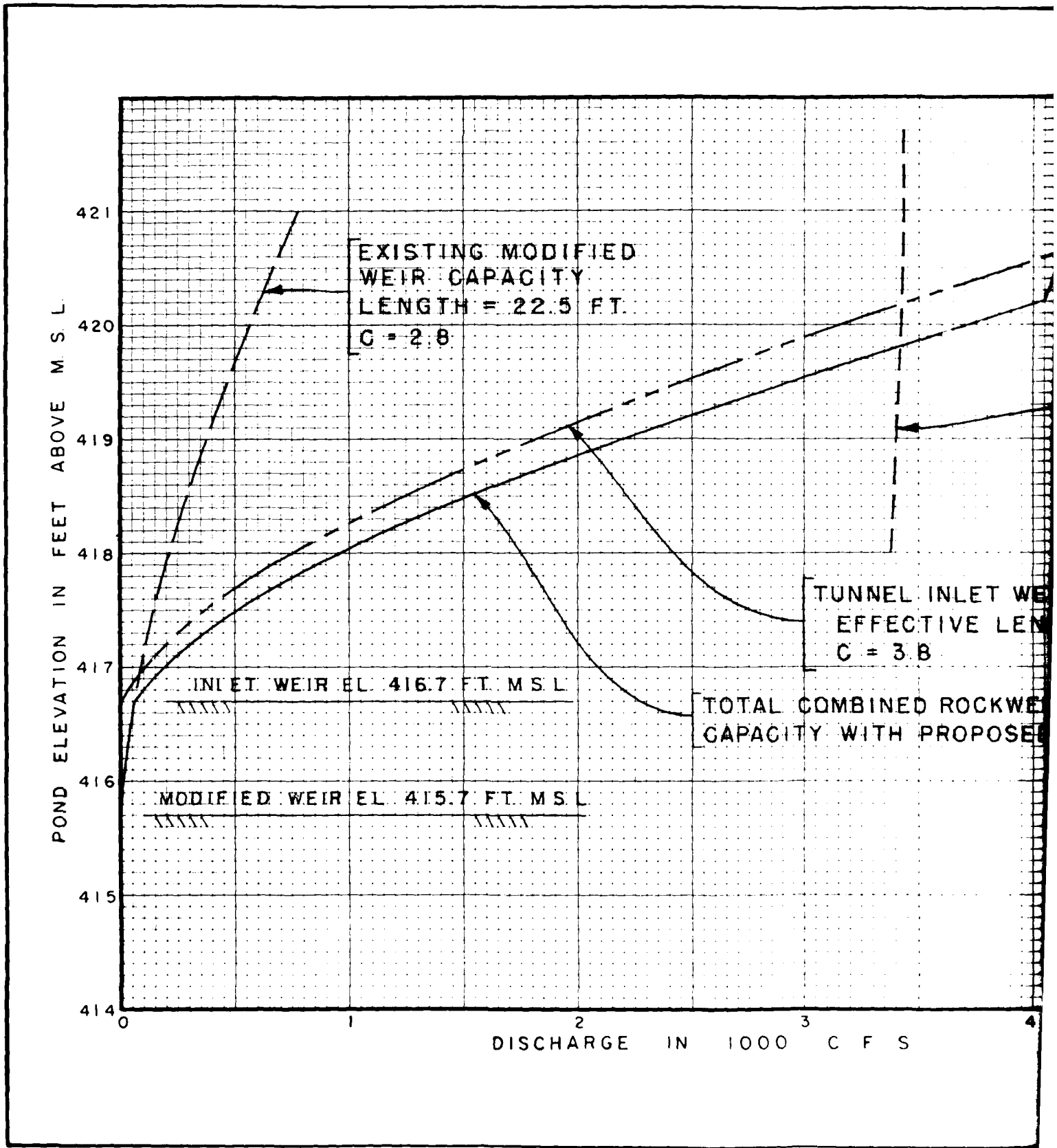
SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF, BRANCH

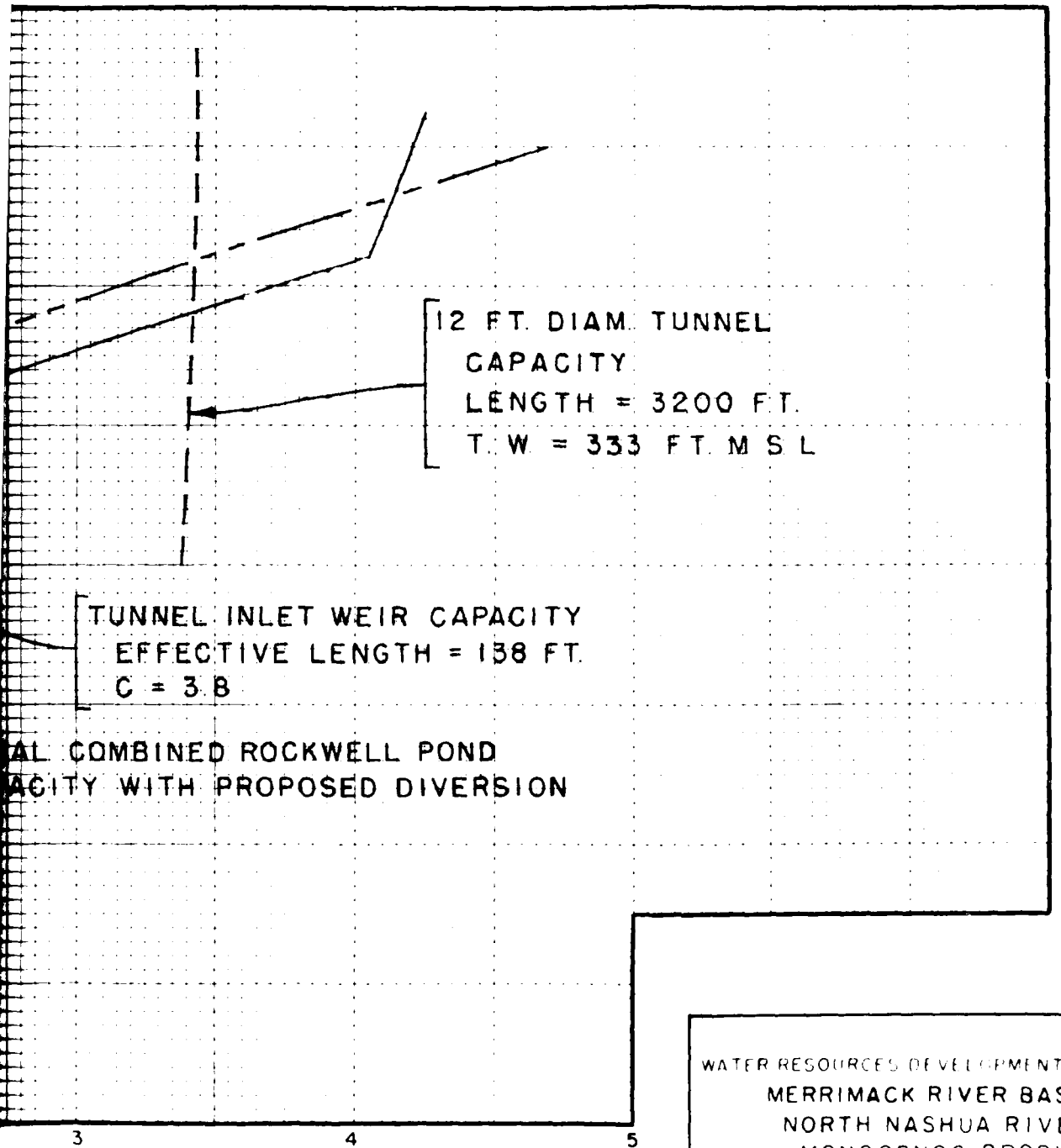
WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK BYPASS
PLANS AND SECTIONS
MONOOSNOC BROOK MASSACHUSETTS

APPROVED
DATE OCT. 1976
CHIEF, ENGINEERING DIVISION

SCALE AS SHOWN SPEC. NO.
DRAWING NUMBER
SHEET

PLATE-13


EXISTING MODIFIED
WEIR CAPACITY
LENGTH = 22.5 FT.
C = 2.8
TUNNEL INLET WE
EFFECTIVE LEN
C = 3.8
TOTAL COMBINED ROCKWE
CAPACITY WITH PROPOSE
INLET WEIR EL. 416.7 FT. M.S.L.
MODIFIED WEIR EL. 415.7 FT. M.S.L.
POND ELEVATION IN FEET ABOVE M.S.L.
421
420
419
418
417
416
415
414
0
1
2
3
4
DISCHARGE IN 1000 C F S



WATER RESOURCES DEVELOPMENT PROJECT
MERRIMACK RIVER BASIN
NORTH NASHUA RIVER
MONOOSNOC BROOK
ROCKWELL POND
RATING CURVES
NEW ENGLAND DIVISION, WALTHAM, MASS.
OCTOBER 1976

PLATE 14

SECTION E

REAL ESTATE STUDIES

REAL ESTATE STUDIES

TABLE OF CONTENTS

SECTION E

REAL ESTATE STUDIES

The purpose of this report is to estimate the real estate costs for the proposed Monoosnoc Brook and Lake Local Protection Project in Leominster, Massachusetts. Local interests are required to provide all lands, easements and rights-of-way necessary for project construction.

Location and Area Data

This project is located generally in the center of the town of Leominster in Worcester County, Massachusetts.

Leominster is bounded by Fitchburg on the north, Westminster and Princeton on the west, Sterling on the south and Lancaster and Lunenburg on the east. It is 20 miles north of Worcester, 45 miles west of Boston and 195 miles from New York City.

Leominster is an industrial community whose principal manufactured goods are plastic products, apparel, finished goods, chemicals and allied products, machinery and furniture.

Its population in 1970 was 37,939, an increase of 5,000 since 1960.

The city has railroad freight service while Piggy-Back service is available in neighboring Fitchburg. Several interstate bus lines serve this community over Routes 2 and 12, the principal highways.

Electricity, gas and telephone are available from local distributors while water service is supplied to the city by surface and groundwater sources. Sewerage is provided by the city.

Zoning was adopted in 1929 and amended in 1961. The major part of this project would be built in Residence "A," Residence "B" and Industrial areas.

Approved
[illegible]

Location and Project Description

This project consists of a 12-foot diameter diversion tunnel about 3200 feet long, originating in Rockwell Pond in the form of a morning glory type spillway and dropping to an elevation approximately 100 feet below the city proper. The subsurface tunnel extends beneath residential commercial and industrial improved lands, terminating in industrial land north of Whitney Street near Monoosnoc Brook. The outlet works would consist of a 200-foot long outlet structure with earth dikes, gravity walls and grading below the outlet.

Land and Improvements

INLET - Section 1

This section of the project would involve an estimated 33 ownerships, two of which are city owned, around the perimeter of the 11-acre pond. The water elevation of the pond is approximately 416 feet above mean sea level. A flowage easement comprised of approximately 185,281 square feet (4.25 acres) of permanent easement land would be required to the 420-foot above mean sea level elevation.

A temporary construction easement would be required on city owned property leased to the Veterans of Foreign Wars organization at the corner of Pond and West Streets. About 17,600 square feet (.40 acre) of paved parking and grass covered area on Pond Street would be required for this purpose.

TUNNEL - Section 2

The subsurface 12-foot diameter conduit would extend beneath a high density residential area improved by large established older homes, under a business zone containing three gasoline service stations and a large apartment building. It continues beneath an industrial zoned area, surfacing near Monoosnoc Brook. It is anticipated that the existing surface uses will not be affected by the construction and operation of the subsurface tunnel. Approximately twenty one private ownerships and five city owned properties are involved in the tunnel alignment.

OUTLET - Section 3

The outlet will surface about 600 feet westerly of Whitney Street Bridge near Monoosnoc Brook in rear industrial lowland. This area is lightly wooded and is subject to seasonal inundation. A gravity wall and an earthen dike will be located on private ownerships in this area. About 330,750 square feet (7.59 acres) of permanent flowage easement will be required plus an additional 53,500 square feet (1.23 acres) of temporary construction easements. Considerable grading will be necessary around industrial buildings south of Whitney Street to control runoff. A total of four private ownerships are involved in this area.

HIGHEST AND BEST USE

The highest and best use of the required land is its present use, that of residential, business and industrial land.

ZONING

The project is zoned residential, business and commercial. Residential zoning requires 12,500 square feet minimum area while business and commercial zones have no minimum area.

Acquisition Costs

It is estimated that real estate interests will be required in about 57 private ownerships in the subject project. Based upon the experience of this office in acquiring various interests in similar properties in other Civil Works projects in the area, the acquisition costs for the Monoosnoc Brook and Lake project are estimated at $2,000 per tract. These costs include mapping, survey, legal descriptions, title evidence, appraisals, negotiations, closings and administrative costs for possible condemnation. The ownerships have been estimated with the benefit of local assessor's maps and project area maps which are considered to be reasonably accurate. Based on this ownership survey, the acquisition costs for the entire project are estimated to be:

57 Private Ownerships	@	$2,000	= $114,000
1 Public Ownership	@	-0-	= -0-
Total Estimated Acquisition Costs			= $114,000

Relocation Assistance Costs

Public Law 91-646, Uniform Relocation Assistance Act of 1970, provides for uniform and equitable treatment of persons displaced from their homes, businesss or farms by Federal or Federally assisted programs. In accordance with this law, an estimate of $21,400 is included in this report to cover relocation expenses for three improvements and payments of expenses incidental to the transfer of real property.

Water Rights

Rockwell Pond was formed in the 1800's by the construction of a stone dam at what is now known as Pond Street. This dam, built in conjunction with a woolen mill, gives the owner the right to flow a pond as high as the spillway. The proposed modification of the dam and the construction of the tunnel will in no way interrupt these rights which are not being exercised because of diversification of the mill.

Severance Damages

Where only a portion of an ownership is being acquired, the owner is entitled to the market value of the part taken plus any severance damage to the remaining portion. Severance damage is the loss in value of the remaining parcel after the taking as compared with the whole. No severance damage is considered in the Rockwell Pond area since the narrow strip of rear sloping land bordering the pond will be taken as flowage easements and will not materially affect their market values. (Severance damages will be estimated for the partial taking of an industrial building in the outlet area.)

Contingencies

A contingency allowance of 20 percent is considered to be reasonably adequate to provide for possible appreciation of property values from the time of this estimate to acquisition date, for possible property line adjustments or for additional hidden ownerships which may be developed by refinement of taking lines, for adverse condemnation awards, and to allow for practical and realistic negotiations.

Government Owned Facilies

Section III of the Act of Congress approved 3 July 1958 (PL 85-500) authorized the protection, realteration, reconstruction, relocation or replacement of municipally owned facilities. Although there are several city owned properties in the tunnel alignment and one at Rockwell Pond, none will be affected by this law.

Tax Loss

Based on information obtained from the local assessor, the tax loss to the town is estimated at approximately $2,000 per year.

Timber and Crops

There are no merchantable timber or growing crops within the project area.

Temporary Construction Easements

Two areas are required for temporary construction easements as previously described in the project description: one contiguous to the work area at the intake of the tunnel on city owned land and the other contiguous to the outlet on rear, wooded industrial land. They consist of 17,600 square feet and 53,500 square feet, respectively. Costs of the temporary easements are predicated upon a fair return of capital invested (fair market value).

The total estimated costs of the temporary easements are for a projected two year construction period.

A summary of real estate costs for the entire project follows:

REAL ESTATE COSTS
RECAPITULATION OF VALUE

Land and Improvements (Fee and Permanent Easements)	$140,500
Temporary Construction Easement	11,700
Acquisition Costs	114,000
Severance Damages	20,000
Relocation Assistance	21,400
Contingencies (20% of above)	61,500
Total Estimated Real Estate Costs	$369,100
Rounded to	$370,000

SECTION F

FORMULATING A PLAN

FORMULATING A PLAN

TABLE OF CONTENTS

TABLES

SECTION F

FORMULATING A PLAN

In the formulation portion of the study, a wide range of alternatives was investigated to find the best method for resolving Leominster's water resource problems and needs. Of the water resource needs studied, only the flood control problem warranted the development of alternative solutions. Various plans were then devised on the basis of technical engineering expertise.

Once comparable levels of flood control were obtained, each plan was evaluated for its costs and its effects on Leominster's economic development. Alternatives that survived the economic assessment were further evaluated for their impacts on the quality of the environment in accordance with the Principles and Standards of Water Resources Planning and Related Land Resources. Both beneficial and adverse effects of the alternatives were outlined and compared. Where possible, the plans were modified to reduce adverse effects. On the basis of the final comparisons, a single plan for flood control was selected and recommended.

Formulation and Evaluation Criteria

Formulation and evaluation of the various plans of improvement for Monoosnoc Brook were based on technical, economic, social and environmental standards. Such criteria permit the selection of only those plans that best respond to the problems and needs of the affected area.

Technical Criteria

The following technical criteria were adopted for use in developing a plan of improvements:

a. The selected water resource plans are consistent with local and regional plans for land use and water related activities.

b. Selected plans are flexible enough to accommodate projected future development.

c. Existing water quality standards should be enforced and future standards should insure improvement of water quality.

d. Total costs of meeting future water supply demand should include those required for distribution systems.

e. A Standard Project Flood (SPF) is considered to be the project design flood.

f. Increased discharges into downstream areas that result from implementation of upstream flood control works will not cause additional flooding to those downstream zones.

Economic Criteria

The economic criteria applied in formulating a plan of local flood protection are summarized as follows:

a. Tangible benefits exceed project economic costs.

b. The scope of the project will provide the maximum net benefits. Intangible benefits will be taken into consideration.

c. There is no more economical means, evaluated on a comparable basis, of accomplishing the same purpose.

d. All benefits and costs are expressed in comparable terms.

e. Annual costs include those for maintenance and operation of the project.

Environmental Criteria

The following environmental and social criteria were utilized in formulating a plan:

a. A systematic interdisciplinary approach is followed to insure the integrated use of natural and social sciences and environmental design.

b. An evaluation of the environmental impact of any proposed action includes adverse impacts.

c. A determination of any irreversible or irretrievable commitment of resources is made.

d. Detrimental environmental effects are avoided and feasible mitigating measures are included, if necessary.

e. Measures are taken to insure public health, safety and social well-being.

Formulation of Alternative Plans

Once the extent of water and related land resources problems and needs for the city of Leominster had been determined, initial planning objectives were formulated. This process was aided by information contained in the Community Development Plan Summary which listed both short-term and long-term objectives. Short-term objectives relating to water resource development and possible methods of implementation are described as follows:

1. To plan, manage, and improve Leominster's water resources. To provide a more rational utilization of land and other natural resources, Leominster must take steps to protect its watershed and water supply. Tuberculation is a problem which reduces water pressure and volume and reduces water purity. It can be corrected by relining or replacing water pipes. Other steps to improve and protect drinking water include reducing foliage deposits in reservoirs, reducing erosion in watershed areas and reducing development in watershed areas of Leominster's reservoirs. Water resource protection helps answer the need to preclude future drinking water crises.

2. To provide adequate community development planning. The establishment of a comprehensive community development program requires good community development planning. Adequate planning supports most of the Community Development needs described therein. However, it has special significance in planning, monitoring and managing the growth of Leominster's population and the development of its land area.

3. To implement an adequate, well-planned economic development program. "Expanding economic opportunities, principally for persons of low or moderate income," is part of the primary objective of the Community Development Program. The short-term objective of economic development relates to the need to expand economic opportunities in the community.

4. To improve the downtown area. To achieve the long-term objective of a healthy downtown, it is necessary to alleviate the conditions which have impaired downtown investment in the past. Specific improvements must be planned in a coordinated manner to maximize long-term benefits and preclude interfacing problems. This short-term objective will support the needs "To restore the flow of commercial activity to the downtown area" and "To expand economic opportunities."

5. To conduct a housing rehabilitation program. Along with enforcement of housing codes, the city should provide incentive to property owners to repair or rehabilitate property which is blighted or deteriorating. Conduct of a housing rehabilitation program will contribute toward the elimination of slums and blight and toward the elimination of conditions which are detrimental to health, safety or public welfare. This objective responds to the community development needs to upgrade the housing stock and to arrest deterioration in the community.

6. To encourage private restoration of potentially esthetic properties. Private property restoration is important. It affects a large part of the community and it utilizes private resources for a common good. The city can take certain short-term measures to encourage citizens to restore properties privately. This includes tax incentives, permit processes and other local regulations which affect private property owners. Improvement of the community will eventually reward private property owners by increasing the resale value of their property as well as improving their living environment. These improvements will help develop a viable urban community. This objective answers the community development need to arrest deterioration.

7. To adopt and enforce rigid land use controls. To satisfy the need to improve land use compatibility, Leominster should adopt and enforce rigid land use controls. These will help eliminate and prevent conditions detrimental to health, safety and public welfare that may arise when, for instance, manufacturing land use is mixed with residential.

8. To adopt measures to protect natural and historic resources. To satisfy the need to preserve historic properties and protect natural resources, it is necessary to take specific measures. These could include purchasing conservation or historic preservation easements or acquiring fee to properties of historic or natural resource value.

9. To adopt a program to rehabilitate properties of historic significance. Rehabilitating properties of historic significance answers the need to preserve historic properties. Preservation of Leominster's heritage and culture is an important part of community revitalization and should not be neglected. This short-term objective helps to meet a major national objective of the Housing and Community Development Act: the restoration and preservation of properties of special value for historic, architectural or esthetic reasons.

10. To provide adequate storm sewer facilities for surface runoff. To meet the need to correct local flooding problems, it is a short-term objective of the city of Leominster to provide adequate facilities of this type. Storm sewer improvements will eliminate conditions detrimental to health, safety and public welfare, especially during winter months when freezing of flooded areas on streets makes travel hazardous, both by foot and by automobile.

11. To provide adequate recreation facilities. Recreation is an important part of Leominster's Community Development Plan because it allows residents to enjoy themselves more fully by providing a more suitable living environment. Recreation facilities will be balanced; they will include both active and passive modes. This short-term objective will support the need to improve recreation facilities and will help to attain the long-term objective of a balanced recreation program.

Long-term objectives taken from the Leominster Community Development Plan Summary follow:

1. Adequate water supply, water distribution and watershed protection. Maintaining an adequate water supply is a long-term objective of the city of Leominster. Achievement of this objective involves acquisition of title or interest in watershed land, where necessary; upgrading of the water distribution system, where necessary; planning for future needs and other actions. Adequate water supply, distribution and watershed protection will meet Leominster's need to protect the water supply.

2. Growth management capability. To avert future problems such as overloading of the sewer treatment system (it resulted in a State imposed ban on sewer connections) and overcrowding in the school system (this resulted in double sessions), one of the long-term objectives of the city is the development of a growth management capability. This relates to the need to plan, monitor and manage the growth of Leominster's population as well as other community development needs. The growth management objective is a significant element of Leominster's Comprehensive Community Development Plan.

3. Adequate wastewater disposal capability. A long-term objective that is corollary to growth management is wastewater disposal capability. To expand the housing stock and provide a decent home and suitable living environment for persons of low and moderate income, the city must be able to provide adequate sewage treatment service for new homes. This objective supports several needs including provision of adequate city services, expansion of economic opportunities and public facilities, and protection of natural resources.

4. A healthy downtown. To become vital and viable, Leominster must have a healthy downtown. The central business district is the hub of activity around which the entire community revolves. An unhealthy, deteriorated downtown will encourage decline in the entire community while improvements to the downtown will help improve the entire community. A healthy downtown is one which serves as the central marketplace for the city. It is alive and vigorous. For Leominster to develop into a viable urban community it must develop a commercial section. Attainment of the long-term objective will affect two community development needs: enhancement of economic opportunities and restoration of the flow of commercial activity to the downtown area.

5. A pleasing city appearance. An ultimate goal of the Leominster Community Development Program is an esthetically pleasing municipality. The elimination of slums, blight and deterioration should allow Leominster to work toward this long-term objective. A pleasing city appearance helps meet the needs for arresting deterioration, encouraging sound design and construction methods, preserving historic buildings and sites, and providing public facilities for neighborhoods.

6. Protection of natural and historic resources. Resource protection is a significant long-term objective of the Community Development Program. Leominster has many natural and historic resources that could be damaged by unwise development. This long-term objective helps satisfy Leominster's need to protect its water supply, arrest deterioration, encourage sound design and preserve historic buildings and sites.

7. Adequate disposal of surface water runoff. The long-term objective of adequate disposal of surface water runoff from rainstorms and melting snow is a very important element of Leominster's Community Development Plan. Due to Leominster's irregular terrain, localized flooding of basements and yards has been a serious problem during rainstorms and after snowfalls. It is important to the residents that this need be addressed by Leominster's Community Development Plan. The objective supports the need to correct local flooding problems.

[illegible] It is felt that the city of Leominster can [illegible] meets the recreational needs of its residents. [illegible] planning process is of greatest benefit to those segments of the [illegible] they are the least able to afford private recreation. [illegible] address [illegible] needs for [illegible] tear a [illegible] that [illegible] residents. [illegible] over-[illegible] activities in a natural environment.

[illegible] for the Metropolitan [illegible] water [illegible] meeting water and related land [illegible] were studied [illegible] flood control, [illegible] recreation, [illegible] (5) water quality improvement, [illegible] and wildlife habitat. Other water resource developments [illegible] power generation, irrigation and navigation were determined [illegible] critically needed in the community and were therefore [illegible] the entire formulation. Although population projections for the [illegible] predict continued increases, indications are that the city will resist such growth, if possible. Therefore, immediate and long-range needs for power generation, irrigation and navigation are not expected.

Categorizing the improvement needs for these planning objectives (Table F-1 follows) was the first procedure in formulating various plans of improvements.

In the next iteration of various planning objectives, they were evaluated to determine the need for further studies. The following water resource objectives fell out of the planning process for the following reasons:

(1) Water Supply. existing and future needs have been met by the recent inclusion of the city of Leominster in the Metropolitan District Commission (MDC) system. Because this is the least expensive method for meeting future needs there is no necessity to develop alternative sources. In addition to the MDC supply, the existing water supply system includes six impoundments in the 10.4-square mile drainage area upstream from Rockwell Pond. These are Notown, Haynes, Morse and Distributing Reservoirs and Goodfellow and Surmond Ponds.

TABLE F-1

PROPOSED MANAGEMENT MEASURES

Planning Objectives	Reservoirs	Walls & Dikes Channel Restoration	Channel Diversions	Land Acquisition & Zoning Relocation	Flood Proofing	Parks	Standards Implementation
Flood Control	X	X	X	X	X		
Water Supply	X						X
Water Quality	X						
Recreation	X			X		X	
Greenbelts		X				X	
Fish & Wildlife Habitat							X

(2) Recreation. Water based recreation needs could have been met by the construction of a multipurpose dam and reservoir such as was proposed in the 1963 study. Since that time, however, private development of land in the vicinity of Carter Hill has made land taking for reservoirs prohibitively expensive. Therefore, there was no longer economic justification for the construction of multipurpose reservoirs in the vicinity of Carter Hill and other sites were nonexistent. Development by private interests at Carter Hill has included recreation facilities in the form of ski slopes.

(3) Water Quality. All of the impoundments located upstream from Rockwell Pond and their tributaries are presently classified by the State of Massachusetts as Class A waters. The main stem of Monoosnoc Brook below Rockwell Pond is classified as Class B water. Because of these relatively high standards there is no need to adopt additional water quality standards for discharges into Monoosnoc Brook at the present time. In addition, the city of Leominster has a mandate from the State of Massachusetts to construct a sewage treatment plant. Future implementation of higher standards would be monitored by both the State and Federal Environmental Protection Agencies.

(4) Land Use Planning. "Greenbelts" or park areas along a revitalized brook channel in a dense urban setting would be of considerable value to the citizens of the community. A plan to provide these was proposed for the city of Leominster in 1969. However, the "urban renewal" plan was rejected in its entirety by the Leominster City Council on 30 September 1967. Because of this lack of public interest for these types of improvements it was in the best interest of the Federal Government not to pursue this matter further.

From the evaluation it became evident that flood control was the primary need of the community and the only one requiring further study at this time. Several alternative measures to solve flood control problems within the city of Leominster were investigated. They included nonstructural, structural and a combination of both.

Nonstructural measures would not reduce or eliminate flooding problems. They are utilized to regulate the use and development of the floodplain, thus lessening damaging effects of large floods. The nonstructural measures available in Massachusetts, as summarized by the Massachusetts Department of Natural Resources, are listed on the following pages.

NONSTRUCTURAL MEASURES AVAILABLE IN MASSACHUSETTS

a. Land Acquisition

1. Land and Water Conservation Fund Act of 1965 (PL 89-578, 78 Stat. 897)	Administered by the U.S. Department of Interior's Bureau of Outdoor Recreation, (BOR) the fund allocates money to communities and political subdivisions for planning, acquisition and development of public outdoor recreation areas. Under the Act, local agencies may be reimbursed up to 50 percent of the costs of purchasing land.
2. Massachusetts Self-Help Program (GL Ch. 132A, Sec 2)	Administered by the Division of Conservation Services in the State's Department of Natural Resources, (DNR) This program offers towns and cities with Conservation Commissions up to 50 percent reimbursement for the cost of land purchased or developed for conservation or passive outdoor recreation. BOR's Land and Water Conservation Fund and DNR's Self-Help Program may be applied together. In that case, a community may receive up to 75 percent reimbursement for the cost of purchasing land.
3. National Register of Historic Places (National Historic Preservation Act of 1966, 80 Stat. 915, 16 U.S.C. 470)	Under this program, the National Park Service can make funds available for the acquisition and development of significant historical, archaeological, architectural and cultural sites.
4. Revenue Sharing (PL 92-572, Acts of 1972)	Open space lands can be purchased with community funds received through the Federal Government's revenue sharing program.

b. Other Methods of Land Acquisition

1. Gifts of land	A community or the State may acquire land through private donation. Such properties as inland wetlands, nature preserves, wildlife sanctuaries and recreational lands are often donated by private owners to the public.
2. Gifts of land in trust	A well recognized device in Massachusetts for preserving land in its natural state is a charitable gift in trust. Land gifted to a private land trust is insured against being diverted for other municipal purposes.
3. Eminent domain	This is usually a means of last resort. Taking land under eminent domain requires a two-thirds vote of the town meeting or city council. There must be reasonable compensation to the landowner accompanying the taking.

c. Local Zoning

1. Floodplain zoning (Zoning Enabling Act, GL Ch. 40A, Sec 2)	In Massachusetts, the Zoning Enabling Act specifically permits municipalities to safeguard lands "deemed subject to seasonal or periodic flooding." The Act further states that these lands "shall not be used as to endanger the health or safety of the occupants thereof." Floodplain zoning, although designed primarily to prevent damage from floods, can permit use of low-intensity recreation areas while restricting urban development. Conservancy Zoning, a device adopted in several Massachusetts towns, is essentially a variation of floodplain zoning.

2. Cluster zoning	The basic idea behind cluster zoning is to create a more attractive environment by permitting a developer to erect houses on smaller lots than the ordinance normally requires, provided the remaining land is permanently preserved for its natural beauty and recreational value as neighborhood open space.

d. Wetlands Regulation

1. Wetlands Protection Act (GL Ch. 131, Sec 40)	This Act controls but does not ban development on wetlands. Wetlands are defined here, for the purpose of brevity, as inland wetlands - marshes, meadows, swamps bordering on rivers, streams and ponds - just about any land which is periodically wet. The Act also covers coastal wetlands. The law requires that any person or governmental agency intending to remove, fill, dredge or alter a wetland must insure, by following various procedural and technical steps, that the activity will have no adverse effect on water supplies, storm and flood prevention, pollution prevention or fisheries protection. In effect, the owner must develop his wetlands in accord with the public's interest and safety.
2. Inland Wetlands Restriction Act (GL Ch. 131, Sec 40A)	This legislation is designed to supplement the regulative approach of the Wetlands Protection Act with a planning approach not dependent upon the landowner coming forward to apply for a permit. The Commissioner of DNR-in order to preserve and promote public safety, private property, wildlife, fisheries, water resources and flood-plain areas and agriculture-is directed to issue orders restricting development of inland wetlands.

e. Tax Incentives

1. Classification and Taxation of Forest Lands and Forest Products (GL Ch. 61, Secs 1-7, as amended in 1969 by Ch. 873)	This law allows forest land to be valued at no more than $10 per acre if the owner of 10 or more acres (valued at not over $400 per acre at the time of application) practices forest management to improve the quantity and quality of a continuing forest crop.

f. Conservation Restrictions

1. Conservation Restriction Act (Ch. 666, Acts of 1969)	A conservation restriction or easement is a written agreement between a property owner and a government or private agency by which the landowner agrees to specific development restrictions on his land. As a result, the property owner often qualifies for certain tax benefits under General Laws, Ch. 719, Acts of 1972.

Other nonstructural measures such as building code regulations and enforcement, floodproofing, permanent evacuation of floodplain areas and purchase of flood insurance were investigated during the course of this study. Floodplain zoning enforcement would be a requirement of the city of Leominster under State regulations and also as part of local cooperation agreements for a structural plan of flood control improvements along Monoosnoc Brook.

Several structural solutions for providing local flood protection in Leominster were investigated. These methods included upstream dams and reservoirs, channel excavation, surface diversions, walls and dikes and tunnel diversions or bypass conduits, or combinations of these plans depending on the degree of flood protection to be afforded.

Effects on Objectives

National Economic Development

To evaluate the impact of various plans of protection on National Economic Development, project first costs, annual charges and annual benefits were estimated for each plan. Federal first costs included

construction costs figured at June 1977 price levels and an allowance for contingency items as well as engineering, design, supervision and administration costs. Non-Federal costs could be shared by the city of Leominster and the State of Massachusetts or could be all local costs associated with the obtaining of lands, easements and rights-of-way, and utility relocations. Property valuations are based on information from local interests and recent sales in the area. Interest charged during construction was not included in the estimate because of the relatively short (less than 2 years) construction period.

Annual charges, both Federal and non-Federal, are based on an interest rate of 6-5/8 percent amortized over a 100-year period. Included with non-Federal annual charges are those for operation and maintenance of the completed works. The evaluation of annual benefits included those for flood damage prevention and the income of local labor required for construction of the projects. These benefits are discussed in Section H of the Technical Appendix.

