PASSAIC RIVER REPORT

Volume I
Main Body

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

JUNE 1972

PASSAIC RIVER BASIN

NEW JERSEY AND NEW YORK

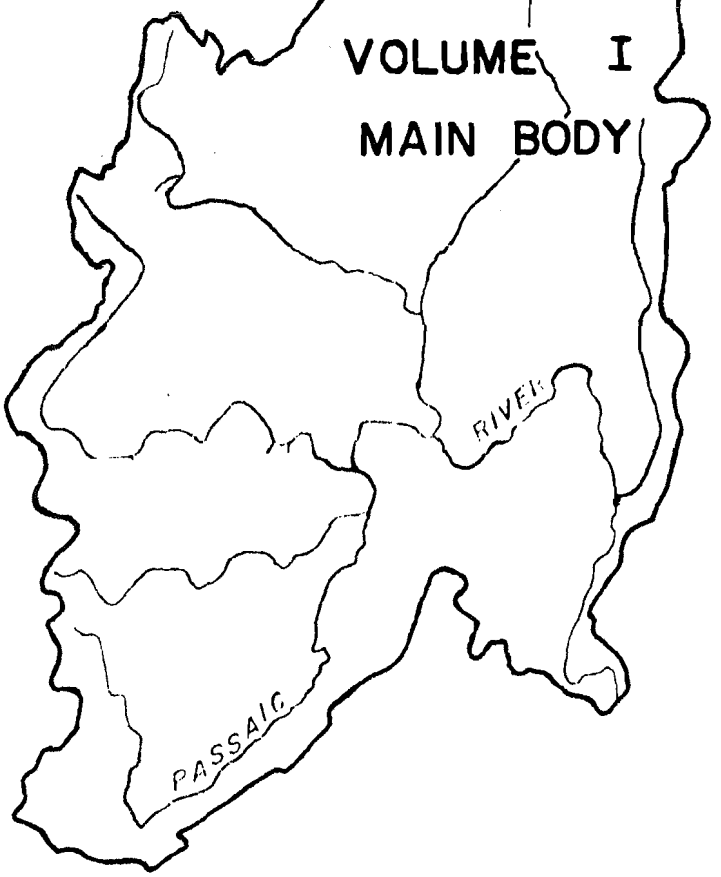
SURVEY REPORT

FOR

WATER RESOURCES

VOLUME I

MAIN BODY



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

JUNE 1972

NADEN-R (15 June 72) 1st Ind
SUBJECT: Survey Report for Water Resources, Passaic River Basin, New Jersey and New York

DA, Engineer Division, North Atlantic, New York, New York 10007
14 July 1972

TO: Resident Member, Board of Engineers for Rivers and Harbors, Washington, D. C.

I concur in the conclusions and recommendations of the District Engineer.

R. H. GROVES
Major General, USA
Division Engineer

PASSAIC RIVER BASIN, NEW JERSEY AND NEW YORK
SURVEY REPORT FOR WATER RESOURCE DEVELOPMENT

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PASSAIC RIVER BASIN, NEW JERSEY AND NEW YORK

SURVEY REPORT FOR WATER RESOURCE DEVELOPMENT

S Y L L A B U S

There is extreme interest by the State of New Jersey in a plan of improvement for flood protection and development of allied water resources in the Passaic River basin. Governor Hughes (in November 1969) endorsed the plans and expressed his intention of recommending to the State Legislature the necessary laws which would provide for the State's assumption of all items of local cooperation. This report estimates projected needs for water resource development in the Passaic River Basin, surveys the resources of the basin, considers alternative measures for meeting the needs, formulates an optimum plan of development, and considers the extent of the Federal interest in participating in such a development, in accordance with pertinent laws and policies.

Environmental impacts of the proposed works are evaluated.

There are some 35,000 acres of land in the Passaic River basin which are subject to inundation due to the inability of the existing stream to contain flood flows at all times. A recurrence of the largest flood of record, which occurred in October 1903, under present conditions would cause damages totaling about $451,330,000 with the accompanying loss of many lives. This area also suffers from periodic droughts, poor water quality along the main stream during the summer months, insufficient outdoor recreational facilities for the basin's expanding population, a periodic mosquito problem and high water tables and poor overland drainage in the Central Basin.

The District Engineer finds that a plan of improvement for the Passaic River basin for water resource development is economically feasible and recommends its authorization, subject to items of local cooperation specified in the report.

The recommended plan of improvement for the Passaic River basin, the most feasible of several alternative plans considered, provides for multiple purpose reservoirs upstream of Two Bridges and Myers Road on the Passaic River for flood control, water supply, water quality improvement, and recreation. The plan also provides for diversion and improvement of the Pompton River, for channel improvement on the Ramapo River and on the main stream from Newark Bay to Two Bridges and from Chatham to Myers Road.

The presently estimated cost of the mainstream plan at January 1970 prices is $720,810,000, of which $565,000,000 would be Federal. The average annual charges at the specified water resource planning interest rate of 5-3/8 percent for a 100 year project life is $49,833,000; the average benefits are $57,574,000. The benefit-cost ratio is 1.2. The inclusion of

$1,725,000 in area redevelopment benefits accruing to the plan of improvement would yield the same benefit-cost ratio.

The District Engineer also recommends for authorization local protection plans as follows:

a. Mahwah River at the Village of Suffern, New York and Mahwah Township, New Jersey at a total first cost of $2,310,000, of which $1,920,000 is Federal. The annual charges are estimated at $147,000 with corresponding annual benefits of $219,000 resulting in a benefit-cost ratio of 1.5.

b. Ramapo River at Oakland Township, New Jersey at a total first cost of $10,830,000, of which $6,290,000 is Federal. The annual charges associated with the works are $623,000 with corresponding annual benefits of $1,776,000 resulting in a benefit-cost ratio of 2.9.

c. Saddle River at the Borough of Lodi, New Jersey at a total first cost of $3,630,000, of which $2,820,000 is Federal. The annual charges associated with the works are $253,000 with corresponding annual benefits of $381,000 resulting in a benefit-cost ratio of 1.5.

d. Molly Ann's Brook in the Borough of Haledon, New Jersey at a total first cost of $5,710,000, of which $4,460,000 is Federal. The annual charges associated with the works are $386,000 with corresponding annual benefits of $809,000 resulting in a benefit-cost ratio of 2.1.

e. Nakoma Brook at the Village of Sloatsburg, New York at a total first cost of $1,490,000, of which $1,330,000 is Federal. The annual charges are estimated at $85,000 with corresponding annual benefits of $125,000 resulting in a benefit-cost ratio of 1.5.

f. Rockaway River at Denville Township, New Jersey at a total first cost of $4,230,000, of which $4,080,000 is Federal. The annual charges are estimated at $238,000 with corresponding annual benefits of $442,000 resulting in a benefit-cost ratio of 1.9.

g. Reconstruction of dams at Picatinny Lake and Lake Denmark in the Picatinny Arsenal area, New Jersey. The cost of reconstruction of the dams is $4,320,000, all of which is Federal.

U. S. ARMY ENGINEER DISTRICT, NEW YORK
CORPS OF ENGINEERS
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10007

NANEN-Cb

SUBJECT: Passaic River Basin, New Jersey and New York
Survey Report for Water Resources Development of
the Passaic River basin.

TO: Division Engineer
U. S. Army Engineer Division, North Atlantic
New York, New York

I. AUTHORITIES

1. FLOOD CONTROL ACTS. This report is submitted in compliance with the Flood Control Act of 22 June 1936 (Public No. 738, 74th Congress), the Flood Control Act of 6 May 1936 (Public No. 574, 74th Congress), and the Flood Control Act of 1958 (Public Law 85-500). Pertinent excerpts from these acts are quoted below.

(a) The Flood Control Act of 22 June 1936 provides in part that; "The Secretary of War is hereby authorized and directed to cause preliminary examinations and surveys for flood control at the following-named localities. . . . . Passaic River, New Jersey."

(b) The Flood Control Act of 6 May 1936 provides in part that, ". . . . . the Secretary of War is hereby authorized and directed to cause a preliminary examination to be made of the Passaic River in the State of New Jersey with a view to the control of floods. . . . . ."

(c) The Flood Control Act of 3 July 1958 provides in part that, "The Secretary of the Army is hereby authorized and directed to cause surveys for . . . . . Streams, river basins and areas in . . . . . , New Jersey for flood control, major drainage, navigation, channel improvement, and land reclamation as follows: . . . . . Passaic River . . . . . ."

2. HOUSE PUBLIC WORKS COMMITTEE RESOLUTION. This report is also in compliance with a Congressional resolution adopted 13 June 1956, which stated, "resolved by the Committee on Public Works of the House of Representatives, United States that the Board of Engineers for Rivers

and Harbors be and is hereby, requested to review the report on the Passaic River, New Jersey, dated 20 October 1948 with a view to determining the feasibility of providing flood measures along tributary Ramapo River in New York."

II - EXTENT OF INVESTIGATION

3. GENERAL. The study of the Passaic River Basin was of survey scope and sufficiently extensive to permit evaluations to be made of various alternative plans of improvement. Field and office investigations were made to serve as a basis for the development and evaluation of these plans. Reconnaissance of the basin by the District Engineer and his staff resulted in the delineation of the needs, problem areas and possible alternatives. Field damage surveys and topographical surveys were made accordingly. Studies of hydrologic, hydraulic, and geologic conditions were then applied to the development of the alternative plans of improvement. Cost estimates and the evaluation of the demands for water resource services and possible benefits were utilized as a basis for the selection of a recommended plan of improvement. Coordination with local officials, the State of New Jersey and other Federal agencies was maintained during the course of the study. Numerous public hearings and presentations were held to solicit the desires of local interests and to keep them informed.

4. FUNCTIONAL AND GEOGRAPHIC SCOPE. In response to the study authorization, this report is concerned with the feasibility of improving the water resources of the Passaic River Basin. Flood control, major drainage, navigation, pollution abatement, and hurricane protection aspects are necessarily concerned with the problems directly associated with the basin while other aspects, such as recreation, water supply, and fish and wildlife, involve consideration of needs of areas extending beyond the basin limits.

5. SCOPE OF PRESENTATION. This report is of survey scope and discusses all phases of the flood problem and water resources development within the Passaic watershed, with the objective of presenting the analysis and considerations leading to the most suitable basin plan of improvement consistent with long range needs.

6. Topographic investigations. Numerous topographic surveys were made throughout the study by the New York District along the main streams, tributaries, and contiguous areas where there was a potential for water resource improvement. This data, supplemented by information furnished by state, county and local agencies, was basic in the development of alternative plans and determination of their benefits and costs.

7. Economic investigations. Field flood damage surveys were conducted subsequent to the various severe floods since the authorization of this study in 1936, the most recent survey being made in 1968. The damage studies have included continuing revisions to reflect changes in price levels and conditions of development, as well as projections of future damages. In addition, background data on economic activity in the basin were developed for use in projecting future water resources needs.

8. Foundations and materials. A reconnaissance of the area was made to obtain information for an analysis of foundation conditions and availability of construction materials. Subsurface investigations undertaken at the sites of proposed improvements included core and auger borings, test pits and laboratory testing and analysis of soil samples. These data were supplemented by local construction records and other existing soils survey data. Details are in Appendix C.

9. Hydrology and hydraulics. The hydrologic history and character of the Passaic River Basin was investigated to establish the basis for analysis of flood damages, developable yields for water supply and for the hydraulic design of the improvements considered. Details are in Appendices A and B.

10. Real estate. On the basis of field investigations, supplemented by information obtained from local authorities and by real estate appraisers, appraisals were made of the existing values of the properties lying within the areas subject to flooding along the main stream and its tributaries, and within possible reservoir areas. Estimates were also made of the enhanced values of properties that would result from considered improvements. Details are in Appendix I.

11. Recreation. Detailed studies were made of local and regional needs for recreational development. This entailed an inventory of existing facilities in the zone of recreational influence and an estimate of future requirements. A field reconnaissance was conducted to determine the physical and esthetic qualities of all potential recreational sites that could be developed as part of the considered reservoir improvements. Recreation studies are described in Appendix H.

12. Water supply. Detailed studies were made of local needs for water supply. These studies included an inventory of all existing and firmly committed water supply developments serving portions of the Passaic River Basin, and an estimate of future requirements for both industrial and municipal developments. The studies were made on a county wide basis for a nine county region in New Jersey and Rockland County, New York. The extent to which the needs could be met by multiple purpose improvements in the Passaic River basin was also studied in detail, as described in Appendix E.

13. Other studies. Investigations were also made to establish the needs and possible means of solution for problems in fish and wildlife,

water quality, navigation, mosquito control, drainage and land reclamation.

14. REPORTS BY OTHER AGENCIES. The flood problem on the Passaic River has been studied by local agencies since Revolutionary times. Numerous reports exist, of which the most noteworthy are tabulated in Appendix T. Special reports were prepared by other Federal agencies in conjunction with this survey report. Among the agencies furnishing draft and final reports were the Fish and Wildlife Service, Environmental Protection Agency, Geological Survey, Bureau of Public Roads, National Park Service, Soil Conservation Service, Federal Power Commission.

15. CONSULTATION WITH INTERESTED PARTIES. In order to determine the extent and type of improvements desired, public hearings were held at Paterson, New Jersey in 1936, 1939, 1946 and 1961, at Washington, D. C. in 1950; at Newark, New Jersey in 1956, and also at Chatham, Troy Hills, Wayne, Belleville and Mahwah in 1961. In addition, public meetings and conferences were frequently held with officials of various governmental agencies, committees, organizations, agencies, groups, and private individuals of the State and local parties. The concept of the plan of improvement was further presented to the local residents in an illustrated brochure dated December 1968 and titled "Passaic River Basin Water Resources Development Study, Information Bulletin." Public meetings were held on 16 and 19 December 1968 at Wayne and Madison, New Jersey to inform all concerned on the latest plans of improvement under consideration.

III - PRIOR REPORTS

16. FLOOD CONTROL. A preliminary examination report was submitted by the District Engineer in December 1936 under the authority referenced in paragraph 1. Concurrently with the foregoing report and under the same authorization the Secretary of Agriculture submitted a preliminary examination report on the Passaic River, New Jersey, in which it was concluded that the expenditure of Federal funds by the Department of Agriculture for runoff and waterflow retardation and soil erosion was not justified. Based on the review of the District Engineer's preliminary report, a survey report was authorized and subsequently submitted to the Chief of Engineers in March 1939. Since local interests consumed considerable time in reviewing the report in attempting to resolve their differences, the report was returned to the District Engineer in April 1945 for updating for changed conditions. In October 1948 the District Engineer submitted a revised report recommending favorable action on a modified plan. This report was returned to the District Engineer in March

1950 for further study because of the divergent views of local interests. In June 1962 the District Engineer submitted an updated and revised draft report recommending favorable action on an alternative plan. This draft report was also returned to the District Engineer in October 1962 for further study because of the divergent views of local interests and the apparent economic deficiency of the recommended plan.

17. NAVIGATION. Under the River and Harbor Act of 10 June 1872, a navigation project in the Passaic River was authorized. This report published as Senate Executive Document No. 35, 42d Congress, 2nd Session, recommended a channel varying from 50 to 200 feet width and in depth from 6 to 7½ feet, mean low water between the Center Street Bridge in Newark and Gregory Avenue highway bridge in Passaic. Subsequently, several modifications to this original project have been authorized and constructed. Pertinent information concerning these survey reports and the authorizing documents are contained in Appendix N, General Information.

18. REPORTS BY OTHERS. Several hundred reports have been compiled on the development of water resources in the Passaic River basin. These reports date back to colonial times when the main emphasis of the studies were for irrigation of the Central Basin and flood protection and navigation in the Lower Passaic River. The most comprehensive of these reports, published in 1931 by the New Jersey State Water Policy Commission, considered several alternative plans and made an inventory of the total flood control benefits which might be delivered within the Passaic watershed from each plan. The report concluded that the total capitalized value of these benefits would be $93,109,000.

IV - BASIN DESCRIPTION

19. LOCATION AND EXTENT. The Passaic River watershed has a total area of 935 square miles of which 787 square miles or 84 percent are in the northeasterly portion of the State of New Jersey, and the remainder in the southerly portion of New York State. The watershed in New Jersey occupies 10.5 percent of the total state area and includes the greater parts of Passaic County, Essex, Morris and Bergen Counties, and lesser parts of Hudson, Somerset, Sussex and Union Counties. In the State of New York, the basin occupies parts of Orange and Rockland Counties. The watershed is located within a 35 mile radius of New York City. The area is shown on published quadrangle sheets of the Corps of Engineers, Army Map Service; U. S. Geological Survey; and the New Jersey Department of Conservation. The watershed area and its vicinity are shown in Figures 1 and 2.

20. TOPOGRAPHY. The watershed is roughly elliptical in shape, with a length of 56 miles and a greatest width of 26 miles. It is topographically divided into three distinct regions known as the Highland Area, the Central Basin and the Lower Valley, Figure 2.

21. Highland Area. This portion of the drainage area, roughly 13 miles wide, 38 miles long and 489 miles in area, is a heavily wooded mountainous region comprising the northwesterly half of the watershed. This area is characterized by a series of parallel ridges deeply dissected by transverse, steep-sided, narrow valleys, in which flow the five major tributaries, and in which are contained numerous lakes and reservoirs which have an aggregate water surface area of 22.9 square miles. The average elevation is 900 feet above mean sea level varying from about 1,200 to 1,400 feet in the uplands at the westerly edge of the watershed to 300 feet in the valley at the easterly edge.

22. Central Basin. This portion of the watershed, containing 253 square miles, is a flat oval shaped depression which is about 10 miles wide and 30 miles long, and which extends in a northeast-southwest direction from Millington to Little Falls. The low-lying land bordering the river is largely composed of fresh water swamps and flat meadow lands, occasionally relieved by low rolling hills and several rock outcrops. The total swamp area in this region is 43 square miles, including the Great Swamp above Millington with an area of eight square miles, and the Great Meadow above Two Bridges with an area of 35 square miles. The Great Meadow includes a chain of low lands known locally as Black Meadows, Troy Meadows, Great Piece Meadows, Long Meadows, Bog and Vly Meadows, and Hatfield Swamp. The average elevation of the Central Basin is 300 feet above mean sea level varying from about 500 feet along the southwesterly rim of the basin to 163 feet at the northeasterly edge.

23. Lower Valley. This portion of the basin is a flat, densely, populated and highly industrialized region that encompasses 193 square miles of the southeasterly portion of the watershed and extends from Little Falls, at the northeasterly edge of the Central Basin, to the mouth of the Passaic River in Newark Bay. This roughly rectangular valley, about eight miles wide and 26 miles long, has rolling sides and a wide flat flood plain. The average elevation of the area is about 250 feet above mean sea level, varying from 500 feet along the westerly edge of the basin to tide level in Newark Bay. The tributaries in this area are short and steep, and enter the main stream at uniform intervals below Two Bridges.

24. STREAMS. Mainstream. The Passaic River from its headwaters in Mendham Township, Morris County, New Jersey to Newark Bay is 87 miles long. The course of the stream is generally south by east for a distance of about eleven miles to a point upstream of the village of Millington where the Great Swamp acts as a collecting basin for the headwater tributaries in this area. At Millington, the stream flows

through a narrow gorge traversing a high trap rock ridge, and then is sharply diverted to the northeast by the Second Watchung Mountain which forms the southeasterly limit of the watershed. From Millington to Chatham, the stream flows for a distance of twelve miles through a narrow corridor between two flanking ridges which limit the width of the watershed in this section to an average of about three miles. Beyond Chatham, the main stream continues in a northerly direction to the Great Meadow area in Caldwell where it turns sharply east through a rock gorge at Little Falls and thence northeast to Paterson, a distance of 40 miles. It then flows south a distance of about 24 miles to its mouth at the northerly end of Newark Bay, which is joined to upper New York Bay by Kill Van Kull and to Lower New York Bay by Arthur Kill.

25. Tributaries. All of the major tributaries of the Passaic River rise in the Highland Area and enter the main stream within the Central Basin, Figure 2. The Pompton River, draining its tributaries, the Pequannock, Wanaque and Ramapo Rivers, enters the main stream from the north at Two Bridges. The Rockaway River, draining its tributary, the Whippany River, enters the main stream from the west near Pine Brook. The Saddle River, the only large tributary downstream of Two Bridges, enters the main stream from the north opposite the City of Passaic.

26. STREAM SLOPES. From its mouth in Newark Bay (mile 0.0) to Dundee Dam at Clifton (mile 17.4), the Passaic River is tidal, Figure 3. In Newark Bay, the mean low water elevation is 2.3 feet below mean sea level, the extreme tide of record has been 8.3 feet above mean sea level and the tidal range is 4.9 feet. At Gregory Avenue Bridge in Passaic (mile 13.8), the mean low water is 2.3 feet below mean sea level and the tidal range is 5.1 feet. Above the Eighth Street Bridge in Passaic (mile 15.0), which is the head of the Federal improvement for navigation, the river is shallow and the tide is increasingly affected by fresh water runoff of the Passaic River.

27. In the 80 miles of its course from Great Swamp above Millington to its mouth in Newark Bay, the Passaic River has a total fall of 220 feet of which about 113 feet occur as vertical falls of 17 feet at Dundee Dam in Clifton, 63 feet at the Great Falls (S.U.M. Dam) in Paterson, and 33 feet at Beattie's Dam in Little Falls. The elevation of the Great Meadows above Two Bridges varies uniformly from 165 feet above mean sea level to 180 feet above mean sea level. The Great Swamp has an elevation of 225 feet above mean sea level at its lower end and an elevation of 240 feet above mean sea level at its upper end. The gradients of the main river and tributaries are summarized in Table 1 and presented in more detail in Appendix B.

28. CHANNEL DIMENSIONS AND CAPACITIES. In the Lower Valley, flooding occurs as a result of insufficient channel capacity, due in part to the flat gradient and meandering character of the stream, but in a larger measure to flagrant encroachments by communities both in the

TABLE 1 - STREAM SLOPES

Stream	Reach	Distance above mouth of Passaic River in miles (a)	Average slope in feet per mile
Passaic River	Mouth to Dundee Dam at Clifton	0-17.4	Tidewater
	Dundee Dam to S.U.M. Dam at Great Falls	17.4-25.2	2.0
	S.U.M. Dam to Beatties Dam at Little Falls	25.2-29.7	1.9
	Beatties Dam to Below Chatham	29.7-58.7	0.3
	In Chatham	58.7-61.5	10.6
	Chatham to Above Millington	61.5-81.0	0.9
	Above Millington to Headwaters	81.0-87.5	58.8
Major Tributaries			
Pompton River	Two Bridges to Pompton Lakes Dam	33.0.41.9	4.5
Pequannock River	Pompton Lakes to Oak Ridge Dam	39.7-59.2	33.9
Wanaque River	Pompton Lakes to Greenwood Lake Dam	41.8-58.4	25.9
Ramapo River	Pompton Lakes to Monroe	41.9-74.6	12.2
Rockaway River	Pine Brook to Petersburg	47.0-83.0	17.2
Whippany River	Pine Brook to Morristown	48.2-60.2	10.2
Other Tributaries			
Weasel Brook	Passaic to Clifton (Jewett Avenue)	14.2-16.7	26.0
Saddle River	Lodi to Upper Saddle River	15.5-33.0	8.0
Hohokus Creek	Ridgewood to Allendale	25.8-31.8	35.0
Diamond Brook	Fairlawn to Glen Rock	22.2-24.7	15.0
Goffle Brook	Hawthorne to Wyckoff	23.3-30.3	47.7
Molly Ann's Brook	Paterson to Franklin Lakes	25.8-32.3	63.1
Slippery Rock Brook	Paterson to West Paterson	26.1-28.1	225.0
Peckman River	West Paterson to Pleasantdale	28.2-34.3	44.0
Singac Brook	Singac to Preakness	31.8-35.8	10.5

Note: (a) 0.0 miles on the Passaic River is the intersection of the Hackensack and Passaic River channels in Newark Bay, approximately 4,000 feet downstream of Central Railroad of New Jersey bridge over the Passaic River, Figure 1. All mileages given are referred to this point.

flood plain and along the river banks. The process of land reclamation by deposition of earth fills adjacent to the river has materially reduced the original channel width. Through erosion and sedimentation, heavy deposits of silt have shoaled the channel and formed islands in several localities. Throughout the Lower Valley numerous bulkheads jut into the waterway and constrict its width. Many of the bridges, built at low level to meet adjacent street grades, afford grossly inadequate waterways for the safe passage of floods; and many bridges, destroyed by the 1903 flood, have since been rebuilt with equal or smaller openings than existed before the flood. In the navigable section, the channel is further restricted by large bridge-pier fenders built in midstream.

29. Under existing conditions the Passaic River varies in width from about 165 feet to 800 feet in the reach from Two Bridges to its mouth. In depth it varies over the same reach from 8 to 45 feet. The major tributaries in the lower reaches vary up to 510 feet in width and up to 24 feet in depth. The minor tributaries, largely in the Lower Valley, vary up to 80 feet in width and up to 7 feet in depth. The channel dimensions of the main stem through the Lower Valley are summarized in Table 2. Other data on cross-sectional dimensions of the main stream and tributaries are given in Appendix B, Hydraulics.

TABLE 2 - CHANNEL DIMENSIONS, LOWER VALLEY

Reach	Miles Above Mouth	Width at Top of Banks (feet)			Thalweg (a) Depth at Bankful Stage (feet)	
		Min.	Max.	Av.	Min.	Max.
Newark Bay to Clifton	0-11.5	260	800	400	14	45
Clifton to Dundee Dam	11.5-17.4	200	730	330	14	33
Dundee Dam to Head of Lake Dundee	17.4-18.6	720	1,300	850	13	19
Lake Dundee to S.U.M. Dam	18.6-25.2	165	750	300	11	20
S.U.M. Dam to Beatties Dam	25.2-29.7	210	620	280	8	15
Beatties Dam to Two Bridges	29.7-33.0	200	390	290	10	12

(a) Lowest point on channel bed at any cross-section, Figure 1.

30. Under present channel conditions, flooding begins to occur in the City of Paterson above Great Falls when the discharge at Great Falls is 3,100 cubic feet per second. Floods of this magnitude occur on an average of twice yearly. Flooding in the river below Little Falls generally occurs when the discharge at Great Falls exceeds 7,700 cubic feet per second, which occurs on the average twice about every 3 years. Extensive flooding through the Lower Valley begins with discharges at Great Falls (S.U.M. Dam) of 11,700 cubic feet per second, with an average occurrence of once every 4 to 5 years. Immediately upstream of Little Falls, flooding occurs as a result of backwater from Beatties Dam and from the narrow approach channel which extends upstream of the dam nearly to Two Bridges. In this section overflow occurs whenever the discharge of the Passaic River at Little Falls exceeds 4,800 cubic feet per second and inundation of meadowlands upstream occurs whenever the discharge exceeds 2,900 cubic feet per second although limited overflow at scattered localities occurs at somewhat lower discharges. Bankfull channel capacities of the main stream and its tributaries at indicated gages are given in Appendix B, Hydraulics.

31. DRAINAGE AREAS. Drainage areas of the Passaic River, as well as the Pompton, which is the major tributary, Whippany and Rockaway Rivers and several other principal tributaries together with watershed areas at designated localities on the main stream are given in Table 3. Other drainage area data are given in Appendix B, Hydraulics.

32. BRIDGES. Several hundred bridges cross the Passaic River and its tributaries. In the 25 miles of stream downstream of S.U.M. Dam, 50 bridges cross the river. Fourteen of these are railroad bridges and the remainder are mainly highway bridges with some footbridges and pipeline crossings. In the Central Basin, downstream of Millington, 50 bridges cross the Passaic River, and a total of 25 bridges cross the Rockaway, Pompton and Whippany Rivers. Of this total, 61 are highway bridges with the rest being made up of railroad bridges, foot bridges and pipeline crossings. Data on the more important bridges in the watershed are listed in Appendix B, Hydraulics.

33. GEOLOGY. The Passaic River watershed falls into two broad physiographic provinces, the Highlands on the west and the Lowlands on the east. The two units are almost equally divided along an inactive fault which runs in a line from the southwest margin of the basin northeastward into New York State. The Highlands are predominantly a mountainous region composed of broad crystalline rock ridges and narrower belts of sedimentary shale, sandstone and conglomerate. The Lowlands constitute a gently sloping area from the foot of the Highlands downward to sea level at Newark Bay. The sedimentary shales and sandstones underlying the Lowlands are broken by a series of igneous basalt ridges trending in a northeasterly direction. Almost the entire basin was subjected to glacial erosion and deposition, producing lasting effects on the topography and drainage of the region. Downstream of Chatham,

TABLE 3 - DRAINAGE AREAS

Stream	Miles above mouth of Passaic River	Drainage area in square miles
Passaic River		
Mouth	0.0	935.0
Dundee Dam	17.4	809.9
Beatties Dam	29.7	762.2
Below Pompton River	33.0	740.8
Below Rockaway River	47.0	347.1
Below Canoe Brook	57.5	115.3
Below Dead River	72.5	77.9
Tributaries (a)		
Saddle River	15.5	60.6
Molly Ann's Brook	25.8	8.6
Pompton River	33.0	378.1
Pequannock River	39.7	192.6
Wanaque River	41.8	108.1
Ramapo River	41.9	160.0
Mahwah River	53.9	25.3
Rockaway River	47.0	205.7
Whippany River	48.2	72.0

(a) All drainage areas for tributaries are at their mouths.

where the stream originally flowed through the Rahway River Watershed, heavy deposits of debris dammed the original channel and diverted stream flow into the Passaic River drainage system. The southernmost limit of the glacial advancement is marked by a terminal moraine ridge from Dover to Summit. An extensive area within the southern half of the Lowlands was covered by a glacial lake in which considerable quantities of impermeable silts and clays were deposited. These clayey deposits underlie the vast meadow lands of the Central Basin. A more detailed analysis of the geology of the basin is contained in Appendix C, Geological and Soils Investigations.

V - ECONOMIC DEVELOPMENT

34. GENERAL. This section describes the nature of both the present and projected economic structure of the Passaic River basin as background for the consideration of water resource plans of improvement. Economic indicators examined were population, manufacturing employment, personal income, agriculture and land utilization, as well as the extent of available public facilities for transportation, power, water supply and other uses. From an economic standpoint the Passaic River watershed is an integral part of the Greater New York Metropolitan area. In the west and south, the development is largely rural and suburban, with a rapid transition to intense industrial development in the easterly portion of the watershed approaching New York City. Detailed discussion of economic aspects are in Appendix D.

35. POPULATION Basin. According to United States Census reports, the population of the Passaic watershed was 1,815,000 in 1970, or about 1,940 inhabitants to the square mile. Of this total, about 58 percent resided in urban centers of 10,000 persons or more, approximately 98 percent resided in the State of New Jersey, and nearly 80 percent was concentrated in the Lower Valley below Little Falls. In 1970, the Passaic watershed contained about 25 percent of the total population of the State of New Jersey. The population of the watershed increased at an average annual rate of 2.25 percent from 1950 to 1960 and 1.6 percent from 1960 to 1970. Population densities vary from an average of 6,125 persons per square mile in the Lower Valley to an average of 282 persons per square mile in the Highland Area. Maximum density occurs in the City of Paterson with 17,500 persons per square mile. The metropolitan character of the watershed, particularly of the Lower Valley, is evident when its population density is compared with approximately 400 persons per square mile for 212 metropolitan districts of the United States, and the value of 7,500 persons per square mile for the Greater New York and New Jersey metropolitan area as a whole. Newark, the largest city in the State of New Jersey, had a 1970 population of 382,400 of which about forty percent resided in the Passaic watershed. Communities located entirely within the Passaic basin, together with their 1970 populations include the following: Paterson (144,824), Passaic (55,124), Clifton (82,437), Montclair (44,043), Bloomfield (52,029), Belleville (34,643) and Garfield (30,722).

36. Service Area. The area that would be affected most by the development of any new supply of water and other water-related facilities from the Passaic River is referred to as the Passaic River Service Area; it consists of nine counties in New Jersey and Rockland County in New York.

The Service Area contains all sub-areas that would benefit from any specified type of water resource improvement. The populations of the 10 counties in the Service Area total 4,256,000, distributed as shown in Table 4. The population of the Service Area is projected to increase to 5,828,000 persons in 1985, 7,069,000 persons in 2000 and 8,858,000 persons in 2020. The area considered to be affected directly by different types of improvement is also indicated in Table 4. For example, recreational development in the Passaic River basin would benefit the counties of Passaic, Bergen, Hudson, Essex and Morris, and portions of Hunterdon, Somerset, and Union which are located within a reasonable commuting distance of 25 miles from the facilities. Additional pertinent information on population of the Service Area is contained in Appendix D, Economic Base Study.

