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STREAMS IN WESTCHESTER COUNTY, N. Y.  
AND FAIRFIELD COUNTY, CONN.

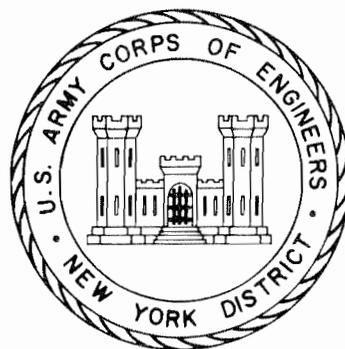
**FEASIBILITY REPORT  
FOR FLOOD CONTROL  
MAMARONECK AND SHELDRAKE  
RIVERS BASIN**

(VILLAGE AND TOWN OF MAMARONECK, N.Y.)

AND

**BYRAM RIVER BASIN**

(GREENWICH, CONN. AND PORT CHESTER, N.Y.)



MAIN REPORT

VOLUME I

OCTOBER 1977



# Syllabus

Flooding occurs along the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, New York, and Byram River at the Town of Greenwich, Connecticut and Village of Port Chester, New York, as well as several other locations in the watersheds.

The purpose of this study is to identify flood problems along the Mamaroneck and Sheldrake Rivers, New York, and Byram River, New York and Connecticut; to develop effective, economical and environmentally acceptable plans for reducing or preventing flooding and the attendant damage to public and private property; and to establish the feasibility and extent of Federal participation in the plans. Investigations have indicated that Federal interest under this authority for the Mamaroneck and Sheldrake Rivers basin and Byram River basin is justified only at the areas of the Village and Town of Mamaroneck, New York, and Greenwich, Connecticut and Port Chester, New York, respectively. The development and evaluation of alternative plans and the selection of the recommended plans of protection at the above areas were guided by the objective of solving the flood problems in ways that would be compatible with the surrounding environment and with prevailing community needs and goals.

The largest floods of record resulted from the storms of October 1955, June 1972 and September 1975. Damages within the Mamaroneck and Sheldrake Rivers basin for the June 1972 and September 1975 floods amounted to \$3,500,000 and \$19,700,000, respectively, based on existing conditions of development and December 1976 price levels. These storms inundated large areas of industrial, commercial and residential property at the Village and Town of Mamaroneck. If the Standard Project Flood were to occur along the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, approximately 330 acres would be inundated up to depths in excess of 16 feet. The October 1955 and June 1972 floods inundated a large area of residential and industrial property at Greenwich, Connecticut and Port Chester, New York, and damages within the Byram River basin from these storms would amount to \$1,066,000 and \$483,000, respectively, based on existing conditions of development and December 1976 price levels. If the Standard Project Flood were to occur along the Byram River at Greenwich and Port Chester, approximately 60 acres would be inundated up to depths of 16 feet.

During the progress of this study several solutions to the flood problems at Mamaroneck, and Greenwich and Port Chester were investigated, including non-structural and structural alternatives. The possible consequences of the alternatives developed during this study were evaluated according to engineering feasibility, and for environmental, social well-being and economic effects in accordance with guidelines on the Water

Resources Council's Principles and Standards. Through the process of plan formulation, it was determined that the best solutions, considering economics, social well-being, community impact, the environment and engineering principles, were structural alternatives.

The selected plan of protection on the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck consists of channel modifications levees, retaining walls and tunnel diversion works, and has an estimated first cost, exclusive of preauthorization studies, of \$34,400,000. The estimated Federal and non-Federal first costs are \$29,530,000 and \$4,870,000, respectively. The total annual cost including interest, amortization, operation and maintenance is \$2,230,000, while the total average annual benefits are estimated at \$3,060,000, resulting in a benefit-cost ratio of 1.4 to 1.

The selected plan of protection on the Byram River at Greenwich, Connecticut and Port Chester, New York consists of channel modifications and local protection works, including levees and floodwalls, and has an estimated total first cost, exclusive of preauthorization studies, of \$4,475,000. The estimated Federal and non-Federal first costs are \$3,540,000 and \$935,000, respectively. The total annual cost including interest, amortization, operation, maintenance and replacements is \$309,000, while total average annual benefits are estimated at \$488,300, resulting in a benefit-cost ratio of 1.6 to 1.

It is recommended that the selected plans of protection for the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, New York, and Byram River at Greenwich, Connecticut and Port Chester, New York be authorized for construction, subject to certain conditions of non-Federal cooperation.

STREAMS IN WESTCHESTER COUNTY, NEW YORK  
AND FAIRFIELD COUNTY, CONNECTICUT  
FEASIBILITY REPORT FOR FLOOD CONTROL  
MAMARONECK AND SHELDRAKE RIVERS BASIN, NEW YORK  
AND  
BYRAM RIVER BASIN, CONNECTICUT AND NEW YORK

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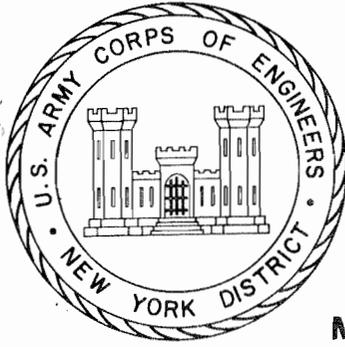
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31 October 1977

**Streams in Westchester County, N.Y.  
and Fairfield County, Conn.  
Feasibility Report for Flood Control  
Mamaroneck and Sheldrake Rivers Basin, NY.  
and  
Byram River Basin, Conn. and N.Y.**

## **The Study and Report**

### **PURPOSE AND AUTHORITY**

The Mamaroneck and Sheldrake Rivers and Byram River watersheds are located along the northern coast of Long Island Sound within the New York City metropolitan area. The Mamaroneck and Sheldrake Rivers basin lies entirely within Westchester County, New York and contains portions of the Village and Town of Mamaroneck, the Cities of New Rochelle and White Plains, the Towns of Harrison and North Castle, and the Village of Scarsdale. The Byram River basin lies principally in Fairfield County, Connecticut and partly in Westchester County, New York and encompasses parts of the Town of Greenwich, Conn., and the Village of Port Chester and Towns of Rye, North Castle, New Castle and Bedford, New York. Areas within these watersheds have been subject to recurrent flooding throughout their histories with severe floods occurring recently in June 1972 and September 1975.

This report is submitted in compliance with resolutions of the United States Senate Committee on Public Works adopted 14 September 1955 and 14 November 1955, and with resolutions of the United States House of Representatives Committee on Public Works adopted 13 June 1956 and is in partial response to these resolutions as they relate to Westchester County, New York, and is in full response in relation to the Mamaroneck and Sheldrake Rivers and the Byram River basins. All of these resolutions were adopted as a result of the damaging floods of August and October 1955. These resolutions are presented in their entirety in Appendix H, Authorizing Documents, Coordination and Pertinent Correspondence.

The Chief of Engineers by letters dated 16 September 1955, 22 and 23 November 1955 and 27 July 1956, requested that the North Atlantic Division prepare and submit a combined report of examination and survey scope covering the resolutions of 14 September 1955, 14 November 1955, and 13 June 1956. The North Atlantic Division Engineer assigned the report

covering the three resolutions by letters dated 27 September 1955, 30 November 1955, 1 December 1955 and 26 October 1956.

The Chief of Engineers by letter to the North Atlantic Division dated 22 April 1976 granted approval for the preparation of an interim report for the Mamaroneck and Sheldrake Rivers under the Westchester County Streams Survey Investigation. Approval for the preparation of an interim report for the Byram River was granted by letter dated 18 January 1977 from the Chief of Engineers to the Division Engineer, North Atlantic Division.

## SCOPE OF THE STUDY

This survey study focused on the evaluation of the flood problems in the Mamaroneck and Sheldrake Rivers and Byram River drainage basins; identification of these problems and their relationship to the overall environmental and socioeconomic needs and desires of the people living and working in the drainage basins; development of alternative solutions for protecting the flood-prone areas and preventing flood damages; determination of the costs, benefits, and environmental impacts associated with implementing these measures; and selection of the plan which would effectively solve the flood problems in a way that would be compatible with the environmental and socioeconomic needs of the study area communities. Investigations have indicated that Federal interest under this authority for the Mamaroneck and Sheldrake Rivers basin, and Byram River basin is justified only at the areas of the Village and Town of Mamaroneck, New York, and the Town of Greenwich, Connecticut and Village of Port Chester, New York, respectively.

## LOCALITIES INVESTIGATED

Detailed investigations were limited to the Village and Town of Mamaroneck along the Mamaroneck and Sheldrake Rivers and the Town of Greenwich, Connecticut and Village of Port Chester, New York along the Byram River where improvements for flood control proved to warrant detailed study. At all other localities where flood damages were reported, preliminary investigations indicated that there was no possibility of developing economically justified plans of protection and no detailed studies were conducted.

## BASIS OF INVESTIGATION

This report is based on area field reconnaissance, field topographic surveys, soils investigations, hydrologic and hydraulic studies, consultation with local interests, review and evaluation of previous reports and other related studies. Data concerning the general description of the basins and their economic development were obtained from field investigations, published maps, United States census reports and consultation with local officials. Records of the United States Geological Survey and the

United States Weather Bureau were utilized for climatologic, hydrologic and hydraulic data. Flood losses, extent of flood area and other data concerning flood conditions for past floods were determined by field damage surveys, interviews with local residents, review of flood data prepared by local officials, newspaper files in the area, and local and published reports. Initial plan formulation and late stage studies in the preparation of this report were coordinated with State and Federal agencies having expertise and interest in flood control and storm runoff, and with environmentally oriented planning groups. See correspondence in Appendix H.

## THE REPORT

The purpose of this feasibility report are: (1) to summarize current and potential problems, needs and alternatives for flood control purposes in the Mamaroneck and Sheldrake Rivers and Byram River watersheds; (2) to present and discuss the results of plan formulation which develops the resource management systems; (3) to identify specific details of the selected plan; and (4) to acquaint the public with information obtained and conclusions drawn during the feasibility studies.

In the interest of clarity and presentation, the results of this study are presented in a main report and eight appendices. The main report is the basic document which presents a broad view of the overall study for the benefit of all readers, both engineers and non-engineers. It also contains conclusions and recommendations.

The eight appendices present supporting data and details of the various aspects of the study:

- Appendix A - Hydrology
- B - Hydraulics
- C - Geology, Soils and Foundations
- D - Flood Damages and Benefits
- E - Cost Estimates
- F - Plan Formulation
- G - Environmental, Social and Economic Effects Assessment
- H - Authorizing Documents, Coordination and Pertinent Correspondence

## PRIOR REPORTS

Previous reports on all or part of the Mamaroneck and Sheldrake Rivers, and Byram River basins are described below. Several of the reports investigated flood control improvements along the same reaches of the Mamaroneck and Sheldrake Rivers and Byram River which are considered in this report. All of these reports were reviewed as part of this study. Table 1 includes a brief summary of prior Corps of Engineer reports on flood control investigations.

TABLE 1 — PRIOR FLOOD CONTROL REPORTS BY THE CORPS OF ENGINEERS

Title of Report	Type	Improvements Considered	Date Submitted to Division
Byram River and Tributaries	Preliminary Examination	Channel improvement and rectification of Byram River above Boston Post Road (U.S. Route 1) in order to protect the Pemberwick area and a small portion of Port Chester, New York, upstream from Boston Post Road. Recommendation was unfavorable.	April, 1942
Mamaroneck Sheldrake Rivers and Tributaries	Preliminary Examination	Channel improvement of Mamaroneck River in the Village of Mamaroneck and Town of Harrison and Sheldrake River in the Village and Town of Mamaroneck, and channel clearing, dredging, removal of obstruction and reconstruction of bridges. Marginally favorable; recommended authorization for a limited survey.	August, 1942
Mamaroneck and Sheldrake Rivers and Tributaries	Survey	Same as in the Preliminary Examination report for Mamaroneck and Sheldrake River. Recommendation was unfavorable.	December, 1945
Byram River Basin Pemberwick, Conn.	Design Memorandum	Found that a small flood control project within the limits of \$400,000 as provided for in PL 685, 84th Congress was warranted on Byram River at Pemberwick, Connecticut.	June, 1958
Streams in Westchester County, NY and Fairfield County, Conn.	Survey	Local protection plan at the Village of Mamaroneck consisting of channel rectification with walls and levees along the Mamaroneck and Sheldrake Rivers. District recommendation was favorable, however, Board of Engineers for Rivers and Harbors returned the report to District for reconsideration of a debris jam occurrence. Restudy indicated the proposed project at Mamaroneck was not economically feasible. There was no justification for improvements along the Bronx River, Hutchinson River, Blind Brook and Byram River, and their tributaries.	May, 1968
Sheldrake River Mamaroneck, NY	Reconnaissance	Channel improvement along the Sheldrake River in the Town of Mamaroneck consisting of reinforced concrete flume. Plan was economically justified, however, the cost apportioned to Federal interests was in excess of the small project authority limitation. Plan was recommended to be considered further under Westchester County Stream Survey investigation.	April, 1973
Byram River, Port Chester, NY and Greenwich, Conn.	Reconnaissance	Local protection at Greenwich, Connecticut, and Port Chester, New York, consisting of a combination of levees, floodproofing and interior drainage facilities along the Byram River. Recommendation was favorable.	April, 1973
Byram River, Port Chester, NY and Greenwich, Conn.	DPR	More detailed study of improvements considered in Byram Reconnaissance Report. Protection economically feasible but recommendation was unfavorable since Federal costs in excess of \$1,000,000.	February, 1976

## Corps of Engineers Flood Control Reports

A Preliminary Examination Report on the Mamroneck and Shel Drake Rivers and bridges in the Village and Town of Mamaroneck and Town of Harrison, was completed by the New York District, Corps of Engineers on 14 August 1942. This report was marginally favorable and recommended further study in the form of a Survey Report. However, the Survey Report which was subsequently completed and submitted to Congress on 9 December 1948 was unfavorable. A Survey Report for streams in Westchester County completed in May 1968 considered local protection works at the Village of Mamaroneck, consisting of channel rectification with walls and levees along the Mamroneck and Shel Drake Rivers. The study was favorable; however, the Board of Engineers for Rivers and Harbors returned the report to the District for reconsideration of a debris jam occurrence. Restudy indicated the considered project was not economically feasible. A Reconnaissance Report was completed in April 1973 which considered channel improvements along the Shel Drake River in the Town of Mamaroneck consisting of a reinforced concrete flume. The report was favorable; however, the cost apportioned to Federal interests was in excess of the small project authority limitation, and further study was recommended under the Westchester County Streams Survey Authority.

A Preliminary Examination Report on the Byram River was completed in April 1946. This report, which was unfavorable, considered channel rectification of Byram River upstream of U. S. Route 1 at Port Chester, New York and Pemberwick, Connecticut. In June 1959, a Design Memorandum was completed for the Byram River at Pemberwick, Connecticut. This report concluded that a small flood control project was warranted on the Byram River at Pemberwick, Connecticut. A Reconnaissance Report was completed in April 1973 which considered local protection at Greenwich, Connecticut and Port Chester, New York consisting of levees and floodproofing measures along the Byram River. The report was favorable and recommended further study in the form of a Detailed Project Report. The subsequently completed DPR, however, indicated that the cost apportioned to Federal interests was in excess of the small project authority limitation, and further study was recommended under the Westchester County Streams Survey Authority.

## Flood Plain Information Reports

A Flood Plain Information Report was completed in January 1967 for the use of local interests along the Mamroneck and Shel Drake Rivers. Flood plain studies have been completed for the use of local interests along the Byram River in October 1964 and January 1966.

## Navigation Reports

Prior navigation reports within the study areas include: Survey reports for the East Basin of Mamaroneck Harbor at the lower estuary of the Mamaroneck River, which was submitted to Congress on 19 June 1959, and for Port Chester Creek at the lower estuary of the Byram River, submitted to Congress on 1 November 1928. Each of the above reports resulted in authorized Federal navigation projects.

## Hurricane Reports

The only previous report which includes the study areas is an Interim Survey Report on Hurricane Study of Westchester County, New York, along Long Island Sound, which was submitted to Congress on 29 November 1967. This report recommended that no improvements designed to protect the shoreline areas of Westchester County, New York, along Long Island Sound, against tidal inundation be authorized at that time. Additionally, Part Two, Chapter XXXIX (unpublished) of the report (Senate Document No. 14, 85th Congress, First Session) on the "Land and Water Resources of the New England - New York Region," prepared by the New England - New York Inter-Agency Committee, includes a brief history of hurricane occurrences in this region, a description of the hurricane problem, and a general discussion of methods of reducing damages.

## Reports by Other Federal Agencies

There are no known published reports by other Federal agencies. All of the communities within the Mamaroneck and Sheldrake Rivers and Byram River watersheds are participating in the National Flood Insurance Program; although no Type 15 Flood Insurance studies have been completed for these communities, a number of studies are currently underway.

## Reports by Non-Federal Agencies

A report on flood conditions on the various streams in Westchester County, including the Mamaroneck and Sheldrake Rivers, was submitted to the Westchester County Board of Supervisors on Storm Water Control on 27 November 1945. Major flood relief measures considered in this report included: (1) channel improvements along the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, (2) the diversion of flood flows from the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, (3) flood detention along the Mamaroneck River at the Westchester Joint Water Works Reservoir, and along the Sheldrake River at Larchmont Reservoir #2 and on the East Branch. This report recommended that a project consisting of channel improvement in the Village of Mamaroneck in combination with upstream flood detention be adopted to control floods along the Mamaroneck and Sheldrake Rivers.

A Reconnaissance Report, titled "Mamaroneck and Sheldrake River Basins -- Analysis of Flood Control Studies," was prepared by Dolph Rotfeld Associates and submitted to the Westchester County Department of Planning in April 1968. This report recommended, subject to further detailed studies, the use of the Westchester Joint Waterworks Reservoir, Silver Lake, Larchmont Reservoir, Forest Lake and Spring Lake as flood control facilities in the Mamaroneck and Sheldrake Rivers Basin.

Additionally, a preliminary report on flood control prepared in July 1958 by Gannett, Fleming, Corddry and Carpenter, Inc. for the Town of Greenwich, Connecticut considered improvements along the Byram River.

## Resources and Economy of Study Area

### BASIN DESCRIPTIONS

The combined watershed of the Mamaroneck and Sheldrake Rivers, located entirely in New York State, has a total drainage area of 23.4 square miles. The leaf-like, two-stem watershed is roughly rectangular shaped, with a maximum length of 9 miles in a north-south direction and with a width that varies from 2 to 3 miles. The terrain is gently rolling, lightly wooded in the upper portion and generally cleared in the lower valley. The ridges extend generally in a north-south direction. Ground elevations range from near sea level at the mouth of the Mamaroneck River to about 500 feet above mean sea level in the northwest corner of the basin. The Mamaroneck River drains into Long Island Sound at Mamaroneck Harbor. Mamaroneck Harbor consists of an inner landlocked harbor and an outer open harbor, connected by an inlet about 350 feet wide. This inner harbor is divided into two basins, East Basin and West Basin, by a projecting land area known as Harbor Island Park.

The Byram River watershed, with a drainage area of 31.0 square miles, is located in the Town of Greenwich, Connecticut and to a lesser extent in Westchester County, New York. Byram River, with a length of 13.5 miles, flows in a southerly direction and empties into the Long Island Sound at Port Chester Harbor. The lower portion of the main stream passes through Pemberwick, Connecticut. The watershed, roughly triangular shaped, is gently rolling with the ridges of the hills running largely north and south. The highest peaks are along the most northerly ridges and attain elevations up to 760 feet above mean sea level.

## CLIMATE

The climate in the study areas is moderate with an average temperature of 51 degrees, Fahrenheit. The extreme temperatures observed, based on the available data for all stations, were 18 degrees Fahrenheit below zero and 105 degrees Fahrenheit above zero at Scarsdale, New York. The average growing season varies from 165 days in the Byram River watershed to 184 days in the Mamaroneck and Sheldrake Rivers watershed. The relative humidity averages about 67 percent. The prevailing winds are from the northwest with an average velocity of 14 miles per hour.

## PRECIPITATION

Data on precipitation are obtainable from five stations in and surrounding the Mamaroneck and Sheldrake Rivers basin. The location, operating status, period of record and type of gage are shown on Figure A1 of Appendix A. For the Byram River basin, data on precipitation is obtained from two stations surrounding the watershed, as shown on Figure A3. The average annual precipitation for the Mamaroneck and Sheldrake Rivers and Byram River basins are approximately 44.2 and 47 inches, respectively. The observed extreme annual values were 66.98 inches (Bedford Hills, 1901) and 25.83 inches (White Plains Maple Moor, 1965). The monthly extremes were 16.64 inches (Bedford Hills, October 1955) and a trace (Bedford Hills, November 1917). The distribution of precipitation throughout the year is fairly uniform, with higher amounts occurring during the summer months.

## PAST STORMS

The past floods of greatest magnitude in the subject watersheds have been caused by: (1) intense rain accompanying transcontinental-type storms; (2) localized thunderstorms; (3) hurricane-like disturbances of West Indian origin; or (4) less intense rains of long duration falling on snow-covered, frozen or saturated ground. Flood-producing storms over the watersheds have occurred most frequently in the spring and fall seasons. Some of the notable storms which have caused flood conditions in the basin occurred in July 1889 (severe summer storm), October 1903 (cloudburst storm extending over a wide area), March 1936 (general transcontinental storm), July 1938 (severe summer storm), September 1938 (tropical hurricane), September 1944 (hurricane), May 1946, March 1953, August 1955 (hurricane), October 1955 (complex storm system), March 1962, May 1968, August 1971, June 1972 and September 1975. The most significant of these storms are described briefly in Appendix A, paragraphs A12 to A22.

## GEOLOGY

The geology of the Mamaroneck and Sheldrake Rivers and Byram River basins are generally similar. The principal structural elements in these basins are the Fordham Gneiss, Inwood Limestone and Manhattan Schist. Outcroppings of bedrock are frequent throughout each of the watersheds. The unconsolidated overlying materials are predominantly of glacial origin. Stratified drift and alluvium deposits cover much of the low-lying lands, while till deposits of varying thickness cover much of the hillside bedrock. Further details are contained in Appendix C.

## WATER SUPPLY

There are two major reservoirs in Westchester County, the Croton Reservoir and the Kensico Reservoir, both of which are part of the New York City water supply system. By agreement with New York City, Westchester County is guaranteed water from the New York City system in volumes equivalent to the per capita rate of consumption in New York City. The Croton Reservoir system, located in north central Westchester, embodies 12 reservoirs and 5 controller lakes which impound approximately 98 billion gallons from 373 square miles of drainage. The Kensico Reservoir, located just north of White Plains, was originally constructed to serve as an equalizing basin on the Catskill Aqueduct. In 1943 water from the upper Croton watershed was fed, via a tunnel, directly into the Kensico Reservoir, and in 1944 water from the Delaware watershed was similarly brought to the Kensico Reservoir, thus utilizing this facility as the principal storage, mixing, and equalizing basin for New York City's entire reservoir system. It has an available storage capacity of about 31 billion gallons. In addition to the foregoing, which supplies over 75 percent of Westchester County's water supply needs of approximately 110 million gallons per day, there are a number of local water supplies which utilize water from streams, ponds and reservoirs in the area. Two reservoirs within the Mamaroneck and Sheldrake Rivers basin were formerly used as local supplies. These facilities, which were used until recently as standby reserves to the supplies obtained from the New York City water supply system, are the Westchester Joint Water Works Reservoir on the Mamaroneck River and Larchmont Reservoir #2 along the Sheldrake River.

## WATER QUALITY

The Mamaroneck River and its tributary, the Sheldrake River, are classified by the State of New York as class D streams within the study area in the Village and Town of Mamaroneck and are considered significantly degraded. The lower tidal portion of the Mamaroneck River is class I and the East and West Basins of Mamaroneck Harbor are classified as SB waters and are closed to shellfishing. U. S. Environmental Protection Agency discharge permits have been issued to local industries that discharge wastes into the streams, primarily into the upper Mamaroneck River, and also into the Harbor

area as well. In addition to industrial discharges, local storm water drains also discharge into the Shel Drake and Mamaroneck Rivers. Visual inspection of the streams at the study area indicates that, although the water consistently exhibits a murky, greenish-brown appearance, in general, they are devoid of obstacles and garbage debris, and present a relatively clean attractive appearance, particularly at the upstream residential areas in the Village and Town. In the vicinity of the confluence and downstream in the Village of Mamaroneck there is increasing evidence of water quality degradation due to the presence of oil and floating debris. The existing water quality condition within the study area is expected to continue due to the urbanized nature of the upland area. The proposed upgrading of the municipal sewage treatment facility at Harbor Island would be expected to decrease the pollution load within Mamaroneck Harbor.

The Byram River is classified as a B stream in the Greenwich-Port Chester area by the State of Connecticut. The lower tidal section of the river is class SD, while the remaining portion from the West Putnam Avenue Bridges downstream to the tidewater, is class D. The U. S. Environmental Protection Agency has issued discharge permits to local industries that discharge wastes into the lower Byram River. The stream water quality and aquatic life shows a marked transition from the upper reaches of the Greenwich-Port Chester area when compared to the downstream areas. Pemberwick Lake contains carp, bluegills, sunfish, eels and largemouth bass, while the river downstream is essentially devoid of life. Salt water intrusion normally reaches up to and just past the West Putnam Avenue Bridges; however, during extreme high tide conditions, it may reach well within the project area and beyond the small lake, upstream. The waters in the Greenwich-Port Chester area are polluted from local runoff and urban pressures, and pollution effects from downstream sources, such as the discharge from the Port Chester Sewage Treatment Plant, can also be carried upstream with the inbound tide. The water quality of the waterway is expected to improve moderately with the elimination of industrial discharges from upstream sources and the proposed upgrading of the Port Chester Sewage Treatment Plant.

The New York and Connecticut State water quality standards are defined in the Water Quality Appendix of the Environmental Impact Statement accompanying this report. The best usage for the applicable New York classifications are noted below:

Class AA - Drinking	SA - Shellfishing & Bathing
A - Drinking	SB - Bathing
B - Bathing	I - All other uses
C - Primary Recreation (Fishing)	
D - All other uses	

## AIR QUALITY

The study area basins are located in one of the nation's most densely populated and heavily industrialized centers, the New York City metropolitan area. Pollutants such as sulfur dioxide and particulate matter from these areas along with local emissions from motor vehicles have resulted on occasions in potentially dangerous air pollution concentrations for residents. However, data obtained from air quality monitoring stations located in Mamaroneck, Rye and Port Chester, New York and Greenwich, Connecticut have generally reported ambient air quality levels within the applicable state standards.

## FISH AND WILDLIFE

Fish and wildlife species in the Mamaroneck and Sheldrake Rivers and Byram River watersheds maintain a degree of diversity considering the ongoing urbanization of the area. In all, approximately 240 species of birds, including 90 nesting and 150 migratory species, 40 species of mammals, 16 species of amphibians and 17 species of reptiles occur within the region of the subject basins. In addition, fresh water fish known to occur in the Mamaroneck and Sheldrake Rivers, and Byram River basins number 15 and 18 species, respectively, and approximately 60 species of fish are typical of the estuaries forming the north shore of Long Island Sound. No endangered or threatened species are known to inhabit the study area, although the migratory species of birds reported in the area includes two rare coastal migrants, the American peregrine falcon and the American osprey.

Vegetation and wildlife habitat areas along the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck are generally limited by the suburban development of the area. Relatively undisturbed areas along the streams can still be found, however, particularly along the Mamaroneck River upstream of the New England Thruway. The vegetative resources located within the immediate project area includes the following: black willow, white ash, sugar maple, white oak, black birch, white birch, red maple, silver maple, sweetgum, scotch pines, low bushes such as viburnums, sumacs and various grasses. Wildlife occurring in the area include squirrels, chipmunks, raccoons, muskrats and rabbits. In addition, numerous resident birds as well as migrating visitors have been observed. These include the following: song sparrows, field sparrows, common starlings, cardinals, robins, bluejays, wood ducks and Canada geese. The fishery resources in the streams are generally limited due to the following reasons: (a) the poor water quality and insufficient flows are nonconductive to fish propagation, particularly game species; (b) insufficient flow within the streams, that is, shallow, low-flow conditions are encountered during part of the year; and (c) relatively poor stream cover is found along the urbanized areas. Some fishery resources, including such species as sunfish, goldfish, white sucker, eels, carp, bass, brown trout, shiners and minnows, are present, however, in the larger waterbodies upstream.

The Mamaroneck River drains into the estuary of Long Island Sound at Mamaroneck Harbor. A fishery for striped bass, bluefish and blackfish exists around the outer harbor, along with some recreational catching of lobster. A small fishery exists within the harbor itself for snappers and bluefish. Eels, stickelback, toadfish, sculpin, killifish, flounder and various rough fish are found on and near the harbor bottom, while the shoal areas adjacent to the north side of Harbor Island Park support some razor clams, soft shell clams and a few hard clams -- all inedible due to the poor quality of the bottom sediments. Some recreational fishing in the harbor for flounder, smelt and snappers is also reported. The soft bottom sediments in the mid-channel areas support little in the way of shellfish. Progressing outward from the harbor, more bottom life of all kinds can be found, particularly away from the channel, in keeping with the improved water quality of the open water areas. In the summertime, large schools of juvenile mossbunkers can be found in the harbor. Little or no spawning appears to take place in the harbor area with the possible exceptions of killifish and silversides.

The Byram River at Greenwich, Connecticut and Port Chester, New York supports various plant, fish and wildlife species. Trees such as the black locust, black willow, alder, red-osier, dogwood, sycamore, red maple, oak and black cherry line both banks of the stream. Numerous resident and migratory avian species also utilize the area including herring gulls, domestic ducks, mallard ducks, Canada geese, redwing blackbirds, sparrows and crows. No significant fishery is reported for the lower Byram River, within the project area, probably as a result of the poor water quality. Despite the stream's degraded water quality, however, the American eel, common shiners and minnows may still be found. Within Pemberwick Lake, and in the upper reaches of the Byram River, carp, bluegills, sunfish, largemouth bass, eels, white suckers and white perch also occur.

## HISTORICAL AND ARCHAEOLOGICAL RESOURCES

Coordination with the state and county historical societies and a review of the National Register of Historic Places reveals several sites of significance near the general vicinity of the watersheds. None of the identified sites are within the study area basins and they would not be affected by the flood control projects proposed in this report. In January 1977 a cultural resources survey for the study areas was completed for the New York District by archaeological consultants. On the basis of this study, no cultural resources eligible for inclusion in the National Register of Historic Places were found within any of the affected project areas. Some buildings or sites with potential of historical interest were, however, discovered. A summary of the detailed cultural resources survey report is included in Appendix G.

## RECREATION

Recreational facilities in Westchester County are bountiful, consisting of picnicking, golfing, swimming, ice skating, fishing, boating, and nature study areas and amusements, most of which are operated under the Westchester County Department of Parks, Recreation and Conservation. Blue Mountain Reservation near Peekskill, New York, Croton Point Park near Croton-on-Hudson, New York, and Ward Pound Ridge Reservation near South Salem, New York, provide over 7,200 acres in or near the area for bathing, hiking, picnicking, playground activities, skating, boating, riding, ball-playing, overnight camping, nature study and sleighing. Playland at Rye, New York, is noted for its prominence as an amusement area for adults and children. This facility features rides, refreshment stands, a kiddyland, ice skating, a game room, and pier and boat-fishing. In addition, numerous other smaller parks and recreation areas supplement these larger facilities.

In the Mamaroneck and Sheldrake Rivers basin the 700-acre Saxon Woods Park, operated by the county, provides opportunities for swimming, golfing, picnicking, hiking, nature study, ice-skating and horseback riding. Existing facilities within the unincorporated area of the Town of Mamaroneck include some 86 acres of large parkland areas including the 25-acre Hommocks Area Park and the 53-acre Sheldrake River (Nature) Trails. The Village of Mamaroneck also owns or operates numerous neighborhood or playground parks including Columbus Park near the confluence of the Mamaroneck and Sheldrake Rivers, and several larger parks, including the 10-acre Florence Avenue Park and the 40-acre Harbor Island Park. This latter facility provides outstanding waterfront recreational opportunities at Mamaroneck Harbor for the Village.

Numerous recreation facilities can be found within the Byram River basin, including the Town of Greenwich, and within nearby areas of Fairfield and Westchester Counties. Recreational boating, for example, is quite popular in Port Chester Harbor and the adjacent water bodies. The Town of Greenwich maintains and operates several beaches and waterfront parks, including Grass Island, Roger Sherman Parks. In addition, the existence of many country clubs, town golf clubs, the Audubon Trails and Montgomery Pinetum provide Greenwich with varied recreation opportunities.

### Golfing

Dunwoodie Course near Yonkers, Maple Moor Course near Purchase, Mohansic Course near Yorktown Heights, Saxon Woods Course near Mamaroneck and White Plains, and Sprain Lake Course near Scarsdale provide over 1,000 acres of public golf course in or near the study area. In addition, numerous private country clubs such as Hampshire in Mamaroneck, Pelham Manor, Siwanoy, Leewood and Vernon Hills in Eastchester, Wykagyl in New Rochelle, Fenway in Scarsdale, Sunningdale in Hartsdale, Westchester and Harrison in Harrison, Blind Brook in Rye, and Century and Old Oaks in

Harrison provide abundant additional facilities for golfing, swimming and other social activities.

## Boating

Some of the most famous yacht clubs in America have their houses and harbors on the Westchester-Connecticut side of Long Island Sound. Some of these are the municipal docking facilities in Mamaroneck, Hudson Park Dock and Neptune Park Dock in New Rochelle, Playland Pier in Rye and the municipal dock in Port Chester. Several marinas are located in the estuary of the Byram River and behind North Manursing Island. In addition, there are over 15 private clubs in the Mamaroneck, New Rochelle, Rye and Greenwich areas, which provide boating facilities, beaches, club houses, dining areas and other recreational facilities in support of the primary boating activity. Numerous public and private boating facilities are also located on the Hudson River within a reasonable distance from the study area.

## HUMAN RESOURCES

### Population Characteristics

The Mamaroneck and Sheldrake Rivers basin, and part of the Byram River watershed, lie in the New York Standard Metropolitan Statistical Area, which is comprised of New York City and Nassau, Suffolk, Rockland and Westchester Counties. Population data for the New York SMSA, New York City, Westchester and Fairfield Counties, the study area basins, and the Village and Town of Mamaroneck, Village of Port Chester, New York and Town of Greenwich, Connecticut are shown in Tables 2 and 3. The above communities are separately identified because flood protection for them is recommended in this report.

The decennial growth rates of Table 3 indicate that the population of New York City increased from 1960 to 1970 at the same rate of decline that occurred from 1950 to 1960. This reversal in trend suggests that the tremendous out-migration from the city that has been taking place in recent years may be coming to an end, and that future growth in suburban areas will decline as a result. Metropolitan areas have historically grown outward from central core areas. First the population for the inner portions of the metropolitan area grow rapidly, since initially there is much open land available. This high rate of growth slows and finally stabilizes when full or near-complete development of these areas is achieved. Thereafter, population growth shifts to areas further from the center of the metropolitan area.

As shown in Table 2, growth for the New York Standard Metropolitan Statistical Area follows this pattern. Population growth for New York City was negligible between 1950 and 1970; it is in the center of the New

York SMSA and its population growth has been completed. Westchester County grew more than twice as much between 1950 and 1960 than between 1960 and 1970. This sequence indicates that population growth in Westchester County is either completed or nearly completed. The 1950, 1960 and 1970 population figures for the study area basins, Mamaroneck Village, Mamaroneck Town, Port Chester Village and Town of Greenwich show greater amounts of growth between 1950 and 1960 than between 1960 and 1970. This would tend to indicate that population growth for these areas is also nearly finished. Fairfield County is on the fringe of the New York SMSA. Rapid population expansion caused by the New York SMSA can still be expected for Fairfield County, but the Town of Greenwich, which lies closest to the New York SMSA, will complete population growth before the rest of the county.

Table 4 contains projections of population to the year 2020 for New York City and Westchester County based on "Series E," which depict the best estimates of what can be expected if there are no policy or program changes of an unusual nature or magnitude during the evaluation period. These baseline projections are policy neutral, to the extent they do not reflect local policies, goals or environmental restraints of growth. Table 5 shows population projections for Westchester County, the Village and Town of Mamaroneck and Village of Port Chester based on Westchester County Department of Planning data which reflects the existing slow rate of residential construction, current zoning and land use trends and other local policies. As shown in Tables 4 and 5, both the OBERS "Series E" and Westchester County projections reflect limited population increases for the south county areas, in which the study areas lie.