Summaries of Federal and non-Federal first costs, annual charges and annual benefits with benefit/cost ratios for investigated flood control alternatives are presented in Table F-2, "Economics and Local Protection Plans" of this Section. The derivation of project benefits for the selected plan is detailed in Section H, "Economics of Selected Plan" of Appendix 1.

From a National Economic Development standpoint the proposed plans of improvements should be sized at the optimal economic capacity. They should provide a high degree of flood protection (SPF) which would preserve and, in some areas, increase the net productivity of goods and services. The recommended project should increase land values and stimulate economic growth in the protected area. During the construction period the project would afford jobs for local citizens.

Environmental Quality

From its origin at Rocky Pond in the hills west of the city of Leominster, Monoosnoc Brook flows in an easterly direction for about 8.7 miles to its confluence with the North Nashua River. The brook has a total drainage area of 11.2 square miles. Its upper 4.7 square miles are heavily forested and contain several water supply lakes while the lower watershed is highly developed and urbanized. The intervening 5.7 square miles between Notown Reservoir and the city are very hilly and conducive to rapid runoff.

Water quality in the upper watershed is very good while lower watershed quality is fair to poor due to discharges of industrial waste into the stream. There is little or no fishing potential in the lower stream. However, limited fishing is possible in Rockwell Pond.

From an environmental standpoint the proposed plan of improvements should afford more beneficial than adverse effects to the environmental account.

Effects Assessment

The impacts of the possible alternative plans on the natural, social and economic environment of the study area were assessed. It must be recognized, however, that the primary goal of each alternative is to alleviate or eliminate the unpleasantness and economic losses caused by flooding. Each of the alternative plans investigated had some similar impacts on the environment, social well-being and regional development of the project area.

The first step of the assessment, delineating the impacts of "no action," was made. The primary consequences of no action would be the continued economic loss, inconvenience and possible danger to human life which exists because of the inadequate channel capacity of Monoosnoc Brook in its course through the central business district of Leominster. The economic loss "without the project" is estimated at $541,000 annually under present conditions. A recurrence of the 1936 record flood would produce an estimated $3,252,000 in damages (at 1974 price levels). The flood problem can be expected to intensify as runoff increases because of additional development in the upper watershed.

Leominster's continual vulnerability to floods would be expected to result in a continuation of depressed property values and relatively low tax assessments in the flood zone. At present, some of the property in these areas is in a deteriorated condition. Without implementation of flood control improvements there is less incentive on the part of owners to upgrade their properties.

Environmental changes without a flood control project would be minimal. Flooding would continue to leave sediment and debris within the flood zone, requiring a cleanup after each event.

With the implementation of flood control improvements along Monoosnoc Brook most of the economic, social well-being and environmental impacts would be favorable. The following paragraphs discuss the impacts of such implementation:

Economic Impacts

a. The positive economic impacts would include a substantial increase in employment during construction, resulting in increased spending for consumer goods. Materials and supplies for the project would provide additional business for local and regional manufacturers.

b. From the municipal point of view the primary positive impact would be the reduction of flood damages at a relatively small cost to the local governments involved.

c. With elimination of flooding, the value of previously flood prone land would tend to rise.

d. Tax revenues could be expected to increase because of revitalization of those properties that were formerly subject to flooding.

e. Decreasing the flood threat would serve to enhance future potential for growth.

Environmental Impacts

Several basic environmental concerns were addressed during the course of the study of various alternative plans for local flood protection in Leominster. It was determined that damage to adjacent structures due to use of explosives would not be permitted in any plan of protection. Specifications would require the contractor to utilize blasting nets and meet safety standards that would preclude such damage.

Social Impacts

In any plan of flood control improvements, the major social well-being factor would be eliminating the anxiety and fear of flood damage felt by citizens residing within the floodplain.

Carrying out a structural plan of improvements would result in some temporary disruption of traffic in the vicinity of the project and on routes where construction materials and equipment are being brought to the site. Air pollution and traffic disruption resulting from construction would be minimal if normal precautions are taken such as watering of dusty streets and utilization of alternate detour routes. All of these inconveniences would be temporary and not of a serious nature.

Minor noise pollution would also result from the construction. However, it would be within the State's acceptable level and its social impact could be minimized by following normal construction practices such as beginning work after 7:00 a.m. and muffling heavy equipment engines. After completion the project would not affect noise levels in the area.

Negative social impacts would be more evident for the construction of a dam and reservoir than they would for a tunnel diversion due to the general objection to loss of wildlife habitat and change of land use which could lower tax revenues.

Regional Development

All alternative plans for local flood protection were designed to alleviate the inconvenience, danger and economic loss resulting from flooding. When considering the positive social and environmental effects of flood control improvements it becomes evident that improvements would make the flood-prone areas of Leominster more desirable for business and industrial activities. Because of past flooding conditions, little future development could be anticipated to expand the economy of the community if no flood protection is provided. Decreasing the flood threat would not only enhance the local economy by reducing property damage and lost business days, it would also serve to enhance future potential for growth.

A positive short-term effect would be the additional jobs created during the construction period. Over the long term there would be no significant effect on direct employment as new employees would not be needed for operation. Studied alternatives would also tend to increase real estate values of properties in the immediate study area. If assessed property taxes rise the community would receive additional tax revenue.

Flood Control Alternatives Considered Further

As the studies for providing local flood protection along Monoosnoc Brook continued the following methods were considered further but were eventually eliminated for the cited reasons. Only the plan to construct a tunnel diversion from Rockwell Pond to below Water Street appeared to meet the required economic and environmental evaluation criteria.

Flood Plain Relocation - A relocation plan was found to be highly impractical for this study area. It is too expensive to buy properties and too disruptive to remove people, industry and businesses from the city center.

Flood Plain Zoning - Zoning and building regulations should be implemented and enforced by the city of Leominster to effectively reduce the flood damage potential of the study area. Planned future development and land use programs would alleviate present encroachment and preclude possible future encroachment on floodplain lands. As a part of local cooperation assurances the city would be required to prevent any encroachment on the existing channel below Rockwell Pond that would impair its capacity to discharge 600 cubic feet per second.

Dams and Channel Improvements - Several dam locations were investigated on Monoosnoc Brook and its tributaries. Because these sites were located too far upstream, their limited storage capacities precluded control of all floodwaters to Leominster. Therefore, channel improvements would be required to supplement any flood control scheme of upstream storage. No integral dam and channel improvement scheme could satisfy Corps criteria and still carry a favorable B/C ratio. In addition, dam construction and disruption associated with channel projects are generally opposed by local officials and citizens of Leominster.

Diversion Channel and Dam - A diversion channel was proposed in conjunction with an upstream dam. Floodflows would be conducted from Pierce Pond through an open channel directly to the North Nashua River. This plan was found to be economically infeasible since condominiums have been constructed along segments of the anticipated alignment.

Rockwell Pond Modification - A plan to lower Rockwell Pond to provide a recreational pool and flood protection was investigated. Because of the limited flood storage area provided by the pond, this plan was not considered feasible.

Dam and Reservoir - During 1964-1965 a water resource development study for the North Nashua River Basin recommended authorization of a plan that included construction of a multipurpose flood control, water supply and recreation dam and lake to be located about 1.5 miles upstream from Leominster's central business district. This dam would have provided 800 acre-feet of flood control storage, equivalent to 6 inches of runoff, at a total first cost of $2,610,000. Based on annual costs of $102,000 (1964 price levels) and annual benefits of $169,000, the project at that time had a 1.7 to 1.0 B/C ratio.

Subsequent to submission of our report, however, additional urban development took place at the site of the proposed spillway, located on the north side of Carter Hill. Reformulation of this plan, with the spillway relocated to the south side of Carter Hill in order to negate the high costs of property acquisition, resulted in a structure with an estimated first cost of $12,850,000 (1974 price levels). Compared with flood control benefits taken on an annual basis, the resulting B/C ratio was 0.5 to 1.0.

Alternative sites for the proposed dam were investigated to determine whether a viable, economically justified plan for local flood protection of downstream areas could be developed. A second dam construction plan was studied for the same location as that described above but with a side channel spillway instead of a spillway located in the earth fill structure. This plan had an estimated first cost of $13,190,000 and a similar 0.7 to 1.0 B/C ratio.

A third dam construction plan involved three separate smaller structures. The main dam would have been located upstream of those in the previously described plans but would not have included control of discharge from the tributary stream that is the outflow from the "Distributing Reservoir." A secondary structure would control this outflow while the third structure would be a subimpoundment dam located about 2,500 feet upstream from the primary dam. This plan had an estimated first cost of $13,268,000 and a B/C ratio of 0.5 to 1.0.

Because of topographic and development constraints, potential dam sites in all the plans described above included downstream channel improvements in order to pass a standard project flood without damage to adjacent flood-prone properties. At all three sites a single purpose flood control dam without downstream improvements was found to be either infeasible or did not have economic justification.

The most important environmental consideration for dam and reservoir construction would be their effect on fish and wildlife habitat and the change in land use for the reservoir area. However, because of the relatively small size of the Monoosnoc Brook watershed, in this case the effect on fish and wildlife would not be significant.

A flood control or multipurpose dam and reservoir would be environmentally unacceptable because of the change in land use for the reservoir and surrounding lands. Areas which are currently wooded would be subject to periodic inundation that would lead to eventual tree kill and esthetic disruption.

Channel Improvements - The substantial development in the Leominster central district prohibits economical and practical improvements to the existing channel. Removal and/or replacement of existing structures and construction of dikes and walls to safely pass SPF levels would be highly disruptive and costly.

During the 1964-1965 study, a plan was investigated that would improve the channel along the existing brook in the city center to supplement upstream dam construction. At that time the plan was justified as it was predicated on two portions of the channel being reconstructed under an urban renewal plan prior to the construction of another two Federally funded sections. The channel would have been widened and deepened in most areas, and rock slope protection, on a 1.2 slope, would have been placed in areas that were not adjacent to existing stable walls. The walls could have been capped to provide additional height. The two zone channel improvement had an estimated first cost of $290,000 (1964 price levels) and a benefit/cost ratio of 2.1 to 1.0. However, the urban renewal project was dropped and the reformulation of a plan of channel improvements without upstream reservoirs was found not feasible. This was primarily because the reformulation would have turned into a relocation plan since the width of the channel required to pass an SPF discharge would have forced the removal of several buildings adjacent to the stream.

Pierce Pond Surface Diversion - Pierce Pond is located on Monoosnoc Brook about 2 miles upstream from Rockwell Pond. A plan to divert excess floodflows from the pond directly to the North Nashua River by means of a 4,100-foot surface ditch was investigated. Because this area is highly urbanized, the diversion would be quite disruptive to the local community. In addition, it did not meet the acceptability criteria and had a marginal benefit/cost ratio. The plan was not recommended for further study.

Tunnel Diversion - A plan to bypass floodflows on Monoosnoc Brook from Rockwell Pond to an area downstream of Water Street was investigated. This plan called for a deep rock shaft and a "morning glory" type intake structure at Rockwell Pond, 3,200 linear feet of deep rock tunnel under the center of Leominster and a concrete outlet structure with energy dissipator blocks. Because of high flows in the channel downstream from the outlet works, it was necessary to plan for appurtenant structures. These would include filling and regrading of lowland adjacent to the Pyrotax Corp. building at Williams Street and removal and relocation of two sewer mains which span Monoosnoc Brook at the end of William and at Whitney Street. In addition to a 12-foot diameter tunnel, a 14-foot diameter, a 10-foot diameter and an 8-foot diameter tunnel were investigated in order to develop a plan which maximizes project benefits.

A tunnel diversion was the [illegible] alternative that was found to have a favorable benefit-cost ratio.

A tunnel diversion would present only limited environmental quality problems; the existing channel would continue to carry normal flows; and safe channel capacity would not be exceeded during flood periods.

The environmental assessment of the tunnel diversion plan determined that the absence of high velocity flows in the existing channel would not cause sediment accumulation in the stream channel which, in turn, would reduce the capacity of the inlet. Studies indicate that after the construction of a diversion to bypass annual flows in Monoosnoc Brook would reach a velocity of [illegible] feet per second. Channel velocities required to transport sediments of loose soil are estimated at 2.5 to 3-feet per second. Therefore, the transport of sediments that have collected during low flow conditions would be unchanged by the diversion.

For a tunnel diversion it would be necessary to insure that the tunnel lining was watertight during the construction and operation phases so that groundwater could not seep through and perhaps lower the water table in the area.

Any tunnel diversion from Rockwell Pond would result in the loss of some small fish during flood periods. However, most fish in the pond, blue gills and pumpkin seeds for instance, would not be washed into the tunnel. A trash and safety control rack would preclude the loss of waterfowl into the tunnel during floods.

Environmental effects include few or no impacts on existing natural resources. Due to the urban nature of the area fish and wildlife habitat is limited or non-[illegible].

The social well-being evaluation of this alternative indicated that its long-term effect on the [illegible] of private property easements would not be great, but it would preclude future encroachment on lands around Rockwell Pond. Again, easements would have no effect on surface land use. Construction of a tunnel diversion could cause some disruption of traffic and some interruption of normal operations in the central business district of Leominster. All of these inconveniences would be temporary and not of a serious nature.

Since this flood control project would neither alter normal streamflow nor affect the normal pool level of Rockwell Pond, no adverse effects on future water quality are anticipated.

Economies of Local Protection Plans -

Economies of the plans of local protection that were studied further are summarized in the following Table.

TABLE F-4

ECONOMICS OF LOCAL PROTECTION PLANS

	Plan	First Cost ($1,000)	Annual Cost ($1,000)	Annual Benefits ($1,000)	B/C Ratio
1.	Dam(Site 1) and Channel Project	$12,850	$821	$603	0.73
2.	Dam(Site 2) and Channel Project	13,600	869	610	0.70
3.	Surface Diversion	9,600	614	591	0.96
4.	14'Ø Tunnel	8,250	541	620	1.14
5.	12'Ø Tunnel	7,640	509	617	1.21
6.	10'Ø Tunnel	6,810	452	502	1.11
7.	8'Ø Tunnel	6,100	408	436	1.07

Selecting A Plan

Selection of the best plan of improvements for the study area involved comparison of the various alternatives that satisfied the formulation and evaluation criteria. The screening process was simplified when the formulation criteria, based on objectives, eliminated the competing alternatives as shown in Table F-3.

Once it was determined that structural plans other than the deep rock tunnel did not have economic justification for Corps implementation, four tunnel alternatives were studied in more detail. A comparison of costs and benefits for the four tunnel alternatives showed that the 12-foot diameter tunnel maximized net benefits (benefits over costs). See Appendix 1, Section H "Economics of Selected Plan," Plate H-1.

In assessing the socioeconomic and environmental impacts of the studied alternatives it was found that the tunnel projects best met the criteria for the Social Well-Being and Environmental Quality accounts. The tunnel project would alleviate the property owners fear of future floods, while the underground construction would not be as noisy as surface construction. Studies of water quality in the proposed tunnel indicate that it would not require pumping as the dissolved oxygen would not be reduced below acceptable levels. An analysis of water quality is contained in Appendix 1, Section G-The Selected Plan.

From an overall flood control standpoint, the advantages offered by a 12-foot diameter tunnel warrant its selection as the recommended plan of improvement for the study area. This tunnel plan will provide the highest degree of protection (SPF) while minimizing adverse effects to the EQ account.

Display of Alternative Plan Effects

The U.S. Water Resources Council's Principles and Standards procedures require that all alternative plans carried through the final planning stage be evaluated against both planning objectives and their contributions to four accounts: National Economic Development, Environmental Quality, Social Well-Being and Regional Development. The significant beneficial and adverse impacts of each alternative are displayed in the System of Accounts. In addition, the System of Accounts describes each alternative carried through the final planning stage, displays the planning objectives, presents each plans performance against the specified evaluation criteria, and indicates the timing, geographical incidence, uncertainty, exclusivity and actuality associated with the evaluation of significant impacts.

TABLE F-3

FORMULATION AND EVALUATION CRITERIA

PLANS	ACCEPTABILITY	COMPLETENESS	EFFECTIVENESS (1)	EFFICIENCY	CERTAINTY	GEOGRAPHIC SCOPE (2)	NED B/C RATIO	ACCESSIBILITY	STABILITY (3)
1. Dam & Lake w/ Channel Improvements	No	Yes	No	No	No	Yes	No	No	No
2. Dam Only	No	No	No	No	No	Yes	No	No	No
3. Channel Improvements Only	No	Yes	Yes	No	No	Yes	No	No	No
4. Surface Diversion	No	Yes	No	No	No	Yes	No	No	No
5. Tunnel Diversion 12' ϕ	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Tunnel Diversion 10' ϕ	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Tunnel Diversion 8' ϕ	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(1) Dam and surface diversion construction, while meeting the flood control objective, would not be effective in contributing a net benefit to the EQ account.

(2) All plans are considered to meet the geographic scope criteria as determined by analyzing the relevancy of the geographic area encompassed by the plan.

3) The more desirable plan has the greater stability.

Alternatives Displayed. The following alternatives are displayed in the System of Accounts:

a. Dam and Channel Restoration

b. Pierce Pond Surface Diversion

c. Rockwell Pond Tunnel Diversion

Planning Objectives. The primary planning objectives are to provide additional flood protection to damage centers along Monoosnoc Brook, Leominster, Massachusetts, to increase the tax base of the community and to satisfy environmental considerations.

National Objectives. Principles and Standards require that alternative plans carried through the final planning stage must be evaluated against the four national accounts. These are National Economic Development, Environmental Quality, Social Well-Being and Regional Development. Section 122 of the River and Harbor and Flood Control Act of 1970 further requires that, at a minimum, the following effects must be identified and assessed:

SOCIAL EFFECTS

Noise
Displacement of People
Esthetic Values
Community Cohesion
Community Growth

ECONOMIC EFFECTS

Tax Revenues
Property Values
Public Facilities
Public Services
Regional Growth
Employment/Labor Force
Business and Industrial Activity
Displacement of Farms

ENVIRONMENTAL EFFECTS

Man-Made Resources
Natural Resources
Air
Water

Regions Displayed. Principles and Standards require that all regions in which a significant impact occurs be displayed. Of the regions suggested for inclusion, only the planning area and the remainder of the Nation are shown since no significant impacts occur in other areas. The following paragraphs define the areas included:

a. Planning Area. The planning or study area that encompasses communities that would be directly affected by Monoosnoc Brook discharges.

b. Remainder of the Nation. In the study, the "Remainder of the Nation" refers to the area outside the study area. Display of this region is a requirement of Principles and Standards.

Evaluation Criteria. Principles and Standards require that specified evaluation criteria be applied to alternative plans and their impacts to test their responsiveness. These criteria and the coding used in the System of Accounts displays are listed below.

a. Timing

Code

1 Impact is expected to occur prior to or during plan implementation.

2 Impact is expected to occur within 15 years following plan implementation.

3 Impact is expected to occur later than 15 years following plan implementation.

4 Impact occurs at indicated period and continues for an indefinite future period.

b. Uncertainty

Code

4 Level of uncertainty associated with the impact is greater than 50 percent.

5 Level of uncertainty is between 10 and 50 percent.

6 Level of uncertainty is between 0 and 10 percent.

c. Exclusivity

Code

7 Overlapping entry; fully monetized in NED account.

8 Overlapping entry; not fully monetized in NED account.

d. Actuality

Code

9 Impact will occur with implementation.

10 Impact will occur only when specific additional actions are carried out during implementation.

11 Impact will not occur because necessary additional actions are lacking.

The following System of Accounts Table shows three alternative methods for providing flood control. Because Alternative 3 (Rockwell Pond Tunnel Diversion) was the only plan to have economic justification it was chosen as the National Economic Development (NED) Plan. Excess benefits were maximized for the 12-foot diameter tunnel, therefore this size was recommended. Because this plan provides the greatest positive input to the Environmental Quality (EQ) account, it was selected as the NED oriented EQ Plan.

SYSTEM OF ACCOUNTS

MONOOSNOC BROOK LOCAL PROTECTION
LEOMINSTER, MASSACHUSETTS

	ALTERNATIVE 1		ALTERNATIVE 2		ALTERNATIVE 3	
	CHANNEL ENLARGEMENT		PROJECT POND; SEWAGE DIVERSION		ROCKWELL POND TUNNEL DIVERSION (12'd)	
	Planning Area (Monoosnoc Brook)	Remainder of the Nation	Planning Area (Monoosnoc Brook)	Remainder of the Nation	Planning Area (Monoosnoc Brook)	Remainder of the Nation
	[illegible]	US Share of Project Cost is $10.1 mil.	$9,250,000 1,329,000 $10,579,000	US Share of Project Cost is $9,250,000	$7,000,000 00,000 $7,100,000	US Share of Project cost is $7.0 mil.
	[illegible]		$ 34,000 3 ,000 $ 40,000		$ 34,300 13,400 $ 40,700	
	[illegible]		$ 47,700 23,300 $ 71,000		$ 40,700 26,000 $ 66,700	
	[illegible]		$ [illegible]		$ 68,400	
	[illegible]		[illegible]		1.21	
	[illegible]	Yes, Same as Alt. 1	[illegible]	Yes, Same as Alt. 1	Yes, Same as Alt. 1	No, Same as Alt. 1

SYSTEM OF ACCOUNTS

MONOOSNOC BROOK LOCAL PROTECTION
LEOMINSTER, MASSACHUSETTS

	ALTERNATIVE 1		ALTERNATIVE 2		ALTERNATIVE 3	
	CHANNEL MODIFICATION		PARTIAL POTENTIAL DIVERSION		ROCKWELL POND TUNNEL DIVERSION (12'ϕ)	
	Planning Area (Monoosnoc Brook)	Remainder of the Nation	Planning Area (Monoosnoc Brook)	Remainder of the Nation	Planning Area (Monoosnoc Brook)	Remainder of the Nation
	No, Same as Alt. 1		No, Same as Alt. 1		No, Same as Alt. 1	
	Yes, Same as Alt. 1	No, Same as Alt. 1	No, only utilizes tunnel during flood.	No, Same as Alt. 1	No, only utilizes tunnel during flood.	No, same as Alt. 1
	No, Same as Alt. 1		No, Same as Alt. 2		No, Same as Alt. 2	
	Yes, Same as Alt. 1		No, Same as Alt. 2		No, but some flowage easements at Rockwell Pond.	
	Yes, Same as Alt. 1		Yes, Same as Alt. 2		Yes, cofferdam constructed at Rockwell Pond.	

SYSTEM OF ACCOUNTS

[illegible] MONOSNOC BROOK LOCAL PROTECTION
LEOMINSTER, MASSACHUSETTS

[illegible]	ALTERNATIVE 1		ALTERNATIVE 2		ALTERNATIVE 3	
	[illegible] RESTORATION		PIERCE POND SURFACE DIVERSION		ROCKWELL POND TUNNEL DIVERSION (12 ϕ)	
[illegible]	Planning Area (Monoosnoc Brook)	Remainder of the Nation	Planning Area (Monoosnoc Brook)	Remainder of the Nation	Planning Area (Monoosnoc Brook)	Remainder of the Nation
[illegible]	Yes, [illegible] [illegible] all right	No, does not affect nation-wide materials req'd.	Yes, 150,000 c.y. of excavated material	No, Same as Alt. 1	Yes, 20,000 c.y. of rock excavation	No, Same as Alt. 1
[illegible]			Yes		Yes	
[illegible]			Yes, Same as Alt. 1		Yes, Same as Alt. 1	
[illegible]		[illegible] a small per [illegible] of total flood	Yes	No, Same as Alt. 1	Yes	No, Same as Alt. 1
[illegible]			Yes, flood flows are diverted		Yes, flood flows are diverted	

SYSTEM OF ACCOUNTS

MONOMOSCOY BROOK LOCAL FLOOD PLAN
LEOMINSTER, MASSACHUSETTS

		ALTERNATIVE 1		ALTERNATIVE 2		ALTERNATIVE 3	
		CHANNELIZATION		LERCH POND SUPPLY DIVERSION		ROCKWELL POND TUNNEL DIVERSION (12 ft)	
	Same as Existing Conditions	Planning Area (Monomoscoy Brook)	Remainder of the Nation	Planning Area (Monomoscoy Brook)	Remainder of the Nation	Planning Area (Monomoscoy Brook)	Remainder of the Nation
Increases open space	No	No		No		No	
Increases scenic beauty	No	Yes, but not to great degree		Yes, open canal is visible		Yes, although most of work is underground	
Increases recreational opportunities	No	Yes, but not to great degree		Yes, same as Alt. 1		Yes, although most of work is underground	
Increases fish and wildlife habitat	No	Yes		Yes		Yes, but would be less than other two plans	
Increases value of land adjacent to improvements	No	Yes, but value of land in area would decrease		Yes, as a result of subdivision construction in recent years		No, except for taking of metal shed bldg. of Pyrotex Mfg. Co.	
Increases value of land adjacent to improvements	No	Yes		Yes		No	
Increases property values	No	Yes	No, not a nationwide concern	Yes	No, Same as Alt. 1	Yes	No, Same as Alt. 1
Increases property values	No	Yes		Yes		Yes	

SYSTEM OF ACCOUNTS

MONOOSNOC BROOK LOCAL PROTECTION

LEOMINISTER, MASSACHUSETTS

	Impact Codes	ALTERNATIVE 1 DAM & CHANNEL RESTORATION Planning Area (Monoosnoc Brook)	 Remainder of the Nation	ALTERNATIVE 2 PIERCE POND SURFACE DIVERSION Planning Area (Monoosnoc Brook)	 Remainder of the Nation	ALTERNATIVE 3 ROCKWELL POND TUNNEL DIVERSION (12 ft) Planning Area (Monoosnoc Brook)	 Remainder of the Nation
[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]	No, [illegible]		No, same as Alt. 1		Yes, Land taking requirements are minimal	
[illegible]	[illegible]	Yes, same as above		No, Same as G above		Yes, Same as G above	
[illegible]	[illegible]	Yes, temporarily		Yes, temporarily		Yes, temporarily	
[illegible]	[illegible]	Yes, allows for [illegible]		Yes, Same as Alt. 1		Yes, Same as Alt. 1	
[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]	[illegible]					
[illegible]	[illegible]	[illegible]		Yes, Same as Alt. 1		Yes, Same as Alt. 1	
[illegible]	[illegible]	[illegible]		Yes, Same as Alt. 1		Yes, Same as Alt. 1	

SECTION G

THE SELECTED PLAN

THE SELECTED PLAN

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SECTION G

THE SELECTED PLAN

The preceding section summarized plan formulation and identified those plans with the best potential for resolving the problems and needs of the study area. The following pages describe the best flood control plan and its accomplishments and effects as well as its significant design, construction, operation and maintenance features.

Plan Description

The most appropriate plan of improvement for flood control in the Monoosnoc Brook Basin calls for construction of a subterranean diversion bypass tunnel from Rockwell Pond to an area between Water and Whitney Streets. Nonstructural measures required to insure the integrity of the selected plan include the acquisition of flowage easements for 4.25 acres of waterfront property at Rockland Pond and about 7 acres at the outlet structure and 3 acres at the Pyrotex Company. In addition, the city of Leominster would be required to prevent encroachment on the existing channel by enforcement of zoning codes.

Principal features of the proposed plan of improvements follow:

A morning glory type spillway inlet at Rockwell Pond.

A 12-foot diameter concrete-lined tunnel extending 3,200 feet from Rockwell Pond to below Rochdale Dam, downstream of Water Street.

An outlet structure and channel at the end of the tunnel to discharge flows back into Monoosnoc Brook.

Modification of the existing outlet works at Rockwell Pond so that a maximum of 600 cfs would be discharged from Rockwell Pond into the existing channel during a Standard Project Flood.

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From Whitney Street to Williams Street approximately 3 acres of bank regrading to provide for drainage away from existing buildings of the Pyrotex Company.

Relocation of the sewer pipes located under the Whitney Street Bridge and at the end of Williams Street. These pipes are hydraulic obstructions to present brook flow.

All land disturbed by the proposed construction would be restored to its natural condition by planting and seeding.

These flood control measures are shown on Plates 1 through 6 of this section, while estimated Federal and non-Federal first costs are presented in Table G-1.

Plan Accomplishments

The major benefit to be accrued from the plan is reduction of future flood damages to about 70 acres of residential, industrial and commercial property that are currently susceptible to flooding. The diversion tunnel would produce substantial benefits from potential urban development and an incentive to restore areas of the city which are now subject to varying degrees of urban decay.

Average annual flood control benefits of $540,700 are estimated for the proposed project. Annual redevelopment benefits attributable to the proposed construction amount to $76,000.

Existing and future developments would be assured of protection against flood damages by the proposed selected plan. Flood protection is crucial to any revitalization program in the Leominster core area. The threat of flooding is now a contributing factor to the deterioration of the core business area in Leominster.

TABLE G-1
ESTIMATED FIRST COST OF SELECTED PLAN
(June 1977 Price Level)

FEDERAL COST

Item	Quantity	Unit	Unit Price	Amount
Preparation of Site	1	JOB	L.S.	$ 20,000
Gen. Earth Excavation	6,400	C.Y.	7.00	45,000
Tunnel Rock Excavation	20,500	C.Y.	71.50	1,465,000
Shafts, Complete	161	V.F.	8,161.50	1,314,000
Open Rock Excavation	110	C.Y.	27.25	3,000
Gravel Fill	1,500	C.Y.	6.40	9,600
Dumped Gravel Fill	1,100	C.Y.	5.40	5,940
Gravel Bedding	800	C.Y.	6.40	5,120
Concrete:				
Intake Structure	430	C.Y.	130.00	55,900
Tunnel	7,400	C.Y.	149.05	1,103,000
Outlet Structure	450	C.Y.	120.00	54,000
Mass	500	C.Y.	60.00	30,000
Portland Cement	60,800	CWT	2.80	170,240
Tunnel Grout	10,000	C.F.	14.00	140,000
Steel Reinforcing	549,000	LB	0.40	219,600
Rock Bolts	2,500	EA	54.00	135,000
Steel Bents	150	EA	450.00	67,500
Drains	210	EA	80.00	16,800
Waterstop	13,600	LF	9.20	125,120
Stone Protection	720	C.Y.	25.00	18,000
Topsoil	2,700	C.Y.	7.50	20,250
Seeding	3.25	Acre	2,500.00	8,125
Dewatering (tunnel)	1	JOB	L.S.	326,000
6' Security Chain Link Fence	170	L.F.	13.00	2,210
Miscellaneous Metals:				
Struct. Steel, Standard	6,400	L.B.	0.40	2,560
Struct. Steel, Curved	2,300	L.B.	0.60	1,380
Galv. Steel Floor Grate	1,820	S.F.	8.00	14,560
Galv. Steel Safety Grate	8,400	L.B.	0.75	6,300
2'x2' Sluice Gate	1	E.A.	300.00	300
		SUBTOTAL		$ 5,384,505
		CONTINGENCY		815,495
		TOTAL CONSTRUCTION COST		$ 6,200,000
Engineering & Design				400,000*
Supervision & Administration				520,000
		TOTAL ESTIMATED FEDERAL FIRST COST		$ 7,120,000

NON-FEDERAL COST

Lands & Damages	370,000
Utility Relocations	150,000
TOTAL ESTIMATED NON-FEDERAL FIRST COST	$ 520,000
TOTAL ESTIMATED PROJECT FIRST COST	$ 7,640,000

*Does not include preauthorization cost of $210,000.

Effects of Plan on Environment

The primary effect of the plan would be the flood protection provided to approximately 70 acres of urban area or mixed land use.

Secondary effects include the potential increase in economic activities for the project area as well as more intense and higher development of the protected area. Other effects include increased real estate values in the urban area and a resulting increased tax base.

Removal of the flood threat would enhance the quality of the human environment and improve the local economy as well.

Human and Economic Resources

The plan would have no significant long-term impact on employment, but it would provide temporary employment during the construction period. In addition, the project would provide a market for local suppliers of gravel, steel and concrete materials.

Long-term impacts are associated with changing real estate values. Area property value would increase because there would be a flood free area, retained open space and improved visual impacts. Residential property values would also be expected to rise. A potential improvement in social and economic well-being could be realized with the implementation of the project.

Beautification

Beautification measures would receive careful consideration throughout the advance planning and construction of the project. Borrow and spoil disposal areas would be chosen to minimize the problem of restoration and would be designed to avoid any water pollution.

In general, visibly disturbed elements surrounding the project area would be landscaped to restore the natural scenic beauty and to provide an attractive appearance for recreational enjoyment.

Items of beautification and esthetics would be coordinated with all elements of the public and the local government.

Natural Resources

The selected plan is designed to minimize disturbance to natural waterways and stream life vegetation and any such disturbance would be temporary. Further erosion would be prevented by restoring banking on Monoosnoc Brook and regrading for natural drainage.

The proposed diversion tunnel would not upset the natural flow in Monoosnoc Brook as it passes through town, but it would prevent overbank flooding by diverting excess flow through the tunnel, thus giving flood protection to property along this section of the brook.

Some temporary adverse environmental effects would be experienced at Rockwell Pond. To facilitate construction of the intake structure. The surrounding area would need to be filled temporarily. Any vegetation that is damaged should recover normally after the fill is removed. Overflow is drawn from the top layer of the pond so the danger of fish being drawn into the tunnel is unlikely as most fish are bottom dwellers.

The regrading area at the Pyrotex Company would mean some loss of trees and shrubs and the habitat associated with them. After construction, reseeding should restore the area to its former natural conditions. Any environmental loss resulting from the project is considered minimal and temporary compared to benefits attributed to the selected plan.

Water Quality

Water stored in the proposed Monoosnoc Brook Diversion Tunnel between flooding events is not anticipated to be depleted of dissolved oxygen. Based upon preliminary studies concerning the effects of water storage on dissolved oxygen concentrations, it is expected that a minimal value of approximately 7 mg/l will always remain in the tunnel. A more detailed sampling program will be required during the design phase to verify these results.

The estimated minimal storage value is due to the good quality of the water in Monoosnoc Brook. There are six water supply impoundments in the 10.4 square mile drainage area contributing to the outlet of Rockwell Pond, the intake site of the proposed diversion. These are Notown, Haynes, Morse and Distributing Reservoirs and Goodfellow and Sumond Ponds. All of these impoundments and their tributaries are presently classified by Massachusetts as Class A waters. Under the standards of the classification system, the dissolved oxygen percent saturation is always equal to or greater than 75 percent for at least 16 hours per 24-hour period. The oxygen concentration in associated tributaries is always equal to or greater than 5 mg/l. Total coliform bacteria per 100 ml do not exceed an average value of 50 counts during any monthly sampling period. Color, turbidity, pH, odor and taste are all of natural origin.