37. MANUFACTURING EMPLOYMENT. In 1970, 670,000 persons or 37 percent of all people employed in the Passaic-Raritan Water Resources Planning Area 01014, an area defined by the United States Office of Business Economics and approximately coextensive with the Service Area, were employed in manufacturing. This proportion did not change significantly from the 37.9 percent figure for 1940. Manufacturing employment in Planning Area 01014 is projected to increase to 674,000 in 1985, 688,000 in 2000 and 729,000 in 2020 and is expected to remain the largest component of total employment.

38. Manufacturing Water Consumption. Paralleling the national situation, five major industrial uses of water account for close to 90 percent of all fresh water used in the basin for industrial purposes. These are: primary metals, chemicals and their products, pulp paper and its products, petroleum and coal products, and food and kindred products.

39. PERSONAL INCOME. Personal income increased at a lower rate in the Passaic River Service Area between 1929 and 1959 than in the nation. Projections indicate that this trend may be expected to continue. The 1959 income of $11.1 billion was 2.1 times as great as the 1929 income of $5.2 billion, representing an annual growth rate of 2.6 percent. Corresponding figures for the nation show an increase of 24 times and an annual growth rate of just over 3 percent. Between 1959 and 2020 personal income in the Service Area is expected to increase approximately 11.3 times, more slowly than the 13.1 times predicted for the nation.

40. It is to be noted that the foregoing figures are based on an average for the entire Service Area. In actuality, the core areas, which represent the bulk of the population and therefore, the major influence on all economic parameters, portray the typical symptoms of the declining cities,

TABLE 4 - PASSAIC RIVER SERVICE AREA

County	Population (thousands)				Applicable improvement[a]
	1970[b]	1985[c]	2035[c]	2085[c]	
Bergen	898,000	1,086,000	1,872,000	3,048,000	FFC, HC, Nav, WQ, WS
Essex	930,000	1,039,000	1,681,000	2,605,000	WS, FFC, HC, Nav, MD, Rec, F&W, WQ
Hudson	609,300	619,000	824,000	1,052,000	FFC, HC, Nav, Rec, WS
Hunterdon	69,700	107,000	269,000	484,000	WS
Middlesex	583,500	755,000	1,645,000	3,313,000	WS, Rec, F&W
Morris	383,500	540,000	1,421,000	3,081,000	FFC, MD, WS, WQ, Rec, F&W
Passaic	460,800	493,000	640,000	833,000	MD, FFC, WS, WQ, Rec, F&W
Rockland	229,900	315,000	503,000	835,000	WS, FFC, Rec
Somerset	198,400	279,000	762,000	1,860,000	WS, FFC, WQ, Rec, F&W
Union	543,100	595,000	853,000	1,215,000	WS, WQ, FFC, Rec, F&W
Total	4,906,200	5,828,000	10,470,000	18,326,000	

(a) Definitions, FFC - fluvial flood control, HC - hurricane control, Nav - navigation, WQ - water quality, WS - water supply, MD - major drainage, Rec - recreation, F&W - fish and wildlife

(b) 1970 Census

(c) Projected population

while the intermediate ring portrayed by the counties of Morris, Rockland, Passaic, Middlesex and Somerset, are experiencing a period of unparalleled growth in population and corresponding increases in employment and personal income, as discussed in Appendix D, Economic Base Study.

41. LAND USE AND DEVELOPMENT. The land use and development within the watershed is highly diversified. Intensely developed industrial and urban areas are located in the southeasterly portion of the watershed. Within the Central Basin, although development has been materially retarded in comparison with other areas by the existence of large expanses of swamp, the influence of metropolitan activity has been such as to cause the growth of numerous suburban and industrial communities, particularly where rail and highway facilities afford commuting service. For example, one has rezoned some 2,300 acres of land from agricultural to industrial use, and many residential developments have sprung up throughout the northern portion of the Central Basin along its water courses. Some of the remaining arable land is devoted to truck farming. The mountainous and wooded Highland Area lying to the west of the Central Basin includes several large publicly owned reservations set aside for water supply use by the metropolitan communities to the east, and contain many summer recreational colonies bordering streams and lakes. Picatinny Arsenal, a military reservation, is located in the westerly portion of the Highland Area on Green Pond Brook in the headwaters area of the Rockaway River. Additional detailed information on land use is contained in Appendices I, Cost Estimates and J, Project Formulation.

42. TRANSPORTION Highways. The Passaic watershed is traversed by most of the important arterial highways connecting the New York City Metropolitan Area with areas to the north, west and south. The super highways traversing the watershed include: The New York State (Governor Thomas E. Dewey) Thruway connecting New York City and Buffalo via numerous other important cities in New York, and the Garden State Parkway connecting the New York Thruway at Spring Valley, New York with the southern tip of New Jersey at Cape May; in addition, construction is now underway for serveral major highways which traverse the watershed. These are as follows: Interstate Route 80, portions of which are complete, extending from the George Washington Bridge generally westward across the watershed to the Pennsylvania border; Interstate Route 280 extending from Interstate Route 80 in the Troy Hills area generally in a south easterly direction to Kearny; Interstate Route 287 extending from the New York State Thruway at Suffern, New York, generally southwest to Somerville, New Jersey and then east toward Perth Amboy; Interstate Route 78 extending in a generally eastward direction intersecting the lower portion of the watershed just below Millington, New Jersey. Other major highways include: State Route 17 starting at its intersection with State Route 3 in the vicinity of Rutherford New Jersey and extending northward along the eastern portion of the watershed through Mahwah, New Jersey and Suffern, New York to the Catskills and

central New York State; Route 202 extending in a generally southerly direction from Suffern, New York to Wilmington, Delaware; U. S. Route 1 to Philadelphia and Washington crossing the Passaic River in the tidal section near its mouth; and New Jersey Route 23 extending generally northwest through the basin from Montclair, New Jersey to Port Jervis, New York.

43. Many improved interstate, state and county roads that have been constructed in the watershed have contributed toward the extensive development of outlying areas in the past fifteen years. Bus lines and passenger vehicles constitute the most important media of local passenger transport.

44. Railroads. Several railroads, carrying a large part of the national commerce, traverse the watershed and converge on the Newark and Jersey City area where freight classification and rail to ferry transfers are made in the course of transportation of goods and passengers to and from New York City. Extensive trackage through the watershed is owned by the Erie-Lackawanna Railroad and the Central Railroad of New Jersey. The Erie-Lackawanna main line extends from railhead in Newark through Ridgewood, Suffern and points beyond the watershed to Chicago. A branch line connects Hackensack, Pompton, Oak Ridge and points west of the watershed to Wilkes-Barre, Pennsylvania. Another branch from Greenwood Lake New Jersey connects Paterson and Passaic to the railhead in Jersey City. The main line of the Central Railroad of New Jersey follows a westerly route connecting Jersey City, Newark, and Elizabeth with Somerville, and points west in Pennsylvania. At High Bridge a main trunk extends north to Chester and Hopatcong.

45. Air and heliports. Immediately south of the Passaic watershed is located the Newark Airport, a major terminus in the east for mail and passenger service. Regular service is maintained to all parts of the United States from this field. Within the Passaic watershed there are eleven airports of the following FAA classification types; one is "Supercontinental", one is "Trunk", three are"Local" and six are "Private." A listing of these airfields is contained in Appendix N. More recently the need for an additional large airfield capable of accommodating jet aircraft to serve the New York Metropolitan area resulted in a study to determine the selection of a suitable site. A report by the Port of New York Authority dated May 1961 recommended among several possible locations two within the watershed which are located at: Fairfield Township and West Caldwell Borough in Essex County extending west into Parsippany-Troy Hills Township in Morris County; and Morris County mainly in Harding, Chatham and Passaic Townships. Local interests have indicated strong opposition to these proposals for a jet airfield in New Jersey and the location of the new jet airport is yet to be resolved. Heliports are

becoming very popular in this region. Because of their small size and adaptability to any location, they are frequently used as a taxi service from existing airports to other areas within the region, including New York City.

46. Navigation. The Passaic River is navigable, under a Federal project, from its mouth to the Eighth Street Bridge in Passaic. The present channel is part of a general project affording navigation facilities in Newark Bay and the Hackensack and Passaic River, New Jersey. In the Passaic River, the project provides for a channel 30 feet deep at mean low water and 300 feet wide from Newark Bay to a point 3,000 feet above the Lincoln Highway Bridge in Newark, a distance of 2.6 miles; thence 20 feet deep and 300 feet wide to the Nairn Linoleum Works, about 4.4 miles; then 16 feet deep and 200 feet wide to the Montclair and Greenwood Lake Railroad bridge, about 1.1 miles; thence 10 feet deep and 150 feet wide to the Eighth Street Bridge in Passaic 7.3 miles; a total distance of 15.4 miles. The approach channel in Newark Bay is 50 feet deep with a minimum width of 400 feet.

47. The existing navigation project for the Passaic River alone was adopted by the River and Harbor Acts of 2 March 1907, 27 February 1911, 25 July 1912, 21 January 1927, 3 July 1930, and 2 March 1945. The total cost to the United States of all work in the Passaic River, Newark Bay and Hackensack River to 30 June 1961, was about $16,512,880 of which about 10,788,280 was for new work and $5,724,600 for maintenance. The average annual maintenance cost during the fiscal years 1962 through 1967 was $306,000. The general project for Newark Bay, Hackensack and Passaic Rivers, New Jersey is about 94 percent completed. On the Passaic River the channels included in the project have been completed to full project dimensions except for the completion of the 20-foot channel from Jackson Street to the Nairn Linoleum Works which is presently considered to be inactive.

48. There are several publicly owned freight terminals and more than 100 usable private wharves and piers along the improved sections of the Passaic River. The navigation season extends throughout the year. Commerce on the Passaic River in 1968 involved a total movement of 11,411,464 tons. The lower Passaic is also used for recreation purposes.

49. RESERVOIRS. There are more than 200 artificial lakes, ponds and reservoirs of the Passaic River basin used mainly for recreation and water supply purposes. Several yacht clubs, boat repair and storage yards provide landing and servicing facilities for numerous recreation craft. About 130 of these are used for recreation 35 for industrial water supply, 20 for potable water supply, and about 15, in whole or in part for water power purposes. Data on the larger reservoirs are contained in Appendix E, Water Use.

50. WATER SUPPLY. The Passaic River and its tributaries are the primary source of water supply for the municipalities in northern New Jersey. Prior to 1894, Jersey City, Newark and many other communities obtained their potable water supplies from the lower river. Communities elsewhere used springs and wells. As demands increased through the years several major supply systems were developed on the Rockaway, Pequannock and Wanaque Rivers. Bayonne, Jersey City, Montclair, Kearny and other communities draw water directly from the Passaic River at Little Falls. The communities of New Providence, Springfield, Summit, Irvington, Chatham among others draw their supply from the upper Passaic River. The major water supply systems that constitute the greater portion of supply for the Northern Metropolitan District comprising an area bounded by the New Jersey-New York state line, Hudson River, Raritan River and the Passaic River are the Pequannock, Rockaway, Wanaque-Ramapo systems, Passaic Valley Water Commission and Commonwealth Water Company. These systems are discussed in detail in Appendix E, Water Use.

51. The Service Area's population density of 1,770 persons per square mile is more than twice the density of the state as a whole. Because of this high density, water is a limiting factor in New Jersey's growth. There has been a constant water shortage in New Jersey which almost became an economic catastrophe in 1965. In the spring of that year, a state of emergency was declared by the governor, and a statewide policy of conservation and rationing of water began in order to provide for the needs of people and industry in the northeastern section of New Jersey. By November of 1965, the regular water supply of the Newark area was exhausted. Consequently, 4 billion gallons were diverted from Lake Hopatcong to the Newark area. During this drought of 1965, there were newspaper advertisements to attract New Jersey's industries to other states for dependable water supplies.

52. Lack of a more dependable water supply will inhibit new invesments in the Service Area because of the possibility of shutdowns and resulting financial losses caused by unavailability of water.

53. WATER POWER. The power resources of the Passaic watershed were utilized to a maximum during the latter part of the 19th Century when more than 200 independent mills were operated on run-of-river flow. Practically all of these have been abandoned, however, in favor of larger power systems having generating efficiencies. Flow diversions for potable use and for industrial processing have been an important contributing factor in this change. There are now only two important hydro-electric plants on the Passaic River. These are on the main stream of the river at Great Falls and Little Falls. The site at Great Falls was originally developed by the Society for Establishing Useful Manufactures (S.U.M.) which was organized by an act of the N.J. State Legislature in 1791 to promote industrial activity in the Passaic Area. The plant is now owned by the City of Paterson but

leased to the Public Service Commission which sells its energy output to local industry. The plant has a total installed hydro-electric capacity of 4,600 KW. The installation at Little Falls is Beatties Dam which was originally constructed in 1867 and is now utilized by the Passaic Valley Water Commission to pump water from the Passaic River and also as a booster plant for furnishing water supplies from the Wanaque system to Paterson, Passaic and Clifton. Surplus energy developed at this site is directed into the lines of the neighboring utility systems. Both of these foregoing plants lack storage, and operate on run-of-river flow, generating mainly secondary power. The total annual output of these plants represents less than one percent of the power now used annually within the Passaic River basin.

54. THERMAL POWER. By far the greater portion of the electrical energy consumed within the Passaic Valley is generated at steam plants. Public utility service within the watershed is furnished by the Orange and Rockland Electric Company, Public Service Electric and Gas Company, Jersey Central Power and Light Company, New Jersey Power and Light Company and the Butler Municipal Plant. All except the Butler Municipal Plant are interconnected. The total capacity of the power facilities is about 5,000,000 KW.

55. SEWAGE DISPOSAL. It is estimated that over 1.54 million people or approximately 83 percent of the population residing within the Passaic River Basin are served by numicipal sewerage systems. The two major systems in the basin are the Passaic Valley Sewerage Commissioners system and the Essex-Union Joint Meeting. These systems serve approximately 63 percent of the total population and discharge out of the basin to tidal waters in Upper New York Harbor and the Arthur Kill. Based on waste disposal data provided by the State of New Jersey and the 1962 Public Health Service Waste Facilities Inventory, there are over 150 waste treatment facilities discharging to the Passaic River and its tributaries. Fourteen plants discharge directly to the Passaic River with the remaining discharge to tributary streams. All of the treatment facilties discharging to the river and its tributaries were designed to provide secondary treatment and chlorination before discharging. However, many of the facilities are either inefficient or overloaded with a resultant poor effluent quality. It is estimated that approximately 49,000,000 gallons of treated wastewater are discharged daily to the Passaic River Basin with an estimated total organic loading of 31,800 pounds of ultimate biochemical oxygen demand (BOD) per day. This is equivalent to a raw sewage discharge from a population of 125,000 persons. In addition to treated and untreated sewage, the stream is also used for the disposal of industrial wastes such as textile dying and finishing, paper board, chemical, phenols, oils, and pharmaceuticals.

56. RECREATION. The Highland Area of the Passaic watershed is well adapted to all types of recreation and has been developed accordingly. There are extensive sub-marginal areas of scrub woodland that are unsuited for either lumbering or agriculture. Numerous lakes and ponds, periodically stocked by the New Jersey Fish and Game Commission, are scattered throughout the region. Many of these have been developed for boating and swimming. Private fish and game preserves have been opened to the public. Many small mill ponds, which formerly furnished power to scattered industries, have in recent years been converted to recreational use. Existing recreational facilities in this area, however, have lagged considerably behind present requirements. This has probably been due to the heavy industrialization of the lower valley and to the mosquito nuisance which originates in the Great Meadow area. Although over 60,000 acres or about ten percent of the watershed is held in public ownership, relatively little of this is available for unrestricted recreational use. More than 45,000 acres of woodland largely in the upper Pequannock watershed and in the vicinity of Wanaque watershed are being held by the city of Newark and other municipalities for the protection of surface water supplies. Federal holdings in the Passaic area include the 958 acre Morristown National Historical Park, which is administered by the National Park Service, and the 3,750 acre Great Swamp National Wildlife Refuge, administered by the United States Fish and Wildlife Service. The refuge will eventually cover 5,750 acres. It is noteworthy that nearly one-sixth of the nation's population is within three hours automobile ride of this area.

57. Currently there are eight state administered parks and forests used for public recreation within the zone of recreation influence which includes all or parts of the following eight counties: Bergen, Essex, Hudson, Morris, Passaic, Union, Somerset, and Hunterdon. The state recreation areas encompass about 8,000 acres with a 1965 attendance record of 2.7 million. In addition there are about 12,500 acres in the county park system supplementing existing Federal and State lands, for which no attendance records are available. For a full discussion of the zone of recreation development see Appendix H, Recreation.

58. MOSQUITO CONTROL. The mosquito nuisance in the Passaic watershed is intimately related to the local water resources problem, and is an important factor influencing the value of property and the economic security of the inhabitants in the lower Highland Area and Central Basin. Seven of the eight counties within the Passaic watershed have active mosquito extermination commissions invested with powers to trespass on private property and undertake action for the protection of the public health. Mosquito control work is under the authority of the State Board of Health and of the New Jersey State Agricultural Experiment Station.

The methods employed include drainage and spraying. Numerous attempts at drainage have been undertaken with local funds in the past, and much work was done by the Works Progress Administration and Civilian Conservation Corps in clearing channels and excavating ditches. A four-county mosquito extermination committee has formulated plans for the improvement of the upper Passaic River above Two Bridges, much of which has been performed.

59. MINERAL RESOURCES. Mineral resources of economic importance are developed to a very limited degree in the Passaic basin. The most important metallic ores, iron and zinc, are found in parts of the watershed's highlands. The non-metallic resources are present to a greater extent and include considerable amounts of granite-gneiss and basalt quarry stone. For the most part the rock is quarried and crushed for the purposes of road fill, concrete and bituminous aggregate and railroad ballast. Small quantities of desirable stone are quarried for local building uses. In addition, unconsolidated sand and gravel bank deposits are extensively developed for uses as aggregates, road subgrades and multi-purpose fill. The peat deposits of the basin's meadowlands have also been used for fuel and in the manufacture of commercial fertilizers.

VI - CLIMATOLOGY

60. CLIMATE. The climate of the Passaic area is moderate. The winters are mild with light snowfalls and with temperatures seldom sustained below freezing for more than a week at a time. The summers are long with occasional hot sultry weather and frequent thunderstorms. In the Central Basin and Lower Valley the air is relatively moist due to the proximity of the ocean, while in the Highland Area, on the southerly prong of the Catskill mountains, the air is cooler and drier. The average annual temperature is 52 degrees, Fahrenheit, with extremes varying from 26 degrees below zero in winter to 108 degrees above zero in summer. The hours of sunshine are 60 percent of the total amount possible. The relative humidity is comparatively high, averaging about 70 percent. The average growing season is 171 days, decreasing with altitudes. Prevailing winds are from the northwest, shifting to the southwest during the summer. Additional and more detailed climatological data are contained in Appendix A, Hydrology.

61. ANNUAL RAINFALL. The average annual precipitation over the watershed is 47.3 inches. It is fairly uniform over the watershed, varying from 46.3 inches in the Lower Valley to 48.4 inches in the Highland Area. The maximum annual precipitation of record was 85.99 inches in 1882 at Paterson, and the minimum was 25.26 inches in 1930 at Morristown. The annual rainfall is fairly well distributed throughout the year, with a slight increase occurring in the summer months due to local thundershowers. The average annual snowfall over the basin is 34.2 inches, with a water equivalent of about four inches in depth.

62. NOTABLE STORMS. A summary of the most notable storms of record over the Passaic River watershed is given in Table 5, which indicates that October 1903 was the most severe with respect to total average rainfall over the basin, resulting in 11.4 inches of rainfall over a 5 day period.

63. DROUGHTS. The Passaic River basin has been affected by several droughts in the last four decades. These have been droughts which affected the entire northeast region such as those of 1879-83, 1892-96, 1953-54, and 1964-66, and localized droughts which affected the New Jersey and New York area such as those of 1923, 1931-32, 1937, 1941 and 1957-58. The most critical dry period from the view point of dependable flow at Chatham and Two Bridges extended from 1964 through 1966.

VII - RUNOFF AND STREAM FLOW DATA

64. RECORDS. Stream flow data within the Passaic River watershed are available at 22 gaging stations which are operated at the present time by the United States Geological Survey. Practically continuous records of stream flow are available for the Passaic River at Paterson from 1877 to date. No stream gaging records are available for many of the smaller tributaries on which flood conditions are known to exist. Complete data on gaging stations and their records are given in Appendix A, Hydrology.

65. RUNOFF. The average annual runoff as recorded at Paterson, New Jersey, where the drainage area is 785 square miles, is 1.55 cubic feet per second (c.f.s.) per square mile, equivalent to about 21.6 inches depth over the total watersned area. This does not include 0.35 c.f.s. per square mile, equivalent to about 4.1 inches of runoff, diverted from the upper tributary areas for water supply purposes. The total average annual runoff of 25.7 inches is about 53 percent of the total average annual rainfall. The peak stream flow as recorded at Paterson occurred in 1903 and was 3.04 cfs per square mile of drainage area or 196 percent of the average discharge at Paterson. The mimimum stream flow occurred in 1965 and was 0.36 c.f.s. per square mile or 23 percent of the average at Paterson. An analysis of available stream flow in the Passaic River indicates a significant potential for the use of water for multiple-purpose use. At Two Bridges, the dependable yield based on available live storage of 68,600 acre-feet from the Pompton River based on the 1964-66 drought, the worst of record, is 100 million gallons per day. The dependable yield of the Passaic River at Myers Road based on the same critical drought and live storage of 21,300 acre-feet is 38 million gallons per day.

TABLE 5 - NOTABLE STORMS

Period of Rainfall	Maximum rainfall		Average Rainfall over Watershed, inches
	Location	Depth, inches	
22-24 Nov 1840	--	--	8(a)
21 Aug 1843	--	--	9(a)
16-17 July 1865	--	--	6(a)
20-24 Sept 1882	Paterson	17.90	9.2
3-7 Feb 1896	Charlotteburg	5.61	4.4
25 Feb-3 Mar 1902	Ringwood	3.46	2.6
7-12 Oct 1903	Paterson	15.51	11.4
19-23 July 1919	Boonton	12.97	7.8
11-22 Mar 1936	Milton	8.95	6.0
16-23 Sept 1938	Chatham	9.73	7.0
15-23 July 1945	Midland Park	14.73	8.5
17-20 Aug 1955	Midland Park	6.40	5.0
27 May - 6 June 1968	Canoe Brook	7.96	6.0

(a) Estimated

VIII - FLOODS OF RECORD

66. FLOOD CHARACTERISTICS. Main Stream and Major Tributaries. Although the Passaic area is subject to relatively intense rainfalls, the overall natural characteristics of the watershed tend to have a moderating influence on floods. Despite this condition, heavy flood damages frequently recur, due to the extensive urban development of the flood plain and its effect in seriously reducing the safe discharge capacity of the river. The main stem of the Passaic above Chatham is little affected by floods, partly because of its long, narrow watershed, and partly because of the moderating effect exerted by Great Swamp on stream flow below Millington. The Whippany River, and to a lesser extent, the Rockaway River have marked peaking characteristics in their upper reaches; but in their lower reaches a high degree of natural storage in the Black and Troy Meadow areas materially reduces the flood peaks on these streams. During the 1903 flood, the maximum of record, the natural storage in this area retained 2.4 inches of runoff from the drainage area of 205 square miles and the flood peak at the mouth of the Rockaway River was reduced to about 53 percent of its value upstream. The Pompton River, carrying the combined flow of the Pequannock, the Wanaque and the Ramapo Rivers, contributes the principal component of flow to the flood peak in the Passaic River. The Wanaque River, which for its size is the most flashy stream in the Passaic watershed, delivers its flood peak several hours before the Pequannock and Ramapo. Although the lower section of the Pequannock below the Macopin Dam is equally flashy, the peak on this stream is considerably reduced by the relatively flat stream slope of the upper watershed. The Ramapo, which contributes the largest volume of flood flow to the Pompton, takes the longest time to reach its peak flow. Due to the relative timing of the flood crests in the upper watershed, the flood peak on the Passaic River at Paterson is not equal to the total of the peaks for each tributary and the contribution that each tributary makes varies with the storm proportional to the individual peaks.

67. All of the foregoing streams discharge into the Great Meadow area above Little Falls. The bottom lands in this section act as a natural detention reservoir in reducing flood intensities downstream. Generally, the Pompton River contributes the preponderant flood inflow to the Great Meadow area, filling the available storage volume at a faster rate than can be discharged at Little Falls, and for a period of 6 to 8 hours causes flood water in the lower reaches of the Rockaway, Whippany and upper Passaic Rivers to flow upstream. The Great Meadow area floods on an average twice each year. During the larger floods, inundation extends over an area of nearly 35 square miles filling a volume of about 20,000 acre-feet or 0.5 inches of runoff for each foot of rise

over the meadowlands. Had the Great Meadows not been available for flood detention, it is estimated that the 1903 flood peak at Paterson would have been nearly 55 percent greater than what actually occurred, and the flood damages would have been almost doubled. It is clear therefore, the Great Meadow area and adjacent natural storage areas have been a significant influence in reducing the severity of past floods.

68. Minor Tributaries. The tributaries of the Lower Valley, which are distributed along the entire length of the main stem, are short, flashy streams controlling relatively small steep drainage areas. These streams peak much earlier than the main stream and are capable of producing a flood peak on the main stem independent of that produced by the Upper Valley. The peak from the lower tributaries may be greater or smaller than that from the Upper Valley depending upon whether the storm is centered over the upper or lower portions of the watershed. In either case the peak from the Lower Valley is sharp and of short duration, while that from the upper watershed is of long duration. Flood stages on the main stem below Dundee Dam are affected by the tides from Newark Bay.

69. Effect of Water Supply Reservoirs. The effects of existing water-supply reservoirs upon flood discharges at Paterson are almost negligible, except for lesser floods of long duration and uniform intensity, which may be wholly or largely retained in the reservoirs. Further upstream, the reservoir effects are somewhat more marked. There are several reasons why the water-supply reservoirs in the Passaic basin have little influence over larger floods in the Lower Valley. Both the Rockaway River upstream of the Boonton Reservoir and the Pequannock River upstream of the Macopin Dam peak significantly before the main stem and hence have little effect on its peak. On the Pequannock, such contributions that are made to the peaks, are derived almost exclusively from the flashy section of the watershed below Macopin Dam. In the case of the Wanaque River, the Wanaque reservoir is operated primarily to insure adequate water supplies and to obtain the necessary head to deliver gravity supplies through the distribution system; the reservoir is kept as nearly full as possible. Storage is therefore depleted by the earlier runoff, and when a flood finally occurs, only the surcharge above spillway crest is ordinarily available for flood detention. Inasmuch as the present system of operation cannot be modified to provide incidental flood protection without seriously jeopardizing the dependable water supply yield of the system, it is not anticipated that the flood conditions in the future will be materially alleviated by changes in reservoir operation.

70. FLOOD DISCHARGES. The peak discharges which have occurred during some of the most seriously known floods on the Passaic River and summarized in Table 6. These data are based partly upon stream flow observations and partly upon computations from flood marks and collateral information. In general, the 1903 flood discharges were the maximum of record at all localities in the watershed, as exemplified at S.U.M. Dam, Paterson, where the peak flow was 33,700 cubic feet per second.

TABLE 6 - FLOOD DISCHARGES
(In cubic feet per second)

Location	Discharge		
	Oct. 1903	March 1936	May 1968
MAINSTREAM			
Passaic River			
Dundee Dam, Clifton	35,800	20,400	--
S.U.M. Dam, Paterson	33,700	19,500	--
Beatties Dam, Little Falls	32,700	19,100	13,200
Chatham	5,150	1,310	2,560
MAJOR TRIBUTARIES			
Pompton River at Pompton Plains	36,000	19,950	16,400
Pequannock River at Macopin Intake	6,100	2,600	
Ramapo River at Pompton Lakes	15,800	12,300	9,530
Rockaway River below Boonton Reservoir (U.S.G.S. gage)	9,500	3,750	3,300
Whippany River at Morristown	3,200	1,500	896
Wanaque River at Wanaque	11,100	--	5,720
MINOR TRIBUTARIES			
Weasel Brook at Monroe Street Bridge	1,660	--	--
Saddle River at Lodi	7,000	1,720	1,900
Hohokus Creek at Hohokus	3,000	--	2,120
Diamond Brook at Oxford Ave Bridge	880	--	--
Goffle Brook at Wagaraw Road Bridge	2,200	--	--
Molly Ann's Brook at Preakness Avenue Bridge	2,180	--	--

71. FLOOD STAGES. Peak flood stages, corrected to suit present conditions of the watershed, for the October 1903, March 1936, and July 1945 and May 1968 floods, are given in Table 7.

72. FLOOD FREQUENCIES. Computed flood stage and discharge frequencies for the main stream and tributaries corrected to present conditions of flow and reservoir storage are given in Table 8. The indicated frequencies are intended to represent the average interval of time for an extremely long period of years, between the recurrences of a storm resulting in discharges equal to or greater than a specified discharge. More extensive data is given in Appendix B, Hydraulics.

TABLE 7 - FLOOD STAGES

Location	Flood Elevation in feet, mean sea level		
	Oct. 1903	July 1945	March 1936
MAINSTREAM			
Passaic River			
Gregory Avenue Bridge, Passaic	21.5	--	9.0
Dundee Dam, Clifton	33.4	31.4	30.9
S.U.M. Dam, Paterson	124.6	122.05	121.04
Beatties Dam, Little Falls	169.1	164.1	165.2
Chatham	180.0	--	173.2
MAJOR TRIBUTARIES			
Pompton River at Boonton Road Bridge, Mountain View	174.3	168.9	170.5
Pequannock River at Macopin Intake	587.4	585.2	585.9
Ramapo River at Pompton Lakes	--	204.0	204.6
Rockaway River below Boonton Reservoir (U.S.G.S. gage)	--	200.7	203.7
Whippany River at Morristown	269.7	--	266.3
MINOR TRIBUTARIES			
Weasel Brook at Monroe Street Bridge (u.s.)	26.4	21.4	--
Saddle River at Borig Place Bridge (u.s.)	38.2	34.4	25.4
Hohokus Creek at Grove Street Bridge (d.s.)	68.5	66.8	--
Diamond Brook at Oxford Ave Bridge (d.s.)	74.0	72.0	--
Goffle Brook at Wagaraw Road Bridge (u.s.)	44.0	42.8	--
Molly Ann's Brook at Preakness Avenue Bridge (u.s.)	135.5	134.1	--
Slippery Rock Brook at Murray Avenue Bridge (u.s.)	131.7	130.5	--
Peckman River at East Main St Bridge (u.s.)	157.2	157.0	--
Singac Brook at Preakness Ave Bridge (u.s.)	203.0	202.4	--

(u.s.) denotes upstream side.
(d.s.) denote downstream side.

TABLE 8 - STAGE-DISCHARGE FREQUENCY DATA

Stream and locality	Frequency in years	Discharge in c.f.s.	Stage elevation in feet, msl
Passaic River at Little Falls	100	29.200	135.2
	50	23,200	133.5
	10	17,800	131.8
	1	6,800	127.2
Passaic River near Chatham	100	5,300	203.9
	50	3,550	202.3
	10	1,900	200.5
	1	1,070	199.3
Saddle River at Lodi	100	6,250	47.7
	50	4,850	40.0
	10	2,570	32.4
	1	950	29.3
Pompton River at Pomtpon Plains	100	28,800	199.6
	50	22,300	196.8
	10	13,000	191.7
	1	4,440	184.7

73. TIDES. In addition to flooding from upland flows, the Passaic River is susceptible to tidal flooding up to Dundee Dam, which is about 17.4 miles upstream of the mouth. The gage at East Newark near the mouth of the Passaic River is useful in comparing various hurricane events with normal conditions. Mean high water at East Newark is 3 feet above mean sea level. During Hurricane Donna on 12 September 1960, the maximum recorded tide occurred at 8.3 feet above mean sea level. However, since the normal tide would have been 2.8 feet above mean sea level, the height of water above the expected level, or surge, was only 5.5 feet. The maximum surge of record is 9 feet; this at a time when the normal tide was low, and the recorded level was 6.5 feet above mean sea level. In areas subject to tidal flooding, damages start to occur when the water level reaches 4.0 feet above mean sea level.

IX - PROJECT HYDROLOGIC DESIGN CONDITIONS

74. STANDARD PROJECT FLOOD. The standard project flood is an estimated or hypothetical flood that might be expected from an extremely severe combination of hydrometeorological conditions that are considered reasonably typical of the region, excluding extraordinarily rare combinations. It is intended as a practicable expression of the degree of protection that should be sought, whenever possible, in the design of flood control works. The standard project flood for the Passaic River at Beatties Dam in Little Falls is estimated at 40,900 cubic feet per second. During the record flood of 1903, the peak flow at Beatties Dam was 32,700 cubic feet per second. Additional details are in Appendix A, Hydrology.