## DEVELOPMENT AND ECONOMY

The Mamaroneck and Sheldrake Rivers and Byram River watersheds are located in the metropolitan New York area, an expanding center of population. Westchester and western Fairfield Counties suburban communities are conveniently situated for commuters to New York City and for those who desire a combination of suburban and city life. Of all counties in New York State, Westchester County had the highest mean family income and the second highest median income and per capita income in 1970. However, there was a significant decline in the population growth rate for Westchester County during the decade from 1960 to 1970 from the high levels achieved in the previous decade. Therefore, no significant population growth is projected. A more detailed discussion concerning economic development is presented in Appendix G, Environmental, Social and Economic Effects Assessment.

TABLE 2 - HISTORICAL POPULATION DATA FOR NEW YORK STANDARD METROPOLITAN AREA, NEW YORK CITY, STUDY AREA BASINS, WESTCHESTER COUNTY, FAIRFIELD COUNTY, MAMARONECK VILLAGE, MAMARONECK TOWN, PORT CHESTER VILLAGE, AND TOWN OF GREENWICH, 1950, 1960 AND 1970

Area	1950	1960	1970
New York Standard Metropolitan Statistical Area	9,580,000	10,700,000	11,600,000
New York City	7,900,000	7,800,000	7,900,000
Westchester County	626,000	809,000	894,000
Fairfield County	504,000	654,000	793,000
Mamaroneck and Sheldrake Rivers Basin	44,000	62,000	66,000
Mamaroneck Village	15,000	17,700	18,900
Mamaroneck Town	9,900	11,800	13,000
Byram River Basin	25,000	32,000	34,000
Port Chester Village	24,000	25,000	25,800
Town of Greenwich, Conn.	40,800	53,800	59,800

NOTE: Numbers have been rounded. Based on U. S. Census of Population.

TABLE 3 - POPULATION DENSITIES AND GROWTH RATES FOR NEW YORK CITY, WESTCHESTER COUNTY AND STUDY AREA BASINS

Area	Persons Per Square Mile		Annual Growth Rate - Percent	
	1960	1970	1950-1960	1960-1970
New York City	26,000	26,300	-0.14	0.14
Westchester County	1,800	2,000	2.62	1.00
Mamaroneck and Sheldrake Rivers Basin	2,600	2,800	3.50	0.63
Byram River Basin	1,000	1,100	2.50	0.62

TABLE 4 - HISTORICAL AND OBERS (SERIES E) PROJECTED POPULATION FOR  
 NEW YORK CITY AND WESTCHESTER COUNTY, NEW YORK  
 1960-2020 (POPULATION IN THOUSANDS)

AREA	Historical		Baseline Projections			
	1960	1970	1980	1990	2000	2020
New York City <sup>1</sup>	7,800	7,904	8,086	8,269	8,430	8,711
Westchester County <sup>1</sup>	809	895	995	1,060	1,106	1,188
South County <sup>2, 3</sup>	636	669	709	708	693	744

1. Based on Series E national population projections.
2. OBERS Series E County Projections disaggregated to the town level. People and the Sound, An Economic Perspective, July 1974.
3. Southern section of Westchester County, including portion within Long Island Sound hydrologic boundary; includes: Rye Town, Rye City, Port Chester, Harrison, White Plains, Mamaroneck, Scarsdale, Greenburgh, New Rochelle, Pelham, Pelham Manor, Eastchester, Mount Vernon and Yonkers.

TABLE 5 - HISTORICAL AND PROJECTED POPULATION FOR WESTCHESTER COUNTY, WESTCHESTER COUNTY DEPARTMENT OF PLANNING, 1960-1985

(Population in Thousands) <sup>1</sup>

AREA	Historical		Projected		
	1960	1970	1975	1980	1985
Westchester County	809	895	900	900	900
South County <sup>2</sup>	636	669	663	650	640
Village of Mamaroneck <sup>3</sup>	17.7	18.9	17.6-18.7		
Town of Mamaroneck <sup>3</sup>	11.8	13.0	12.5-13.3		
Village of Port Chester <sup>3</sup>	25.0	25.8	23.4-24.8		

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1. Source: Westchester County Department of Planning, The Population of Westchester County, 1970-1985 (March 1975).
  2. Southern portion of Westchester County, including Rye Town, Rye City, Port Chester, Harrison, White Plains, Mamaroneck, Scarsdale, Greenburgh, New Rochelle, Pelham, Pelham Manor, Eastchester, Mount Vernon and Yonkers.
  3. Source: Westchester County Department of Planning, 1976 Current Population Estimates.

## Land Use and Development

The land use of the flooded areas of the Mamaroneck and Sheldrake Rivers and Byram River basins vary from open undeveloped lands to highly urbanized communities. Many residents of the basins are employed elsewhere, particularly in New York City. Commercial activities within the watersheds, including the operation of wholesale, retail and service establishments, are numerous and fairly well distributed. Industrial activities, including the manufacture of apparel and textile products, printing, publishing and allied products, food and kindred products, machinery, equipment and supplies, electronic products, fabricated metals, textile mill products and chemicals and allied products, are largely centered in the southern portions of the basins, although industrialization of suburban areas is steadily increasing and is expected to continue. Table 6 presents population and development projections for the study area basins for the year 1975 and for ultimate development subsequent to the year 2000.

A comprehensive plan was prepared for the Village of Mamaroneck in 1962, and in 1966 a master plan was prepared for the Town of Mamaroneck. These plans, still in effect, closely adhere to the existing land use patterns and are designed to perpetuate the existing character of the respective communities. The upper reaches of the Mamaroneck River in the Village and the Sheldrake River in the Town are zoned as low density residential areas and existing development consists almost exclusively of one-family detached dwellings. These areas are shown in aerial photographs Nos. 2 and 3, respectively. The areas downstream of the New England Thruway along the lower reaches of the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck are zoned for residential and commercial purposes mixed with light industry. As shown in aerial photograph No. 1, the principal industrial development lies in the area bounded by the New Haven Railroad and the right bank of the Sheldrake River. The Mamaroneck Harbor area in the Village generally reflects mixed zoning with the area bordering the East Basin generally commercially developed while the West Basin area is zoned for both commercial and residential uses. Table 7 presents a summary of the number and classification of structures in the Village and Town of Mamaroneck floodplain area.

A land use plan of development was prepared for the Town of Greenwich, Connecticut in 1963. The plan closely adheres to existing land use and is reflected in the zoning for the areas along the Byram River. The flood prone area along the Byram River north of West Putnam Avenue (U. S. Route 1) is zoned primarily for medium density residential structures and consists mostly of one or two family detached dwellings. The reach of the Byram River near West Putnam Avenue is zoned for business and residential uses and existing development at this area consists primarily of light industrial and commercial structures. As shown in Table 7, the Greenwich-Port Chester floodplain area is primarily residential in nature.

TABLE 6 - POPULATION AND LAND COVER PROJECTIONS  
 MAMARONECK AND SHELDRAKE RIVERS BASIN, NEW YORK<sup>1</sup>  
 AND BYRAM RIVER BASIN, NEW YORK AND CONNECTICUT

BASIN	LAND AREA (acres)	1975		ULTIMATE CAPACITY <sup>2</sup>	
		POPULATION ESTIMATE	LAND COVER <sup>3</sup> (acres)	POPULATION ESTIMATE	LAND COVER <sup>3</sup> (acres)
Mamaroneck and Sheldrake Rivers	15,100	63,000	3,100	68,000	3,800
Byram River <sup>4</sup>	19,840	36,000	2,200	43,000	2,300

1. Based on Westchester County Water Quality Planning Program projections.
2. The projections and ultimate capacities are based upon current local development controls and policies as well as the presence of significant environmental constraints. Ultimate capacities do not include development potential of small vacant parcels or potential for redevelopment of existing sites to a higher intensity.
3. Impervious surfaces.
4. Projections based on Westchester County data extrapolated to include portion of basin in Fairfield County.

TABLE 7 - CLASSIFICATION OF EXISTING STRUCTURES WITHIN FLOODPLAIN<sup>1</sup>  
 AREAS AT THE VILLAGE AND TOWN OF MAMARONECK, NEW YORK, AND  
 GREENWICH, CONNECTICUT AND PORT CHESTER, NEW YORK

<u>AREA</u>	<u>RESIDENTIAL</u>	<u>COMMERCIAL<sup>2</sup></u>	<u>INDUSTRIAL<sup>2</sup></u>	<u>PUBLIC</u>	<u>TOTAL</u>
Mamaroneck and Sheldrake Rivers					
Village of Mamaroneck, New York <sup>3</sup>	374	78	113	8	573
Town of Mamaroneck, New York	115	0	0	0	115
TOTAL	489	78	113	8	688
Byram River					
Town of Greenwich, Connecticut	206	3	1	0	210
Village of Port Chester, New York	29	0	1	0	30
TOTAL	235	3	2	0	240

1. SPF floodplain.
2. Some commercial and industrial sites contribute more than one structure.
3. Includes homes in Harrison, New York.

## TRANSPORTATION

Adequate transportation is available throughout southern Westchester County as a result of continued expansion of services to keep pace with population growth. The facilities described in the paragraphs below are located throughout Westchester County, but directly serve the Mamaroneck and Sheldrake River and Byram River basins and are economically indispensable to its residents.

### Airfields

There are no airfields within the study area basins. The nearest major airport outside of the watershed is the Westchester County Airport, which is located about 4 miles northeast of White Plains near the Connecticut border. It services all of Westchester County, including communities in surrounding areas. Helicopter service provides rapid interconnection between Westchester County Airport and other major airports in New York City.

### Railroads

The Penn-Central Railroad provides adequate rail service in the basin. The New Haven Division provides service to certain eastern Westchester and Connecticut communities. The Hudson Division services western Westchester communities, while the Harlem Division serves those communities midway between the Hudson River and Long Island Sound.

### Highways

Numerous superhighways and first class highways provide good vehicular transportation facilities. In the interstate category the New York State Thruway (Interstate Route 87) extends along western Westchester County linking New York City with Tarrytown, New York and the intervening communities. From Tarrytown, New York, this highway extends north along the Hudson and west along the Barge Canal as far as Buffalo, New York. The New England Thruway (Interstate Route 95), paralleling the Connecticut shoreline of Long Island Sound, links northeastern New York City with points in eastern Connecticut and Massachusetts. The Cross-Westchester Expressway (Interstate Route 287) connects the New York State Thruway with the New England Thruway in the vicinity of White Plains, New York. In addition, other first class highways such as the Saw Mill, Bronx and Hutchinson River (Merritt) Parkways provide service in a north-south direction while the Cross County Parkway provides service in an east-west direction linking the Saw Mill, Bronx and Hutchinson River Parkways and the New York State Thruway.

## Navigation

Navigable channels exist at the mouths of both the Mamaroneck and Byram Rivers. Federal navigation projects at Mamaroneck and Port Chester Harbors provide the respective basins with commercial opportunities. In addition to the associated commercial activity, Mamaroneck Harbor provides approximately 800 slips and 1000 moorings and Port Chester Harbor 300 slips and 40 moorings for recreational pleasure craft.

# Problems and Needs

## PROBLEM IDENTIFICATION

The citizens of the Mamaroneck and Sheldrake Rivers basin and the Byram River watershed have each experienced recent flood related economic losses and human misery and have long recognized the potential for flood damage and threats to human life which may occur in the future. Protection from these potential losses have been sought by local interests in both watersheds for many years. The existing flood hazard and associated flood damages constitute by far the most serious water resources problem in each of the study area basins.

## PAST FLOODS

The largest floods of record in the Mamaroneck and Sheldrake Rivers basin, and Byram River watershed occurred in 19-27 September 1975, and 14-18 October 1955, respectively. The September 1975 flood had an estimated peak discharge of 4,260 cubic feet per second on the Mamaroneck River at the Mamaroneck gage in the Village of Mamaroneck. The flood of October 1955 had an estimated peak discharge of 4,520 cubic feet per second on the Byram River at West Putnam Avenue (U. S. Route 1). Data concerning peak discharges of the most notable floods in the study area basins are contained in Appendix A.

## THE FLOODING PROBLEM

Flooding in the Mamaroneck and Sheldrake Rivers and Byram River basins, which occurs principally from runoff caused by precipitation of high intensity or prolonged duration, has an adverse effect on the economy and the general well-being of the flood-prone areas. Flooding causes physical damage to property and loss of commercial, industrial and public activity, with consequent loss of business and wages. Rail and vehicular traffic

are also affected adversely with consequent loss to those who depend on these modes of transportation. In addition to the foregoing, recurring flooding represents a threat to the health and safety of those who live or work in these areas. The extent and character of the flooded areas within the study area basins are discussed in the following paragraphs.

## Mamaroneck and Sheldrake Rivers Basin

### Village of Mamaroneck, New York

During the June 1972 flood, hundreds of residents, employees and school children were evacuated by boats and trucks as the Mamaroneck and Sheldrake Rivers overflowed their banks, inundating local streets and numerous homes and business establishments. Areas inundated in the Village of Mamaroneck from this flood include approximately 107 acres of industrial, commercial and residential property. Along the Mamaroneck River the flood damage area is located on both banks between Ward Street and First Street. From First Street upstream to the New England Thruway damages are confined to the left bank and in the reach between Chestnut Avenue and the Joint Waterworks Dam; the Village flood damage area lies on the right bank. Along the Sheldrake River the flood damage area is on both banks between the confluence with the Mamaroneck River and Fenimore Road. Between Fenimore Road and the Village line the damage area lies on the right bank. During the June 1972 storm, 26 industrial structures, 33 commercial establishments, 5 public buildings and 207 dwellings were flooded. Columbus Park was completely submerged. The industrial park was inundated to a depth of two feet and many businesses were not able to resume production for a week or more. Hardest hit industrial areas were at the Sealectro Corporation Plant on Hoyt Street, where 60 employees were evacuated, and Bordow Corporation, located at Mamaroneck and Jefferson Avenues, which had several feet of water in its buildings. The main floors of many dwellings between Mamaroneck Avenue and the Mamaroneck River were flooded to a depth of one foot. Other areas with significant damages include the residential and business areas of the Washingtonville section of the Village of Mamaroneck, and residents who live along the upper Mamaroneck River on Chestnut and Winfield Avenues in the village. Along Chestnut Avenue basements were flooded to a depth of 5 feet causing severe content damage. Several homes along Winfield Avenue suffered first floor flooding when the Winfield Avenue Bridge was overtopped. If the Standard Project Flood were to occur along the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck, approximately 300 acres would be inundated up to depths in excess of 16 feet. See Figure D2, Appendix D, for the June 1972 and SPF flood limits in the Village of Mamaroneck.

### Town of Mamaroneck, New York

Areas inundated in the Town of Mamaroneck from the September 1975 flood of record along the Sheldrake River include approximately 21 acres of residential property. The flood damage area is located on both banks

of the Sheldrake River from Hickory Grove Drive to the Bonnie Briar Country Club. During the September 1975 flood, 80 dwellings, including 8 homes along the East Branch, were flooded. The homes along the main stream suffered severe structural and property damage. In many of these buildings the concrete basement floor slabs cracked and swelled. The floodplain of the Standard Project Flood along the Sheldrake River includes an area of approximately 32 acres which contains 115 homes. See Figure D3, Appendix D, for the June 1972 and SPF flood limits in the Town of Mamaroneck.

#### Town of Harrison, New York

Areas inundated in the Town of Harrison during the June 1972 flood include Maple Moor Golf Course, the Hutchinson River Parkway and approximately 9 acres of residential property along the left bank of the Mamaroneck River, from West Street upstream to Winfield Avenue. In this latter reach, the Mamaroneck River forms the boundary with the Village of Mamaroneck, and this area lies directly across from the Chestnut Avenue area in the Village. During the June 1972 storm, 10 dwellings at this area experienced basement and grounds flooding. The Standard Project Flood would inundate this area to depths in excess of ten feet. Damages also occurred along the East Branch of the Mamaroneck River during the June 1972 storm. During this flood, and also the September 1975 flood, approximately 6 homes on Pine Hurst and Tamershan Drives, and Duxbury Lane suffered basement and grounds damage.

#### Village of Scarsdale, New York

The Fenway Golf Club and 1 acre of residential property along the East Branch of the Sheldrake River were flooded during the June 1972 storm. The damages to the affected homes along Cayuga, Seneca, Canterbury and Oneida Roads were limited to grounds and basements. The Standard Project Flood would inundate several structures, and would result in considerable damage to the grounds and basements of most of the homes in this reach.

#### Byram River Basin

#### Town of Greenwich, Connecticut and Port Chester, New York

Areas inundated in the Greenwich-Port Chester area from the June 1972 flood include approximately 39 acres of commercial, industrial and residential property. The flood damage area is located between West Putnam Avenue (U. S. 1) and Rex Street on the left bank, and between West Putnam Avenue and the old Homelite Factory on the right bank. During the June 1972 storm, 2 industrial structures, 3 commercial establishments and 66 residences were inundated. Several homes had flood waters above the main floor. The October 1955 flood of record produced stages approximately 2.3 feet higher than the June 1972 storm and the Standard Project Flood would inundate an area of approximately 60 acres to depths up to 16 feet.

In addition to damage at the Greenwich and Port Chester areas described above, the 1955 storm resulted in damage to twelve town roads in North Castle, New York and several dwellings in Riversville (Town of Greenwich), Connecticut.

## EXISTING CORPS OF ENGINEERS PROJECTS

### Flood Control

A flood control project was constructed by the Corps of Engineers on the Byram River at Pemberwick, Connecticut. This project was constructed in 1961 under Public Law 685, 84th Congress. The project consists of approximately 3,000 feet of channel modification including realignment, widening and deepening of the channel and construction of earthen levees. Construction was commenced on 25 July 1959 and was completed in August 1961. The cost of the project to 30 June 1974 was \$363,515.

### Navigation

Federal navigation projects have been constructed in the estuaries of the Mamaroneck and Byram Rivers, as previously noted. However, neither of these improvements has any effect on flood conditions along the subject streams. The project at Mamaroneck Harbor, which was adopted in 1922 and modified in 1935 and 1960, consists of a main channel from Long Island Sound to just below Boston Post Road, a branch channel extending 300 feet northeast of the main channel, two anchorages near the head of navigation in the East Basin, and an anchorage in the West Basin with a connecting channel to the main channel. The project at Port Chester Harbor, which was adopted in 1910 and modified in 1930, consists of about 1.7 miles of channel from Long Island Sound to Mill Street, a turning basin, breakwater at Byram Point, an anchorage near the breakwater and fenders opposite Fox Island.

## IMPROVEMENTS BY OTHER FEDERAL AGENCIES

No flood control improvements constructed by other Federal agencies are located within the study area basins. However, the Village of Mamaroneck in the Mamaroneck-Sheldrake Rivers basin has on two occasions received Federal funds for implementing locally-conceived flood control improvements on the Mamaroneck and Sheldrake Rivers. In 1933, using Federal work relief funds, the village cleared the channels of these streams within its corporate limits. In 1937, using Works Progress Administration funds, the channel of the Mamaroneck River was widened to 30 feet and masonry walls were constructed from North Barry Avenue to Jefferson Avenue, a distance of 2,400 feet. Only the middle 1,000 feet of this project centered

on Hillside Avenue now remain, the upper reach having been replaced by a channel relocation required for the construction of the New England Thruway and the lower reach, by channel work done by the village in 1953 and 1954.

## IMPROVEMENTS BY NON-FEDERAL AGENCIES

Numerous improvements for flood control, including considerable channel rectification, have been made throughout the study area basins, although there are still long reaches of the streams which are in a natural or near-natural state. Also, in certain instances channel relocations and other work unrelated to flood control have produced some flood control benefits. However, many of these improvements are of limited value since their effect on relatively severe floods is minimal and therefore are not considered further in this report. Only those improvements which are of substantial significance are described in subsequent paragraphs.

In 1953-1954 the Village of Mamaroneck straightened the Mamaroneck River between Nostrand and Jefferson Avenues and deepened it between Halstead Avenue and a point downstream of the U.S.G.S. gaging station weir. This work has resulted in lower stages than would otherwise have prevailed during the substantial floods which have occurred since the completion of this work.

In connection with the construction of the New England Thruway in the early 1950's, two reaches of channel of the Mamaroneck River totalling 1800 feet in length were improved within the reach of stream extending from the vicinity of the south end of First Street to the Town of Harrison boundary line. Wider channels on better alignments were provided and the old low, short-span bridge at North Barry Avenue was replaced with a higher, longer triple-span structure on a new alignment several hundred feet downstream of the old bridge. Also in connection with the construction of the Thruway, two reaches of channel of the Sheldrake River totalling nearly 3,000 feet in length within the reach of stream extending from the vicinity of Larchmont Gardens Lake to a point 600 feet below Fenimore Road were replaced with wider reaches on better alignments, and old, low, short-span bridges at Rockland Avenue and Fenimore Road were replaced with higher, longer, twin-span structures.

## FLOOD DAMAGES

The principal flood damage areas in the Mamaroneck and Sheldrake Rivers basin are located at the Village and Town of Mamaroneck, the Town of Harrison, and the Village of Scarsdale. In the Byram River basin, flood damages primarily occur at the Town of Greenwich, Connecticut and the Village of Port Chester, New York. Flood damages in the basins affect a wide

range of land use, which varies from open, undeveloped lands to highly urbanized communities. As a result, flood damage is incurred because of physical damage to property, loss of commercial, industrial and public activity and impaired rail and vehicular traffic. In addition, damages affect the economy and general well-being of the flooded areas. Damage estimates are based on field surveys made by the Corps of Engineers in connection with previous flood control reports, a survey made in 1956 to determine flood damages resulting from the flood of October 1955, and more recent surveys made in 1964, 1965, 1971, 1972, 1975 and in 1976. In addition, information on damages was furnished by local interests. All damage estimates have been converted to December 1976 price levels by the application of appropriate updating techniques.

## FLOODS OF RECORD

The most damaging floods of record resulted from the storms of 15-16 October 1955, 19 June 1972 and 26-27 September 1975. Property and material losses were high for each of these floods in both study area basins. Damages within the Mamaroneck and Sheldrake Rivers basin for the June 1972 and September 1975 floods, including allowances for emergency costs incurred in anticipating or fighting the flood and resulting business and financial losses within the flood areas, are estimated at \$3,500,000 and \$19,700,000, respectively. The damages within the Byram River basin for the October 1955 and June 1972 floods are estimated at \$1,334,000 and \$483,000, respectively. However, a recurrence of the October 1955 flood along the Byram River would result in flood damages of \$1,066,000 when considering existing conditions of development and the damages that would be prevented by the existing Corps' project at Pemberwick, Connecticut. A detailed tabulation of flood damages within the basins, including date of flood, type and location of damages, and the estimated value of recurring damage, is contained in Table 8. Flood damages within the Mamaroneck and Sheldrake Rivers and Byram River basins are discussed in considerable detail in Appendix D.

## LOSS OF LIFE

During the September 1975 flood of record on the Mamaroneck River, one person was drowned when the car he was traveling in was submerged. People have been evacuated from areas along both the Mamaroneck and Sheldrake Rivers, and Byram River because of flooding, but there are no records of the number of people evacuated or the length of time they were required to stay away from their homes. However, Red Cross estimates indicated that more than 200 people were evacuated in Mamaroneck during the September 1975 flood.

TABLE 8 - SUMMARY OF ESTIMATED RECURRING FLOOD DAMAGES  
MAMARONECK AND SHELDRAKE RIVERS BASIN, N.Y.

AND

BYRAM RIVER BASIN, CONN. AND N.Y.  
(DECEMBER 1976 PRICE LEVEL IN DOLLARS)

Basin & Community	Flood	DAMAGE CLASSIFICATION						Total
		Residential	Commercial	Industrial	Public	Rail- road	Utilities	
<u>Mamaroneck and Shel Drake Rivers Basin</u>								
Village of Mamaroneck	June 72	\$1,206,200	\$ 634,700	\$1,030,800	\$347,900	0	\$ 51,000	\$3,270,600
	Sept 75	5,000,000	2,804,000	10,000,000	1,000,000	0	300,000	19,104,000
Town of Mamaroneck	June 72	178,000	0	0	3,000	0	0	181,000
	Sept 75	525,500	0	0	4,000	0	0	529,500
Town of Harrison	June 72	22,000	0	0	3,000	0	0	25,000
	Sept 75	66,000	0	0	4,000	0	0	70,000
Village of Scarsdale	June 72	9,000	0	0	1,000	0	0	10,000
<u>Byram River Basin</u>								
Town of Greenwich	Oct 55	730,000	0	12,000	5,000	0	80,000	827,000
	June 72	346,000	0	6,250	3,000	0	43,625	398,875
Town of Port Chester	Oct 55	125,500	0	43,300	2,000	0	11,700	182,500
	June 72	57,380	0	20,000	1,000	0	5,350	83,730
Town of North Castle	Oct 55	0	0	0	56,400	0	0	56,400

## IMPROVEMENTS DESIRED

A public hearing was held in White Plains, New York, on 24 January 1956, by the District Engineer to obtain the views of local interests as to what could be done to alleviate the flood problems along the various streams of Westchester County, New York, and the Byram River, New York and Connecticut. Flooding resulting from the overflow of the Mamaroneck and Sheldrake Rivers, and Byram River was discussed. At this hearing local interests at the Village and Town of Mamaroneck, City of New Rochelle, Village of Port Chester, New York and Town of Greenwich, Connecticut expressed desires for some type of flood control improvement. Subsequently, many public hearings, meetings with local officials and small meetings with local citizens were conducted in connection with flood control studies along the Mamaroneck, Sheldrake and Byram Rivers previously discussed. In addition, plan formulation stage public meetings were held in Greenwich, Connecticut on 30 October 1975, and in Mamaroneck, New York on 29 March 1976, to obtain views and comments of local interests and other interested parties regarding the flood control improvements along the Byram River, and Mamaroneck and Sheldrake Rivers, respectively, which are under study in this report. A late stage meeting was held for both study areas in Rye, New York on 31 January 1977 to further acquire views and comments of local interests and to obtain assurances of local cooperation. A digest of these meetings is contained in Appendix H.

## MOST PROBABLE FUTURE CONDITIONS

In order to develop plans which would be responsive to both the immediate and future needs of the flood-prone communities of the Mamaroneck and Sheldrake Rivers and Byram River basins and to the overall goals of the region, future conditions were projected based on available planning data and information obtained from various Federal, state and local agencies. The most probable future for the flood-prone areas within the subject basins assumes a basically stable level of development for the flood plains and a continuation of the present patterns. This is so, because residential, commercial and industrial uses generally require specialized structures which have remained in these particular areas for a significant period in the past (due to the desirable features of the areas, such as low transportation costs caused by easy access and close proximity to New York City). Since floodplain regulations minimize new construction in areas which are subject to damage by the 100 year flood, it is considered that future reallocations of new residential, commercial and industrial uses are not likely. If the areas are considered to remain a viable segment of their respective communities in the future, the most probable future is expected to be one of a stable, almost fully developed, floodplain with relatively few new developments. The population, per capita income, output, etc. ascribed to the areas under the most probable future are discussed in detail in Appendix G.

## PLANNING OBJECTIVES

The lists in the following paragraphs comprise the final array of planning objectives derived by analyzing the water and related land resources problems and needs of the Mamaroneck and Sheldrake Rivers and Byram River basins, respectively, in relation to the most probable future, and reflects several iterations of the planning process. Thus, the planning objectives listed below provide a basis for plan formulation. These objectives primarily address the serious flood control problems and other associated needs, such as the preservation of open space, and fish and wildlife at the flood problem areas, within each of the subject basins. The objectives addressing the associated environmental needs were directed at preserving and maintaining the existing stream resources. As previously discussed, no highly productive habitat areas such as salt water marshes or fresh water wetlands exist within the study areas. Rather, the problem areas are urban in nature with the lower reaches of the streams burdened with pollution load. Thus, when considering that the environmental quality aspects of the respective streams are generally degraded and have a limited potential for enhancement, and that there are no other environmental problems and needs other than the preservation of the existing stream resources and certain aesthetically pleasing reaches along the streams, the enhancement and management of environmental resources was not considered as an appropriate component of the planning objectives. Comprehensive recreational enhancement was not considered in light of the extensive number and variety of recreational facilities which exist in or near the Mamaroneck and Sheldrake Rivers and Byram River basins, and indications by local interests that there is no desire to incorporate recreational features into plans of flood protection.

The development of water supply sources within the subject basins was also not considered as a planning objective. Westchester communities within the Mamaroneck and Sheldrake Rivers basin, for example, have abandoned existing reservoirs and treatment facilities which were formerly used for water supply purposes in lieu of the more economical purchase of water supplies from New York City sources; hence, the further development of water supply facilities is not considered appropriate for this study, but should be addressed in a study of larger geographical scope which would include the area tributary to the New York City water supply system. A cultural resources reconnaissance study has indicated that no resources in the Mamaroneck and Sheldrake Rivers and Byram River study areas are eligible for nomination into the National Register of Historic Places, and that no other significant archeological or cultural resources are known to exist. Additionally, the needs of the watersheds with regard to wastewater treatment and water quality problems are considered under programs of other Federal, State and local governmental agencies and are not treated in this study, except for the prevention of further degradation of water quality through stream bank erosion at the flood problem areas. The specific objectives developed for the Mamaroneck and Sheldrake Rivers and Byram River basins are presented in the following paragraphs.

## MAMARONECK AND SHELDRAKE RIVERS

The final array of planning objectives for the Mamaroneck and Shel-drake Rivers are listed below:

- a. Reduction of the flood hazard and associated urban flood damages in the Village and Town of Mamaroneck.
- b. Preserve and maintain the resources of the existing stream environment.
- c. Preserve existing open space areas and associated recreational opportunities.

## BYRAM RIVER

The final array of planning objectives for the Byram River are listed below:

- a. Reduction of the flood hazard and associated urban flood damages in the Town of Greenwich, Connecticut and Village of Port Chester, New York.
- b. Preserve and maintain the resources of the existing stream environment.
- c. Maintain the existing water levels and associated recreational opportunities at Pemberwick Lake.

## FORMULATION AND EVALUATION CRITERIA

The development of alternate plans, including the screening of individual measures and entire alternatives, must of necessity be within the context of an appropriate set of formulation criteria. Such criteria, technical, economic, environmental, social and other intangible considerations, permit the development of alternatives which would, as a minimum, make a partial contribution to objective fulfillment while responding to the problems and needs of the study area. The environmental criteria applied in the formulation of plans of protection was directed towards achieving the National Economic Development (NED) and Environmental Quality (EQ) as equal objectives, as required by the Water Resources Council's Principles and Standards. Such formulation and evaluation criteria are discussed in detail in Appendix F.

# Plan Formulation

## MAMARONECK AND SHELDRAKE RIVERS

The formulation portions of this study involved the development and analysis of alternative plans through repeated iterations of the functional planning tasks (problem identification, formulation of alternatives, impact assessment, and evaluation) to achieve the planning objectives outlined above for each study area basin. The formulation and evaluation of all possible alternatives were based on the Water Resources Council's Principles and Standards and related Corps regulations and guidelines.

After establishing the planning objectives and the formulation and evaluation criteria, the formulation procedure next required the identification of applicable water resources management measures which address the planning objectives. Every attempt was made to identify all appropriate measures without bias and without regard to who might be capable of implementing the measure. After all applicable water resources management measures were identified, alternative water resources management plans were developed from either one, or a combination, of the identified measures. The formulation phase of the Mamaroneck and Sheldrake Rivers study is presented in detail in Section 2, Appendix F. A summary of this process follows below.

### POSSIBLE SOLUTIONS

Flood problems in the Mamaroneck and Sheldrake Rivers basin are centered largely along the mainstreams in the Village and Town of Mamaroneck, and also along the East Branch of the Mamaroneck River in the Town of Harrison and the East Branch of the Sheldrake River in the Village of Scarsdale and Town of Mamaroneck. Accordingly, since flood control is the primary objective of this study, for the possible solutions to meet the water resources problems and needs of Mamaroneck and Sheldrake Rivers basin, they must consider the reduction of flood damages at the above-mentioned problem areas. Several alternative measures to satisfy the problems and needs of the flood areas are possible; however, some of these measures are not practical or economical. The possible solutions may be divided into the two broad categories of nonstructural and structural measures. Nonstructural measures include floodplain zoning, floodproofing, building code regulations, permanent and/or temporary evacuation of floodplain areas, and no action (or maintaining the base condition). Structural measures include reservoirs, diversions, channel modification, levee and floodwall improvements, and several combinations of these. Also, combinations of nonstructural and structural measures are possible. Table 9 presents a

preliminary categorization of the possible management measures in relation to the planning objectives of the Mamaroneck and Sheldrake Rivers study area.

## NONSTRUCTURAL MEASURES

The various nonstructural techniques are described in considerable detail in Appendix F, Plan Formulation. During the initial iterations of the planning process, the nonstructural measures discussed above were examined with respect to their: (a) result in achieving the planning objectives; (b) cost of implementation; and (c) intangible advantages and disadvantages. This investigation indicated that nonstructural plans of protection warrant further consideration only at the Village and Town of Mamaroneck along the Mamaroneck and Sheldrake Rivers. Nonstructural techniques applied to the damage areas along the East Branch of the Mamaroneck River in Harrison would reduce residential content damage; however, total damages would not be reduced substantially because of the large proportion of public damages. At the problem area in Scarsdale, along the East Branch of the Sheldrake River, flooding occurs largely on grounds, driveways and streets, and the cost to implement nonstructural measures for flood-prone structures would far exceed the damages prevented. The nonstructural alternates considered at the Village and Town of Mamaroneck are discussed further in subsequent sections.

## STRUCTURAL MEASURES

Subsequent to investigating possible nonstructural solutions, structural flood control measures were considered. A variety of structural measures exist for reducing flood damages, as well as minimizing or preventing the occurrence of floods. These measures include flood detention reservoirs, flood diversions, local protection measures such as levees, floodwalls and channel modifications, and combinations of each of the foregoing structures. A preliminary investigation was made to determine the structural measures required to prevent damages experienced up to the floods of record along the various reaches of the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, Harrison and Scarsdale. The evaluation revealed that only along the Mamaroneck River at the Village of Mamaroneck, and the Sheldrake River at the Village and Town of Mamaroneck were flood damages sufficient to warrant further investigation of structural flood protection. The structural measures considered as possible solutions for the flood problems at these areas are fully described in Appendix F, and are discussed in the following paragraphs.

## RESERVOIRS

There are several upstream sites within the Mamaroneck and Sheldrake Rivers basin at which flood detention reservoirs are possible, as shown on

TABLE 9 - PRELIMINARY CATEGORIZATION OF MANAGEMENT MEASURES  
MAMARONECK AND SHELDRAKE RIVERS, N.Y.

STUDY AREA	MANAGEMENT MEASURES															
	NONSTRUCTURAL MEASURES							STRUCTURAL MEASURES								
	FLOODPROOFING	PERMANENT EVACUATION	TEMPORARY EVACUATION	RELOCATION	ZONING	FLOODWARNING SYSTEMS	BUILDING CODES	TAX ADJUSTMENTS	FLOOD INSURANCE	NO ACTION	RESERVOIRS	DIVERSIONS	LEVEES/FLOODWALLS	CHANNEL MODIFICATION	STRUCTURAL COMBINATIONS	STRUCTURAL AND COMB.
MAMARONECK AND SHELDRAKE RIVERS																
PLANNING OBJECTIVES																
Flood Damage Reduction	*	**	*	**	0	*	0	*	*	-	**	**	**	**	**	*
Stream Environment Preservation	**	**	**	**	**	**	**	**	**	**	0	0	0	0	0	*
Open Space Preservation	*	**	*	**	*	*	*	*	*	*	*	*	*	*	*	*

LEGEND

- \*\* MOST POSITIVE CONTRIBUTION
- \* POSITIVE CONTRIBUTION
- NEGATIVE CONTRIBUTION
- 0 UNKNOWN OR NEUTRAL

Plate 2. These sites include two areas which are currently occupied, in part, by existing reservoirs which were formerly used for water supply purposes. These facilities, which were used until recently as standby reserves to the supplies obtained from the New York City water supply system, are Larchmont Reservoir No. 2 along the Sheldrake River, and the Westchester Joint Water Works Reservoir on the Mamaroneck River. Additional sites exist along the Mamaroneck River at Maplemoor Golf Course and at Silver Lake. However, the development of a flood storage reservoir at each of these sites was precluded because of excessive costs and/or limited regulation and effectiveness at the downstream areas. The investigation of flood detention at each of the possible sites is discussed in paragraphs F23 through F28 of Appendix F.