The main stem of Monoosnoc Brook is classified as Class B water. Under this classification dissolved oxygen in the stream should be at levels above 75 percent of saturation during at least 16 hours of any 24-hour period, and at a concentration of not less than 5 mg/l at any time. Total coliform bacteria counts should not exceed an average value of 1,000/100 ml nor more than 1,000 in 20 percent of the samples. Color, turbidity and chemical constituents should be present in such concentrations that no impairment of Class B uses will occur and no harm will be caused to humans and aquatic life.

The water quality study concerning the effects of storage on dissolved oxygen concentrations is based upon results from Rockwell Pond water collected on 18 May 1976. Table 1 lists the values of the parameters measured and the calculated ultimate biochemical oxygen demand (BOD).

To determine the effects of storage on dissolved oxygen concentrations in the proposed tunnel, four assumptions were made:

(1) It was assumed that the data from the later phase of the storage experiment was incorrect because the dissolved oxygen values increased after 4 June 1976 (Table 2). The manufacturer of the dissolved oxygen meter was contacted to discuss the possibility that oxygen was introduced into the test bottles when measurements were being obtained. The manufacturer indicated that only an insignificant amount of oxygen would be normally introduced. However, similar studies performed by Dr. F. DiGiano of the University of Massachusetts for the Corps proposed Beaver Brook Lake Project also experienced increasing dissolved oxygen concentrations in his storage studies. He attributed the increase to dissolved oxygen introduction during sampling even though precautions were taken during the experiment to exclude this occurrence.

(2) Based upon engineering judgment, it was assumed that the portion of the data reflecting oxygen consumption during the initial phase of the study is representative of the type of consumption for the entire test period.

(3) It was also assumed that the water stored in the Monoosnoc Brook diversion tunnel between flood events will have a low BOD because it is water retained during the recessional side of the hydrograph. Studies done elsewhere disclose that organic matter and other pollutants are usually washed from the watershed during the first hours of a storm event. The low BOD during sample collection is considered representative of values in the tunnel after diversion has ceased.

(4) An asymptotic decay curve was assumed because bacteria in the stored water will consume oxygen and organic matter. When all the nutrients are utilized, dissolved oxygen depletion will stop. Since the ultimate BOD is low, not all the oxygen will be consumed. The calculated lower limit of dissolved oxygen (k) can be considered the approachable asymptotic value. Therefore, the equation for the dissolved oxygen depletion will take the generalized form:

$$Y_c = k + ab^x$$

Based upon these assumptions, the following equation for dissolved oxygen prediction in the proposed tunnel is:

$$C_{DO} = 6.58 + 3.8 \ (0.79)^x$$

C_{DO} = dissolved oxygen concentration in mg/l

x = days of storage

According to Figure 1, it will take approximately 22 days to reach the minimum dissolved oxygen concentration of 6.58 mg/l in the tunnel.

The maximum dissolved oxygen concentration in the test bottle was 10.0 mg/l while the ultimate BOD concentration of the water was 2.6 mg/l, leaving 7.4 mg/l. The difference between 7.4 mg/l and the minimum value of approximately 6.6 mg/l is the amount of oxygen that will react with ferric ions in the water to produce a ferric hydroxide precipitate.

As previously stated, a more detailed analysis of water quality would be initiated during subsequent studies.

Other Effects

Area redevelopment benefits include employment during the construction period and an improved economic climate. Risk to human life will be greatly reduced by a flood-free zone. Intangible benefits of a flood-free zone are improved public health and well-being and increased morale to residents. In addition,project lands required for an underground tunnel would not decrease the city's tax revenues but would potentially increase land values and encourage economic stability.

TABLE G-2

MONOOSNOC BROOK DIVERSION PROJECT
LEOMINSTER, MASSACHUSETTS

WATER QUALITY
ROCKWELL POND

Parameter	Value
Date	18 May 1976
Time	0935
Air Temperature	18.8° C
Water Temperature	20.0° C
Dissolved Oxygen	8.5 mg/1
pH	6.4
Specific Electrical Conductance	13 umhos
Ultimate BOD	2.6 mg/1

TABLE G-3

MONOOSNOC BROOK DIVERSION PROJECT
LEOMINSTER, MASSACHUSETTS

DISSOLVED OXYGEN/STORAGE PERIOD

LABORATORY STUDY*

Date (1976)	Dissolved Oxygen (mg/l)
18 May	9.3
20 May	9.3
24 May	10.0
26 May	10.0
28 May	9.4
1 Jun	8.0
2 Jun	7.9
4 Jun	7.9
7 Jun	8.4
9 Jun	9.0
11 Jun	8.8
14 Jun	9.6
16 Jun	9.2
21 Jun	9.6

*Test conditions were performed at the expected tunnel temperature range of 50-55°F.

Geotechnical Information

Foundation Explorations. Three borings (Stations 1+30, 20+75, 31+90) and three seismic lines (Station 28+00) were accomplished along the alinement of the proposed tunnel. The locations of the explorations are shown on the general plan (Plate 2). All bore holes were pressure tested in rock. Seismic investigations were made to determine the depth to bedrock beneath the terrace feature.

Boring FD-2 at Station 1+30 near the inlet indicates about 15 feet of overburden consisting of silty gravelly sand, sandy gravel and gravelly silty sand. Boring FD-3 at Station 20+75 showed 19 feet of overburden which is comprised of silty and gravelly sands, silty sandy gravel and some till overlying rock. At the outlet site, boring FD-1 at about Station 31+90 showed bedrock at a depth of 28 feet. The overburden is silty sandy gravel and silty sands.

Rock at the intake (boring FD-2) is a gray, dense, hard, slightly calcareous, unweathered phyllite. It is massive with occasional joints that are usually tight. There are occasional hairline healed joints and fractures. Foliation is generally dipping about 35°. Core recovery for the entire boring was 98 percent. At Station 20+75, boring FD-3 showed a phyllite foliated and slightly calcareous. There are occasional joints and local weathered zones. The rock has numerous hairline steeply dipping healed joints and fractures. Many have calcareous fillings and many are stained. Core recovery was 97 percent. At Station 31+90 near the outlet, rock is at elevation 302. The rock is primarily a gray, hard schist with zones. Healed high angle fractures are common. Weathering is along joints and localized zones. Core recovery was 88 percent.

Foundation Conditions

The inlet will be founded in Rockwell Pond. The tunnel invert is at elevation 308 at the intake and elevation 264 feet at the outlet. From preliminary data, the tunnel will be in rock with at least two diameters of rock cover.

Intake Structures. The intake structure is founded on phyllite in Rockwell Pond (Plates 2 and 3). About 10 feet of bottom sediments are anticipated in the pond. Rock is assumed to be near elevation 400. The rock is competent and appears adequate for the structure. Dewatering will be required for construction.

Intake Shaft. The 12-foot finished diameter intake shaft will be in phyllite to the invert elevation of 308. The rock is competent but may have some localized weathered or fractured zones because of the shallow depth. A permanent lining is required.

Outlet Shaft. The outlet shaft will be in rock between the invert elevation of 264 and the rock surface at elevation 305. The schist and phyllite encountered are generally hard and competent although some fractured and weathered zones will be found. There is about 15 feet of overburden consisting of 5 feet of silty gravelly sand overlying 6 feet of silty sandy gravel followed by 4 feet of till. The materials are adequate for shaft construction.

Tunnel. The 12 foot finish diameter tunnel will be in rock. The rock near the intake will be primarily phyllite. Downstream of the intake zones of schist will be encountered. Maximum rock cover will be about 80 feet. Weathered and fractured zones will be encountered within shallow depths closer to the outlet. From the limited data, tunneling of rock is not expected to be difficult. The permanent lining is considered necessary for tunnel support.

Design

The proposed Rockwell Pond bypass tunnel would divert anticipated floodflows above the densely populated commercial and residential area via a 3,200 foot long deep rock tunnel to a point approximately 900 feet downstream of the Rochdale Dam below Water Street. With a design discharge of 3,400 cfs, flow velocity in the tunnel is estimated to be 28 feet per second. The diversion project would, in effect, reduce the flow in Monoosnoc Brook as it passes through the center of Leominster, thus giving this section of town adequate flood protection. Monoosnoc Brook would be flowing at a nondamaging channel capacity of from 600 cfs at Rockwell Pond to 800 cfs below Water Street.

The proposed spillway inlet would be located in Rockwell Pond just upstream of the existing dam. The circular intake structure would have a diameter of 46.64 feet, at a weir crest elevation of 416.7 msl. A galvanized steel grating would be placed over the intake as a safety measure and to prevent trash from entering the tunnel. The shaft would drop 90 feet below the assumed bedrock surface of elevation 398 feet msl to the tunnel invert of 308 feet msl. The shaft diameter would be 14 feet to elevation 348 feet msl with a transition to 12 feet in the neck between elevations 348 and 338 feet msl. The 3,200 foot long tunnel would be drilled and/or blasted through rock and would have a permanent concrete liner to prevent any

intrusion of groundwater. The invert of the tunnel would slope to elevation 264 msl at the outlet shaft. The 12 foot diameter outlet shaft would rise 56 feet to the outlet structure invert. The concrete outlet structure would widen to 32 feet at an invert elevation of 320 feet msl (See Plate G-6). A discharge channel would be excavated from this area for a distance of about 250 feet to the existing channel. Although discharge velocities would not cause erosion in the channel, either concrete blocks or large rocks would be placed in the channel to provide sheltered areas for fish habitat.

The present dam maintains the level at Rockwell Pond by a weir about 13 feet high with a crest elevation at 415.7 feet msl and an effective length of 68 feet. The proposed improvement would modify the existing dam by reducing the effective length of the weir to 22.5 feet while maintaining the same crest elevation. This elevation is one foot less than the proposed diversion crest and would, therefore, allow normal flow passage of up to 70 cfs downstream through Leominster in the Monoosnoc Brook channel before the diversion goes into automatic operation.

Additional construction would include regrading of about 3.5 acres of flood-prone property at the Pyratex Company, located about 300 feet downstream from Whitney Street. Existing ground which is as low as elevation 309 msl would be sloped from the riverbank to an elevation of 317 msl near the building. A plan of the proposed regrading is shown on Plate 5.

Two existing sewer lines which cross the river under the Whitney Street Bridge and at the end of Williams Street would be relocated downstream or replaced as a syphon under the brook at these locations.

In general, this planned improvement is intended to divert excess flow from Monoosnoc Brook and would not take normal flow away from the brook. The design capacities are such that existing conditions would be maintained above and below the diversion.

Construction

Assuming the authorization and availability of construction funds, it is estimated that the project could be designed and constructed in about three years. The actual construction period is estimated to be less than two years.

During the construction phase, earthfill would be required for the temporary worksite at Rockwell Pond in order to construct the proposed spillway. Estimated rock excavation for a 3,200 foot length of tunnel would be 20,500 cubic yards. Excess excavation materials would be disposed of by the contractor at Government approved disposal sites. Concrete required for the intake and outlet structures and the tunnel itself is estimated at 8,780 cubic yards.

All necessary easement lands, temporary and permanent, would be restored to their natural environmental setting after construction.

Operation and Maintenance

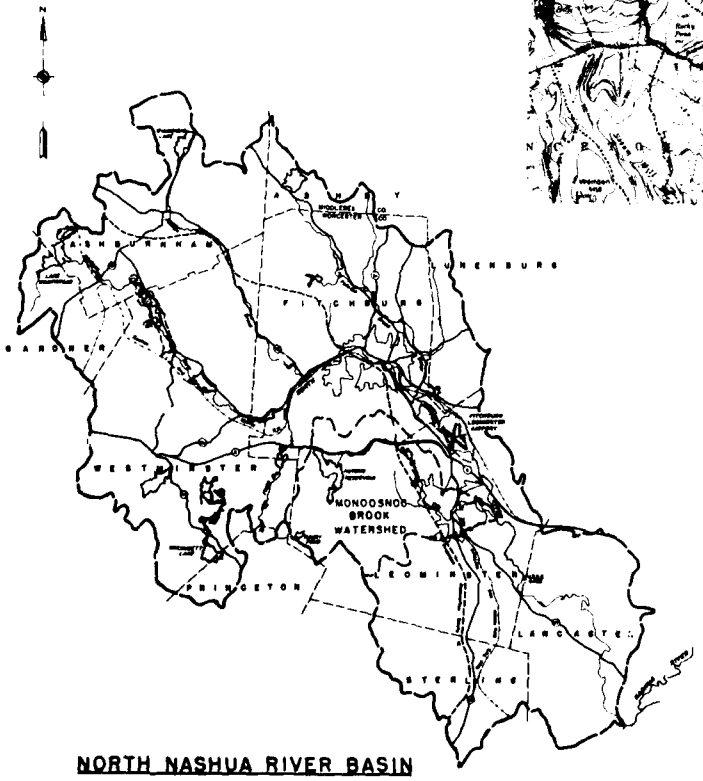
Assurances would be obtained from the Commonwealth of Massachusetts of acceptance of the tunnel and appurtenant structures after completion and the assurance of maintenance and operation in accordance with Federal regulations.

No significant problems are anticipated in connection with the operation and maintenance of the selected plan after its completion. As designed, the diversion will automatically take any excess flow from Rockwell Pond and Monoosnoc Brook will flow at nondamaging channel capacities without overtopping its banks. Therefore, operational cost is zero. Initially, Federal standards are established for the structures themselves with the cooperation of the city. Its maintenance of those standards is then a local responsibility. In addition, local interests would be required to maintain the existing channel to pass the maximum nondamaging flood flow of 600 cfs to 800 cfs. The projected cost of maintenance is estimated at $1,700 dollars a year.

CORPS OF ENGINEERS

MONOOSNOC BROOK WATERSHED MAP

SCALE IN FEET



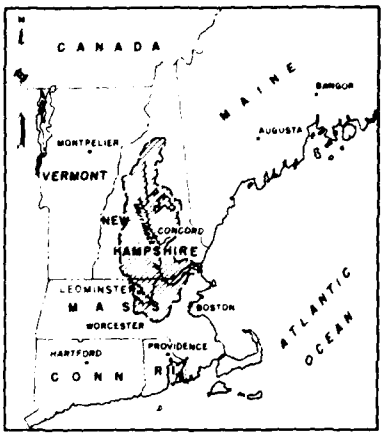
NORTH NASHUA RIVER BASIN

SCALE IN MILES

D E F G H U. S. ARMY

MONOOSNOC BROOK WATERSHED MAP

SCALE IN FEET



LOCATION MAP

SCALE IN MILES

25 0 25 50 75 100

REVISION	DATE	DESCRIPTION	BY

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

WATER RESOURCES DEVELOPMENT PROJECT
LEOMINSTER, MASSACHUSETTS
LOCAL PROTECTION PROJECT
WATERSHED MAP
MONOOSNOC BROOK MASSACHUSETTS

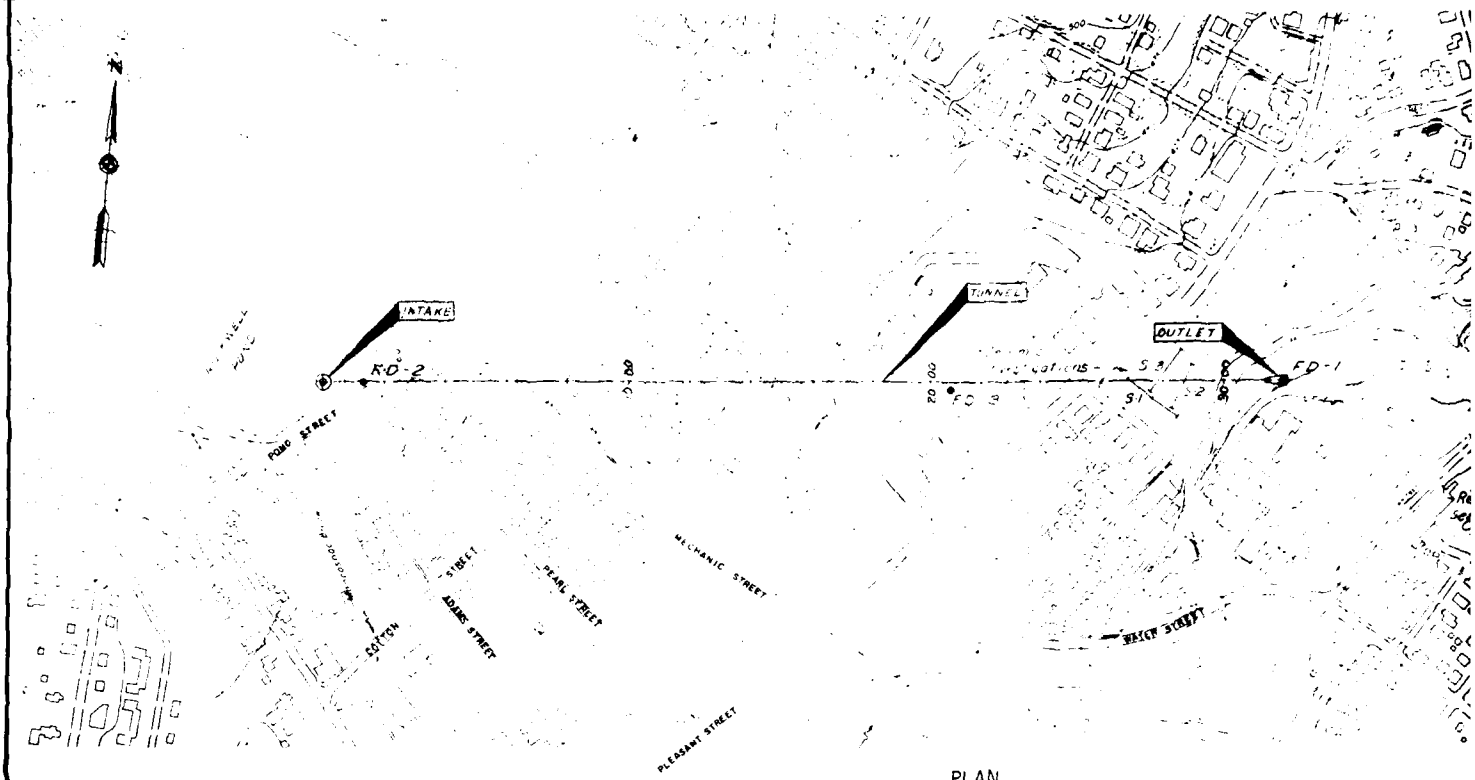
APPROVED

SCALE SPEC NO DACW 33

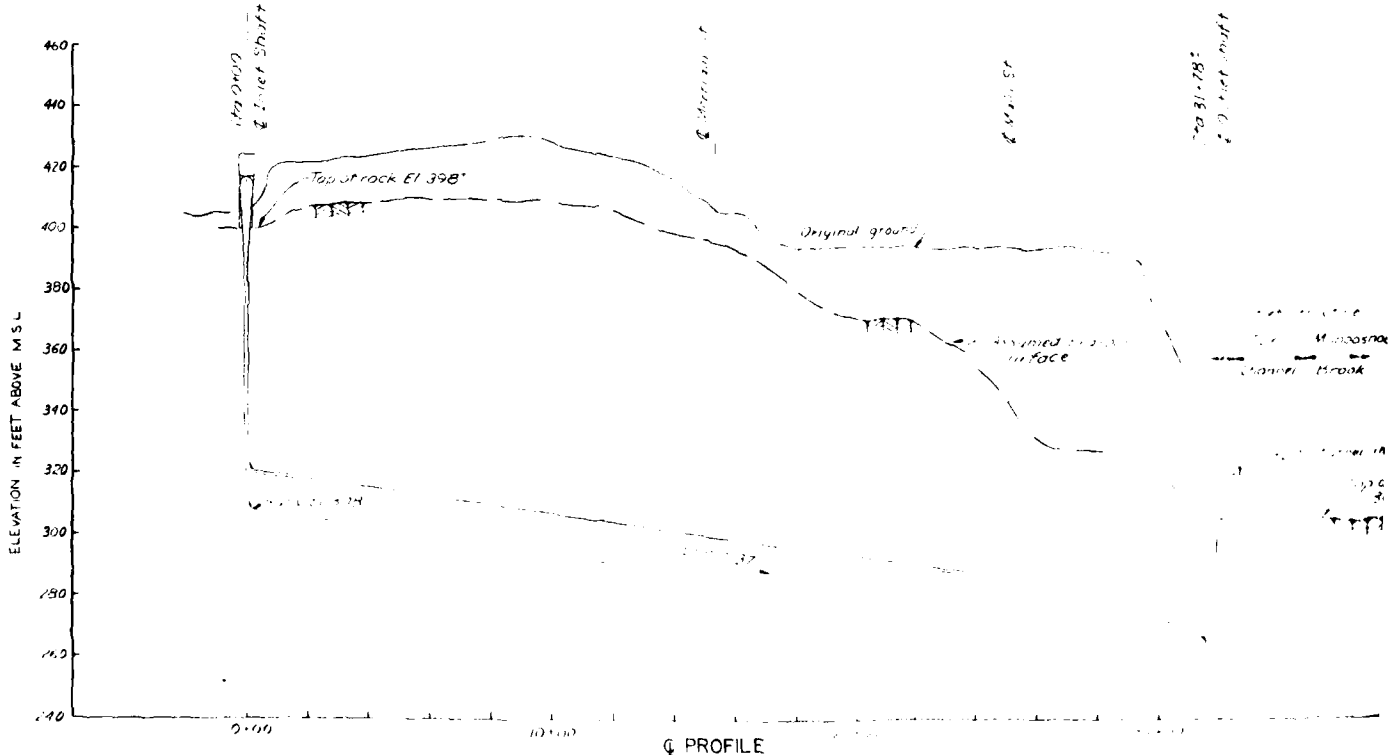
SHEET

PLATE G 1

CORPS OF ENGINEERS

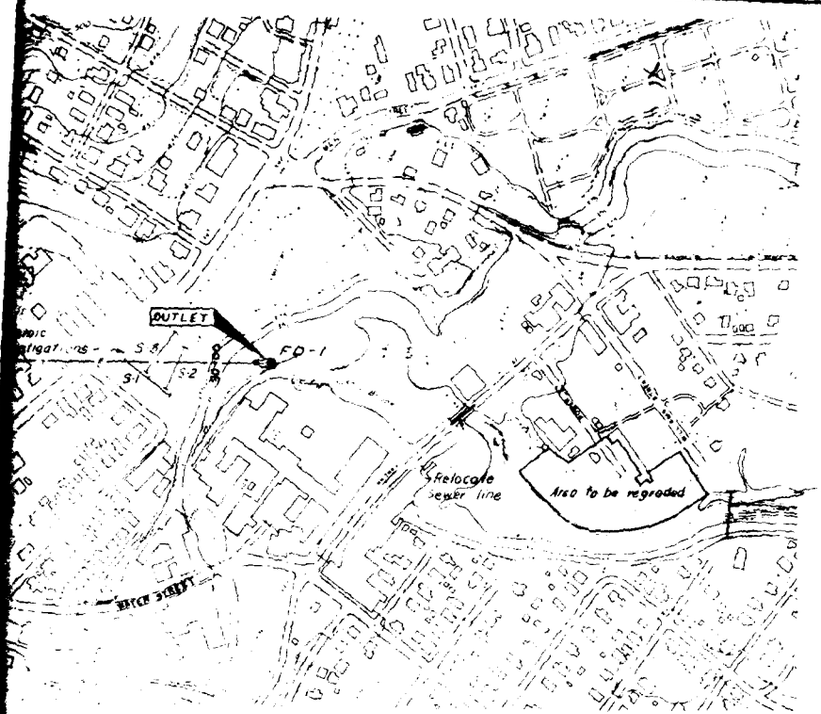


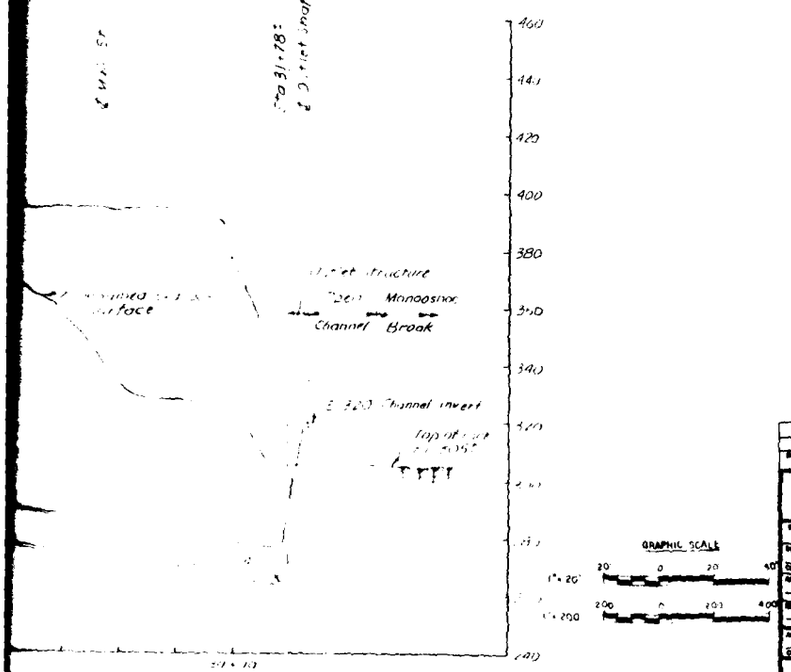
PLAN
SCALE 1" = 200' ±



℄ PROFILE
SCALE HORIZ 1" = 200'
VERT 1" = 20'

U S ARMY





GRAPHIC SCALE

1" = 20' 20 0 20 40

1" = 200' 200 0 200 400

REVISION	DATE	DESCRIPTION	BY

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

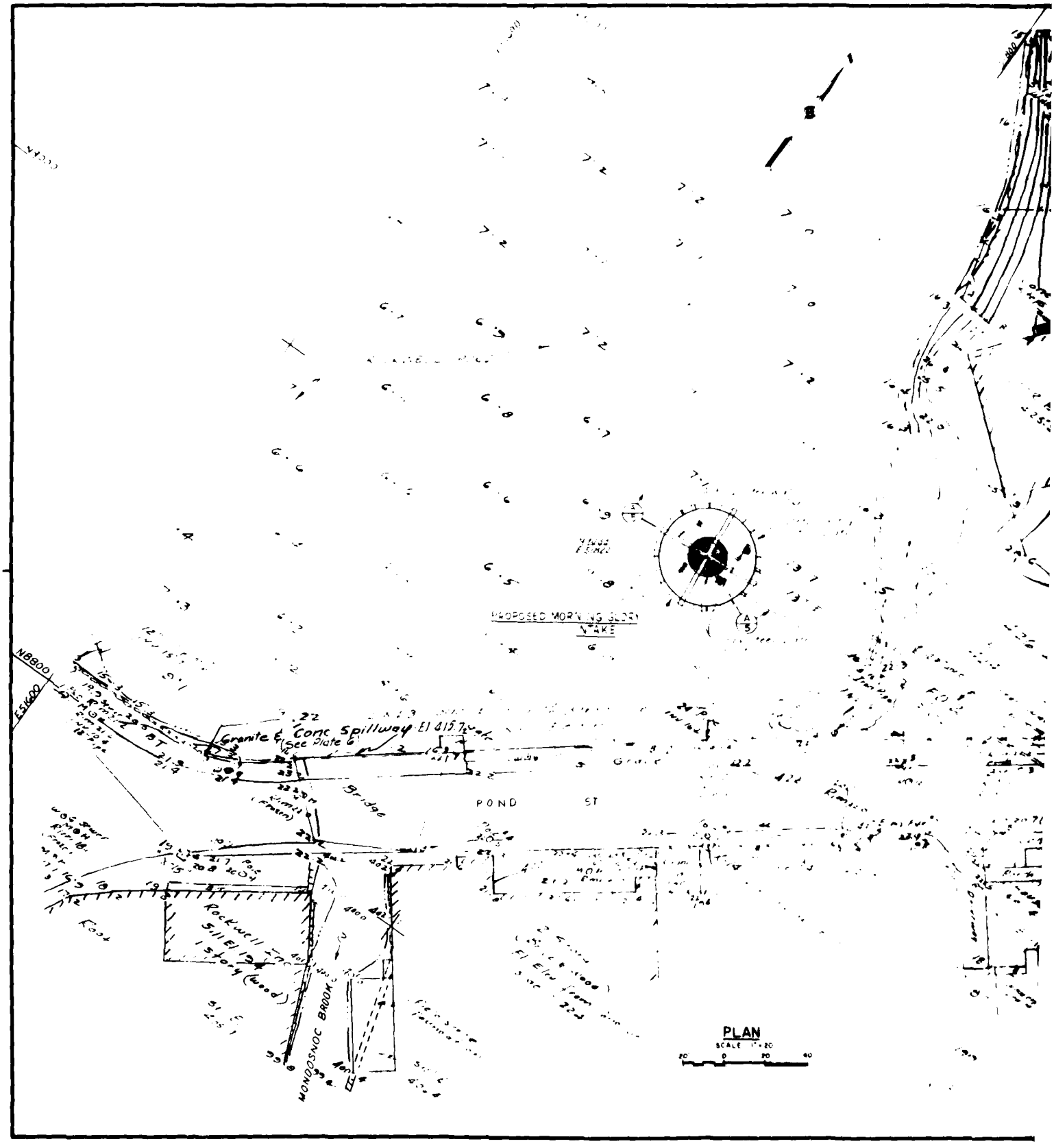
WATER RESOURCES FEASIBILITY REPORT
LEOMINSTER, MASS
LOCAL PROTECTION PROJECT
GENERAL PLAN & PROFILE
MONOOSNOC BROOK MASSACHUSETTS

APPROVED DATE NOV 1978

SCALE AS SHOWN SPEC. NO.
DRAWING NUMBER
SHEET

PLATE G 2

CORPS OF ENGINEERS



U S ARMY

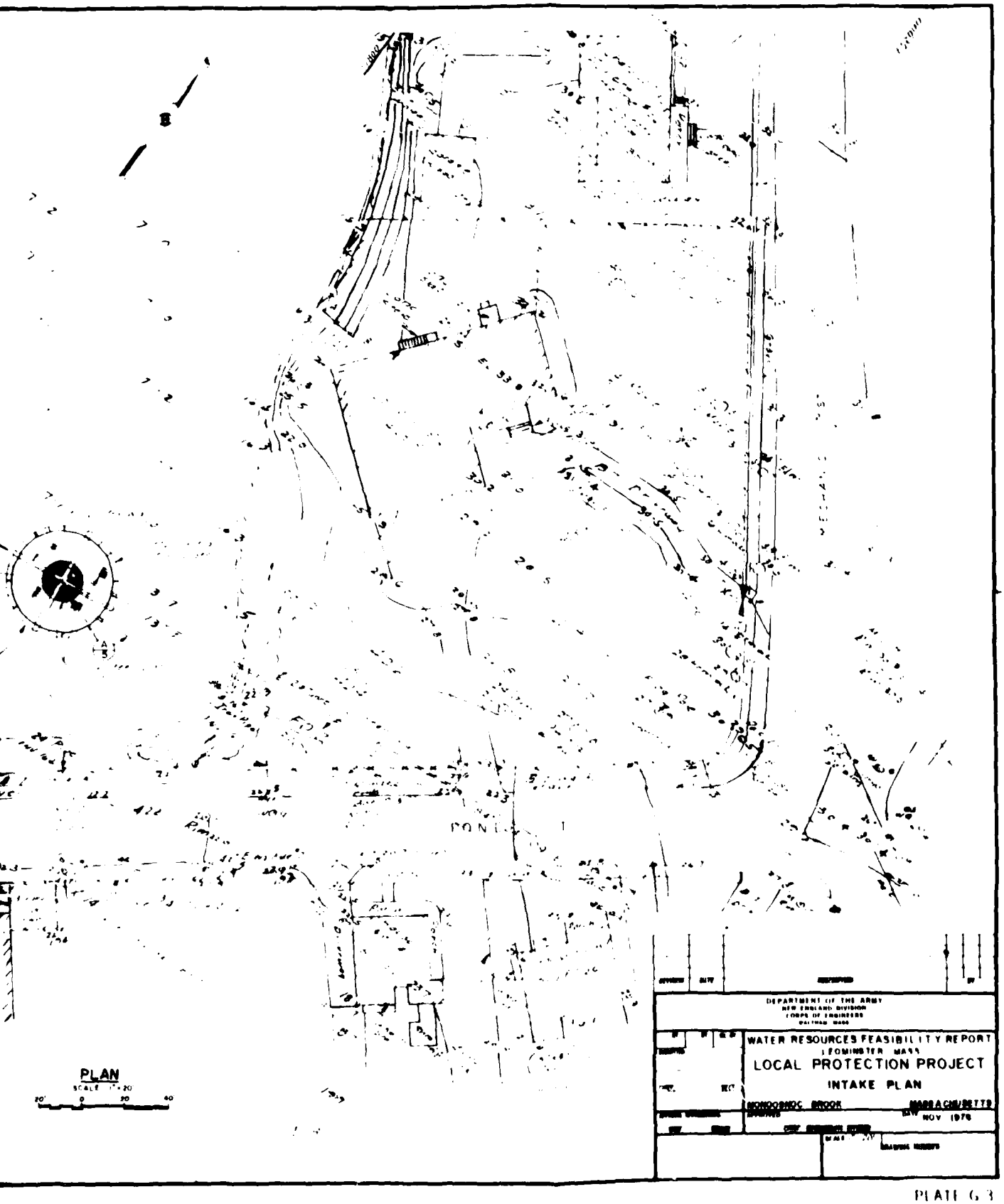
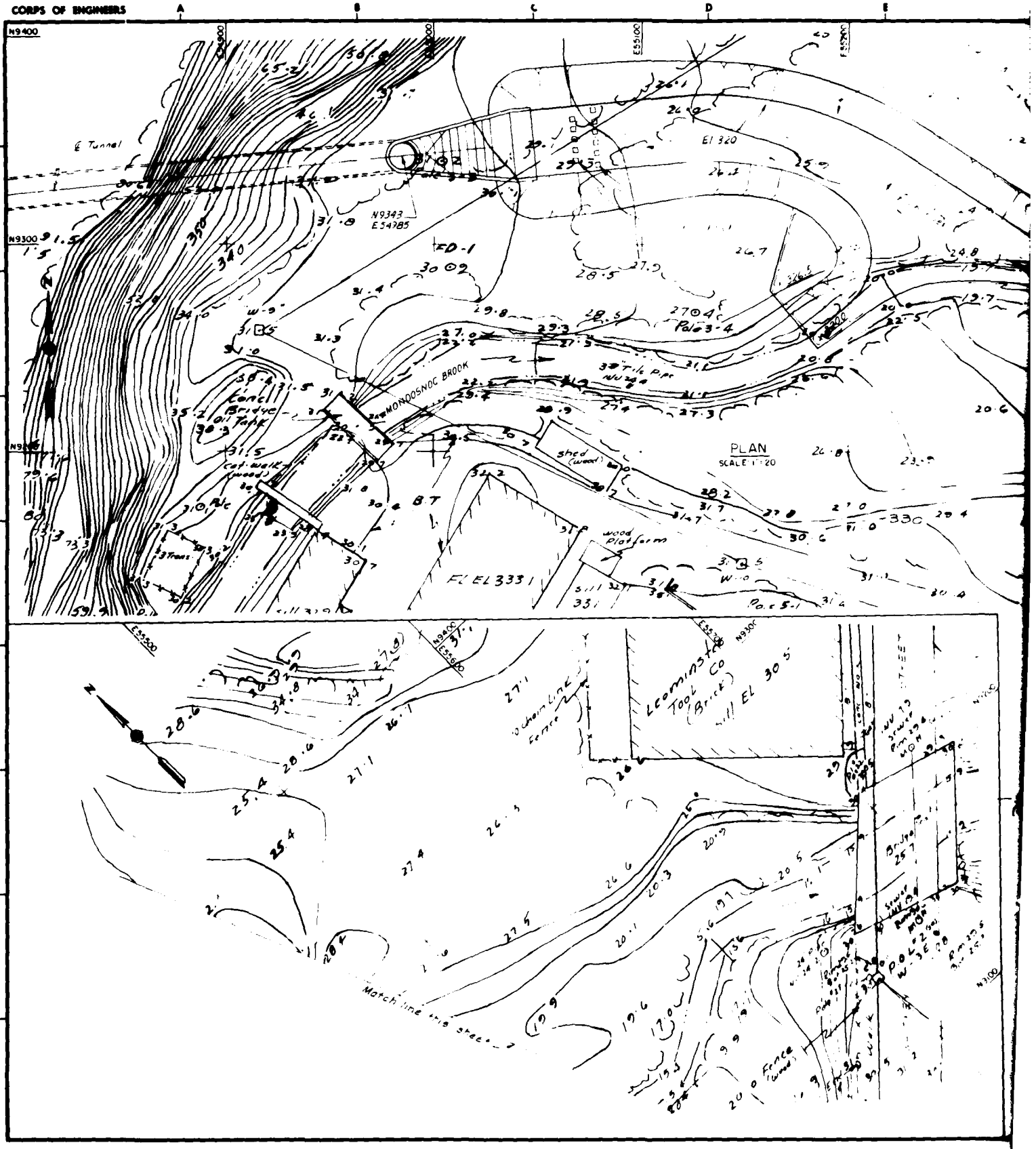