75. PROBABLE MAXIMUM FLOOD. The probable maximum flood represents a flood that can be attained but is not likely to be exceeded in a given area. It is used as the standard for design of any structure requiring a conservative degree of safety such as the spillway of a dam. The probable maximum floods for locations on the main stream and on major and minor tributaries were synthesized from the probable maximum precipitation, probable maximum infiltration and unit hydrographs. The probable maximum flood on the Passaic River at Beatties Dam is estimated at 88,000 cubic feet per second.

76. STANDARD PROJECT AND PROBABLE MAXIMUM HURRICANES. The standard project hurricane is similar as a design standard to the standard project flood. The surge resulting from such a hurricane is estimated at 14 feet, which occurring simultaneously with mean high tide would result in a water level of 17.0 feet above mean sea level. The surge that would result from the probable maximum hurricane is estimated at 17.4 feet, which in combination with a mean high tide would result in an elevation of 20.4 feet above mean sea level.

X - THE FLOOD PROBLEM

77. EXTENT AND CHARACTER OF FLOODED AREA. Passaic River and major tributaries. The area which would be subject to inundation during a recurrence of the October 1903 flood is estimated at approximately 35,000 acres, as broken down in Table 9. Within the 1903 flood area at the present time there are about 15,400 dwellings, 3,500 business establishments, 200 industrial plants and 200 utility plants and public institutions. The areas subject to the most serious flooding along the main stem of the Passaic River, and its major tributaries, the Pompton, Ramapo, Rockaway and Whippany Rivers, lie in three well defined areas. One is a highly developed business, industrial and residential area in the Lower Valley from Newark to Little Falls. The second is a suburban area upstream of Little Falls, composed largely of residential developments in the northerly portion of the Central Basin along the Passaic River from Little Falls to Two Bridges and along the lower reaches of the Pompton and Ramapo Rivers. The third is an agricultural and swamp area, with a continuing influx of industry and residential homes in the southern portion of the Central Basin along Passaic River from Two Bridges to Chatham and along the lower reaches of the Rockaway and

Whippany Rivers.

TABLE 9 - AREAS INUNDATED BY 1903 FLOOD

Reach (a)	Maximum Depth (Feet)	Area Inundated (Acres)	Swamp Area Included (Acres)
Mouth to Dundee Dam	14.5	1,529	--
Dundee Dam to S.U.M. Dam	9.9	846	--
S.U.M. Dam to Beatties Dam	10.2	761	--
Beatties Dam to Two Bridges	11.1	1,564	538
Two Bridges to Chatham	14.2	16,100	11,240
Two Bridges to Pompton Lake	14.5	3,200	1,022
TOTAL		35,000	19,300

(a) All indicated reaches are along Passaic River except Two Bridges to Pompton Lakes.

78. The most critical flood condition in the Passaic River watershed occurs in the Lower Valley downstream of Little Falls, where the cause is insufficient channel capacity and the flood plain extends generally 500 to 1,000 feet beyond both banks of the river. The principal focal points of damage are the City of Paterson below Great Falls and the City of Passaic below Dundee Dam. Extensive losses, formerly suffered in the section of the river below Passaic, were relieved in large measure by channel enlargement for the existing Federal navigation project. During a flood recurrence of 1903 magnitude, over 3,000 acres would be subject to inundation in this section, comprising parts of the urban centers of Paterson, Passaic and numerous other communities. In all, there are 18 communities bordering this 21 mile reach of waterway having a total population of 979,000 and annually producing goods having an estimated value added of about $2,900,000,000 according to the 1967 Census of Manufactures.

79. The flood plain in the northerly portion of the Central Basin varies from one-half to three miles in width, and contains about 5,000 acres of land subject to flooding, of which about 1,600 acres are swampland. The principal damage center immediately upstream of Little Falls is the village of Singac, the lower half of which would be completely inundated under a recurrence of a flood of 1903 magnitude. Further upstream, the principal flood damage occurs along the Pompton River from Mountain View to Pompton Plains. In this section, which includes the communities of Lincoln Park, Wayne, Pequannock, Pomtpon and Pompton Plains, minor freshets cause inundations, and a flood of 1903 magnitude would cover certain areas to depths of 10 to 14 feet, resulting in hazards to life and health, as well as property damage. Considerable expanses of bottom lands well within the flood plain have been subdivided for the development of residential communities. Noteworthy in

this category is such an area in lower Wayne Township on the left bank of the Pompton River upstream of Mountain View, which was inundated to depths of 8 to 10 feet during the 1903 flood.

80. The flood plain in the upstream or southerly portion of the Central Basin extends for a width of from one to two miles over adjacent swamp and lowlands between Two Bridges and Chatham, a distance of 15 miles. Above Chatham, the flood plain becomes narrower, varying from 1,000 to 4,000 feet in width. About 27,000 acres, of which 18,000 are swampland, are inundated in this area, a condition largely responsible for the mosquito problem in the Passaic area.

81. Minor tributaries. The flood plains of the minor tributaries that enter the Passaic River below Two Bridges are generally narrow, and flood damage results more from scour than from inundation. There are exceptions such as the Saddle River flood plain which is about a thousand feet wide and increases to as much as a mile in width over lowland areas in the vicinity of Rochelle Park and Paramus. At the latter locality the Hohokus Creek flood plain widens to more than a thousand feet above its junction with the Saddle River. The flood areas of Molly Ann's Brook, Peckman River and Singac Brook widen to as much as 3,000 feet near the mouths of the streams where they are affected by backwater from the Passaic River. Portions of Weasel Brook, Saddle River, Goffle Brook and Molly Ann's Brook traverse scattered industrial and commercial developments. Urban communities and moderately developed residential areas are located elsewhere along portions of Weasel Brook and on Molly Ann's Brook, Slippery Rock Brook and Peckman River. High grade suburban communities are located along sections of Saddle River, Hohokus Creek, and Diamond Brook. In total, approximately 3,800 acres are inundated by flooding on the smaller tributaries much of which is intensively developed suburban property.

82. Property Values. The 1967 true value of improved real estate in the 1903 inundated area is about $297,715,700, Table 10. Of this total, $174,344,000 or 58.5 percent is concentrated below Little Falls. If allowance is made for railroads, highways, bridges, utilities, industrial equipment, supplies and personal property not included in the foregoing valuation, the total value of all property subject to flood damage by 1903 flood levels is estimated at about $600,000,000.

83. DAMAGES. The damages that would result on the Passaic River and its tributaries from recurrence of the major floods of the part under current conditions are listed in Table 11. Also indicative of the flood problem are the estimated average annual damages that can be expected by the year 2085; with allowances made for continuing development in flood prone areas and the increased investment of wealth within the flood plain because of increased wealth during that period of time. These considerations indicate an increase in average annual damages of 483 percent in the Lower Valley and 1560 percent in the Central Basin and Highland Area beyond damage levels under present conditions of development. Average annual damages were computed on the basis of correlation of estimates of flood frequencies and damages expected to result from floods of various frequencies and were projected to 2085. Based on the forgoing average annual equivalent

TABLE 10

MARKET VALUE OF PROPERTY INUNDATED BY 1903 FLOOD LEVELS
(January 1970 Prices)

Stream and Reach	Area Inundated (Acres)	Real Value (a)
Passaic River		
Mouth to Dundee Dam	1,529	$ 41,436,900
Dundee Dam to S.U.M. Dam	846	22,668,000
S. U. M. Dam to Beatties Dam	761	23,108,000
Beatties Dam to Two Bridges	1,564	8,124,800
Upstream from Two Bridges	22,116	71,311,100
Tributaries		
Pompton River	3,200	16,066,600
Ramapo River	304	1,298,000
Rockaway River(b)	1,487	5,792,800
Whippany River(b)	5,646	28,602,700
Weasel Brook(b)	253	6,526,600
Saddle River	2,928	35,731,800
Hohokus Creek	852	13,240,100
Diamond Brook	191	4,397,100
Goffle Brook	339	4,202,900
Molly Ann's Brook(b)	173	3,573,800
Slippery Rock Brook	52	1,610,600
Peckman River(b)	333	5,600,300
Singac Brook(b)	830	4,223,600
Total	43,404	$297,715,500

(a) Exclusive of railroads, highways, bridges, utilities, industrial equipment, supplies, structures and personal property.

(b) Value of property affected by backwater in lower reach of stream included in Passaic River valuations.

flood damages from 1985 to 2085 are estimated at $53,052,000 for the Passaic River basin.

TABLE 11 - FLOOD DAMAGES
(January 1970 price levels)

Flood	Passaic River	Tributaries	Total
October 1903	$373,054,200	$78,277,100	$451,331,300
July 1945	75,741,600	27,547,900	101,289,500
March 1936	47,002,500	13,067,700	60,070,200
May 1968	5,617,200	15,420,400	21,037,600
March 1951	1,216,500	10,008,000	11,224,500
September 1960	9,077,000	--	9,077,000
August 1955	771,400	3,435,200	4,206,600
June 1952	704,800	3,466,300	4,171,100
October 1955	761,500	1,822,200	2,583,700

XI - THE WATER SUPPLY PROBLEM

84. AREA AFFECTED. The Northeastern New Jersey region consisting of Bergen, Essex, Hudson, Hunterdon, Middlesex, Morris, Somerset, Passaic and Union Counties, in addition to Rockland County, New York, which draws a major portion of its supplies from waters of the Passaic River basin are considered to form the Passaic River water service area. This region, with a population in excess of 4.9 million is increasing at an average of 5,400 people a month. In addition to the municipal supplies that are needed to support this population growth, water will be needed to meet the demands of accompanying industrial and commercial development.

85. DEMAND. The current demand for water is 790 million gallons per day. The water utility component of this aggregate is 660 million gallons per day, which is equivalent to 89 percent of the existing supply of 748 mgd. The self-supplied demand is 127 million gallons per day, which is assumed to be equal to 100 percent of the existing supply. These gross figures indicate that there is no water shortage in the study area at this time. In most sub-regions of the study area this is true. However, it is not true in the Middlesex and Hunterdon-Somerset sub-region, where the demand exceeds the supply and where the lack of interconnection prohibits the temporary use of existing surpluses of other sub-regions. The total projected demand for water to be supplied by utilities in the study area by the year 2035 is 1950 million gallons per day. Self-supplied water is expected to increase by 2035 to 130 million gallons per day.

86. EXISTING AND FIRMLY COMMITTED SUPPLIES. The service area has extensive fresh water resources in several major and numerous minor river basins. It also has extensive brackish and salt water resources along its coast line which are suitable for purposes not requiring a high quality water which in effect, can reduce the demand for fresh water resources. The major river basins contributing to the fresh water resources are the mainstream and some tributaries of the Passaic, Raritan, Hackensack and Delaware Rivers. The minor ones are those of various small coastal streams. The fresh water resources include both surface runoff and underground flow of which in general, the surface component is the larger. The water utility sector of the study area is presently estimated to provide a dependable yield of 748 million gallons per day. In addition, development of the full potential of existing supplies in combination with firmly planned projects will provide an additional dependable yield of 146 million gallons per day.

87. NEEDS TO BE MET. The preceding paragraphs indicate that to satisfy the water needs, facilities will have to be planned and constructed to provide a total additional dependable yield of 1,060 million gallons per day.

XII - THE WATER QUALITY PROBLEM

88. EXISTING CONDITIONS. The Passaic River, from its headwaters to Chatham, is of a quality that allows its use as a municipal water supply after treatment. Below Chatham, industrial and municipal waste load discharge affects the Passaic River for 25 miles, resulting in severe quality degradation. Below the Pompton River to tidewater the Passaic is generally of suitable quality to be used for municipal and industrial water supplies after complete treatment except during summer months when the quality in this reach is seriously degraded. The tidal portion below Dundee Dam, is of a brackish nature and polluted by high levels of dissolved solids, phenols, biochemical oxygen demand (BOD) settleable solids, nutrients, coliform concentrations and low dissolved oxygen content. The Pequannock, Wanaque, Ramapo and Pompton Rivers are of high quality and are used as sources of municipal water supply. The Whippany River downstream of the Whippany Paperboard Company and the Rockaway River downstream of Boonton Reservoir are highly polluted.

89. SEWAGE DISPOSAL. The major sewage disposal system in the basin is operated by the Passaic Valley Sewerage Commissioners. The system serves the communities of Newark, Belleville, Nutley, Passaic, Paterson, Clifton, Garfield, Rutherford, East Rutherford, Wallington, Lyndhurst, North Arlington, Kearny, Harrison, East Newark, Prospect Park, Haledon, Bloomfield, Glen Ridge, East Orange, Montclair and Orange. It consists of a main trunk or intercepting sewer constructed along the west bank of the Passaic River from Great Falls to a pumping station in the Newark Meadows. Thence the sewage is pumped through mains under Newark Bay and across Bayonne to an

outfall in upper New York Bay near Robbins Reef Light where the currents are sufficiently strong to diffuse the effluent. The system became fully operative in August 1924. It has a capacity of 324 million gallons daily. The Federal Water Quality Administration reported in November 1969 that this system is in great need of modernization.

90. Communities above Great Falls, those of East Paterson, Fairlawn and Hawthorne in the Lower Valley and those along the Saddle River, do not contribute to the Passaic Valley Sewerage Commissioners system. These are dependent upon local treatment works that discharge their effluent directly into the river. Although a substantial degree of pollution abatement has been achieved by these sewerage systems, residual pollution from the sections of the river not served by the Passaic Valley Sewerage Commissioners, and urban storm drainage, are sufficient to cause pollution of the lower reaches of the stream, particularly during the low flow period of the summer season. Even when a comparatively high minimum summer monthly average flow occurs, the dissolved oxygen content in the lower river may fall to less than 26 percent saturation, leading to color and odorous conditions in the lower reaches of the stream.

91. FUTURE CONDITIONS. It is estimated that without some type of stream flow regulation, residual organic waste loads projected for the year 2035 would result in pollution levels of dissolved oxygen in freshwater reaches over 10 percent of the time. These low dissolved oxygen concentrations would prohibit use of water of all reaches of the mainstream for the propagation of fish and the other aquatic life, restrict use for recreation, and increase treatment costs for municipal and industrial water supplies. The waters would also be esthetically unappealing, having color and odorous characteristics and would constitute a public health hazard.

92. FLOW REQUIREMENTS. The water quality problem is illustrated by an estimate of the minimum flows needed to meet a desirable water quality objective in the Passaic River. The Environmental Protection Agency states that the objective should be a minimum dissolved oxygen content of 5 milligrams per liter in the summer months and 4 milligrams per liter in the winter months. To attain this objective by 2035, even assuming that all wastes in the basin are given an adequate treatment, it would be necessary to provide sufficient storage to permit releases each year averaging 391 million gallons per day. It is considered that adequate treatment would consist of 99% removal of BOD and 99.9 percent removal of coliform bacteria. This yield of dependable water can not be developed from the remaining uncommitted water resources in the basin. The low flow augmentation requirements are subject to modification pending the certification of a Watershed Management plan for the Passaic River by the Governor. Alternative programs of wastewater management will have to consider higher levels of treatment at the source, other methods of collection and disposal of wastes, and interbasin transfers of water.

XIII - RECREATION

93. NEEDS. While the State of New Jersey has experienced a 15 percent increase in population within the last six years, the demands on outdoor rec-

reational facilities have grown at a rate of 60 percent. All available data concerning trends of higher personal income, greater leisure time, and an increased mobility of the general population indicates an increase in this proportion in the next decade. Although the State of New Jersey's population is presently approximately 7 million, almost 5 million people visited State Parks and other attendance-recording recreational areas during the period from July 1966 to June 1967. These recreation outings and their supporting services made vacation activities the largest single dollar producing industry in the State during this period. In view of the trends of increased leisure time, mobility and personal income, there is a significant lack of non-urban public recreational facilities in relation to the size of the expanding population, and only a small part of the demand for outdoor recreational facilities is being met by existing facilities. Additional discussion of recreation needs appears in Appendix H, Recreation.

XIV - NAVIGATION

94. The need for navigation improvements on the Passaic River was investigated and the findings published in House Document No. 494, 89th Congress, 2nd Session, covering Newark Bay, Hackensack and Passaic Rivers. It was found that although these improvements would produce benefits to water-borne commerce on the lower Passaic River, only deepening of the deep draft turning basin for ocean going vessels at the confluence of the Hackensack and Passaic Rivers, could be economically justified as a single purpose navigation project at this time. Therefore, the needs of local interests for an improved channel which would allow deeper draft vessels to navigate the Passaic River is still unsatisfied. However, deepening of the existing 10 foot shallow draft channel and provisions of a turning basin would result in more economical petroleum products transportation. At present, barges must navigate in the channel with partial loads and experience delays due to low tides resulting in frequent occurrences of accidents and groundings. In 1968 there were 1,191,500 tons of commerce on the 10 foot channel. By 2085 the tonnage is expected to rise to 3,448,000 tons.

XV - FISH AND WILDLIFE

95. FISH AND WILDLIFE CONSERVATION. The Passaic River basin has numerous meadows woodlands and streams which provide natural habitats for propagation of wildlife and opportunities for hunting, sport fishing and nature study. However, the increasing growth rate and corresponding demand for undeveloped land in the Central Basin and Highland Areas has prompted several organizations and communities to support reclamation and development of these areas to meet the needs of an expanding population and economy. The areas that are of significant value to wildlife in the Passaic basin, total approximately 30,000 acres and are all located in the Central Basin. They are: Great Swamp, Troy and Black Meadows, Great Piece Meadows, Hatfield Swamp, Upland Flood Plain areas between Hatfield Swamp and Millington, and the Dead River Marsh. Long Meadow in Essex County, and Bog, Vly and

Rockway Meadows in Morris County are gradually losing their original marsh characterisitics as a result of active reclamation and development programs. The Troy Meadows and adjacent marsh areas, comprising in all several thousand acres are one of the most desirable fresh-water marsh habitats existing for wildlife on the Atlantic Coast between tidewater and the Appalachian Mountains in the United States. Fish and Wildlife Service reports that within the Great Piece and Troy Meadow areas are some the finest and most productive fresh water swamps in the Northeast. They provide hunting for waterfowl, upland game, and big game for residents of northeastern New Jersey, and attract numerous sportsmen from the New York City area. These marshes have more than a local significance since they are of considerable importance with respect to the continental waterfowl population. There is also a heavy population of fur-bearing animals which are an important resource to trappers and landowers. In the conservation of wild life, public opinion and sentiment are considered of greater consequence than is indicated by the monetary factors involved. Convenient location makes the meadows a principal outdoor wildlife laboratory for study by such large national conservation organization, who have expressed opinions against the disturbance of the natural conditions in Troy Meadows by flood control measures. In addition to its value to the nation and to the State of New Jersey as a wildlife habitat, this area is a haven for song and insectivorous birds and is visited often by local nature study groups. Moreover, it serves as a refuge for upland game birds and is of tremendous interest to local sportsmen. A draft report on fish and wildlife in the Central Basin was prepared by the Fish and Wildlife Service, Department of the Interior and is contained in the files of the New York District for inspection.

96. The State of New Jersey through the Department of Conservation and Economic Development whose functions are now vested in the Department of Environmental Protection, has shown its concern regarding the destruction of the fish and wildlife resources within the State of New Jersey by the New Jersey Green Acres Open Space Land Conservation Program. The result of the first phase of the program as conceived and financed in a State Referendum in 1961 was virtually completed in June 1967. The planned acqusition under this program was 140,918 acres of open space conservation land. However due to fiscal cutbacks on the Federal and State level the program did not acquire the total acreage originally planned. In the Central Basin, only 300 acres were acquired of the approximately 2,781 acres in the Troy-Black Meadows area, and about 2,800 acres at Great and Little Piece Meadows planned for acquisition.

XVI - OTHER PROBLEMS

97. MOSQUITOS. The swamp and marshlands in the lower Highland Area and Central Basin are breeding grounds for mosquitos which are a nuisance affecting the health, comfort and economic security of the area. Mosquito-producing floods occur on the average of twice each year. These floods are followed by the hatching of countless mosquitoes and subject the residents of the area to a serious health menace. Studies have shown that

up to 10 percent of the mosquitoes are of the malarial transmitting type and are sufficient in number to start an epidemic under suitable conditions of contact. The increased emphasis on the developments of flood plain land bordering these swamps and marsh lands are currently increasing the possibilities of a serious health menace because of the effect of bringing increased population in close proximity to the areas where these mosquito types are generally found to concentrate. Aside from the acute discomfort and the serious public health menace, there are also several economic consequences of the mosquito nuisance in the Passaic River basin. Real estate immediately adjacent to the lowlands is valued at from 50 to 70 percent of equivalent property situated beyond the mosquito flight vector. The Morris County Mosquito Extermination Commission in conjunction with representatives of Essex and Passaic Counties in 1961 estimated that the costs of house screening and mosquito repellants, damage to business and recreational activity amounts to approximately $3,000,000 annually.

98. DRAINAGE. Generally, 27,000 acres of flood plain land in the Central Basin are flat with very mild shapes to the streams which drain these lands. This condition induces the soils to be continually wet or retain moisture for a long time after a rainfall. The results of this poor drainage condition in the Central Basin are marsh and meadow lands with surface water levels and ground water levels that persist at detrimental elevations for long periods. This condition causes the breeding of mosquitos, damages to basements walls structures, and requires that sump pumps and other protective facilities be installed most homes within these flat areas.

XVII - EXISTING CORPS OF ENGINEERS PROJECTS

99. FLOOD CONTROL AND NAVIGATION. There are no major existing Federal projects for flood control on the Passaic River or its tributaries. However, several small clearing and snagging projects have been accomplished on the Pompton River, Pequannock Township Ditch and Ramapo River. On the Pompton River, shoals were removed and the channel was restored in the reach extending from the Delaware, Lackawanna and Western Railroad Bridge upstream to the Erie Railroad Bridge. The work was completed in 1954 under the authority of Section 13 of the 1946 Flood Control Act, at a Federal Cost of $50,000. On Beaver Brook and Pequannock Township Ditch, snags and other debris were removed for a total distance of 20,200 feet and the channel was restored to its original dimensions. The project was completed in 1951, at a Federal Cost of $67,400. On the Ramapo River the main channel was excavated for a distance of 1000 feet and a parallel secondary channel was filled with suitable material. Work was completed in 1950 at a Federal Cost of $27,200. The existing Federal navigation project in the Passaic River is described in Paragraph 46.

XVIII - IMPROVEMENTS BY OTHER AGENCIES

100. FEDERAL. There are no improvements by any other Federal Agencies for the control of flood in the Passaic River basin although several sites are being studied by the United State Soil Conservation Service.

101. NON-FEDERAL. A number of channel improvement projects to provide local flood relief on the smaller tributaries throughout the Passaic area have been constructed by local agencies and individual property owners at various times. The improvements include: Weasel Brook in the Cities of Passaic and Clifton, with funds from the Federal Emergency Relief Program; Hohokus Creek in the Borough of Ridgewood, also with Federal Emergency Relief funds, the Peckman River in the Boroughs of Cedar Grove and Verona; the Second River in Bloomfield and Belleville; Molly Ann's Brook in the city of Paterson and the Saddle River in Fairlawn and Rochelle Park. All of these improvements are considered to provide a relatively low degree of flood protection. Some measure of benefit is also derived from drainage improvements of an extensive nature accomplished by the local county mosquito control commissions in the swamp and meadow areas of the Central Basin. The work has been done in numerous areas along the Passaic, Rockaway, and Whippany Rivers. Further information on improvements planned and constructed by non-Federal agencies is available in N. Y. District files.

XIX - IMPROVEMENTS DESIRED

102. PUBLIC HEARINGS. Local desires concerning improvements in the Passaic River basin have been expressed at the public hearings listed in Table 12. Digests of these hearings are included in Appendix M, Pertinent Correspondence. In addition to the hearings, there have been an unusual number of other meetings, including many informal public gatherings, meetings with local governmental agencies, civic groups, industrial firms, environmental and conservation interests and private individuals. These interests have also actively expressed their desires by numerous written communications throughout the course of the study. Following is a discussion of the principal desires in the basin as obtained from this extensive public contact.

103. LOWER VALLEY. Any presentation of the desires for improvements in the Passaic River basin would be characterized by divergent views between the expressions of upstream and downstream interests. In general, however, flood control reservoirs or local channel improvements, or a combination of both have been advocated by various local interests desiring flood relief along the main stem of the Passaic River. Downstream of Little Falls most interests are primarily in favor of obtaining relief in the Lower Valley by means of flood retardation by upstream reservoirs. Industrial and power interests have concurred in the desire for channel improvements downstream of Little Falls, but the latter have expressed opposition to any upstream improvement that would adversely affect the usable flow of the river. The Passaic Valley Water Commission has indicated that it would be in accord with any project that provides for the development of a water supply in the Passaic River and suggested the inclusion of conservation storage in any flood control reservoir which might be constructed in order to increase the low water flow of the Passaic River during the critical summer months for potable and industrial use. Individuals concerned with pollution in the lower river are opposed to any plan which would eliminate the flushing action of spring floods and the aeration of high waters passing over the dam at Great Falls.

104. CENTRAL BASIN. Above Little Falls in the Central Basin, several communities objected to any reservoir project which would remove large land areas from local tax lists with consequent loss of income to these municipalities. They have advocated local channel improvements exclusively. Between Little Falls and Two Bridges some interests desired that the outlet of the Great Meadow area be enlarged by installation of gates in Beatties Dam and by channel excavation upstream therefrom. Agricultural interests upstream of Little Falls concurred in this recommendation which would permit the drainage of the Great Meadow. Property owners in Wayne, Lincoln Park and Pompton expressed a desire for channel improvement on the Pompton and Pequannock Rivers, together with elimination of ice gorges downstream. The strongest exponents for flood relief in this section are individuals whose property and improvements are closely crowded upon the low bank of the river, and real estate interests who have invested heavily in flood-arrested developments in the flood plain. Wildlife interests are in favor of flood detention reservoirs and permanent flooding if regulated, but were opposed to any unregulated land drainage of the Great Meadow area which might alter the present condition of the area and render it unsuited to wildlife conservation. Environmental groups were generally against permanent inundation of any part of the Great Meadows and favored a plan of flood plain land acquisition. The mosquito extermination interests have presented a program involving the improvement of the Passaic River from Little Falls to Two Bridges, the installation of gates in Beatties Dam, partial drainage of wet lands upstream and flood detention reservoirs that would cause permanent flooding over the Great Meadow and prevent mosquito breeding. The Passaic Valley Flood Commission has recommended the immediate construction of a combined recreation lake and flood control reservoir on the lower Rockaway River. It has also been suggested that suitable legislation be enacted to enforce the provision of flood control storage in existing reservoirs, particularly by drawdown of water surfaces in anticipation of a flood when watershed conditions so warrant. An additional suggestion is a combined water supply and flood control reservoir on the Ramapo River to be operated in conjunction with modification of the Wanaque Reservoir for water supply and flood control. Bergen County objected to any damming of the Ramapo River due to residential and recreational use of the land in that valley.

TABLE 12 - PUBLIC HEARINGS

Date	Locality	Office conducting hearing
29 September 1936	Paterson, New Jersey	New York District
18 December 1939	Paterson, New Jersey	Board of Engineers for Rivers and Harbors
25 April 1946	Paterson, New Jersey	New York District
26 January 1950	Washington, D. C.	Board of Engineers for Rivers and Harbors
1 February 1956	Newark, New Jersey	New York District
13 December 1961(a)	Jersey City, New Jersey	New York District
16 December 1968	Wayne, New Jersey	New York District
18 December 1968	Madison Borough, New Jersey	New York District
10 May 1972	Wayne, New Jersey	New York District

(a) Covered areas in addition to Passaic River basin

105. GUBERNATORIAL DESIRES. The overall views of local interests as to their desires were expressed by letter dated 21 December 1956 from Robert B. Meyner, Governor of New Jersey, who acknowledged the plans developed by the Corps of Engineers in 1948 but also requested that new plans be developed for basin wide flood control in view of extensive development, economic changes and the desires of the people for a more comprehensive program, in accordance with the following criteria:

a. That flood control in the Passaic Valley is a single problem which can only be solved by a comprehensive plan which will prevent or alleviate flood damage and loss of life for all times throughout the entire basin.

b. That the plan provide for a reasonable amount of channel improvement of the lower river and a reasonable amount of flood storage in the upper valley.

c. That the plan insofar as possible, incorporate the individual desires of all portions of the basin.

d. That an effort be made to minimize the volume of storage required in the Central Basin by development of detention basins on upland tributaries.

e. That inclusion of water supply as part of a flood control project is objectionable to the people of the Upper Valley and should not be included except as a possible alternate benefit to be considered separately.

f. That greater emphasis than in previous studies be placed on the strategic location of the area in and adjacent to the nation's most important metropolitan area, the danger of great loss of life as well as extensive property damage and secondary benefits such as recreation, mosquito control and increased land values.

This letter established the criteria and guidelines used by the Corps of Engineers for development of the considered plans of improvement presented in a draft report completed in 1962 and one of the considered plans of improvement presented in this report.

106. By letter dated 2 April 1963, Governor Richard Hughes requested that the Corps of Engineers more fully investigate the plans which contain conservation storage within flood detention reservoirs in light of the increasing need for municipal water supplies within the Northeastern region of the State. This letter also requested that reclamation of the bottom lands within the Central Basin be incorporated into the plans as compatible with the purposes of flood control and allied water resources development.

XX - PROJECT FORMULATION

107. GENERAL. This section describes the analysis involved in the formulation of a plan for the Passaic River basin and the resulting conclusions. In general, needs for water resources development as described in Sections X through XVI were the basis for formulating a variety of alternative plans. These plans are discussed in detail in Appendix J, Project Formulation. The various type of basic facilities considered are de-

scribed in the following paragraphs. Also described here are the four key Plans which emerged from the process of screening alternatives so as to provide maximum satisfaction of the needs consistent with minimal investment in funds, resources, and environmental effects.

108. BASIC FACILITIES. Water resource improvements generally consist of certain basic facilities or combinations thereof. The basic facilities are reservoirs, channel and levee improvements, diversion channels, and non-structural measures. Non-structural measures refer to flood protective works which are not constructed on the flooding stream itself, but rather to flood damage reduction by management of use and occupancy of the flood plain and flood proofing of existing facilities. In the formulation process for the Passaic, the basic facilities were varied in location and size to determine the functional and economic effects to form a basis for the comparative evaluation of alternatives.

109. RESERVOIRS. In the Passaic River basin there are suitable reservoir sites in the uplands, where the controllable drainage areas are limited, and sites on the main stream in the Great Meadows area, where the major portion of the basin drainage area may be controlled. Development of the upland sites for the most part would involve little disruption to existing facilities, whereas on the main stream, development is such that any major reservoir would require the relocation of structures and roads. Numerous sites were investigated as to the feasibility of combining recreation with flood control and it was found that, with the exception of a site near Myers Road upstream of Chatham, they were either insufficient in available storage volume or were too far upstream of damage centers to be effective as flood facilities. Additional reservoir possibilities in the uplands are the modification of existing lakes and reservoirs to provide beneficial amounts of flood storage. However, these measures were found to be economically infeasible because (1) the dependable water supply yields would be jeopardized if conservation storage were to be preempted by flood storage, or (2) increasing the scale of development of the reservoir to include the addition of flood storage would be too costly. The Myers Road reservoir site was found suitable for economic improvement for both flood detention and conservation storage.

110. The most appropriate flood control reservoir sites in the Great Meadow areas are at Two Bridges, where the Pompton and Passaic Rivers join, and on the Rockaway River between its confluence with the Whippany River and the Passaic River. The Two Bridges site is suitable, not only for flood storage, but for the impoundment of conservation storage for multiple uses. Both sites were considered in project formulation.

111. MAINSTREAM CHANNEL IMPROVEMENTS. Enlargement of the existing Passaic River channel to pass flood flows more rapidly in the more severely damage-prone areas would be complex and costly due to excessive relocation of existing developments and the high value of riverfront property, especially in the densely developed portions of Paterson and Passaic, where the existing channel narrows. The removal of several existing dams in the

mainstream was also investigated, and it was found that, for the most part, these structures influenced only the immediate area in their vicinity. A case in point is Beatties Dam, where the upstream flood stages are controlled by the narrow rock lined approach channel rather than the dam itself. Channel deepening is practicable in only limited reaches of the mainstream and then only to limited depths because of the underlying aquifers in those areas. For the most part however the channel is underlain by rock and any appreciable deepening would require the underpinning of several bridges and construction of channel retaining walls where development is very close to the river banks. Levee and floodwall improvements would be costly because of necessity of raising bridges and associated work on bridge approaches in heavily built up areas. The most appropriate flood protection works would consist of channel deepening and widening, levees and floodwalls in various combinations depending on which is more suitable based on existing development and subsurface conditions.