## DIVERSIONS

The upstream diversion of stream flow which is in excess of the natural bankfull channel capacity at downstream damage areas is possible when there are bodies of water into which the diverted flow can be safely discharged without creating or worsening flood problems. The flood damage areas along the Mamaroneck and Sheldrake Rivers in the Village of Mamaroneck are favorably located for such diversion with respect to Mamaroneck Harbor of Long Island Sound. Diversion systems investigated along the Mamaroneck River, however, were precluded because of either highly excessive costs, limited effectiveness, or technical unfeasibility, as discussed in paragraphs F29 through F31 of Appendix F. Along the Sheldrake River two schemes were investigated which considered the diversion of flood flows upstream of the damage reach in the Village of Mamaroneck, at Larchmont Gardens Lake. However, as discussed in paragraph F33, it was found that the point of diversion at Larchmont Gardens Lake lies sufficiently far upstream from the damage center so as to allow the incremental flows that are generated from local runoff in the drainage area below the diversion to result in substantial flood losses in the Village. Therefore, in addition to either of the tunnel diversions, local protection works would still be required along the Sheldrake River, below the point of diversion, for protection against less frequent storms, resulting in excessive costs. For this reason, and as discussed in paragraph F34, Appendix F, further consideration was given to a tunnel along the Sheldrake River with its point of diversion further downstream at Fenimore Road, closer to the damage center, so as to reduce the drainage area generating the incremental flows below the diversion inlet.

## LOCAL PROTECTION MEASURES

After most of the reservoir and diversion considerations were precluded, it became evident that because of the physical characteristics of the watershed and location of the damage areas, the flood control objective for the

study area could best be achieved by local protection and channel modification measures, possibly in combination with the above-mentioned diversion scheme at Fenimore Road for the lower Shelldrake River in the Village of Mamaroneck. Local protection measures such as levees, floodwalls, channel modifications and various combinations of each were considered as possible solutions to the flood problem along the Mamaroneck and Shelldrake Rivers at the Village and Town of Mamaroneck. The Village of Mamaroneck and Town of Mamaroneck study area locations are shown in Plate 4.

## NONSTRUCTURAL AND STRUCTURAL COMBINATIONS

Providing a relatively low level of flood protection by structural methods does not appear to be a practical solution along the Mamaroneck and Shelldrake Rivers since this would only encourage development in areas that would still be subject to flooding from larger storms. However, at independent reaches of stream where nonstructural measures can be selectively substituted for structural measures, at a compatible level of protection, overall combination plans of protection were considered as possible solutions. Additionally, flood plain management techniques should be considered at flood problem areas where structural and other nonstructural solutions are not feasible. The most appropriate measure for these areas is often zoning regulations which would prevent any large increases in future flood damages.

## DEVELOPMENT OF INTERMEDIATE PLANS

As a result of reconnaissance and preliminary type estimates, preliminary screening and analysis of applicable measures, an array of alternative plans that could fulfill the study objectives for the Mamaroneck and Shelldrake Rivers were developed utilizing either one or a combination of the applicable water resources management measures described in the preceding paragraphs. Only alternative plans which were considered to approach economic, environmental and social acceptability were evaluated in detail and presented here. To provide a common base for evaluation, and to facilitate quantitative and qualitative analyses and comparisons, protection against a flood with a one percent exceedence frequency was used as the protection level in the initial development of alternative plans. This degree of protection was selected because, as explained in detail in Appendix F, complete protection against the Standard Project Flood (SPF) is clearly not economically justified at the study areas along the Mamaroneck and Shelldrake Rivers. Additionally, based on factors such as projected residual damages and the potential for a catastrophe at the study area, protection against a flood with a one percent exceedence frequency is considered the minimum degree of protection acceptable along the Mamaroneck and Shelldrake Rivers. In applying this approach, it was recognized that the design storm for the selected plans of protection could actually be greater than the one percent

flood, depending on the tradeoffs between an acceptable flood risk and socio-economic and environmental costs. Those plans which warranted further consideration are described fully in Appendix F and are briefly outlined below.

## INTERMEDIATE PLANS - MAMARONECK AND SHELDRAKE RIVERS

The Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck can be divided into three study reaches for clarity during further formulation of alternatives. The lower Mamaroneck and Sheldrake Rivers, in the Village of Mamaroneck, lies along the Mamaroneck River from its mouth upstream to the New England Thruway, and along the Sheldrake River from its confluence with the Mamaroneck River upstream to the Thruway. The upper study reach along the Mamaroneck River in the Village of Mamaroneck lies from the New England Thruway upstream to Winfield Avenue; and the study area along the Sheldrake River in the Town of Mamaroneck lies from the Thruway upstream to Bonnie Briar Lane. These study reaches are shown in Figure F2 of Appendix F.

The alternative plans outlined below are described in considerable detail in Section 2, Appendix F, and are presented in Figures F3 through F11. Table 10 presents a summary description of the alternatives considered for each of the three study reaches, and an economic comparison of the alternatives is presented in Table 11.

## VILLAGE OF MAMARONECK - LOWER MAMARONECK AND SHELDRAKE RIVERS

A total of six alternatives were generated for consideration for the lower Mamaroneck and Sheldrake Rivers at the Village of Mamaroneck. Of these six alternatives, one is a nonstructural plan, three plans consist of combinations of levees, floodwalls and channel modification, one plan involves levees, floodwalls and channel modification along the Mamaroneck River in combination with diversion works along the Sheldrake River, and one plan consists of a combination of levees and floodwalls. In addition to these alternates, schemes which consist of only channel modification measures along the Mamaroneck and Sheldrake Rivers were also considered during the intermediate planning stage, but these alternatives did not approach engineering, economic or social acceptability. These intermediate plans are discussed in considerable detail in Appendix F, while summary descriptions and economic data are contained in Tables 10 and 11.

## VILLAGE OF MAMARONECK - UPPER MAMARONECK RIVER

Three alternative plans were considered along this reach of the Mamaroneck River in the Village of Mamaroneck. These plans include a non-structural alternate, a floodwall and levee plan, and a channel modification plan, each of which is summarized in Table 10.

TABLE 10 - SUMMARY DESCRIPTION OF INTERMEDIATE PLANS  
MAMARONECK AND SHELDRAKE RIVERS, NEW YORK

<u>AREA</u>	<u>DESCRIPTION</u>
<u>Lower Mamaroneck and Sheldrake Rivers</u>	
Nonstructural Plan	220 residential, commercial, industrial and public structures floodproofed; 230 residential structures acquired.
Plan 1	Modified 50-30 ft. channel (5,600 LF), and levees (3,000 LF) and floodwalls (3,725 LF) along the Mamaroneck River; modified 20-30 ft. channel (5,800 LF), and levees (2,450 LF) and floodwalls (3,900 LF) along the Sheldrake River.
Plan 2	Modified 60-37 ft. channel (5,600 LF), and levees (2,400 LF) and floodwalls (3,725 LF) along the Mamaroneck River; modified 22-30 ft. channel (5,800 LF), and levees (2,400 LF) and floodwalls (3,450 LF) along the Sheldrake River.
Plan 3	Modified 70-45 ft. channel (6,000 LF), and levees (1,700 LF) and floodwalls (3,700 LF) along the Mamaroneck River; modified 25-30 ft. channel (5,800 LF), and levees (2,350 LF) and floodwalls (3,150 LF) along the Sheldrake River.
Plan 4	Modified 70-45 ft. channel (6,000 LF), and levees (1,700 LF) and floodwalls (3,700 LF) along the Mamaroneck River; modified 25 ft. channel (650 LF) and tunnel diversion works along Sheldrake River.

TABLE 10 (continued)

<u>AREA</u>	<u>DESCRIPTION</u>
Plan 5	Levees (1,150 LF) and floodwalls (4,800 LF) along the Mamaroneck River; and levees (650 LF) and floodwalls (5,750 LF) along the Sheldrake River.
<u>Upper Mamaroneck River</u>	
Nonstructural Plan	15 homes floodproofed and 16 residential structures acquired.
Floodwall and Levee Plan	Floodwall (1,600 LF) and levee (200 LF) along the Mamaroneck River.
Channel Modification Plan	Modified 45 ft. channel (3,000 LF) and levees (1,400 LF) along the Mamaroneck River.
<u>Upper Sheldrake River</u>	
Plan I	Modified 12 ft. concrete rectangular channel (1,800 LF); tie-back levees; stilling basin.
Plan II	Modified 16 ft. concrete rectangular channel (1,800 LF); tie-back levees; stilling basin.
Plan III	Modified 12 ft. earthen trap. channel (1,800 LF); tie-back levees.
Plan IV	Floodwall (2,850 LF) and levee (750 LF) along Sheldrake River.

TABLE 10 (continued)

<u>AREA</u>	<u>DESCRIPTION</u>
Plan V	Modified 17.5 ft. concrete rectangular channel (1,600 LF) with floodwall; tie-back levees.
Plan Va	Modified 17.5 ft. concrete rectangular channel (1,600 LF); tie-back levees.
Plan VI, VIA	Modified 12 ft. earthen trap. channel (3,700 LF); tie-back levees; stilling basin.
Plan VII	Modified 12-14 ft. concrete rectangular channel (3,700 LF); tie-back levees; stilling basin.
Plan VIII, VIIIa, IX	Modified 12 ft. concrete (2,200 LF) and earthen (1,500 LF) channel; tie-back levees; stilling basin.
Plan X	Floodwall (5,900 LF) and levee (1,200 LF) along the Sheldrake River.
Nonstructural Plan I	24 homes floodproofed and 15 residential structures acquired.
Nonstructural Plan II	45 homes floodproofed and 30 residential structures acquired.

TABLE 11 - ECONOMIC EVALUATION OF ALTERNATIVES  
VILLAGE AND TOWN OF MAMARONECK, N.Y.

DECEMBER 1976 PRICE LEVEL IN DOLLARS  
(100 Year Project Life and 6-3/8% Interest Rate)

ALTERNATIVE	NON-FEDERAL FIRST COST	FEDERAL FIRST COST	TOTAL FIRST COST	ANNUAL MAINTENANCE & OPERATION	TOTAL ANNUAL COST	ANNUAL (1) BENEFITS	BENEFIT- COST RATIO	EXCESS BENEFITS OVER COST
<u>LOWER MAMARONECK AND SHELDRAKE RIVERS, VILLAGE OF MAMARONECK</u>								
NON-STRUCTURAL PLAN								
PLAN 1	4,800,000	12,600,000	17,400,000	36,000	1,150,000	1,640,000	1.43	490,000
PLAN 2	5,700,000	13,600,000	19,300,000	33,000	1,270,000	1,790,000	1.41	520,000
PLAN 3	5,800,000	14,700,000	20,500,000	32,000	1,350,000	1,960,000	1.45	610,000
PLAN 4	4,400,000	20,400,000	24,800,000	20,000	1,610,000	2,310,000	1.43	700,000
PLAN 5	7,900,000	12,200,000	20,100,000	25,000	1,310,000	1,240,000	0.9	-70,000
<u>UPPER MAMARONECK RIVER, VILLAGE OF MAMARONECK</u>								
NON-STRUCTURAL PLAN								
FLOODWALL AND LEVEE PLAN	140,000	1,030,000	1,170,000	3,000	78,000	111,000	1.4	33,000
CHANNEL MODIFICATION PLAN	410,000	620,000	1,030,000	8,000	74,000	130,000	1.8	56,000

(1) Includes benefits from flood damage reduction, advanced replacement of bridges and NED employment.

TABLE 11 (CONT'D.) - ECONOMIC EVALUATION OF ALTERNATIVES  
VILLAGE AND TOWN OF MAMARONECK, N.Y.

DECEMBER 1976 PRICE LEVEL IN DOLLARS  
(100 Year Project Life and 6-3/8% Interest Rate)

ALTERNATIVE	NON-FEDERAL FIRST COST	FEDERAL FIRST COST	TOTAL FIRST COST	ANNUAL MAINTENANCE & OPERATION	TOTAL ANNUAL COST	(1) ANNUAL BENEFITS	BENEFIT- COST RATIO	EXCESS BENEFITS OVER COST
<u>UPPER SHELDRAKE RIVER, TOWN OF MAMARONECK</u>								
<u>INITIAL INTERMEDIATE PLANS (2)</u>								
<u>NON-STRUCTURAL PLAN I</u>								
PLAN I	300,000	1,320,000	1,960,000	2,500	133,000	170,000	1.3	37,000
PLAN II	500,000	1,700,000	2,200,000	2,000	143,000	221,000	1.5	78,000
PLAN III	1,270,000	1,000,000	2,270,000	3,000	148,000	224,000	1.5	76,000
PLAN IV	350,000	2,130,000	2,480,000	7,500	166,000	207,000	1.2	41,000
PLAN V	540,000	1,670,000	2,210,000	2,000	145,000	215,000	1.5	70,000
PLAN Va	510,000	1,500,000	2,010,000	2,000	131,000	211,000	1.6	80,000
<u>REFORMULATED INTERMEDIATE PLANS *</u>								
<u>NON-STRUCTURAL PLAN II(3)</u>								
PLAN VI (4)	1,700,000	1,890,000	3,780,000	4,500	246,000	258,000	1.05	12,000
PLAN VIa (4)	1,700,000	1,880,000	3,590,000	4,000	233,000	316,000	1.4	83,000
PLAN VII (5)	730,000	3,410,000	4,140,000	3,000	268,000	343,000	1.3	75,000
PLAN VIII (6)	850,000	2,200,000	3,050,000	3,500	198,000	324,000	1.6	126,000
PLAN VIIIa (6)	850,000	2,190,000	3,040,000	5,500	200,000	322,000	1.6	122,000
PLAN IX (7)	670,000	2,110,000	2,780,000	3,500	181,000	320,000	1.8	139,000
PLAN X (8)	450,000	4,440,000	4,890,000	15,000	327,000	300,000	0.9	-27,000

(1) Includes benefits from flood damage reduction, advanced replacement of bridges and NED employment.

(2) Initial plans protect both banks of the Sheldrake River from Brookside Place downstream to just past Briarcliff Road. The economic justification of the added increment of protection downstream to Hickory Grove Drive is noted below for the reformulated plans.

(3) Consists of initial Nonstructural Plan I with added protection downstream. B/C ratio of added increment is 0.8.

(4) Consists of initial Plan III with added protection downstream. B/C ratio of added increment is 1.1.

(5) Consists of initial Plan I with added protection downstream. B/C ratio of added increment is 0.8.

(6) Consists of initial Plan I with added protection downstream. B/C ratio of added increment is 1.2.

(7) Consists of initial Plan I with added protection downstream. B/C ratio of added increment is 1.4.

(8) Consists of initial Plan IV with added protection downstream. B/C ratio of added increment is 0.6.



## TOWN OF MAMARONECK - SHELDRAKE RIVER

At the Town of Mamaroneck, five plans were initially generated for consideration along the upper Sheldrake River for the reach lying from approximately 300 feet downstream of Briarcliff Road, upstream for approximately 1,800 feet to just past Brookside Place (see Plate 4). Of these plans, one was a nonstructural plan, three were channel modification plans, and one was a floodwall and levee plan. In addition to these initial plans, two other channel modification alternatives were later considered for this reach in response to requests by local interests. These seven plans are designated as Nonstructural Plan I, and Plans I - Va on Tables 10 and 11.

During the formulation of the above-described plans, however, flooding occurred in September 1975 also at the reach immediately downstream from the area under consideration. This lower reach of the Sheldrake River extends from below Briarcliff Road downstream to Hickory Grove Drive (see Plate 4). Accordingly, subsequent to the plan formulation public meeting, local interests requested that the above-described plans be reformulated to also consider protection at this downstream reach of the Sheldrake River at the Town of Mamaroneck. The intermediate plans thus developed for the expanded study area from Hickory Grove Drive upstream for 3,700 feet to just past Brookside Place, formed the basis of subsequent formulation in the planning process. These plans, which were designated as Nonstructural Plan II, and Plans VI through X, include a nonstructural plan, six channel modification plans, and a levee and floodwall plan, as shown in Table 10.

## ASSESSMENT AND EVALUATION OF INTERMEDIATE PLANS

In compliance with the Principles and Standards for Water Resources Development, the economic, environmental and social effects of the various intermediate plans for the Mamaroneck and Sheldrake Rivers were evaluated. The alternatives were analyzed individually for their beneficial and adverse effects and collectively so that the differences among the alternatives could be identified, and the tradeoffs required to achieve the various planning objectives could be determined. The results of the impact assessment and evaluation studies are discussed in detail in sections III and IV, respectively, of Section 2, Appendix F. In addition, summary evaluations of the intermediate plans contributions are contained in Table 12 for the Mamaroneck and Sheldrake Rivers.

## ALTERNATIVES CONSIDERED FOR DETAILED ANALYSIS

Based on the assessment and evaluation studies described above, and presented in Appendix F, alternative plans were identified for the Mamaroneck and Sheldrake Rivers to be carried into the final planning stage. Further analysis of the identified alternates towards developing detailed

TABLE 12 - RESPONSE TO PLANNING OBJECTIVES, AND EVALUATION AND FORMULATION CRITERIA  
VILLAGE AND TOWN OF MAMARONECK, N.Y.

PLANNING OBJECTIVES	INTERMEDIATE PLANS																							
	POSSIBLE MEASURES			LOWER MAMARONECK AND SHELDRAKE RIVERS			UPPER MAMARONECK RIVER			UPPER SHELDRAKE RIVER														
	WESTCHESTER JOINT W.M. RES.	LARCHMONT RESERVOIR #2	HAPLEMOOR DETENTION	SILVER LAKE DETENTION	MAMARONECK RIVER DIVERSION	LARCHMONT GARDEN DIVERSIONS	NONSTRUCTURAL PLAN	PLAN 1	PLAN 2	PLAN 3	PLAN 4	PLAN 5	CHANNEL MODIFICATION	NONSTRUCTURAL PLAN	FLOODWALL AND LEVEE PLAN	CHANNEL MODIFICATION PLAN	NONSTRUCTURAL PLAN	PLAN VI	PLAN VII	PLAN VIII	PLAN VIIIa	PLAN IX	PLAN X	
<u>EVALUATION CRITERIA</u>																								
Acceptability	+	0	0	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Certainty	+	0	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Completeness	+	-	-	-	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Effectiveness	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Efficiency	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Geographic Scope	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
NED Benefit-Cost Ratio	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Reversibility	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Stability	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
<u>OTHER FORMULATION CRITERIA</u>																								
Implementability	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Adequacy of Level of Protection	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Public Health and Safety	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Cultural Resources	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

LEGEND  
 ++ MOST POSITIVE  
 + POSITIVE CONTRIBUTION  
 0 NEUTRAL OR MINIMAL  
 - NEGATIVE CONTRIBUTION  
 -- MOST NEGATIVE

plans that more fully address the planning objectives, and ultimately the selection of the most desirable plans, is contained in subsequent sections. Of the intermediate plans investigated along the Mamaroneck and Sheldrake Rivers, the following alternatives were identified for further consideration.

Village of Mamaroneck, lower section:

- Plan 3 (levees, floodwalls, channel modification)
- Plan 4 (levees, floodwalls, channel modification, tunnel diversion)
- Plan 4/Plan 1 Combination

Village of Mamaroneck, upper section:

- Nonstructural Plan
- Channel Modification Plan

Town of Mamaroneck:

- Nonstructural Plan II
- Plan IX (channel modification)

## CONTRIBUTIONS TO NATIONAL OBJECTIVES

During this iteration of the planning process, alternatives were designated as NED, and EQ Oriented NED plans. For the Mamaroneck and Sheldrake Rivers, the NED Plan was designated as consisting of Plan 4 (Figure F5) for the lower portion of the Village of Mamaroneck, the Channel Modification alternate for the upper section of the Mamaroneck River (Figure F6), and Plan IX along the Sheldrake River in the Town of Mamaroneck (Figure 11). As discussed in Appendix F, in the designation of a final EQ Plan, the one overriding requirement is that it make a net positive contribution to the EQ account (natural environment) when compared to the without condition. A review of the intermediate plans and the assessment of their associated impacts, as presented in paragraphs F65 through F74, Section 2, Appendix F, reveals that none of the alternatives result in a net positive contribution to the EQ account. Furthermore, it appears that because of the setting of the study area (i.e., suburban and urban development along the streams), the nature of the flood problem, and other factors, such as the marginal existing aquatic resources, poor water quality, and the generally limited and stressed vegetative and wildlife habitats, there is no apparent means of providing a net positive EQ contribution at the study area in conjunction with flood control measures, and it is not possible to designate an EQ Plan. Therefore, an EQ Oriented NED Plan was identified as that alternate which most nearly meets the minimum requirement for an EQ Plan. The EQ Oriented NED Plan was identified as consisting of the levee, floodwall and channel modification features of Plan 1 for the lower Mamaroneck River in combination with the Fenimore Road tunnel diversion features of Plan 4 for the Sheldrake River in the Village of Mamaroneck, and the nonstructural alternatives for the upper portion of the Mamaroneck River in the Village and the Sheldrake River in the Town. The development

of the EQ Oriented NED Plan is discussed in detail in Appendix F, and the resulting significant beneficial and adverse contributions are summarized in Table 13.

## NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

The NED Plan was selected on the basis that it maximizes net economic benefits, considering both scale optimization and plan efficiency, while addressing the range of planning objectives. As shown on Table 11, of the plans considered for the lower Mamaroneck and Sheldrake Rivers, the upper Mamaroneck River in the Village of Mamaroneck, and the Sheldrake River in the Town of Mamaroneck, Plan 4, the Channel Modification Plan, and Plan IX, respectively, produce the greatest net economic return. These intermediate plans considered protection against a flood with a one percent exceedence frequency; when the scale of development and level of protection are considered, the economic return of the NED Plan can be further maximized. Additionally, the NED Plan was further modified and refined in the detailed planning stage as discussed below. The development of the NED Plan is discussed in detail in Appendix F, and the resulting significant beneficial and adverse contributions are summarized in Table 13.

## FINAL ITERATION OF THE NED PLAN

During this final iteration the NED Plan was further refined by modifying or deleting measures to develop a plan which is fully implementable and represents the best plan formulated on the basis of economic criteria. These refinements not only included adjustments to increase net NED benefits, but also involved increasing net EQ contributions, and more fully addressing the planning objectives. As shown on Figure F18, in the Village of Mamaroneck the refined NED plan consists of a combination of tunnel diversion, channel modification, levees and retaining walls. The existing channel of the Mamaroneck River would be widened and deepened from a point downstream of Tompkins Avenue, upstream for approximately 10,000 feet to just past Winfield Avenue. The modified channel bottom along the Mamaroneck River would average 60 feet in width from the lower limit of the plan upstream to a point about 300 feet past Jefferson Avenue, and 45 feet in width from this point to the upstream limit of the channel works. The channel modification would include the relocation of the confluence of the two rivers to eliminate the two sharp bends in the existing alignment, and a number of discontinuous retaining walls. The plan additionally involves the replacement of the Ward Avenue, Halstead Avenue, Station Plaza, and Hillside Avenue Bridges, and the replacement of Valley Place sewer bridge with an inverted siphon. The Sheldrake River would be diverted into a tunnel at Fenimore Road leading to the West Basin of Mamaroneck Harbor. This tunnel diversion would consist of three segments. For 1,600 feet from the Sheldrake River to Stanley Avenue, the tunnel consists of a 15 foot x 15 foot box culvert; from Stanley Avenue for 1,450 feet to just north of Boston Post Road, the diversion consists of

a 15.5 foot diameter tunnel and thence the tunnel consists of a 15 foot x 15 foot box culvert to just south of Boston Post Road where the tunnel leads to an open channel and stilling basin at the West Basin of Mamaroneck Harbor. From the diversion inlet at Fenimore Road upstream to Rockland Road the existing channel of the Sheldrake River would be modified into a semi-trapezoidal channel, with retaining wall along the right bank, and thence to the New England Thruway the channel would be trapezoidal with a levee along the right bank. Interior drainage for the works in the Village is provided by a system of ditches and drains through the line of protection, and several areas along the streams would be filled and graded. No residential, commercial or industrial structures would be acquired as part of this plan. The portion of the refined NED plan along the Sheldrake River in the Town of Mamaroneck consists of only the upper section of Plan IX; the resulting plan, which was originally designated as Plan I during the intermediate planning stage, consists of a 12 foot wide rectangular concrete channel from upstream of Brookside Place downstream for 1,800 feet to a point approximately 300 feet below Briarcliff Road. The portions of the final NED plan discussed above for the lower Mamaroneck and Sheldrake Rivers differs from its corresponding components considered in the intermediate planning stage in the following respects:

1. The final NED Plan includes a larger capacity tunnel diversion at Fenimore Road, and consequently provides a higher level of protection than the one percent frequency flood considered along the Sheldrake River in the intermediate planning stage. For the final NED Plan, the tunnel diversion and modified channel upstream of the inlet are designed to contain the Standard Project Flood along the Sheldrake River. Additionally, unlike the diversion proposed in Plan 4, which diverted only a portion of the flood flow, the system considered in the NED plan would divert the total flow of the Sheldrake River upstream of Fenimore Road into the tunnel, with the stream flow in the Sheldrake channel downstream of Fenimore Road to the confluence with the Mamaroneck River comprised of the incremental runoff which enters this reach of stream. The lower portion of the Sheldrake River downstream of Fenimore Road would be maintained at its existing capacity by the Village of Mamaroneck to prevent flooding from local runoff, and to contain design flood stages resulting from backwater of the Mamaroneck River. This total diversion system at a high level of protection was requested by and is strongly supported by local interests. Furthermore, for diversion works of Standard Project Flood capacity, this total diversion system at Fenimore Road is considered to provide greater reliability in design and a higher degree of safety for the affected public at reaches which have extremely high damages under existing conditions.

2. The channel modification works proposed in Plan 4 for the lower Mamaroneck River were further refined during the detailed planning stage to more fully address the planning objectives, and to respond to requests by local interests. The diversion of flows from the Sheldrake River enabled the works along the Mamaroneck River to be refined with a reduction in cost of approximately 1.5 million dollars and resulting in minimized real estate

requirements along the Mamaroneck River with corresponding reductions of the adverse impacts to open space and social well-being. The modified channel along the Mamaroneck River described above for the NED plan is generally two feet deeper in cut than the channel proposed in Plan 4, and has a base width 10 feet narrower at the reach downstream of the confluence. When this deeper modified channel along the Mamaroneck River is combined with the above-mentioned total flow diversion of the Sheldrake River, a level of protection against greater than the one percent flood considered in the intermediate planning stage can be achieved without levees and floodwalls along the Mamaroneck River. The resulting works are designed to protect against a flood with a .5 percent exceedence frequency along the lower Mamaroneck River, and at areas along the Sheldrake River which are within backwater influence of the mainstream. By continuing the refined design of the channel modification of the lower Mamaroneck River into the reach of stream upstream of the Thruway, protection against a flood with a one percent exceedence frequency is achieved at this upper area without a levee along the right bank, as was proposed by the Channel Modification Plan for the upper Mamaroneck River in the intermediate planning stage, and would thus avoid the environmental, and social and aesthetic impacts associated with the levee, as discussed in paragraph F71, Appendix F.

3. The rectangular concrete channel along the Sheldrake River in the Town of Mamaroneck described above for the NED Plan includes works for only the upper section of Town of Mamaroneck study area from just upstream of Brookside Place downstream to a point 300 feet below Briarcliff Road. As discussed in Appendix F, the downstream works proposed in intermediate Plan IX were eliminated from the NED Plan subsequent to the late stage public hearing when local interests requested that they be deleted. The Town of Mamaroneck, in response to the desires as expressed by local residents, requested that no further consideration of flood control measures be given to the reach of the Sheldrake River from below Briarcliff Road to Hickory Grove Drive because they considered the existing flood risk more acceptable than the socio-economic and environmental impacts of local importance associated with the construction activities and protective works of any flood control improvement at this reach. Thus, the resulting component of the NED Plan for the Town of Mamaroneck reach of the Sheldrake River is identical to initial intermediate Plan I, as described in paragraph F51, Appendix F. Flood protective works for the reach of the Sheldrake River from below Briarcliff Road to Hickory Grove Drive were also deleted from the other alternates considered in the detailed planning stage.

4. In order to minimize the adverse EQ contributions of the structural works proposed for the Mamaroneck and Sheldrake Rivers, measures are incorporated to mitigate these impacts. These measures are considered appropriate for the NED Plan since coordination with Federal and state agencies has indicated that provisions of this type are necessary for the recovery of losses resulting from implementation, and are required for

acceptability. These measures, which were developed in coordination with the U. S. Department of the Interior, Fish and Wildlife Service, include, in addition to the erosion and sediment control measures outlined for the EQ Oriented NED Plan in subsequent paragraphs, the following:

a. In the upper Mamaroneck River area, the existing channel generally will be widened by limiting the proposed channel excavations to one bankside, so as to decrease the removal of trees and other vegetation. Investigations during preconstruction planning would determine if other areas exist within the project area for which this technique is also suitable.

b. A pool and riffle low flow channel would be incorporated into the entire channel areas to be modified, except at the portion of the upper Sheldrake River where a flume is proposed. For the upper Sheldrake River a shallow V-shaped pilot channel would be incorporated into the plan.

c. Small log and rock dams would also be employed in the longer riffle areas in order to create lowhead pools as an aquatic shelter and habitat area.

d. Trees and shrubs eliminated by the structural elements would be partially replaced through beautification measures and a tree planting program.

## EQ ORIENTED NED PLAN

The EQ Oriented NED Plan was selected on the basis that it addresses the planning objectives for the Mamaroneck and Sheldrake Rivers while emphasizing contributions to preserving and maintaining portions of the existing stream environment, aesthetically pleasing sections of stream, and open space within the study area. The plan which provides the minimum net negative contributions to the above-mentioned components of the National objective of Environmental Quality, and most nearly meets the minimum requirement for designation as an EQ Plan, consists of the levee, floodwall and channel modification features of Plan 1 for the lower section of the Mamaroneck River, in combination with the Fenimore Road tunnel diversion for the Sheldrake River in the Village of Mamaroneck, and the nonstructural alternates for the upper portion of the Mamaroneck River in the Village and the Sheldrake River in the Town. A summary description of the EQ plan is included below:

At the lower Mamaroneck and Sheldrake Rivers the EQ plan differs from the NED plan in that the channel modification and tunnel diversion works for this plan are generally less extensive. The existing channel of the Mamaroneck River would be widened and deepened from a point about halfway between Tompkins and Ward Avenues, upstream to the New England Thruway, a distance of about 5,600 feet. The modified channel would average approx-

imately 50 feet in width from the lower limit of the plan, upstream to a point about 300 feet past Jefferson Avenue; from this point upstream to the Thruway, the modified channel would average about 30 feet in width. This plan would also include a number of discontinuous levees and floodwalls along the banks of the Mamaroneck River. All other features of this plan along the lower Mamaroneck River are similar to the NED plan, including the bridge work; however, the levees and floodwalls would necessitate the acquisition of two homes and would require extensive interior drainage works. The tunnel diversion along the Sheldrake River would be similar in alignment to the one proposed in the NED plan; however, for this plan the diversion would lead to a 11.5 foot diameter tunnel, and the diversion works would divert only a portion of the flow along the Sheldrake River while allowing a base flow to pass to the reach of stream downstream of Fenimore Road. No other structural work along the Sheldrake River upstream of the tunnel inlet, except for the filling of low-lying areas, would be called for. As shown on Table 13, the nonstructural portions of this plan include the floodproofing of 39 residential structures and the acquisition of 31 homes.

The level of protection of the EQ Oriented NED Plan is considered optimum at the one percent frequency flood, as formulated. A higher level of protection would result in more extensive structural works along the lower Mamaroneck and Sheldrake Rivers, thus increasing adverse EQ contributions; similarly, a lower level of protection is not consistent with the flood damage reduction objective. The significant positive contributions made by the elements of the EQ Oriented NED Plan are outlined below:

1. The flood proofing and relocation measures along the Sheldrake River in the Town of Mamaroneck would preserve and maintain the scenic section of aesthetically pleasing features and human enjoyment at the lower portion of this reach, as described in paragraph F72. Additionally, these nonstructural measures would not result in any adverse or disruptive impacts to the fishery resources downstream at Larchmont Gardens Lake.

2. The nonstructural measures proposed at the Village of Mamaroneck area upstream of the New England Thruway would preserve the less stressed fish and wildlife resources and moderately undeveloped woodlands at this reach of the Mamaroneck River.

3. The diversion of floodwaters in excess of the bankfull capacity of the Sheldrake channel would provide protection along the Sheldrake River in the Village while preserving the existing stream environment. Additionally, the base flow maintained downstream of Fenimore Road would approximate the natural flows at this reach of stream. Although limited wildlife habitat remain within this reach, the present resources would be preserved, and a future potential for enhancement is maintained.

4. As outlined in Appendix G, Environmental, Social and Economic Effects Assessment, the aquatic resources along the lower Mamaroneck River

are stressed and limited by community development and pollution load. Due to the marginal importance of this area as a fish and wildlife habitat, the structural elements proposed by the EQ Oriented NED Plan for this reach cannot be considered to cause significant impacts. Additionally, the narrower modified channel along the lower Mamaroneck River proposed in this plan would minimize impacts to the bankside environment and would be less disruptive than the other identified plans. Furthermore, the EQ Oriented NED Plan includes mitigation measures to offset negative EQ contributions resulting from the proposed channel modification of the lower Mamaroneck River. These measures, which were developed in coordination with the U. S. Department of the Interior, Fish and Wildlife Service, include:

a. The existing channel would be widened by excavating only one bank, so as to eliminate the minimum number of trees and stream cover. The side which is excavated would alternate between banks, depending on existing development, topography.

b. The modified stream would follow the existing contours of the channel, where possible.

c. A low flow channel with a pool and riffle configuration would be incorporated into the modified channel.

d. Small log and rock dams would be employed at the longer riffle areas to create lowhead pools as an aquatic shelter and habitat area.

e. Trees and shrubs eliminated by the structural elements would be replaced through beautification measures and a tree planting program.

f. During construction, control measures would be utilized to minimize adverse effects to the water quality of the rivers within the study area and at downstream reaches. Measures to minimize increases in turbidity levels and to limit the erosion of denuded channel slopes would include: (1) exposing the minimum area of land to erosion that is practical at any one time during construction; (2) applying temporary mulch, with or without seeding temporary vegetation, immediately after rough grading is completed; (3) construction of temporary sediment basins or the placement of silt screens or barriers to precipitate silt before it leaves the site.

The significant economic, environmental and social effects of the EQ Oriented NED Plan for the Mamaroneck and Sheldrake Rivers are summarized in Table 13.

## IDENTIFIED PLANS

As discussed in the previous paragraphs, the NED and EQ Oriented NED Plans were identified for the Mamaroneck and Sheldrake Rivers during the detailed planning stage. To facilitate further analysis and comparisons, the identified plans are re-designated, for clarity, as shown below.

PLAN A (NED Plan) - consists of refined versions of Plan 4 for the lower portion of the Mamaroneck and Sheldrake Rivers, the Channel Modification alternate for the upper section of the Mamaroneck River in the Village of Mamaroneck, and Plan I for the Sheldrake River in the Town of Mamaroneck.

PLAN B (EQ Oriented NED Plan) - consists of the Plan 4/Plan 1 Combination for the lower Mamaroneck and Sheldrake Rivers; and the Nonstructural Plans for the upper Mamaroneck River in the Village, and the Sheldrake River in the Town, as previously described.

PLAN C - consists of Plan 3 for the lower Mamaroneck and Sheldrake Rivers; the Channel Modification Plan for the upper portion of the Mamaroneck River in the Village, and Plan I for the Sheldrake River in the Town, as described below:

This plan consists of a combination of channel modification, levees and floodwalls along the Mamaroneck and Sheldrake Rivers. The improved channel bottom along the Mamaroneck River would average approximately 70 feet in width, from Tompkins Avenue, upstream to a point about 300 feet past Jefferson Avenue. From this point upstream to Winfield Avenue, the modified channel bottom would average approximately 45 feet in width. Along the Sheldrake River in the Village of Mamaroneck, the improved channel bottom width would average about 25 feet for the reach of stream from the confluence upstream to Fenimore Road. From Fenimore Road to the Thruway, the improved channel width averages about 30 feet. This plan would also include a number of discontinuous levees and floodwalls along the banks of the Mamaroneck and Sheldrake Rivers, including along the upper Mamaroneck River at the Chestnut Avenue area. The levees and floodwalls along the Mamaroneck River would average approximately  $4\frac{1}{2}$  and 4 feet in height, respectively, while along the Sheldrake River the levees and walls would average about 4 and 6 feet in height, respectively. Ponding areas, pumping stations, and associated interior drainage facilities would be provided on the protected side of the levees and walls. Additionally, one industrial, two commercial and four residential structures must be acquired. This plan would require the replacement of the Mamaroneck, Waverly and Center Avenue bridges and the Fayette footbridge, in addition to those called for in Plan A. The portion of this plan along the Sheldrake River in the Town of Mamaroneck is identical to the works considered in Plan A. This plan would protect areas along the Mamaroneck and Sheldrake Rivers in the Village and Town of Mamaroneck against a flood with a 1 percent exceedence frequency (100 year flood).