PLATE G 3


CORPS OF ENGINEERS
A
B
C
D
E
N9400
N9300
E5500
E5600
E Tunnel
N9343
E5478S
ED-1
MONOOSNOC BROOK
Concr Bridge
oil Tank
cat-walk (wood)
shed (wood)
wood Platform
EL 332
EL 333
EL 330
PLAN
SCALE 1"=20
Leominster Tool Co (Brick)
Bridge
Pole
March line
Fence

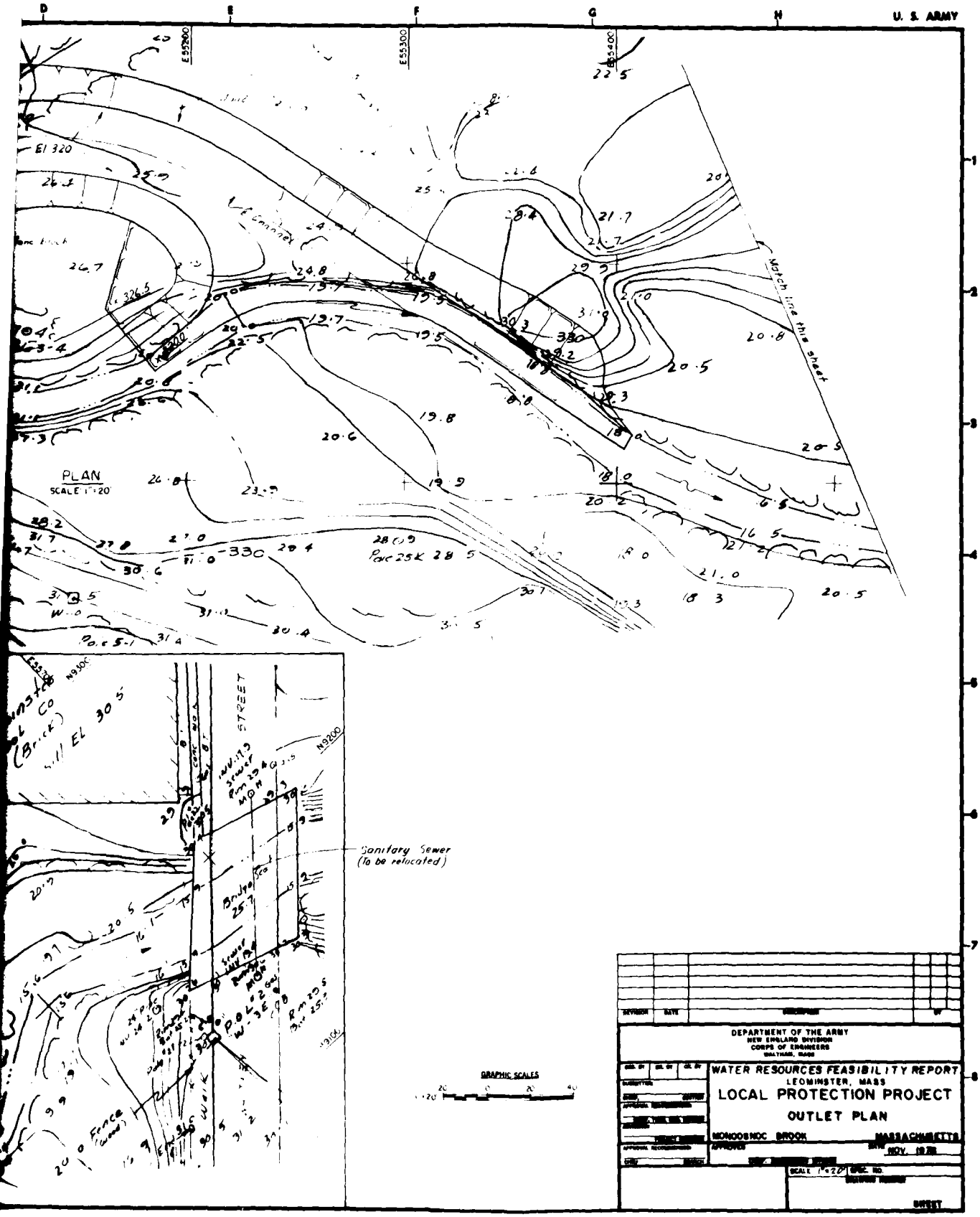
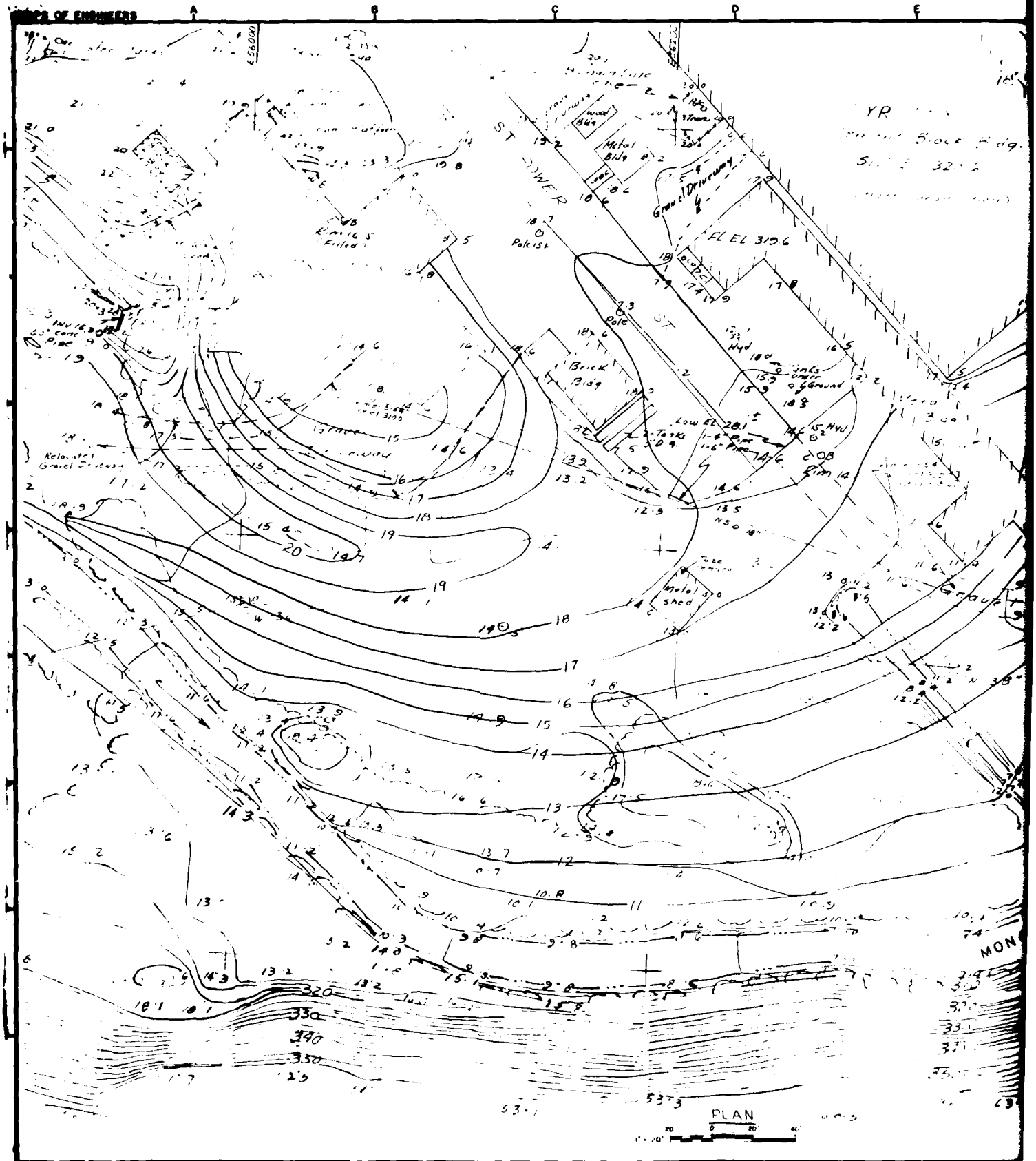

D
E
F
G
H
U. S. ARMY
E55200
E55300
E55400
PLAN
SCALE 1"=20'
Match line this sheet
Sanitary Sewer
(To be relocated)
STREET
GRAPHIC SCALES
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS
WATER RESOURCES FEASIBILITY REPORT
LEOMINSTER, MASS
LOCAL PROTECTION PROJECT
OUTLET PLAN
MONOOSNOC BROOK
MASSACHUSETTS
NOV. 1978
SCALE 1"=20'

PLATE G 4


A
B
C
D
E
ST SEWER
FL EL 319.6
Brick
Metal Bldg
Metal shed
Low EL 281
Gravel
PLAN

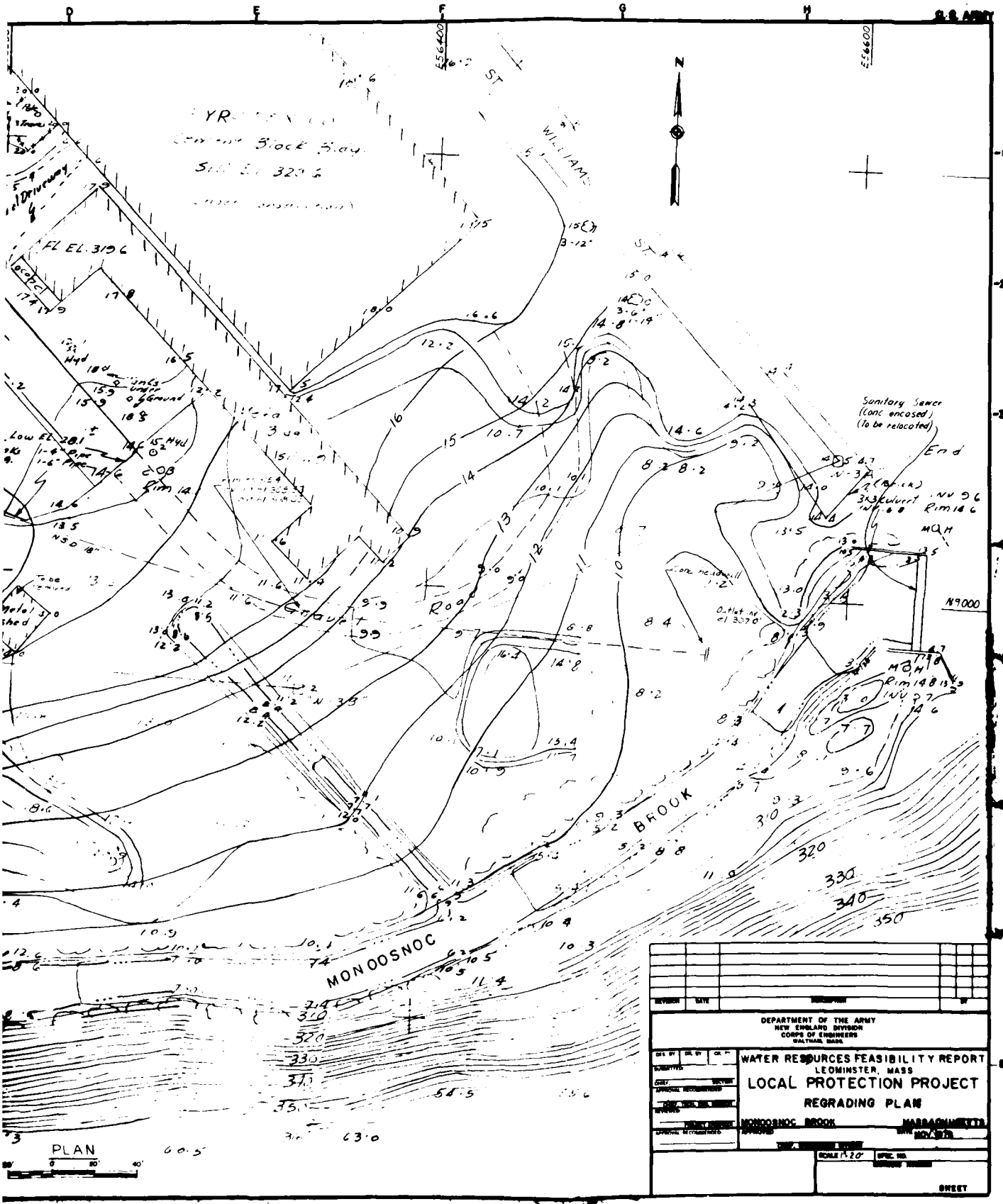
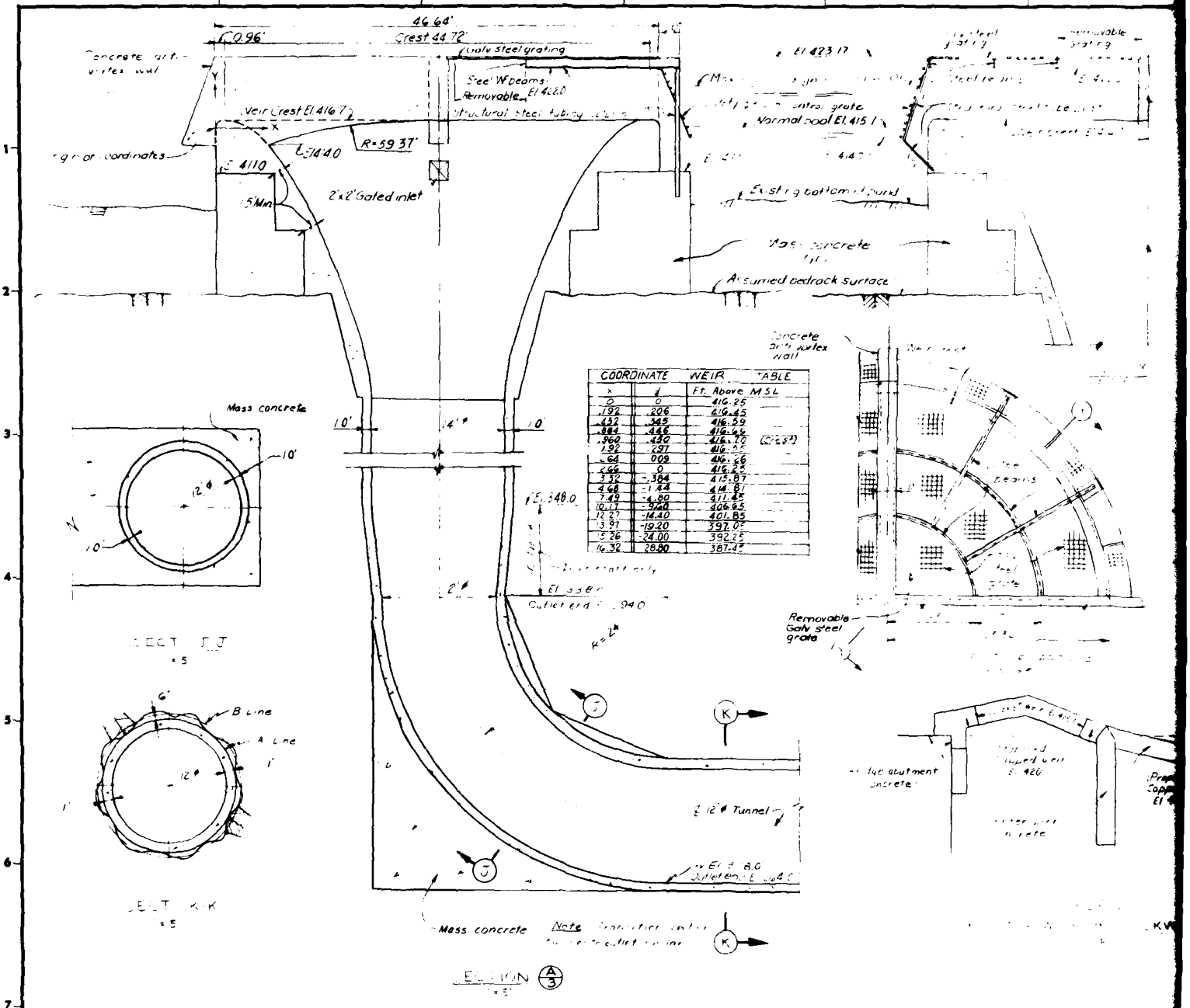

D
E
F
G
H
E56400
E56600
N
N9000
Sanitary Sewer
(Conc encased)
(To be relocated)
End
MQH
Rim 14.8
Rim 14
Outlet Inv el 307.0'
Road
Gravel
MONOOSNOC BROOK
PLAN
0 80' 40'
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
WATER RESOURCES FEASIBILITY REPORT
LEOMINSTER, MASS
LOCAL PROTECTION PROJECT
REGRADING PLAN
MONOOSNOC BROOK
MASSACHUSETTS
SCALE 1"=20'
SHEET

PLATE G 5

CORPS OF ENGINEERS



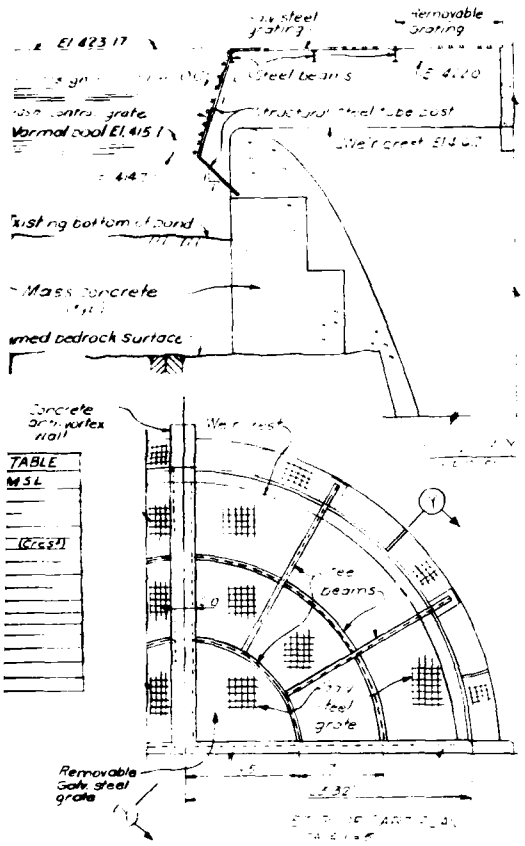
COORDINATE		WEIR TABLE
x	y	Ft. Above MSL
0	0	416.25
.192	.206	416.45
.432	.345	416.59
.864	.446	416.64
.960	.430	416.70
1.92	.297	416.52
.64	.009	416.56
.466	0	416.25
3.32	-.384	415.87
4.68	-1.44	414.81
7.49	-4.80	411.45
10.17	-9.40	406.85
12.27	-14.40	401.85
13.91	-19.20	397.05
15.26	-24.00	392.25
16.32	-28.80	387.45

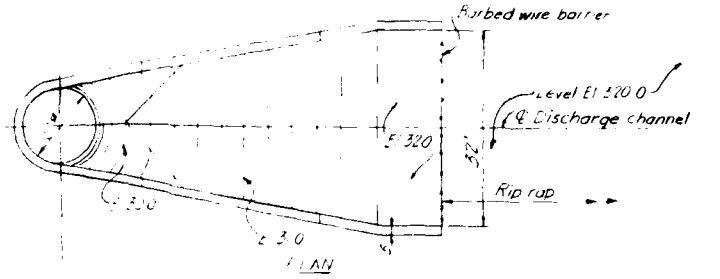
SECTION J-J

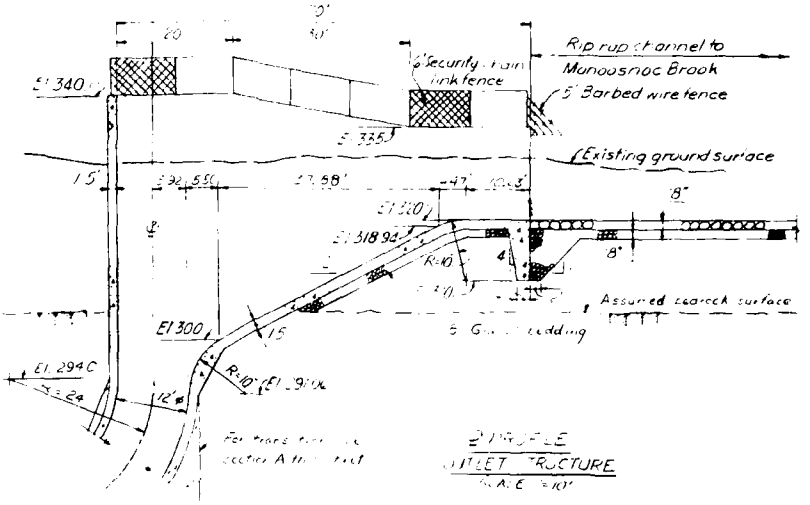
SECTION K-K

ELEVATION A/3

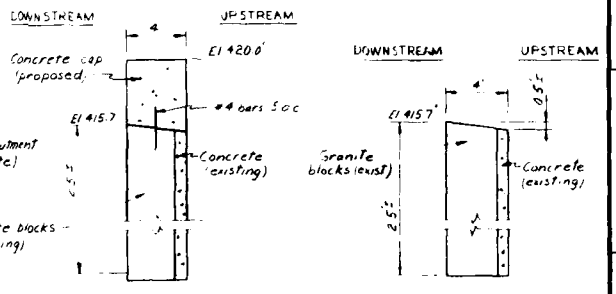
D E F G H U. S. ARMY

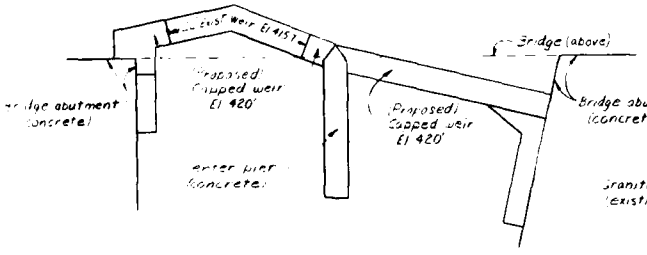






SPILLWAY OUTLET STRUCTURE





PLAN

SPILLWAY WEIR SECT

SPILLWAY WEIR SECT

GRAPHIC SCALES

REVISION	DATE	DESCRIPTION	BY

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

WATER RESOURCES FEASIBILITY REPORT
LEOMINSTER, MASS
LOCAL PROTECTION PROJECT
SECTIONS AND DETAILS
MONOOSNOC BROOK MASSACHUSETTS
DATE NOV. 1979

SCALE AS SHOWN SPEC. NO.
DRAWING NUMBER
SHEET

PLATE G-6

SECTION H

ECONOMICS OF SELECTED PLAN

ECONOMICS OF THE SELECTED PLAN

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TABLE OF CONTENTS (CONT'D)

LIST OF TABLES

TABLE OF CONTENTS (CONT'D)

LIST OF PLATES

SECTION H

ECONOMICS OF THE SELECTED PLAN

The purpose of this section is to centralize economic material, including both cost and benefit data. The material presented in the following pages concerns only those facets of the proposed improvement which can be readily quantified in dollar values.

Methodolgy

The tangible economic justification of the proposed improvements, which provide essentially complete flood protection against a Standard Project Flood in the urban center of Leominster, can be ascertained by comparing the equivalent average annual charges (i.e., interest, amortization and operation and maintenance) with an estimate of the equivalent average annual benefits which probably would be realized over the 100-year period of analysis selected. The average annual benefits preferably should equal or exceed the annual costs if the Federal Government is to contribute toward the project.

The values given to benefits and costs at their time of accrual are made comparable by conversion to an equivalent time basis using an appropriate interest rate. An interest rate of 6-5/8 percent applicable to public works projects was used in this report. The net effect of converting benefits and costs in this manner is to develop equivalent average annual values.

Because of the high degree of protection afforded and the high quality of maintenance that would be required for flood control works in an established urban area, the physical life of the works would exceed 100 years. Based on these factors, a 100-year period of analysis was selected.

The development of costs and benefits follows standard Corps of Engineers practice. The value of all goods and services used in the project is estimated on the cost side. On the benefit side, damages prevented and area redevelopment benefits created are estimated. The assessment of damages prevented is based on damage surveys which provide damage information related to stages or elevations of such damage. This material is then related to frequency data to convert it to average annual values. Annual benefits are then computed by changing the average annual values to reflect the impacts the project will have on the study area. Graphic development of stage-damage and damage-frequency relationships are shown on Plates H-4 through H-13. Stage-frequency curves developed for three index stations are presented on Plates H-1 through H-3.

Another consideration is maximizing net quantifiable benefits. This is an economic concept aimed at sizing a project or investment to the point where the greatest excess of benefits over costs occurs. In effect, this is the point where the last increment in project size has an incremental cost equal to incremental benefits, and any further increase in size would not be economically justified. Maximization does not, however, reflect qualitative values. Plate H-14 depicts the results of maximization studies with an Excess Benefits Curve.

Costs

First Costs

The estimates of first costs provide for a relief tunnel project as described in Section G and shown on Plate G-2. The estimates provide for the construction of the 12-foot diameter tunnel inlet and outlet structures and other appurtenant items. Quantities of the principal construction items were estimated on the basis of a preliminary design which would provide safe structures for given conditions. The estimates for first costs were based on June 1977 prices. A contingency allowance of 15 percent is included. Engineering and design and supervision and administration are estimated in lump sum items based on the cost of similar projects throughout the Boston area and amount to about 6 percent and 8 percent, respectively.

Table H-1 summarizes the estimated cost of the plan of improvement.

TABLE H-1

SUMMARY OF FIRST COSTS

First Costs

Preparation of Site		$ 20,000
Earth Excavation		45,000
Tunnel Rock Excava ion		1,465,000
Open Rock Excavation		3,000
Shafts, Complete		1,314,000
Gravel Fills		20,660
Topsoil and Seeding		28,375
Concrete		1,553,140
Steel Reinforcing and Misc. Metals		449,410
Drains		16,800
Waterstops		125,120
Stone Protection		18,000
Dewatering (tunnel)		326,000
	Subtotal	5,384,505
	Contingency	815.495
Total Estimated Construction Cost		6,200,000
Engineering and Design		400,000*
Supervision and Administration		520,000
Lands and Damages		370,000
Utility Relocations		150,000
TOTAL PROJECT COST		$7,640,000

*Does not include $210,000 for pre-authorization studies

Annual Costs

Estimates of annual costs are based on a 100-year period of analysis. Interest during construction is not included since the construction period is estimated as being only two years. The investment cost thus equals the first cost. Interest and amortization charges are based on an interest rate of 6-5/8 percent. The estimated cost of operation and maintenance is also included. Table H-2 summarizes the annual costs.

TABLE H-2

SUMMARY OF ESTIMATED ANNUAL COSTS

Item	Cost
Federal	
Interest and Amortization (.06635 x $7,120,000)	$ 472,400
Non-Federal	
Interest and Amortization (.06635 x $520,000)	34,500
Operation and Maintenance	1,700
TOTAL ANNUAL COST	$ 508,600

Floods Losses

Extent and Character of the Flood Area

Approximately 70 acres used principally for business and industry are subject to flooding when Monoosnoc Brook overflows its banks. The flood-prone section of Leominster, for the purpose of this study, describes an irregular pattern in the city's core area and includes the southwestern half of Monument Square, its civic and business center. It extends from Rockwell Pond on Pond Street downstream along Monoosnoc Brook to the Williams Street sewer crossing, a distance of 1.4 miles. This area is hereafter referred to as the Project Area.

The project area is characterized by low-to-middle income residential neighborhoods closely mixed with manufacturing and business structures, some few of which are now vacant or partially used, and a tight network of paved roads. There are 64 residential structures here, predominantly multifamily housing with some single-family homes. The quality of housing varies; spot demolition of deteriorated structures is occurring and extensive improvements are planned. However, even with problems of upkeep, the overall appearance of the area is good with ample informal green space and tidy streets.

The current 1975 Leominster land use map shows the following urban functional activities in the project area: residences, heavy manufacturing, vacant lots, commercial and retail sales, auto and marine services, a few semiprivate or public service institutions and minimal formal green space. In addition to the 64 residential structures mentioned above, there are 10 factories and 94 small businesses.

Damage Surveys

A detailed damage survey was conducted by damage analysts of the NED in 1974. The survey consisted of a property-by-property canvas of all structures in the floodplain as defined by the highwater lines and all adjacent properties up to elevations of three feet higher than the record flood level. The damage analysts made their own assessment of potential flood losses and verified them with some of the property owners. Knowledgeable property owners were consulted when available.

The damage survey evaluated physical damages to buildings and contents as well as nonphysical losses, utilities for instance, and the emergency costs associated with a flood, including the costs of temporary shelter and subsistence. Estimates were also made for stages below the record flood level as well as the stage at which damage would begin.

Recurring and Annual Losses

Losses by stages referenced to the record flood level were tabulated for the flood-prone area as delineated by hydrologists. Recurring losses are estimated at $3,952,500 (1977 price levels) in the event of a flood of the proportions of the 1936 record flood. It was determined that the losses would be 13.5 percent residential, 38.4 percent industrial. 45.0 percent commercial and 3.0 percent public. Recurring losses were combined with stage-frequency data to derive annual losses. Annual losses so obtained amount to $554,300 at 1977 price levels.

Trends of Development

The potentially floodable area is primarily commercial and industrial in character and it is substantially developed. This concentrated development consists of 94 business establishments, 10 factories and 64 residential structures. A small number of public facilities are affected. From a social point of view the project area appears to be valuable because it provides both low income housing and opportunities to foreign immigrants for work and acculturation in a small, stable city.

Benefits

Flood Damage Prevention Benefits

Tangible flood damage prevention benefits are determined by the following method: The difference is taken between annual losses under the without-project conditions and residual annual losses to be anticipated with the proposed project. In the present case, such benefits so obtained amount to $540,700 (1977 price levels). Residual annual losses with the project amount to $13,600 (1977 price levels). The distribution of annual benefits by geographical areas and related hydrologic index stations is shown in Table H-3.

TABLE B-3

AVERAGE ANNUAL BENEFITS
(1977 Price Levels)

	12' Ø Tunnel
AREA 1 - Index 3 (Cotton Street to Pond Street)	$ 88,300
AREA 2 - Index 3 (Central Street to Cotton Street)	255,400
AREA 3 - Index 2 (Railroad Bridge to Central Street)	108,900
AREA 4 - Index 1 (Whitney Street to Railroad Bridge)	87,000
AREA 5 - Index 1 (Downstream of Whitney Street)	1,100
TOTAL AVERAGE ANNUAL BENEFITS	$ 540,700

Significant intangible benefits would also ensue from the proposed project. These include a reduction in health hazards caused by polluted floodwaters, a potential improvement of the social and economic well-being of both residents and economic activities in the area, and a cutback in the demand for municipal services (police, fire, public works departments) during flood emergencies.

Area Redevelopment Benefits

In labor market areas which have been designated as Redevelopment Areas, Senate Document No. 97 of the 87th Congress directs that the project benefits shall be considered to be increased by the value of the labor and other resources required for the project construction and expected to be used in project operation, project maintenance and additional area employment during the life of the project. Otherwise, such labor and resources would not be utilized or would be underutilized. Leominster lies in the Leominster-Fitchburg SMSA, which has been designated by the Economic Development Administration as a Title IV Redevelopment Area under P.L. 89-136. In July 1976, the unemployment rate was 8.7 percent and in August 1975 it was 13.6 percent.