112. DIVERSIONS. Consideration was given to solving the flood problem downstream of Beatties Dam by means of diversion tunnels from the Paterson - Little Falls area to downstream of Dundee Dam. Plans of this type were found to involve costs considerably in excess of what it would cost to obtain the same benefits by improvements in the channel, and were thus not considered viable alternatives. However, diversions were found practical in other areas, such as the Passaic River at Two Bridges and the Lower Pompton River.

113. NON - STRUCTURAL MEASURES. This type of flood damage reduction program involves no works in the flooding channels. It is an alternative whereby action is taken on the flood plain lands to reduce and eliminate, where possible, future flood damages. Typical non-structural measures include regulation of flood plain land to exclude damagable uses, flood proofing of existing facilities to minimize damage and relocation of existing facilities to flood-free areas. Normally the non-structural approach would be most applicable in areas that are undeveloped or only partially developed. Consideration was given to the non-structural alternative in those flood damage areas in the basin where it could possibly be practical. Non-structural measures were found to be a partial solution to the Passaic flood problem. The details of the investigation and information useful to communities planning for flood plain use along the Passaic River are presented in Appendix L, Flood Plain Management.

114. MULTIPLE PURPOSE DEVELOPMENT. Dams with reservoir storage are key components of a plan for flood control, water supply, recreation, and fish and wildlife. It is possible to combine the various kinds of facilities as discussed previously, in water resource development and realize economies of scale because one facility could serve various purposes. The storage facility can retain water for conservation use and permit detention of flood waters. The availability of dam and reservoir sites previously noted, indicated that the possibility of such a plan should be investigated. In so doing, two basic approaches were employed. The

first approach was development of a plan to test the possibility of providing the multiple benefits while at the same time reclaiming maximum lands in the Central Basin for subsequent development. The second approach was to utilize the Central Basin primarily for flood detention along with various amounts of conservation storage; this second approach formed the basis for three alternative plans. The four alternatives are briefly described as follows. Costs are at January 1970 price levels, 5-3/8 percent interest rate and 100 year project lives.

115. Plan I. This plan of improvement would provide for flood control and allied water resource development with a view to reclaiming the Central Basin area. The principal features of this plan of improvement are the construction of 3 detention reservoirs in the Central Basin upstream of Two Bridges and Myers Road on the Passaic River and upstream of U. S. Interstate Route I-280 on the Whippany River. The two reservoirs on the Passaic River would include conservation storage for municipal water supply and water quality improvement, while the reservoir on the Whippany River would have a small pool for waterfowl habitat purposes. The plan of improvement would also include diversion of the Pompton River into Great Piece Meadows for water supply and flood detention storage and the improvement of the existing channels in combination with the construction of levees and floodwalls at certain localities on the Pompton and Ramapo Rivers and on the Passaic River from Newark Bay to Two Bridges. In addition, this plan would provide for the construction of a flood diversion channel on the Rockaway River and channel improvement on the Whippany and Passaic Rivers in combination with filling and grading of swamp lands in the Central Basin. The first cost of this plan of improvement is estimated at $1,085,320,000, and the annual costs would be $68,621,000.

116. Plan II. This plan of improvement emphasizes the utilization of the Central Basin's existing flood detention capabilities. It involves a combination of reservoir control in the upper basin and channel improvement from Newark Bay to Two Bridges and from Chatham to Myers Road, in addition to channel improvement of the Pompton, Pequannock, Wanaque and Ramapo Rivers. The dry detention reservoir located upstream from Two Bridges would extend along the main stream to Chatham, New Jersey. In addition, a multiple purpose reservoir with conservation storage would extend from Myers Road to Osborn Pond along the Passaic River with an arm extending along the Dead River and Great Brook. The first cost of this plan of improvement is estimated at $603,010,000. The average annual costs would be $41,577,000.

117. Plan III. This plan of improvement is derived from the preceding plan and differs only in the inclusion of a conservation pool in Great Piece Meadows in the Two Bridges Reservoir. This conservation pool would be formed by the diversion of the Pompton River into the pool area and the utilization of Route I-80 as a conservation dam. The reservoir would extend along the mainstream to Chatham, New Jersey, with arms extending along the lower Whippany and Rockaway Rivers and along the Pompton River to Pompton Lakes. Two Bridges Reservoir would be supplemented by the con-

struction of an upland reservoir at Myers Road. Channel improvement on the Passaic River would be from Two Bridges to Newark Bay and from Chatham to Myers Road. Channel improvements on the Ramapo River would be upstream of Pompton Lakes and in the Mahwah-Suffern area. The first cost of this plan of improvement is estimated at $720,810,000. The average annual costs would be $49,833,000.

118. Plan IV. This plan of improvement can also be considered as an extension of Plan II: It utilizes the maximum development of the conservation storage available from the Pompton and Passaic Rivers. Two Bridges Reservoir would impound long term storage in a conservation pool which would extend to Chatham, New Jersey with arms extending along the lower Whippany and Rockaway Rivers and along the Pompton River to Pompton Lakes Dam. Channel improvement along the Passaic River from Two Bridges to Newark Bay and from Chatham, New Jersey to Myers Road, and along the Ramapo upstream of Pompton Lakes Dam would be similar in extent and degree to that as previously described in Plan II and III. The first cost of this plan of improvement is estimated at $918,160,000. The average annual costs would be $67,362,000.

119. SELECTION OF OPTIMUM PLAN. The selection of the most favorable plan from among the four multiple purpose alternatives was made by comparison of costs and benefits, as indicated in Table 13. The benefit cost ratios vary from a high of 1.2 for Plans II and III to a low of 0.9 for Plans I and IV. The comparison further reveals, as shown in the table, that Plan II provides the maximum excess benefits over cost, $8,720,000, followed by Plan III. Plan I ranks last in excess benefits due principally to the excessive cost of channel work that performs the function that would otherwise be performed by more economical flood storage, the lands for which would be reclaimed under this plan. Plan II is more favorable primarily because it utilizes the Central Basin lowlands for flood detention storage thereby reducing the cost of downstream channels to accommodate flood flows. Plan III is considered the optimal design because it combines the use of maximum flood detention storage with beneficial conservation storage. Plan IV is less favorable than Plan III generally because the additional conservation benefits obtained are exceeded by the additional costs of construction. Additional factors influencing selection of the best plan are environmental quality and beneficial impact on the local economy. Consideration of the above factors resulted in the conclusion that Plan III would provide the most economic development of the Passaic River basin for flood protection and related water resource purposes. Environmental effects are discussed in the Environmental Impact Statement.

120. OPTIMUM LEVEL OF DEVELOPMENT. Further analysis of Plan III was made to determine the optimum level of development as reflected by the degree of tidal and fluvial protection and navigational improvement in the reach between Newark Bay and Dundee Dam. It was found that the most economic level of development for tidal protection was against a tidal stage of 9.5

TABLE 13 - ECONOMIC COMPARISON OF ALTERNATIVE PLANS
(In dollars and January 1970 price levels)

Item	PLAN I	PLAN II	PLAN III	PLAN IV
Benefits				
Flood control	40,787,000	36,221,000	36,221,000	36,221,000
Hurricane control	3,058,000	3,058,000	3,058,000	3,058,000
Major drainage	213,000	367,000	367,000	367,000
Fish and wildlife	775,000	342,000	827,000	552,000
Recreation	1,728,000	1,800,000	3,566,000	4,312,000
Water supply	5,400,000	1,740,000	6,310,000	9,875,000
Water quality	2,616,000	2,491,000	2,758,000	2,491,000
Mosquito control	1,208,000	555,000	744,000	1,392,000
Navigation	389,000	389,000	389,000	389,000
Land enhancement	4,192,000	2,951,000	2,951,000	2,951,000
Advanced replacement	318,000	383,000	383,000	383,000
Total	60,684,000	50,297,000	57,574,000	61,991,000
Costs				
First cost	1,085,320,000	603,010,000	720,810,000	918,160,000
Annual cost	68,621,000	41,577,000	49,833,000	67,362,000
Evaluation				
Benefit cost ratio	0.9	1.2	1.2	0.9
Excess benefits	-7,957,000	8,720,000	7,741,000	-5,371,000

feet above mean sea level, in combination with an improved navigational channel to depth of 14.6 feet below mean low water (17 feet mean sea level) in the Passaic River from mile 7.7 to the Eighth Street Bridge.

121. The plan was then investigated to determine the optimum level of flood protection by analysis of various levels of flood detention storage in the proposed reservoirs and various levels of channel improvement in the downstream reaches. It was determined by the analysis that Plan III providing 231,000 acre-feet of flood detention storage in combination with local protection works which would provide protection against a design discharge varying from 10,500 cubic feet per second at Two Bridges to 30,000 cubic

feet per second at Newark Bay was very close to the optimum protection for this reach. An analysis was also made to determine the optimum combination of flood detention and conservation storage in the proposed multiple purpose reservoirs. This analysis indicated that the optimum degree of conservation storage was very close to 82,400 acre-feet with corresponding flood detention storage of 231,000 acre-feet.

122. SINGLE PURPOSE ALTERNATE. Another tool used in the plan formulation process is the comparison of the costs of providing the purposes in a multiple purpose improvement against the provision of a specific purpose by a single purpose alternate improvement. When the economics of the most feasible of each of these possible single purpose improvements are established, it becomes possible to evaluate the relative feasibility of more comprehensive multiple purpose proposals. These single purpose or basic alternatives are described below. To establish comparability among all considered alternatives, they were evaluated on the basis of standards of performance that could be expected from a multiple purpose plan. For example, flood control alternatives along the mainstream were considered to protect against a flood twenty percent greater than the 1903 record flood, and water supply alternatives were considered to provide a dependable water supply 138 million gallons per day. Comparisons of annual cost in the following paragraphs are based on January 1970 price levels, 5-3/8 percent interest rate and project lives of 100 years. Table 14 summarizes the costs of the various single purpose alternatives.

TABLE 14 - COSTS OF SINGLE PURPOSE ALTERNATIVES
(January 1970 Price Levels)

Purpose	First cost	Average annual costs
Flood control	$494,890,000	$32,877,000
Water supply	54,570,000	6,310,000
Recreation	170,730,000	11,263,000
Fish and wildlife	315,864,000	18,759,000
Water quality	142,120,000	20,780,000
Major drainage	30,070,000	1,933,000
Navigation	13,470,000	741,000
Hurricane protection	21,130,000	1,290,000

123. Flood control. The most feasible single purpose flood control project would consist of two normally dry detention reservoirs, one upstream of Two Bridges, and one upstream of Myers Road, and channel improvement from Newark Bay to Two Bridges and from Chatham to Myers Road. The first cost of such an improvement would be $494,890,000 and the average annual costs would be $32,877,000.

124. Water Supply. The most feasible means of developing water supply in the magnitude of 138 million gallons a day for the more immediate needs of the area, would be the development of three sources in the Raritan River basin under a three stage program. The first stage, needed by 1986, would provide for the unobligated 80 million gallon per day balance of supply from the Round Valley - Spruce Run system by pumping from the Raritan River at Bound Brook to the Dead River, where it would then flow by gravity to Chatham and then via the Passaic River to the point of withdrawal. The second stage, required by 1988, is the construction of a dam and reservoir on Six Mile Run upstream of its confluence with the Millstone River; this would permit impoundment of Six Mile Run waters to yield 10 million gallons per day and impoundment of currently unallocated waters pumped from the Delaware and Raritan Canal for another 28 million gallons per day, a total of 38 million gallons per day. The third stage, required by 1994, would be the construction of a dam and reservoir at the confluence of the North and South Branches of the Raritan River, and the installation downstream of additional pumps at Bound Brook on the Raritan River. This work would permit an additional 50 million gallons per day of which 20 million gallons a day would be purchased for the alternate plan to be drawn off and transported into the Passaic River. The first cost of this three stage program would be $54,570,000 and the average annual cost would be $6,310,000.

125. Recreation. The development of water oriented recreation facilities would involve two reservoirs formed by dams at Two Bridges and Myers Road, and associated perimeter land development along with strip park development along the Passaic River from U. S. Route 46 to Chatham. The first cost would be $170,730,000 and the average annual cost would be $11,263,000.

126. Fish and wildlife. The development of high quality warm water fisheries would best be accomplished by dams and reservoir impoundments as noted for recreation. In addition, about 4,200 acres of swamp and marsh lands would be acquired for maintenance as a waterfowl and wildlife refuge. The total first cost would be $315,864,000 and the average annual cost would be $18,759,000.

127. Water quality. The most economically reasonable approach to establishment of desirable water quality in the Passaic River is to provide advanced treatment of all sewage prior to discharge into streams. The criteria used to estimate the cost of such programs are based on the desirable objectives for each reach of stream as reflected by the amount of BOD, dissolved oxygen, coliform bacteria and other qualities such as color and taste. The attainment of the water quality objectives by means of reservoir storage is unfeasible. The average annual cost of the program of advanced treatment facilities is estimated at $20,780,000. The first cost is estimated at $142,120,000.

128. Major Drainage. The most feasible means of improving drainage in the low lands between Beatties Dam and Myers Road is by filling and grading these lands and the improvement of existing and construction of new drainage channels to accommodate the land runoff resulting from a storm with an

average frequency of occurrence of once every five years. Poor drainage in this reach has led to saturated soil conditions and swamp-like land characteristics. The first cost would be $30,070,000 and the average annual cost of such work is $1,933,000.

129. Navigation. Improvements in the Passaic River to permit more economical shallow draft navigation would be the deepening of the existing channel and the extension of the channel from the Eighth Street Bridge in Passaic to Dundee Dam. The first cost of such work would be $13,470,000 and the average annual cost of this improvement to a depth of 14.6 feet at mean low water is estimated at $741,000.

130. Hurricane Protection. Improvements in the Passaic River estuary to provide protection against tidal inundation would require the construction of levees and floodwalls along the banks of the river from Newark Bay to Dundee Dam. The first cost of such work would be $21,130,000 and the average annual cost of the improvement to provide tidal protection against a stage of 9.5 feet mean sea level is $1,290,000.

131. LOCAL PROTECTION IMPROVEMENTS ON TRIBUTARY STREAMS. An investigation was made as to the optimum level of protection afforded by the local protection projects along the tributary streams. These investigations indicated that the optimum level of development were very close to discharges equal to 20 percent in excess of the October 1903 flood on the Ramapo River at Oakland, New Jersey, on the Mahwah River at Mahwah, New Jersey, and Suffern, New York; and about equal to the October 1903 flood on the Saddle River at Lodi, New Jersey, on Molly Ann's Brook at Haledon, New Jersey, on Nakoma Brook at Sloatsburg, New York and on the Rockaway River at the Town of Denville, New Jersey.

XXI - PLAN OF IMPROVEMENT

132. GENERAL. The Passaic River improvement, found to be most suitable for the reasons described in Section XX of this report, provides for the use of stored water in conjunction with river improvements in the interest of flood control, recreation, water supply, water quality and other purposes. This section describes in greater detail the components of the plan and pertinent related matters such as its operation and effects on existing development. The elements comprising the overall plan of improvement are presented in two categories. The first group comprises those elements integral to Plan III on the Passaic River and the second group comprises improvements on tributaries that are independent of Plan III. The breakdown is given below, followed by descriptions of each component. Pertinent data is given in Table 15. The plan should be supplemented by a program of flood plain management by local interest to minimize damages in areas where structural improvements are not feasible.

Integral to Plan III.

a. Improvement of the Passaic River from Newark Bay to Two Bridges, Figures 6 through 14

TABLE 15 - PERTINENT RESERVOIR DATA FOR CONSIDERED PLAN

ITEM	TWO BRIDGES RESERVOIR	MYERS ROAD RESERVOIR
General Data		
River Impounded		
Conservation	Pompton River	Passaic River
Flood Detention	Pompton & Passaic Rivers	Passaic River
Drainage Area Controlled (sq.mi.)		
Conservation	377	82
Flood Detention	735	82
Percent of Area above Paterson	93.8	10.5
Controlling Levels (ft., m.s.l.)		
Conservation Pool	183.0	225
Spillway Crest	190.5	225
Maximum Pool	197.4	232.4
Top of Dam	202.4	237.4
Taking Line	194.3	230.0
Land Required (Acres)	18,709	4,525
Conservation Pool		
Surface Area (acres)	4,960	2,700
Dead Storage (acre-ft)	13,800	2,600
Live Storage (acre-ft)	68,600	21,300
Total Storage (acre-ft)	82,400	23,900
Dependable Yield (mil. gal/day)	100	38
Flood Control Pool		
Flood Pool Area (acre)		
Design Flood	16,800	4,200
Maximum Flood	18,800	7,500
Flood Storage (acre-ft)		
Design Flood	231,000	10,100
Maximum Flood	116,000	24,900
Other Features		
Levee Height (ft, msl)	199.4	231.5
Levee Length (miles)	52	8
Raised Roads, Height (ft, msl)	Varies	231.5
Raised Roads, Length (miles)	17.3	4.7
Structures Relocated	512	48
Perimeter Structures Protected	7,500	500

b. Two Bridges dam and reservoir, Figure 4

c. Pompton River diversion, Figure 20

d. Passaic River diversion, Figures 31 and 32

e. Improvement of the Passaic River from Chatham to Myers Road, Figures 15 through 18

f. Myers Road dam and reservoir, Figure 5

Improvement on Tributaries.

g. Channel improvement of the Ramapo River at Pompton Lakes and Oakland, New Jersey, Figures 20 and 21

h. Local protection works on the Mahwah River at Mahwah, New Jersey and Suffern, New York, Figure 23

i. Local protection on Saddle River at Lodi, New Jersey, Figure 24

j. Local protection on Molly Ann's Brook in Haledon, Figure 25

k. Local protection on Nakoma Brook at Sloatsburg, New York, Figure 26

l. Local protection on the Rockaway River at Denville, New Jersey, Figure 27

m. Reconstruction of the dams at Lakes Denmark and Picatinny, Figures 28 through 30

133. IMPROVEMENT OF THE PASSAIC RIVER FROM NEWARK BAY TO TWO BRIDGES. Newark Bay to Dundee Dam. The Passaic River in this reach would be improved to a trapezoidal shaped channel, varying from a bottom width of 300 feet and bottom elevation of 17.0 feet below mean sea level at Newark to a 150 foot bottom width trapezoidal shaped channel with a bottom elevation of 12.5 feet below mean sea level at the Eighth Street Bridge in Passaic, Figures 6 through 10. The water surface elevations for design flood conditions could vary from 9.5 feet mean sea level to 18.4 feet at Dundee Dam. There would be about 6.1 miles of levee and 3.1 miles of concrete walls. Top elevations of levees and walls would be 3 feet higher than the design water surface. Bridges would be raised so that their bottoms would be only 2.5 feet above the design water surface because of the high cost of construction in heavily developed areas. Ten pumping stations would be provided to drain areas protected by levees and walls.

134. Dundee Dam to Beatties Dam. In this reach, improvement of the existing channel would consist of the excavation of the Island Park at West Broadway Bridge to the depth of the adjacent channel bottom, Figure 12. There would be local protection facilities along both banks totaling about 8.7 miles of earth levees and 1.7 miles of concrete walls. The top elevations of the levees and walls would vary from 34.6 feet mean sea level at the downstream end of the reach to 58.5 feet at S.U.M. Dam. Above S.U.M. Dam the top elevation varies from 124.0 feet to 133.5 feet. These elevations are 3 feet above the design water surface. There would be a pumping station on each side of the river for draining protected areas. A total of 8 bridges would be raised; an additional 7 bridges on tributary streams draining into this reach of the Passaic would also be raised, Figures 10 through 13.

135. Beatties Dam to Two Bridges. In this reach, the channel for its full length of 3.3 miles, would be excavated to provide a 200-foot bottom width with side slopes of 1 on 3, Figures 13 and 14. Bottom elevations would vary from 146.0 to 154.5 feet mean sea level. In addition, three new tainter gates, each 35 feet wide, would be installed in Beatties Dam, Figure 36. In the uppermost section just downstream of the Two Bridges Dam spillway for a distance of 1,500 feet, a channel would be excavated to provide a 250 to 600-foot bottom width and side slopes of 1 on 3. A levee 1,600 feet in length and about 12 feet high would be constructed on the left bank and a similar structure 1,600 feet long and about six feet high would be constructed on the right bank. The levees would be rolled earth embankments with a top width of eight feet with an impervious, compacted core and cutoff. They would vary in elevation from 164.5 feet mean sea level to 165 feet. Side slopes would be 1 on 3 throughout. Flood walls would be reinforced concrete with a 15-inch top width and a steel sheet piling cutoff extending on an average of 17 feet below the wall foundation to an impervious soil strata. Top elevations of both levees and walls would be three feet above the design discharge including the navigable portion of the river downstream from the Eighth Street Bridge. Bottoms of bridges would be 2.5 feet above the design water surface. Additional works involved in the channel improvement portion of the plan would include the reconstruction of 3 bridges.

136. TWO BRIDGES DAM AND RESERVOIR. Main dam. The dam structures are described in three sections; a main dam, a conservation dam and the Pompton dam. The main dam would be located across the Passaic and Pompton Rivers in the Township of Fairfield and the Borough of Lincoln Park, 0.3 miles upstream from Two Bridges. The site for the main dam consists of flat rolling land which extends over a valley approximately 13,000 feet wide. Along the length of the dam, the greater portion of the valley floor is composed of variable thickness of stratified fine alluvial sand overlying plastic clay and glacial till. Except for one locality, rock was generally not encountered by exploration within 100 feet of the surface. In the valley wall above the north abutment of the dam, rock outcrops at approximately elevation 200 feet mean sea level, but dips sharply toward the dam, so that

the north abutment is deeply covered with a glacial deposit consisting of a compact mixture of clay, silt, sand, gravel and bounders. Similarly, the south abutment consists of a firm moraine deposit. At the site of the spillway on the south bank of the Passaic River, the surface layer of fine sand with silt was found to be 8 to 25 feet deep, underlain with hardpan or glacial till, below which rock was encountered at a depth of 36 feet. The main dam would be a rolled earth embankment 17,800 feet long with a maximum height of 51.5 feet, a top width of 20 feet, and a top elevation of 202.4 feet mean sea level. Embankment slopes in the higher sections of the dam, totaling 9,000 feet in length, would be 1 on 5 on both sides below elevation 190.5 feet mean sea level and 1 on 3 above this level. An impervious core of compacted fill would be provided for the full length and depth of the embankment. The structure would be protected from the erosive effects of wave and wind action by placing 9 inches of bedding material overlain with 27 inches of riprap from elevation 177.0 feet, to 202.4 feet mean sea level on the conservation pool side slopes.

137. The spillway would be a concrete ogee type structure, 1,020 feet in length, constructed on a hardpan foundation on the south bank of the Passaic River about 5,300 feet from the north abutment. The crest elevation would be 190.5 feet mean sea level, with a lower weir, 120 feet in length, having a crest elevation of 183.0 feet mean sea level. Outlet works in the Passaic Section would consist of two 5-foot conduits, located in the spillway section. Each conduit would be equipped with two power operated sluice gates. The intake elevation would be at 156.0 feet mean sea level.

138. Conservation dam. The conservation section of the dam would extend a distance of approximately 3,600 feet southwest along the alignment of U. S. Interstate Route 80 from just upstream of Horseneck Road to the U. S. Interstate Route 80 bridge over the Passaic River. At this point, the conservation dam would extend 2,850 feet in a westerly direction to high ground north of the community of Pine Brook. The foundation conditions in this section are substantially similar to those of the main dam. The conservation dam would be a rolled earth embankment with a top width of 80 feet to accommodate existing U. S. Interstate Route 80, a six lane Interstate highway. This section would have a maximum height of 31 feet, a top elevation of 199.4 feet mean sea level and variable side slopes to suit foundation conditions as used in the Passaic Section. An impervious core of compacted fill would extend through the full length and depth of the embankment. The structure would be protected from the erosive effects of wind and wave action by placing 9 inches of bedding material overlain with 24 inches of riprap from elevation 176.0 feet to 199.4 feet mean sea level, on the conservation pool side slopes.

139. The spillway in the Conservation Section of the dam would have a length of 1,200 feet and would consist of five ogee type structures, each 240 feet long, spaced along the length of the dam, with a crest elevation of 183.0 feet, mean sea level.

140. Pompton dam. The Pompton Section of the dam would operate in conjunction with the Pompton diversion discussed in a subsequent paragraph. It would extend 11,500 feet across the Pompton River Valley from high ground in the vicinity of the old Route 23 bridge in Wayne to the high ground between the Pompton and Passaic Rivers in Lincoln Park, Figure 19. This section would also form the east bank of the Pompton River diversion channel. Foundation conditions in this section are substantially similar to those existing at the abutments of the main dam. The dam would be a rolled earth embankment. It would have a maximum height of 45 feet, a top width of 20 feet, a top elevation of 202.4 feet mean sea level, and side slopes of 1 on 5 on both sides below elevation 190.5, and 1 on 3 above this level. An impervious core of compacted fill would extend for the full length and depth of the embankment. The structure would be protected from the erosive forces of wind and wave action by placing 9 inches of bedding material overlain by 24 inches of riprap from elevation 176.0 to 202.4 feet mean sea level on the conservation pool side slopes.

141. The outlets in the Pompton dam would consist of four 5-foot by 5-foot conduits. They would be located at the upstream end of the diversion channel and would discharge directly into the existing Pompton River downstream of the Pompton Dam. In addition to the outlets, two 5-foot siphon conduits would be integrated within the structure to accommodate interior drainage from the west bank of the Pompton River, which would be protected by a levee, into the existing Pompton River channel downstream of the dam. Each outlet conduit would be regulated by a power operated slide and sluice gate. The intake elevation of the outlet and siphon conduits would be at approximately 160.0 feet mean sea level, Figure 34.

142. Conservation pool. The conservation pool would contain Pompton River water impounded by the conservation dam. The conservation pool level would be elevation 183.0 feet mean sea level with a corresponding flowage area of 4,960 acres and storage of 82,400 acre-feet. Of this total storage, 68,600 acre-feet would be available for conservation uses, 4,400 acre-feet would be reserved for silting, 5,800 acre-feet for evaporation and 3,600 acre-feet for contingency losses. Backwater at pool level would extend about 6 miles along the Pompton River to Pompton Lakes Dam. The works would be arranged so that normal flow on the main stem of the Passaic River would by-pass the conservation pool in discharging to the lower river, Figures 4, 31, and 32.

143. Flood control pool. The reservoir area, at the fixed spillway elevation of 191.4 feet mean sea level would be 16,800 acres with a corresponding total storage of 313,000 acre-feet, equivalent to 8.0 inches over the controlled drainage area of 735.2 square miles. Of this total storage, an amount of 231,000 acre-feet, equivalent to 6.0 inches over the controlled watershed area would be utilized for flood control. This is 3.7 inches more than the amount stored on the meadows during the 1903 flood. The reservoir would extend upstream for a distance of 11 miles to Chatham, along the Rockaway River a distance of 6 miles to above Lake Hiawatha, and along the Whippany River a distance of 6 miles to Florham Park. It would also

extend up the Pompton River and diversion channel a distance of seven miles to Pompton Lakes, Figures 3 and 4.

144. Reservoir local protection works. Within the reservoir area, approximately 52 miles of protection works are proposed for construction as circle levees and perimeter levees in and adjacent to the flood detention pool. The levees would vary in height between 34.0 feet at Pine Hill and zero at the tie back elevation of 199.4 feet mean sea level. They would have a top width of 8 feet, the side slopes would be constructed on a grade of 1 on 4 and the water side would be lined with 6 inches of bedding material overlain by 12 inches of riprap. Seventy-one pumping plants with a combined capacity of 7,215 cubic feet per second would be constructed behind the levees for interior drainage. The construction of these levees would afford protection to approximately 7,500 structures. The facilities of all water, sewage and power utilities crossing the reservoir area would be protected, and roads and highways would be raised to an elevation of 3 feet above the stage of the largest flood of record. The reservoir area to be utilized for flood control storage would be cleared of fallen timber below elevation 194.0 feet mean sea level. The reservoir area to be utilized for conservation storage would, in addition to the above, be cleared of all trees and brush, and all root matter and soil containing vegetative compositions would be excavated. The area of the conservation pool would be excavated to a minimum bottom elevation of 176.0 feet mean sea level on a 1 on 3 side slope. These side slopes would be protected from erosion by a 12 inch gravel covering.

145. Reservoir land usage. The Two Bridges Reservoir would require the acquisition of 18,700 acres of land. Of this total, 4,960 acres would be contained within the conservation pool, 1,170 acres would be required for recreational use and approximately 4,200 acres would be required as waterfowl and wildlife habitats. Of the remaining 8,370 acres, approximately 75 percent, or about 6,300 acres would lie above the stage of the 20 year flood. Because of the large acreage removed from productive use and the accompanying hardship imposed on several of the reservoir communities in this urban area, a portion of the lands would be made available on a lease basis for activities that are compatible with the flood threat. These activities could consist of open air theatres, municipal recreation, grazing, agriculture, and parking lots in the vicinity of protected industrial and commercial areas.

146. POMPTON RIVER DIVERSION AND CHANNEL IMPROVEMENT. The Pompton River channel improvement would involve straightening, deepening and widening of the Pompton River downstream from Pompton Lake Dam and levees and flood walls along both banks to the vicinity of Park Avenue in Lincoln Park, Figures 19 and 20. The new channel would be 200 feet wide at the bottom and have 1 on 3 side slopes. From this point a diversion channel would be excavated to carry the flow into the detention pool through Hook Mountain at Lincoln Park. The diversion channel would be 9,500 feet long and would have a 200-foot bottom and side slopes of 1 on 3 through soil

excavation and 4 on 1 through rock cut in Hook Mountain. From the upper end of the diversion channel, a dry weather flow of 60 cubic feet per second would be released into the original Pompton River channel by the outlets and siphon outlets. Several railroad and highway bridges would be raised as appropriate. The levees along the right bank of the Pompton River and the diversion channel for protection of Lincoln Park, Pequannock and Pompton Plains against flooding would extend for 21,500 feet from Jackson Avenue in Pompton to the Hook Mountain divide at Lincoln Park. The levee would have an average height of 16 feet, a top width of 8 feet, a top elevation varying from 199.4 to 200.0 feet mean sea level and side slopes of 1 on 4. Interior drainage would be carried to the Pompton River downstream of the Pompton Section of the dam by two siphon conduits, Figure 34.

147. PASSAIC RIVER DIVERSION. Within the flood detention portion of the reservoir the Passaic River would be diverted to the dry side of the main dam. The diversion channel would be situated on an alignment between the main dam and U. S. Interstate Route 80 and would discharge into the existing Passaic River channel at Two Bridges. This channel would consist of a 180 foot bottom width channel with 1 on 3 side slopes and would be 26,700 feet in length. It is designed to accommodate a maximum regulated discharge of 10,500 cubic feet per second with 3 feet freeboard below the existing ground elevation. The diversion channel upstream of the dam would intercept the existing Passaic River just upstream of U. S. Route 46. This channel would be sized with a bottom width of about 180 feet, Figures 3, 4, 31 and 32.

148. Outlet works. The outlet works for the Passaic Diversion would consist of eighteen, 5-foot conduits constructed through the earth embankment of the Passaic Section of the dam to discharge into the diversion channel which empties into the Passaic River between Two Bridges and Beatties Dam. Each conduit would be regulated by a hydraulically operated sluice gate. A gate tower with control gates would be located at the upstream end of the conduits. These outlets were sized so that they would pass the bank-full flood under a head of five feet. The elevation of the outlet was placed so as to be at least as low as the existing channel on the Passaic River at the proposed location of the dam, Figure 34.

149. IMPROVEMENT OF THE PASSAIC RIVER FROM CHATHAM TO MYERS ROAD. This improvement would extend upstream from the Two Bridges Reservoir at Chatham to Myers Road Dam, Figures 3, and 15 through 17. The channel would be trapezoidal in shape with an 80 foot bottom width and one on three side slopes with the top of channel banks being formed by land filling operation of the flood plain marsh land which will drain towards the channel. Bridges would be reconstructed to provide a minimum of three feet of free board above the design flood stage. The improved channel bottom would start at the elevation of the existing channel at mile 51.0, 177.0 feet mean sea level, thence it would extend upstream with uniform slope to elevation 186.1 feet at mile 52.8, thence at a uniform slope to elevation 195.5 feet at the downstream toe of Myers Road Dam.

150. MYERS ROAD DAM AND RESERVOIR. Dam. The dam would be located on the upper Passaic River about 1,500 feet upstream of Myers Road near Millington, Morris County, New Jersey, and would have a top elevation of 237.5 feet, Figure 3. The dam, an earth gravity structure with an overall length of 5,160 feet, would include a concrete 150-foot long, ogee, overflow spillway, and a 150-foot long, non-overflow, gravity section that would be anchored into the earth gravity sections of the dam on each side. The spillway crest would be at 225.0 feet with a maximum height of 29.8 feet above the streambed. There would be two 24 inch gated conduits with invert elevations of 202.5 feet. The stilling basin for the spillway and outlet discharges would be 150 feet wide and 84.0 feet long. The channel downstream of the stilling basin would be relocated and riprapped for a distance of about 300 feet, Figure 35.