## COMPARISON OF IDENTIFIED PLANS

A comparison analysis is used to provide a basis for plan selection. The process used to compare the identified plans consists of a trade-off analysis of the contributions to the planning objectives, the beneficial and adverse effects of each alternate, and the responses to specific evaluation criteria such as tests of acceptability, effectiveness, efficiency and completeness. This type of comparison categorizes the various impacts and displays each plan in terms of the components of the system of accounts. A summary comparison of Plans A (NED Plan), B (EQ Oriented NED Plan) and C along the Mamaroneck and Sheldrake Rivers is contained in Table 13, and the system of accounts for each plan are displayed in Tables F11, F12 and F13 in Appendix F.

Examination of the data in the above-mentioned tables for the Mamaroneck and Sheldrake Rivers indicates the significant tradeoffs made between the identified plans. As summarized in Table 13, the major monetary beneficial effect that would result from the alternate plans is the reduction of existing and future flood damages at the Village and Town of Mamaroneck, New York. The NED Plan produces the greatest amount of gross economic flood control and total benefits. With respect to adverse economic effects, the differences between the plans is the higher cost for the NED Plan as compared to the EQ Oriented NED Plan and Plan C. However, the greater costs of the NED are partly attributed to the higher levels of protection it provides. For this plan, the levels of protection along reaches in the lower Village of Mamaroneck range from protection against a flood with a .5 percent exceedance frequency to the Standard Project Flood; in the upper Village and Town of Mamaroneck the design storm is the 1 percent flood. Both the EQ Oriented NED Plan and Plan C protect the Village and Town against a flood with a 1 percent exceedance frequency. But more significantly, the NED plan achieves the flood damage reduction objective while maximizing net positive NED benefits. However, the EQ Oriented NED Plan achieves the flood control objective while best preserving the existing stream environment of the Mamaroneck and Sheldrake Rivers, and the natural setting of the upper Sheldrake River in the Town of Mamaroneck; Plan C and the NED Plan would each result in greater negative EQ contributions, although measures are included to mitigate the adverse effects of the channel modification features of the NED Plan. The impacts associated with the diversion of the entire flow of the Sheldrake River as proposed in the NED Plan differ from those associated with the partial diversion of the EQ Oriented NED Plan. The major difference in the impacts associated with the two diversions is that the total diversion of Plan A (NED Plan) would effectively eliminate the aquatic habitat along the Sheldrake River downstream of Fenimore Road, while the partial diversion scheme of the EQ Oriented NED Plan (Plan B) would preserve this reach of stream. However, since the aquatic resources along the lower Sheldrake River are stressed and limited, and of marginal importance, the impacts associated with the total diversion of Plan A are not expected to be significant. Impacts to water quality, as discussed in paragraph F68, Appendix F, would be similar for both Plans A and B.

As outlined in Table 13, Plan C requires the greatest total amount of real estate, approximately 46 and 32 acres of permanent and temporary easements, respectively, including the acquisition of one industrial, two commercial and four residential structures. This plan would result in negative contributions to the preservation of open space planning objective and would greatly disrupt the community during construction. The NED Plan would require 32 and 15 acres of permanent and temporary easements, respectively, and the EQ Oriented NED Plan's real estate requirements for its structural works consist of 25 acres of permanent easements and 10 acres of temporary easements, including the acquisition of two homes. The social impacts associated with the real estate requirements of each of the plans should be noted since they are judged to be of high local importance. The EQ Oriented NED Plan, in addition to the two homes to be acquired mentioned above, would impact on the residential community since 31 additional homes would be acquired and the residents relocated as part of the nonstructural portions of the plan at the upper Village and Town. The NED Plan would not require the acquisition of any residential, commercial or industrial structures. Additionally, the NED Plan, which does not include extensive protective levees and floodwalls in the Village of Mamaroneck, would best preserve the existing open space and associated recreational opportunities at the Columbus park area. Plan C, and to a lesser extent the EQ Plan, require a number of discontinuous levees and floodwalls in the Village. Both these plans would reduce the available open space at Columbus Park. This impact is considered to be an adverse effect of high magnitude of local importance when considering the limited open space available in the Village study area.

An additional consideration in comparing the identified plans involves the residual damages and disaster potential associated with each plan. In the Village of Mamaroneck the tunnel diversion and channel modification features of the NED Plan enable it to reduce the elevation of floodwaters for all storms up to the SPF. The design level for the works proposed by the NED Plan at reaches along the Mamaroneck and Sheldrake Rivers in the Village would contain flows ranging from the one percent storm to the SPF. No levees or floodwalls are called for in the NED Plan; however, for Plan C along the lower Mamaroneck and Sheldrake Rivers and the EQ Oriented NED Plan along the lower Mamaroneck River, less frequent floods which would result in stages greater than 3 feet above the one percent design level would top the levees and floodwalls in the Village. The residual damages in the Village of Mamaroneck corresponding to the SPF stages for the NED Plan, EQ Oriented NED Plan and Plan C are approximately .7 million, 30 million and 60 million dollars, respectively. At the upper Mamaroneck River in the Village and the Sheldrake River in the Town of Mamaroneck, the channel modification features proposed in the NED Plan and Plan C would reduce the stages of floods above the one percent design level, while the non-structural features of the EQ Oriented NED Plan at the upper Mamaroneck and Sheldrake Rivers would not reduce flood stages, or residual damages for the SPF, at those areas.

TABLE 13 - SUMMARY COMPARISON OF IDENTIFIED PLANS  
MAMARONECK AND SHELDRAKE RIVERS AT THE VILLAGE AND TOWN  
OF MAMARONECK, N.Y.

	PLAN A (NED PLAN) SELECTED PLAN	PLAN B (EQ ORIENTED NED PLAN)	PLAN C
<b>A. PLAN DATA</b>			
<b>Structural Measures</b>			
1) Mamaroneck River, Village of Mamaroneck, downstream of Thruway	Channel modification, retaining walls and bridge replacements.	Channel modification, levees, floodwalls and bridge replacements.	Channel modification, levees, floodwalls and bridge replacements.
2) Mamaroneck River, Village of Mamaroneck, Town of Harrison, upstream of Thruway	Channel modification.	-----	Channel modification and levee.
3) Shel Drake River, Village of Mamaroneck	Tunnel diversion, channel modification, retaining walls, levee.	Tunnel diversion.	Channel modification, levees, walls, bridge replacements.
4) Shel Drake River, Town of Mamaroneck	Channel modification, bridge replacement, training levees.	-----	Same as NED plan.
<b>Nonstructural Measures</b>			
1) Mamaroneck River, Village of Mamaroneck, upstream of Thruway	-----	15 residential structures floodproofed; 16 homes acquired.	-----
2) Shel Drake River, Town of Mamaroneck	-----	24 residential structures floodproofed; 15 homes acquired.	-----
<b>Lands</b>			
	32 acres of permanent easements; 15 acres of temporary easements.	25 acres of permanent easements including the acquisition of 2 residential structures in village; 10 acres of temporary easements.	46 acres of permanent easements including the acquisition of 1 industrial, 2 commercial and 4 residential structures; 32 acres of temporary easements.
<b>B. SIGNIFICANT IMPACTS</b>			
	1) Plan removes approximately 200 acres from the .5 percent floodplain in the lower Village of Mamaroneck, 30 acres from the one percent floodplain in the upper Village of Mamaroneck and Town of Harrison and 15 acres from the one percent floodplain in the Town of Mamaroneck.	1) Plan removes approximately 180 acres from the one percent floodplain in the lower Village of Mamaroneck.	1) Plan removes approximately 225 acres from the one percent floodplain in the Village and Town of Mamaroneck and Town of Harrison.
	2) Approximately 300 homes and 160 businesses protected from .5 percent flood in lower Village of Mamaroneck and 70 homes protected from the 1 percent flood in upper Village of Mamaroneck and Town of Mamaroneck and Harrison.	2) Approximately 340 homes and 150 businesses protected from 1 percent flood in Village and Town of Mamaroneck and Town of Harrison.	2) Same as EQ plan.
	3) Encroachment and loss to some of the limited fish and wildlife habitat due to the structural works along both streams and the total diversion of Shel Drake River. Measures to mitigate these effects would minimize these losses.*	3) Less significant loss of some of the limited fish and wildlife habitat due to less extensive structural works and the partial diversion of the Shel Drake River in the lower Village of Mamaroneck. Measures to minimize these losses are included. No significant impacts along the Shel Drake River, or Mamaroneck River upstream of Thruway.*	3) Similar to NED plan, however, these impacts would be greater due to more extensive channel modification along the Shel Drake River.*
	4) Undetermined number of trees and shrubs removed for construction along both streams in Village and Town of Mamaroneck and Town of Harrison. Project beautification measures and tree planting program would partially replace these losses.*	4) Undetermined number of trees and shrubs removed for construction of River downstream of Thruway. Project beautification measures and tree planting program would partially replace these losses.*	4) Similar to NED plan, however, impact would be greater due to more extensive structural works along Mamaroneck and Shel Drake Rivers in Village of Mamaroneck.*

TABLE 13 - SUMMARY COMPARISON OF IDENTIFIED PLANS (Cont'd)  
MAMARONECK AND SHELDRAKE RIVERS AT THE VILLAGE AND TOWN  
OF MAMARONECK, N.Y.

PLAN A (NED PLAN)  
SELECTED PLAN

PLAN B  
(EQ ORIENTED NED PLAN)

PLAN C

B. SIGNIFICANT IMPACTS  
(Cont'd)

- 5) Construction activities would result in short-term adverse impacts on appearance of project area. After construction the structural works would have adverse aesthetic effects, particularly along Sheldrake River in Town of Mamaroneck.\*
- 6) Temporary increases in turbidity and sedimentation levels from excavation within channels of Mamaroneck and Sheldrake Rivers in Village and Town of Mamaroneck and Town of Harrison. Use of erosion control measures and temporary sediment basins or silt barriers screens would minimize this impact.
- 7) Diversion of Sheldrake River would result in abandonment of 2400' of down-stream channel and loss of habitat area. Stagnation pools may develop in abandoned channel. The quality of the streams and harbor is degraded and diversion should not have a significant effect on water quality.\*
- 8) Acquisition of 33 homes and relocation of residents would impact on community cohesion.\*

C. PLAN EVALUATION  
1. CONTRIBUTIONS TO  
PLANNING OBJECTIVES

- a) Flood Damage Relocation
  - 1) Approximately 300 homes and 160 businesses protected from .5 percent flood in lower Village of Mamaroneck and 70 homes protected from the 1 percent flood in upper Village of Mamaroneck and Towns of Mamaroneck and Harrison.
  - 2) Total average annual damages reduced by 99.98%.
- b) Stream Environment Preservation
  - 1) The structural works along both streams and the total diversion of the Sheldrake River would impact on the limited aquatic and wildlife habitat.
  - 2) Mitigation measures would minimize the permanent effects after construction.
- c) Open Space Preservation
  - 1) Modified channel of Mamaroneck River would reduce existing open space in the Village of Mamaroneck and Town of Harrison; however, since no levees are required, the permanent impact at Columbus Park would be minimal.

\* Item specified in Section 122

- 5) Overall the natural rivers would remain intact except along the Mamaroneck River downstream of the Thruway. At this reach the temporary impacts would be the same as NED plan, however, after construction the levees and walls would present an obstacle to those who wish to view the river and its surroundings.\*
- 6) Less significant temporary increases in turbidity and sedimentation during construction of levees and walls and excavation within the Mamaroneck River channel in the Village of Mamaroneck. Erosion control measures would minimize this impact.
- 7) Levee at Columbus Park in Village of Mamaroneck would reduce the available open space and associated recreational opportunities at the park.\*
- 8) Acquisition of 33 homes and relocation of residents would impact on community cohesion.\*

- 1) Approximately 340 homes and 150 businesses protected from 1 percent flood in Village and Town of Mamaroneck and Town of Harrison.
- 2) Total average annual damages reduced by 86%.

- 1) Same as EQ plan.
- 2) Total average annual damages reduced by 80%.

- 1) Similar to NED plan, however, these impacts would be greater due to more extensive works in the village.
- 2) Similar to NED plan, however, these impacts would be greater due to more extensive works in the village.

- 1) Levees at Columbus Park and at Chestnut Avenue area would reduce the available open space at these areas.
- 2) Levees at Columbus Park and at Chestnut Avenue area would reduce the available open space at these areas.

TABLE 13 - SUMMARY COMPARISON OF IDENTIFIED PLANS (Cont'd)  
 MAMARONECK AND SHELDRAKE RIVERS AT THE VILLAGE AND TOWN  
 OF MAMARONECK, N. Y.

	PLAN A (NED PLAN)	PLAN B (EQ ORIENTED NED PLAN)	PLAN C
<b>2. NATIONAL ECONOMIC DEVELOPMENT</b>			
Beneficial	\$3,060,000	\$2,560,000	\$2,090,000
Adverse	\$2,230,000	\$1,990,000	\$1,550,000
Net	\$ 830,000	\$ 570,000	\$ 540,000
NED benefit-cost ratio	1.4	1.3	1.3
<b>3. ENVIRONMENTAL QUALITY</b>			
a) Quality of Water, Air* and Land Resources	Temporary adverse effects to air and water quality during construction and vegetative resources would be lost, as summarized above in SIGNIFICANT IMPACTS section.	Less significant negative contribution than NED plan, as summarized above in SIGNIFICANT IMPACTS section.	Similar to NED plan, however, impacts would be greater, as summarized above in SIGNIFICANT IMPACTS section.
b) Fish and Wildlife Resources	Encroachment and loss to some of the limited habitat area would result, as summarized above in SIGNIFICANT IMPACTS section.	Nonstructural measures along upper Mamaroneck and Sheldrake Rivers and tunnel diversion along lower Sheldrake River would result in minimal impacts to fish and wildlife resources.	Similar to NED plan, however, impacts would be greater, as summarized above in SIGNIFICANT IMPACTS section.
c) Historical-Archeological Resources*	Cultural resources survey indicated no sites eligible for National Register.	Same as NED plan.	Same as NED plan.
d) Aesthetics*	Temporary adverse effects to appearance of project area. After construction the structural works would have negative aesthetic impacts, particularly along Sheldrake River in Town.	Overall the natural rivers would remain intact except along the Mamaroneck River downstream of the Thruway. As summarized above in SIGNIFICANT IMPACTS section, the levees and walls along the Mamaroneck River would have adverse aesthetic effects.	Temporary impacts same as NED plan, however, increased number of levees and walls would have adverse aesthetic effects.
<b>4. REGIONAL DEVELOPMENT</b>			
	Increased employment opportunity for construction workers during construction.*	Same as NED plan.	Same as NED plan.
<b>5. SOCIAL WELL-BEING</b>			
a) Life, Health, and Safety	Reduced threat to life, health and safety of residents.	Same as NED plan.	Same as NED plan.
b) Displacement of People*	No people would be displaced.	33 homes would be acquired and the residents relocated.	1 industrial, 2 commercial and 4 residential structures would be acquired.
c) Income Effect	Increased employment during construction.	Same as NED plan.	Same as NED plan.
d) Recreation*	Temporary reduction of recreational opportunities at Columbus Park and at Chestnut Avenue area during construction.	Levee at Columbus Park would reduce the available open space and associated recreation opportunities at these areas.	Levees at Columbus Park and at Chestnut Avenue area would reduce the available open space and associated recreational opportunities at these areas.

TABLE 13 - SUMMARY COMPARISON OF IDENTIFIED PLANS (Cont'd)  
 MAMARONECK AND SHELDRAKE RIVERS AT THE VILLAGE AND TOWN  
 OF MAMARONECK, N.Y.

	PLAN A (NED PLAN)	PLAN B (EQ ORIENTED NED PLAN)	PLAN C
<b>2. IMPLEMENTATION RESPONSIBILITIES</b>			
1. Federal	Federal first cost of \$29,530,000 would be 86% of total first cost.	Federal first cost of \$25,480,000 would be 84% of total first cost.	Federal first cost of \$17,000,000 would be 72% of total first cost.
2. Non-Federal	Non-Federal first cost of \$4,870,000 would be 14% of total first cost. Lands, rights-of-way and easements account for largest position thereof. Operation and maintenance costs estimated at \$33,000 annually would be local responsibility.	Non-Federal first cost of \$5,030,000 would be 16% of total first cost. Lands, rights-of-way and easements account for largest portion thereof. Operation and maintenance costs estimated at \$30,000 annually would be local responsibility.	Non-Federal first cost of \$6,500,000 would be 28% of total first cost. Lands, rights-of-way and easements account for largest portion thereof. Operation and maintenance costs estimated at \$44,000 annually would be local responsibility.

Various other evaluation criteria were considered in the selection of a plan and are shown summarized in tabular form in Table F7 of Appendix F. Furthermore, although all of the identified plans are generally acceptable, the local communities of the Village and Town of Mamaroneck have expressed strong support for the NED Plan.

## THE SELECTED PLAN

The development of the most desirable plan of protection for the Mamaroneck and Sheldrake Rivers study area involved the comparison and trade-offs among the identified plans, as described above and presented in Table 13. At the completion of this final iteration and based primarily on the comparative analysis, and input from local government agencies and the public, the selected plan was identified as the NED Plan, as shown in Plates 5 and 6 of the main body of this report. Details of the technical aspects of the selected plan is discussed in Appendices A, B and C. A comprehensive technical description of the selected (NED) plan is contained in Appendix B, Hydraulics. A summary description of the selected plan is included below. No residential, commercial or industrial structures would be acquired as part of this plan. For clarity, the plan is described below in segments.

## COMPONENTS OF THE SELECTED PLAN

VILLAGE OF MAMARONECK - Mamaroneck River. The plan of protection involves a combination of channel modification, retaining walls and bridge replacement. As shown on Plate 5, the existing channel of the Mamaroneck River would be widened and deepened from a point downstream of Tompkins Avenue, upstream for approximately 10,000 feet to just past Winfield Avenue. The modified channel bottom along the Mamaroneck River would average 60 feet in width from the lower limit of the plan upstream to a point about 300 feet past Jefferson Avenue, and 45 feet in width from this point to the upstream limit of the channel works. The channel modification would include the relocation of the confluence of the two rivers to eliminate the two sharp bends in the existing alignment, and a number of discontinuous retaining walls. These walls lie along both banks from just below Valley Place upstream for 600 feet to Station Plaza, along the right bank for 1,150 feet from Nostrand Avenue to First Street, along the left bank from First Street upstream for 1,700 feet to Lewis Street, and for 300 feet on the right bank at Willow Street. The plan additionally involves the replacement of the Ward Avenue, Halstead Avenue, Station Plaza and Hillside Avenue Bridges, and the replacement of the Valley Place sewer bridge with an inverted siphon. Interior drainage is provided by a system of ditches and outlet drains through the line of protection, and several areas along the streams would be filled and graded. This plan is designed to protect against a flood with a .5 percent exceedence frequency (200 year flood) along the

Mamaroneck River downstream of the New England Thruway, and against a flood with a 1 percent exceedence frequency (100 year flood) along the Mamaroneck River upstream of the Thruway to Winfield Avenue. The rationale for selecting this level of protection is contained in paragraphs F96 and F97, Appendix F.

VILLAGE OF MAMARONECK - Sheldrake River. The Sheldrake River would be diverted into a tunnel at Fenimore Road leading to the West Basin of Mamaroneck Harbor. This tunnel diversion would consist of three segments. For 1,600 feet from the Sheldrake River to Stanley Avenue, the tunnel consists of a 15 foot x 15 foot box culvert; from Stanley Avenue for 1,450 feet to just north of Boston Post Road, the diversion consists of a 15.5 foot diameter tunnel and thence the tunnel consists of a 15 foot x 15 foot box culvert to just south of Boston Post Road where the tunnel leads to an open channel and stilling basin at the West Basin of Mamaroneck Harbor. The coincidental tailwater to the tunnel is taken to be the one year tide level in the harbor. The use of a one year tailwater elevation for capacity design was chosen as a reasonable and practical criteria since tidal levels are no higher than usual when fluvial flooding occurs. In addition, the stilling basin at the outlet of the tunnel, which is needed to prevent damages to boats moored in the harbor, is designed using a tailwater of mean low water to ensure that the hydraulic jump would not occur in the harbor. From the diversion inlet at Fenimore Road upstream to Rockland Road, the existing channel of the Sheldrake River would be modified into a semi-trapezoidal channel, with retaining wall along the right bank, and thence to the New England Thruway the channel would be trapezoidal with a levee along the right bank. The tunnel diversion and modified channel upstream of the inlet are designed to contain the Standard Project Flood along the Sheldrake River. This diversion system would divert the total flow of the Sheldrake River upstream of Fenimore Road into the tunnel. The stream flow in the Sheldrake River channel downstream of Fenimore Road to the confluence with the Mamaroneck River would be comprised of the incremental runoff which enters this reach of stream and the existing capacity of the lower Sheldrake River would be maintained for this purpose.

TOWN OF MAMARONECK - Sheldrake River. This portion of the plan of protection consists of a twelve foot wide concrete rectangular channel from a point approximately 250 feet upstream of Rockland Avenue, at Brookside Place, downstream for approximately 1,800 feet to a point about 300 feet downstream of Briarcliff Road. The plan also includes a transition/stilling basin approximately 300 feet downstream of Briarcliff Road, and a 32 foot long drop structure and tie back levees at the upstream limit. The Forest Avenue and three driveway bridges would be replaced, and low-lying areas along the stream would be filled and graded. This section of the plan is designed to protect against a flood with a one percent exceedence frequency (100 year flood), as discussed in paragraph F98, Appendix F.

In order to minimize the adverse effects the channel modification work would have on the stream environment, measures are included to mitigate these impacts. These measures include the following:

a. In the upper Mamaroneck River area, the existing channel generally will be widened by limiting the proposed channel excavations to one bank-side, so as to decrease the removal of trees and other vegetation. Investigations during preconstruction planning would determine if other areas exist within the project area for which this technique is also suitable.

b. A pool and riffle low flow channel would be incorporated into the entire channel areas to be modified, except at the portion of the upper Shelldrake River where a flume or rock-cut channel is proposed. For the upper Shelldrake River a shallow V-shaped pilot channel would be incorporated into the plan.

c. Small log and rock dams would also be employed in the longer riffle areas in order to create lowhead pools as an aquatic shelter and habitat area.

d. Trees and shrubs eliminated by the structural elements would be partially replaced through beautification measures and a tree planting program.

e. During construction, control measures would be utilized to minimize adverse effects to the water quality of the rivers within the study area and at downstream reaches. Measures to minimize increases in turbidity levels and to limit the erosion of denuded channel slopes would include: (1) exposing the minimum area of land to erosion that is practical at any one time during construction; (2) applying temporary mulch, with or without seeding temporary vegetation, immediately after rough grading is completed; (3) construction of temporary sediment basins or the placement of silt screens or barriers to precipitate silt before it leaves the site.

Nonstructural Requirement - In addition to the structural portions of the plan described above, nonstructural measures are recommended for adoption by local interests for floodplain areas elsewhere in the Village and Town of Mamaroneck. In particular, floodplain regulation techniques are recommended as part of the total plan of protection at the Village and Town of Mamaroneck for the floodplain area lying along the Shelldrake River between the structural portions of the selected plan.

## Environmental Effects

The environmental effects of the selected plan for the Mamaroneck and Shelldrake Rivers are fully discussed in Appendix G and the significant impacts are summarized in Table 13. Some of these impacts are associated with construction and would be only short-term, but others of a more enduring nature are involved. Construction activities would, of course, create noise and dust which would be annoying and possibly harmful to residents along the waterways. The traffic delays and detours associated with construction and movement of supplies and material would adversely affect local travel and trucks carrying supplies would add to the traffic load. Reconstruction of the bridges at Ward, Halstead and Hillside Avenues, Station Plaza and Forest Avenue, and the temporary partial loss of parking facilities at Columbus Park, will aggravate the problem and require careful planning with adequate signing for control of traffic.

One of the most obvious impacts associated with any project which includes channelization is the aesthetic effect of the changes in the streams. In the case of the Mamaroneck and Sheldrake Rivers, the project would involve channels which would have a man-made appearance even after vegetation has been replaced. For residents in portions of the Town of Mamaroneck sector, these features would detract from the natural setting to which they are accustomed.

Associated with these changes in the nature and appearance of the stream are the losses in biological resources. The natural plant life in and near the streams would be destroyed during construction, and even though a replanting program would be required after the construction ends, there is no method of replacing mature communities of vegetative types. Consequently, there would be a period of near barrenness followed by a period of regrowth. All of this would influence the limited fish and wildlife resources in the project areas. Some of the fish and wildlife would not find suitable habitats in which to reestablish following construction, and construction activities would destroy some forms of life and displace others.

The Fenimore Road diversion system would result in the Sheldrake River being diverted into the West Basin of Mamaroneck Harbor. This diversion would not result in significant effects to the West Basin; however, it would result in the abandonment of the Sheldrake River downstream of Fenimore Road, except for incremental runoff flows. Stagnation pools could develop in this lower reach if local flows are not sufficient enough to cause periodic flushing.

Impacts beneficial to residents and public services would result from the project. The alleviation of the flood problem would reduce the frequency of inundation of streets, commercial establishments and homes, thereby reducing the degree of danger to life and health associated with floods as well as the many inconveniences and disruptions which occur during flood situations. Traffic and especially emergency vehicles would be free to travel without restrictions during floods.

## Plan Formulation

### BYRAM RIVER

After establishing the planning objectives for the Byram River study area, the formulation procedure next required the identification of applicable water resources management measures which address the planning objectives. After all applicable water resources management measures were identified, alternative water resources management plans were developed from either one, or a combination, of the identified measures. The formulation phase of the Byram River study is presented in detail in Section 3, Appendix F. A summary of this process follows below.

## POSSIBLE SOLUTIONS

Flood problems along the Byram River occur principally in the Town of Greenwich, Connecticut and Village of Port Chester, New York. Several alternative measures to satisfy the problems and needs of the flood areas are possible; however, some of these measures are not practical or economical. The possible solutions may be divided into the two broad categories of nonstructural and structural measures. Nonstructural measures include floodplain zoning, floodproofing, building code regulations, permanent and/or temporary evacuation of floodplain areas, and no action (or maintaining the base condition). Structural measures include reservoirs, diversions, channel modification, levee and floodwall improvements, and several combinations of these. Also, combinations of nonstructural and structural measures are possible. Table 14 presents a preliminary categorization of the possible management measures in relation to the planning objectives of the Byram River study area.

## NONSTRUCTURAL MEASURES

The various nonstructural techniques are described in considerable detail in Appendix F, Plan Formulation. During the initial iterations of the planning process, the nonstructural measures discussed above were examined with respect to their: (a) result in achieving the planning objectives; (b) cost of implementation; and (c) intangible advantages and disadvantages. The nonstructural alternates considered further at Greenwich and Port Chester are discussed in subsequent sections.

## STRUCTURAL MEASURES

Subsequent to investigating possible nonstructural solutions, structural flood control alternatives were considered. The structural measures which were investigated are fully described in Appendix F, and are discussed in the following paragraphs.

## DIVERSIONS AND RESERVOIRS

The problem area along the Byram River at Greenwich and Port Chester, which lies about 9,000 feet upstream of the mouth as shown on Plate 10, is not suitably located for the development of diversion type protection. To divert flood flows from a point upstream of the Byram River damage area to the closest large body of water, Byram Harbor, a tunnel of more than 6,000 feet in length would be required. Although such an improvement would reduce fluvial flooding, damages resulting from tidal inundation would not be prevented and the scheme would be highly uneconomical. Furthermore, a solution involving upstream flood detention is also not a practical solution to the flood problem at Greenwich and Port Chester.

TABLE 14 - PRELIMINARY CATEGORIZATION OF MANAGEMENT MEASURES  
BYRAM RIVER, N.Y. AND CONN.

STUDY AREA	MANAGEMENT MEASURES																
	NONSTRUCTURAL MEASURES							STRUCTURAL MEASURES									
	FLOODPROOFING	PERMANENT EVACUATION	TEMPORARY EVACUATION	RELOCATION	ZONING	FLOODWARNING SYSTEMS	BUILDING CODES	TAX ADJUSTMENTS	FLOOD INSURANCE	NO ACTION	RESERVOIRS	DIVERSIONS	LEVELS/FLOODWALLS	CHANNEL MODIFICATION	STRUCTURAL COMBINATIONS	STRUCTURAL AND NONSTRUCTURAL COMB.	
BYRAM RIVER	*	**	*	**	*	*	*	*	*	-	**	**	**	**	**	*	*
PLANNING OBJECTIVES																	
Flood Damage Reduction	**	**	**	**	**	*	*	*	*	-	0	**	**	**	**	*	*
Stream Environment Preservation	**	**	**	**	**	**	**	**	**	**	0	**	*	**	0	*	*
Maintain Pemberick Lake	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	*

LEGEND

\*\* MOST POSITIVE CONTRIBUTION

\* POSITIVE CONTRIBUTION

- NEGATIVE CONTRIBUTION

0 UNKNOWN OR NEUTRAL

Any possible upstream detention area would lie more than two miles upstream from the problem area. The incremental flows generated by local runoff downstream of any potential site would be in excess of bankfull capacity at the downstream damage area. Additionally, like a diversion scheme, upstream retention would not alleviate tidal flooding, and its excessive costs cannot be supported by the potential benefits at Greenwich and Port Chester.

## LOCAL PROTECTION MEASURES

After reservoir and diversion considerations were precluded, it became evident that local protection measures could best achieve the flood control objective. Local protection measures such as levees, floodwalls, channel modification and various combinations of each were considered as possible solutions to the flood problem at Greenwich, Connecticut and Port Chester, New York.

## NONSTRUCTURAL AND STRUCTURAL COMBINATIONS

Providing a relatively low level of flood protection by structural methods does not appear to be a practical solution along the Byram River, since this would only encourage development in areas that would still be subject to flooding from larger storms. However, at independent reaches of stream where nonstructural measures can be selectively substituted for structural measures, at a compatible level of protection, overall combination plans of protection were considered as possible solutions.

## DEVELOPMENT OF INTERMEDIATE PLANS

As a result of reconnaissance and preliminary type estimates, preliminary screening and analysis of applicable measures, an array of alternative plans that could fulfill the study objectives for the Byram River were developed utilizing either one or a combination of the applicable water resources management measures described in the preceding paragraphs. Only alternative plans which were considered to approach economic, environmental and social acceptability were evaluated in detail and presented here. To provide a common base for comparison and evaluation, and to facilitate quantitative and qualitative analyses, protection against a flood with a one percent exceedence frequency was used as the protection level in the initial development of alternative plans. This degree of protection was selected because, as explained in detail in Appendix F, complete protection against the Standard Project Flood (SPF) is clearly not economically justified at the study area along the Byram River. Additionally, based on factors such as projected residual damages and the potential for a catastrophe at the study area, protection against a flood with a one percent exceedence frequency is considered the

minimum degree of protection acceptable along the Byram River. In applying this approach, it was recognized that the design storm for the selected plans of protection could actually be greater than the one percent flood, depending on the tradeoffs between an acceptable flood risk and socio-economic and environmental costs. Those plans which warranted further consideration are described fully in Appendix F, and are briefly outlined below.

## INTERMEDIATE PLANS - BYRAM RIVER

Flood damages along the Byram River are centered in the reach lying from West Putnam Avenue upstream to Rex Street in the Town of Greenwich, Connecticut and Village of Port Chester, New York. An existing Corps of Engineers project lies immediately upstream of this study area at Pemberwick, Connecticut. This project is shown on Figure F17. The alternates discussed below for the Greenwich-Port Chester area along the Byram River are discussed in considerable detail in Section 3, Appendix F and are presented in Figures F13 through F16. Table 15 presents a summary description of the alternatives considered at Greenwich and Port Chester, and economic data are presented in Table 16.

A total of seven plans of protection were generated for consideration along the Byram River. Included among these alternates is a nonstructural plan, three plans consisting of combinations of levees, floodwalls and channel modification, one plan involving a combination of levees and floodwalls, a bridge replacement plan, and an alternate combining bridge replacement with other structural measures. These intermediate plans are discussed in considerable detail in Appendix F.

## ASSESSMENT AND EVALUATION OF INTERMEDIATE PLANS

In compliance with the Principles and Standards for Water Resources Development the economic, environmental and social effects of the various intermediate plans for the Byram River were evaluated. The alternatives were analyzed individually for their beneficial and adverse effects and collectively so that the differences among the alternatives could be identified, and the tradeoffs required to achieve the various planning objectives could be determined. The results of the impact assessment and evaluation studies are discussed in detail in sections III and IV, respectively, of Section 3, Appendix F. In addition, summary evaluations of the intermediate plans contributions are contained in Table 17 for the Byram River.

TABLE 15 - SUMMARY DESCRIPTION OF INTERMEDIATE PLANS  
 BYRAM RIVER

<u>PLAN</u>	<u>DESCRIPTION</u>
Nonstructural Plan	One industrial and 61 residential structures floodproofed, and 80 residences acquired.
Plan 1	Modified 60 ft. channel (2,000 LF), and levees (3,400 LF), floodwalls (1,100 LF) and the floodproofing of one industrial structure.
Plan 2	Modified 60 ft. channel (2,400 LF), and levees (3,400 LF), floodwalls (1,100 LF) and the floodproofing of one industrial structure.
Plan 3	Modified 40 ft. channel (2,400 LF), and levees (3,400 LF), floodwalls (1,100 LF) and the floodproofing of one industrial structure.
Plan 4	Levees (3,400 LF) and floodwalls (1,100 LF) at study area; and additional floodwall (500 LF) along right bank and knee wall atop existing levee on left bank at the Pemberton wick flood control project.
Plan 5	Replacement of West Putnam Avenue Bridges.
Plan 6	Modified 60 ft. channel (1,950 LF), and levees (3,400 LF), floodwalls (1,100 LF), replacement of bridges, and the floodproofing of one industrial structure.

TABLE 16 - ECONOMIC EVALUATION OF ALTERNATIVES  
GREENWICH, CONN. AND PORT CHESTER, N.Y.

DECEMBER 1976 PRICE LEVEL IN DOLLARS  
(100 Year Project Life and 6-3/8% Interest Rate)

ALTERNATIVE	NON-FEDERAL FIRST COST	FEDERAL FIRST COST	TOTAL FIRST COST	ANNUAL MAINTENANCE & OPERATION	TOTAL ANNUAL COST	(1) ANNUAL BENEFITS	BENEFIT- COST RATIO	EXCESS BENEFITS OVER COST
NON-STRUCTURAL PLAN								
PLAN 1	1,076,000	3,221,000	4,297,000	16,500	292,200	458,500	1.57	166,300
PLAN 2	1,098,000	3,274,000	4,372,000	16,700	297,100	470,500	1.58	173,400
PLAN 3	1,022,000	3,270,000	4,292,000	16,700	292,000	477,500	1.64	185,500
PLAN 4	1,561,000	3,288,000	4,849,000	12,800	325,500	437,000	1.3	112,000
PLAN 5	3,450,000	--	3,450,000	--	221,000	71,000	0.3	-150,000
PLAN 6	4,500,000	3,230,000	7,730,000	16,300	511,200	464,500	0.9	- 26,700

(1) Includes benefits from flood damage reduction and NED employment, and advanced replacement of bridges, where applicable.

TABLE 17 - RESPONSE TO PLANNING OBJECTIVES, AND FORMULATION CRITERIA  
TOWN OF GREENWICH, CONN. AND VILLAGE OF PORT CHESTER, N.Y.