The records of this office indicate that in the average civil works project, the labor cost approximates 27 percent of total construction costs. The construction cost of this project is currently (June 1977) estimated at $6,200,000. Labor's share amounts to $1,674,000.

It is regular practice for a contractor to maintain a skilled skeleton crew and fill the rest of his requirements from the local labor pool. For this project it is estimated that 75 percent of the laborers will be locally hired. While not all of this labor will come from the rolls of the unemployed, the jobs that they leave will be filled by either the unemployed or the underemployed; thus, 75 percent will be used. It is estimated that the work will take two years to complete.

No benefit is considered for labor engaged in maintenance and operation of the project after construction; the work will be handled by the community's regular public work force.

With interest at 6-5/8 percent, the derivation of the annual redevelopment benefits is as follows:

$6,200,000 x 0.27	=	$1,674,000	TOTAL LABOR COST
$1,674,000 x 0.75	=	$1,255,500	LOCAL LABOR
$627,750 x 0.938	=	$ 588,830	
$627,750 x 0.88	=	$ 552,420	
		$1,141,250	

$1,141,250 x .06635 (CRF 100 @ 6-5/8%) = $75,722 or $76,000 (redevelopment benefits)

Future Benefits

The purpose here is to determine the extent of possible future benefits due to growth and to evaluate the practicality of computing such benefits in each of the three benefit categories. These benefit categories are inundation reduction, intensification and location. They are differentiated as follows:

1. The future inundation reduction benefit is the value of reducing flood losses to activities which will use the floodplain without a project. The benefit consists of the reduction of the amount of future damages and related costs, flood fighting for example. Future damages are discounted to the base year of the project.

2. The intensification benefit accrues to commercial, industrial and agricultural sectors. The benefit is the value of a plan to activities which, with protection, are enabled to utilize their land more intensively.

3. The location benefit is the value of making the floodplain available for new uses by reducing flood hazards to activities that would use the floodplain only with protection.

Field Work

Field work consisted of inspections and surveys of the site in Leominster. A map of the floodplain was utilized in conjunction with a zoning map and a land use map. The 1974 Damage Study of the Monoosnoc Brook, referenced to the 1936 flood, was employed. All vacant land in the floodplain was noted, zoning for such land was determined and future probable use hypothesized. The Leominster Planning Board was consulted about possible zoning changes and present and future demolitions. Citizens with a practical knowledge of the community's affairs were also consulted. Owners and managers of industrial plants and commercial operations within the floodplain were surveyed and inquiry was made as to whether space within their operations is presently underutilized due to the threat of possible flooding.

The purpose of the field work was to ascertain which future benefit categories have applicability in the Monoosnoc Brook floodplain.

The following results in each of the three benefit categories were obtained:

1. Future Inundation Reduction Due to Growth

The residential sector covers the largest portion of floodplain lands. Future growth of residential land use is expected to occur outside the floodplain, however, because the residential area in the floodplain is already well developed. While some demolition is possible in the future,

there is no way to predict at this time its possible extent. The city of Leominster has no floodplain demolition plans for the immediate future. Existing residential damages account for 13.5 percent of all damages. A growth in affluence is expected so some urban inundation reduction benefits are obtainable for future losses.

In the commercial and industrial sectors, little growth is possible. Current land use is not susceptible to substantial changes in the floodplain, and no significant zoning changes in the floodplain are foreseen by the City Planning Board. Vacant lands consist of four lots amounting to less than two acres. They are discussed later in this section. Most of the activities that would locate in the floodplain if no land use plan is adopted would be replacing vacated structures. Since urban renewal and the revised master plan are not available in any detail, replacements are assumed to sustain losses similar to those of the present occupants.

2. Intensification

During the field work a survey was conducted to determine how much industrial and commercial space is now underutilized in the floodplain. None of the manufacturers surveyed reported any such underutilized space due to possible flooding. Commercial establishments gave substantially the same answers. Those that reported dry cellars utilize every possible space under appropriate economic circumstances. Those shopkeepers with wet cellars utilize skids, pallets, shelving and tables; and they raise their goods 4 to 6 inches from the floor. The lost space is a negligible amount and these costs were already accounted for in the 1974 Damage Study. Since few are aware of the 1936 flood proportions, they have not taken precautions that might be expected.

3. Location

This third type of benefit results from making the floodplain available to those who would locate there only with a land use plan. In Leominster, however, flooding does not appear to be a factor in site preference. Businesses are currently locating in its floodplain. As noted earlier, the flood potential is unknown to most concerned. The new businesses would have damages comparable to those occupying the properties at the time of the 1974 study. Businesses currently locating in Leominster are moving into existing structures.

Vacant Lands

Four parcels of floodplain land are vacant.

1. An industrially zoned corner lot at Water St. and Whitney. Property is for sale and is currently serving as a parking lot for R & M Manufacturing Co.

2. A commercially zoned 10,638 sq. ft. lot on Adams St. Property is for sale.

3. A business B zoned 34,000 sq. ft. lot on Pleasant St. with brick bldgs. and garages. This is the former city water works and is city owned. The approval of the City Council is necessary for its sale.

4. A commercially zoned small lot on Main St.

The available vacant land has a total area of less than two acres. The industrially zoned corner lot is at least partially in the floodway. The commercial lot is small with footage on a busy two way street. The business B zoned lot can only be sold if the Leominster City Council approves. A bid was recently rejected, and there is a possible zoning dispute. It had been suggested that the property become a "green belt." The Main St. lot could be developed into a commercial operation. It is not for sale at this time.

Conclusion

Future benefits from economic growth are limited by the lack of vacant and buildable land, and residential growth in the floodplain is not expected. There is a small urban inundation reduction benefit due to affluence which would accrue to residences. The intensification benefit is virtually nil in the Monoosnoc Brook floodplain.

The awareness of the possibility of severe flooding is quite limited. Economic activities do not consider possible flooding as a factor in locating in the floodplain of Monoosnoc Brook. There are businesses replacing vacated structures at the present time. These new occupants are economically comparable to the previous occupants.

Future benefits due to the project areas economic growth are primarily inundation reduction benefits to commercial and industrial activities as well as affluence benefits to the residential areas. Such benefits are negligible and would not result in a significant change in the B/C Ratio.

Summary of Benefits

Evaluated flood damage prevention and area redevelopment benefits are summarized in Table H-4.

TABLE H-4

SUMMARY OF ESTIMATED ANNUAL BENEFITS
(June 1977 Price Levels)

Type	Annual Benefit
Flood Damage Prevention	$ 540,700
Area Redevelopment	76,000
TOTAL	$ 616,700

Justification

The estimated annual costs, annual benefits and the ratio of benefits to costs for the selected plan are summarized in Table H-5. This analysis indicates that the plan of improvements to provide flood protection along Monoosnoc Brook is economically justified.

TABLE H-5

SUMMARY OF ECONOMIC ANALYSIS

Average Annual Benefits	
Flood Damage Prevention	$ 540,700
Area Redevelopment	76,000
TOTAL	$ 616,700
Average Annual Costs	$ 508,600
Economic Ratio	
Benefit/Cost (without area redevelopment)	1.06
Benefit/Cost (with area redevelopment)	1.21

Maximization

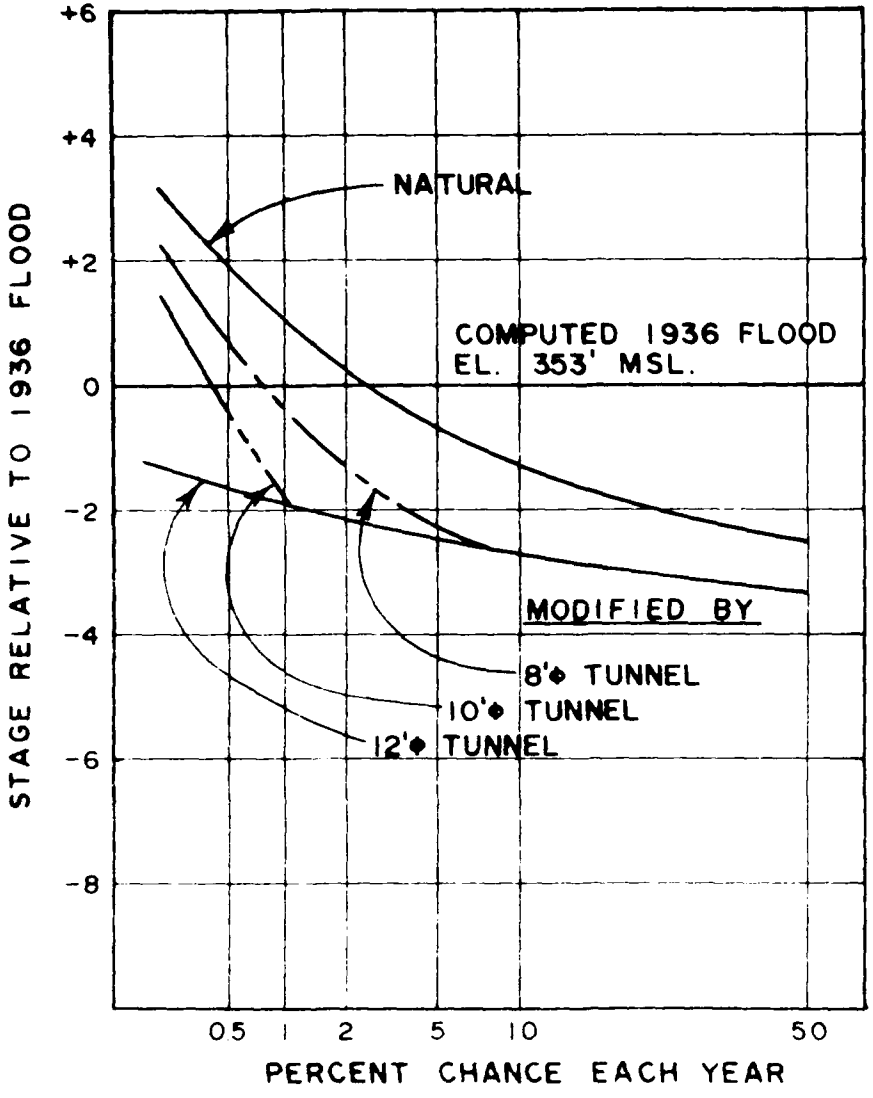
Maximizing net tangible benefits is an economic concept utilized to size a project or investment to the point where the greatest excess of benefits over costs occurs.

Once it was determined, during the plan formulation phase of the study, that only a tunnel bypass project had economic justification, it was necessary only to determine what size tunnel would result in the greatest excess of benefits over cost. Excess benefits are shown in Table H-6. The excess benefits curve shown on Plate H-4 indicates that maximization occurs for the 12 foot diameter conduit. This size tunnel will safely convey the standard project flood discharge of 4,000 cfs (less 600 cfs in the existing channel) under the commercial center of Leominster.

TABLE H-6

EXCESS BENEFITS

Tunnel	Cost ($1,000)	Annual Benefits ($1,000)	Excess Benefits ($1,000)
8'Ø	408	436	28
10'Ø	452	502	50
12'Ø	509	617	108
14'Ø	541	620	79



LEOMINSTER LOCAL PROTECTION

MONOOSNOC BROOK, MASSACHUSETTS

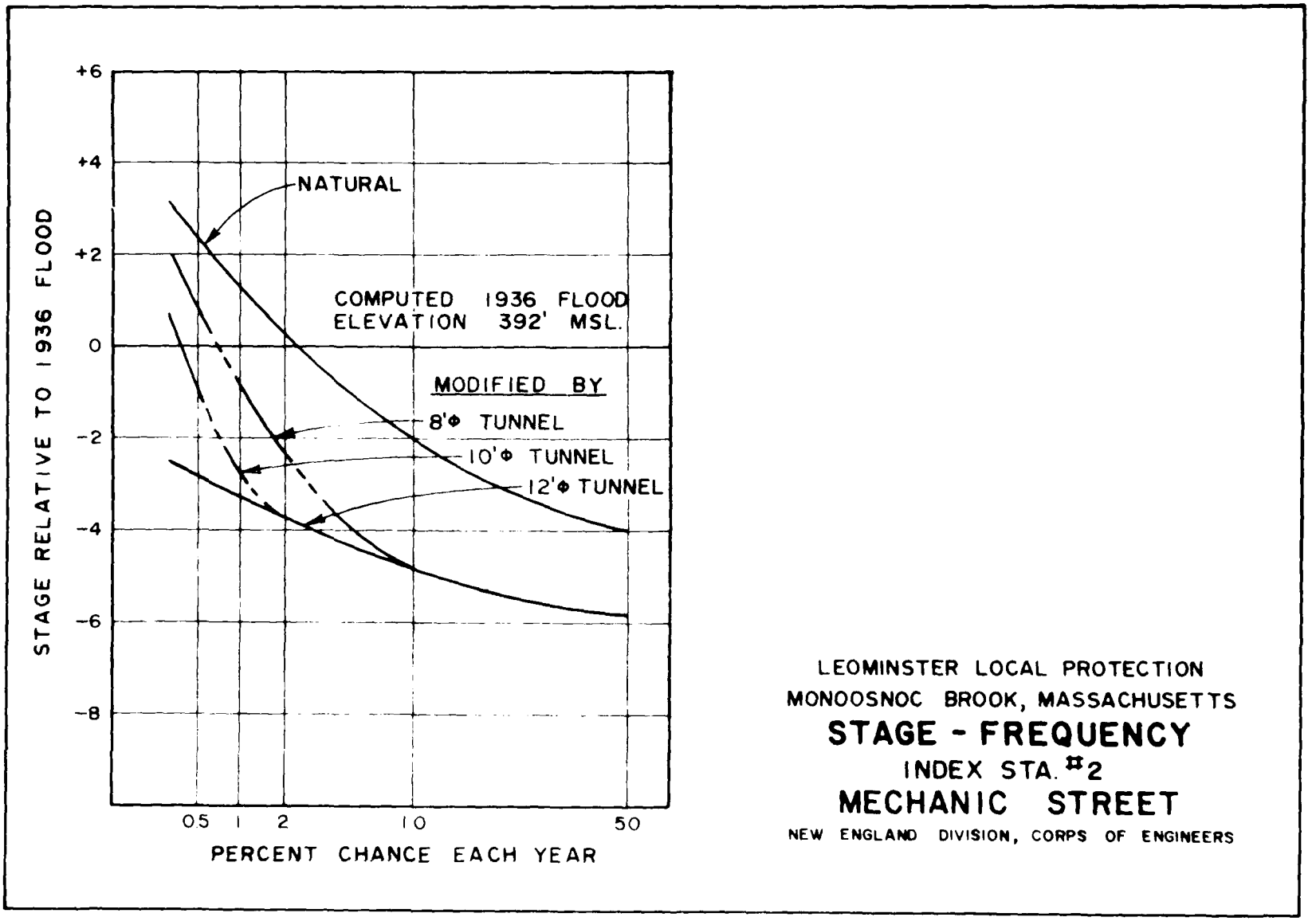
STAGE - FREQUENCY

INDEX STA. # 1

WATER ST. DAM

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE H-1



LEOMINSTER LOCAL PROTECTION
MONOOSNOC BROOK, MASSACHUSETTS

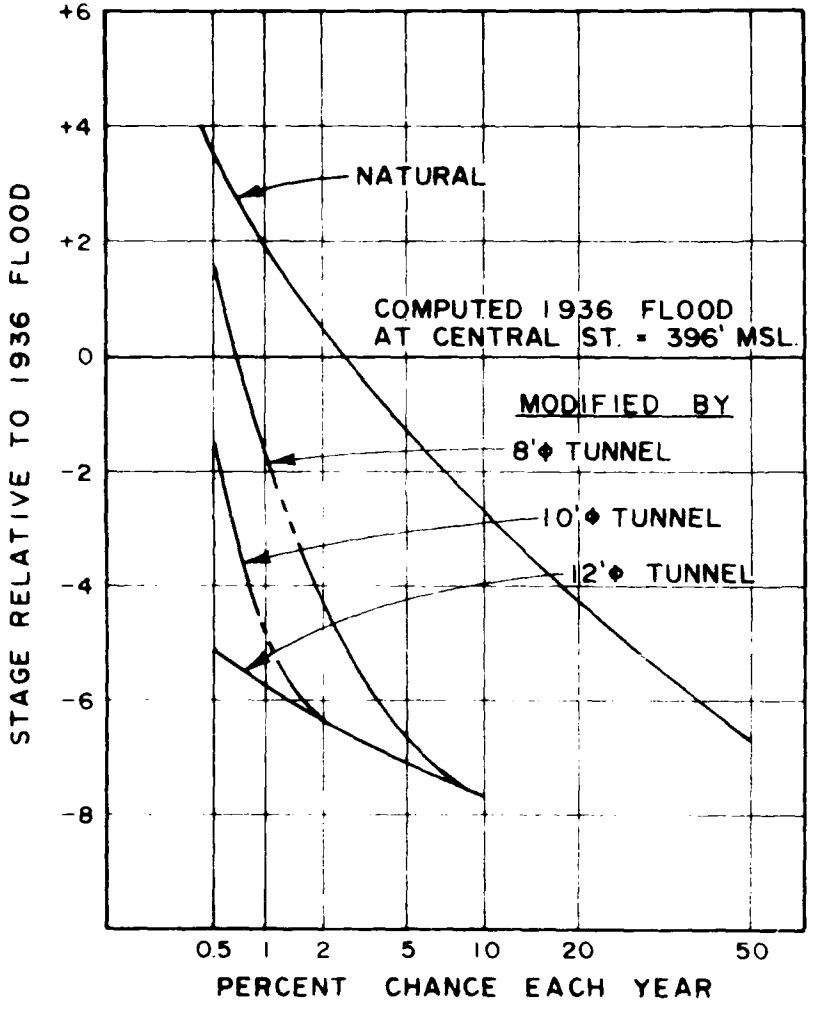
STAGE - FREQUENCY

INDEX STA. #2

MECHANIC STREET

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE H-2



LEOMINSTER LOCAL PROTECTION
MONOOSNOC BROOK, MASSACHUSETTS

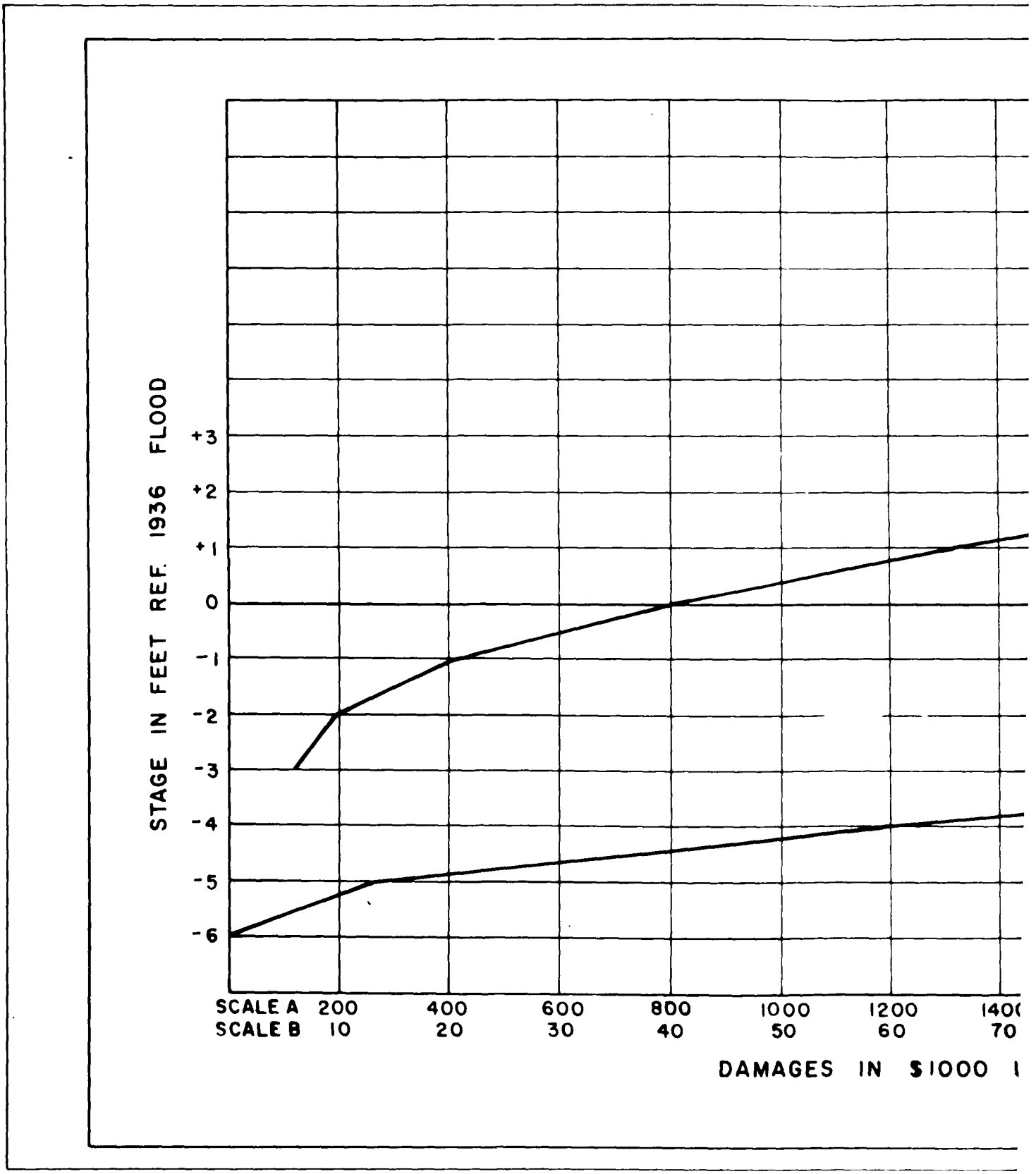
STAGE - FREQUENCY

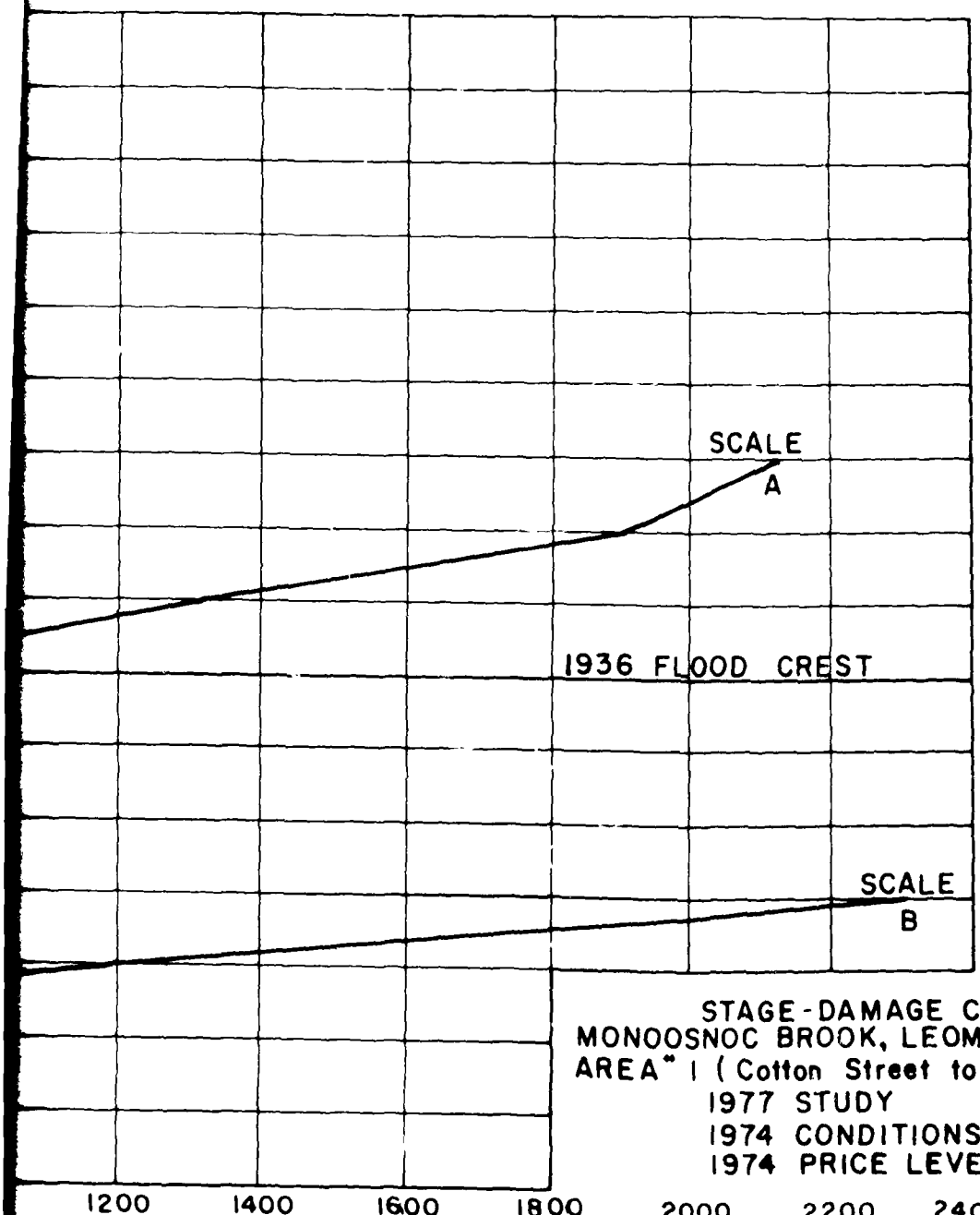
INDEX STA. ✱3

CENTRAL STREET

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE H-3

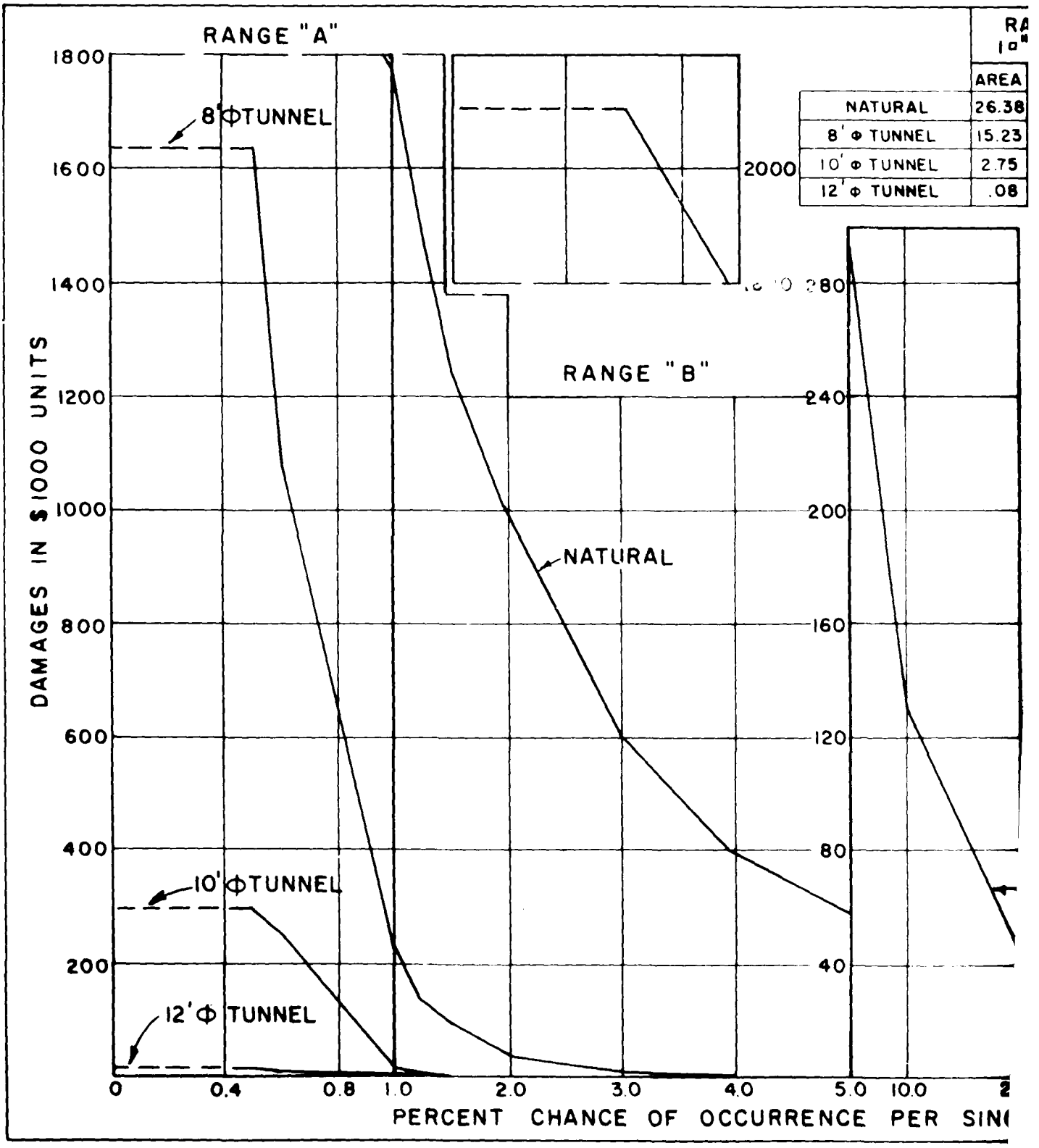

STAGE IN FEET REF. 1936 FLOOD
+3
+2
+1
0
-1
-2
-3
-4
-5
-6
SCALE A 200 400 600 800 1000 1200 140(
SCALE B 10 20 30 40 50 60 70
DAMAGES IN $1000 I



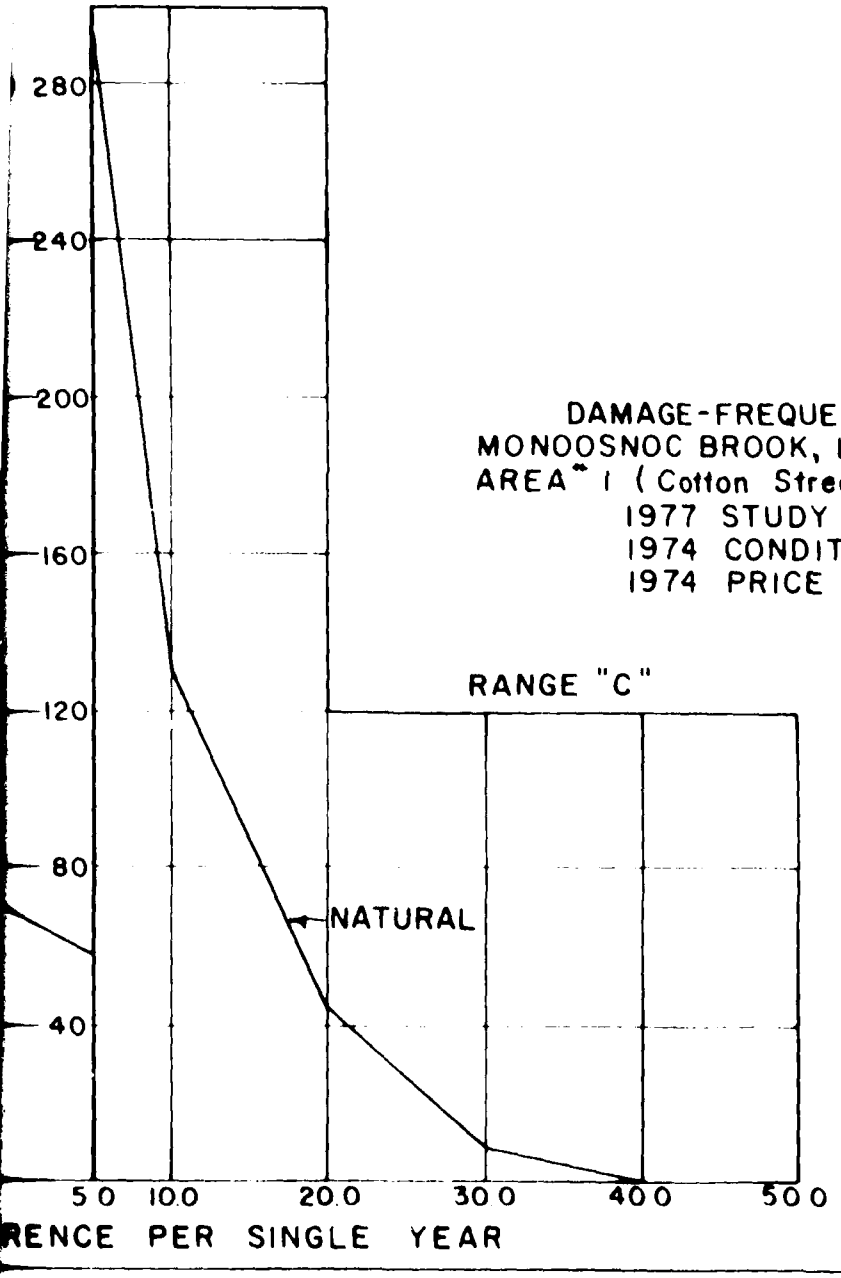
STAGE-DAMAGE CURVE
MONOOSNOC BROOK, LEOMINSTER, MASS.
AREA" 1 (Cotton Street to Pond Street)
1977 STUDY
1974 CONDITIONS
1974 PRICE LEVEL