151. Reservoir. The Myers Road reservoir would be located in Dead River Swamp and portions of the Great Swamp, Figure 4. The swamps are rectangular dish-like hollows that once were a part of an ancient glacial lake, which formed one of the major headwaters of the Passaic River. The reservoir, including the entire Dead River and portions of the Great Swamp, would be generally divided into two sections by the natural rock gorge located about 400 feet downstream of Basking Ridge Road near Millington. The downstream portion of the reservoir encompassing the Dead and Passaic River Meadows would be generally used for conservation purposes, recreation, water supply storage, flood detention storage, and fishery enhancement; the upstream portion would be used for wildlife refuge, waterfowl habitat, land oriented recreational facilities and for flood detention storage.

152. The conservation pool at elevation 225.0 feet mean sea level would have an area of 2,700 acres. The pool would contain about 23,900 acre-feet of storage, equal to 5.4 inches of runoff over the 82.0 square miles of drainage area. Of this storage, 21,300 acre-feet would be used for low flow augmentation and water supply purposes, 1,000 acre-feet for silting, 950 acre-feet for evaporation and 650 acre-feet for other losses. The dependable yield produced by this conservation storage and river flow would be 38 million gallons per day based on the worst drought of record, which occurred from May 1965 through May 1967. A levee and pumping station with reversible pumps would be constructed in the conservation pool upstream of Millington to control water levels in the Great Swamp. In the event that water needs or water levels in the wildlife refuge area would be above or below the requirements, water would be discharged into, or borrowed from the conservation pool. The conservation pool would be cleared of all growth and the bottom would be excavated to elevation 218 feet mean sea level throughout, providing a minimum depth of seven feet to discourage aquatic growth and satisfy recreational needs.

153. Flood control storage for the design flood would be contained as surcharge storage above the conservation pool at elevation 225 feet mean sea level to an elevation of 228.0 feet mean sea level, 3.0 feet above the spillway level. This would provide 10,100 acre-feet of flood storage,

equal to 2.3 inches over the drainage area, and would reduce the design flood flow at Chatham from 6,180 cubic feet per second to 3,700 cubic feet per second. The conservation pool could be emptied with the gated conduits in 28 days. The maximum reservoir level for the spillway design flood would be elevation 232.4 feet mean sea level with an area of 7,500 acres and surcharge storage of 35,000 acre-feet above conservation pool level equal to 8.1 inches on the watershed. Diking of developed perimeter area and raising of road would be accomplished as required, Figure 4.

154. LOCAL PROTECTION ON RAMAPO RIVER AT OAKLAND, NEW JERSEY. The proposed plan would involve channel improvement on the Ramapo River extending from 2,500 feet upstream of Lenape Avenue to Pompton Lakes, in order to provide adequate protection to residential and recreational areas, Figures 21 and 22. The design discharge is equal to 20 percent in excess of the October 1903 flood and varies from 14,100 cubic feet per second at a point approximately 2,500 feet above Lenape Avenue, to 18,960 cubic feet per second at Pompton Lakes. The channel would be trapezoidal shaped with a 250-foot wide bottom with 1 on 3 side slopes. Bank elevations would be 3 feet above the design water surface. The improved channel would follow the existing channel for about 1.9 miles downstream of the limit. There, because of the meandering channel alignment and the recreational developments close to the stream banks, a new diversion channel would be constructed to Pompton Lakes. The improved channel would be adequate to carry the design flow within the banks of the stream except for the portion of the reach of improvement from the New York Susquehanna and Western Railroad downstream to Pompton Lakes, where land fill, levees, and walls would be required to raise the banks to closure to high ground at elevations ranging from elevation 208.4 feet mean sea level to elevation 214.0 feet. Minor closure levees would be necessary to prevent Pompton Lakes backwater from entering the adjacent built-up areas. At about 4,000 feet upstream of Pompton Lakes, a lake with swimming, beach and picnic areas would be relocated to preserve these recreational facilities, Figure 22. The existing channel from which the flood waters would be diverted between the points of diversion would be retained in its present condition by maintaining in it low water flow by the installation of a gated diversion structure where the diversion starts. Such a diversion would preserve whatever water rights that exist along the existing channel and would maintain the recreational benefits currently being derived. The existing channel would also provide a means of draining the adjacent built-up areas.

155. LOCAL PROTECTION ON THE MAHWAH RIVER AT MAHWAH, NEW JERSEY AND SUFFERN, NEW YORK. Local protection would be provided along the Mahwah River from its confluence with the Ramapo River to the Boulevard Bridge in Suffern, New York, Figure 23. The works would be continued along Masonicus Brook, a tributary of the Mahwah River, to include major plants of the American Brake Shoe Company. The works on the Mahwah River would consist of over one mile of channel relocation, deepening and widening to a 10-30 foot bottom width about 1,830 feet of concrete wall, 5,070 feet of levee and several ponding areas and appurtenant drainage works.

156. LOCAL PROTECTION ON SADDLE RIVER AT LODI, NEW JERSEY. The plan for flood control on the Saddle River would provide protection for a concentrated industrial and commercial area located on the left bank of the river between Passaic Street and State Highway Route 46 in the borough of Lodi, for a total length of about 4,000 feet, and for a commercial and residential area along a tributary stream entering the Saddle River about midway between the limits of the proposed improvement, Figure 24. On the right bank, except for a power plant which would experience only minor flooding under the design flood, the area in undeveloped. The improvement would afford protection against a flood of 7,000 cubic feet per second, equal to recurrence of the 1903 flood. It would involve channel relocation, levee and wall construction, and improvement of the tributary stream. The work would include 1,800 feet of channel excavation, 2,200 feet of earth levee and 1,350 feet of concrete wall, a 390 cubic feet per second pumping station and raising or removal of 7 bridges. The levees and walls would vary in elevation from 30.1 to 33.7, three feet above the design water surface. Bottoms of bridges would be 3 feet above the surface.

157. LOCAL PROTECTION ON MOLLY ANN'S BROOK AT HALEDON, NEW JERSEY. The plan for flood control on Molly Ann's Brook would provide protection for residential, commercial and industrial developments between West Broadway and Church Street in the borough of Haledon, for a total length of about 6,000 feet, Figure 25. The design flood is equal to 1,950 cubic feet per second. The works would include 3,100 feet of channel excavation, 2,900 feet of earth levee, 2,800 feet of concrete flume 30 feet wide, two pumping plants totaling 49.7 cubic feet per second capacity and raising or removal of 7 bridges. The tops of levees and walls would vary in elevation from 141.3 feet mean sea level and 177.6 feet mean sea level, three feet above the design water surface. Bottoms of bridges would be 3 feet above the surface.

158. LOCAL PROTECTION ON NAKOMA BROOK AT SLOATSBURG, NEW YORK. The plan of improvement on Nakoma Brook provides protection to a residential, commercial, and industrial area in the Village of Sloatsburg, New York. The improvement involves channel improvements, concrete flumes, levees and flood walls, and extends from Sterling Mine Road on the South Branch of Nakoma Brook and from Long Swamp on the North Branch downstream to the confluence of the two branches at Route 17, and thence downstream along the Main Branch of Nakoma Brook to its confluence with the Ramapo River, Figure 26. The improvement would afford protection against design discharges of 920 c.f.s. along the South Branch, 550 c.f.s. along the North Branch, and 1,470 c.f.s. along the Main Branch. The improved channel along the Main Branch would be a trapezoidal section with a 50 foot bottom width and side slopes of 1 on 2, and would extend from the new confluence of the North and South Branches (150 feet downstream of Route 17) to near its confluence with the Ramapo River, a distance of 2,860 feet. Concrete flumes totalling 3,040 feet in length would be provided along the North and South Branches. The flumes would be 12 feet wide on the North Branch, and 8 feet wide on the South Branch, and would average 7 feet deep on both branches.

159. LOCAL PROTECTION ON THE ROCKAWAY RIVER AT DENVILLE TOWNSHIP, NEW JERSEY. The plan of improvement on the Rockaway River provides protection to a concentrated residential and commercial area located in the Township of Denville, New Jersey, Figure 27. The improvement would afford protection against a design flood of 7,350 c.f.s. at Denville, equal to the October 1903 flood, the largest of record. The improvement would involve levees for 3,955 feet with an average height of 11.4 feet and flood walls for 5,710 feet with an average height of 11.7 feet. Three ponding areas would be constructed behind the levees at Gardner Field, at the downstream part of the improvement, and between U. S. Routes 46 and 80. Two pumping stations with capacities of 10 and 20 c.f.s. would be required for interior drainage.

160. RECONSTRUCTION OF DAMS AT LAKES DENMARK AND PICATINNY. The existing Lake Denmark and Picatinny Lake dams on small tributaries of the Rockaway River would be replaced by new structures with enlarged spillways to accommodate safely, but with minimum freeboard, the discharge of the maximum probable flood, Figure 28.

161. The existing Lake Denmark Dam would be replaced by a new concrete dam and spillway with a total length of about 575 feet, founded on rock. The non-overflow section would have a top width of five feet, and a top elevation of 828.0 feet mean sea level. A freeboard of 4.2 feet would be provided to the top of dam above a standard project inflow flood of 4,400 cubic feet per second. The spillway would be an ogee section located near the north end of the dam. It would be 100 feet long, and would have a crest elevation of 818.0 feet mean sea level, which is substantially the same as the elevation of the existing rock spillway. The five existing 72-inch pipes through the railroad and highway embankment downstream from the dam would be replaced by a new railroad and highway bridge which would span the spillway channel. Two 18-inch outlets with manually operated gates would be provided through the non-overflow section at the ends of the spillway. A section of the Wharton and Northern Railroad which crosses the proposed dam near the south abutment would require raising a maximum height of about three feet.

162. The existing Picatinny Lake Dam would be replaced by a new earth dam and concrete spillway having a total length of about 1,200 feet. The earth section would have a top width of 20 feet, side slopes of 1 on 3, a maximum height of 22 feet, and a top elevation of 725 feet mean sea level. The maximum water surface elevation for the standard project inflow flood of 5,400 cubic feet per second would be 717.5 feet mean sea level, corresponding to a freeboard of 7.5 feet to the top of dam. The spillway would be an ogee section located near the north end of the dam, and would be 125 feet in length with a crest elevation of 712.4 feet mean sea level. The new crest elevation is the same elevation as the top of the existing flash boards. A chute 87.5 feet long, a drop section 110 feet long with a drop of 16 feet, and a stilling basin 95 feet long, would be constructed with a uniform width of 125 feet. Two 24-inch pipe outlets with manually operated

gates would be provided through a short concrete non-overflow section at the south end of the spillway. A sheet pile cutoff would be provided in the foundation under the dam and spillway, and under the stilling basin sill to prevent detrimental underseepage. An existing highway bridge immediately downstream from the proposed stilling basin would be replaced by a new bridge with two 62.5-foot spans raised about nine feet above the existing roadway. A single track railroad and adjacent highway which parallel the north wall of the new spillway channel would be replaced on higher ground toward the north for a distance of about 1,800 feet.

163. MAJOR RELOCATIONS. The proposed plan encompassing reservoirs and channel improvements along some 66 miles of the Passaic River and 17 miles of its tributary streams would entail the relocation of several major highways, sewage treatment plants, trunk sewers and water supply aqueducts. Major relocations in Two Bridges Reservoir would include the raising of 5 miles of Interstate Route 80, 4.5 miles of Interstate Route 280, and 2.5 miles of U. S. Route 46, the relocation of approximately 4.7 miles of oil and gas transmission lines and the protection of 0.9 mile of the Jersey City Aqueduct which would underlie the conservation pool. In the Myers Road area approximately 4.7 miles of roadway and 7.0 miles of gas and oil transmission lines would require relocation. In addition, 4.6 miles of levees would be constructed to protect Interstate Route 78 from inundation in lieu of its raising. Relocations would also be required in the reaches of channel improvement among which the major items include the raising of several bridges and the relocation of the Jersey City Aqueduct near Nutley, New Jersey.

164. PROJECT OPERATION. The operation of the project would be such that the area along the Passaic River from Newark Bay to Osborn Pond in Bernards Township would be provided protection against the design flood by a combination of reservoir control and local protection works. Two Bridges Reservoir would be regulated during the design flood in a manner such that all gates controlling the inflow into the Passaic River diversion would remain open until a maximum discharge of 10,500 cubic feet per second is reached at Two Bridges from the combination of flow from the Passaic diversion channel and the spillway in the vicinity of Two Bridges. Upon approaching this maximum discharge, the gates controlling the diversion channel would be closed so that when the reservoir reaches a stage of 190.5 feet mean sea level the entire existing flow would be discharged over the spillway. Subsequently, when the flood pool starts to recede from its maximum stage of 191.4 feet, the outlets controlling the Passaic River diversion Channel would be opened to maintain a maximum flow of 10,500 c.f.s. when the flood pool reaches elevation 183.0 feet mean sea level, the entire flood detention pool upstream of the conservation dam would start to be discharged through the Passaic Diversion Channel.

165. The Two Bridges Reservoir would suppress the design flood of 53,000 cubic feet per second entering the reservoir to 10,500 cubic feet per second being discharged downstream of the dam. The local protection works downstream of the dam are designed to accommodate this exiting discharge in

addition to the drainage of the intervening area which would increase the design flow to 30,000 cubic feet per second at Newark Bay. Similarly, during the occurrence of the standard project flood the existing discharge from Two Bridges Reservoir and at Newark Bay would be almost identical to that of the design flood; however, a large difference in discharge between the two floods would occur in the vicinity of Dundee Dam where the discharge from the design flood would be 20,000 cubic feet per second and the standard project flood, 27,000 cubic feet per second. Myers Road reservoir would have an uncontrolled spillway and all suppression would be the result of surcharged storage. The design flood would be suppressed from 5,050 cubic feet per second entering the reservoir to 3,700 cubic feet per second at Chatham just upstream of Two Bridges reservoir. Similarly, during the standard project flood, the entering discharge of 8,100 cubic feet per second would be reduced to 5,250 cubic feet per second at Chatham.

XXII - MULTIPLE PURPOSE FEATURES

166. FLOOD CONTROL. The proposed plan would provide flood protection for the communities bordering the main stream downstream of Osborn Pond and along the Pompton River between Two Bridges and Pompton Lake Dam against a flood 20 percent in excess of the 1903 flood. The design flood of 39,800 cubic feet per second at Little Falls would be reduced to 12,600 cubic feet per second through reservoir regulation. Residual damage areas downstream of the dams would be protected by channel improvement, levees and walls. Local protection works would also provide flood protection against a flood 20 percent in excess of the 1903 flood in the communities of Oakland and Pompton Lakes, New Jersey on the Ramapo River and Mahwah, New Jersey and Suffern, New York on the Mahwah River. In addition, local protection work would provide flood protection against a flood equal in magnitude to the 1903 flood in the communities of Lodi, New Jersey on the Saddle River, Haledon and Prospect Park, New Jersey on Molly Ann's Brook, Sloatsburg, New York on Nakoma Brook and Denville, New Jersey on the Rockaway River.

167. HURRICANE PROTECTION. The improvements in the lower Passaic River would provide protection against tidal inundation for approximately 2,000 flood prone acres of land located downstream of Dundee Dam. The level of development of this protection would be at elevation 9.5 feet mean sea level which is one foot higher than that of the largest tide of record, 8.5 feet mean sea level which occurred during Hurricane Donna in September 1960. The level of this protection is considered sufficient to allow for a coincidental fluvial flow in the Passaic River of 30,000 cubic feet per second at Newark Bay. Pertinent data relating to this feature of the plan are contained in Appendix F, Flood Damages and Benefits.

168. WATER SUPPLY. Two Bridges Reservoir would impound 82,400 acre-feet of conservation storage from the flow of the Pompton River. The usable conservation storage of 68,600 acre-feet would provide a dependable yield of 100 million gallons a day of high quality water from municipal use. In addition, a dependable yield of 8 million gallons a day could be developed from 3 ground water aquifers which are contained in Troy, Black and

Hatfield Swamp Areas of Two Bridges Reservoir. Myers Road Reservoir would impound 23,900 acre-feet of conservation storage which would provide a dependable yield of 38 million gallons a day of good quality water for municipal use. Pertinent details on water supply are in Appendix E, Water Use.

169. The proposed plan of improvement would have no effect on the Pequannock River, Rockaway River, or the Wanaque-Ramapo systems. However, it would affect the Passaic Valley Water Commission's system and the system operated by the Commonwealth Water Company. Channel improvement of the Pompton River from Two Bridges upstream to Pompton Lakes would consist of deepening and widening the existing channel, thus affecting the Passaic Valley Water Commission's Point View Reservoir pumping station. This pumping station is located on the east bank of the existing channel in the vicinity of the confluence of the Pequannock and Pompton Rivers. The channel alignment would be adjusted so as not to interfere with the pumping station. However, the diversion and measuring weir acress the Pompton River and the intake sill to the pumping station would require replacement. This would be accomplished by the construction of a weir further upstream at a point just below the confluence of the Pequannock and Pompton Rivers, together with a raceway to convey the water to the pumping station.

170. Realignment and deepening of the Passaic River at Millburn and Florham Park would necessitate replacement and relocation of the river intakes and pumping stations of the Commonwealth Water Company. The new intake and pump station would be located on the right bank of the improved channel and the present pumping capacity facilities which contain provisions for expansion would be matched. The minimum regulated flow from the proposed Myers Road Reservoir would be adjusted so as to insure that the diversion rights of the Commonwealth Water Company would be maintained. The use of the dependable yield from Myers Road Reservoir would be predicated on the return of the water in the vicinity of diversion comparable in quality and quantity with the water withdrawn.

171. RECREATION. Recreational facilities would be provided at Myers Road and Two Bridges Reservoirs in the form of fishing, swimming, boating, picnicking and nature and wildlife study. In addition, Two Bridges Reservoir would be developed to provide an environmental center and hiking and camping sites with adequate trailer parking. One recreational site would be developed for water oriented uses and five sites for a combination of land and water oriented recreation in Two Bridges Reservoir. In Myers Road Reservoir, one site would be exclusively devoted to water oriented facilities, and two sites to land oriented facilities. All facilities in Myers Road and Two Bridges Reservoirs would be developed in conjunction with their construction. These facilities are estimated to be capable of accommodating an ultimate annual visitation of 2,850,000 one day outings. Details of the recreational features of the plan are contained in Appendix H, Recreation.

172. WATER QUALITY. The permanent pool at Myers Road would provide regulated dry season flows of 59 cubic feet per second on a sustained daily basis. The need for low flow augmentation is evidenced by the polluted

condition of the stream above Two Bridges from municipal and industrial wastes which receive minimal treatment and cause odors, turbidity, unsightly stagnated effluent, sludge deposits, and low dissolved oxygen content. The situation is most prevalent along the Whippany River where several large industrial facilities are located that affect the Passaic River downstream as far as Two Bridges. The regulated dry season flows would greatly improve the stream condition by reducing the deposits and odors and generally make the stream attractive for other uses. Details on water quality aspects are in Appendix E, Water Use.

173. MOSQUITO CONTROL. The proposed improvements would reclaim approximately 10,740 acres of existing swamp and meadow lands in the Central Basin. Of this total, approximately 3,300 acres located along the Passaic River between Myers Road and Chatham and along the Pompton River from Pompton Lakes to Two Bridges, would either be filled, or protected and drained. Some 7,440 acres of mosquito breeding grounds upstream of Myers Road and Two Bridges would be eliminated due to permanent inundation by the conservation pools. The area along the perimeter of the conservation pool would undergo a program of larvicide control. The remaining swamp and meadow lands that would be preserved in their natural conditions are situated along the Whippany and Rockaway Rivers within the limits of the reservoir and along the Passaic River between Chatham and Pine Brook. However, the stream in the flood detention portion of Two Bridges Reservoir would undergo clearing and snagging operations as well as selective widening and straightening to reduce the frequency of mosquito breeding floods of the marsh lands. Pertinent data concerning this feature of the plan are in Appendix E, Water Use.

174. LAND ENHANCEMENT. This plan of improvement, although utilizing much of the flood plain for flood detention and conservation storage, would enhance approximately 11,800 acres of land. Of this total, approximately 2,450 acres would be located downstream of Two Bridges with more than 50 percent concentrated along the reach of main stream between Two Bridges and Little Falls. In addition, approximately 1,510 acres of enhanced land would be situated along the reach of channel improvement and land filling works between Myers Road and Chatham. The remaining enhanced areas would generally be located along the Pompton River from Pompton Lakes to Two Bridges and along the Passaic River in the vicinity of Two Bridges and Warren Township. Details regarding the land enhancement features of the plan are discussed in Appendix F, Flood Damages and Benefits.

175. MAJOR DRAINAGE. The channel improvement and land filling and grading operations, in addition to the construction or reconstruction of drainage ditches in the areas protected by this plan would also affect the natural drainage pattern of these lands. These improvements would allow the protected flood plain lands to effectively transport rainfall into existing channels because of increased land slopes, in addition to reducing the moisture content of the soils. The deepened channel would also facilitate

ground water flow from these lands into the channel and effectively further lower the high ground water levels in the swamp and meadow lands. Pertinent data concerning this feature of the plan are contained in Appendices F, Flood Damages and Benefits, and E, Water Use.

176. FISH AND WILDLIFE. The elements of the plan that affect significant fish and wildlife resources of the existing area are Two Bridges and Myers Road Reservoirs. The effects on the resources of the Central Basin result in general increases of waterfowl habitat and warm water lake fisheries. Specifically, the plan would retain almost all of the Great Swamp in its natural form to be used as a wildlife preserve and for nature study purposes, in addition to making available approximately 700 acres of land adjacent to the Great Swamp National Wildlife Refuge to be preserved in its natural state, and provide for a warm water fishery in the Dead River area. With the exception of certain general recreational lands, the plan would further set aside the entire area within the Troy Meadows - Black Meadows for wildlife, waterfowl and additional hunting opportunities. An additional large warm water fishery would also be provided in the Great Piece Meadows for the development of warm water fishing opportunities in Two Bridges Reservoir.

177. The plan would effect certain losses in big game and upland hunting, fur animals harvested and trout and stream fisheries. As a means of retaining and enhancing wildlife value, certain changes have been incorporated into the plan, which would primarily consist of magnifying the Two Bridges and Myers Road Reservoirs to provide additional facilities for fishery, waterfowl and wildlife resources. This recommendation as it applies to the warm water fisheries created within Two Bridges and Myers Road Conservation pool, is for the incorporation of an initial fish control program and construction of suitable perimeter gradients, boat ramps, fishing piers, access and parking facilities. To maximize the waterfowl and wildlife resources within Two Bridges Reservoir, the lands in the Troy Meadows - Black Meadows Area, excluding those which may be reserved for intensive development of general recreation or for safe and efficient project operation, would be made available for wildlife management. In addition, to maximize the development of waterfowl resources in the Great Swamp area of Myers Road Reservoir, those lands on the west bank of the Passaic River, upstream of White Bridge Road in Bernards and Passaic Townships, except for that land administered by the Somerset County Park Commission, would be transferred to the United States Fish and Wildlife Service for administration, provided this usage does not interfere with the flowage rights necessary for long and short term storage. In addition, a levee and pumping station to be constructed within the conservation pool in the Great Swamp Area to control the water surface levels within the refuge, would also be administered by the Fish and Wildlife Service.

178. The plan would cause losses to warm and cold water stream fisheries and big and upland game because of improved channels and permanent inundation of about 7,600 acres of marsh and woodland by the conservation lakes.

Mitigation measures have been incorporated into the plan to replace these losses with similar resources in the same general area. The mitigation measures include the purchase of 2,700 acres of woodland adjacent to the Great Swamp National Wildlife refuge for big game and upland game habitat, the purchase of a 25 foot wide strip along the banks of the Ramapo River for 8.5 miles upstream from Pompton Lakes and along the Passaic River downstream of Myers Road dam for 1 mile, and the use of the banks of the Pompton and Passaic Rivers within the Two Bridges Reservoir for warm and cold water stream fishery resources. Pertinent data concerning mitigation measures and cost thereof are contained in Appendix G, Fish and Wildlife.

179. NAVIGATION. The channel improvement works in the Lower Passaic River would include deepening of the existing navigational project from an authorized project depth of 10 feet mean low water to a depth of 14.6 feet mean low water for a distance of approximately 7.5 miles between the Erie Lackawanna Bridge in Arlington and the Eighth Street Bridge in Passaic, New Jersey. This increase in depth would allow the use of greater capacity, deeper draft vessels, in addition to reducing the high tide waiting time for many vessels which now operate in this reach. Pertinent data concerning this feature is contained in Appendices D, Economic Base, and E, Water Use.

180. OPEN SPACE LAND CONSERVATION. The plan of improvement in the Central Basin would also make approximately 6,300 acres of flood detention lands available for open space land conservation use. These areas would consist generally of the meadow and swamp lands bordering the Passaic River from Chatham to Pine Brook and along the Whippany and Rockaway Rivers, which would not be utilized for general recreation purposes. These lands within the reservoir are estimated to provide a net increase of 3,070 acres to the land already utilized for this purpose under the State of New Jersey's Green Acre Open Space Land Conservation Program, Phase I, which was completed in January 1968. Pertinent data relating to this feature of plan of improvement are discussed in detail in Appendix J, Project Formulation.

XXIII - ESTIMATE OF FIRST COST

181. BASIS OF ESTIMATE. The estimated first cost of the selected basin plan is summarized in Table 16. The first cost includes such items as: lands and damages; relocations; dams; fish and wildlife and recreational facilities; reconstruction of roads, railroads and bridges; channel improvement; levee and floodwalls; contingencies; engineering and design; and supervision and administration. The contingency allowance which was used in estimates of cost for construction and relocation features of the considered plans of improvement was 20 percent of the estimated direct construction costs. Contingency allowance used for real estate and damage separation for lands and structures varied between 10 and 15 percent. The costs for engineering and design are generally 8 percent of the construction cost, excluding lands, but vary with the nature and magnitude of the improvement. The costs for inspection, supervision, administration and over-

TABLE 16 - ESTIMATE OF FIRST COST
(In dollars and January 1970 price levels)

Cost Item	Main Stream and associated works (a)	Ramapo River at Oakland New Jersey	Mahwah River at Mahwah, New Jersey and Suffern, New York	Molly Ann's Brook at Haledon, New Jersey	Saddle River at Lodi, New Jersey	Nakoma Brook at Sloatsburg, New York	Rockaway River at Denville, New Jersey	Lake Denmark and Picatinny Lake
Lands and damages	206,650,000	680,000	310,000	420,000	300,000	80,000	130,000	-
Relocations	102,250,000	4,770,000	80,000	870,000	760,000	90,000	20,000	570,000
Reservoirs	55,620,000	-	-	-	-	-	-	-
Dams	99,600,000	-	-	480,000	-	-	-	3,750,000
Fish and wildlife facilities	2,290,000	-	-	-	-	-	-	-
Roads, railroads and bridges	450,000	-	-	-	-	-	-	-
Channels and canals	41,970,000	3,600,000	220,000	1,500,000	190,000	1,130,000	-	-
Levees and floodwalls	142,030,000	1,150,000	1,670,000	1,240,000	1,380,000	190,000	3,930,000	-
Pumping plants	25,660,000	440,000	30,000	1,200,000	1,000,000	-	90,000	-
Recreation facilities	10,300,000	-	-	-	-	-	-	-
Floodway control and diversion structures	17,410,000	-	-	-	-	-	-	-
Advanced waste water treatment	6,260,000	-	-	-	-	-	-	-
Mitigation measures	10,300,000	190,000	-	-	-	-	-	-
TOTAL	$720,810,000	10,830,000	2,310,000	5,710,000	3,630,000	1,490,000	4,230,000	4,320,000

(a) Improvements consist of all work on Passaic River from Newark Bay to Osborn Road and portions of work associated with Two Bridges Reservoir on Pompton, Rockaway and Whippany Rivers.

head are taken generally at 8 percent of the construction cost plus the engineering and design costs. The administration and supervision cost for real estate were generally taken as 10 percent of the construction cost. The total estimated first cost, based on January 1970 price levels, is presented in Table 16.

XXIV - ESTIMATE OF ANNUAL CHARGES

182. BASIS OF ESTIMATE. The estimate of annual charges is shown in Table 17. It is 5-3/8 percent on total investment costs, comprised of the first cost and interest during construction. Charges for amortization of the various structures are based on a life expectancy of 100 years, except for the reconstruction of Picatinny and Denmark Lake Dams which are computed on a 50 year life of structures. Where length of construction is less than 2 years, there was assumed to be no interest during construction. Consideration was given to tax losses resulting from the acquisition of land in the studied reservoir sites; however, it is considered that the increase in taxes from the areas enhanced and the lands and structures protected would more than balance those losses as demonstrated in Appendix J, Project Formulation. The total estimated annual charges are $51,822,000 based on January 1970 price levels.

XXV - ESTIMATE OF BENEFITS

183. TOTAL BENEFITS. The average annual tangible benefits that would be derived from the proposed plans are estimated at $61,326,000, as broken down in Table 18. In addition, annual benefits estimated at $1,725,000 would accrue to the proposed plan in the category of area redevelopment. An explanation of the bases for the benefit determinations is contained in the subsequent paragraphs.

184. FLOOD CONTROL. Benefits for flood control are the estimated average annual damages that would be prevented over the 100 year assumed life of the project. The estimate allows for increases in the value of damageable assets in currently developed flood plain areas and for future development in currently undeveloped flood areas that would occur without protection. Fluvial benefits are separated from tidal benefits due to the different cost-sharing procedures that apply to these purposes.

185. WATER SUPPLY AND WATER QUALITY. Benefits for water supply are equal to the average annual cost of producing the same yield as the proposed plan by the most likely alternative means. Similarly, for water quality, the benefits are equal to the average annual cost of the most likely alternative means of upgrading river quality to the same extent as the proposed plan.

186. RECREATION AND FISH AND WILDLIFE. These benefits are the value of the new and enhanced facilities that are part of the proposed plan as expressed by the product of the number of users of the facilities over the project life and the amount that they would be willing to pay for such use, reduced to average annual terms.

TABLE 17 - ESTIMATES OF ANNUAL CHARGES
(In dollars and January 1970 price levels)

Cost Item	Main Stream and associated works (a)	Ramapo River at Oakland, New Jersey (b)	Mahwah River at Mahwah, New Jersey and Suffern, New York	Molly Ann's Brook at Haledon, New Jersey	Saddle River at Lodi, New Jersey	Nakomm Brook at Sloatsburg, New York	Rockaway River at Denville, New Jersey	Lake Denmark and Picatinny Lake
Investment								
First cost	720,810,000	10,830,000	2,310,000	5,710,000	3,630,000	1,490,000	4,230,000	4,320,000
Interest during construction	100,820,000	-	-	-	-	-	-	-
Total investment	821,630,000	10,830,000	2,310,000	5,710,000	3,630,000	1,490,000	4,230,000	4,320,000
Annual charges								
Interest	44,165,000	582,000	124,000	303,000	196,000	81,000	227,000	232,000
Amortization	236,000	3,000	1,000	1,000	1,000	-	1,000	1,000
Operations and maintenance	3,278,000	34,000	21,000	60,000	42,000	4,000	8,000	24,000
Major replacements	574,000	4,000	1,000	17,000	14,000	-	2,000	-
Lost land productivity	1,580,000	-	-	-	-	-	-	-
Total annual charges	49,833,000	623,000	147,000	386,000	253,000	85,000	238,000	257,000

(a) Includes costs for mitigation measures and advanced waste water treatment.
(b) Includes costs for mitigation measures.

TABLE 18 - ESTIMATES OF BENEFITS

Improvement	Annual Benefits
Mainstream and associated works	
Flood protection, fluvial	$36,221,000
Flood protection, tidal	3,058,000
Water supply	6,310,000
Water quality	2,758,000
Recreation	3,566,000
Fish and wildlife	827,000
Major drainage	367,000
Land enhancement	2,951,000
Vector control	744,000
Advanced replacement of facilities	383,000
Navigation	389,000
Subtotal	$57,574,000
Ramapo River	
Flood protection, fluvial	$ 1,712,000
Major drainage	16,000
Land enhancement	25,000
Advanced replacement of facilities	23,000
Subtotal	$ 1,776,000
Mahwah River at Suffern, New York and Mahwah, New Jersey	
Flood protection, fluvial	$ 219,000
Molly Ann's Brook at Haledon, New Jersey	
Flood protection, fluvial	$ 809,000
Saddle River at Lodi, New Jersey	
Flood protection, fluvial	$ 381,000
Nakoma Brook at Sloatsburg, New York	
Flood protection, fluvial	$ 125,000
Rockaway River at Denville, New Jersey	
Flood protection, fluvial	$ 442,000
TOTAL	$61,326,000

187. NAVIGATION. Benefits are equal to the average annual saving resulting from more economical transportation brought about by the deeper navigation channel. They were estimated on the basis of the number of vessel trips needed to transport quantities of goods and the reduced waiting time for high tide.