	INTERMEDIATE PLANS						
	BYRAM RIVER						
	NONSTRUCTURAL PLAN	PLAN 1	PLAN 2	PLAN 3	PLAN 4	PLAN 5	PLAN 6
<u>PLANNING OBJECTIVES</u>							
Flood Damage Reduction	+	++	++	++	++	0	+
Stream Environment Preservation	++	-	-	-	0	0	-
Maintain Pemberwick Lake	++	+	+	+	+	+	+
<u>EVALUATION CRITERIA</u>							
Acceptability	-	+	+	++	-	-	+
Certainty	+	+	+	+	+	-	+
Completeness	+	+	+	+	+	-	+
Effectiveness	+	+	+	+	+	-	+
Efficiency	-	-	+	++	+	-	-
Geographic Scope	+	+	+	+	+	+	+
NED Benefit-Cost Ratio	-	+	+	++	+	-	-
Reversibility	++	0	0	0	+	+	0
Stability	+	+	+	+	+	+	+
<u>OTHER FORMULATION CRITERIA</u>							
Implementability	+	+	+	+	+	+	+
Adequacy of Level of Protection	+	+	+	+	+	0	+
Public Health and Safety	+	++	++	++	++	+	+
Cultural Resources	0	0	0	0	0	0	0

LEGEND

- ++ MOST POSITIVE
- + POSITIVE CONTRIBUTION
- 0 NEUTRAL OR MINIMAL
- NEGATIVE CONTRIBUTION
- MOST NEGATIVE

## ALTERNATIVES CONSIDERED FOR DETAILED ANALYSIS

Based on the assessment and evaluation studies described above, and presented in Appendix F, alternative plans were identified for the Byram River to be carried into the final planning stage. The rationale utilized in the screening of the alternatives is fully discussed in part IV of Section 3, Appendix F. Further analysis of the identified alternatives towards developing detailed plans that more fully address the planning objectives, and ultimately the selection of the most desirable plans, is contained in subsequent sections. Of the intermediate plans investigated, the plans which have been identified for further consideration along the Byram River are:

- Plan 3 (levee, floodwall, channel modification and floodproofing)
- Plan 4 (setback levee, and floodwall)

## CONTRIBUTIONS TO NATIONAL OBJECTIVES

During this iteration of the planning process, alternatives were designated as NED and EQ plans. For the Byram River, Plan 3 was designated as the NED Plan. The NED Plan was selected on the basis that it maximizes net economic benefits in meeting the range of planning objectives. As discussed in Appendix F, in the designation of an EQ Plan one overriding criterion was utilized; that criterion being that the final EQ Plan must make a positive net contribution to the EQ account (natural environment) when compared to the without condition. A review of the intermediate plans and the assessment of their associated impacts, as presented in paragraphs F121 through F126, Section 3, Appendix F, reveals that none of the alternatives result in a net positive contribution to the EQ account. Furthermore, like the Mamaroneck and Sheldrake Rivers area, it appears that because of the setting of the study area, the nature of the flood problem, and other factors, such as the existing marginal aquatic resources at the lower reaches of stream, there is no apparent means of satisfying the flood control objective for the Byram River without resulting in a net negative effect to the environment. Therefore, an EQ Oriented NED Plan was identified as that alternative which most nearly meets the minimum requirement for an EQ Plan. Plan 4 was designated as the EQ Oriented NED Plan since it minimizes net negative contributions to the EQ account. This plan addresses the planning objectives while emphasizing contributions to preserving the existing stream environment and open space through minimizing adverse and disruptive impacts. The development of the NED, and EQ Oriented NED plans is discussed in detail in Appendix F.

## NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

The NED Plan was selected on the basis that it maximizes net positive economic benefits while addressing the array of planning objectives for the Byram River study area. As shown in Tables 16 and 18, Plan 3 produces the greatest net excess benefits over costs. Thus Plan 3 is designated as the NED Plan.

## FINAL ITERATION OF THE NED PLAN

The final NED plan for the Byram River differs from Plan 3, as considered in the intermediate planning stage, in that it includes measures to mitigate negative EQ contributions to the stream environment caused by the structural works. These measures are considered appropriate for the NED plan since coordination with Federal and state agencies, including U. S. Department of the Interior, Fish and Wildlife Services, has indicated that provisions of this type are necessary for the recovery of losses resulting from implementation, and are required for acceptability. These measures would include, in addition to the erosion and sediment control measures to be included for the EQ Oriented NED Plan, the following:

a. The existing channel would be widened by excavating only one bank, where possible, so as to eliminate the minimum number of trees. At those reaches within the study area where the natural channel approaches 40 feet in width, the stream would not be further widened.

b. A pool and riffle low flow channel would be incorporated for the entire length of the modified channel. Also, gabion wire baskets or some other similar materials would be used for the creation of a diversified aquatic bottom habitat.

c. A beautification and a tree planting program would be implemented after construction so as to replace some of the trees and shrubs removed as a result of levee and floodwall construction or channel excavations.

## EQ ORIENTED NED PLAN

The EQ Oriented NED Plan was designated on the basis that it addresses the planning objectives for the Byram River while emphasizing ecological and aesthetic contributions including the preservation of the existing stream environment and Pemberwick Lake. The identified plan which provides the minimum net negative contributions to the above-mentioned components of the National objective of Environmental Quality is the setback levee alternate, Plan 4. This plan would result in minimal adverse effects to the aquatic habitat since channel modifications are not included. Although the existing fishery resources are limited at the lower portion

of the study area, Plan 3's reduced effects to the channel environment would preserve the resources at the upper end of the study area, and offer a future potential for enhancement downstream of Pemberwick Lake. Additionally, the use of setback levees would preserve the bankside vegetation along the stream. Erosion and sediment control measures are proposed during the construction activities to prevent negative siltation impacts to water quality at the study area and at downstream reaches. Finally, trees and shrubs which would be eliminated by the levee construction would be replaced through beautification measures and a tree planting program.

## COMPARISON OF IDENTIFIED PLANS

A comparison analysis is used to provide a basis for plan selection. The process used to compare the identified plans consists of a trade-off analysis of contributions to the planning objectives and the beneficial and adverse effects of each alternate, and the responses to specific evaluation criteria such as tests of acceptability, effectiveness, efficiency, and completeness. This type of comparison categorizes the various impacts and displays each plan in terms of the components of the system of accounts. A summary comparison of Plans 3 (NED) and 4 along the Byram River is contained in Table 18, and the system of accounts for each plan are displayed in Tables F22 and F23 of Appendix F.

Examination of the data in the above-mentioned tables for the Byram River reveals the significant tradeoffs made between the identified plans. As summarized in Table 18, the major monetary beneficial effect that would result from the alternate plans is the reduction of existing and future flood damages at Greenwich, Connecticut and Port Chester, New York. With respect to adverse economic effects, the difference between the plans is the higher cost for the setback levee plan (Plan 4) as compared to the combination channel levee plan (Plan 3). But more significantly, Plan 3 achieves the flood damage reduction objective while maximizing net positive NED benefits; Plan 4 does not maximize the economic return, although it does produce positive net benefits. However, Plan 4 achieves the flood control objective while preserving the existing stream environment; Plan 3 would result in greater negative EQ contributions, although impacts to the existing stream environment are not judged to be significant at the reach for which channel works are proposed (downstream of Pemberwick Lake) when considering the measures included to mitigate the adverse effects of the channel modification. Additionally, it is noted that the 40 foot base width modified channel considered in Plan 3 is the narrowest and least disruptive of the channel improvements considered in the intermediate planning stage.

As outlined in Table 18, the total amount of real estate required as easements is approximately equal for both plans, although Plan 4 would require about 1 more acre of permanent easements. However, the social impacts associated with the real estate requirements of the plans should be

TABLE 18 - SUMMARY COMPARISON OF IDENTIFIED PLANS  
BYRAM RIVER AT GREENWICH, CONN. AND  
PORT CHESTER, N.Y.

	PLAN 3 (NED PLAN) SELECTED PLAN	PLAN 4 (EQ ORIENTED NED PLAN)
<b>A. PLAN DATA</b>		
Structural measures	Combination of levee, floodwalls and channel modification.	Setback levee and floodwall.
Nonstructural measures	One structure floodproofed; regulatory zoning within flowage easements.	One structure floodproofed; regulatory zoning within flowage easements.
Lands	20.9 acres of permanent easements; one residential structure acquired; 2.9 acres of temporary easements.	22.5 acres of permanent easements; ten residential structures acquired; 3.1 acres of temporary easements.
<b>B. SIGNIFICANT IMPACTS</b>		
	<ol style="list-style-type: none"> <li>1) Plan removes approximately 54 acres from the one percent floodplain.</li> <li>2) Approximately 140 homes and 5 businesses protected from damage from one percent flood.</li> <li>3) Encroachment and loss to some of the limited fish and wildlife habitat. Measures to mitigate these effects would minimize these losses.*</li> <li>4) Undetermined number of trees and shrubs removed for construction. Project beautification measures and tree planting program would partially replace these losses.*</li> <li>5) Temporary increases in turbidity and sedimentation levels during construction of levees and walls, and from excavation within channel. Use of erosion control measures and temporary sediment basins or silt barrier screens would minimize this impact.</li> <li>6) Construction activities would result in short-term adverse impacts on the appearance of the project area. After construction the levee and walls would present an obstacle to those who wish to view the river.*</li> </ol>	<ol style="list-style-type: none"> <li>1) Same as NED plan.</li> <li>2) Same as NED plan.</li> <li>3) Acquisition of ten homes and relocation of residents would impact on community cohesion.*</li> <li>4) Construction of the setback levee would remove a loss significant number of trees and shrubs. Project beautification measures would further minimize this impact to study area.*</li> <li>5) Less significant temporary increases in turbidity and sedimentation levels from denuded side slopes of levees and from excavations during floodwall construction. Erosion control measures would minimize this impact.</li> <li>6) Same as NED plan, except construction activities, and the associated adverse impacts, would be carried into the upstream Pemberwick area.*</li> </ol>
<b>C. PLAN EVALUATION</b>		
<b>1. CONTRIBUTIONS TO PLANNING OBJECTIVES</b>		
a) Flood Damage Reduction	<ol style="list-style-type: none"> <li>1) Approximately 140 homes and 5 businesses protected from damage from one percent flood.</li> <li>2) Total average annual damages reduced by 95%.</li> </ol>	<ol style="list-style-type: none"> <li>1) Same as NED plan.</li> <li>2) Total average annual damages reduced by 92%.</li> </ol>
b) Stream Environment Preservation	<ol style="list-style-type: none"> <li>1) Downstream of Pemberwick Lake the channel modification of the Byram River would impact on the limited aquatic and wildlife habitat.</li> <li>2) Mitigation measures would minimize the permanent effects after construction.</li> </ol>	<p>The existing river system would be preserved, however, construction activities along the banks would result in some disruptive impacts.</p>
c) Maintain Pemberwick Lake	<p>A low sill would be constructed to maintain the present water surface elevations of the lake.</p>	<p>Lake would be preserved in its existing condition.</p>

\* Item specified in Section 122.

TABLE 18 - SUMMARY COMPARISON OF IDENTIFIED PLANS (Cont'd)  
 BYRAM RIVER AT GREENWICH, CONN. AND  
 PONT CHESTER, N.Y.

PLAN 3 (NED PLAN)  
 (EQ ORIENTED NED PLAN)

PLAN 3 (NED PLAN) SELECTED PLAN	PLAN 4 (EQ ORIENTED NED PLAN)
2. NATIONAL ECONOMIC DEVELOPMENT	
Beneficial	\$448,500
Adverse	\$346,000
Net	\$102,500
NED benefit-cost ratio	1.3
3. ENVIRONMENTAL QUALITY	
a) Quality of Water, Air, and Land and Lead resources	Similar to NED plan. Set back levee would result in less extensive vegetative loss.
b) Fish and Wildlife Resources	Negative contributions would be similar to NED plan; however, these impacts would be minimal.
c) Historical-Archaeological Resources	Same as NED plan.
d) Aesthetics	Same as NED plan, however, construction activities would carry the associated impacts upstream into the Pemberwick area.
4. REGIONAL DEVELOPMENT	Same as NED plan.
5. SOCIAL WELL-BEING	
a) Life, Health and Safety	Same as NED plan.
b) Displacement of People	Ten homes would be acquired and the residents relocated.
c) Income Effect	Same as NED plan.
d) Recreation	Same as NED plan.
D. IMPLEMENTATION RESPONSIBILITIES	
1. Federal	Federal first cost of \$3,580,000 would be 70% of total first cost.
2. Non-Federal	Non-Federal first cost of \$1,560,000 would be 30% of total first cost. Lands, rights-of-way and easements account for largest portion thereof. Operation, maintenance and replacement costs estimated at \$18,800 annually would be local responsibility.

noted since they are considered to be of high local importance. The land required for the setback levee (Plan 4) would impact on the residential community since ten homes would be acquired and the residents relocated. Furthermore, the floodwalls to be constructed atop the existing levee at the upstream Pemberwick project as part of Plan 4 would have a negative aesthetic impact on that area, and would also carry the temporary effects associated with the construction activities into this reach of the Byram River. The real estate requirements for Plan 3 are, in general, closer to the stream and would not result in widespread disruption to the community since one home would be acquired, and minor work would be necessary at the Pemberwick area.

An additional consideration in evaluating the identified plans concerns the possibility of floodwaters overtopping the levees and floodwalls of either plan of protection. The channel modification features of Plan 3 enable it to also reduce the elevation of floodwaters for storms greater than 3 feet above the design level.

Various other evaluation criteria were considered in the selection of a plan and are shown summarized in tabular form in Table F18 in Appendix F. Additionally, the local communities of Greenwich, Connecticut and Port Chester, New York have expressed their support for the NED plan.

## THE SELECTED PLAN

The development of the most desirable plan of protection for the Byram River study area involved the comparison and tradeoffs among the identified plans, as described above and presented in Table 18. At the completion of this final iteration and based primarily on the comparative analysis, and input from local government agencies and the public, the selected plan was identified as the NED plan, as shown in Figure 11 of the main body of this report. Details of the technical aspects of the selected plan are discussed in Appendices A, B and C. A comprehensive technical description of the selected (NED) plan is contained in Appendix B, Hydraulics. A summary description of the selected plan is included below:

## COMPONENTS OF THE SELECTED PLAN

The selected plan along the Byram River involves channel excavation, floodwalls and levees. The channel of the Byram River would be dredged for approximately 700 feet downstream of the southern U.S. 1 Bridge. The new channel would be 70 feet wide and the riverbed beneath the two U.S. 1 Bridges would also be lowered. Rip-rap would be placed in the bridge openings to protect against erosion. Upstream of the two U.S. 1 Bridges a 50 foot wide rectangular channel running for 550 feet is proposed. From this point upstream for 260 feet a semi-trapezoidal channel 50 feet wide with a wall on the right bank would be constructed. From this point, approximately 400 feet below Den Lane to the proposed sill at Monica Street, the channel would be a 40 foot wide trapezoid. A floodwall 810 feet long would be built on the right bank between the two factories. A wall 550 feet long is proposed for the left bank upstream of the Southbound U.S. 1 Bridge. A levee would be built on the left bank from the upstream end of the left bank wall and would continue to the upstream limit of the proposed project at Rex Street, where it would tie into the existing levee. Some modification is necessary to the 400 feet of existing left bank levee upstream from where the river enters the lake. An average raising of 2 feet along the length of existing levee is required to guarantee closure against the 6920 cfs design flow. Approximately 700 yd<sup>3</sup> of fill will be required to make this minor adjustment to the existing levee. A concrete sill with a top elevation of 6.0 feet Mean Sea Level is proposed for the mouth of Pemberwick Lake to maintain its elevation during times of low flow. Ponding areas, pumping stations, storm drainage interceptors and other associated interior drainage facilities would be provided behind the levees and walls to carry surface runoff from the area protected. This plan is designed to protect against a flood with a 1 percent exceedence frequency (100 year flood). The rationale for selecting this level of protection is contained in paragraph F142, Appendix F. In order to minimize the adverse effects the channel modification work would have on the stream environment, measures are included to mitigate these impacts. These measures would include, in addition to the erosion and sedimentation control measures previously described for the considered plan for the Mamaroneck and Sheldrake Rivers, the following:

a. The existing channel would be widened by excavating only one bank, where possible, so as to eliminate the minimum number of trees. At those reaches within the study area where the natural channel approaches 40 feet in width the stream would not be further widened.

b. A pool and riffle low flow channel would be incorporated for the entire length of the modified channel. Also, gabion wire baskets or some other similar materials would be used for the creation of a diversified aquatic bottom habitat.

c. A beautification and a tree planting program would be implemented after construction so as to replace some of the trees and shrubs removed as a result of levee and floodwall construction or channel excavations.

## Environmental Effects

The environmental effects of the selected plan for the Byram River are fully discussed in Appendix G, and the significant impacts are summarized in Table 18. Some of the impacts are associated with construction and would be only short-term, but others of a more enduring nature are involved. Construction activities would, of course, create noise and dust which would be annoying and possibly harmful to residents along the waterways. The traffic delays and detours associated with construction and movement of supplies and material would adversely affect local travel and trucks carrying supplies would add to the traffic load.

One of the most obvious impacts associated with any channelization project is the aesthetic effect of the changes in the streams. In the case of the Byram River, the project would involve trapezoidal channels which would have a man-made appearance even after vegetation has been replaced. The areas which would be lined with levees and floodwalls would be especially noticeable and obtrusive. For residents in the sector, these features would detract from the natural setting to which they are accustomed and the view of the stream would be blocked.

Associated with these changes in the nature and appearance of the stream are the losses in biological resources. The natural plant life in and near the streams would be destroyed during construction, and even though a replanting program would be required after the construction ends, there is no method of replacing mature communities of vegetative types. Consequently, there would be a period of near barrenness followed by a period of regrowth. All of this would influence the fish and wildlife resources in the project area. Some of the fish and wildlife would not find suitable habitats in which to reestablish following construction and construction activities would destroy some forms of life and displace others.

Impacts beneficial to residents and public services would result from the project. The alleviation of the flood problem would reduce the frequency of inundation of streets and homes, thereby reducing the degree of danger to life and health associated with floods as well as the many inconveniences and disruptions which occur during flood situations.

## ECONOMICS OF THE SELECTED PLANS

### METHODOLOGY

The tangible economic justification of the proposed improvements was determined by comparing the equivalent average annual charges (i.e., interest, amortization and maintenance costs) with the estimated equivalent

average annual benefits anticipated to accrue over the economic life of the project. A discount rate of 6-3/8% was used to obtain comparable equivalent average annual costs and benefits. In accordance with the economic criteria for the project, a 100 year project life was used in the economic analysis.

## ESTIMATE OF FIRST COSTS

The estimated first cost of selected plans for the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, and the Byram River at Greenwich, Connecticut and Port Chester, New York are \$34,400,000 and \$4,475,000, respectively, as shown in Table 19. These estimates include allowances for contingencies, engineering and design, supervision, planning, surveys, appraisals and administration. All estimates are based on December 1976 price levels. Detailed cost estimates of the various components of the plan are contained in Appendix E, Cost Estimates.

## ESTIMATE OF ANNUAL CHARGES

The estimated annual charges for the selected plans are based on an interest rate of 6-3/8 percent for Federal and non-Federal interests. Charges for amortization of the costs of the various improvements and real estate are based on a 100 year useful life expectancy. The total estimated annual costs for the plans for Mamaroneck and Sheldrake Rivers and Byram River are \$2,230,000 and \$309,000, respectively, including operation, maintenance and replacement charges, as shown in Table 20. A detailed breakdown of these charges is presented in Appendix E.

## ESTIMATE OF ANNUAL BENEFITS

The benefits derived from the recommended plan of protection along the Mamaroneck and Sheldrake Rivers consist of the average annual flood damages the improvement prevents, benefits from advanced replacement of bridges and less frequent pavement maintenance, and NED employment benefits. Along the Byram River, the benefits derived from the recommended plan consist of the average annual flood damages prevented, benefits from less frequent pavement maintenance and NED employment benefits. These benefits are discussed in the following paragraphs. See Appendix D, Flood Damages and Benefits, for additional detail.

### Annual Flood Control Benefits

The average annual benefits that accrue as a result of the proposed flood control plans under existing conditions of development are estimated at \$2,240,000 along the Mamaroneck and Sheldrake Rivers at the

TABLE 19 - COST ESTIMATE SUMMARY  
 SELECTED PLANS OF IMPROVEMENT  
 VILLAGE AND TOWN OF MAMARONECK AND  
 GREENWICH, CONNECTICUT AND PORT CHESTER, NEW YORK  
 (December 1976 Price Level)

<u>Description</u>	<u>Cost</u>
MAMARONECK AND SHELDRAKE RIVERS BASIN	
I. ESTIMATED FEDERAL COST	
Relocations	\$ 153,000
Channels and Canals	5,885,630
Floodways and Diversions	12,545,200
Contingencies	5,044,080
SUBTOTAL	<u>\$23,627,910</u>
Engineering and Design	3,544,180
Supervision and Administration	<u>2,362,800</u>
TOTAL FEDERAL COST (ROUNDED)	\$29,530,000
II. ESTIMATED NON-FEDERAL COST	
Lands and damages	\$ 1,689,400
Contingencies	168,940
SUBTOTAL	<u>\$ 1,858,340</u>
Planning, Surveys, Appraisals and Administration	<u>92,920</u>
SUBTOTAL LAND ACQUISITION COST	\$ 1,951,260
Relocations	1,868,500
Contingencies	467,130
SUBTOTAL	<u>\$ 2,335,630</u>
Engineering and Design	350,350
Supervision and Administration	<u>233,570</u>
SUBTOTAL CONSTRUCTION COST	\$ 2,919,550
TOTAL NON-FEDERAL COST (ROUNDED)	\$ 4,870,000

TABLE 19 (continued)

<u>Description</u>	<u>Cost</u>
III. TOTAL ESTIMATED COST	
Federal Cost	\$29,530,000
Non-Federal Cost	<u>4,870,000</u>
TOTAL ESTIMATED FIRST COST	\$34,400,000
BYRAM RIVER BASIN	
I. ESTIMATED FEDERAL COST	
Relocations	\$ 55,000
Channels and Canals	448,400
Levees and Floodwalls	1,497,260
Pump Plants	264,900
Contingencies	<u>566,400</u>
SUBTOTAL	\$ 2,831,960
Engineering and Design	424,800
Supervision and Administration	<u>283,200</u>
TOTAL FEDERAL COST (ROUNDED)	\$ 3,540,000
II. ESTIMATED NON-FEDERAL FIRST COST	
Lands and Damages	\$ 778,100
Contingencies	<u>77,810</u>
SUBTOTAL	\$ 855,910
Planning, Surveys, Appraisals and Administration	<u>42,800</u>
SUBTOTAL LAND ACQUISITION COST (ROUNDED)	\$ 899,000
Relocations	\$ 23,000
Contingencies	<u>5,750</u>
SUBTOTAL	\$ 28,750
Engineering and Design	4,310
Supervision and Administration	<u>2,880</u>
SUBTOTAL CONSTRUCTION COSTS (ROUNDED)	\$ 36,000
TOTAL NON-FEDERAL COST	\$ 935,000

TABLE 19 (continued)

<u>Description</u>	<u>Cost</u>
III. TOTAL ESTIMATED COST	
Federal Cost	\$ 3,540,000
Non-Federal Cost	<u>935,000</u>
TOTAL ESTIMATED FIRST COST	\$ 4,475,000

TABLE 20 - SUMMARY OF ANNUAL COSTS FOR SELECTED PLANS OF IMPROVEMENT FOR THE  
 VILLAGE AND TOWN OF MAMARONECK, NEW YORK  
 AND GREENWICH, CONNECTICUT AND PORT CHESTER, NEW YORK

(DECEMBER 1976 PRICE LEVELS)

Item	VILLAGE AND TOWN OF MAMARONECK		GREENWICH, CONN. AND PORT CHESTER, N. Y.		Total
	Federal	Non-Federal	Federal	Non-Federal	
Project First Cost	\$29,530,000	\$4,870,000	\$3,540,000	\$935,000	\$4,475,000
Interest and Amortiza- tion for 100 Year Life at 6-3/8%	1,886,000	311,000	226,000	60,000	286,000
Operation, Mainten- ance and Replacement	0	33,000	0	23,000	23,000
TOTAL ANNUAL CHARGES	\$ 1,886,000	\$ 344,000	\$ 226,000	\$ 83,000	\$ 309,000

Village and Town of Mamaroneck, New York and \$289,800 along the Byram River at Greenwich, Connecticut and Port Chester, New York. Future urban inundation reduction benefits were evaluated utilizing affluence factors based on the most probable future conditions of the study areas, as described in Appendix G, and the values of residential structure and contents presented in Appendix D. The average annual benefits that would accrue under future conditions are estimated at \$2,465,000 along the Mamaroneck and Sheldrake Rivers, and \$431,400 along the Byram River. The future growth rate that is reflected in these amounts is a specific figure applied only to residential contents, and is based on the economic information and projections as presented in Appendix G, Environmental, Social and Economic Effects.

### Replacement of Bridges

The plans of protection along the Mamaroneck and Sheldrake Rivers will require the replacement of several existing bridges. The bridges to be replaced are the Ward Street, Halstead Avenue, Station Plaza and Hillside Avenue Bridges on the Mamaroneck River in the Village of Mamaroneck, and the Forest Avenue Bridge on the Sheldrake River in the Town of Mamaroneck. The replacement of an existing bridge as a project cost actually extends the life of the structure with a reduction of maintenance costs. These net reductions were considered as benefits accruing to the plans of protection. For the Village of Mamaroneck the average annual benefits from the advanced replacement of bridges are estimated at \$52,000 based on extending the lives of the existing bridges from 30 to 45 years; for the Town of Mamaroneck the average annual benefits are estimated at \$3,000 based on extending the life of the existing bridge 40 years. A sample calculation for estimating these benefits for the Ward Street Bridge is shown in Table D8, Appendix D.

### Resurfacing of Pavement

The streets in the Village of Mamaroneck that would be inundated under existing conditions as a result of a recurrence of the June 1972 flood require resurfacing on the average of once every 15 years during a 100 year period and costs \$30,300 annually. Under improved conditions, if the plan were to be constructed, it is estimated that the streets located in the Village would require resurfacing every 30 years during the 100 year life of the project, at a cost of \$8,300 annually. Therefore, the benefits that would be realized from less frequent pavement maintenance attributed to the plan of protection would amount to \$22,000 annually, as shown on Table D9 of Appendix D. Similar benefits in the Town of Greenwich attributed to the Byram River plan of protection amount to \$3,500. These benefits were derived from data gathered from local officials based on their past experience at the flood-prone and flood-free areas within their communities.

## Employment Benefits

The Mamaroneck and Sheldrake Rivers and Byram River study areas and the surrounding vicinity within a 30-mile radius, including Westchester County and New York City, are designated as having substantial unemployment by the U. S. Department of Labor as of March 1977. NED employment benefits would be realized from the use of unemployed resources in project construction, as described in Appendix D. The average annual NED employment benefits are estimated at \$520,000 for the Mamaroneck and Sheldrake Rivers plan of protection, and \$53,400 for the Byram River improvement.

## Annual Benefit Summary

The total average annual benefits from the entire recommended plans of improvement, under existing conditions of development, are estimated at \$2,260,000 for the Mamaroneck and Sheldrake Rivers and \$293,300 for the Byram River. Based on future conditions of development, as described in Appendix G, the total average annual benefits are estimated at \$3,060,000 for the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck and \$488,300 for the Byram River at Greenwich, Connecticut and Port Chester, New York. These totals are detailed in Table D14 of Appendix D, Flood Damages and Benefits.

## ECONOMIC JUSTIFICATION

The comparison of average annual benefits and the average annual costs result in benefit-cost ratios of 1.4 and 1.6 for the Mamaroneck and Sheldrake River plan of protection, and the Byram River improvement, respectively. Without employment benefits, the benefit-cost ratios for the recommended plans are 1.1 and 1.4, respectively.

## DIVISION OF RESPONSIBILITIES

Legislative and administrative policies have established the basis for Federal and non-Federal sharing of responsibilities in the construction, operation and maintenance of Federal water resources projects. Significant in this regard is the sharing of first costs for construction and the responsibilities as well as costs for maintaining the completed project. These responsibilities are discussed in the following paragraphs and the Federal and non-Federal shares of the projects are presented in Table 21. The legislation providing for Federal and non-Federal participation, and a summary of the institutional analysis is contained in Section 4, Appendix F. A summary of the Federal and non-Federal responsibilities is included below.

## FEDERAL RESPONSIBILITIES

The Federal Government would design and prepare detailed plans, construct the projects, and share in the cost of the projects. Construction of the projects would be contingent on Congressional authorization and appropriation of funds and on the receipt of the non-Federal share of the project cost. The Federal Government would assume all costs for the pre-authorization studies. It would also share in the total cost of the projects as shown below.

## NON-FEDERAL RESPONSIBILITIES

Non-Federal interests' share of the project first cost consists of the cost for lands, easements, rights-of-way, utility relocations and bridge replacements. In addition, non-Federal interests are responsible for operating, maintaining and providing replacements for the completed projects.

TABLE 21 - COST APPORTIONMENT

Plan	Estimated first costs	Annual maintenance, operation and replacement costs
MAMARONECK AND SHELDRAKE RIVERS		
Federal	\$29,530,000	0
Non-Federal	4,870,000	\$33,000
TOTAL	\$34,400,000	\$33,000
BYRAM RIVER		
Federal	\$ 3,540,000	0
Non-Federal	935,000	\$23,000
TOTAL	\$ 4,475,000	\$23,000

# Plan Implementation

Submission of this report by the District Engineer constitutes the first step in a chain of events which must take place before a project can become a reality. It may be modified at any stage of review and only if it successfully passes each stage will it ultimately be constructed. These events are:

a. Review of the report and the environmental impact statements by higher Corps of Engineers authorities, including the North Atlantic Division, the Board of Engineers for Rivers and Harbors and the Office of the Chief of Engineers.

b. At the request of the Chief of Engineers, formal review by the Governor of the State of New York and the State of Connecticut for the proposed Byram River project.

c. Comment by other interested Federal agencies at the request of the Chief of Engineers.

d. Submission of the final report to the Chief of Engineers and the final environmental impact statement to the Secretary of the Army.

e. Review and comment by the Office of Management and Budget regarding the relationship of the project to the program of the President.

f. Submission of the environmental impact statement by the Secretary of the Army to the Council on Environmental Quality.

g. Endorsement by the Secretary of the Army and submission of the report to the Congress.

h. Review and hearing by the Public Works Committees of both houses of Congress culminating in project authorization by Congress.

i. Inclusion in his budget requests, when appropriate, of funds for design and construction of the authorized project by the Chief of Engineers.

j. Appropriation of the necessary funds by the Congress.

k. Fulfillment of the required measures of local cooperation.

l. Completion of the necessary surveys and investigations, preparation of plans, specifications and an estimate of the construction cost by the District Engineer, followed by an invitation for bids and awarding of the construction contract.

- m. Assumption of responsibility for maintenance by local interests.

It is not possible to accurately estimate a schedule for the above steps, because of the uncertainty in the reviewing and funding processes. Once the project is authorized and is initially funded, it should be possible to complete design and construction within a four year period if appropriation of funds is adequate.

## VIEWS OF NON-FEDERAL INTERESTS

Included among the non-Federal interests with which the considered plans for the Mamaroneck and Sheldrake Rivers were coordinated were New York State Department of Environmental Conservation; New York State Planning and Development Clearinghouse, Division of the Budget; County of Westchester Department of Public Works, and Department of Planning; the Village of Mamaroneck; Town of Mamaroneck; and Town of Harrison. The Byram River plans were coordinated with, in addition to the above-mentioned New York State and Westchester County agencies, the State of Connecticut Department of Environmental Protection; the Village of Port Chester, New York; and the Town of Greenwich, Connecticut.

As discussed in Section 4 of Appendix F, the State of New York, through the Commissioner of the Department of Environmental Conservation, acts as the primary non-Federal cooperating agency for Corps' projects in New York. Letters of local cooperation for the proposed project for the Mamaroneck and Sheldrake Rivers have been furnished by the State of New York, and the Village and Town of Mamaroneck. Letters of intent have also been obtained from the State of New York, Village of Port Chester, New York, and the Town of Greenwich, Connecticut for the proposed project along the Byram River. For the Connecticut portion of the Byram River project, the Town of Greenwich acts as the local cooperating agency. All of these letters are included as attachments in Appendix H, Authorizing Documents, Coordination and Pertinent Correspondence. Additionally, Tables H1, H2, H3 and H4, Appendix H, summarize the viewpoints expressed at the public meetings held in connection with the respective studies.

## COORDINATION WITH OTHER FEDERAL AGENCIES

The considered plans of improvement for the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, and the Byram River at Greenwich, Connecticut and Port Chester, New York were coordinated with interested agencies at Federal, state and local levels. These agencies include: U. S. Fish and Wildlife Service of the U. S. Department of the Interior, Soil Conservation Service of the U. S. Department of Agriculture, Federal Power Commission, Environmental Protection Agency, Federal Highway Administration, U. S. Department of Housing and Urban Development, Bureau of Outdoor Recreation of the U. S. Department of the Interior, U. S. Department

of Commerce, Economic Development Administration, Federal Railroad Administration, United States Coast Guard and the National Park Service of the U. S. Department of the Interior. The views and comments of those agencies that were considered a great concern are discussed in the following paragraphs. A complete summary of all the coordinating agencies is given in Appendix H, Authorizing Documents, Coordination and Pertinent Correspondence.

## DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE

Subsequent to the joint field inspection of the study area held on 30 March 1976, between representatives of the Fish and Wildlife Service and the Corps, the Service indicated, by letter dated 21 July 1976 (Attachment H2), that the limited wildlife and fishery resources at the study area in the Village and Town of Mamaroneck, New York are representative of the urban setting found along the Mamaroneck and Sheldrake Rivers. Additionally, it was pointed out that since the study area is essentially urban in nature, and the lower reaches of streams burdened with pollution load, an estimate of changes in aquatic and terrestrial wildlife resources attributable to the considered plans of protection could not be made. However, the Fish and Wildlife Service did recommend that the artificial creation of bottom habitat be considered at those sections of the plans of protection for which channel modification is proposed.

It was also recommended that channel modifications follow the existing contours of the channels, and that at some areas of proposed channel work only one side of the stream be excavated. As part of the Corps' reply dated 11 November 1976 (Attachment H3), this office informed the Service that, where possible, the measures they suggested will be incorporated into the plan of protection, in order to minimize the adverse effects of the channel modification. In addition, the Fish and Wildlife Service was asked to provide assistance during preconstruction planning regarding the design of the artificial bottom habitat and pools which were suggested in their letter of 21 July 1976.

Subsequent to the joint field inspection of the study area on 28 February 1975, the Fish and Wildlife Service indicated, by letter dated 2 May 1975 (Attachment H11), that although located in a highly urban environment, the Byram River within the study area presents a pleasant appearance, and supports various plant, fish and wildlife species. It was explained that the Service prefers flood control measures which would have minimal impact on fish and wildlife resources and their habitats, with less consideration given to the costs to implement such measures. With this in mind the Service believes that a non-structural plan of protection would be the least damaging to fish and wildlife resources. It was additionally pointed out that the levee alternative, while somewhat less desirable than the non-structural plan, is preferable to alternates which

include channel modifications. However, the Service indicated that if a plan including channel work is proposed, they would accept, with modification, the alternate which includes a modified channel with a 40 foot base width. The Service further suggested several measures which should be taken to minimize adverse impacts on the environment if a structural plan of protection which includes channel modification is selected, including excavating only one bank of the existing channel, a V-shaped low flow channel which follows the natural course of the stream, and pool and riffle areas. As part of the Corps' reply dated 1 December 1976 (Attachment H12), this office informed the Service that, where possible, the measures they suggested will be incorporated into the plan of protection.

## FEDERAL HIGHWAY ADMINISTRATION

By letter dated 25 August 1976 (Attachment H6), the United States Department of Transportation, Federal Highway Administration, indicated that filling of the existing channel by local interests could possibly occur at the reach of stream along the Sheldrake River between the Fenimore Road diversion tunnel and the confluence of the Mamaroneck and Sheldrake Rivers, if the diversion plan is implemented. The Federal Highway Administration also emphasized that Federal aid highway funds would not be available to defray any part of the cost of constructing or reconstructing highways that local interests agree to assume as a condition of the undertaking of a flood control project. As part of the Corps' reply dated 11 November 1976 (Attachment H7), this office informed the Federal Highway Administration that the terms of local cooperation items to be agreed upon by the Village of Mamaroneck would prohibit the filling of the existing Sheldrake River channel downstream of the proposed tunnel, if this plan is implemented.

# Flood Plain Management

In those flood problem areas for which the provision of flood protection is economically unfeasible, limited relief from flooding can be obtained by the floodproofing of existing improvements, and by control of the future use and occupancy of these undeveloped flood prone areas through proper flood plain management activities. Control of the future use and occupancy of flood prone land can prevent the extension of existing development in flood problem areas. Flood Plain Information reports have been completed and distributed to local interests in the Mamaroneck and Sheldrake Rivers, and Byram River basins. In view of the extensive

amount of flood plain data that has been developed and distributed to local interests, this survey report has not included any additional flood plain data.