S IN $1000 UNITS

PLATE H-4

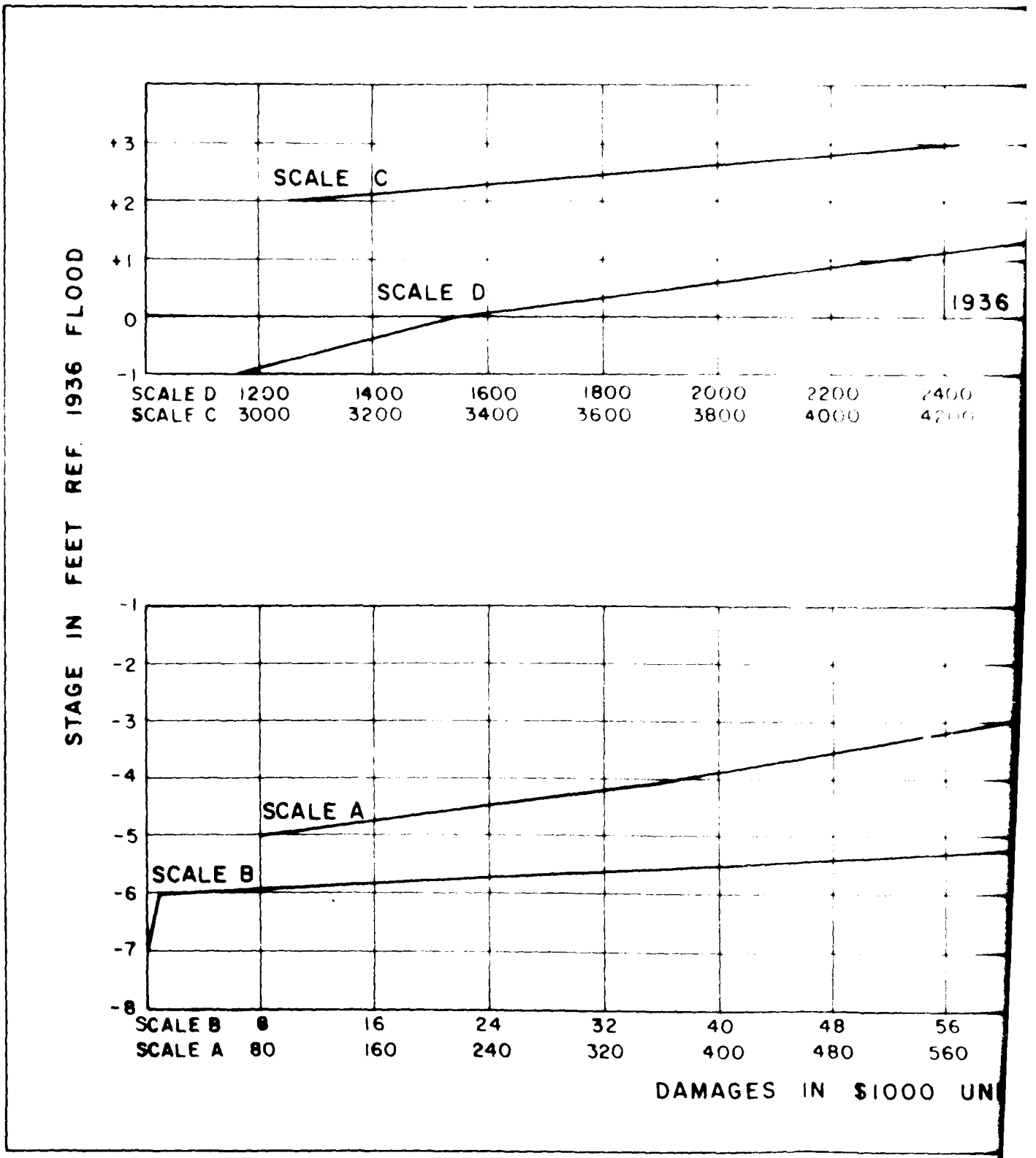

RANGE "A"
RANGE "B"
8'ΦTUNNEL
10'ΦTUNNEL
12'Φ TUNNEL
NATURAL
DAMAGES IN $1000 UNITS
PERCENT CHANCE OF OCCURRENCE PER SIN
1800
1600
1400
1200
1000
800
600
400
200
2000
280
240
200
160
120
80
40
0
0.4
0.8
1.0
2.0
3.0
4.0
5.0
10.0
AREA
NATURAL 26.38
8' Φ TUNNEL 15.23
10' Φ TUNNEL 2.75
12' Φ TUNNEL .08

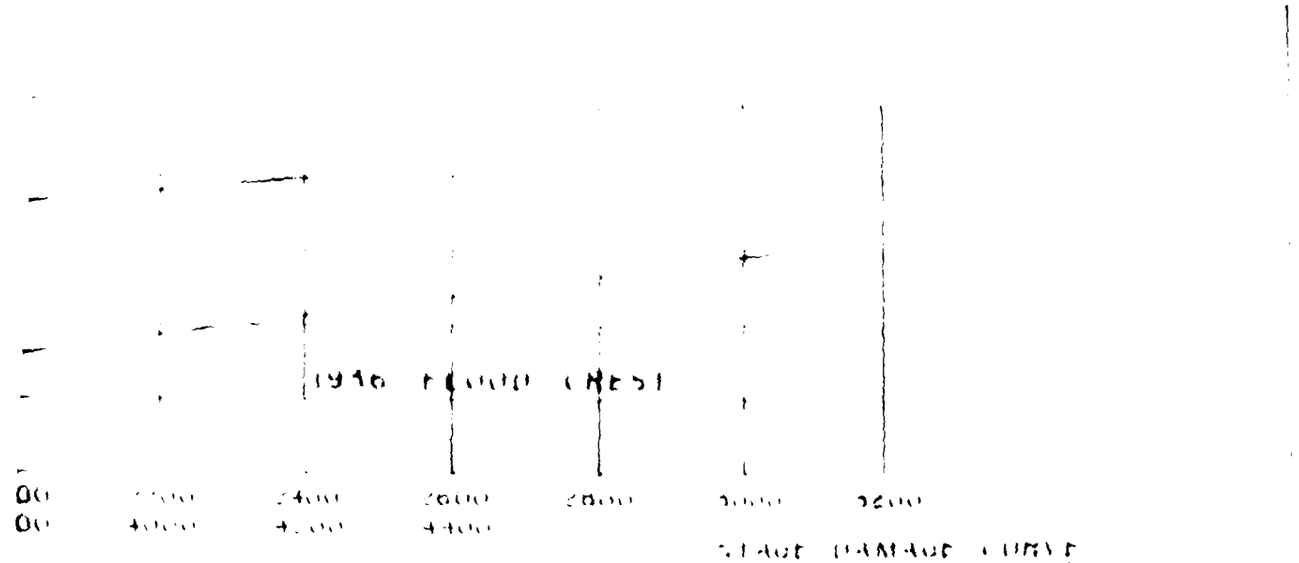
	RANGE "A" 1" = $ 800			RANGE "B" 1" = $ 2000			RANGE "C" 1" = $ 4000			AVERAGE ANNUAL	
	AREA	LOSS	BEN	AREA	LOSS	BEN	AREA	LOSS	BEN	LOSSES	BENEFITS
NATURAL	26.38	21104	—	14.62	29240	—	5.6	22400	—	$ 72744	—
8' Φ TUNNEL	15.23	12184	8920	.57	1140	28100	0	0	22400	$ 13324	$ 59420
10' Φ TUNNEL	2.75	2200	18904	.02	40	29200	0	0	22400	$ 2240	$ 70504
12' Φ TUNNEL	.08	64	21040	0	0	29240	0	0	22400	$ 64	$ 72680



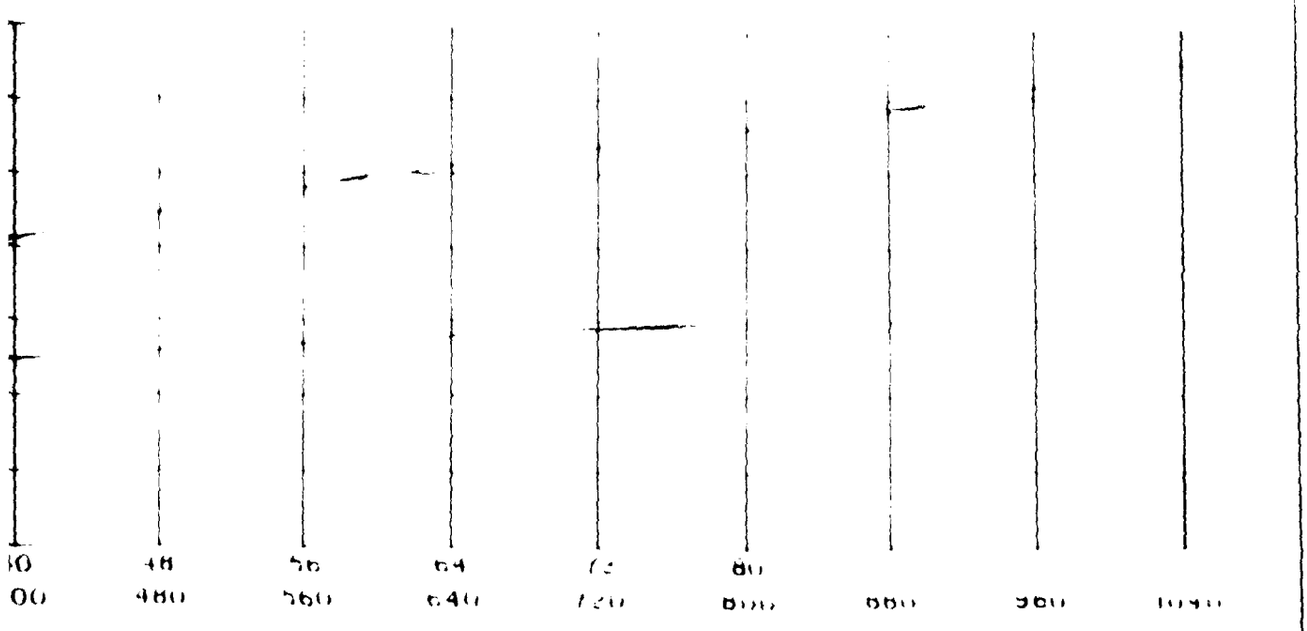
DAMAGE-FREQUENCY CURVE
MONOOSNOC BROOK, LEOMINSTER, MASS.
AREA 1 (Cotton Street to Pond Street)
1977 STUDY
1974 CONDITIONS
1974 PRICE LEVEL

PLATE H-5


STAGE IN FEET REF. 1936 FLOOD
+3
+2
+1
0
-1
SCALE C
SCALE D
1936
SCALE D 1200 1400 1600 1800 2000 2200 2400
SCALE C 3000 3200 3400 3600 3800 4000 4200
-1
-2
-3
-4
-5
-6
-7
-8
SCALE A
SCALE B
SCALE B 0 16 24 32 40 48 56
SCALE A 80 160 240 320 400 480 560
DAMAGES IN $1000 UN

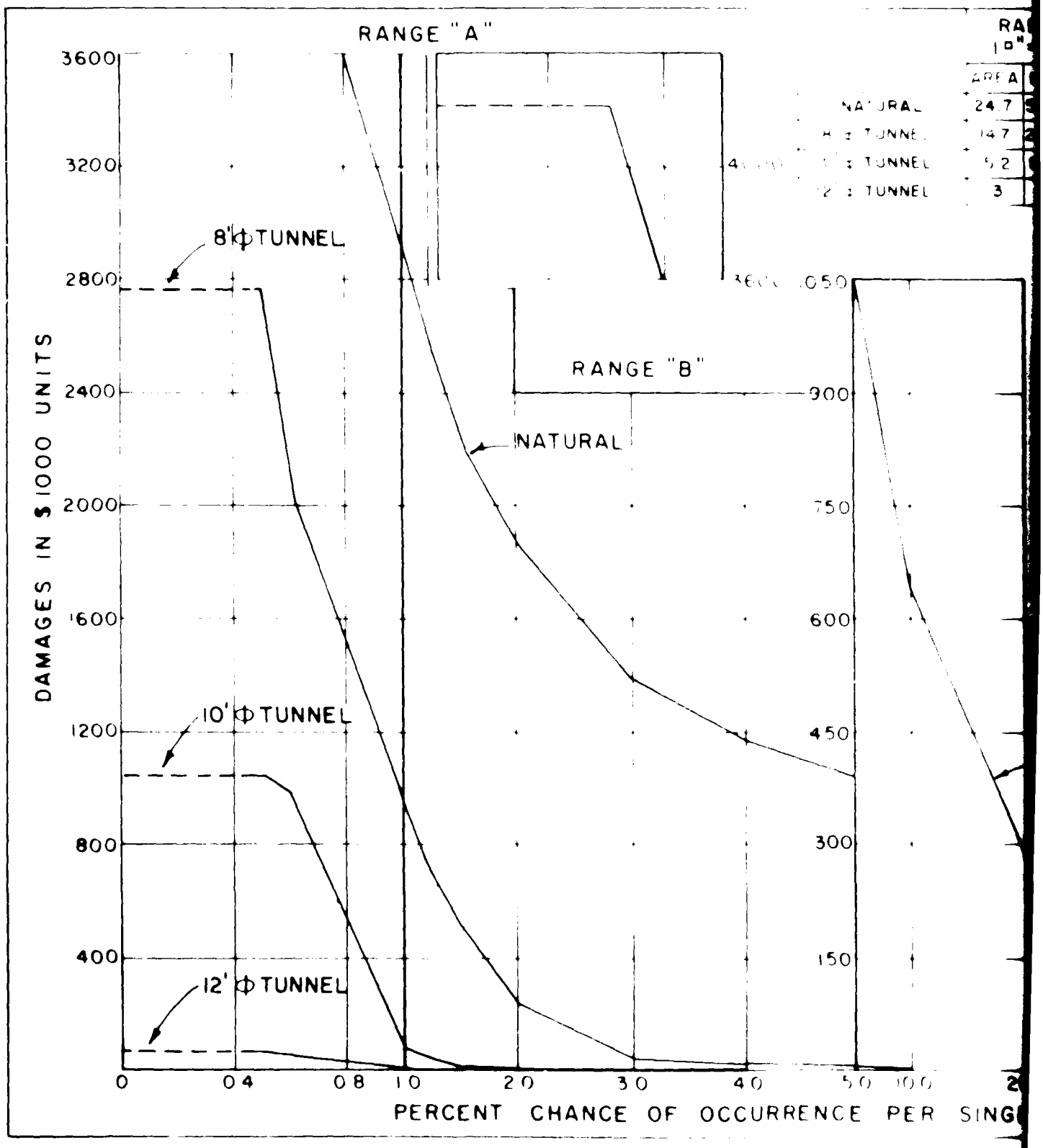


STAGE DAMAGE CURVE
MONOPOSNOT BROOK, LEOMINSTER, MASS
AREA
1974 CONDITIONS
1974 PRICE LEVEL

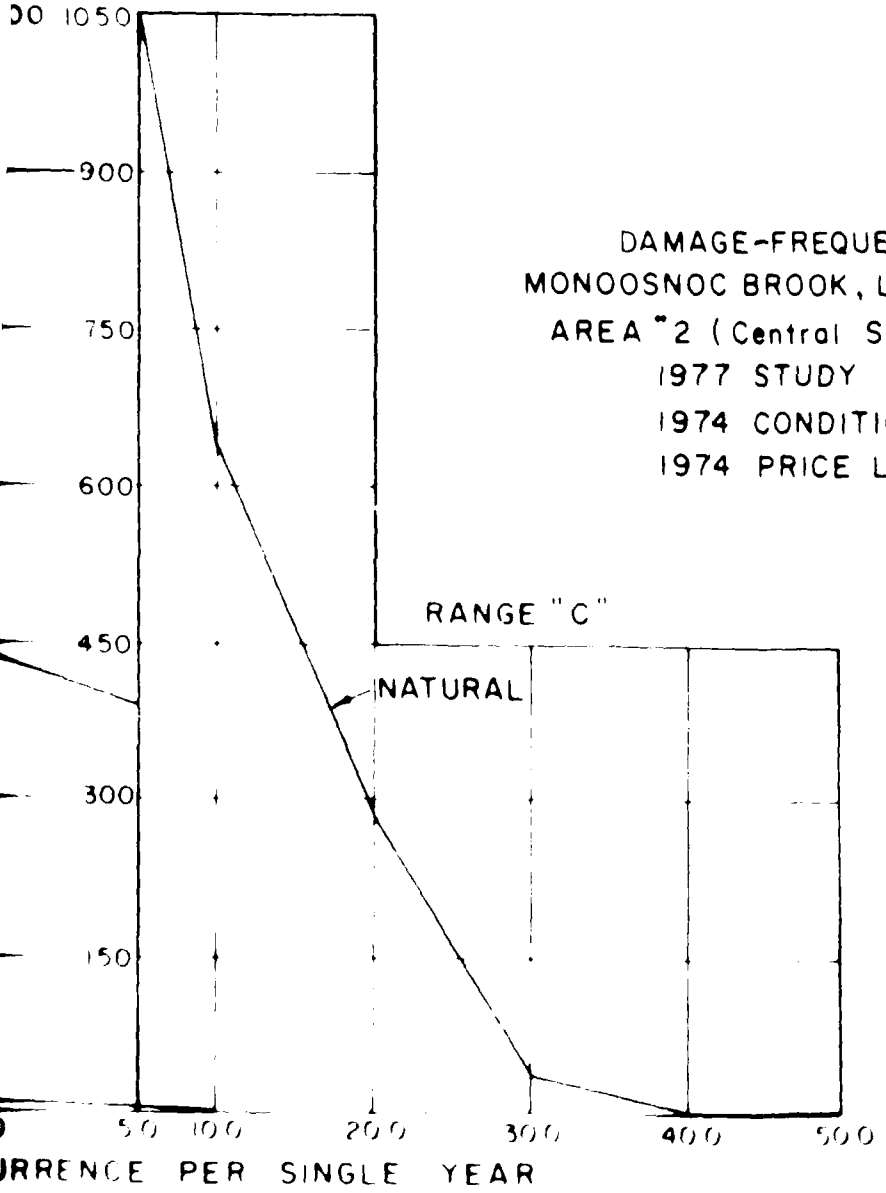


AGES IN $1000 UNITS

PLATE II 6

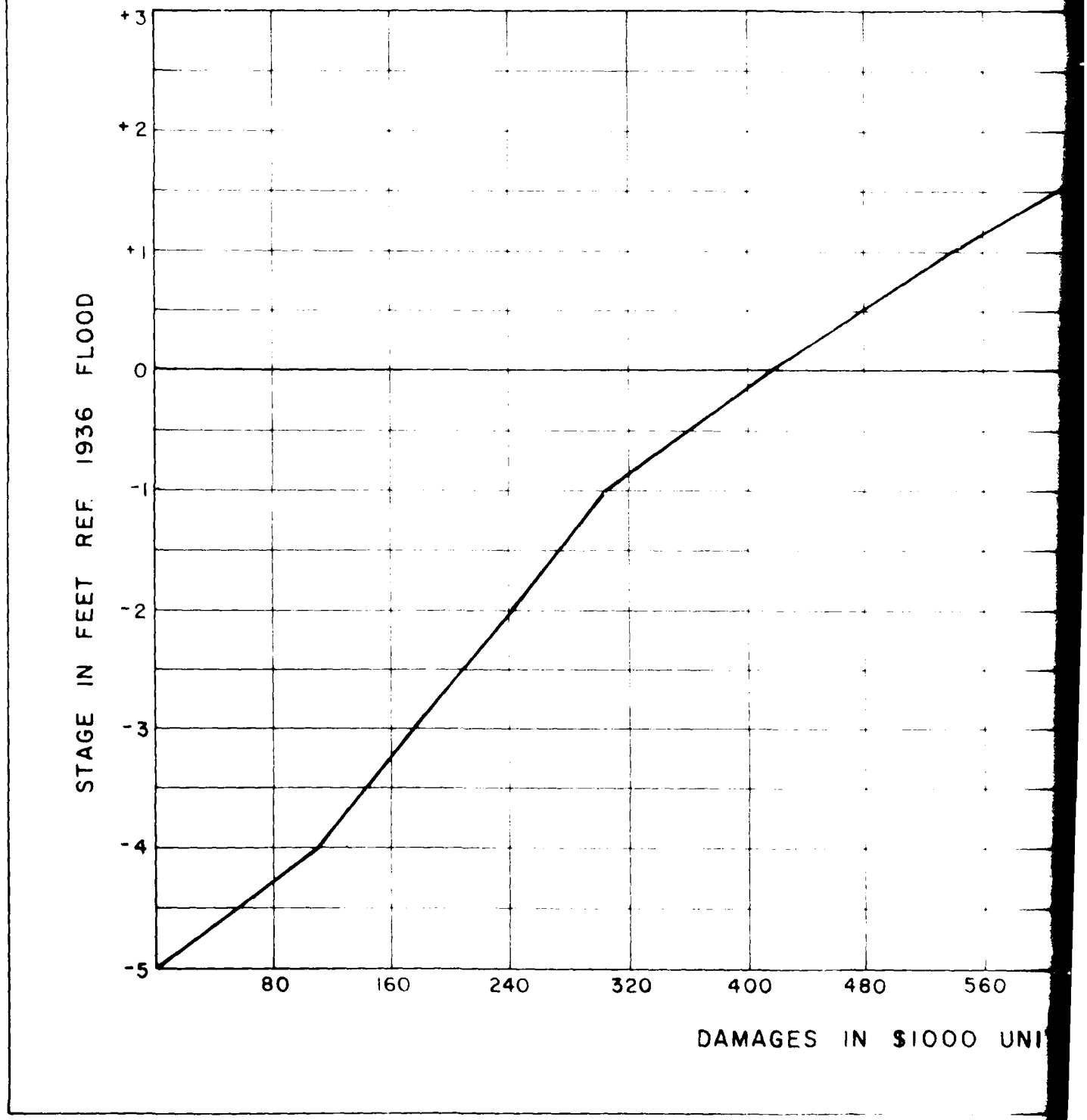

RANGE "A"
RANGE "B"
DAMAGES IN $1000 UNITS
PERCENT CHANCE OF OCCURRENCE PER SING
3600
3200
2800
2400
2000
1600
1200
800
400
900
750
600
450
300
150
0
04
08
10
20
30
40
50
8' Φ TUNNEL
10' Φ TUNNEL
12' Φ TUNNEL
NATURAL

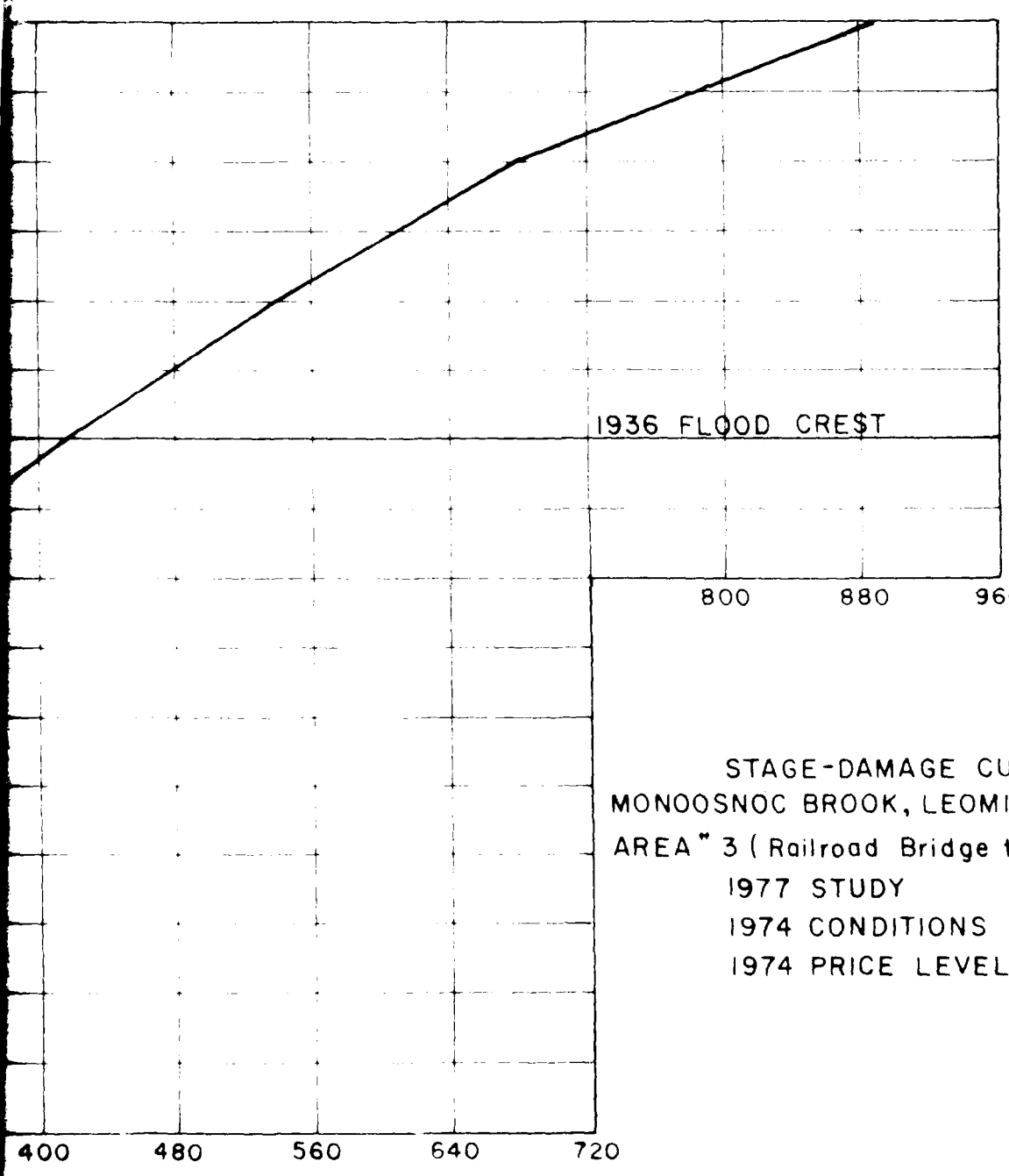
	RANGE "A" 1" = $1600			RANGE "B" 1" = $4000			RANGE "C" 1" = $15000			AVERAGE ANNUAL	
	AREA	LOSS	BEN	AREA	LOSS	BEN	AREA	LOSS	BEN	LOSSES	BENEFITS
NATURAL	24.7	59520	—	15.2	62400	—	7.0	105000	—	$ 206920	—
8 ± TUNNEL	14.7	23620	16000	1.2	4800	57600	.01	150	104850	$ 28470	$ 178450
0 ± TUNNEL	5.2	8320	31200	.07	280	62120	0	0	105000	$ 860	$ 198320
2 ± TUNNEL	3	480	39240	.02	80	62320	0	0	105000	$ 560	$ 206360



DAMAGE-FREQUENCY CURVE
MONOOSNOC BROOK, LEOMINSTER, MASS.
AREA "2 (Central St. to Cotton St.)
1977 STUDY
1974 CONDITIONS
1974 PRICE LEVEL

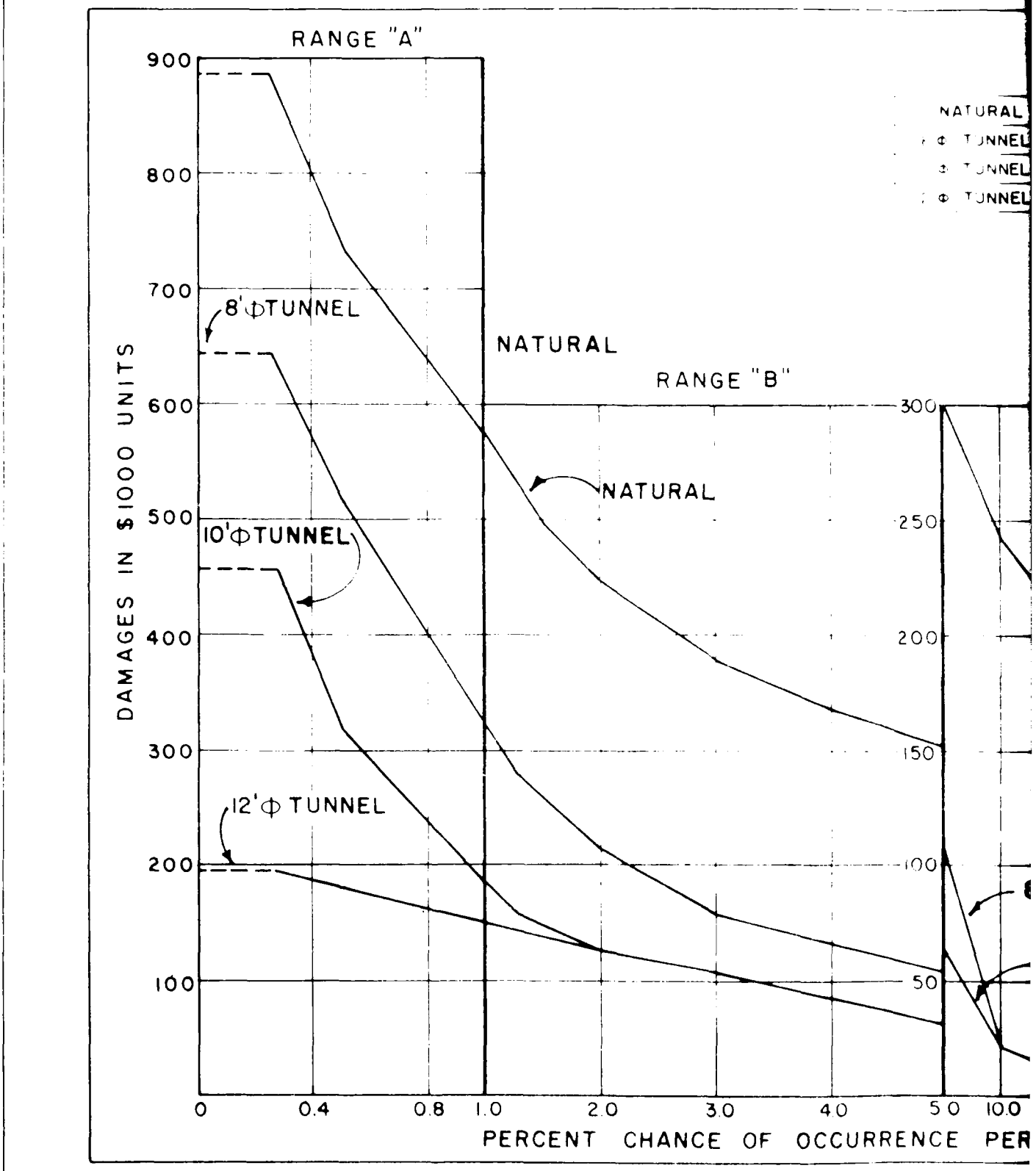
PLATE H-7


+3
+2
+1
0
-1
-2
-3
-4
-5
STAGE IN FEET REF. 1936 FLOOD
80
160
240
320
400
480
560
DAMAGES IN $1000 UNI



STAGE-DAMAGE CURVE
MONOOSNOC BROOK, LEOMINSTER, MASS.
AREA " 3 (Railroad Bridge to Central St.)
1977 STUDY
1974 CONDITIONS
1974 PRICE LEVEL

PLATE H-8


RANGE "A"
RANGE "B"
NATURAL
8'ΦTUNNEL
10'ΦTUNNEL
12'Φ TUNNEL
NATURAL
NATURAL
DAMAGES IN $1000 UNITS
900
800
700
600
500
400
300
200
100
300
250
200
150
100
50
0
0.4
0.8
1.0
2.0
3.0
4.0
5.0
10.0
PERCENT CHANCE OF OCCURRENCE PER

	RANGE "A" 1□" = $ 400			RANGE "B" 1□" = $ 1000			RANGE "C" 1□" = $ 5000			AVERAGE ANNUAL	
	AREA	LOSS	BEN	AREA	LOSS	BEN	AREA	LOSS	BEN	LOSSES	BENEFITS
NATURAL	18.9	7560	—	16.0	16000	—	15.0	75000	—	$ 98560	—
8'Φ TUNNEL	13.0	5440	2120	7.1	7100	8900	0.9	4500	70500	$ 17040	$ 81520
'Φ TUNNEL	8.5	3400	4160	4.4	4400	11600	0.6	3000	72000	$ 10800	$ 87760
2'Φ TUNNEL	4.5	1800	5760	4.2	4200	11800	0.6	3000	72000	$ 9000	$ 89560