188. MOSQUITO CONTROL. Benefits are equal to the estimated average annual cost of the alternative control measures that would have to be used to effect the same degree of protection as the proposed plan.

189. MAJOR DRAINAGE. Benefits are equal to the reduction of average annual damages caused by standing water and high soil moisture content to structures and public health consideration.

190. ADVANCED REPLACEMENT OF EXISTING FACILITIES. Benefits are equal to the average annual value of extending the useful lives of structures, such as bridges, and any associated reductions in the cost of maintaining these facilities.

191. LAND ENHANCEMENT. Where flood protection by the proposed plan would result in a higher utilization of land, the increased value expressed in average annual terms, is the land enhancement benefit.

192. OTHER BENEFITS. There are other monetarily evaluable benefits that are not included as direct project benefits, but would have an impact on the region. These are in the form of an increase in the net tax gain due to the increased land values in the Lower Valley and Central Basin, revitalization of the flooded area and recoverable depreciation of property, and benefits for providing employment and strengthening the economy of the area. Detailed discussions are in Appendices D, Economic Base, and J, Project Formulation.

193. INTANGIBLE BENEFITS. These are benefits that cannot be expressed in monetary terms, but which are real and must be considered in project evaluation. The proposed plan would benefit the public welfare by decreasing the hazard to life, the possibility of flood-induced unsanitary conditions and general inconvenience brought about when floods cause evacuations and disruption to the community, which is currently a frequent occurrence in the Passaic River basin. In addition, the two new lakes and the improved channels would add aesthetically to the environment in the area. The elimination of mosquito breeding grounds would measurable add to the economic value of surrounding areas and improve the general health and environment of the area.

XXVI - ECONOMIC EVALUATION

194. BENEFIT-COST RATIO. The total average annual cost of all components of the proposed basin plan are $51,822,000 and the total annual tangible benefits are $61,326,000. The resulting benefit-cost ratio is 1.2, indi-

cating that the plan is economically justified. A breakdown of annual benefits, annual charges, benefit-cost ratio and excess benefits is contained in Table 19 by individual plan components. The plan would also provide $1,725,000 in area Redevelopment Benefits annually. Including the Area Redevelopment Benefits in the economic comparison would yield a benefit-cost ratio of 1.22 for the proposed plan.

XXVII - PROPOSED LOCAL COOPERATION

195. GENERAL. Federal laws on flood control and water resource improvements require that local interests furnish assurances of cooperation prior to implementation of a plan of improvement by the Government. In the proposed plan, the United States would acquire the reservoir lands, design and construct all the works and operate and maintain the dams and reservoirs. Local interests would agree to items of cooperation that vary with respect to reservoirs and local protection facilities.

196. RESERVOIRS. The items of cooperation required of local interests for the two reservoirs of the proposed plan are that they:

a. Pay all costs allocated to water supply.

b. Pay half the cost of facilities for fish and wildlife and recreation in the plan and all costs of operation and maintenance.

c. Pay half the cost allocated to major drainage and operate and maintain the associated works.

d. Maintain all roads and utilities that are changed or relocated because of the dams and reservoirs.

197. LOCAL PROTECTION. Additional items of cooperation for local protection works would be that local interests:

a. Provide all lands, easements and rights-of-way.

b. Hold the United States free from damages.

c. Operate and maintain the completed works.

d. Prevent any actions that would prevent proper functioning of the works.

e. Provide all necessary relocations as required.

f. Pay at least 30 percent of the cost allocated to hurricane protection, which includes items a through e above.

g. Provide depths in navigation berthing areas commensurate with depth of the improved channel.

TABLE 19 - ECONOMIC EVALUATION OF PROPOSED IMPROVEMENTS
(January 1970 prices)

Improvement	Annual Benefits (dollars)	Annual Charges (dollars)	Benefit Cost Ratio	Excess Benefits (dollars)
Mainstream and associated works	57,574,000	49,833,000	1.2	7,741,000
Ramapo River	1,776,000	623,000	2.9	1,153,000
Mahwah River at Mahwah, New Jersey and Suffern, New York	219,000	147,000	1.5	72,000
Molly Ann's Brook at Haledon, New Jersey	809,000	386,000	2.1	423,000
Saddle River at Lodi, New Jersey	381,000	253,000	1.5	128,000
Nakoma Brook at Sloatsburg, New York	125,000	85,000	1.5	40,000
Rockaway River at Denville, New Jersey	442,000	238,000	1.9	204,000
Total(a)	61,326,000	51,565,000	1.2	9,761,000

(a) Excludes the costs for reconstruction of Picatinny and Denmark Lake Dams which is estimated at a first cost of $4,320,000 and annual charges of $257,000.

198. LOCAL INTENT. New Jersey. By letter of 19 November 1969, Governor Richard J. Hughes of New Jersey expressed his support of Plan III as the best plan and the intent of the State of New Jersey to provide the items of local cooperation in accordance with the requirements for Federal water resources improvements. He requested that every effort be extended to expedite all phases of the plan to permit authorization of Plan III and funding by Congress at the earliest possible date. By letter dated 4 May 1971, Governor William T. Cahill requested that this report be expedited so that the State of New Jersey could make its final comment on the proposed plan.

199. New York. The New York State Conservation Department, by letter dated 15 September 1969, indicated support of the proposed plans of improvement for the Villages of Suffern, and Hillburn, New York, and indicated the intent of the State of New York to provide the items of local cooperation, in accordance with the requirements for Federal flood protection improvements. The Commissioner further requested that every effort be extended to expedite the processing of this report to permit authorization of these improvements and funding by Congress at the earliest possible date. By letter dated 4 November 1971, the New York State Department of Environmental Conservation indicated support of the proposed plans of improvement for the Village of Sloatsburg, New York, and indicated the intent of the State of New York to provide the items of local cooperation, in accordance with the requirements for Federal flood protection improvements.

XXVIII - ALLOCATION OF COSTS

200. COST ALLOCATION. Project costs are allocated among the project purposes to provide a basis for applying Federal cost-sharing policies that are appropriate for each purpose. The separable cost-remaining benefit method was used in developing the allocation which is presented in Table 20 and discussed in detail in Appendix K, Allocation of Costs and Cost Sharing.

XXIX - APPORTIONMENT OF COSTS

201. GENERAL. The sharing of project cost between Federal and non-Federal costs differs for the various project purposes. The formula for each purpose as prescribed by Federal law was applied to the allocated costs to arrive at the cost sharing arrangement shown in Table 21. Details including options available to non-Federal interests for payment are discussed in Appendix K, Allocation of Costs and Cost Sharing. Following are descriptions of the formulas applied.

202. FLUVIAL FLOOD CONTROL. Based on the Flood Control Act of 1936, flood control costs associated with dams and reservoirs are entirely Federal, except for maintenance of raised roads and relocated utilities. For channel works, local interests provide land, easements, rights-of-way, relocations and operation and maintenance.

TABLE 20 - ALLOCATION OF COSTS AMONG PURPOSES
(In dollars and January 1970 prices)

Improvement and Purpose	First Cost	Annual Operation, Maintenance and Replacement Charges
Mainstream and associated works		
Flood control	491,870,000	2,031,000
Hurricane protection	18,430,000	82,000
Navigation	4,940,000	15,000
Major Drainage	9,450,000	27,000
Water supply	94,530,000	621,000
Water quality	44,520,000	203,000
Recreation	44,900,000	768,000
Fish and wildlife	12,170,000	105,000
Subtotal	720,810,000	3,852,000
Local Protection[a]		
Ramapo River	10,830,000	38,000
Rockaway River at Denville, New Jersey	4,230,000	10,000
Mahwah River at Mahwah, New Jersey and Suffern, New York	2,310,000	22,000
Saddle River at Lodi, New Jersey	3,630,000	56,000
Molly Ann's Brook at Haledon, New Jersey	5,710,000	77,000
Nakoma Brook at Sloatsburg, New York	1,490,000	4,000
Picatinny and Denmark Lake Dams, New Jersey	4,320,000	24,000
Subtotal	32,520,000	231,000
TOTAL	753,330,000	4,083,000

(a) All cost associated with the local protection improvements are allocated to flood control.

TABLE 21 - APPORTIONMENT OF COSTS FOR ENTIRE PLAN
(In dollars and January 1970 prices)

Reach	First Cost			Annual Operation, Maintenance and Replacement Costs	
	Total	Federal	Non-Federal	Federal	Non-Federal
Mainstream and associated works					
Flood Control	491,870,000	455,625,000	36,245,000	1,565,000	466,000
Hurricane Protection	18,430,000	12,650,000	5,780,000	--	82,000
Navigation	4,940,000	540,000	4,400,000	15,000	--
Water supply	94,530,000	--	94,530,000	--	621,000
Water quality	44,520,000	44,520,000	--	203,000	--
Recreation	44,900,000	36,380,000	8,520,000	--	768,000
Fish and wildlife	12,170,000	11,060,000	1,110,000	3,000	102,000
Major drainage	9,450,000	4,205,000	5,245,000	--	27,000
Subtotal	720,810,000	564,980,000	155,830,000	1,786,000	2,066,000
Local Protection					
Ramapo River	10,830,000	6,290,000	4,540,000	--	38,000
Mahwah River at Suffern, New York and Mahwah, New Jersey	2,310,000	1,920,000	390,000(a)	--	22,000(b)
Molly Ann's Brook at Haledon, New Jersey	5,710,000	4,460,000	1,250,000	--	77,000
Saddle River at Lodi, New Jersey	3,630,000	2,820,000	810,000	--	56,000
Nakoma Brook at Sloatsburg, New York	1,490,000	1,330,000	160,000	--	4,000
Rockaway River at Denville, New Jersey	4,230,000	4,080,000	150,000	--	10,000
Lake Denmark and Picatinny Lake, New Jersey	4,320,000	4,320,000	--	24,000	--
TOTAL	753,330,000	590,200,000	163,130,000	1,810,000	2,273,000

(a) First costs of $390,000 are apportioned as $305,000 to New Jersey and $85,000 to New York.
(b) Annual charges of $22,000 for maintenance, operation, and replacements are apportioned $17,000 to New Jersey and $5,000 to New York.

TABLE 21A - APPORTIONMENT OF COSTS FOR TWO BRIDGES AND MYERS ROAD RESERVOIRS
(In dollars and January 1970 prices)

Reservoir	First Cost			Annual Maintenance, Operation & Replacements	
	Total	Federal	Non-Federal	Federal	Non-Federal
Two Bridges Reservoir					
Flood Control	407,450,000	407,450,000	--	1,542,000	18,000
Recreation	27,030,000	22,730,000	4,300,000	--	432,000
Water Supply	74,600,000	--	74,600,000	--	43,000
Water Quality	4,360,000	4,360,000	--	2,000	--
Fish and Wildlife	7,290,000	6,610,000	680,000	--	52,000
Major Drainage	7,200,000	3,600,000	3,600,000	--	5,000
Subtotal	527,930,000	444,750,000	83,180,000	1,544,000	550,000
Myers Road Reservoir					
Flood Control	5,830,000	5,830,000	--	23,000	1,000
Recreation	17,870,000	13,650,000	4,220,000	--	336,000
Water Supply	19,930,000	--	19,930,000	--	578,000
Water Quality	40,160,000	40,160,000	--	201,000	--
Fish and Wildlife	4,880,000	4,450,000	430,000	3,000	50,000
Subtotal	88,670,000	64,090,000	24,580,000	227,000	965,000
Total	616,600,000	508,840,000	107,760,000	1,771,000	1,515,000

TABLE 21B - APPORTIONMENT OF COSTS FOR MAIN STREAM REACHES EXCLUDING RESERVOIRS
(In dollars and January 1970 prices)

Reach	First Cost			Annual Maintenance, Operation & Replacements	
	Total	Federal	Non-Federal	Federal	Non-Federal
Newark Bay to Dundee Dam					
Flood Control	38,630,000	22,470,000	16,160,000	--	127,000
Hurricane Control	18,430,000	12,650,000	5,780,000	--	82,000
Navigation	4,940,000	540,000	4,400,000	15,000	--
Subtotal	62,000,000	35,660,000	26,340,000	15,000	209,000
Dundee Dam to Beatties Dam					
Flood Control	26,310,000	8,400,000	17,910,000	--	213,000
Beatties Dam to Two Bridges					
Flood Control	2,490,000	2,110,000	380,000	--	53,000
Major Drainage	1,010,000	510,000	500,000	--	18,000
Subtotal	3,500,000	2,620,000	880,000	--	71,000
Mile 51.0 to Mile 61.9					
Flood Control	11,160,000	9,365,000	1,795,000	--	54,000
Major Drainage	1,240,000	95,000	1,145,000	--	4,000
Subtotal	12,400,000	9,460,000	2,940,000	--	58,000
Total	104,210,000	56,140,000	48,070,000	15,000	551,000

203. TIDAL FLOOD CONTROL. In accordance with the Flood Control Act of 1958, local interests must pay at least 30 percent of the allocated cost for this purpose; this cost would include the lands, easements, rights-of-way and relocations and any cash contribution necessary to meet the 30 percent minimum participation level.

204. WATER SUPPLY. In accordance with the Water Supply Act of 1958, all costs allocated to water supply storage would be charged to non-Federal interests.

205. WATER QUALITY. The Federal Water Pollution Control Act of 1956 permits reservoir storage in Federal reservoirs for water quality if it is not in lieu of adequate local waste treatment. Because of the widespread nature of this benefit, the cost allocated to water quality control would be entirely Federal.

206. RECREATION AND FISH AND WILDLIFE. The basis for cost sharing is the Federal Water Project Recreation Act of 1965, which stipulates the Federal and non-Federal interests will share equally the cost of including these purposes as a project purpose, while the Federal Government will pay the entire cost of facilities that are used jointly with other purposes as well. Operation and maintenance of recreation and fish and wildlife facilities would be a non-Federal responsibility. All cost associated with recreation or fish and wildlife areas administered by Federal interests are considered to be Federal.

207. NAVIGATION. In accordance with established Federal policy, non-Federal interests would provide the maintenance of berthing areas adjacent to the deepened channel, while all other costs associated with the works are considered Federal.

208. MAJOR DRAINAGE. Costs would be shared equally between Federal and non-Federal interests on the basis that improvements to drainage are equally beneficial to the local area and the nation. The 50 percent local share includes lands, easements, rights-of-way, and relocations. Operation and maintenance would also be local.

XXX - COORDINATION WITH OTHER AGENCIES

209. FEDERAL AGENCIES. Evaluations of the basin's needs and the proposed plan of improvement were coordinated with Federal agencies in order to insure that there would be no conflicts with their plans or activities. As a result of this coordination, several reports on the resources of the basin were prepared by various Federal agencies, in addition to their review of the proposed plans. The plan of improvement was coordinated with the Soil Conservation Service, Department of Agriculture, Federal Power Commission, Environmental Protection Agency, Department of Housing and Urban Development, Fish and Wildlife Service, National Park Service, Bureau of Outdoor Recreation, Geological Survey, Department of the Interior, and Federal Highway Administration.

210. LOCAL INTERESTS. Coordination with local interests was effected throughout the study. Recent coordination included a series of meetings to which the mayors, planning board chairmen and municipal engineers of over 50 communities and 8 counties affected by the plan were invited as well as representatives of the appropriate agencies of the States of New Jersey and New York. In addition, numerous public and private meetings were conducted with representatives of environmental and conservation groups, municipal planning boards and councils, citizens, business and civil defense organizations, as well as with concerned individuals. Primary agencies of state coordination have been the New Jersey Department of Environmental Protection, formerly the Department of Conservation and Economic Development, and the New York Department of Environmental Conservation, formerly the Department of Conservation.

211. In compliance with the Bureau of the Budget Circular A-95, coordination has also been effected with Tri-State Transportation Commission, which is the metropolitan clearing house for review of Federal grants in aid in Northern New Jersey. Coordination in compliance with their circular on a state level was effected with the Division of State and Regional Planning, New Jersey Department of Community Affairs.

XXXI - DISCUSSION

212. GENERAL. The findings of the Passaic River study are based on consideration of the water-related problems and needs and the available alternatives.

213. PROBLEMS. The Passaic River basin is the most serious flood problem area in New Jersey. The average equivalent annual damages expected over the period from 1985 to 2085 are estimated at $53,052,000 and the past history of fatalities indicates that no abatement of danger to life can be expected without some protection facilities. In recent years there has been intensive development of all kinds in flood plain areas, continually increasing the flood damage potential.

214. No less an important problem in the basin as well as in contiguous areas is that of the future water supply. The area affected is the most heavily developed portion of New Jersey, which is the most urbanized state in the nation. The continuing population growth, and the accompanying need for supporting economic activities indicates a need for facilities to provide 1,060 additional million gallons per day by 2035, beyond those that either exist or are firmly planned for. There are several areas where growth is even now inhibited by lack of assured water supply. Emergency conditions existed during the drought of 1961 to 1965 when numerous measures were taken to alleviate the problem, such as prohibition on certain uses, diversion of water from recreation lakes and investigation of possible new ground water supplies.

215. The need for new water-oriented recreation facilities is demonstrated by the failure of new facility development to keep pace with recreation

growth, which in recent years has been four times as rapid. At present, the available opportunities for water recreation in comparison to population is severely lacking in Northern New Jersey. The current trend of higher income, more leisure time and greater mobility is expected to aggravate the problem in the coming years. Similar considerations, in combination with the current trends of development of existing wet land, also demonstrate the need for enhancement of existing, and creation of new fish and wildlife resources.

216. The Passaic River has been publicized as one of the 10 most polluted rivers in the United States. Extensive new treatment facilities will be required to bring the river up to the desirable standards promulgated by the State of New Jersey. Even with such facilities, a need will still exist for certain amounts of fresh water to supplement low flows during the dryer months of the year, and the possible rearrangement of several existing waste water treatment and effluent discharge systems. Since improved water quality is a critical factor in the improvement of the environmental quality of life in the study area, a basin wide approach to waste water management is necessary for the optimum use of resources to enhance water quality.

217. Among the other of the basin's water related needs are: additional land for beneficial development for residential and other uses to accommodate the continually growing population; the elimination of mosquito breeding areas; improved drainage in developed areas; and more economical water transportation of commodities.

218. AVAILABLE ALTERNATIVES. There are numerous alternative means of meeting, to various extents, the water needs of the area. Through the many years of study, all reasonable possibilities have been examined. With regard to control of flooding from fluvial sources, detailed consideration has been given to detention basins, tunnel diversions, channel improvements, levees and walls, preservation of flood plain lands and non-structural protection, not only to serve the sole purpose of flood control, but as a component of multiple purpose plans to meet other needs as well. Tidal flooding was considered in conjunction with such works. Furthermore, in the formulation of a plan, alternative improvements to meet these other needs were evaluated, including water supply and quality, recreation and fish and wildlife, drainage, mosquito control, and navigation. The primary finding of these investigations was that multiple purpose development, which permits several purposes to share in the cost of construction, is the most economical way of responding to the basin's needs. Subsequent investigations were conducted with a view to determining in precise terms the scope of such a project. In doing this, alternatives were developed based on common criteria for flood control, and emphasis was placed on different aspects of development. For example, Plan I emphasized the reclamation of swampland for new development, Plan II emphasized economy by limiting the major storage facility to flood detention only, Plan III was designed to provide a balance of conservation storage and flood storage, and Plan IV emphasized conservation storage by providing for its maximum development.

Throughout the studies, thorough coordination was effected with interested Federal and State agencies, especially the New Jersey Department of Conservation and Economic Development, now the Department of Environmental Protection. The work of these agencies and their views were incorporated to the maximum extent possible. It was found that Plan III, with the basic criterion of flood protection in the main stream against a flood 20 percent greater than the 1903 flood of record, along with a local protection works in several tributaries, offers the most economically desirable approach to alleviating the basin water resource problems. The total first cost of this plan is $753,330,000 at January 1970 price levels. The average annual costs are $51,822,000, which compared to the total average annual benefits of $61,326,000 results in a benefit-cost ratio of 1.2 and annual excess benefits of $9,761,000. Implementation of the proposed plan would also provide $1,725,000 annually in area redevelopment benefits as presented in Appendix D, Economic Base Study. Inclusion of these benefits in the economic analysis would yield a benefit-cost ratio of 1.22 and annual excess benefits of $11,486,000.

219. SMALL PROJECTS. There have been several requests by local interests for consideration of small flood control projects under the authority of the Flood Control Act of 1948, as amended. Such projects permit construction without specific Congressional authorization if the Federal cost is no more than $1,000,000, they are economically feasible, and local interests furnish the necessary items of local cooperation. Currently, consideration is being given to small projects at the Township of Mahwah, New Jersey, and the Village of Suffern, New York. In addition, studies under this authority have been requested by the Cities of East Orange and Clifton, the Boroughs of Bernardsville, East Paterson and Saddle River, and the Towns of Nutley, Little Falls, Bloomfield, Belleville and Montville. It is considered that these investigations will be undertaken in calendar years 1972 and 1973. The investigations for Mahwah and Suffern involve works that are physically independent of improvements at these localities discussed elsewhere in this report.

220. FLOOD PLAIN MANAGEMENT. While the possibility of flood damage alleviation by means other than river improvement works were investigated, this approach was found not to be sufficiently effective to warrant general application throughout the basin. However, such non-structural measures should be applied in those areas where the damages are not sufficiently severe to make river work feasible and where there is still time to take the necessary non-structural measures. These measures consist primarily of flood proofing structures subject to damage, regulation of undeveloped land to exclude development incompatible with occasional flooding, and relocation, where possible, of damage-prone structures out of the flood plain. As an aid to local interests in applying these measures, pertinent technical data for the Passaic River tributaries developed in connection with determining the best plan of improvement are presented in Appendix L, Flood Plain Management.

221. LOCAL COOPERATION. Support for the proposed plan was communicated by former Governor Richard J. Hughes in a letter dated 19 November 1969 to the District Engineer, who expressed his preference for Plan III, and the intent of the State to furnish the required item of local cooperation. He requested that every effort be made to expedite all phases of the report to permit authorization of Plan III and funding by Congress at the earliest possible date. By letter dated 4 May 1971, Governor William T. Cahill expressed his desire for expeditious completion of this report. A similar letter was received from Commissioner Henry L. Diamond of the New York State Department of Environmental Conservation on 15 September 1969 expressing the state's support of the plans of improvement and its intent to provide the necessary items of local cooperation.

222. LAND ACQUISITION. In view of the urgent nature of the problems that the proposed plan is designed to meet and of the continuing threat of preemption of the proposed reservoir lands for other uses resulting ultimately in higher project costs, it is considered advisable that the most immediate action possible be taken to acquire the lands needed for the proposed dams and reservoirs. It would therefore be appropriate for Congress to consider the appropriation of funds for land acquisition of these elements concurrently with its consideration of authorization of the project recommended in this report.

XXXII - CONCLUSIONS

223. CONCLUSIONS. The conclusion of this study is that Plan III, as described in Section XXI, consisting of two multiple purpose reservoirs and associated channel works on the Passaic and Pompton Rivers, along with local protection works along certain tributaries, should be recommended for Congressional authorization. This is based on the favorable benefit cost ratio of 1.2 and the local intent to cooperate as expressed by the Governor of New Jersey. It is also concluded that the urgency of the plan warrants consideration for the earliest possible reservoir land acquisition to preclude excessive cost increases that would jeopardize the feasibility of the plan.

XXXIII - RECOMMENDATIONS

224. RECOMMENDATIONS. It is recommended that:

a. Congress authorize two multiple purpose reservoirs on the Passaic River, diversions of the Passaic and Pompton Rivers, channel improvement and local protection works on the Passaic and Pompton Rivers: tributary local protection flood control works on Molly Ann's Brook at Haledon, New Jersey; Saddle River at Lodi, New Jersey; Ramapo River at Oakland, New Jersey; Mahwah River at Suffern, New York and Mahwah, New Jersey; Rockaway River at Denville, New Jersey, Nakoma Brook at Sloatsburg, New York; and the reconstruction of the Federally-owned dams at Lake Denmark and Picatinny

Lake at Picatinny Arsenal, New Jersey; all with such modifications as the Chief of Engineers may consider advisable; and at a total estimated first cost to the United States of $590,200,000 and annual operation, maintenance and replacement costs of $1,810,000.

b. Concurrent with authorization of the recommended plan, Congress authorize immediate detailed investigations for accurate definition of the project reservoir lands required and the acquisition of such immediately upon such determination to preclude incompatible uses.

c. No funds be expended by the United States on the recommended plan unless local interests give assurances satisfactory to the Secretary of the Army that they will meet the following items of local cooperation.

(1) For the dams and reservoirs;

-Repay all costs allocated to water supply presently estimated at $94,530,000 for construction and $621,000 annually for operation, maintenance, and major replacements, all in accordance with the Water Supply Act of 1958 as amended;

-Agree to preserve the integrity of water quality releases from the Myers Road Reservoir by returning to the Passaic River undiminished in quantity and quality all withdrawals made for water supply and further construct, maintain and operate waste water treatment works for this purpose;

-Agree to administer project land and water areas for recreation and fish and wildlife;

-Pay one half of the separable costs of lands and facilities for recreation and fish and wildlife presently estimated at $9,630,000 for construction and all costs for operation, maintenance, and replacements thereof presently estimated at $870,000 annually;

-Pay one half the total allocated cost of construction for major drainage, presently estimated at $3,600,000;

-Agree to administer project lands and operate facilities required for major drainage improvements currently estimated at $5,000 annually;

-Maintain all facilities that are changed or relocated because of the reservoir flood control and conservation pools. These costs are currently estimated at $19,000 annually for the flood control pool and are included within the maintenance costs of recreation, water supply and fish and wildlife for the conservation pool.

(2) In addition, for local protection work;

- Provide all lands, easements and rights-of-way currently estimated at a construction cost of $53,725,000;

- Hold and save the United States free from damages due to the construction works;

- Operate and maintain the works after their completion in accordance with regulations prescribed by the Secretary of the Army currently estimated at $748,000 annually;

- Protect the channels, ponding areas and other flood works from future encroachment or obstruction including waste disposal, that would reduce their flood carrying capacity;

- Pay at least 30 percent of the cost allocated to hurricane protection, which is included in all the items enumerated above for local flood protection;

- Establish and enforce regulations prohibiting discharge of untreated sewage, garbage, and other pollutants in the waters of the Passaic River in accordance with applicable laws or regulations of Federal, State, and local authorities responsible for pollution prevention and control;

- Provide and maintain depths in berthing areas and local access channels serving navigation terminals commensurate with the depths provided in the related project area;

- Pay all costs for land easements and rights-of-way allocated to major drainage currently estimated at $1,455,000, in addition to repaying a cash contribution, the difference between the former amount and one half the allocated construction cost for major drainage, presently estimated at $190,000.

XXXIV - STATEMENT OF FINDINGS

225. I have reviewed and evaluated, in light of the total public interest, documents concerning the proposed action, as well as the views of other agencies and the general public, relative to the various alternatives in accomplishing the development of water resources in the Passaic River basin located in New Jersey and New York.

226. The possible consequences of these alternatives have been studied and evaluated according to engineering feasibility, environmental effects, social well being, and economic factors including regional and national development.

227. I have considered several alternatives to provide for the optimal development of water resources including the prevention of damages caused by fluvial and tidal inundation, development of supplies of potable water for municipal use, enhancement of undeveloped flood plain lands, development of outdoor recreation opportunities, preservation and enhancement of fish and wildlife resources, elimination of mosquito breeding grounds, enhancement of water quality in the mainstream, increased saving for commercial navigation vessels and preservation of lands for open space, requested by local interests. These alternatives include, provision of upstream reservoirs, and reconstruction of existing water supply reservoir, preservation of flood plain lands, tunnel diversions, channel improvement and local protection works and non-structural means of providing flood protection. In addition, several plans consisting of multiple purpose reservoirs in various locations and with varying degrees of conservation storage were investigated independently and in combination with downstream local protection works. However, none of the other plans would provide for optimal development of a major portion of the above mentioned needs consistent with the required investment of resources.

228. I find that the action, as proposed in my recommendations, is based on thorough analysis and evaluation of various practicable alternative courses of action for achieving the stated objectives; that wherever adverse effects are found to be involved, they cannot be avoided by following reasonable alternatives which will achieve the Congressionally specified purposes of the recommendation; that the recommended action is consonant with national policy, statutes, and administrative directives; that where the proposed action has an adverse effect, this effect is either ameliorated or substantially outweighed by other considerations of national policy; and that on balance the total public interest should best be served by its implementation.

229. I, therefore, present my conclusion not as perfection, but as the best balancing of all elements in the total public interest.

a. From an engineering standpoint, I have optimized flood protection and potable water development.

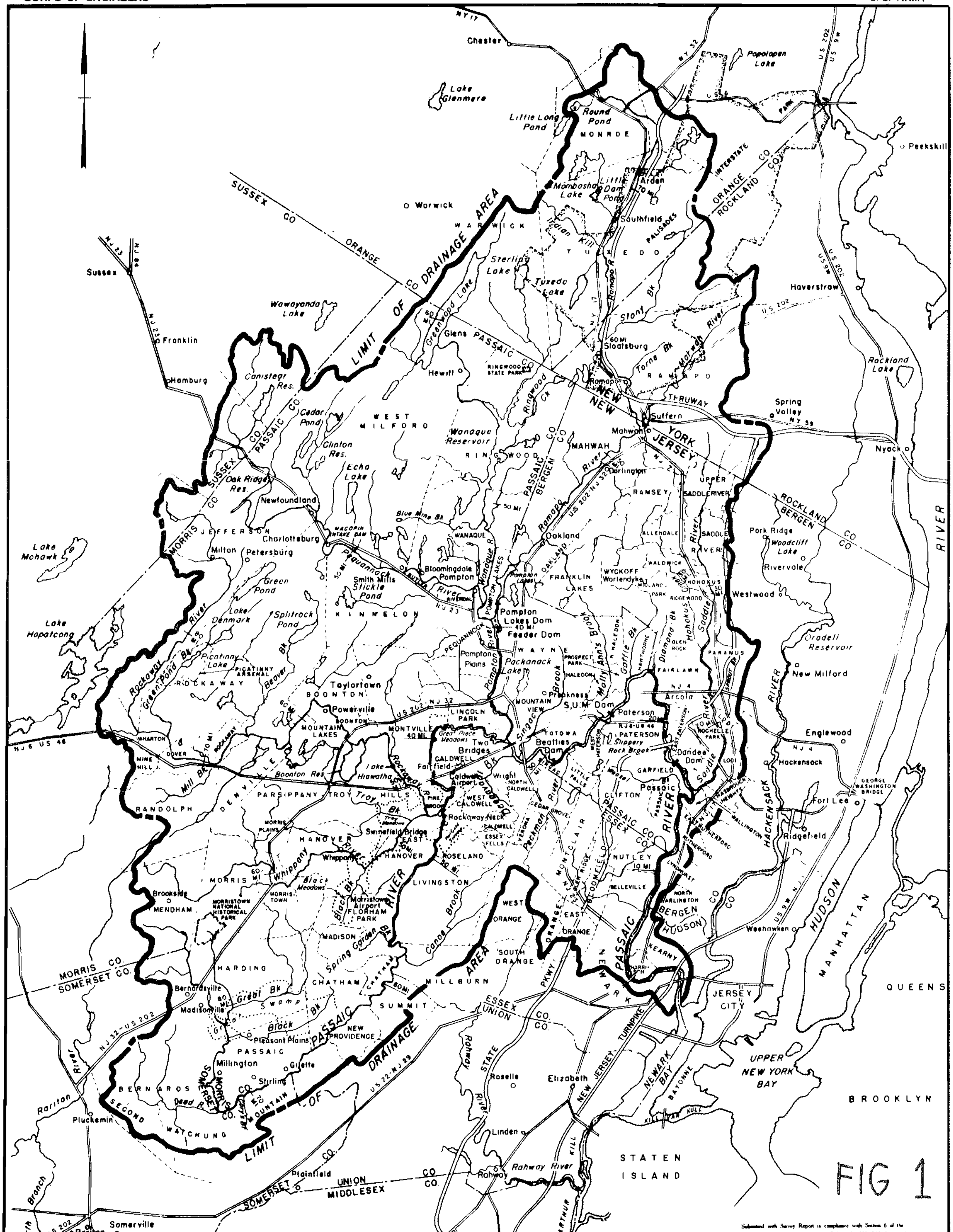
b. From an environmental standpoint, I have accepted minor aesthetic degradation, viz, some losses to a natural environmental setting and a controlled risk of eutrophication.

c. From an economic standpoint, I have departed from the best economic solution, since the difference between the most economic plan and the recommended plan is relatively small, and because the recommended plan is considered to be the optimal development of both flood control and allied water resource development.