Specifically, at localities in the Village and Town of Mamaroneck where flooding has occurred, and where local protection works are not recommended, the level of damage from recurring floods can be kept within reasonable bounds by the application of the principles of flood prone area use and occupancy contained in the Flood Plain Information Reports.

## Summary

Flood problems exist along the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, Town of Harrison and Village of Scarsdale, and along the Byram River at the Town of Greenwich, Connecticut and Village of Port Chester, New York. In the Mamaroneck and Sheldrake Rivers basin, the wide distribution of the above-mentioned areas, the physical configuration and flood characteristics of the basin, and the lack of indicated need for multiple purpose project development all precluded the practical possibility of furnishing comprehensive flood protection by means of a basin-wide plan. Preliminary investigations indicated that there is no possibility of developing economically justified plans of protection along the East Branch of the Mamaroneck River at Harrison, New York or along the East Branch of the Sheldrake River at the Town of Mamaroneck, and Village of Scarsdale and no detailed studies were conducted in these areas. Hence, detailed flood control studies were considered to be warranted in this report at the Village and Town of Mamaroneck along the Mamaroneck and Sheldrake Rivers, and at Greenwich, Connecticut and Port Chester, New York along the Byram River.

The flood problems along the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, New York and Byram River at Greenwich, Connecticut and Port Chester, New York have resulted in considerable flood damage in the past. These problems are caused by insufficient channel capacities and channel restrictions at the study areas. Both the nonstructural and structural flood control purpose alternatives were investigated and evaluated according to engineering feasibility and for environmental, social well-being and economic effects in accordance with guidelines on the Principles and Standards for Water Resources Development promulgated by the Water Resources Council.

From these investigations it was determined that the most practical plans of improvement consist of a combination of channel modification, levees, retaining wall, and tunnel diversion along the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, New York, and a combination of channel modification, levee and floodwalls along the Byram River at Greenwich, Connecticut and Port Chester, New York. The selected plan at the Village and Town of Mamaroneck is designed against a flood with a .5 percent exceedence frequency along the Mamaroneck River from Tompkins Avenue upstream to the New England Thruway, and the Sheldrake River from its mouth to Fenimore Road; the tunnel diversion at Fenimore Road and its associated upstream channel works along the Sheldrake River would protect against the Standard Project Flood; and the portions of the selected plan along the Mamaroneck and Sheldrake Rivers upstream of the New England Thruway would provide protection against a flood with a 1 percent exceedence frequency. The total estimated first cost of the Mamaroneck and Sheldrake Rivers plan is \$34,400,000, of which \$29,530,000 would be the Federal share and \$4,870,000 would be the non-Federal share; the annual charges resulting from the plan would be \$2,230,000 and compared to annual benefits of \$3,060,000, the benefit-cost ratio is 1.4. The total estimated first cost of the Byram River plan is \$4,475,000, of which \$3,540,000 would be the Federal share and \$935,000 would be the non-Federal share; the annual charges resulting from the plan would be \$309,000 and compared to annual benefits of \$488,300 the benefit-cost ratio is 1.6.

The overall findings of this study indicate that the construction of the selected plans of improvement would produce monetary benefits by reducing flood damages, business losses and enhancing land values. The most significant adverse environmental effects would occur as a result of the construction activities. The pavement will be broken, the soil excavated and stored, and there will be increased noise and dust. Traffic will be diverted during the reconstruction and raising of the bridges and vehicles will be present to the areas transporting construction material and machinery, contributing to greater congestion. These impacts are of a temporary nature and with proper construction procedures many of them can be held to a minimum. However, more permanent impacts resulting from the proposed works would include damage to the existing fisheries and wildlife. Measures to mitigate these adverse effects include provisions for restoration and replanting of the project reach so wildlife can return to the area, and, with respect to aquatic life, the creation of bottom habitat and lowhead channels, allowing fish to habitate during periods of low flow. In connection with the environmental and hydrologic studies of this report, the possible adverse effects the respective plans may have at downstream areas was investigated. These evaluations indicated that the downstream increases of flood stages along the Byram River and Sheldrake River, the Town of Mamaroneck, are not measurable and that the plans would have no adverse downstream effects.

The Village and Town of Mamaroneck, New York, and Town of Greenwich, Connecticut and Port Chester, New York have expressed strong support for

the respective selected flood control plans, and the States of New York and Connecticut have indicated their intentions to cooperate in the proposed projects, as contained in Appendix H.

## Statement of Findings

I have reviewed and evaluated, in light of the total public interest, the data and information pertaining to the Mamaroneck and Sheldrake Rivers, and Byram River plans of improvement. The principal elements considered in this review are engineering feasibility, environmental impacts, economic factors of regional and national resource development and social well-being, all of which have been evaluated in the light of the purpose of the proposed improvements. The data and information reviewed include investigations and studies prepared by my staff, documents and information furnished by local interests, and the stated views of these interests and agencies relative to the various practical alternatives in accomplishing the plans of protection for effective flood control at the Village and Town of Mamaroneck, New York and Greenwich, Connecticut and Port Chester, New York.

### BACKGROUND

This study is in compliance with resolutions of the United States Senate Committee on Public Works adopted 14 September 1955 and 14 November 1955, and with resolutions of the United States House of Representatives Committee on Public Works adopted 13 June 1956, and is in partial response to these resolutions as they relate to Westchester County, New York, and is in full response in relation to the Mamaroneck and Sheldrake Rivers and Byram River basins.

Flooding occurs along the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, New York, and Byram River at the Town of Greenwich, Connecticut and Village of Port Chester, New York, as well as several other locations in the watersheds. The existing flood hazard and associated flood damages constitute by far the most serious water resources problem in each of the subject basins. During the past five years, three major floods have occurred in each of the watersheds.

Consideration was given to several alternative flood control measures, including non-structural and structural solutions. The possible consequences of the alternatives developed during the study were evaluated according to engineering feasibility, and for environmental, social well-being and economic effects in accordance with guidelines on the Water

Resources Council's Principles and Standards. From review and evaluation, I have found that the best plans of protection consist of channel modifications, retaining walls, levees and tunnel diversion works along the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, New York, and channel modification, levee and floodwalls along the Byram River at Greenwich, Connecticut and Port Chester, New York.

## COORDINATION AND PUBLIC MEETINGS

The considered plans of protection along the Mamaroneck and Sheldrake Rivers, and Byram River have been coordinated with interested agencies at the Federal, state and local levels. Coordination with U. S. Department of the Interior, Fish and Wildlife Service resulted in the incorporation of measures into the recommended plans to minimize adverse effects to the stream environment from the structural works. Several public hearings and many informal meetings held with local officials and citizenry provided local requests and preferences used in the impact assessment and evaluation of the alternatives and resulted in the development and selection of plans that are generally more acceptable to the public than the previously developed intermediate plans.

## EVALUATION

From an environmental standpoint, I have accepted minor aesthetic degradation, namely, some alterations to the natural environmental settings, possible minor losses to the existing fisheries, temporary decreases of water quality due to turbidity during construction, and expectation of traffic delays, particularly in the Village of Mamaroneck. Overall, the proposed projects will not significantly impair the environment.

From a viewpoint of the total public interest and social well-being, the projects will reduce the risk to human life and safety and will alleviate the health hazards, damages, and inconveniences associated with flooding. However, during construction, there will be some temporary inconveniences due to the type of improvements involved. In addition, I have investigated the impact of these improvements on areas downstream and judge that there will be no increase in flood damages in these areas as a result of the proposed improvements.

From an economic standpoint, the plans of improvement will create a reduction in financial losses, including: costs of restoring damaged public and private facilities to preflood conditions; the losses to business and wage earners caused by the stoppage of normal activities during floods; and costs of flood fighting and cleanup.

## CONCLUSION

I find that the plans of improvement for the Mamaroneck and Shel-drake Rivers, and Byram River, as developed in this report, are based on a thorough analysis and evaluation of the various practical 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 authorized purposes; that where the proposed actions have adverse effects, these effects are either ameliorated or substantially outweighed by other considerations of national policy; and that, while the conclusion presented herein is not the perfect solution to the problem, that on balancing all elements in the public interest, that interest would best be served by construction of these improvements.

## Recommendations

The District Engineer recommends that the selected plans of protection on the Mamaroneck and Shel Drake Rivers at the Village and Town of Mamaroneck, New York, and Byram River at the Town of Greenwich, Connecticut and Village of Port Chester, New York, as described in this report, be authorized for construction as Federal projects for flood control purposes, subject to such modifications that may be prescribed by the Chief of Engineers. The estimated Federal first costs of the plans of improvement for the Mamaroneck and Shel Drake Rivers, and Byram River are \$29,530,000 and \$3,540,000, respectively. Prior to initiation of construction, the local interests will give assurance satisfactory to the Secretary of the Army that they will provide all assurances of local cooperation as follows:

a. Provide without cost to the United States all lands, easements, and rights-of-way required for the project, including borrow, ponding and waste disposal areas necessary for construction of the project, and effect compliance with the requirements of Sections 210 and 305 of Public Law 91-646, subject, however, to the provisions of Section 207;

b. Accomplish without cost to the United States all alterations and relocations of buildings, transportation facilities, storm drains, utilities and other structures and improvements made necessary by the construction (excluding railroad bridges and approaches and facilities necessary for the normal interception and disposal of local interior drainage at the line of protection);

c. Hold and save the United States free from damages due to the construction works, not to include damages due to the fault or negligence of the United States or its contractors;

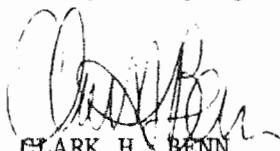
d. Maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army;

e. Prescribe and enforce regulations to prevent encroachment on flood plain storage areas, channels, and rights-of-way, as necessary for the proper functioning of the project, and agree to take appropriate measures to control development of the fringe areas not protected by the improvement, to prevent an undue increase in the flood damage potential, and to provide additional gravity outlets, pumping capacity or ponding areas due to the modification of, or encroachment upon, such area by local interests;

f. Agree to adopt and enforce adequate regulations to maintain the existing channel capacity along the Sheldrake River downstream of Fenimore Road (Village of Mamaroneck only);

g. Publicize flood plain information in the areas concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to insure compatibility between future development and protection levels provided by the project;

h. At least annually inform affected interests regarding the limitations of the protection afforded by the project.



CLARK H. BENN  
Colonel, Corps of Engineers  
District Engineer



NADDE (31 Oct 77) 1st Ind

SUBJECT: Feasibility Report for Flood Control, Mamaroneck and Sheldrake Rivers Basin (Village and Town of Mamaroneck, N.Y.) and Byram River Basin (Greenwich, Conn. and Port Chester, N.Y.)

DA, North Atlantic Division, Corps of Engineers, 90 Church Street  
New York, New York 10007 28 March 1978

TO: HQDA (DAEN-BR/Resident Member) Kingman Bldg., Ft Belvoir, VA 22060

1. I concur in the District Engineer's conclusions and recommendation.
2. The economic data in the District Engineer's report are based on an interest rate of 6-3/8 percent. Based on the current interest rate of 6-5/8 percent, the economic data for the recommended plans are as follows:
  - a. Mamaroneck and Sheldrake Rivers. Average annual benefits and costs are \$3,065,000 and \$2,315,000, respectively, resulting in a benefit-cost ratio of 1.3.
  - b. Byram River. Average annual benefits and costs are \$480,200 and \$319,800, respectively, resulting in a benefit-cost ratio of 1.5.

  
JAMES A. JOHNSON  
Major General, USA  
Division Engineer



STREAMS IN WESTCHESTER COUNTY, N.Y.  
AND FAIRFIELD COUNTY, CONN.  
FEASIBILITY REPORT FOR FLOOD CONTROL  
MAMARONECK AND SHELDRAKE RIVERS BASIN, NEW YORK  
AND  
BYRAM RIVER BASIN, CONNECTICUT AND NEW YORK

INFORMATION CALLED FOR BY  
SENATE RESOLUTION 148, 85th CONGRESS  
ADOPTED 28 JANUARY 1958



## SUPPLEMENT

1. INTRODUCTION. The information in this supplement is furnished in response to Senate Resolution 148, 85th Congress, 1st Session, adopted 28 January 1958. This resolution calls for data in addition to that now presented in support of plans recommended for authorization and on possible alternatives thereto. Reasons are given why alternatives are rejected in favor of the recommended plan.

2. RECOMMENDED PLAN. The plan of protection for the Mamaroneck River in the Village of Mamaroneck involves a combination of channel modification, retaining walls and bridge replacement. As shown on Plate 5, the existing channel of the Mamaroneck River would be widened and deepened from a point downstream of Tompkins Avenue, upstream for approximately 10,000 feet to just past Winfield Avenue. The modified channel bottom along the Mamaroneck River would average 60 feet in width from the lower limit of the plan upstream to a point about 300 feet past Jefferson Avenue, and 45 feet in width from this point to the upstream limit of the channel works. The channel modification would include the relocation of the confluence of the two rivers to eliminate the two sharp bends in the existing alignment, and a number of discontinuous retaining walls. These walls lie along both banks from just below Valley Place upstream for 600 feet to Station Plaza, along the right bank for 1,150 feet from Nostrand Avenue to First Street, along the left bank from First Street upstream for 1,700 feet to Lewis Street, and for 300 feet on the right bank at Willow Street. The plan additionally involves the replacement of the Ward Avenue, Halstead Avenue, Station Plaza and Hillside Avenue Bridges, and the replacement of the Valley Place sewer bridge with an inverted syphon. Interior drainage is provided by a system of ditches and outlet drains through the line of protection, and several areas along the stream would be filled and graded.

The plan of protection for the Sheldrake River in the Village of Mamaroneck is as follows: The Sheldrake River would be diverted into a tunnel at Fenimore Road leading to the West Basin of Mamaroneck Harbor. This tunnel diversion would consist of three segments. For 1,600 feet from the Sheldrake River to Stanley Avenue, the tunnel consists of a 15 foot x 15 foot box culvert; from Stanley Avenue for 1,450 feet to just north of Boston Post Road, the diversion consists of a 15.5 foot diameter tunnel and thence the tunnel consists of a 15 foot x 15 foot box culvert to just south of Boston Post Road where the tunnel leads to an open channel and stilling basin at the West Basin of Mamaroneck Harbor. The coincidental tailwater to the tunnel is taken to be the one year tide level in the harbor. The use of a one year tailwater elevation for capacity design was chosen as a reasonable and practical criteria since tidal levels are no higher than usual when fluvial flooding occurs. In addition, the stilling basin at the outlet of the tunnel, which is needed to prevent damages to boats moored in the harbor, is designed using a tailwater of mean low water to ensure that the hydraulic jump would not occur in the harbor. From the diversion inlet at Fenimore Road upstream to Rockland Road, the existing channel of the Sheldrake River would be modified into a semi-trapezoidal channel, with retaining wall along the right bank, and thence to the New England Thruway the channel would be trapezoidal with a levee along the right bank. This diversion system would divert the total flow of the Sheldrake River upstream of Fenimore Road into the tunnel. The stream

flow in the Sheldrake River channel downstream of Fenimore Road to the confluence with the Mamaroneck River would be comprised of the incremental runoff which enters this reach of stream and the existing capacity of the lower Sheldrake River would be maintained for this purpose. The portion of the plan of protection for the Sheldrake River in the Town of Mamaroneck consists of a twelve foot wide concrete rectangular channel from a point approximately 250 feet upstream of Rockland Avenue, at Brookside Place, downstream for approximately 1,800 feet to a point about 300 feet downstream of Briarcliff Road. The plan also includes a transition/stilling basin approximately 300 feet downstream of Briarcliff Road, and a 32 foot long drop structure and tie back levees at the upstream limit. The Forest Avenue and three driveway bridges would be replaced, and lowlying areas along the stream would be filled and graded.

In order to minimize the adverse effects the channel modification work would have on the stream environment, measures are included to mitigate these impacts. These measures include the following:

a. In the upper Mamaroneck River area, the existing channel generally will be widened by limiting the proposed channel excavations to one bankside, so as to decrease the removal of trees and other vegetation. Investigations during preconstruction planning would determine if other areas exist within the project area for which this technique is also suitable.

b. A pool and riffle low flow channel would be incorporated into the entire channel areas to be modified, except at the portion of the upper Sheldrake River where a flume or rock-cut channel is proposed. For the upper Sheldrake River a shallow V-shaped pilot channel would be incorporated into the plan.

c. Small log and rock dams would also be employed in the longer riffle areas in order to create lowhead pools as an aquatic shelter and habitat area.

d. Trees and shrubs eliminated by the structural elements would be partially replaced through beautification measures and a tree planting program.

e. During construction, control measures would be utilized to minimize adverse effects to the water quality of the rivers within the study area and at downstream reaches. Measures to minimize increases in turbidity levels and to limit the erosion of denuded channel slopes would include: (1) exposing the minimum area of land to erosion that is practical at any one time during construction; (2) applying temporary mulch, with or without seeding temporary vegetation, immediately after rough grading is completed; (3) construction of temporary sediment basins or the placement of silt screens or barriers to precipitate silt before it leaves the site.

Additionally, nonstructural measures are recommended for adoption by local interests for flood plain areas elsewhere in the Village and Town of Mamaroneck. In particular, floodplain regulation techniques are recommended as part of the total plan of protection at the Village and Town of Mamaroneck for the floodplain area lying along the Sheldrake River between the structural portions of the recommended plan.

The recommended plan along the Byram River involves channel excavation, floodwalls and levees. The channel of the Byram River would be dredged for approximately 700 feet downstream of the southern U.S. 1 Bridge. The new channel would be 70 feet wide and the riverbed beneath the two U.S. 1 Bridges would also be lowered. Rip-rap would be placed in the bridge openings to protect against erosion. Upstream of the two U.S. 1 Bridges a 50 foot wide rectangular channel running for 550 feet is proposed. From this point upstream for 260 feet a semi-trapezoidal channel 50 feet wide with a wall on the right bank would be constructed. From this point, approximately 400 feet below Den Lane to the proposed sill at Monica Street, the channel would be a 40 foot wide trapezoid. A floodwall 810 feet long would be built on the right bank between the two factories. A wall 550 feet long is proposed for the left bank upstream of the Southbound U.S. 1 Bridge. A levee would be built on the left bank from the upstream end of the left bank wall and would continue to the upstream limit of the proposed project at Rex Street, where it would tie into the existing levee. Some modification is necessary to the 400 feet of existing left bank levee upstream from where the river enters the lake. An average raising of 2 feet along the length of existing levee is required to guarantee closure against the 6920 cfs design flow. Approximately 700 yd<sup>3</sup> of fill will be required to make this minor adjustment to the existing levee. A concrete sill with a top elevation of 6.0 feet Mean Sea Level is proposed for the mouth of Pemberwick Lake to maintain its elevation during times of low flow. Ponding areas, pumping stations, storm drainage interceptors and other associated interior drainage facilities would be provided behind the levees and walls to carry surface runoff from the area protected. In order to minimize the adverse effects the channel modification work would have on the stream environment, measures are included to mitigate these impacts. These measures would include, in addition to the erosion and sedimentation control measures previously described for the considered plan for the Mamaroneck and Sheldrake Rivers, the following:

a. The existing channel would be widened by excavating only one bank, where possible, so as to eliminate the minimum number of trees. At those reaches within the study area where the natural channel approaches 40 feet in width, the stream would not be further widened.

b. A pool and riffle low flow channel would be incorporated for the entire length of the modified channel. Also, gabion wire baskets or some other similar materials would be used for the creation of a diversified aquatic bottom habitat.

c. A beautification and a tree planting program would be implemented after construction so as to replace some of the trees and shrubs removed as a result of levee and floodwall construction or channel excavations.

3. FIRST COSTS. The estimated first cost of the recommended plan for the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, New York, based on December 1976 prices and conditions, is \$34,400,000 of which \$29,530,000 is Federal cost and \$4,870,000 is non-Federal cost. The estimated first cost of the recommended plan for the Byram River at Greenwich, Connecticut and Port Chester, New York, based on December 1976 prices and conditions, is \$4,475,000 of which \$3,540,000 is Federal cost and \$935,000 is non-Federal cost. The Federal cost does not include pre-authorization costs.

4. ANNUAL COSTS AND BENEFITS. The average annual costs for the recommended plans were computed for an economic life of 100 years based on an interest rate of 6-3/8 percent for Federal and non-Federal construction costs. The benefits derived from the recommended plan of protection along the Mamaroneck and Sheldrake Rivers consist of the average annual flood damages the improvement prevents, benefits from advanced replacement of bridges and less frequent pavement maintenance, and NED employment benefits. Along the Byram River, the benefits derived from the recommended plan consist of the average annual flood damages prevented, benefits from less frequent pavement maintenance and NED employment benefits. A summary of first cost, annual benefits, annual cost, benefit-cost ratio, and excess benefits for the recommended plans for the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, N.Y., and the Byram River at Greenwich, Conn. and Port Chester, N.Y., respectively, are presented in Table 1.

5. APPORTIONMENT OF COSTS. The cost of the recommended plans has been apportioned between the Federal Government and local interests in accordance with the Flood Control Act of 1936, as amended. For the recommended plan for the Mamaroneck and Sheldrake Rivers, the Federal cost of \$29,530,000 includes the excavation of channels, the construction of levees, floodwalls, a diversion tunnel, a concrete flume and interior drainage facilities, and stream relocation. The non-Federal cost of \$4,870,000 includes lands, easements and rights-of-way, the replacement of bridges and the relocation of utilities that will be encountered during construction. For the recommended plan for the Byram River, the Federal cost of \$3,540,000 includes the excavation of channels, the construction of levees and floodwalls, and ponding areas, pumping stations and storm drainage facilities, which would be provided behind the levees and walls to carry surface runoff from the area protected. The non-Federal cost of \$935,000 includes lands, easements and rights-of-way, and the relocation of utilities that will be encountered during construction.

6. DISCUSSION. The recommended plan along the Mamaroneck and Sheldrake Rivers at the Village and Town of Mamaroneck, New York is designed to protect against a flood with a .5 percent (200 year) exceedence frequency along the Mamaroneck River from Tompkins Avenue upstream to the New England Thruway, and the Sheldrake River from its mouth to Fenimore Road; the tunnel diversion at Fenimore Road and its associated upstream channel works along the Sheldrake River would protect against the Standard Project Flood; and the portions of the selected plan along the Mamaroneck and Sheldrake

Rivers upstream of the New England Thruway would provide protection against a flood with a 1 percent (100 year) exceedence frequency. Other methods of flood protection investigated were divided into the two broad categories of nonstructural and structural measures. Nonstructural measures including floodplain zoning, floodproofing, building code regulations and permanent or temporary evacuation of flood plain areas were considered separately and in various combinations as possible solutions to the flood problem at the Village and Town of Mamaroneck. However, each of the nonstructural plans investigated was economically unjustified and/or unacceptable to local interests. Subsequent to investigating possible nonstructural solutions, structural flood control alternatives were developed. There are several upstream sites within the Mamaroneck and Sheldrake Rivers basin at which flood detention reservoirs are possible, as shown on Plate 2; however, the development of a flood storage reservoir at each of these sites was precluded because of excessive costs and/or limited regulation and effectiveness at the downstream areas. Hence, flood diversions and local protection measures such as levees, floodwalls, channel modification and various combinations of each were considered as alternatives. Certain features are common to most of the plans, including the channel modification of the Mamaroneck and Sheldrake Rivers. However, each of the alternatives provides for different combinations of channel width and levee and floodwall height, both with and without diversion measures, along the Mamaroneck and Sheldrake Rivers and thus each offers a different extent of flood protection. The recommended plan was selected as the best alternate overall, based on engineering, economic, environmental and social criteria, to meet the area's existing and prospective needs for flood control and has been endorsed by the local communities of the Village and Town of Mamaroneck. The plan was coordinated with interested agencies at Federal, State and local levels. The Village and Town of Mamaroneck have agreed to meet the requirements of local cooperation.

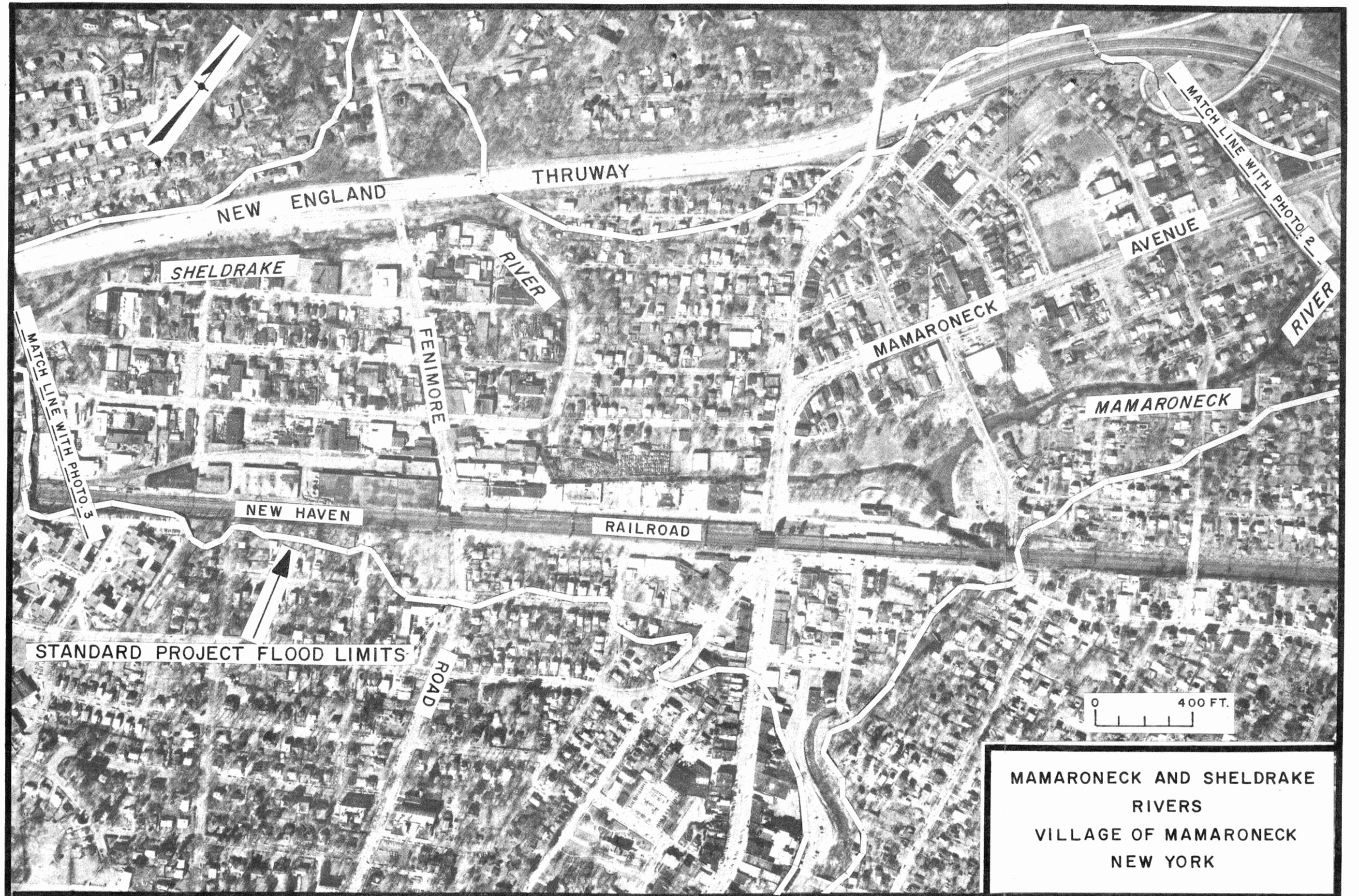
The recommended plan along the Byram River at Greenwich, Connecticut and Port Chester, New York is designed to protect against a flood with a 1 percent exceedence frequency (100 year flood). Other methods of flood protection investigated were divided into the two broad categories of nonstructural and structural measures. Nonstructural measures including floodplain zoning, floodproofing, building code regulations and permanent or temporary evacuation of floodplain areas were considered separately and in various combinations as possible solutions to the flood problem at the Town of Greenwich and Village of Port Chester. However, each of the nonstructural plans investigated was economically unjustified and/or unacceptable to local interests. Subsequent to investigating possible nonstructural solutions, structural flood control alternatives were then developed. Upstream flood detention is not a practical solution to the flood problem at Greenwich and Port Chester, since any possible upstream detention area would lie more than two miles upstream from the problem area. The incremental flows generated by local runoff downstream of any potential site would be in excess of bankfull capacity at the downstream damage area. Also, upstream retention would not alleviate tidal flooding, and its excessive costs cannot be supported by the potential benefits at Greenwich and Port Chester. Additionally, there are no upstream locations within the Byram River Basin where a diversion into Byram Harbor is economically

feasible. Hence, local protection measures such as levees, floodwalls, channel modification and various combinations of each were considered as alternatives. Certain features are common to most of the plans, including channel modification of the Byram River. However, each of the alternatives provides for different combinations of channel width and levee and floodwall height along the Byram River and thus each offers a different extent of flood protection. The recommended plan was selected as the best alternate overall, based on engineering, economic, environmental and social criteria, to meet the area's existing and prospective needs for flood control and has been endorsed by the local communities of Greenwich and Port Chester. The plan was coordinated with interested agencies at Federal, State and local levels. The Town of Greenwich and the Village of Port Chester have agreed to meet the requirements of local cooperation.

TABLE 1 - SUMMARY OF FIRST COST, ANNUAL BENEFITS,  
ANNUAL COST AND BENEFIT-COST RATIO FOR THE  
RECOMMENDED PLANS FOR FLOOD CONTROL

Study Area	Economic Life	Total* First Cost	Total Annual Cost	Annual Benefits	Benefit Cost Ratio	Excess Benefits
Mamaroneck & Sheldrake Rivers	100 Years	\$34,400,000	\$2,230,000	\$3,060,000	1.4	\$830,000
Byram River	100 Years	\$4,475,000	\$309,000	\$488,000	1.6	\$179,000

\*Excluding pre-authorization study costs



MAMARONECK AND SHELDRAKE  
RIVERS  
VILLAGE OF MAMARONECK  
NEW YORK



MATCH LINE WITH PHOTOGRAPH NO. 1

MAMARONECK RIVER

MAMARONECK AVENUE

STANDARD PROJECT FLOOD LIMITS

NEW ENGLAND THRUWAY

0 400 FT.

UPPER MAMARONECK R.  
VILLAGE OF  
MAMARONECK  
NEW YORK

5

1911

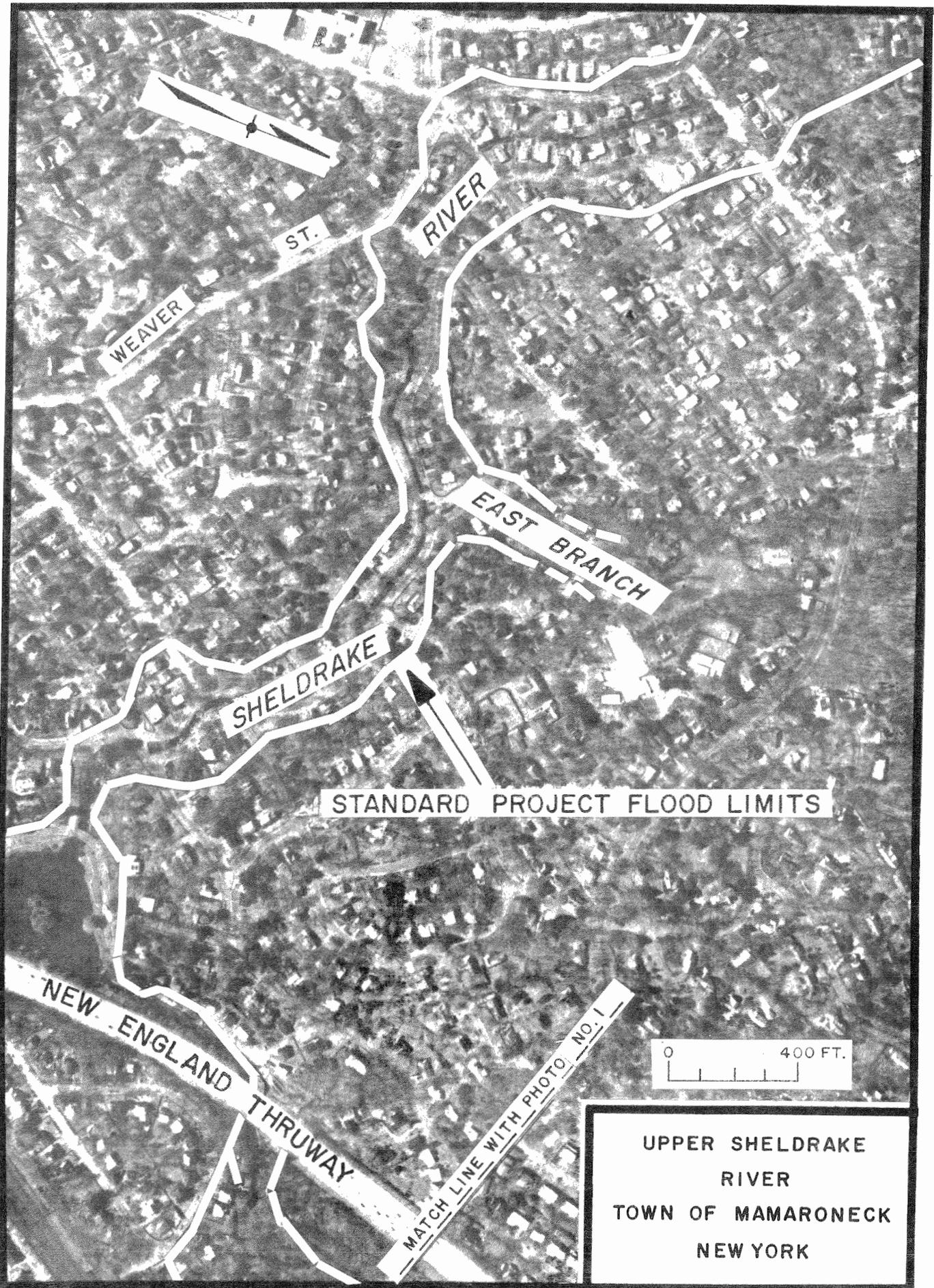
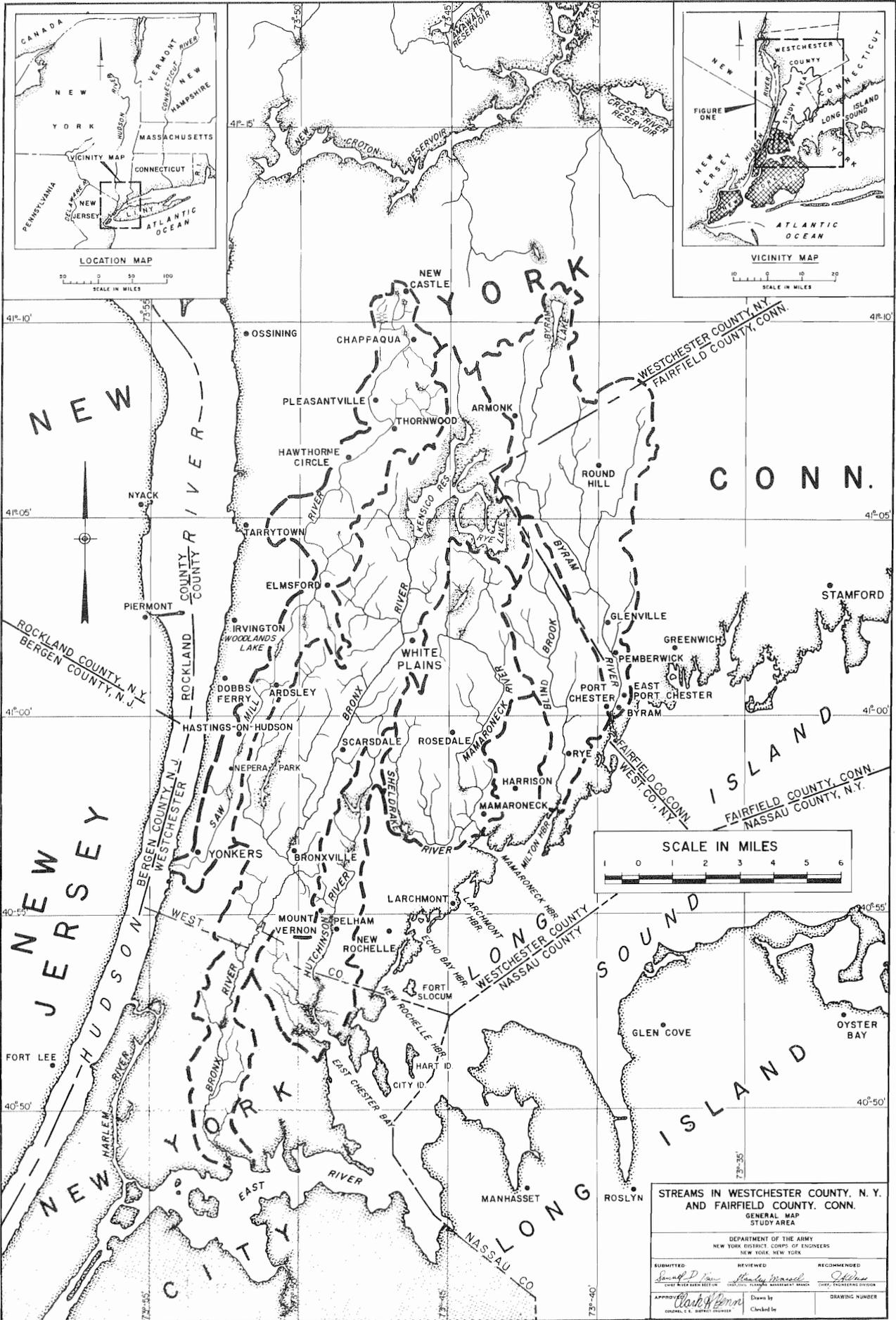