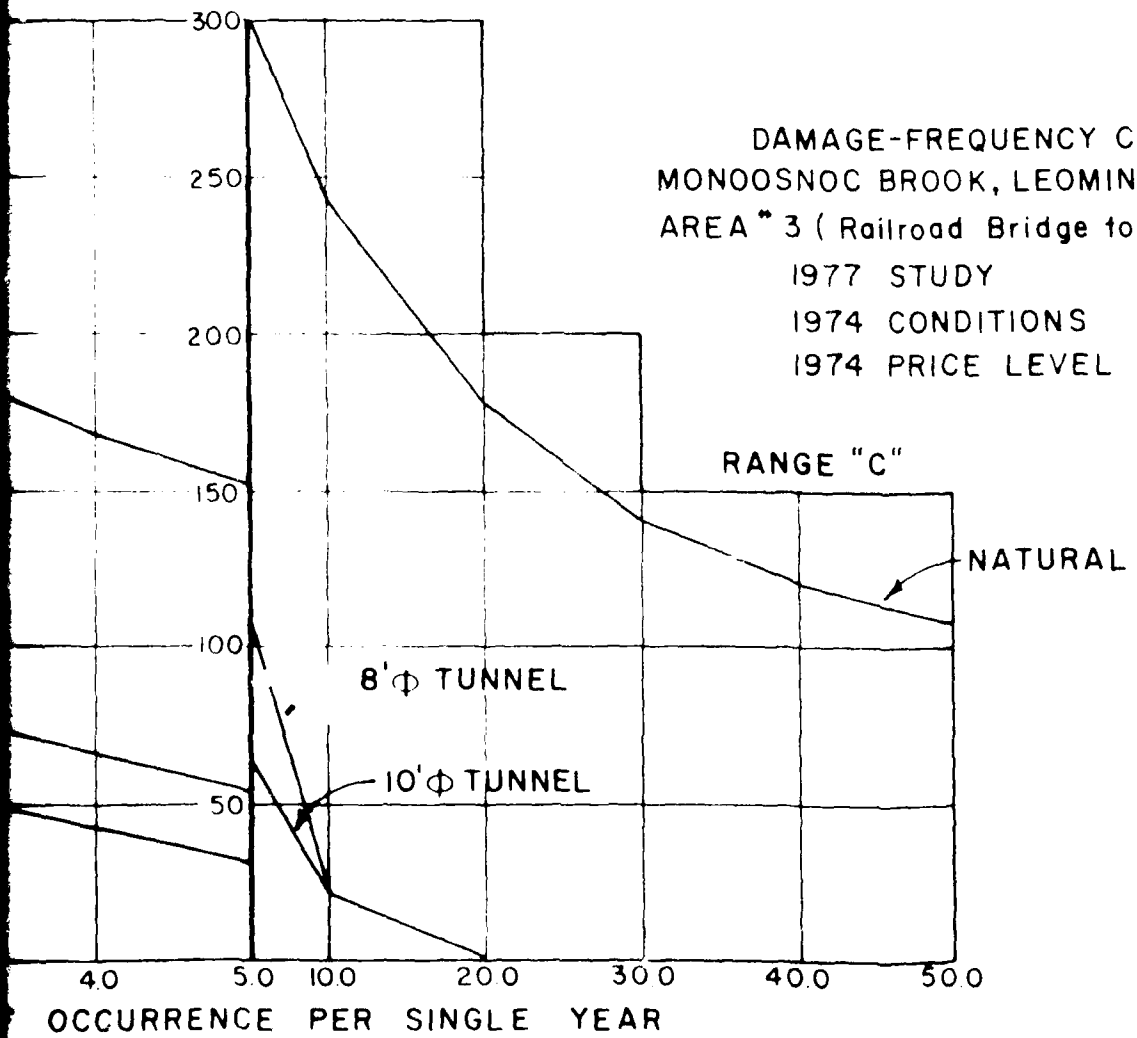
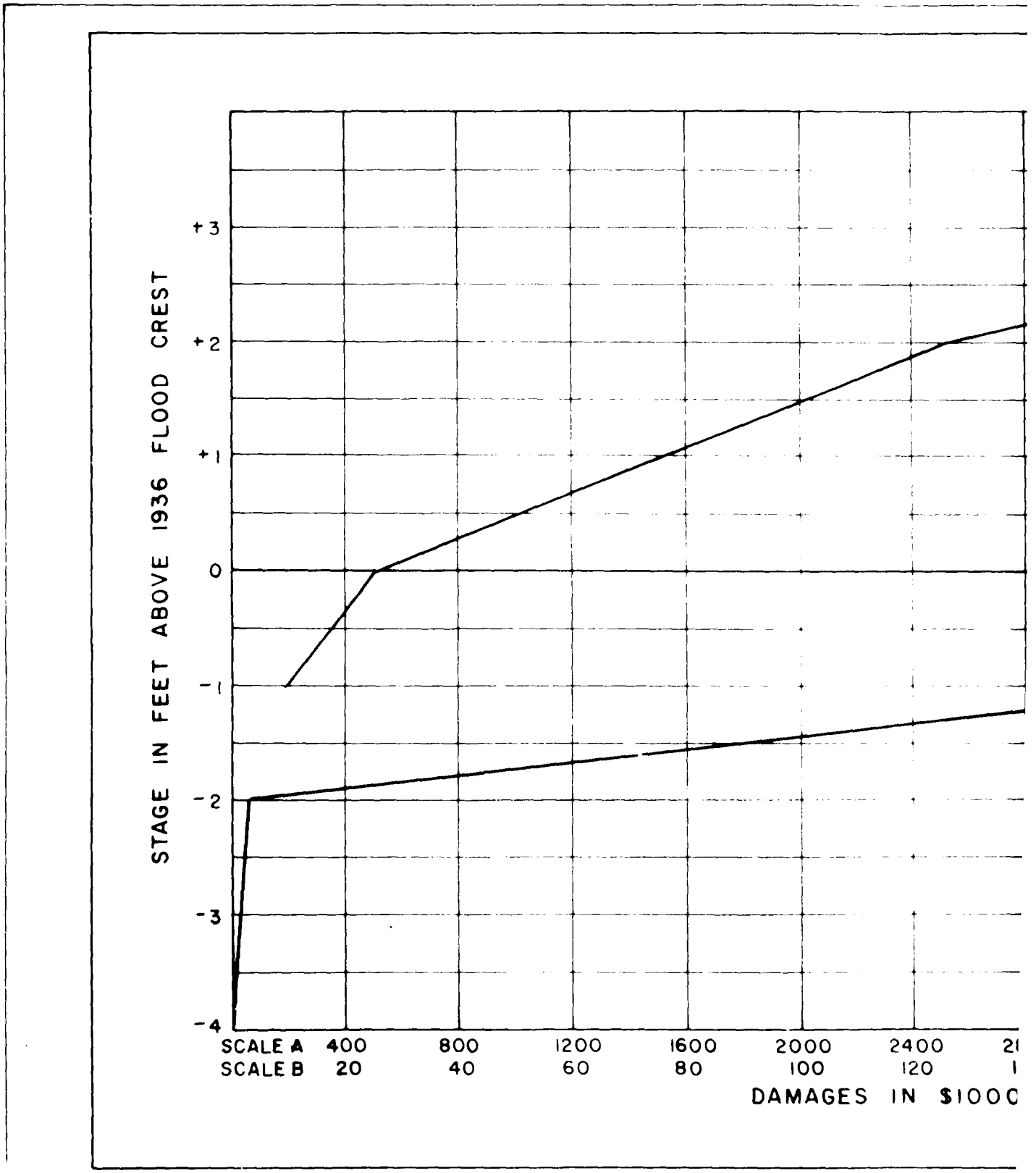
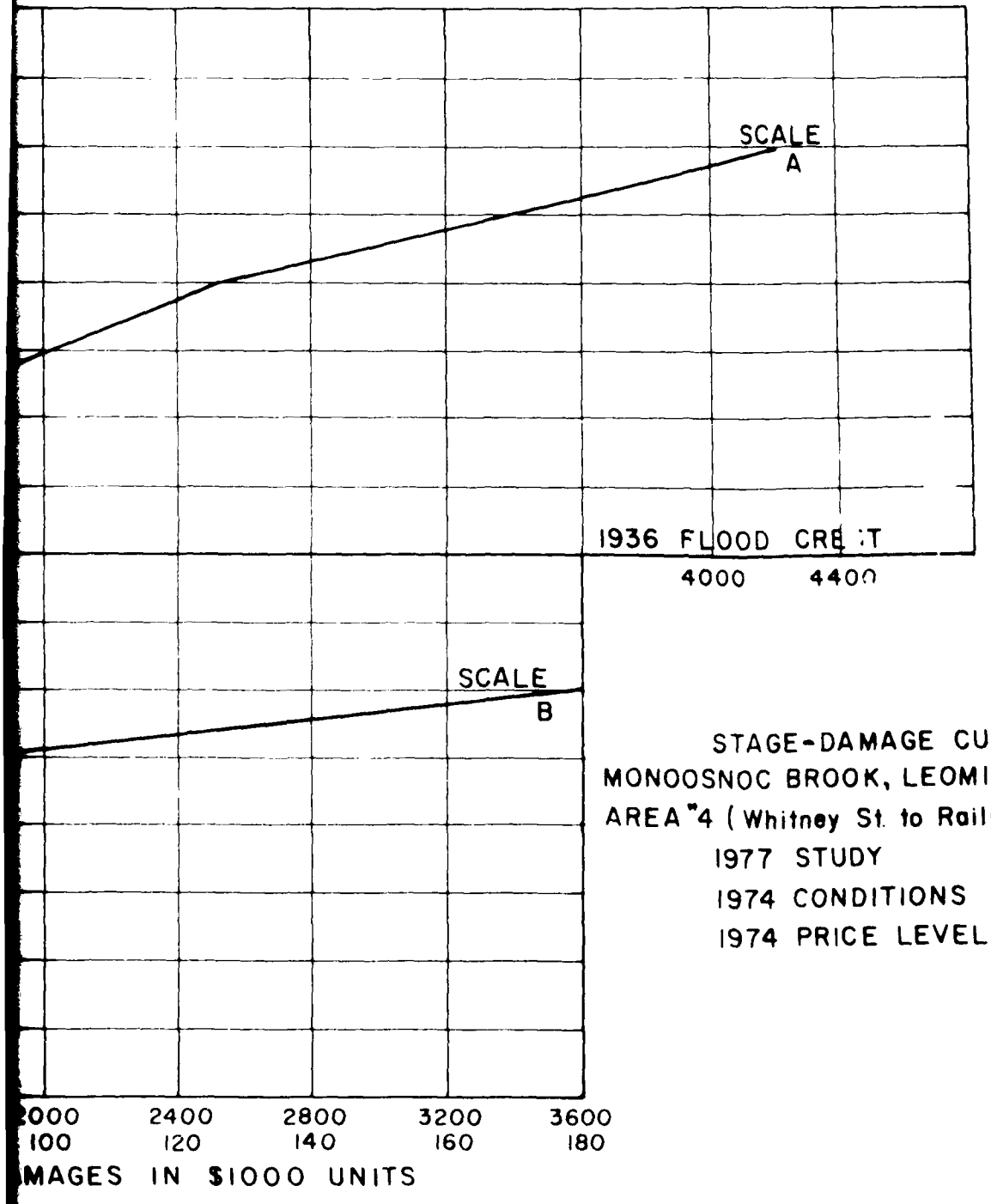


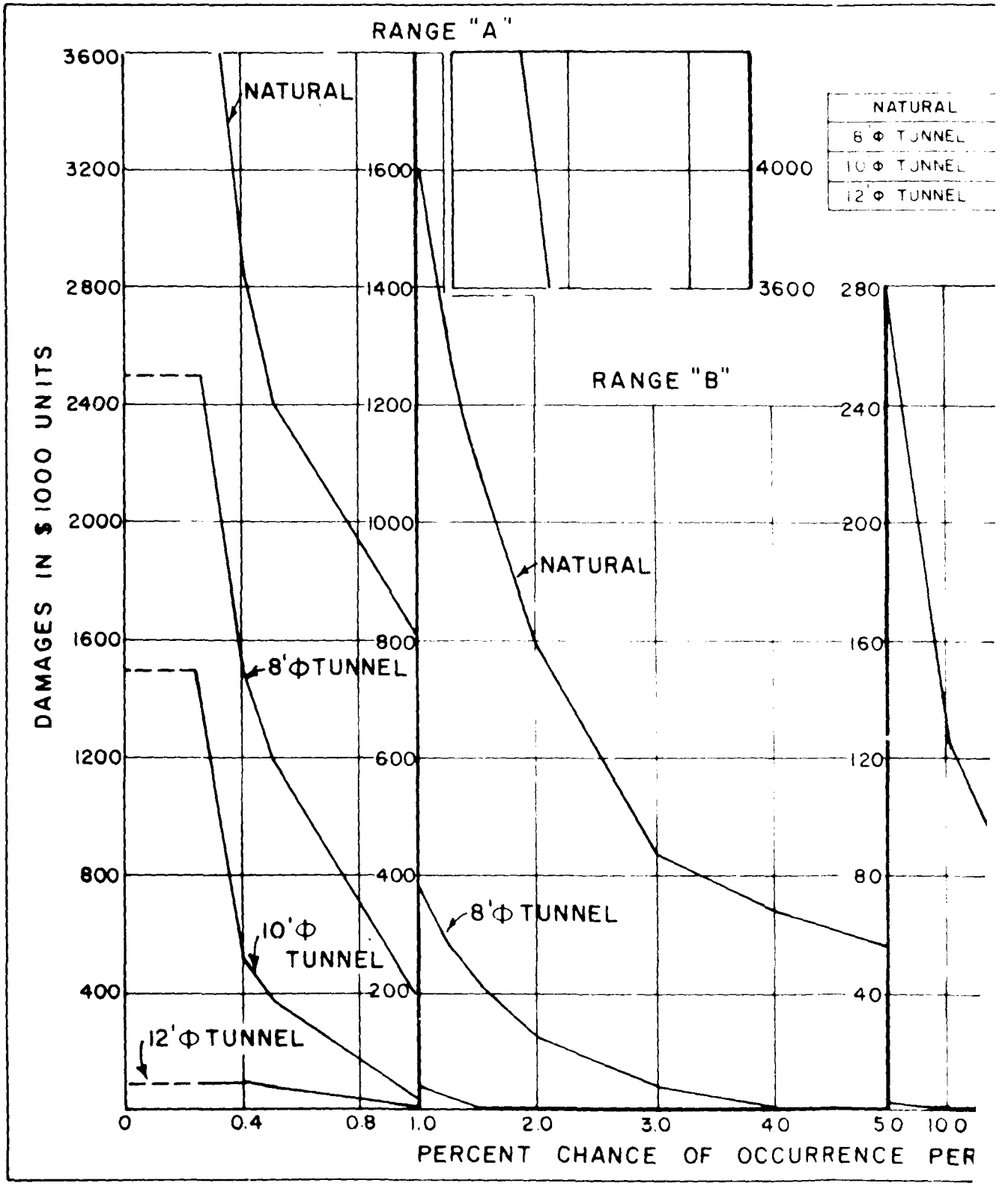
PLATE H-9


STAGE IN FEET ABOVE 1936 FLOOD CREST
+3
+2
+1
0
-1
-2
-3
-4
SCALE A 400 800 1200 1600 2000 2400
SCALE B 20 40 60 80 100 120
DAMAGES IN $1000

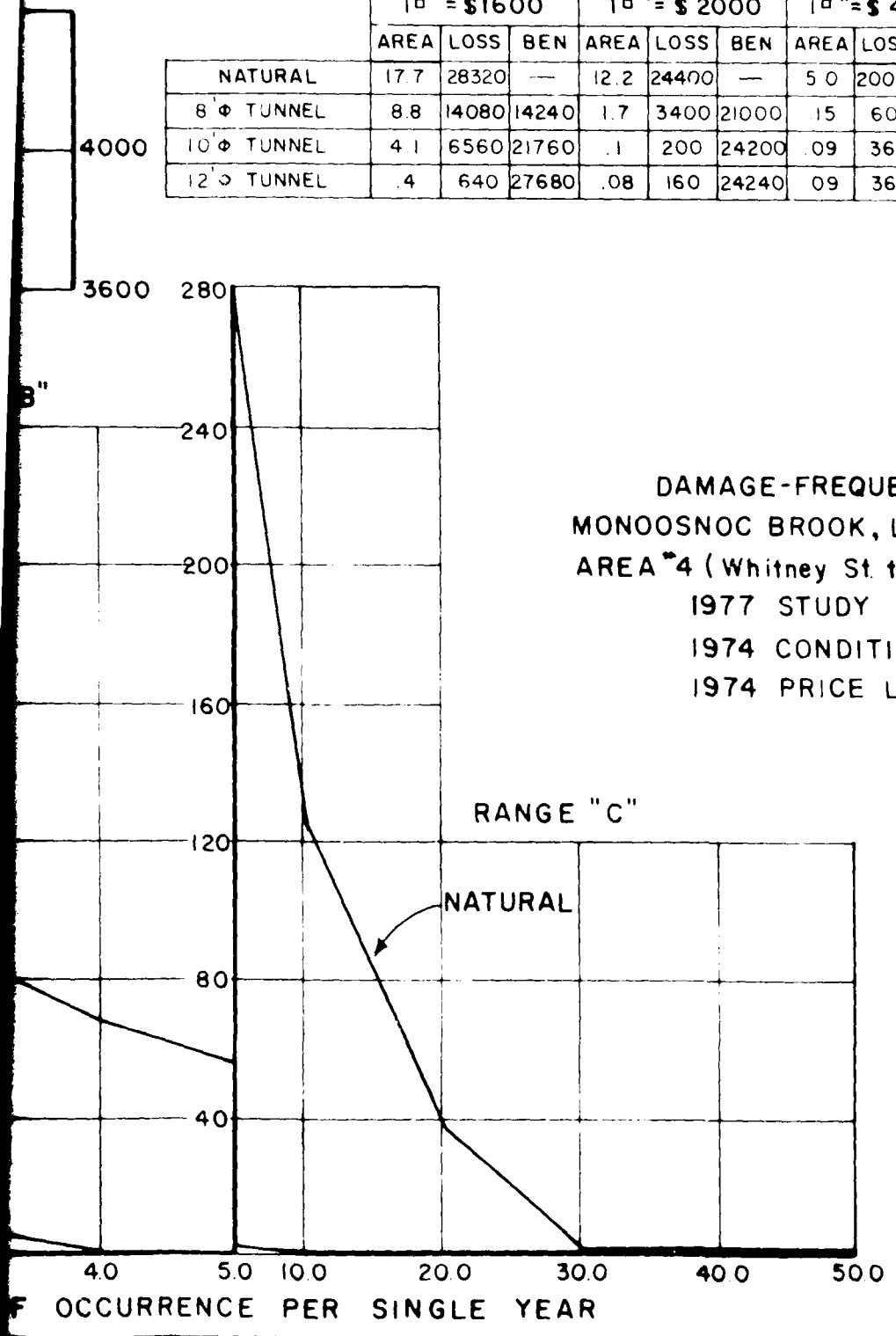


STAGE-DAMAGE CURVE
MONOOSNOC BROOK, LEOMINSTER, MASS.
AREA "4 (Whitney St. to Railroad Bridge)
1977 STUDY
1974 CONDITIONS
1974 PRICE LEVEL

PLATE H-10

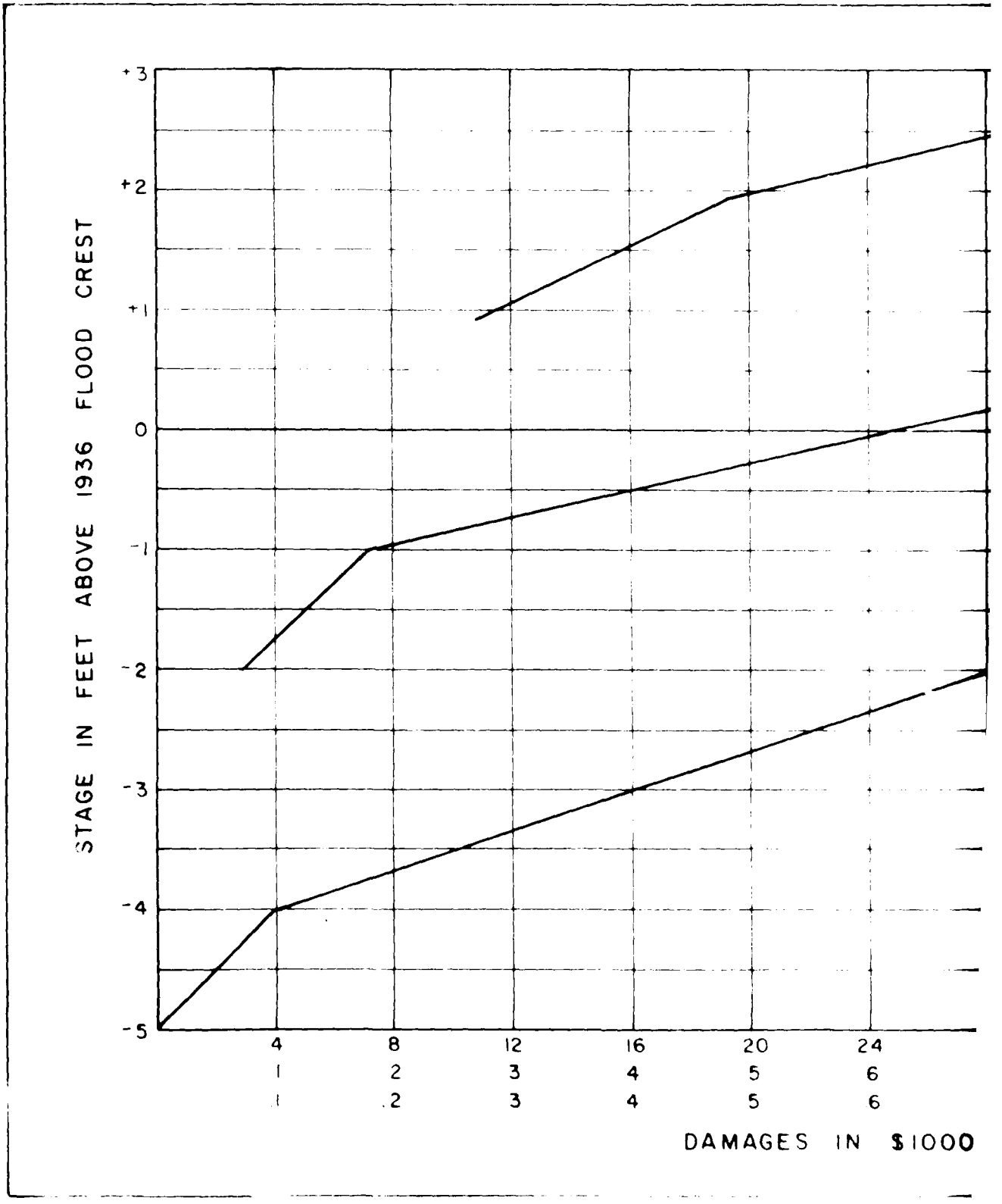

RANGE "A"
RANGE "B"
NATURAL
8 Φ TUNNEL
10 Φ TUNNEL
12 Φ TUNNEL
DAMAGES IN $1000 UNITS
PERCENT CHANCE OF OCCURRENCE PER
3600
3200
2800
2400
2000
1600
1200
800
400
4000
1600
1400
1200
1000
800
600
400
200
280
240
200
160
120
80
40
0
0.4
0.8
1.0
2.0
3.0
4.0
5.0
10.0
NATURAL
8'ΦTUNNEL
10'Φ TUNNEL
12'Φ TUNNEL
NATURAL
8'Φ TUNNEL

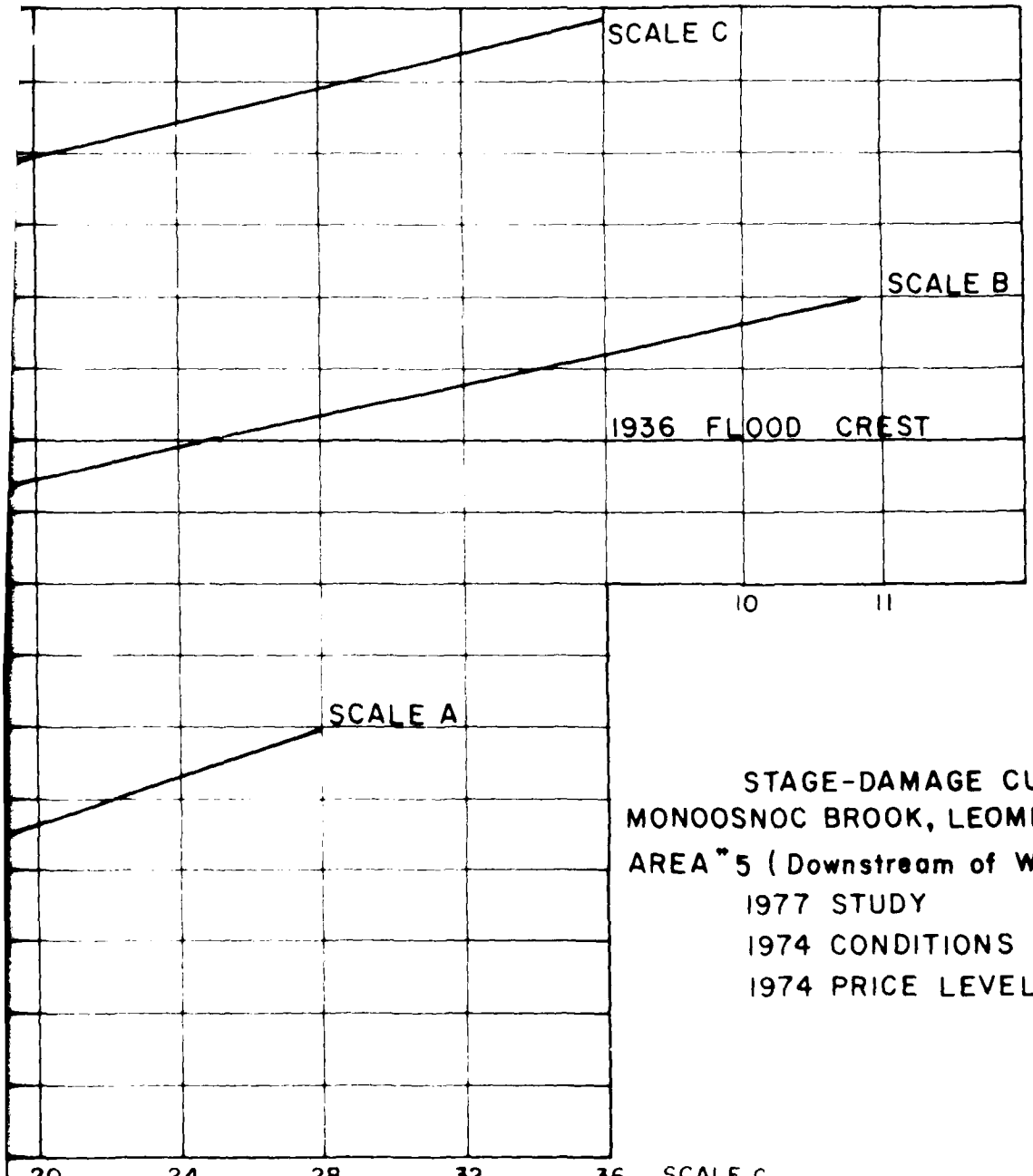
	RANGE "A" 1□"=$1600			RANGE "B" 1□"=$2000			RANGE "C" 1□"=$4000			AVERAGE ANNUAL	
	AREA	LOSS	BEN	AREA	LOSS	BEN	AREA	LOSS	BEN	LOSSES	BENEFITS
NATURAL	17.7	28320	—	12.2	24400	—	5.0	20000	—	$ 72720	—
8'Φ TUNNEL	8.8	14080	14240	1.7	3400	21000	.15	600	19400	$ 18080	$ 54640
10'Φ TUNNEL	4.1	6560	21760	.1	200	24200	.09	360	19640	$ 7120	$ 65600
12'Φ TUNNEL	.4	640	27680	.08	160	24240	.09	360	19640	$ 1160	$ 71560



DAMAGE-FREQUENCY CURVE
MONOOSNOC BROOK, LEOMINSTER, MASS.
AREA #4 (Whitney St. to Railroad Bridge)
1977 STUDY
1974 CONDITIONS
1974 PRICE LEVEL

PLATE H-11

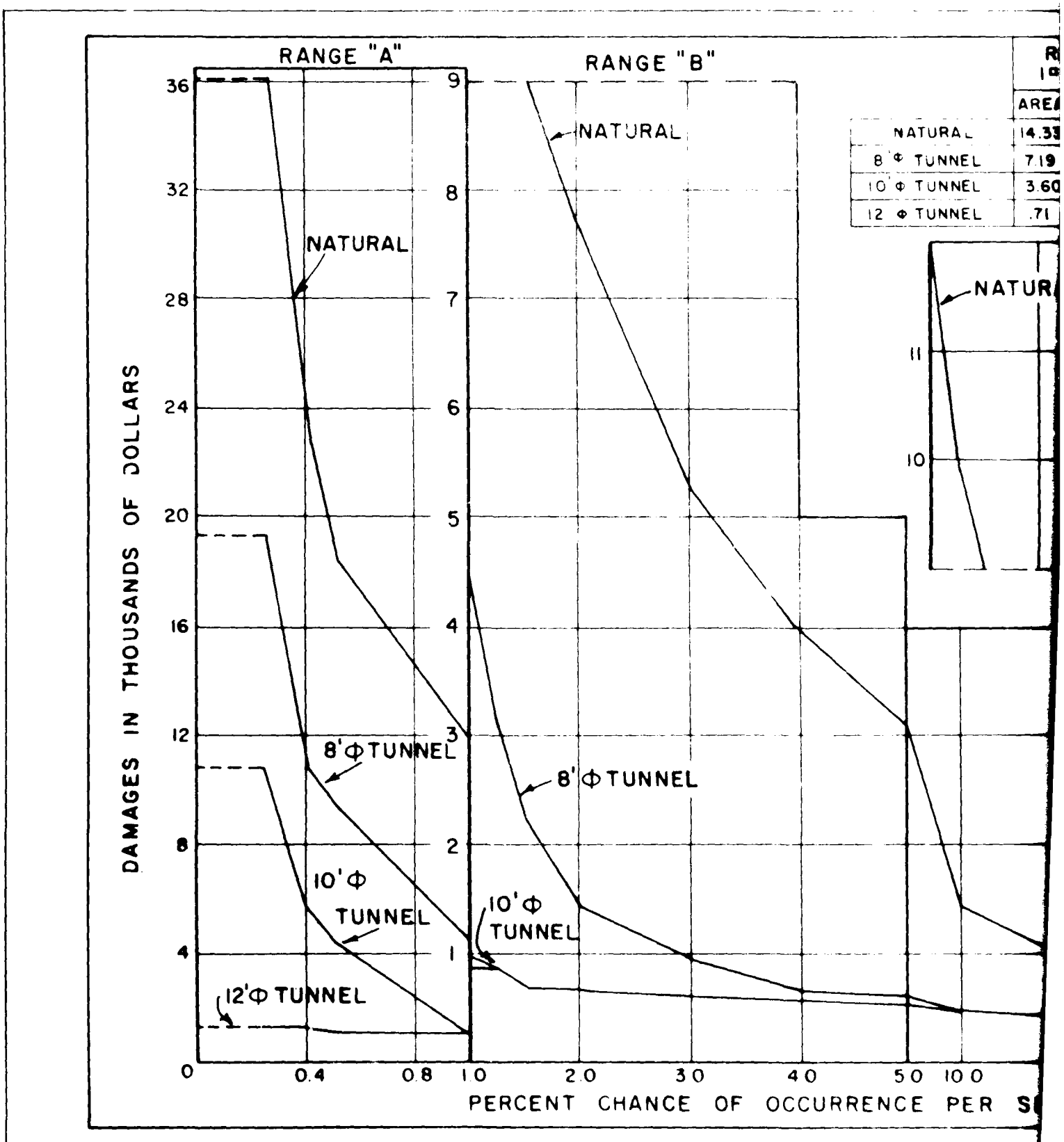

STAGE IN FEET ABOVE 1936 FLOOD CREST
+3
+2
+1
0
-1
-2
-3
-4
-5
4
8
12
16
20
24
1
2
3
4
5
6
1
.2
3
4
5
6
DAMAGES IN $1000



STAGE-DAMAGE CURVE
MONOOSNOC BROOK, LEOMINSTER, MASS.
AREA "5 (Downstream of Whitney Street)
1977 STUDY
1974 CONDITIONS
1974 PRICE LEVEL

MAGES IN $1000 UNITS

PLATE H-12


RANGE "A"
RANGE "B"
DAMAGES IN THOUSANDS OF DOLLARS
PERCENT CHANCE OF OCCURRENCE PER
NATURAL
8'Φ TUNNEL
10'Φ TUNNEL
12'Φ TUNNEL
36
32
28
24
20
16
12
8
4
0
9
8
7
6
5
4
3
2
1
0.4
0.8
1.0
2.0
3.0
4.0
5.0
10.0
11
10
NATURAL 14.33
8'Φ TUNNEL 7.19
10'Φ TUNNEL 3.60
12 Φ TUNNEL .71

	RANGE "A" 1" = $ 16			RANGE "B" 1" = $ 20			RANGE "C" 1" = $ 100			AVERAGE ANNUAL	
	AREA	LOSS	BEN	AREA	LOSS	BEN	AREA	LOSS	BEN	LOSSES	BENEFITS
NATURAL	14.33	229	—	24.77	489	—	4.66	466	—	$ 1184	—
8 Φ TUNNEL	7.19	115	114	5.22	104	385	1.94	194	272	$ 413	$ 771
10 Φ TUNNEL	3.60	58	171	2.75	55	434	1.92	192	274	$ 305	$ 879
12 Φ TUNNEL	.71	11	218	2.56	51	438	1.92	192	274	$ 254	$ 930