230. Therefore, I recommend that the proposed plan for water resource development be authorized for implementation.

JAMES W. BARNETT
Colonel, Corps of Engineers
District Engineer

CORPS OF ENGINEERS U. S. ARMY



Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738, 74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

BASIN MAP

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

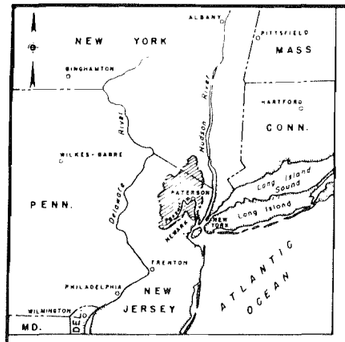
SUBMITTED	REVIEWED	RECOMMENDED
Samuel P. Tosi, CHIEF RIVER BASIN SECTION	Stanley Mansel, CHIEF BASIN & PROJECT PLANNING BR	T. C. Pagano, CHIEF ENGINEERING DIVISION
APPROVED James W. Barnett, COLONEL C E DISTRICT ENGINEER	Drawn by / Checked by	DRAWING NUMBER CR-PRB-1

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 1

CORPS OF ENGINEERS

U.S. ARMY



LOCATION MAP

SCALE IN MILES

25 0 25 50

VICINITY MAP

SCALE IN MILES

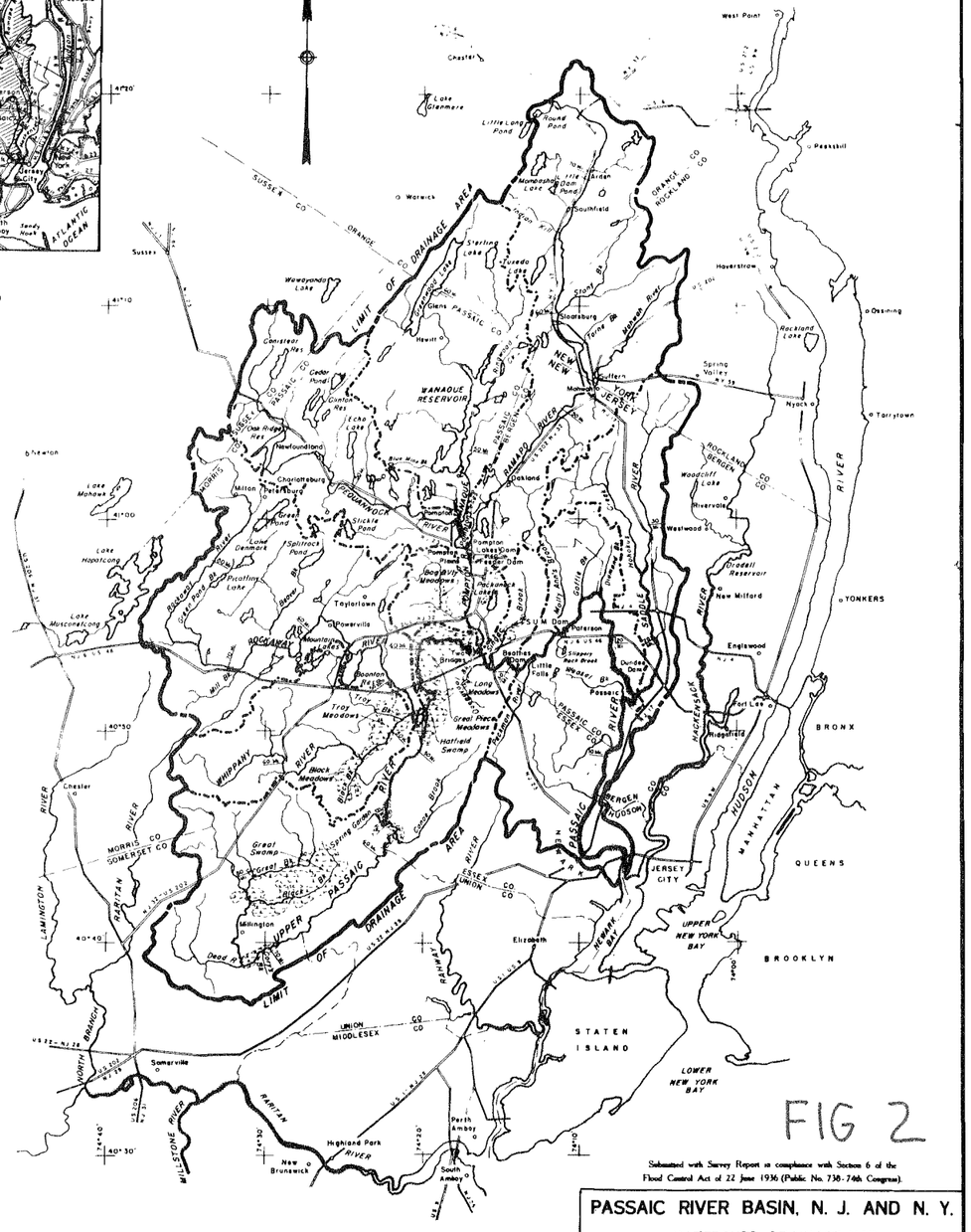
10 0 10 20

Note:
Datum Plane is Mean Sea Level

WATERSHED AREA

SCALE IN MILES

2 0 2 4 6 8 10



WATERSHED DRAINAGE MAP

SCALE IN MILES

2 0 2 4 6 8 10

FIG 2

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

WATERSHED DRAINAGE MAP

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

SUBMITTED:	REVIEWED	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Stanley Maisel, CHIEF, BASIN & PROJECT PLANNING BR	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED:	Drawn by	DRAWING NUMBER
James W. Leavitt, COLONEL, C. E. DISTRICT ENGINEER	Checked by	CR-PRB-2

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 2

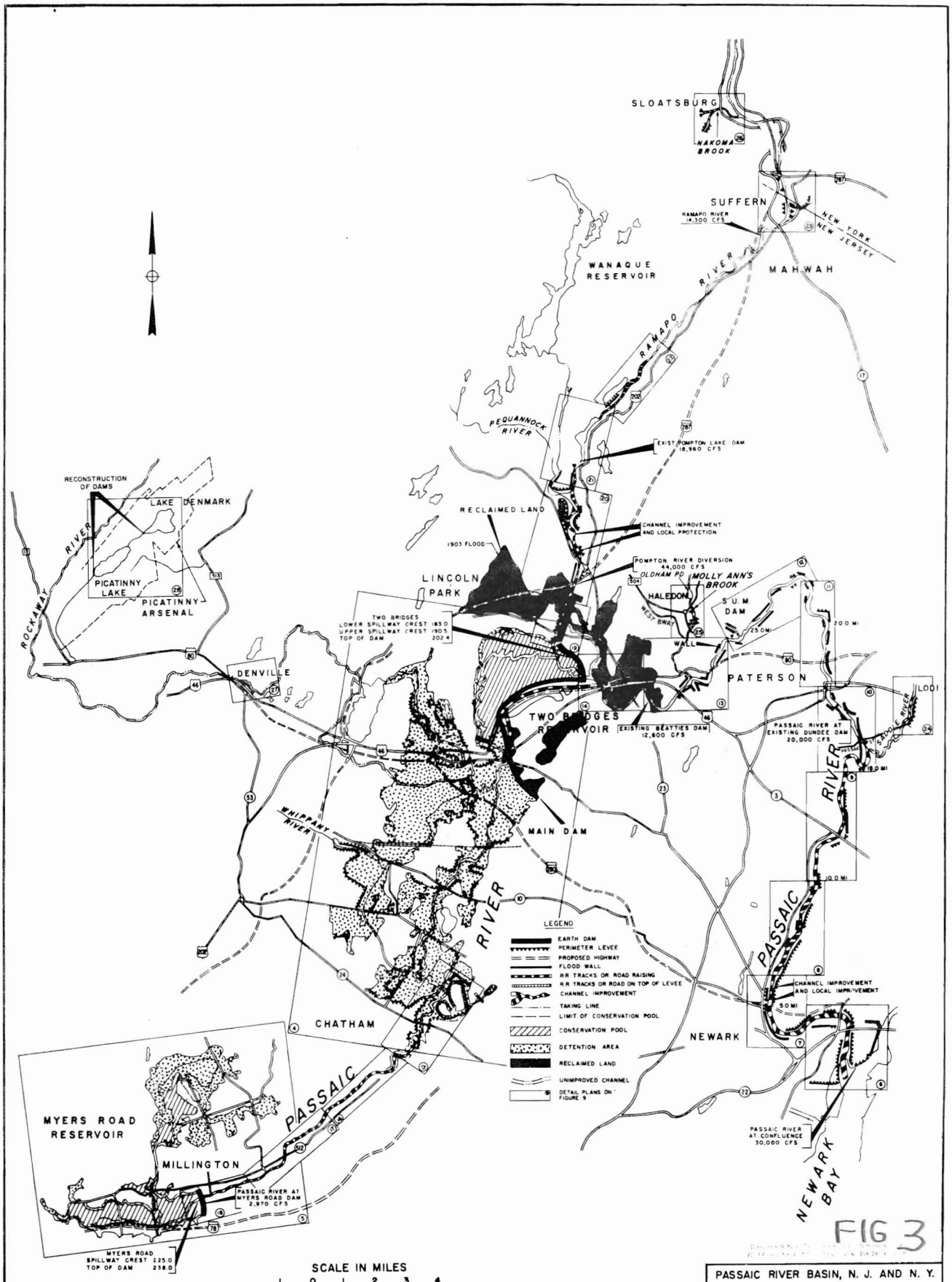


FIG 3

PASSAIC RIVER BASIN, N. J. AND N. Y.

GENERAL PLAN AND INDEX MAP CONSIDERED PLAN

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tsai, CHIEF, RIVER BASIN SECTION	Stanley Maisel, CHIEF, BASIN & PROJECT PLANNING BR	F. R. Pagano, CHIEF ENGINEERING DIVISION

APPROVED:	Drawn by	DRAWING NUMBER
Harold A. Everett, COLONEL, U. S. DISTRICT ENGINEER	Checked by	CR-PRB-3

FIGURE 3

CORPS OF ENGINEERS

U. S. ARMY

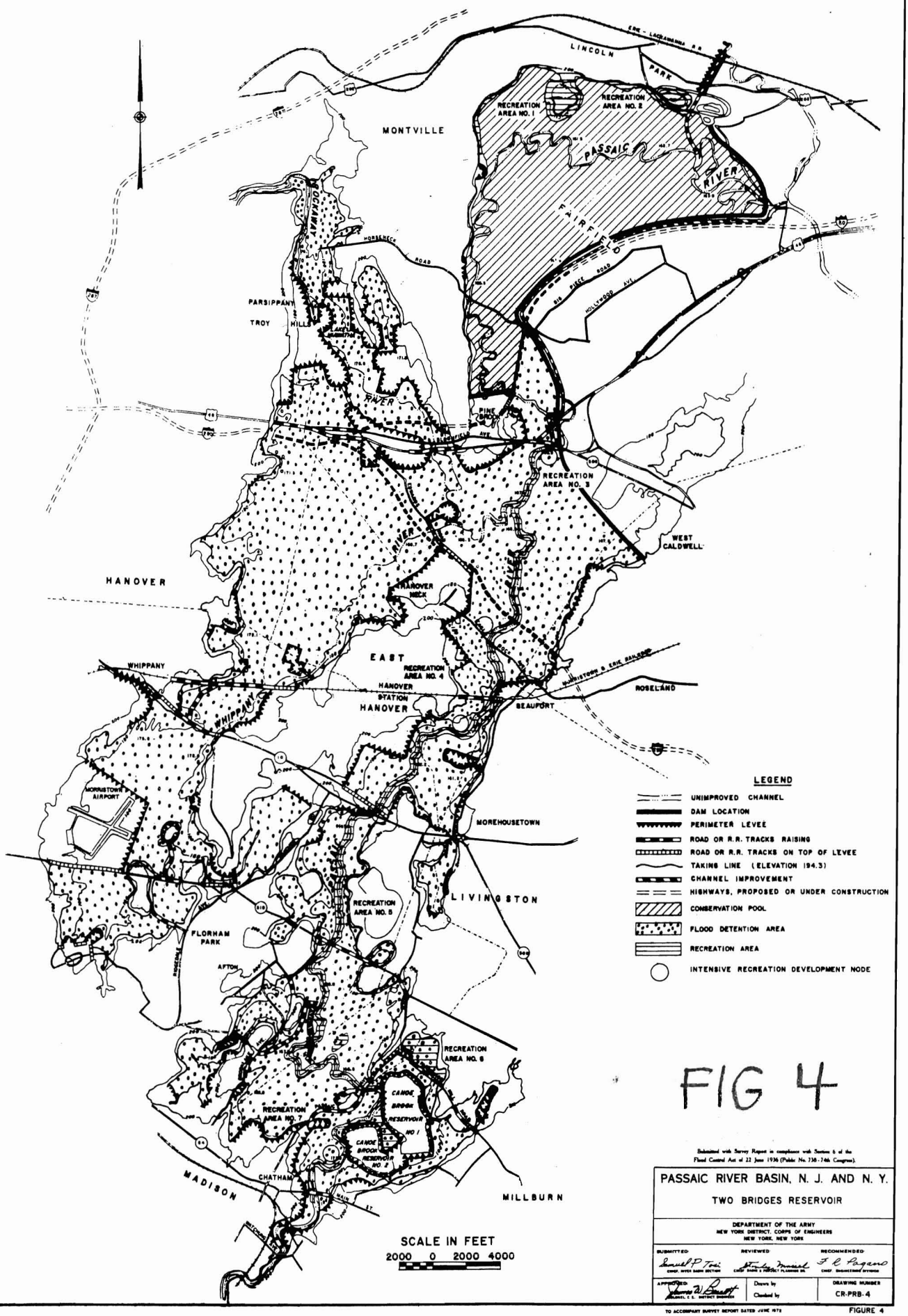


FIG 4

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738 - 74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

TWO BRIDGES RESERVOIR

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

SUBMITTED	REVIEWED	RECOMMENDED
Samuel P. Tosi, CHIEF, RIVER BASINS SECTION	Stanley Maxwell, CHIEF, BASINS & HYDROLOGY PLANNING BR.	F. C. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED	Drawn by	DRAWING NUMBER
James W. Bennett, COLONEL, C. E., DISTRICT ENGINEER	Checked by	CR-PRB-4

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 4

CORPS OF ENGINEERS

U. S. ARMY

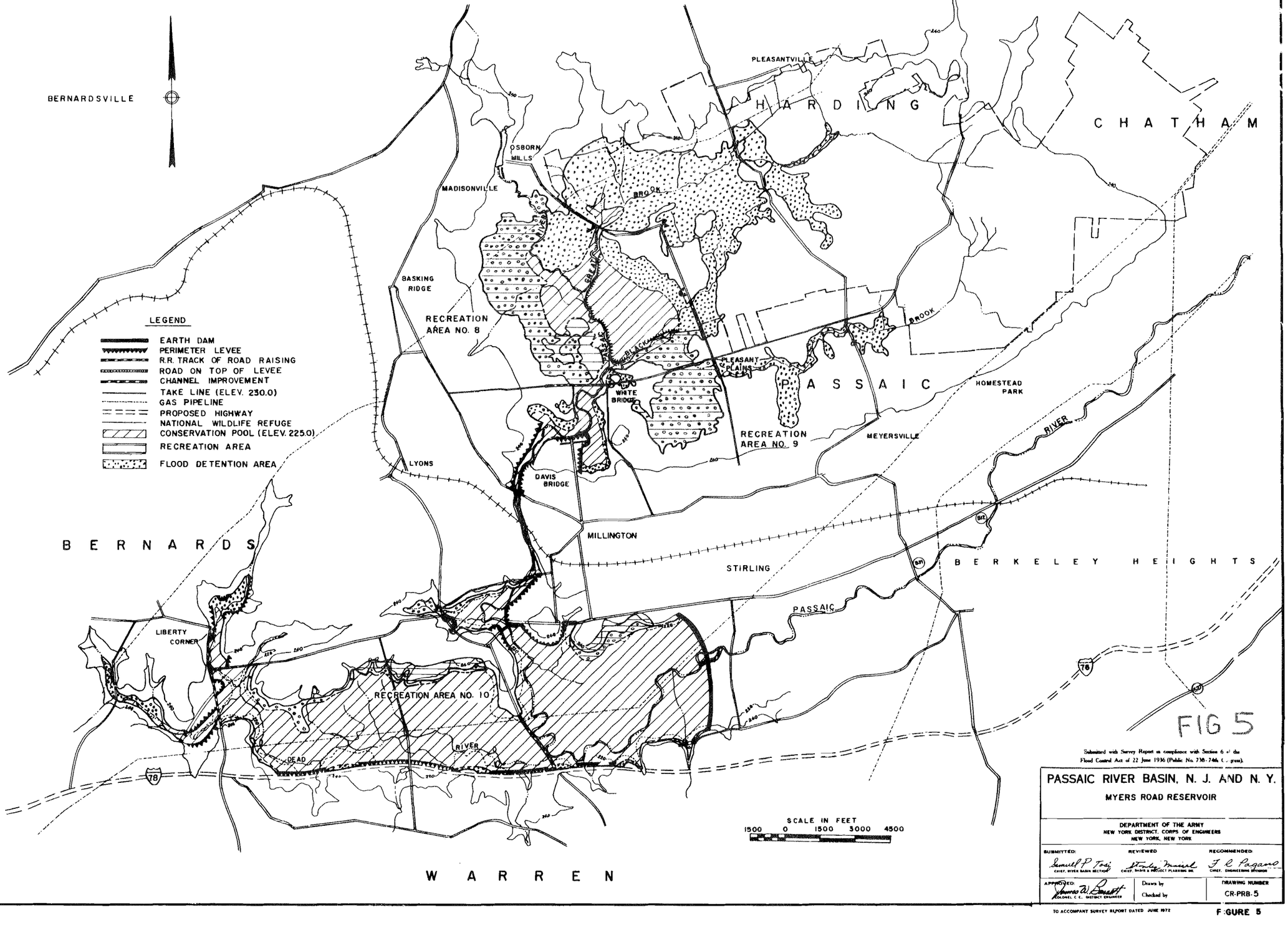


FIG 5

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Cong.).

PASSAIC RIVER BASIN, N. J. AND N. Y.

MYERS ROAD RESERVOIR

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

SUBMITTED:	REVIEWED	RECOMMENDED:
Samuel P. Fox, CHIEF, RIVER BASIN SECTION	Hale Mussel, CHIEF, BASIN & PROJECT PLANNING BR.	J. C. Pagano, CHIEF, ENGINEERING DIVISION

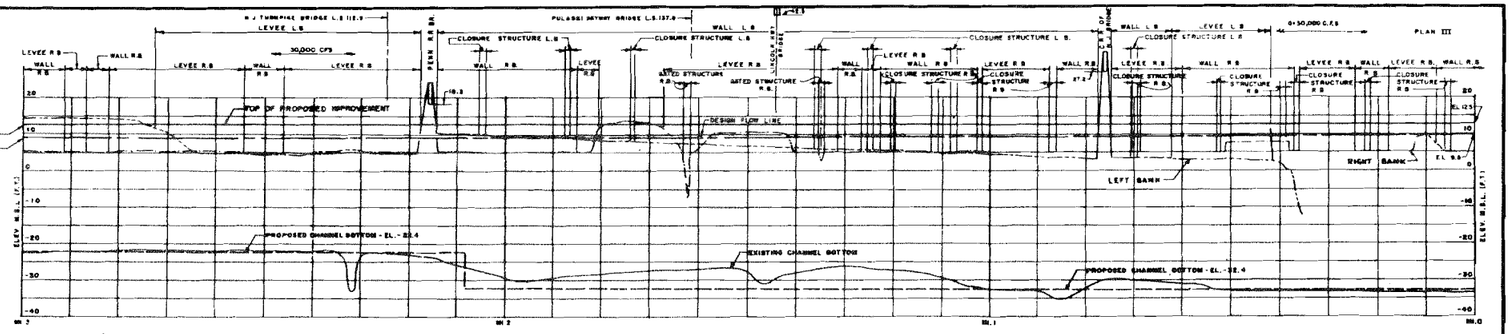
APPROVED:	Drawn by	DRAWING NUMBER
James W. Benét, COLONEL, C.E., DISTRICT ENGINEER	Checked by	CR-PRB-5

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 5

CORPS OF ENGINEERS

U. S. ARMY



PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30

NOTE: NO BRIDGE WORK REQUIRED - MILE 0.0 THRU MILE 3.0

FIGURE NO. 7

PLAN

SCALE IN FEET

600 0 600 1200

SECTION AT MILE LO

SCALE IN FEET

50 0 50 100

LEGEND

- FLOOD WALL
- LEVEE
- CHANNEL CUT
- GATED STRUCTURE
- PUMP STATION
- CLOSURE STRUCTURE

FIG 6

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 0.0 TO MILE 3.0

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tracy, CHIEF, RIVER BASIN SECTION	Stanley Maisel, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

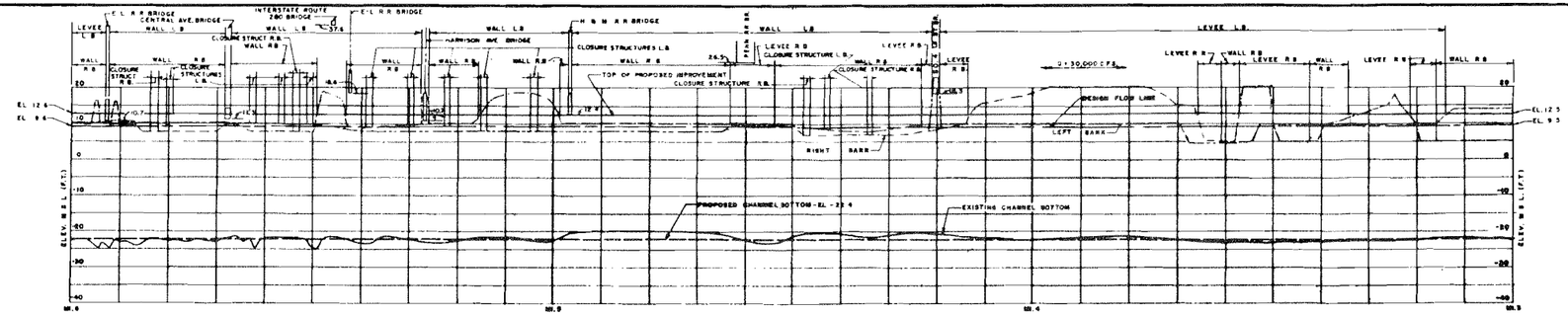
APPROVED:	Drawn by	DRAWING NUMBER
James W. Leonard, COLONEL, C.E., DISTRICT ENGINEER	Checked by	CR-PRB-6

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 6

CORPS OF ENGINEERS

U. S. ARMY



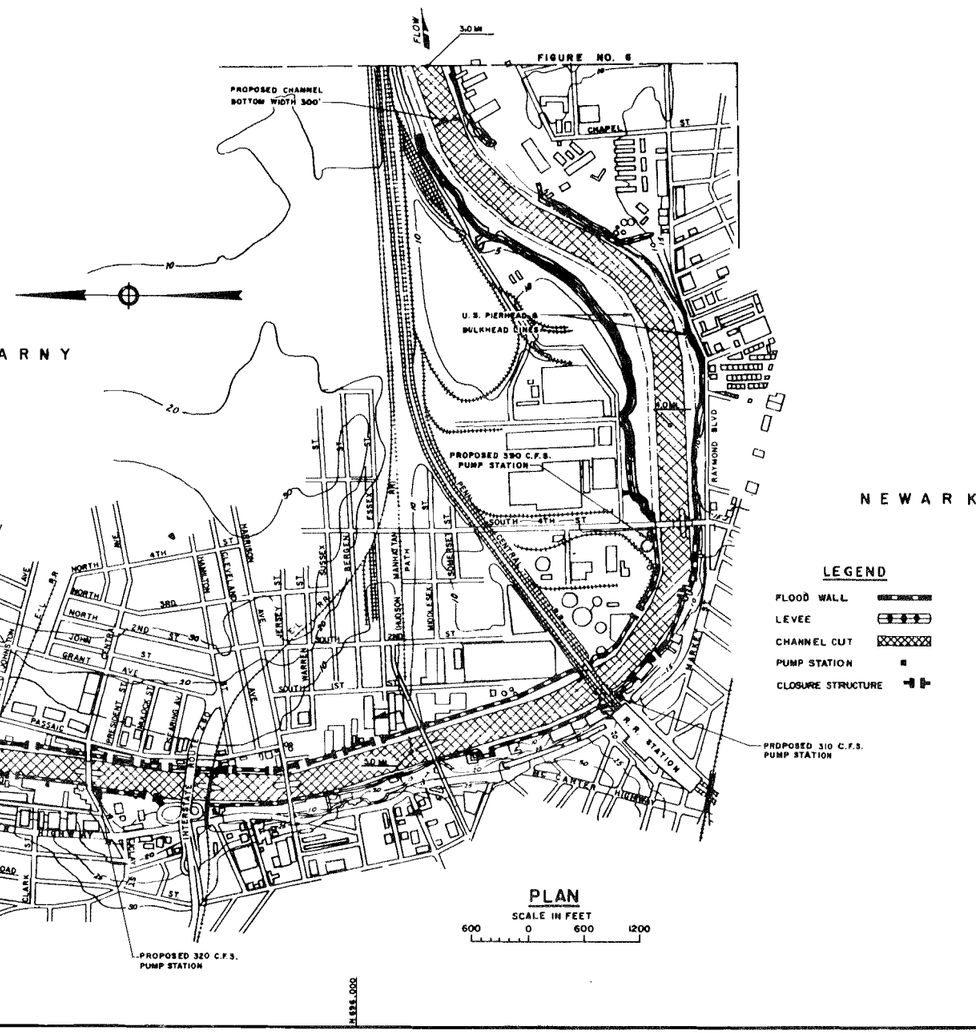
PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30

NOTE: NO BRIDGE WORK REQUIRED - MILE 3.0 THRU MILE 6.0



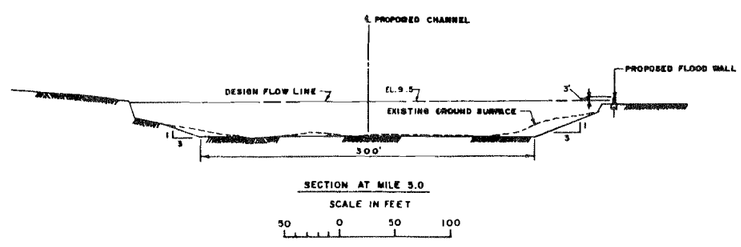
PLAN

SCALE IN FEET

600 0 600 1200

LEGEND

- FLOOD WALL
- LEVEE
- CHANNEL CUT
- PUMP STATION
- CLOSURE STRUCTURE



SECTION AT MILE 5.0

SCALE IN FEET

50 0 50 100

FIG 7

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738 - 74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 3.0 TO MILE 6.0

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

SUBMITTED:	REVIEWED	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Frederick Maund, CHIEF BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

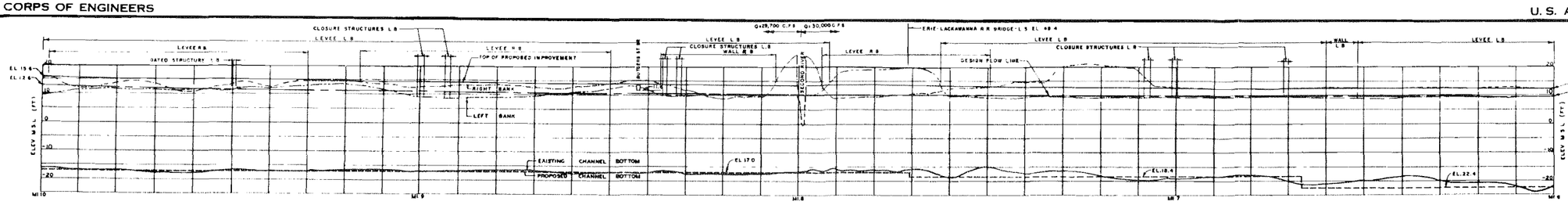
APPROVED:	Drawn by	DRAWING NUMBER
James W. Bennett, COLONEL, C.E. DISTRICT ENGINEER	Checked by	CR-PRB-7

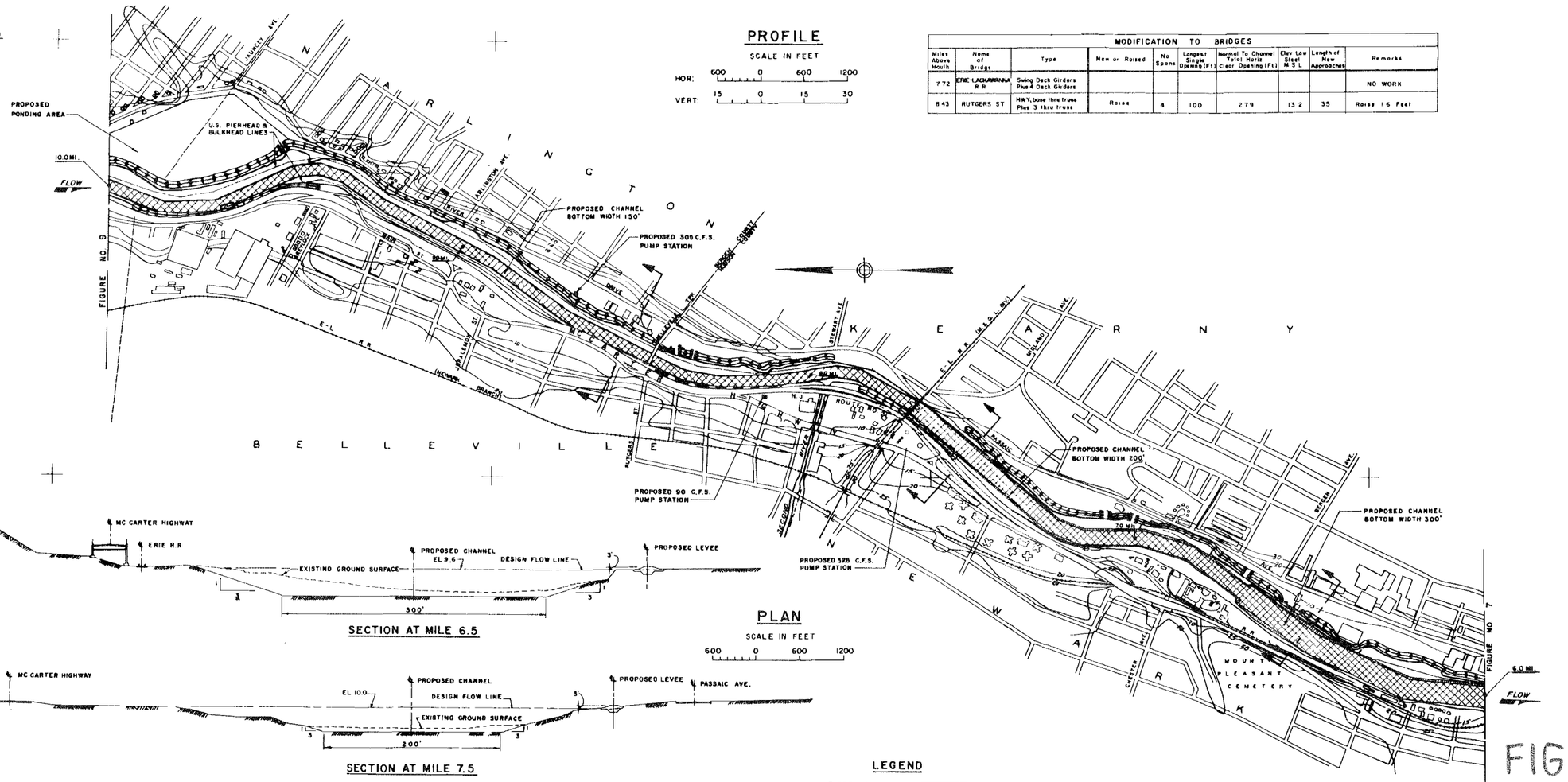
TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 7