PHOTO. NO. 3

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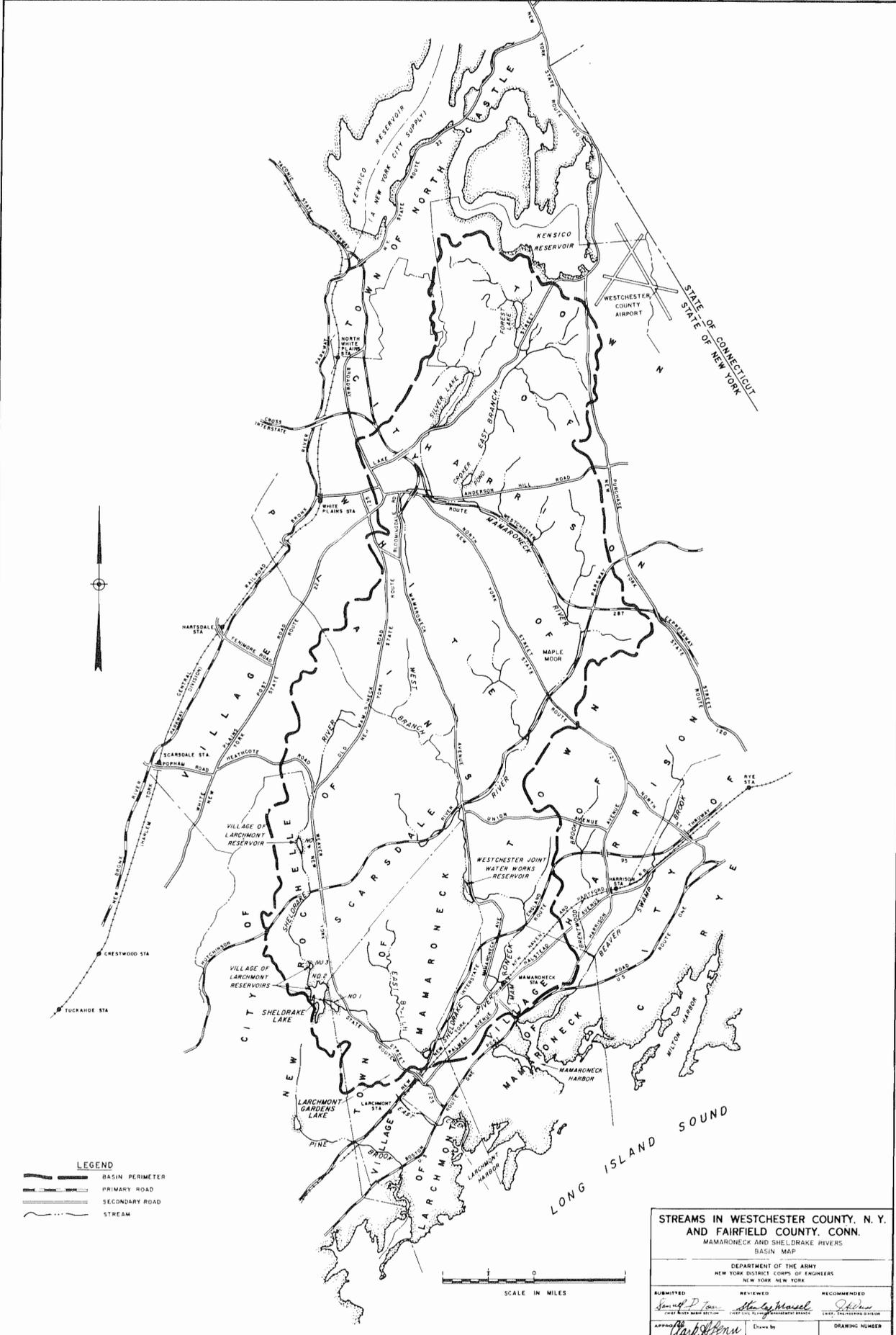
STREAMS IN WESTCHESTER COUNTY, N. Y.  
AND FAIRFIELD COUNTY, CONN.  
GENERAL MAP  
STUDY AREA

DEPARTMENT OF THE ARMY  
NEW YORK DISTRICT CORPS OF ENGINEERS  
NEW YORK, NEW YORK

SUBMITTED	REVIEWED	RECOMMENDED
<i>Samuel P. ...</i>	<i>Henry ...</i>	<i>John ...</i>
APPROVED	Drawn by	DRAWING NUMBER
<i>Clark ...</i>	Checked by	

10 ACCORDING SURVEY REPORT DATED OCTOBER 1977





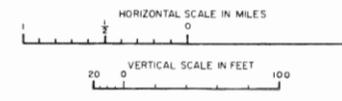
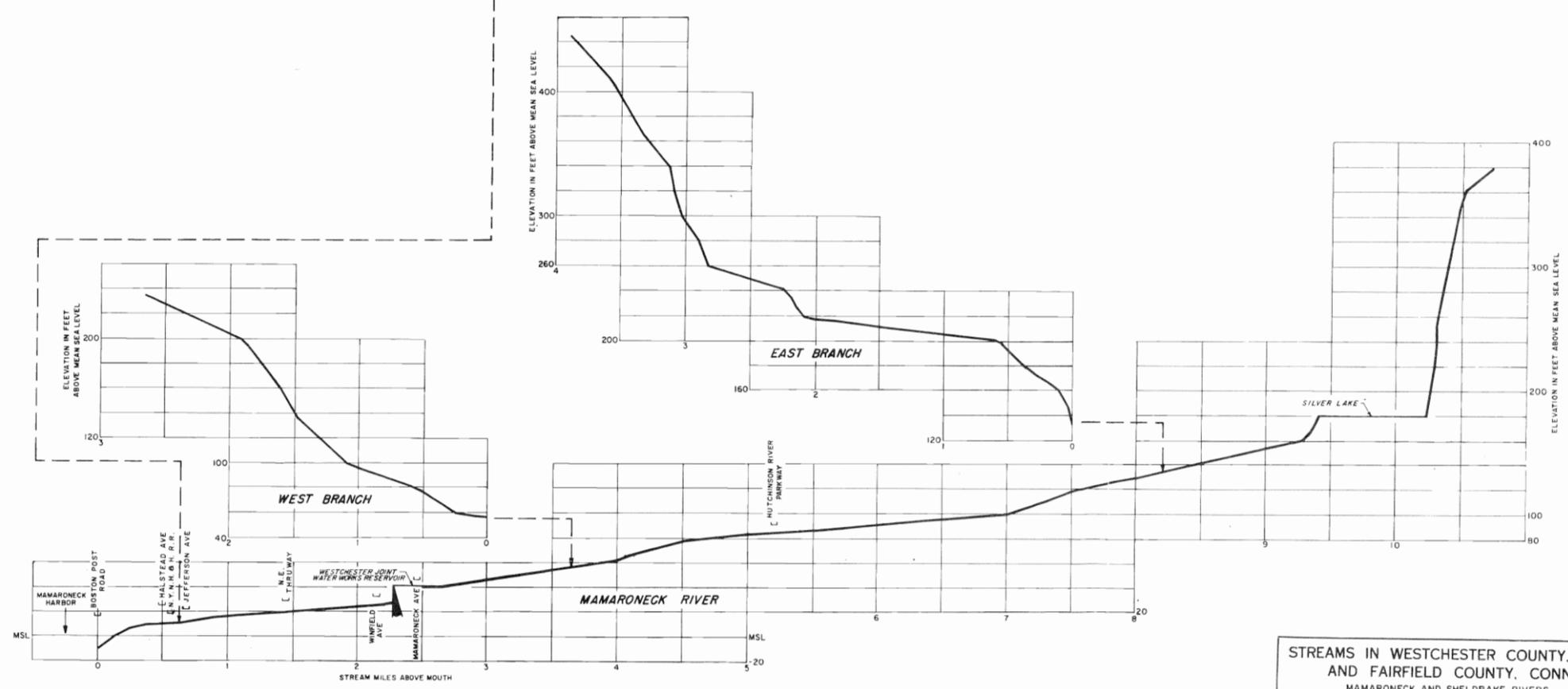
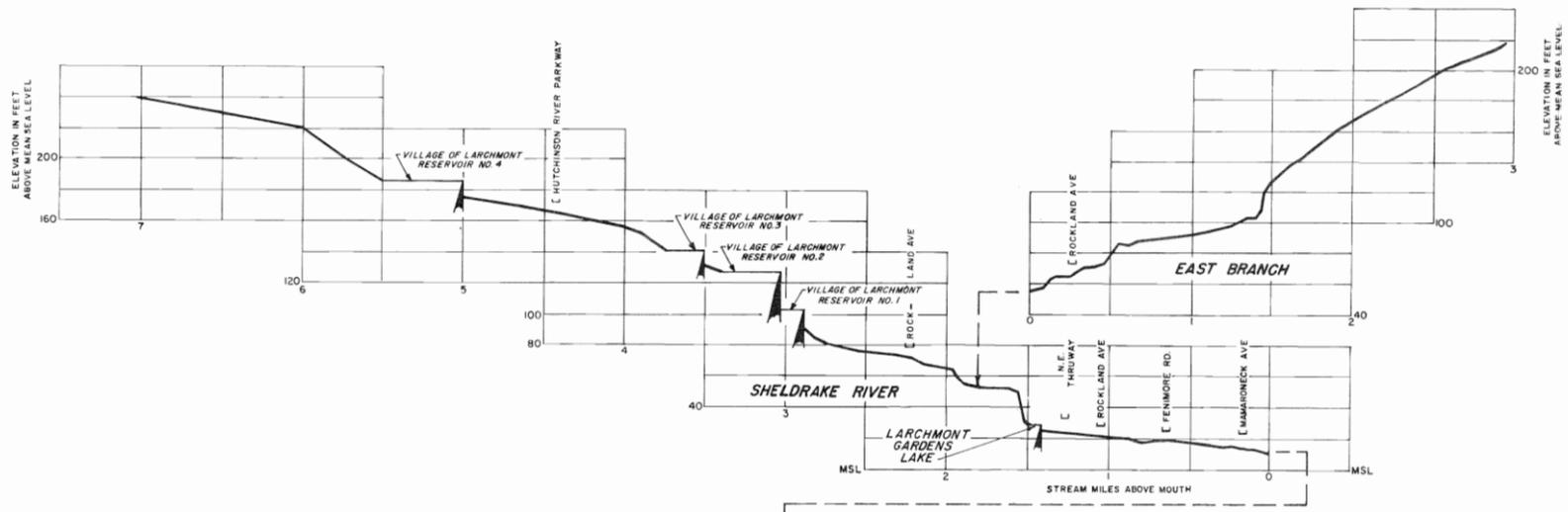
**STREAMS IN WESTCHESTER COUNTY, N. Y.  
AND FAIRFIELD COUNTY, CONN.  
MAMARONECK AND SHELDRAKE RIVERS  
BASIN MAP**

DEPARTMENT OF THE ARMY  
NEW YORK DISTRICT CORPS OF ENGINEERS  
NEW YORK, NEW YORK

SUBMITTED	REVIEWED	RECOMMENDED
<i>[Signature]</i>	<i>[Signature]</i>	<i>[Signature]</i>
APPROVED	Checked by	DRAWING NUMBER
<i>[Signature]</i>	<i>[Signature]</i>	

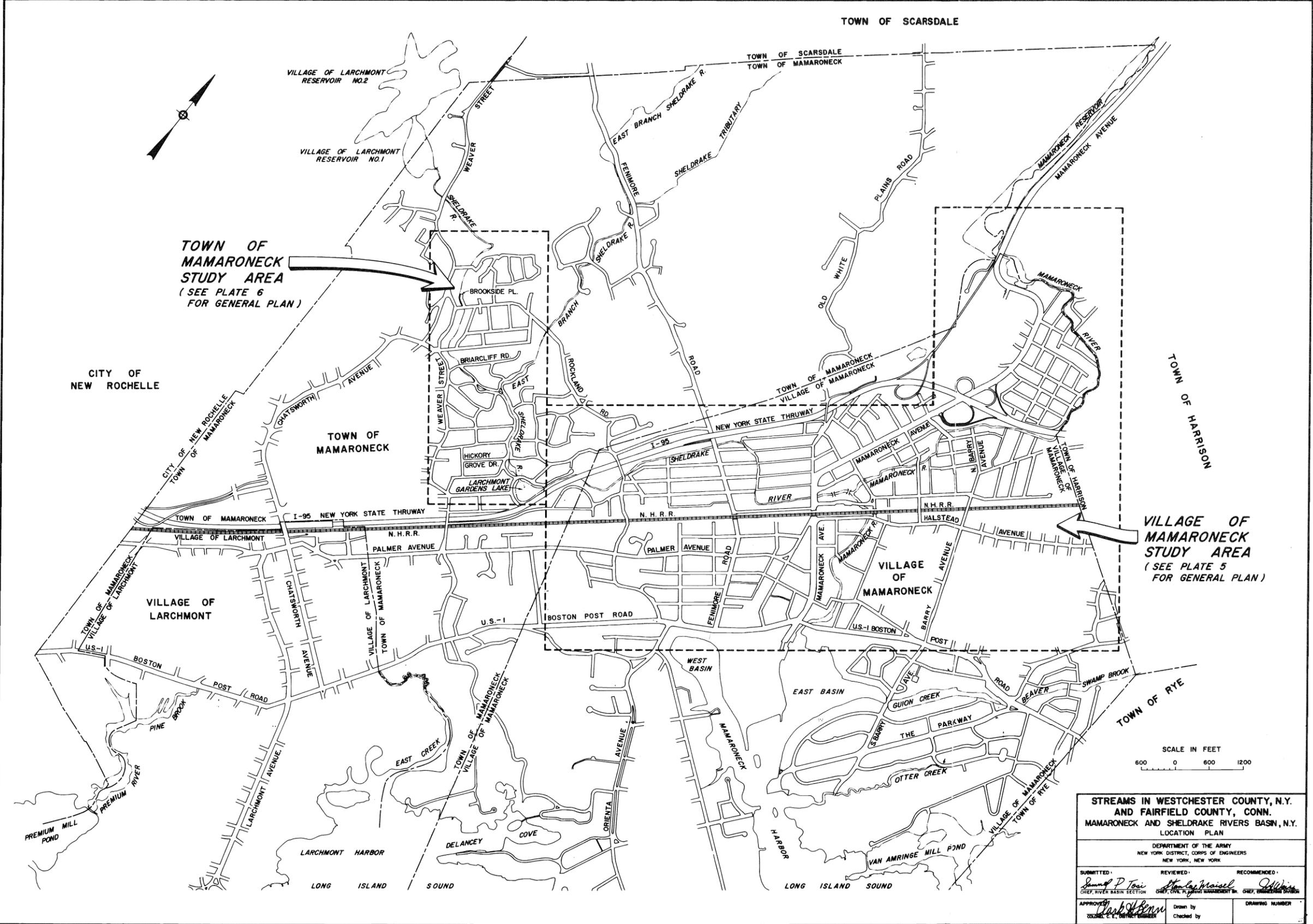
TO ACCOMPANY SURVEY REPORT DATED 1977





STREAMS IN WESTCHESTER COUNTY, N. Y.  
AND FAIRFIELD COUNTY, CONN.  
MAMARONECK AND SHELDRAKE RIVERS  
STREAM PROFILES

DEPARTMENT OF THE ARMY NEW YORK DISTRICT, CORPS OF ENGINEERS NEW YORK, NEW YORK		
SUBMITTED	REVIEWED	RECOMMENDED
<i>Charles P. Tice</i> CHIEF, RIVER DIVISION	<i>Stanley Marsel</i> CHIEF, CIVIL FLUVIUM MANAGEMENT BRANCH	<i>W. H. ...</i> CHIEF, ENGINEERING DIVISION
APPROVED <i>Charles P. Tice</i> COLONEL, U.S. DISTRICT ENGINEER	Drawn by Checked by	DRAWING NUMBER



**STREAMS IN WESTCHESTER COUNTY, N.Y.  
AND FAIRFIELD COUNTY, CONN.  
MAMARONECK AND SHELDRAKE RIVERS BASIN, N.Y.  
LOCATION PLAN**

DEPARTMENT OF THE ARMY  
NEW YORK DISTRICT, CORPS OF ENGINEERS  
NEW YORK, NEW YORK

SUBMITTED: <i>Samuel P. Toai</i> CHIEF, RIVER BASIN SECTION	REVIEWED: <i>Harley M. Mair</i> CHIEF, CIVIL PLANNING SUBDIVISION	RECOMMENDED: <i>William</i> CHIEF, ENGINEERING DIVISION
APPROVED: <i>Robert H. ...</i> COLONEL, U.S. DISTRICT ENGINEER	Drawn by Checked by	DRAWING NUMBER

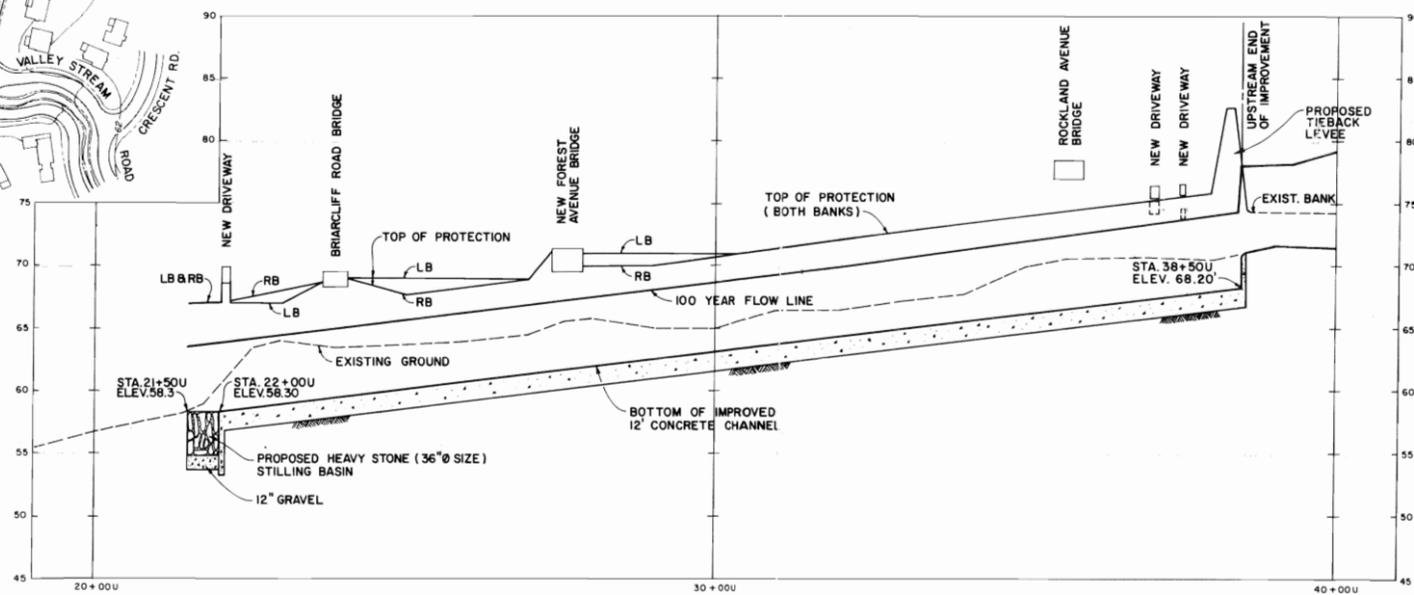
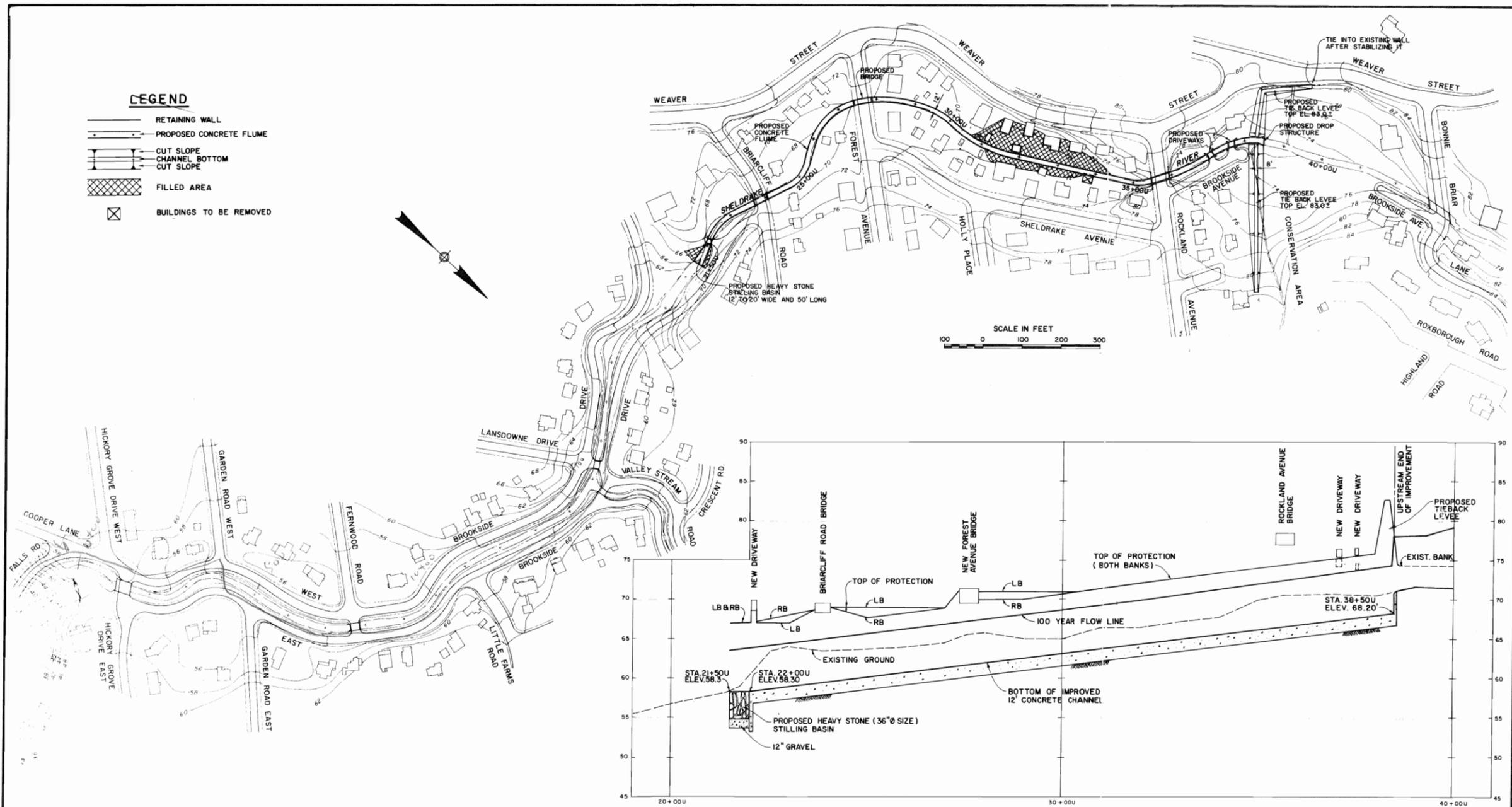
TO ACCOMPANY SURVEY REPORT DATED OCTOBER 1977  
PLATE 4



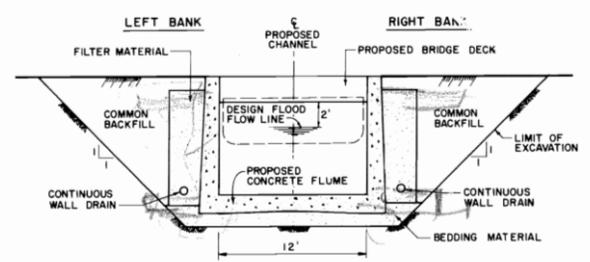


**LEGEND**

- RETAINING WALL
- PROPOSED CONCRETE FLUME
- CUT SLOPE  
— CHANNEL BOTTOM  
— CUT SLOPE
- ▨ FILLED AREA
- ⊗ BUILDINGS TO BE REMOVED

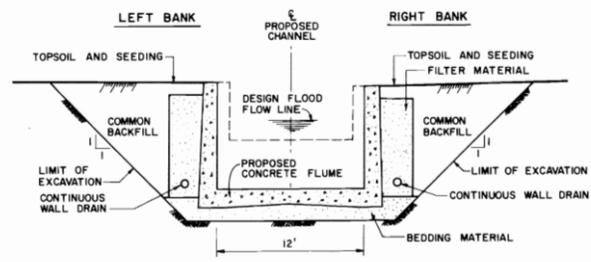


**PROFILE ALONG CENTER LINE OF CHANNEL, SHELDRAKE RIVER**



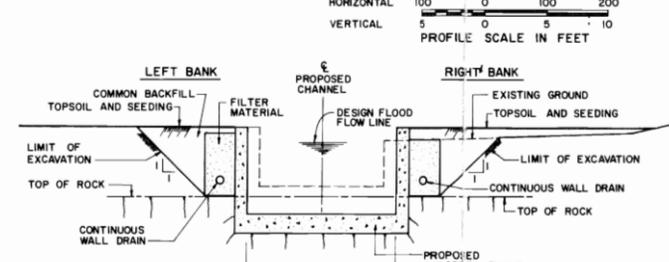
**PROPOSED FOREST AVENUE BRIDGE**

SCALE IN FEET



**VICINITY OF STA. 29+00**

SCALE IN FEET



**VICINITY OF STA. 34+00**

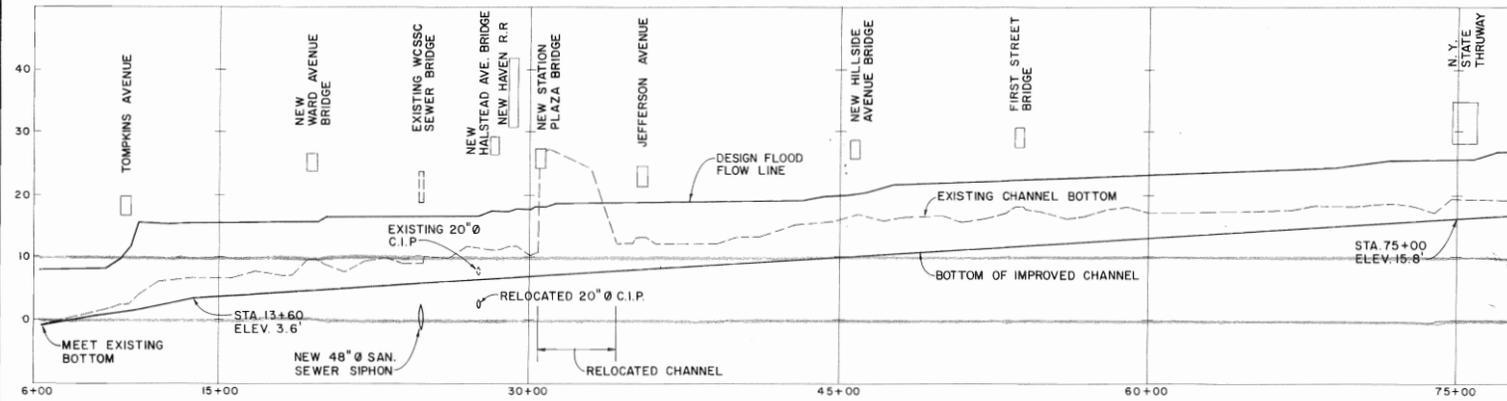
SCALE IN FEET

**STREAMS IN WESTCHESTER COUNTY, N.Y.  
AND FAIRFIELD COUNTY, CONN.  
MAMARONECK AND SHELDRAKE RIVERS BASIN, N.Y.  
TOWN OF MAMARONECK GENERAL PLAN, PROFILE AND DETAILS**

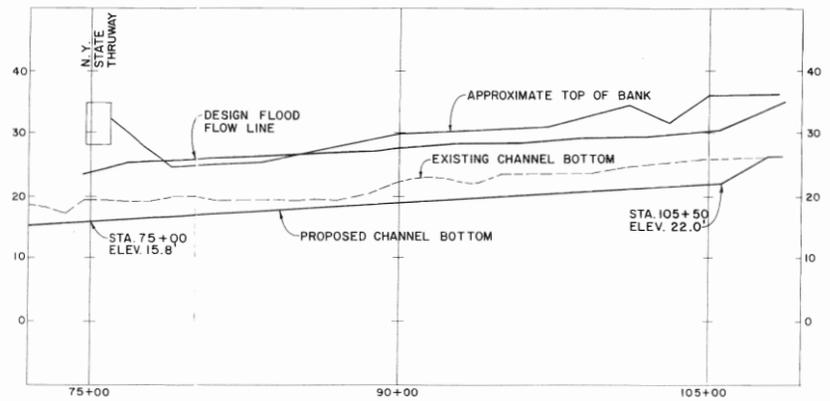
DEPARTMENT OF THE ARMY  
NEW YORK DISTRICT, CORPS OF ENGINEERS  
NEW YORK, NEW YORK

SUBMITTED: *Samuel P. Tori*  
REVIEWED: *Stanley Maisel*  
RECOMMENDED: *John W. Brown*

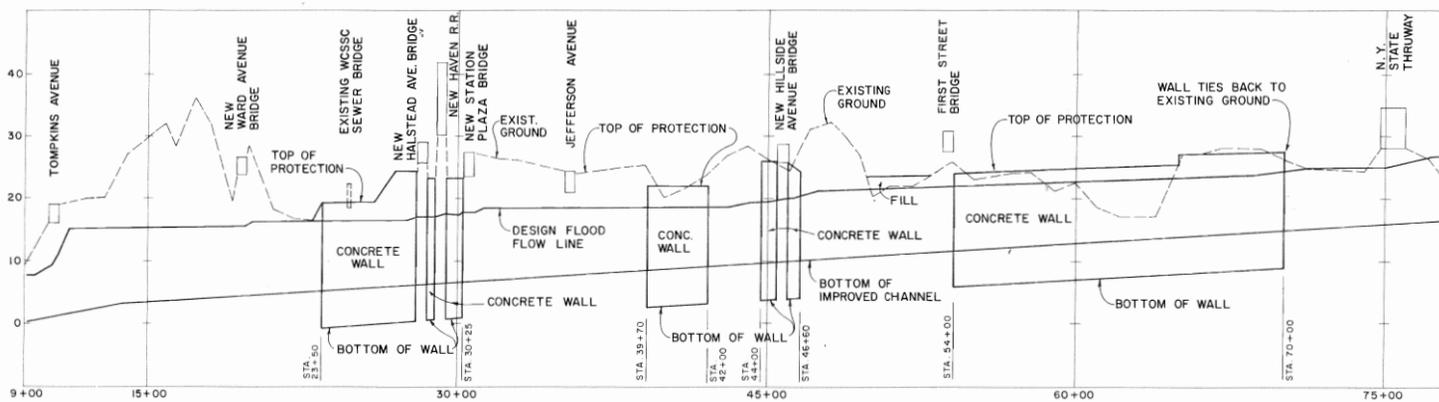
APPROVED: *John W. Brown*  
DRAWN BY: *John W. Brown*  
CHECKED BY: *John W. Brown*



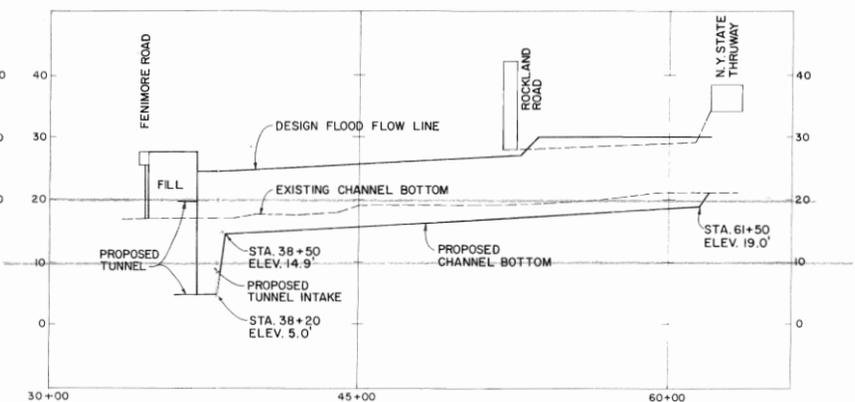
PROFILE ALONG CENTER LINE OF CHANNEL IMPROVEMENT MAMARONECK RIVER



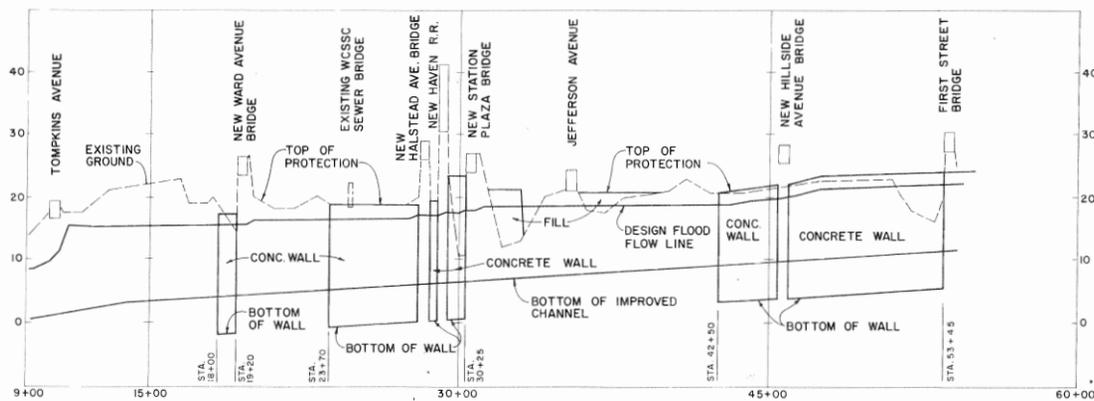
PROFILE ALONG CENTER LINE OF CHANNEL IMPROVEMENT MAMARONECK RIVER



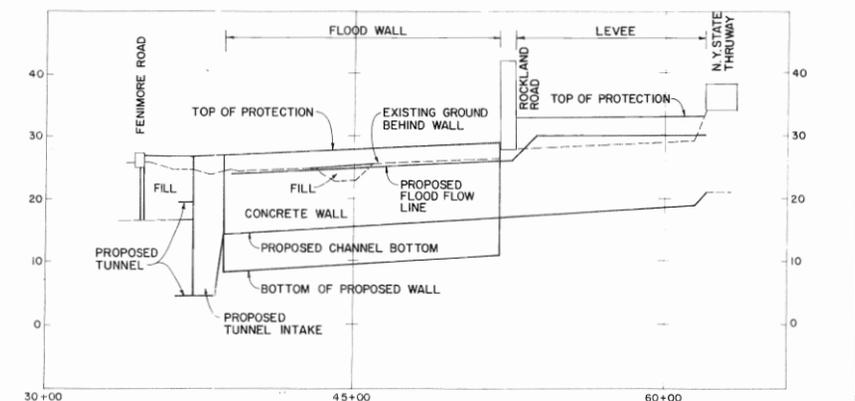
PROFILE ALONG CENTER LINE OF LEFT BANK IMPROVEMENT MAMARONECK RIVER



PROFILE ALONG CENTER LINE OF CHANNEL IMP. SHELDRAKE R.