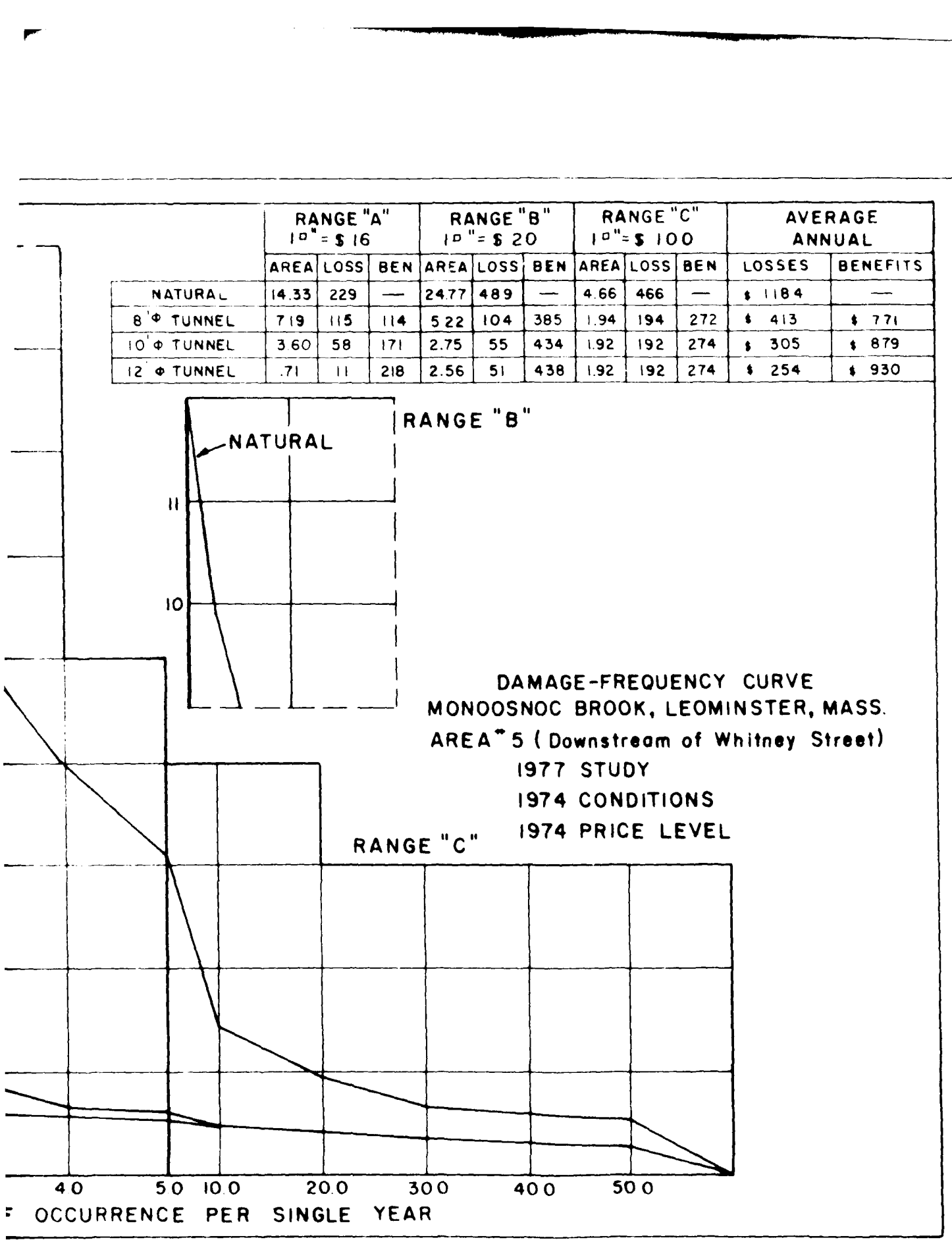
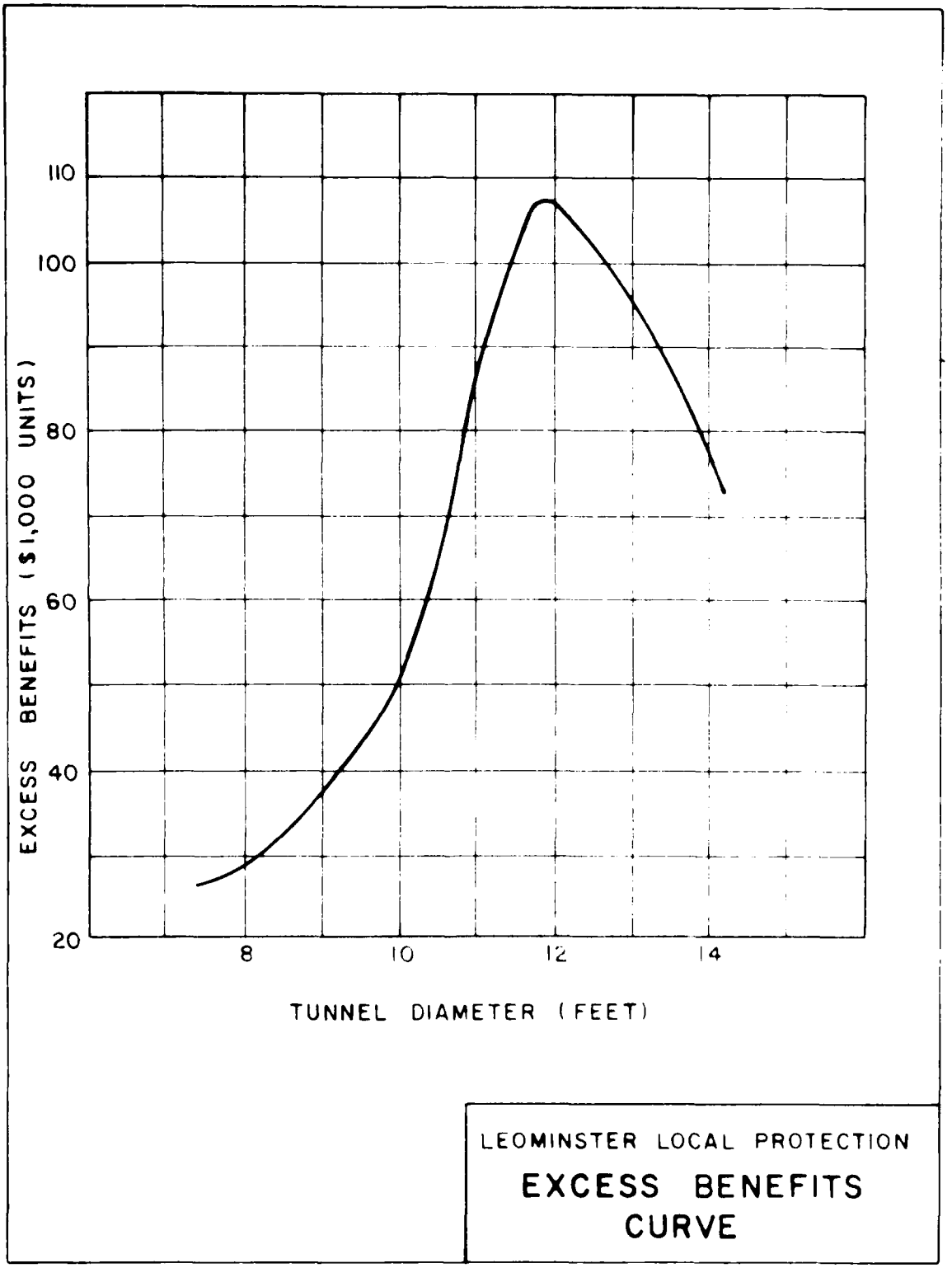


PLATE H-13



LEOMINSTER LOCAL PROTECTION

EXCESS BENEFITS CURVE

PLATE H-14

SECTION I

DIVISION OF PLAN RESPONSIBILITIES

DIVISION OF PLAN RESPONSIBILITIES

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SECTION I

DIVISION OF PLAN RESPONSIBILITIES

This section presents pertinent information regarding cost apportionment between Federal and non-Federal interests for the proposed plan. The apportionment is based on federal legislation and administrative policies governing local flood control projects. Although nonstructural measures such as floodproofing of individual structures, zoning and building codes are not requirements of the recommended plan, local interests should consider and adopt such nonstructural measures as necessary. The responsibility for implementing nonstructural measures is non-Federal, although technical advice can be furnished. The basis for apportioning the costs for the project is described in the following paragraphs.

Cost Apportionment

Sharing of costs between Federal and non-Federal interests for the diversion tunnel protection project is based on the requirements established as Federal policy for "local protection" improvement.

Under this policy, the Federal government would be responsible for all flood control construction costs. Non-Federal interests would be required to furnish all lands and rights-of-way and damages, including relocations, required by the plan. Non-Federal interests would also bear the cost of operating and maintaining project features after construction in accordance with Federal requirements. Total project costs for the recommended diversion tunnel project are estimated at $7,640,000.

Federal Responsibilities

The presently estimated federal share of the total first costs of the recommended combined project is $7,130,000.

The Federal Government would design and prepare detailed plans and construct the project following Congressional authorization and funding and after receipt of the non-Federal share of the cost.

Non-Federal Responsibilities

The currently estimated non-Federal share of the total first costs of the diversion tunnel project is $520,000. In addition, the non-Federal interests would maintain the project at an estimated average annual cost of $1,700.

Letters of assurance have been received from the Commonwealth of Massachusetts and the city of Leominster indicating their willingness and ability to participate in the project and to fulfill the conditions of local cooperation.

The requirements of local cooperation follow:

a. Provide without cost to the United States all land, easements and rights-of-way necessary for the construction and maintenance of the project.

b. Hold and save the United States free from damages due to construction works except damages due to the fault or negligence of the United States or its contractors.

c. Maintain and operate all works after completion in accordance with regulations prescribed by the Secretary of the Army.

d. Provide without cost to the United States all alterations and replacements of existing utilities.

e. Prescribe and enforce regulations to prevent encroachment on both the improved and unimproved channels, and manage all project-related channels to preserve capacities for local drainage as well as for project functions.

f. Comply with the provisions under Sections 210 and 305 of Public Law 91-646, 91st Congress, approved 2 January 1971, entitled: "Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970."

Item "e" above covers not only the taking of easements around Rockwell Pond, as described in Appendix 1, Section E, "Real Estate Studies," but also the enforcement of codes which will insure that the existing channel, downstream from Rockwell Pond, passes a design flood discharge of between 600 and 800 cfs without restriction.

LEOMINSTER LOCAL PROTECTION
MONOOSNOC BROOK
LEOMINSTER, MASSACHUSETTS

FEASIBILITY REPORT FOR
WATER RESOURCES DEVELOPMENT

Pertinent Correspondence

APPENDIX 2

PREPARED BY THE
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

TABLE OF CONTENTS

The Commonwealth of Massachusetts

EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGR.
DIVISION OF WATERWAYS

100 Nashua Street, Boston 02114

January 13, 1976

John H. Mason, Colonel
Division Engineer
Department of the Army
New England Division, Corps of Engineers
424 Trapelo Rd.
Waltham, Massachusetts 02154

Dear Colonel Mason:

I am in receipt of your correspondence dated December 22, 1975 addressed to Governor Michael S. Dukakis informing him of the favorable results progressing from the investigation for local flood protection along Monoosnoc Brook in Leominster, Massachusetts.

We have reviewed the scope of the proposed construction activity and concur with the concept.

Please be advised that we desire to be recorded in favor of the project at the public meeting on January 27, 1976, and additionally offer whatever assistance is necessary to provide State assistance.

Should I be of further assistance, please call me in Boston at 727-2690.

Very truly yours,

DAVID STANDLEY
Commissioner

DS:jmp
cc: Governor Michael S. Dukakis

Exhibit No. 1

EVELYN F. MURPHY
SECRETARY

Executive Office of Environmental Affairs
100 Cambridge Street
Boston, Massachusetts 02202

April 15, 1977

Mr. Joseph L. Ignazio
Chief, Planning Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham
Mass. 02154

Dear Mr. Ignazio:

Thank you for sending this office a copy of the Draft Environmental Statement for the Leominster Local Protection Project. The following comments refer to that report.

1. On p.2-4, the present channel capacity of the brook is given as 800cfs. There is no indication of what the channel capacity was at the time of the 1936 flood. More to the point, there is no indication as to whether the 800cfs capacity refers to the channel in its present debris-choked state, or in its proposed cleared-out state. If the 800cfs refers to the former condition, how would a brook cleaning affect the channel capacity?

2. It is stated on p.4-1 that up to 75% of the labor force employed on the project might be drawn from the local area. Given that most of the project will involve shaft and tunnel construction requiring relatively specialized skills, is this a reasonable figure?

3. The EIS should describe in more detail the plans for construction debris disposal (p.4-2). It should discuss how and where both cleared debris and excavated rock will be disposed of in an environmentally sensitive manner.

4. The discussion of the DO characteristics of water trapped in the tunnel between diversions (p.4-2) is cursory and very unsatisfactory. Aside from its apparent experimental errors, the approach described in the appendix is oversimplified and does not consider such conditions as the high BOD and COD of urban runoff; the oxygen demand of decaying organic matter, such as leaves, which may be left in the tunnel between storms; and a series of storms large enough to produce flow into the tunnel, but not large enough to flush out the tunnel completely. Many towns in Massachusetts have experienced pollution problems from unmaintained catch basins, and the proposed tunnel represents the same problem magnified enormously. Much more thought and study should be given to the biological and chemical impacts of the tunnel on downstream waters.

5. This office is expecting to review a plan for the proposed expansion of the Fearstown shopping center in the near future; this plan includes the relocation

and diking of the lower end of Monoosnoc Brook. Would this activity, in conjunction with the Corps' proposed project, lead to more serious downstream flooding problems than described on p.4-3?

6. "Safety factors" are listed as a long-term impact on p.5-2. What kinds of safety precautions will be taken to prevent injuries related to the intake and discharge structures?

7. According to the February 1977 Nashua River Watershed Association newsletter, there are firm plans for a city mini-park along Monoosnoc Brook. Any impacts the proposed project would have on this site should be described in the EIS.

8. The benefit/cost ratio of this project should be stated and explained in the EIS.

9. Finally, a minor point: carbon monoxide is not the same as TSP (total suspended particulates) as implied on p.2-3.

Yours truly,

Evelyn F. Murphy
Secretary

EFM/LF

Commonwealth of Massachusetts Office of the Secretary
Massachusetts Historical Commission
294 Washington St, Boston, Massachusetts 02108 (617) 727-8470

December 11, 1975

Mr. Joseph L.Ignazio
Chief, Planning Division
N.E.Div. Corps of Engineers
424 Trapelo Road
Waltham, Ma. 02154

Dear Mr. Ignazio :-

I have your letter of December 8 in regard to the Monoosnoc Brook project. I have compared the map with the archaeological survey and find that there are no known archaeological sites in the area.

As the tunnel route lies through previously disturbed areas I would also have the opinion that any sites which may have been in the project area have lomg ago been destroyed by construction.

It follows that the projected work will not result in any archaeological impact.

very truly yours
Maurice Robbins
State Archaeologist

MR/clr

Exhibit No. 3

The Commonwealth of Massachusetts
Executive Office of Transportation and Construction
Department of Public Works
Office of the Commissioner
100 Nashua Street, Boston 02114

April 12, 1977

Mr. Joseph L. Ignazio, Chief Planner
Planning Division
Department of the Army Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Subject: Review of Draft EIS for Monoosnoc Brook, Leominster Local Protection Project

Dear Mr. Ignazio:

The Draft Environmental Statement for the "Leominster Local Protection Project, Monoosnoc Brook, Leominster, Massachusetts", which accompanied your letter of February 22, 1977 has been received by the Department of Public Works for review and comment.

The Statement has been reviewed by the Departments Environmental Section in Boston and District #3 Projects and Environmental Engineer in Worcester and there appears to be no conflict with any Department projects in the area.

Thank you for providing the opportunity to review this statement.

Very truly yours,

John J. Carroll
Commissioner

Exhibit No. 4

JOHN B. McLAUGHLIN
MAYOR

Leominster, Massachusetts 01453

Office of the Mayor

January 27, 1976

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

SUBJECT: PROPOSED TUNNEL UNDER LEOMINSTER TO CURB FLOODING ON MONOOSNOC BROOK

Gentlemen:

Since the 1936 flood, Monoosnoc Brook has been a problem to the downtown area. Because of the nature of this stream which originates at Rockwell Pond on Pond Street, it takes a meandering course through the downtown area of Leominster. At the present time due to federal regulations, we have 70 acres of residential, industrial and commercial properties which are in the designated flood zone.

By being designated as a flood zone, this involves the purchase of Federal Flood Insurance, and restrictions on any new construction or additions to buildings in such an area. So by its very inception, such a by-pass as a tunnel to divert any possibilities of a flood in this area certainly would be to the advantage of not only all the owners of this property, but to all of our citizens because of the impact it has on our tax rate.

Even though from all indications the idea is very feasible, I would hold off final judgment until all the information is in, and more specifically, what the cost would be to the City of Leominster. From my understanding this would involve the moving of utilities and any land acquisition costs.

At the present time this seems as though it would be very minimal but until actual costs are obtained, I would reserve judgment until a final decision as far as the City is concerned.

Looking ahead as far as the downtown area is concerned, we are all well aware that once I-190 is completed, which should be by the year 1979, that traffic which now moves through downtown Leominster on Route 12 would be diverted to the easterly side of Leominster. So in turn, with the completion of such a project as proposed by the Army Corps of Engineers and the completion of I-190, it could and should have a tremendous impact on the downtown area.

(continued)

I would hope that all of the input that is received by all of our citizens is carefully evaluated before a decision is reached pertaining to this project and I would like to take this opportunity to thank you and the Corps for your outstanding work on this project.

Very truly yours,

John B. McLaughlin

John B. McLaughlin
Mayor

JBMCL/bd

AUDREY J. JOHNSON

OFFICE OF CITY CLERK
25 WEST STREET
LEOMINSTER, MASS. 01453

April 1, 1976

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Attention: Mr. Ciriello

Dear Mr. Ciriello:

By a vote of 8 - 1 by the Leominster City Council, it is the intent of the city to move forward to go along with the tunnel proposal from Rockwell Pond for a distance of 3,400 feet to an area near Whitney Street, and this also has been endorsed by Mayor John B. McLaughlin.

Sincerely,

Audrey J. Johnson

Audrey J. Johnson
City Clerk and Clerk of the City Council

DEPARTMENT OF PUBLIC WORKS

City of Leominster, Massachusetts 01453
109 GRAHAM STREET
AREA CODE (617) 537-8388

RAYMOND J. BENOIT
DIRECTOR

February 12, 1976

Mr. John H. Mason
Cononel Corps of Engineers
424 Tropeto Road
Waltham, Massachusetts 02154

Re: Review of Proposed Overflow Tunnel, Leominster, Mass.

Dear Sir:

The proposed tunnel is expected to be a significant improvement to the possible flooding conditions in the downtown area. This department is in full support of the project.

However, we are fearful of the structural stability of the two above ground sewer lines crossings that occur downstream of the proposed outlet to the tunnel. We hope that a relocation (possibly by means of an inverted siphon) be included in your final proposal.

The City presently has three below ground sewage pumping stations. They are all the Smith and Loveless package station. If, in order to empty the tunnel, a pumping station is required, the City will request the same type below ground station.

Very truly yours

Malcolm R. Fortune, Jr.
Engineering Department

MRF/b

Exhibit No

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
New England Field Office
P. O. Box 1518
55 Pleasant Street
Concord, NH 03301

December 21, 1976

Division Engineer
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Dear Sir:

This is our revised Conservation and Development Report on your flood control local protection project on Monoosnoc Brook at Leominster, Worcester County, Massachusetts. This project was planned under authority contained in the February 9, 1961 Resolution of the Senate Committee on Public Works, authorized by the Flood Control Act of 1966, P.L. 89-789, and restudied at the request of local officials.

This report is submitted in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), and supercedes our Conservation and Development Report of October 2, 1964.

We understand the proposed project calls for a subsurface diversion tunnel 3,400 feet long by 12 feet in diameter, from Rockwell Pond to just downstream of the Water Street Dam, in the City of Leominster. Other project features would consist of an inlet structure in the eastern corner of Rockwell Pond, and an outlet structure in a wooded lot adjacent to Monoosnoc Brook several hundred feet downstream of the Water Street Dam. Water will enter the tunnel inlet when flows out of Rockwell Pond exceed 70 cubic feet per second, with the tunnel capacity being 3,100 cubic feet per second. Tunnel use is expected to occur three to four times per year, and water remaining in the tunnel will not be pumped out, but flushed out with the next use.

No long term adverse effects at Rockwell Pond are expected to occur as a result of construction and operation of the project. Monoosnoc Brook is stressed by pollutants from industries in the project area, but sampling by the Massachusetts Division of Fisheries and Wildlife indicates a fairly diversified population of warmwater fish species, including the

white sucker, fallfish, pumkinseed, common shiner, yellow bullhead, blacknose dace, and largemouth bass. Benthic food organisms are also present.

The project as presently proposed seems to be a good solution to the flooding problem from a biological perspective, since no stream channelization is involved and other perturbations are minor. One concern we do raise is the quality of the water, stored in the tunnel between use, and its effects on Monoosnoc Brook after it is flushed out. Although preliminary studies on effects of water storage on dissolved oxygen (DO) concentrations have shown a minimum of 7 mg/l will remain in the water, these studies depend on several assumptions which may not always be true. Specifically, the assumption that water stored in the tunnel will have a low biological oxygen demand (BOD) may not always occur. It is possible that organic matter, sewage or other pollutants could enter the tunnel at the end of the high water event, thus adding to the BOD observed during the test, and lowering the DO level below minimum standards.

Since Monoosnoc Brook will be stressed in any event during flood flows, we do not feel tunnel pumpout devices are necessary. However, we do recommend that the tunnel outlet be designed to aerate the water as it is flushed out. This should provide reasonable assurance that oxygen deficient water is not returned to Monoosnoc Brook.

Sincerely yours,

Melvin R. Evans

Melvin R. Evans
Field Supervisor, NEAO

FSS/bmk:MRE

cc: RO, AEV

Planning Div

United States Department of the Interior

BUREAU OF MINES

4800 FORBES AVENUE

PITTSBURGH, PENNSYLVANIA 15213

LR 77/203

March 15, 1977

District Engineer
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Sir:

Re: Review of Draft Environmental Statement for Leominster Local Protection Project, Monoosnoc Brook, Worcester County, Massachusetts

The proposed action is the construction of a tunnel 3,200 feet long and 12 feet in diameter to by-pass flood waters around 70 acres of downtown Leominster. The Monoosnoc Brook channel would also be somewhat modified.

Construction of a tunnel of the dimensions proposed would produce about 20,000 cubic yards of excavated material taking into account the swell factor. About 10 percent of this material could be used for grading the Monoosnoc stream channel as part of the overall protection project. Plans for disposal of the rest of the material is left up to the contractor (p. 4-2).

Inadequate consideration is given to the disposal of this quantity of material and how it might effect local crushed stone producers. The proposed action will have no impact on other mineral resources.

Sincerely yours,

William Clarke
for Robert D. Thomson, Chief
Eastern Field Operations Center

Exhibit No. 9

United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VIRGINIA 22092

In Reply Refer To:
EGS-ER-77/203
Mail Stop 760

APR 13 1977

Mr. Joseph L. Ignazio
Chief, Planning Division
New England Division
Corps of Engineers
Department of the Army
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Ignazio:

We have reviewed the draft environmental statement for the Leominster project on Monoosnoc Brook, Worcester County, Massachusetts, as requested in your letter of February 22 to the Department of the Interior.

It would be useful if the statement would show the location of the wells used to supply the city in relation to the alignment of the tunnel. The aquifer(s) tapped by the wells should be indicated, especially if they penetrate bedrock. If the wells are in the vicinity of the tunnel site, evaluation of the potential for seepage from the tunnel, and/or perhaps the degree of treatment of the ground water would be appropriate.

Thank you for the opportunity to comment on the draft statement.

Sincerely yours,

Acting Director

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!

Exhibit No. 10

United States Department of the Interior

NATIONAL PARK SERVICE

NORTH ATLANTIC REGION
150 CAUSEWAY STREET
BOSTON, MA. 02114

L-7619-NAR-(PE)
ER-77/203

April 14, 1977

Colonel John P. Chandler
Division Engineer
Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Chandler:

Our Departmental Office of Environmental Project Review has asked us to comment directly to you upon our review of your draft environmental statement (February 1977) for a flood control project of Nonoshoc Brook in Leominster, Massachusetts.

We note on page 4-5 the commitment to a more in-depth archeological survey should the project be authorized. As our Department has reserved the right to comment upon review of the proposal by the Chief of Engineers at a later date, we suggest the commitment to further survey be sustained in the Chief's proposal or an adequate discussion of the outcome of the survey should it be accomplished for any reason prior to finalization of the Chief's proposal.

Sincerely yours,

L. J. Hovig
Acting Regional Director

Exhibit No 11

United States Department of the Interior

BUREAU OF OUTDOOR RECREATION
NORTHEAST REGIONAL OFFICE
Federal Building - Room 9310
600 ARCH STREET
Philadelphia, Pennsylvania 19106

IN REPLY REFER TO:
4120

March 22, 1977

Mr. Joseph L. Ignazio
Chief, Planning Division
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Ignazio:

This is in response to a February 22, 1977 letter to the Department of the Interior, Office of Environmental Project Review, requesting comments on the draft environmental statement for the Leominster Local Protection Project, Monoosnoc Brook, Leominster, Massachusetts. At this time, we are unable to provide comments because our manpower and funds are committed to other ongoing activities.

Sincerely yours,

JAMES S. DONOGHUE
Assistant Regional Director

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

Exhibit No. 12

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

29 Cottage Street, Amherst, Massachusetts 01002

March 24, 1977

Mr. Joseph L. Ignazio
Chief, Planning Division
Department of the Army
New England Division,
Corps of Engineers
Attention: NEDPL-P
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Ignazio:

We appreciate the information you have provided on the proposed diversion tunnel project on Monoosnoc Brook in Leominster, Massachusetts. Our only comment is to advise you that there is no existing or planned Soil Conservation Service - assisted project that would be affected by this proposed action.

Sincerely,

Philip Christenson

for Dr. Benjamin Isgur
State Conservationist

Exhibit No. 13

REGION I
Room 800
John F. Kennedy Federal Building
Boston, Massachusetts 02203

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
AREA OFFICE
BULFINCH BUILDING, 15 NEW CHARDON STREET
BOSTON, MASSACHUSETTS 02114

April 12, 1977

IN REPLY REFER TO:
1.12

Joseph L. Ignazio, Chief
Planning Division
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Subject: Leominster Local Protection Project
Monoosnoc Brook
Leominster, Massachusetts

Dear Mr. Ignazio:

The Boston Area Office of HUD has reviewed the above Draft Environmental Statement, which was sent to the Regional Office of HUD, and finds no conflicts with its objectives.

Thank you for giving this office the opportunity to review and comment on the above statement.

Sincerely,

/s/ [illegible]
Acting Area Office Director

Exhibit No. 14

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION I
J F KENNEDY FEDERAL BUILDING, BOSTON MASSACHUSETTS 02203

March 31, 1977

Mr. Joseph L. Ignazio
Chief, Planning Division
U. S. Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, MA 02154

Dear Mr. Ignazio:

We have reviewed the Draft Environmental Impact Statement (EIS) for Monoosnoc Brook Local Protection project in Leominster, Massachusetts and have the following comments to offer for your consideration in preparing the Final EIS.

As in all projects which use inverted syphons, there is a possibility that water stored in the syphon can become anoxic. This could result in objectionable anaerobic gas formation and eventual discharge of oxygen poor water to the receiving stream. This possibility was recognized in the Draft EIS. Comments of this same nature were made with regard to the Pawtuxet River and Furnace Brook Flood Control projects. It is agreed that, due to the relatively high quality of Rockwell Pond water, organic material is probably not present in high enough concentrations to cause sufficient oxygen depletion so as to result in an anoxic condition. However, in view of the erratic test results presented in the draft, it is felt that the EIS's conclusion that "the dissolved oxygen content in the tunnel's water should not drop below 6.6 mg/l" is not warranted. As with the other inverted syphon projects we recommend that some method of tunnel dewatering be provided for and that the tunnel either be dewatered regularly or the water be monitored for D.O. and dewatered as necessary.

Based on EPA's national rating system for EIS's, we have classified this draft as ER-1, a copy of which is enclosed.

Exhibit 1
Page 1 of 1

Thank you for the opportunity to review the Draft EIS and we look forward to receiving a copy of the Final when it becomes available.

Sincerely,

Wallace E. Stickney, P.E., Director
Environmental Policy Coordination Office

enclosure

EXPLANATION OF EPA RATING

Environmental Impact of the Action

LO -- Lack of Objections

EPA has no objections to the proposed action as described in the draft environmental impact statement; or suggests only minor changes in the proposed action.

ER -- Environmental Reservations

EPA has reservations concerning the environmental effects of certain aspects of the proposed action. EPA believes that further study of suggested alternatives or modifications is required and has asked the originating federal agency to reassess these aspects.

EU -- Environmentally Unsatisfactory

EPA believes that the proposed action is unsatisfactory because of its potentially harmful effect on the environment. Furthermore, the Agency believes that the potential safeguards which might be utilized may not adequately protect the environment from hazards arising from this action. The Agency recommends that alternatives to the action be analyzed further (including the possibility of no action at all).

Adequacy of the Impact Statement

Category 1 -- Adequate

The draft environmental impact statement sets forth the environmental impact of the proposed project or action as well as alternatives reasonably available to the project or action.

Category 2 -- Insufficient Information

EPA believes that the draft environmental impact statement does not contain sufficient information to assess fully the environmental impact of the proposed project or action. However, from the information submitted, the Agency is able to make a preliminary determination of the impact on the environment. EPA has requested that the originator provide the information that was not included in the draft environmental impact statement.

Category 3 -- Inadequate

EPA believes that the draft environmental impact statement does not adequately assess the environmental impact of the proposed project or action, or that the statement inadequately analyzes reasonably available alternatives. The Agency has requested more information and analysis concerning the potential environmental hazards and has asked that substantial revision be made to the impact statement.

If a draft environmental impact statement is assigned a Category 3, no rating will be made of the project or action; such a basis does not generally exist on which to base such a determination.

Advisory Council on
Historic Preservation
1522 K Street N.W.
Washington, D.C. 20005

March 3, 1977

Mr. Joseph L. Ignazio
Chief, Planning Division
New England Division
Corps of Engineers
U.S. Department of the Army
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Ignazio:

Thank you for your request of February 22, 1977, for comments on the environmental statement for the proposed Leominster Local Protection Project, Monoosnoc Brook, Leominster, Massachusetts.

Pursuant to our responsibilities under Section 102(2)(C) of the National Environmental Policy Act of 1969 and the Council's "Procedures for the Protection of Historic and Cultural Properties" (36 C.F.R., Part 800), we have determined that your draft environmental statement appears procedurally adequate; however, we have the following substantive comments to make:

> To ensure a comprehensive review of cultural and historical resources, the Council recommends that the final environmental statement contain evidence of contact with the appropriate State Historic Preservation Officer and a copy of her comments concerning the effects of the undertaking upon these resources.

The Council appreciates the opportunity to review your draft environmental statement.

Sincerely yours,

John D. McDermott
Director, Office of Review
and Compliance

Exhibit No. 16

The Council is an independent Federal agency. Prior to the Federal commitment charged by the Act of

LOCAL FLOOD PROTECTION

MONOOSNOC BROOK

LEOMINSTER, MASSACHUSETTS

STATEMENT OF FINDINGS

1. As Division Engineer of the New England Division of the Corps of Engineers, I have completed the Monoosnoc Brook Feasibility Report for local flood protection improvements in Leominster, Massachusetts. The study was undertaken in compliance with the resolution adopted on 9 February 1961, by the committee on Public Works of the House of Representatives. These findings comply with the National Environmental Policy Act of 1969, and will be attached to the Final Environmental Impact Statement of the report.

2. I have reviewed and evaluated, in light of the overall public interest, all pertinent data and documents concerning the proposed plan of improvement, as well as the stated views of other interested agencies and the concerned public, relative to the various practicable alternatives in accomplishing local flood protection along Monoosnoc Brook in the city of Leominster, Massachusetts.

3. The possible consequences of these alternatives have been studied for environmental, social well-being, and economic effects, including regional and national economic development and engineering feasibility. Other factors bearing on my review include the need for a general upgrading of the watershed and the preservation of existing open space for public benefit in the midst of a highly urbanized area.

4. In evaluation of the selected and other viable alternatives, the following points were considered pertinent:

a. Environmental Considerations. From an environmental standpoint, I have selected the optimum plan which will afford more enhancement than adverse effects. The recommended project will have beneficial effects on flood control, aesthetics, land traffic,

recreation and urban development. Only minimal vestiges of a natural environment remain and no possibility exists for a reversal in the urbanization process and restoration of the natural environment. Overall, the project would minimize the danger of flooding in 70 acres of developed land in the lower reaches of the brook in Leominster. Reduction of hazards associated with flooding will result in an upgrading in aesthetics and urban environment. The aesthetics of the area will be enhanced not only by the installation of a deep rock flood by-pass tunnel but also by preservation of the existing brook through the urban center of Leominster. No adverse environmental effects are anticipated if the project is implemented. However, some increased siltation and temporary turbidity is expected during construction of the tunnel intake structure. Measures will be taken to hold these effects to a minimum. In addition, some vegetation will be destroyed in the area of the channel improvement, but this condition will be temporary, until revegetation is accomplished.

b. Social Well-Being Considerations. I find that the overriding social well-being consideration in the Leominster area is the reduction of the flood damages and hazards that has caused human suffering and economic loss. The recommended project will provide a high degree of protection resulting in greater community cohesion and ensuring availability of public facilities during times of flooding. Construction of the flood control improvements will make possible higher utilization of the area for recreation opportunities, open space, and visual impacts, as well as provide security for business activity, which would improve the physical and social environment. No displacement of residential or commercial properties is required for construction of the project.

c. Engineering Considerations. From an engineering standpoint, I have designed the project that would provide a high practicable degree of flood protection, because of the highly urbanized nature of the project area. Studies have also been made of increasing or decreasing the degree of protection and the scope of the project, for maximizing flood control excess benefits and for determining the most economical and feasible plan of improvements. I have selected the plan having the least social, economical and environmental impact on the project area. The recommended project

was found to be the most practical method of meeting the flood control needs in Leominster. Other considered project alternatives, including solely non-structural measures, did not meet the criteria and requirements for various economic, social and environmental reasons.

d. Economic Considerations. From an economic standpoint, I have selected the optimum plan by providing a high degree of flood protection which will be conducive to the enhancement of social well-being and economic growth. The recommended project will have a net effect of increasing employment, tax revenues, and property values and will preserve the urban character of the flood prone areas.

e. Other Public Interest Considerations. I find that flood protection for the city of Leominster, along Monoosnoc Brook, is feasible and economically justified based on tangible benefits alone. The flood control improvement will also provide substantial intangible environmental, social and other benefits. I concur with the requests and desires of local interests and Massachusetts state officials indicating strong support for the flood control project and early implementation of the construction works, as expressed at the 27 January 1976 Public Meeting.

5. I find that the proposed improvements, as developed in the findings and recommendations of the report, are based on thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objectives; that wherever adverse effects are found to be involved they cannot be avoided by following reasonable alternative courses of action which would achieve the congressionally specified purposes; that where the proposed action has an adverse effect, this effect is either ameliorated or substantially outweighed by other considerations of national policy; that the recommended action is consonant with the national policy, statutes, and administrative directives; and that on balance the total public interest would best be served by the implementation of my recommendations.

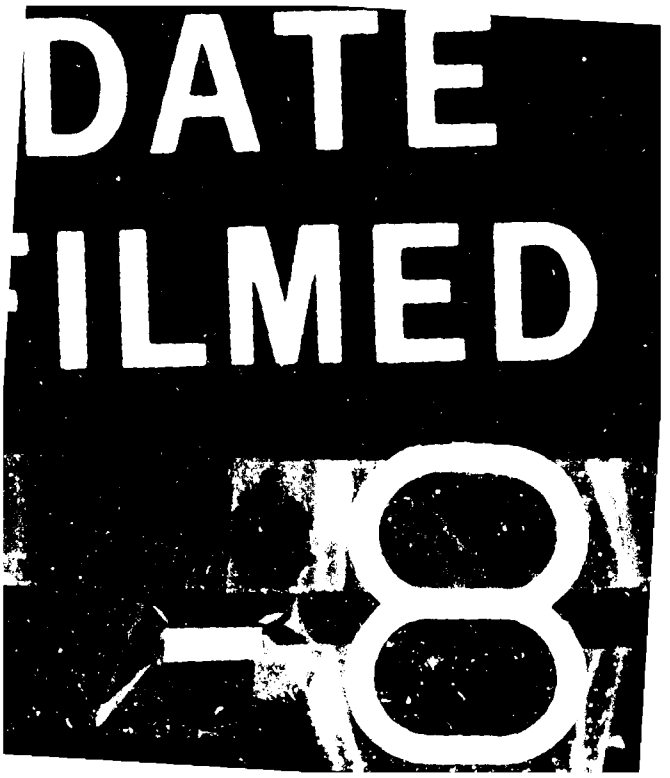
JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

22 August 1978
(date)

I concur in the findings of the Division Engineer.

(date)

Director of Civil Works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