PROFILE ALONG CENTER LINE OF RIGHT BANK IMPROVEMENT MAMARONECK RIVER



PROFILE ALONG CENTER LINE OF RIGHT BANK IMPROVEMENT SHELDRAKE RIVER

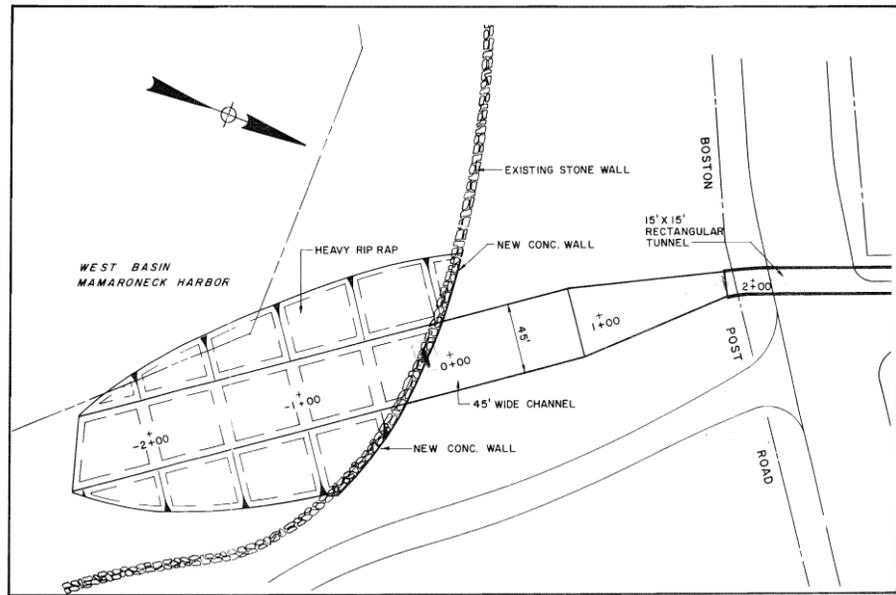
STREAMS IN WESTCHESTER COUNTY, N.Y.  
AND FAIRFIELD COUNTY, CONN.  
MAMARONECK AND SHELDRAKE RIVERS BASIN, N.Y.  
PROFILES

DEPARTMENT OF THE ARMY  
NEW YORK DISTRICT, CORPS OF ENGINEERS  
NEW YORK, NEW YORK

SUBMITTED <i>Samuel P. Tosi</i> CHIEF, RIVER BASIN SECTION	REVIEWED <i>Stanley Masel</i> CHIEF, CIVIL PLANNING MANAGEMENT BR.	RECOMMENDED <i>John W. ...</i> CHIEF, ENGINEERING DIVISION
APPROVED <i>Clark W. ...</i> COLONEL, C. E., DISTRICT ENGINEER	Drawn by Checked by	DRAWING NUMBER

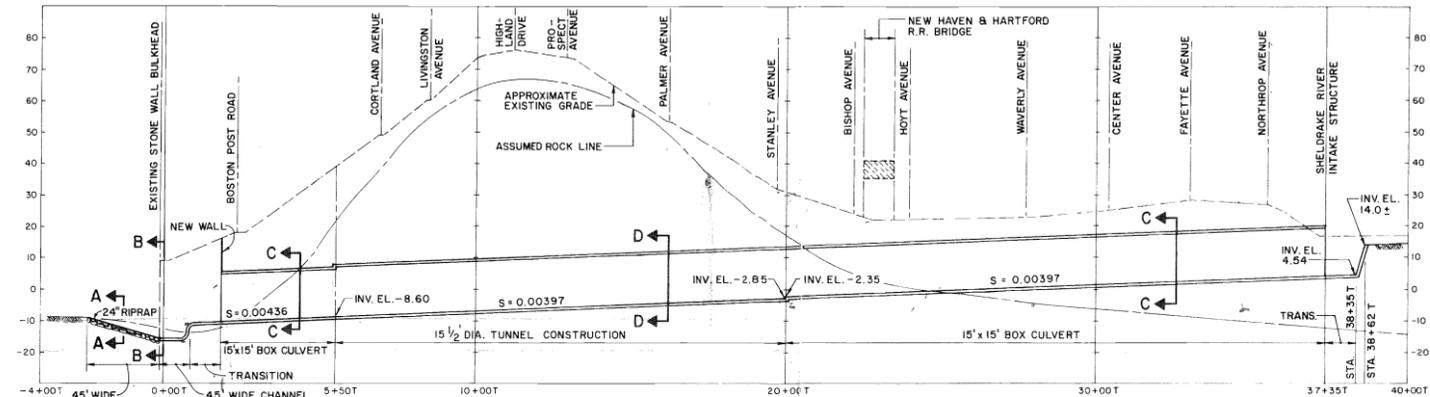


TO ACCOMPANY SURVEY REPORT DATED OCTOBER 1977



**PROPOSED SHELDRAKE RIVER OUTLET STRUCTURE**

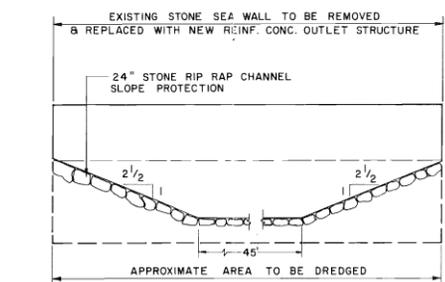
INSET SCALE IN FEET



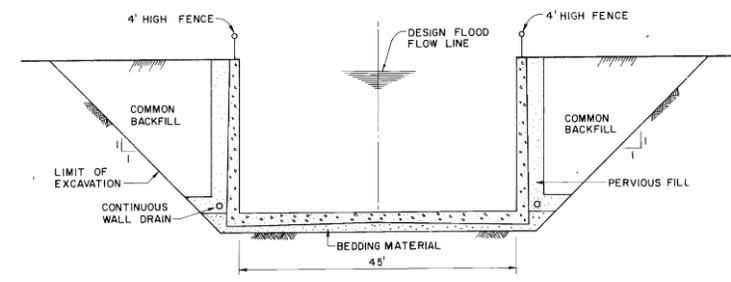
**PROFILE OF PROPOSED SHELDRAKE RIVER DIVERSION TUNNEL**

STA. 2+40T TO STA. 37+35T

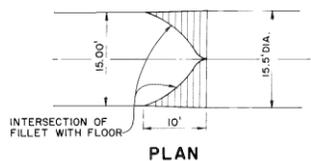
PROFILE SCALE IN FEET



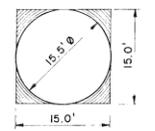
**SECTION A-A**  
**ELEVATION AT PROPOSED OUTLET STRUCTURE**  
STA. 2+40T TO STA. 0+00T



**SECTION B-B**

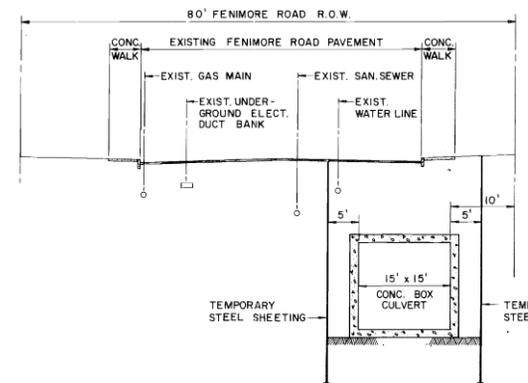


**PLAN**

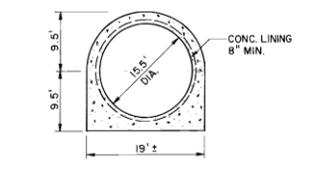


**SECTION**

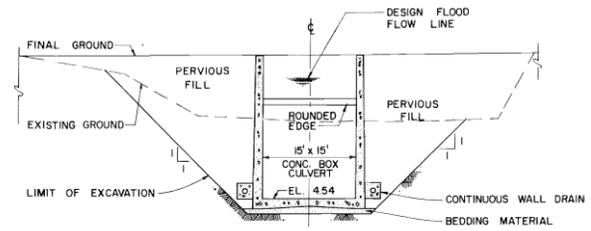
**TRANSITION DETAIL BETWEEN TUNNEL AND BOX CULVERT**  
STA. 5+50T & STA. 20+00T



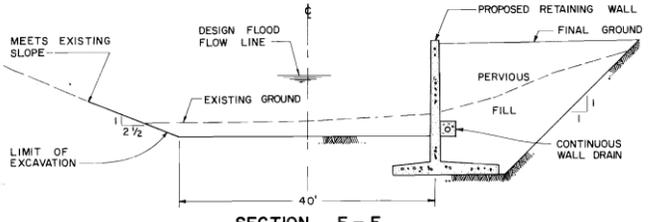
**SECTION C-C**  
**TYPICAL BOX CULVERT SECTION**  
STA. 1+83T TO STA. 5+50T & STA. 20+00T TO STA. 37+35T



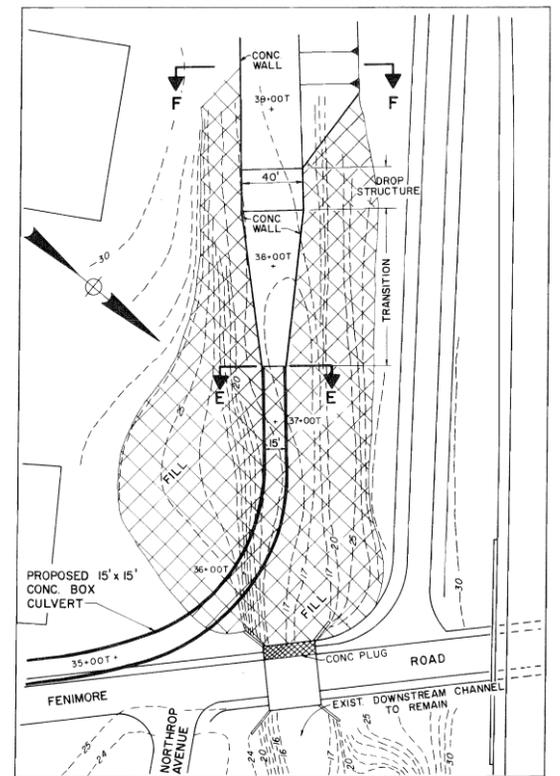
**SECTION D-D**  
**TYPICAL TUNNEL SECTION**  
**EXCAVATION BY DRILLING AND BLASTING**  
STA. 5+50T TO STA. 20+00T



**SECTION E-E**  
**PROPOSED ENTRANCE TO BOX CULVERT**  
STA. 37+35T



**SECTION F-F**  
**VICINITY OF STA. 39+00 SHELDRAKE RIVER**



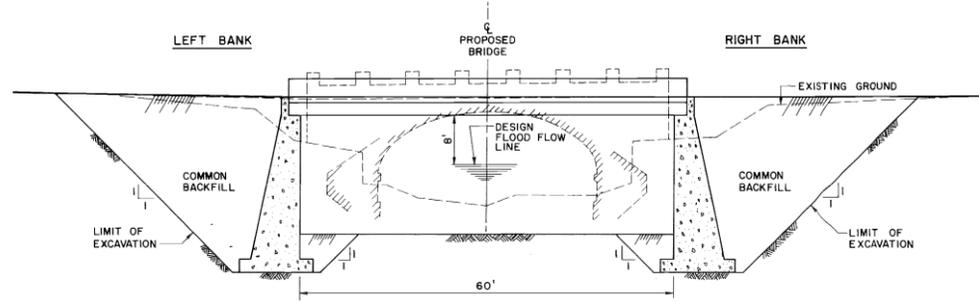
**PROPOSED SHELDRAKE RIVER INTAKE STRUCTURE**

INSET SCALE IN FEET

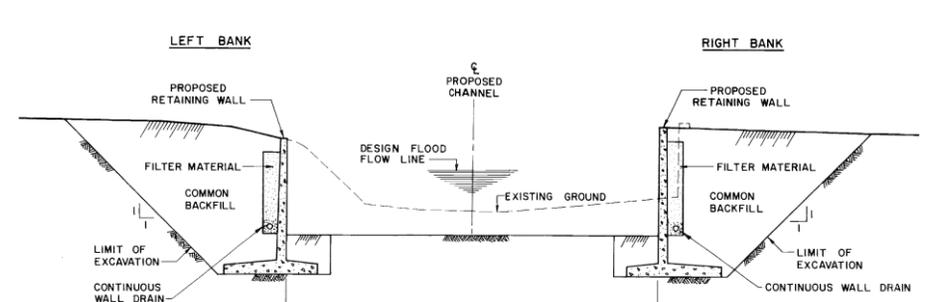
DETAILS SCALE IN FEET

<b>STREAMS IN WESTCHESTER COUNTY, N.Y. AND FAIRFIELD COUNTY, CONN. MAMARONECK AND SHELDRAKE RIVERS BASIN, N.Y. PROFILE AND DETAILS OF PROPOSED DIVERSION TUNNEL</b>		
DEPARTMENT OF THE ARMY NEW YORK DISTRICT, CORPS OF ENGINEERS NEW YORK, NEW YORK		
SUBMITTED: <i>Samuel P. Tosi</i> CHIEF, RIVER BASIN SECTION	REVIEWED: <i>Stanley M. Mair</i> CHIEF, CIVIL PLANNING AND MANAGEMENT BR.	RECOMMENDED: <i>D. W. ...</i> CHIEF, ENGINEERING DIVISION
APPROVED: <i>Carl ...</i> COLONEL, C. E., DISTRICT ENGINEER	Drawn by Checked by	DRAWING NUMBER

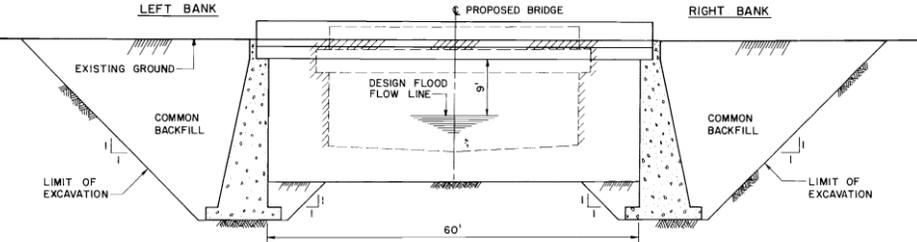
TO ACCOMPANY SURVEY REPORT DATED OCTOBER 1977



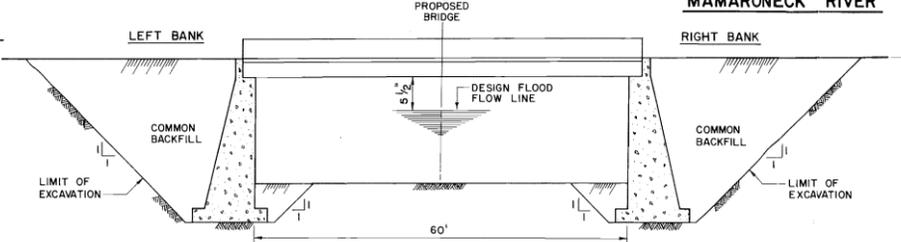
**PROPOSED WARD AVENUE BRIDGE  
MAMARONECK RIVER**



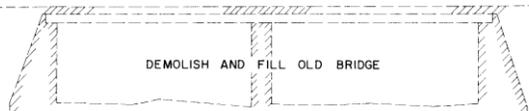
**VICINITY OF STA. 25+00  
MAMARONECK RIVER**



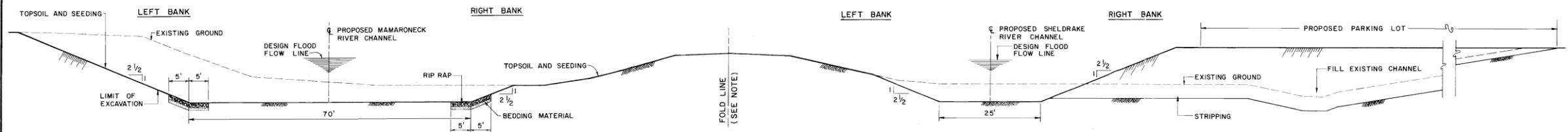
**PROPOSED HALSTEAD AVENUE BRIDGE  
MAMARONECK RIVER**



**PROPOSED STATION PLAZA BRIDGE  
MAMARONECK RIVER**

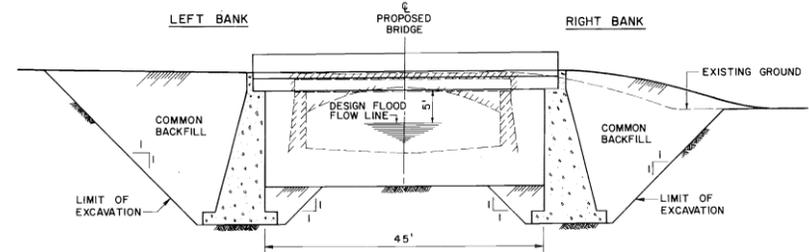


DEMOLISH AND FILL OLD BRIDGE

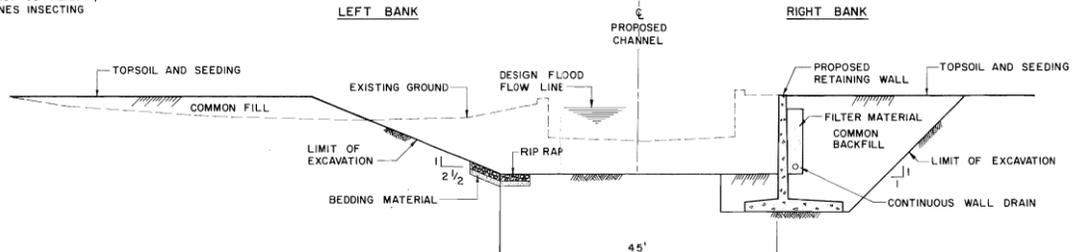


**APPROACH TO THE CONFLUENCE OF MAMARONECK AND SHELDRAKE RIVERS  
VICINITY OF STA. 34+00 MAMARONECK RIVER AND STA. 1+00 SHELDRAKE RIVER**

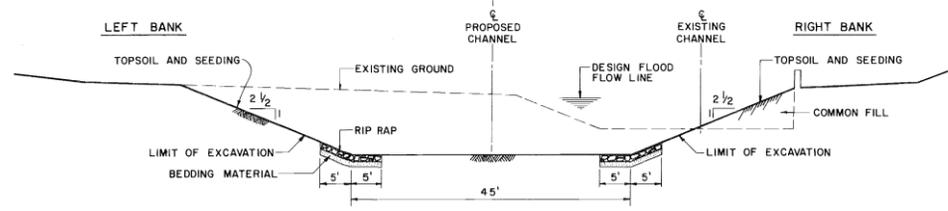
NOTE: THIS IS A COMPOSITE CROSS-SECTION. SUB CROSS-SECTIONS ARE NOT CO-PLANAR, BUT LIE IN SEPARATE PLANES INSECTING AT THE "FOLD LINE."



**PROPOSED HILLSIDE AVENUE BRIDGE  
MAMARONECK RIVER**



**VICINITY OF STA. 50+00  
MAMARONECK RIVER**

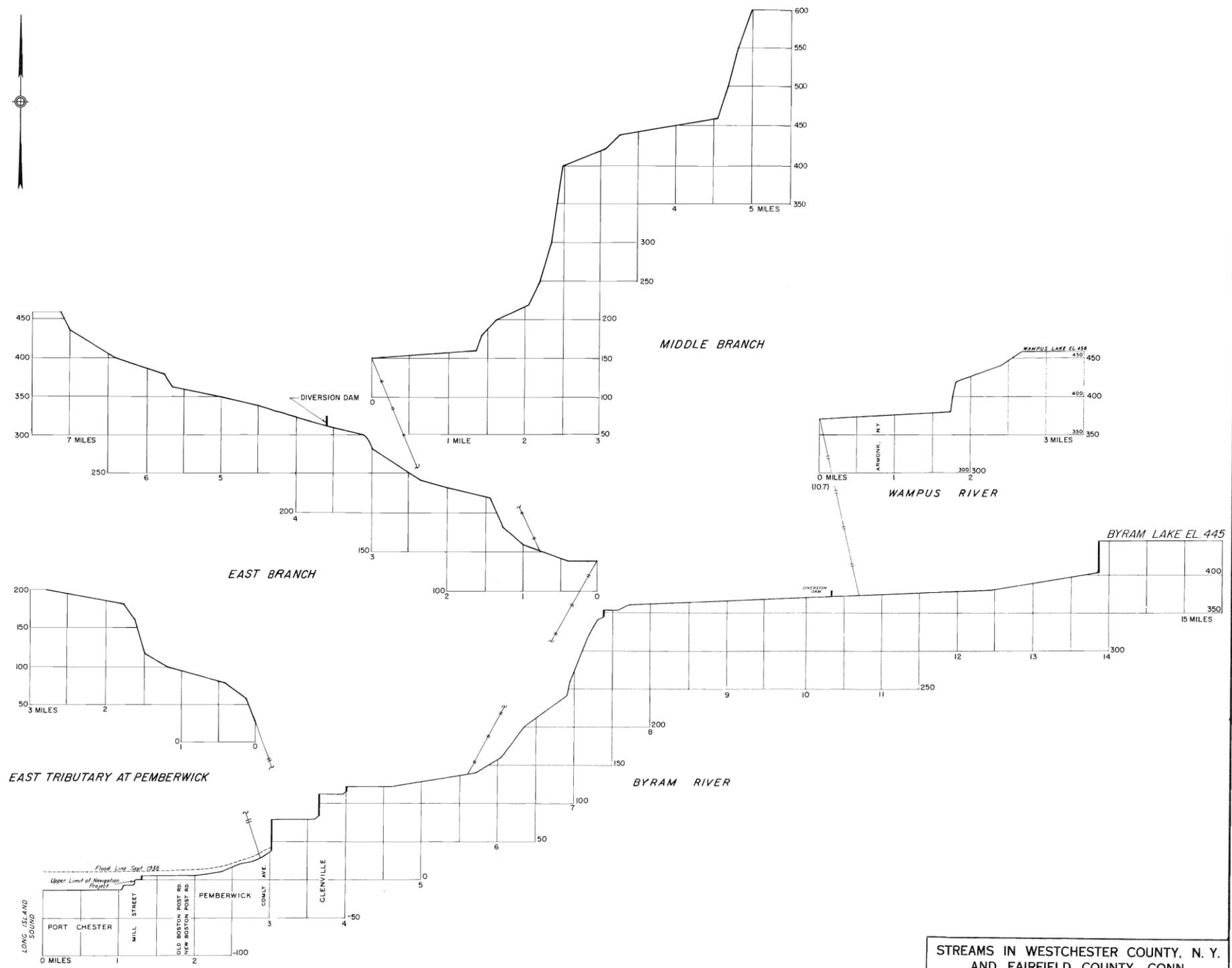
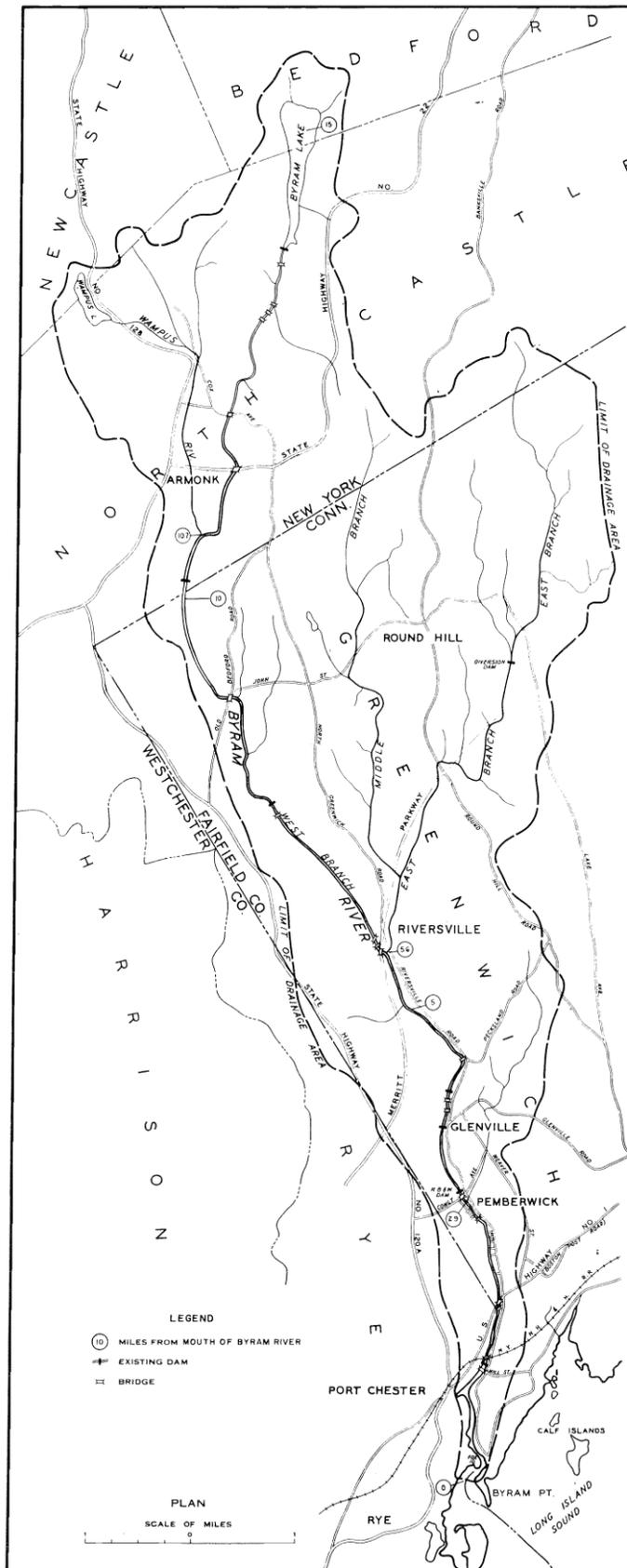


**VICINITY OF STA. 92+00  
MAMARONECK RIVER**

SCALE IN FEET

<b>STREAMS IN WESTCHESTER COUNTY, N.Y. AND FAIRFIELD COUNTY, CONN. MAMARONECK AND SHELDRAKE RIVERS BASIN, N.Y. DETAILS</b>		
DEPARTMENT OF THE ARMY NEW YORK DISTRICT, CORPS OF ENGINEERS NEW YORK, NEW YORK		
SUBMITTED: <i>Samuel P. Topp</i> CHIEF, RIVER BASIN SECTION	REVIEWED: <i>Stanley Massey</i> CHIEF, CIVIL PLANNING MANAGEMENT	RECOMMENDED: <i>John J. ...</i> CHIEF, ENGINEERING DIVISION
APPROVED: <i>Clark H. Penn</i> COLONEL, C. E., DISTRICT ENGINEER	Drawn by Checked by	DRAWING NUMBER

TO ACCOMPANY SURVEY REPORT DATED OCTOBER 1977

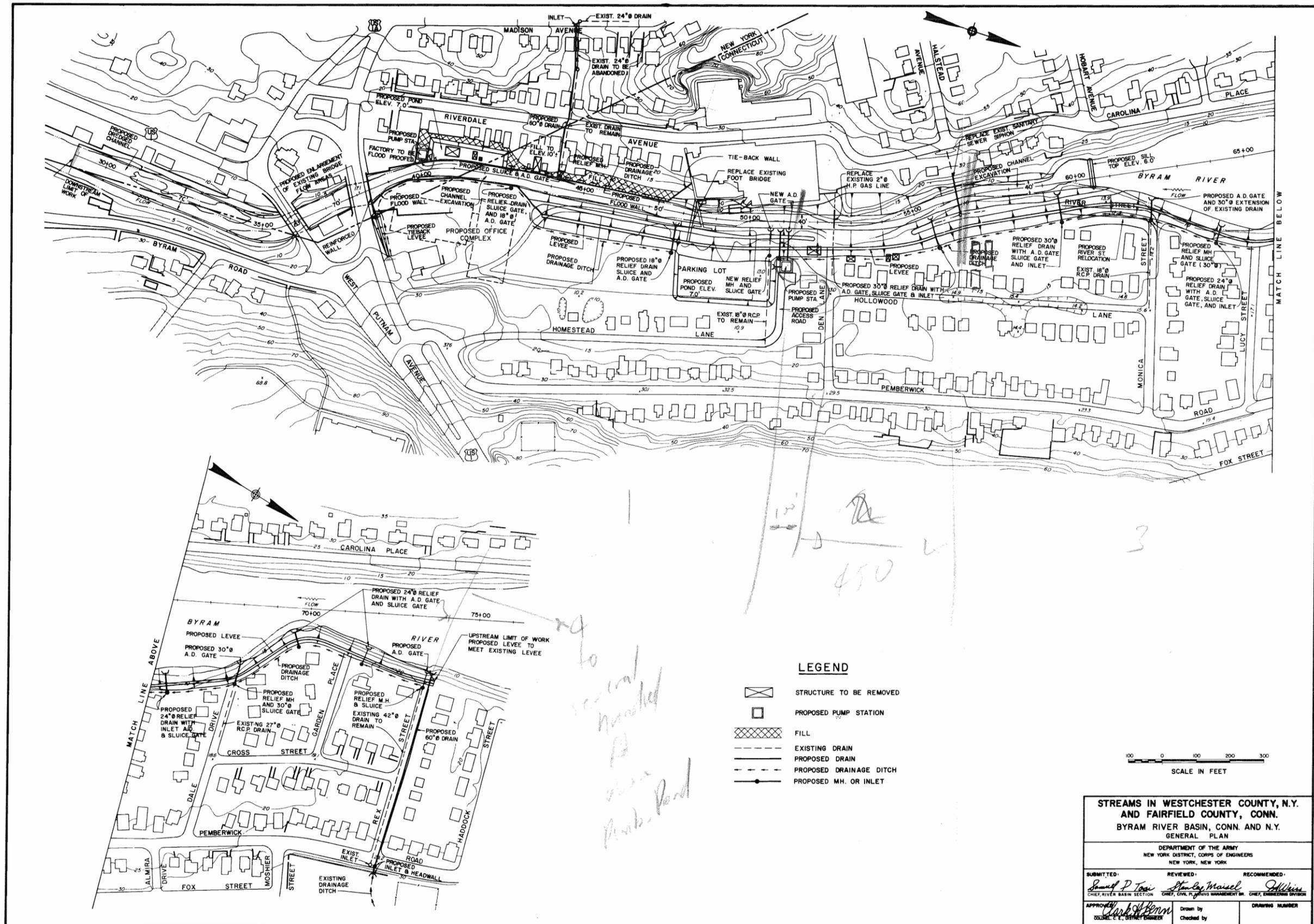


**NOTE**  
ELEVATIONS ARE IN FEET ABOVE MEAN  
SEA LEVEL AT SANDY HOOK, N. J.

**STREAMS IN WESTCHESTER COUNTY, N. Y.  
AND FAIRFIELD COUNTY, CONN.  
BYRAM RIVER BASIN MAP  
AND STREAM PROFILES**

DEPARTMENT OF THE ARMY  
NEW YORK DISTRICT, CORPS OF ENGINEERS  
NEW YORK, NEW YORK

<b>SUBMITTED:</b> Samuel P. Tose CHIEF, RIVER BASIN SECTION	<b>REVIEWED:</b> Stanley M. Meisel CHIEF, CIVIL PLANNING MANAGEMENT BRANCH	<b>RECOMMENDED:</b> H. W. Davis CHIEF, ENGINEERING DIVISION
<b>APPROVED:</b> Clark H. Bonn COLONEL, C. E. DISTRICT ENGINEER	Drawn by B. B. Checked by J. T.	<b>DRAWING NUMBER</b>

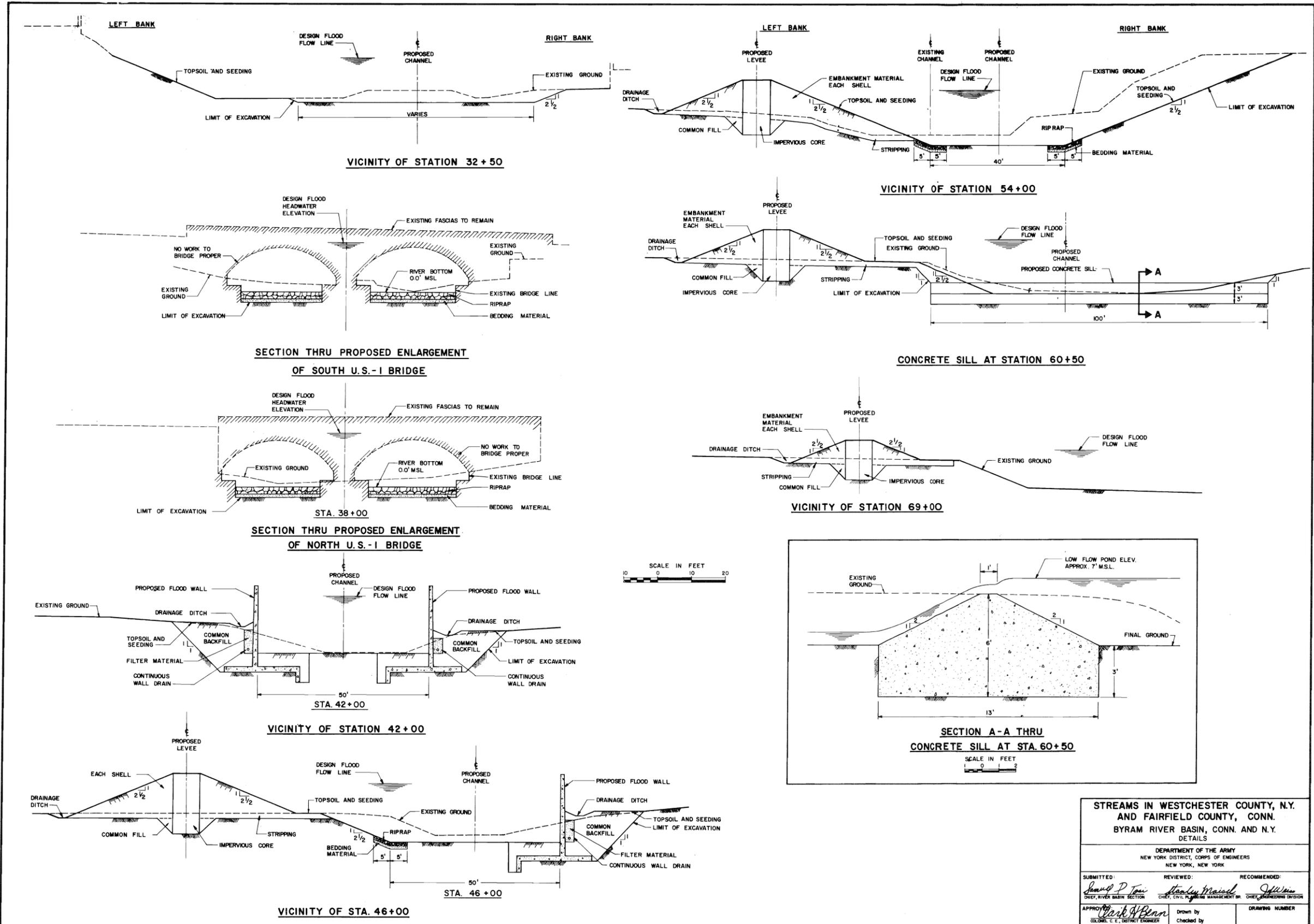


*to be handled by Park Pond*

*450*

*3*





**STREAMS IN WESTCHESTER COUNTY, N.Y. AND FAIRFIELD COUNTY, CONN. BYRAM RIVER BASIN, CONN. AND N.Y. DETAILS**

DEPARTMENT OF THE ARMY  
 NEW YORK DISTRICT, CORPS OF ENGINEERS  
 NEW YORK, NEW YORK

SUBMITTED: *James P. Tice*  
 CHIEF, RIVER BASIN SECTION

REVIEWED: *Stanley Mair*  
 CHIEF, CIVIL PLANNING MANAGEMENT BR.

RECOMMENDED: *John W. ...*  
 CHIEF, ENGINEERING DIVISION

APPROVED: *Clark A. Benn*  
 COLONEL, C. E., DISTRICT ENGINEER

Drawn by: \_\_\_\_\_  
 Checked by: \_\_\_\_\_

DRAWING NUMBER: \_\_\_\_\_