CORPS OF ENGINEERS

U. S. ARMY





PROFILE

SCALE IN FEET

HOR: 600 0 600 1200

VERT: 15 0 15 30

PLAN

SCALE IN FEET

600 0 600 1200

LEGEND

- FLOOD WALL
- LEVEE
- CHANNEL CUT
- GATED STRUCTURE
- PUMP STATION
- CLOSURE STRUCTURE

MODIFICATION TO BRIDGES

Miles Above Mouth	Name of Bridge	Type	New or Raised	No Spans	Longest Single Opening (Ft.)	Normal To Channel Total Horiz Clear Opening (Ft.)	Elev Low Steel M.S.L.	Length of New Approaches	Remarks
7.72	ERIE-LACKAWANNA R.R.	Swing Deck Girders Plus 4 Deck Girders							NO WORK
8.43	RUTGERS ST.	HWY, base thru truss Plus 3 thru truss	Raise	4	100	279	13.2	35	Raise 1.6 Feet

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 736 - 74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 6.0 TO MILE 10.0

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Stanley Muscal, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: James W. Leavitt, COLONEL, C.E., DISTRICT ENGINEER

Drawn by

Checked by

DRAWING NUMBER CR-PRB-8

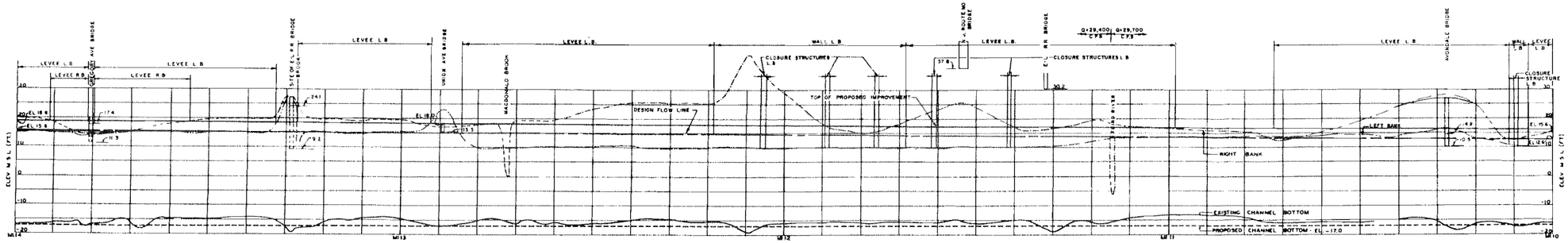
TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 8

FIG 8

CORPS OF ENGINEERS

U. S. ARMY

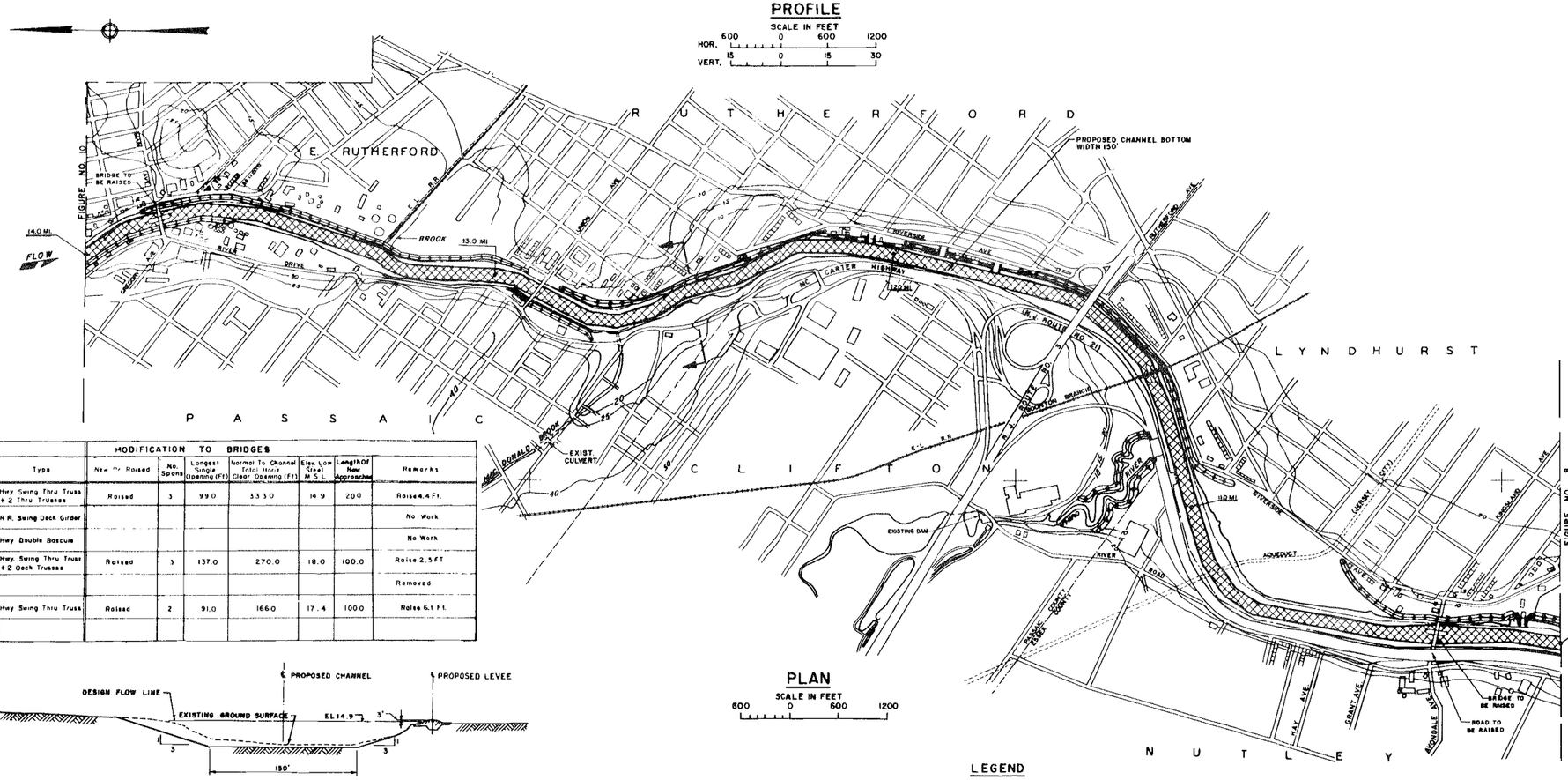


PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30



MODIFICATION TO BRIDGES									
Miles Above Youth	Name Of Bridge	Type	New Or Raised	No. Spans	Longest Single Opening (Ft)	Normal To Channel Total Horiz. Clear Opening (Ft)	Elev. Low Steel M.S.L.	Length Of New Approaches	Remarks
10.26	AVONDALE (PARK AVE.)	Hwy Swing Thru Truss + 2 Thru Trusses	Raised	3	99.0	333.0	14.9	200	Raise 4.4 Ft.
11.31	D.L.&W. RR (Boonton Br)	R.R. Swing Deck Girder							No Work
11.55	ROUTE 3	Hwy Double Bascule							No Work
12.88	UNION AVE.	Hwy Swing Thru Truss + 2 Deck Trusses	Raised	3	137.0	270.0	18.0	100.0	Raise 2.5 FT
13.29	E-L RR								Removed
13.80	GREGORY AVE.	Hwy Swing Thru Truss	Raised	2	91.0	166.0	17.4	1000	Raise 6.1 Ft.

SECTION AT MILE 12.5

SCALE IN FEET

50 0 50 100

PLAN

SCALE IN FEET

600 0 600 1200

LEGEND

FLOOD WALL

LEVEE

CHANNEL CUT

CLOSURE STRUCTURE 11

FIG 9

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 10.0 TO MILE 14.0

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASINS SECTION	Stanley Musial, CHIEF BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

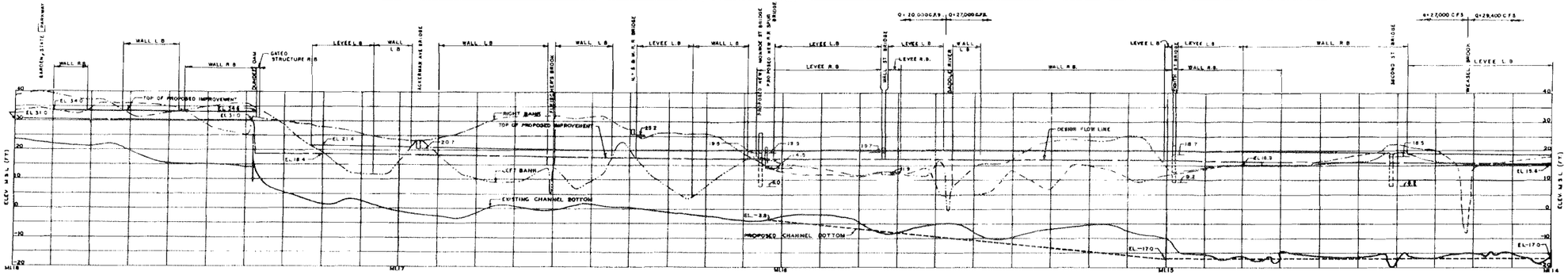
APPROVED:	Drawn by	DRAWING NUMBER
James W. Bennett, COLONEL, C. E., DISTRICT ENGINEER	Checked by	CR-PRB-9

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 9

CORPS OF ENGINEERS

U. S. ARMY

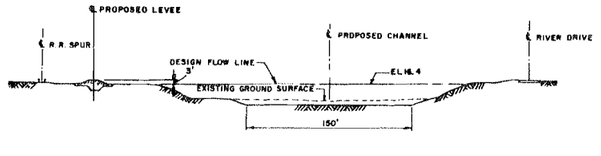


PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30



SECTION AT MILE 16.0

SCALE IN FEET

50 0 50 100

MODIFICATION TO BRIDGES

Miles Above Mouth	Name of Bridge	Type	New or Raised	No Spans	Longest Single Opening (Ft)	Normal to Channel Total Horiz Clear Opening (Ft)	Elev Low Steel M.S.L.	Length Of New Approaches	Remarks
14.41	SECOND ST (Market ST)	Hwy Deck Girder Double Bascule +2 Conc Encased Girders	Raise	3	99.0	267.0	18.5	500	Raise 10.3 Ft.
14.98	EIGHTH ST	Hwy Thru Truss Bascule +2 Thru Trusses	Raise	3	108.0	244.0	18.7	450	Raise 9.5 Ft
15.74	WALL ST	Hwy, Thru Steel Girder	Raise	3	73.0	219.0	19.7	400	Raise 7.8 Ft.
16.04	E-L RR	Wood Trestle	New	23	11.0	231.0	19.5	100	Steel, Raise 5.0 Ft.
16.06	MONROE ST	Hwy Deck Conc Arch	New	3	91.0	247.0	19.5	150	Steel, Raise Road 3.4 Ft.
16.39	N Y S & W R R	Wood Trestle							No Work
16.95	ACKERMAN AVE	Hwy Deck Conc Arch	Raise	7	55.0	379.0	20.7	100	Raise 1.7 Ft
17.93	GARDEN ST PARKWAY	Hwy Deck Steel Girder							No Work
		SADDLE RIVER							
	MIDLAND AVE	Hwy Steel Beam	New	1	60.0	60.0	18.7	400	Steel Beam, Raise Road 8.4
		FLEISCHERS BROOK							
	RIVER DRIVE	Hwy Conc Beam	New	1	40.0	40.0	19.6	450	Steel Beam, Raise Road 8.6
	LIZETTE ST	Hwy, Conc. Beam	Raise	1	30.0	30.0	19.6	200	Raise 3.6'

LEGEND

- FLOOD WALL
- LEVEE
- CHANNEL CUT
- GATED STRUCTURE
- PUMP STATION

PLAN

SCALE IN FEET

600 0 600 1200

FIG 10

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 14.0 TO MILE 18.0

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, WATER BASINS SECTION	Stanley Mussel, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: James W. Bancroft, COLONEL, C.E., DISTRICT ENGINEER

Drawn by

Checked by

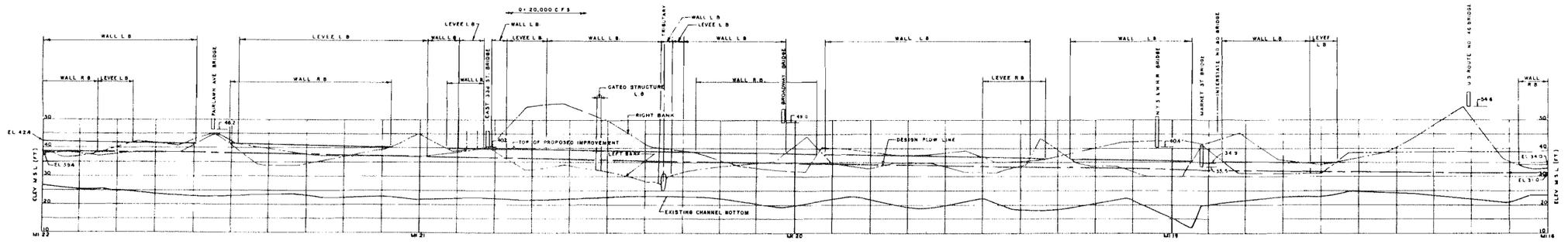
DRAWING NUMBER CR-PRB-10

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 10

CORPS OF ENGINEERS

U. S. ARMY

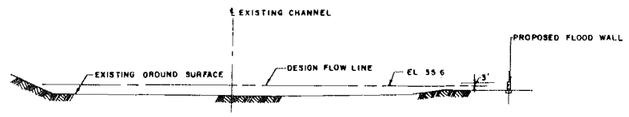


PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

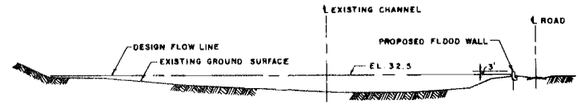
VERT. 15 0 15 30



SECTION AT MILE 20.40

SCALE IN FEET

50 0 50 100



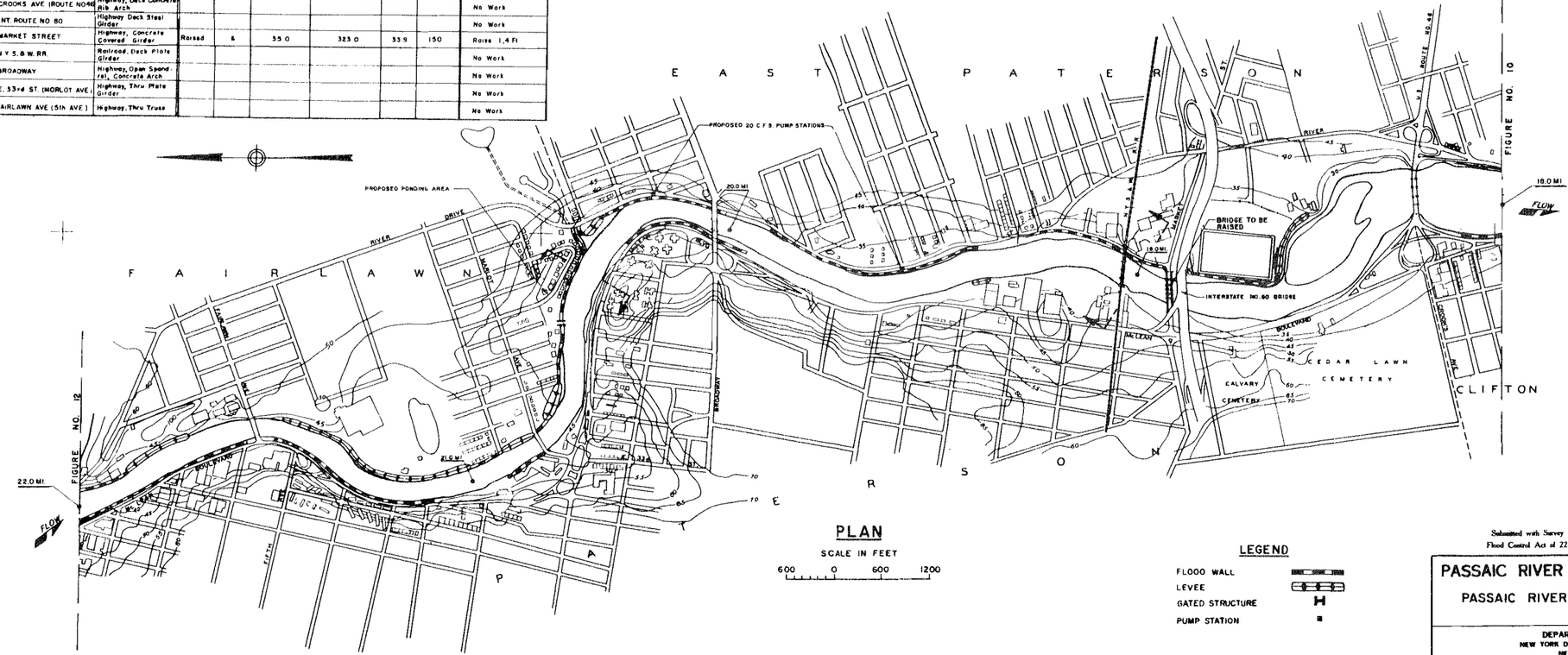
SECTION AT MILE 19.0

SCALE IN FEET

50 0 50 100

MODIFICATION TO BRIDGES

Miles Above Mouth	Name of Bridge	Type	New or Raised	Number Spans	Longest Single Opening (Ft.)	Normal to Channel Total Horizontal Clear Opening (Ft.)	Elev. Low Steel M.S.L.	Length of New Approaches	Remarks
18.21	CROOKS AVE (ROUTE NO 46)	Highway, Deck Concrete Rib Arch							No Work
18.88	INT. ROUTE NO. 80	Highway Deck Steel Girder							No Work
18.92	MARKET STREET	Highway, Concrete Covered Girder	Raised	6	35.0	325.0	33.9	150	Raise 1.4 Ft
19.04	N.Y.S.&W.RR.	Railroad, Deck Plate Girder							No Work
20.03	BROADWAY	Highway, Open Spand. rel, Concrete Arch							No Work
20.08	E. 53rd ST. (MORLOT AVE.)	Highway, Thru Plate Girder							No Work
21.55	FAIRLAWN AVE (5th AVE.)	Highway, Thru Truss							No Work



PLAN

SCALE IN FEET

600 0 600 1200

LEGEND

FLOOD WALL

LEVEE

GATED STRUCTURE H

PUMP STATION ■

FIG 11

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738 - 74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 18.0 TO MILE 22.0

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Stanley Maisel, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: Thomas N. Sweet, COLONEL, C. E., DISTRICT ENGINEER

Drawn by

Checked by

DRAWING NUMBER CR-PRB-11

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

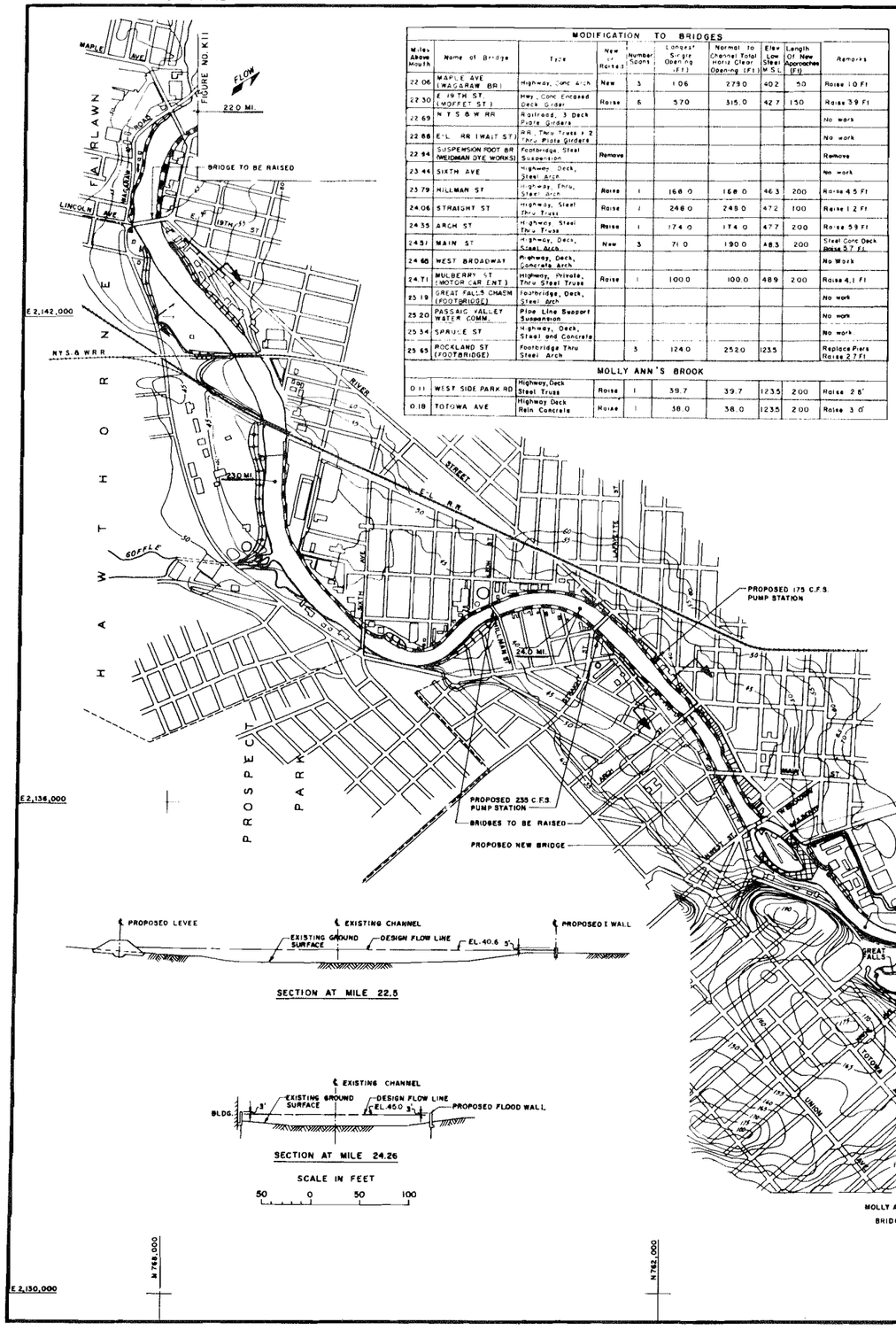
FIGURE 11

CORPS OF ENGINEERS

U. S. ARMY

MODIFICATION TO BRIDGES

Miles Above Mouth	Name of Bridge	Type	New or Raised	Number Spans	Longest Single Opening (Ft.)	Normal to Channel Total Horiz Clear Opening (Ft.)	Elev Low Steel M.S.L.	Length Of New Approaches (Ft.)	Remarks
22.06	MAPLE AVE (WAGARAW BR.)	Highway, Conc Arch	New	3	106	279.0	402	50	Raise 10 Ft
22.30	E. 19TH ST. (MOFFET ST.)	Hwy., Conc Encased Deck Girder	Raise	6	57.0	315.0	427	150	Raise 3.9 Ft
22.69	N.T.S. & W. RR	Railroad, 3 Deck Plate Girders							No work
22.88	E'L RR (WAIT ST.)	RR. Thru Truss & 2 Thru Plate Girders							No work
22.94	SUSPENSION FOOT BR (WEIDMAN DYE WORKS)	Footbridge, Steel Suspension	Remove						Remove
23.44	SIXTH AVE	Highway, Deck, Steel Arch							No work
23.79	HILLMAN ST	Highway, Thru, Steel Arch	Raise	1	168.0	168.0	463	200	Raise 4.5 Ft
24.06	STRAIGHT ST	Highway, Steel Thru Truss	Raise	1	248.0	248.0	472	100	Raise 1.2 Ft
24.35	ARCH ST	Highway, Steel Thru Truss	Raise	1	174.0	174.0	477	200	Raise 5.9 Ft
24.51	MAIN ST	Highway, Deck, Steel Arch	New	3	71.0	190.0	483	200	Steel Cone Deck Raise 5.7 Ft
24.65	WEST BROADWAY	Highway, Deck, Concrete Arch							No Work
24.71	MULBERRY ST. (MOTOR CAR ENT.)	Highway, Private, Thru Steel Truss	Raise	1	100.0	100.0	489	200	Raise 4.1 Ft
25.19	GREAT FALLS CHASM (FOOTBRIDGE)	Footbridge, Deck, Steel Arch							No work
25.20	PASSAIC VALLEY WATER COMM.	Pipe Line Support Suspension							No work
25.34	SPRUCE ST	Highway, Deck, Steel and Concrete							No work
25.65	ROCKLAND ST (FOOTBRIDGE)	Footbridge Thru Steel Arch		3	124.0	252.0	1235		Replace Piers Raise 2.7 Ft
MOLLY ANN'S BROOK									
0.11	WEST SIDE PARK RD	Highway, Deck Steel Truss	Raise	1	39.7	39.7	1235	200	Raise 2.8'
0.18	TOTOWA AVE	Highway Deck Rein. Concrete	Raise	1	38.0	38.0	1235	200	Raise 3.0'



PROPOSED LEVEE — EXISTING CHANNEL

EXISTING GROUND SURFACE — DESIGN FLOW LINE EL. 40.6 — PROPOSED I WALL

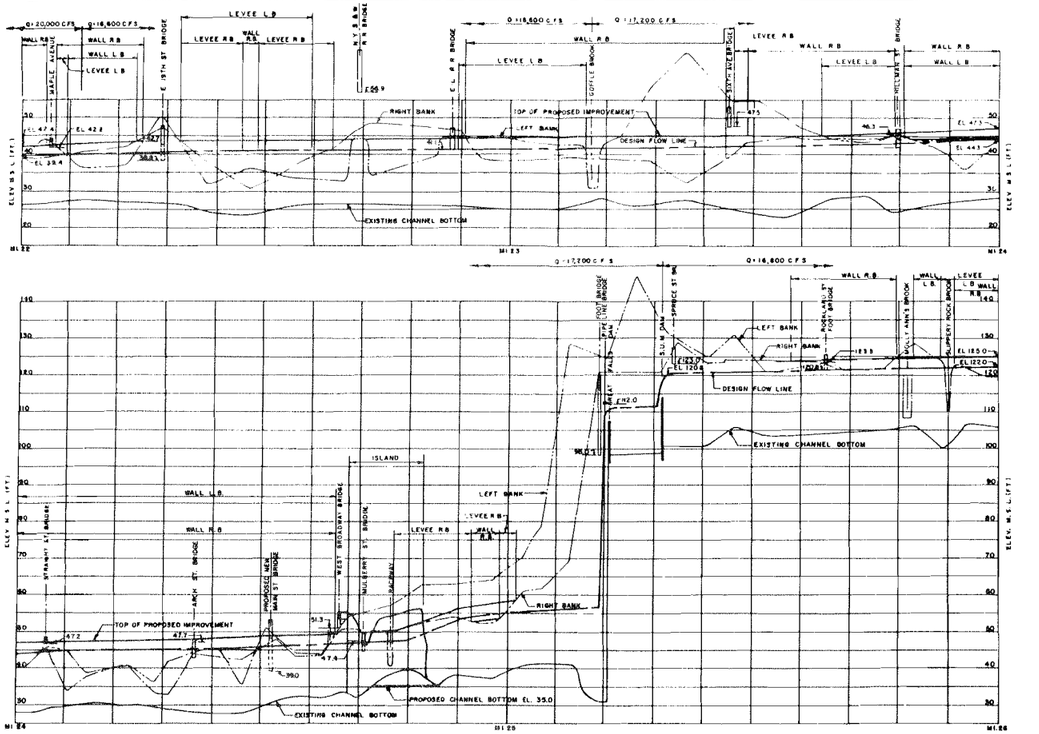
SECTION AT MILE 22.5

BLDG. — EXISTING CHANNEL — EXISTING GROUND SURFACE — DESIGN FLOW LINE EL. 46.0 — PROPOSED FLOOD WALL

SECTION AT MILE 24.26

SCALE IN FEET

50 0 50 100



PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30

LEGEND

FLOOD WALL

LEVEE

PUMP STATION

CHANNEL CUT

FIG 12

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738 - 74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 22.0 TO MILE 26.0

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

SUBMITTED	REVIEWED	RECOMMENDED
CHIEF, RIVER BASIN SECTION	CHIEF, BASIN & PROJECT PLANNING BR.	CHIEF, ENGINEERING DIVISION

APPROVED: COLONEL, C.E., DISTRICT ENGINEER

Drawn by

Checked by

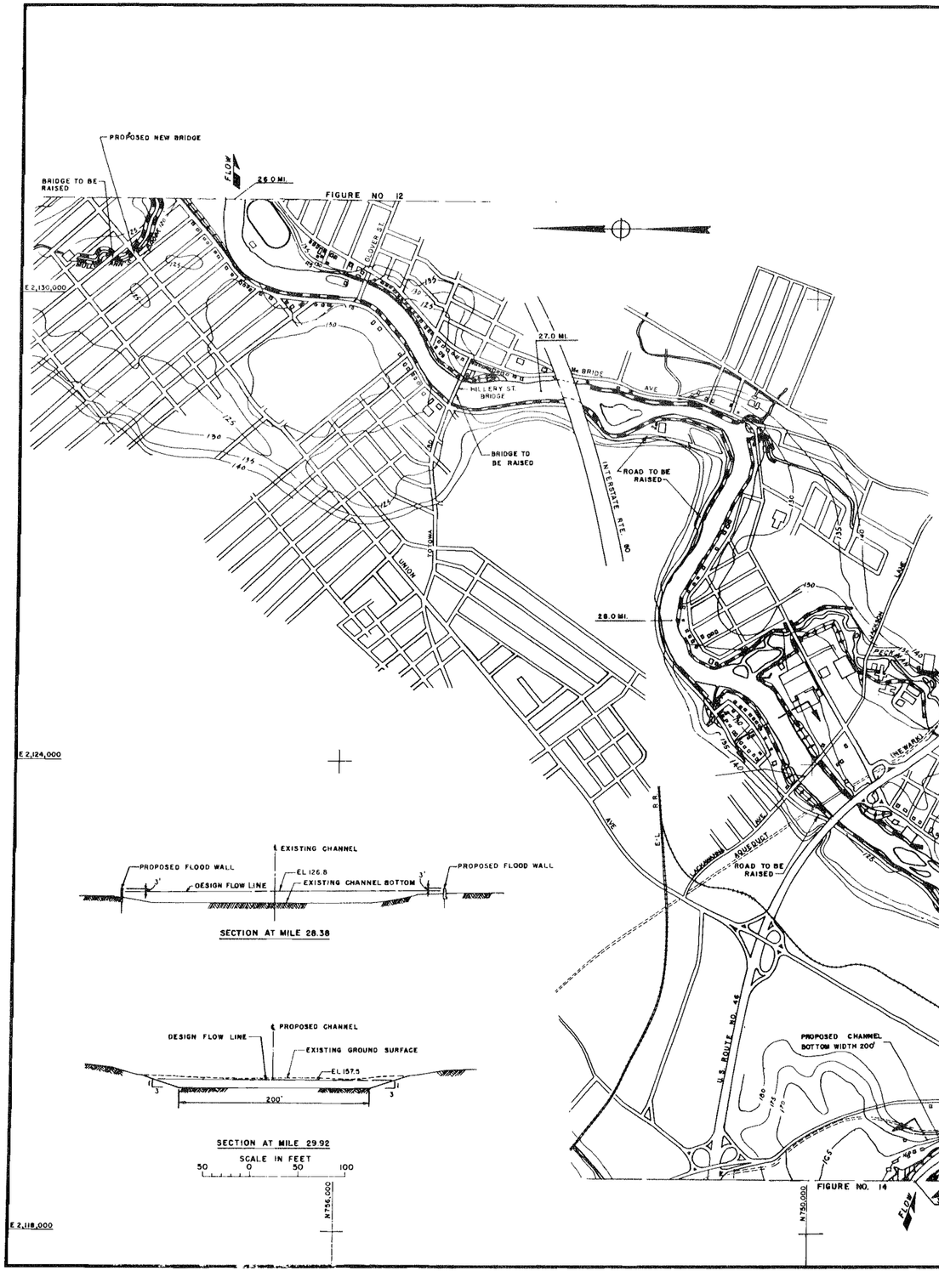
DRAWING NUMBER CR-PRB-12

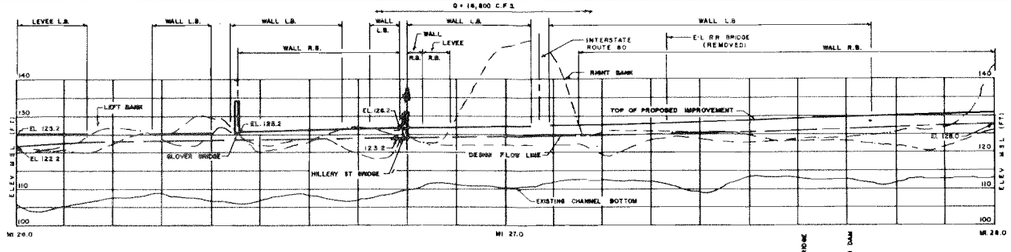
TO ACCOMPANY SURVEY REPORT DATED JUNE 1973

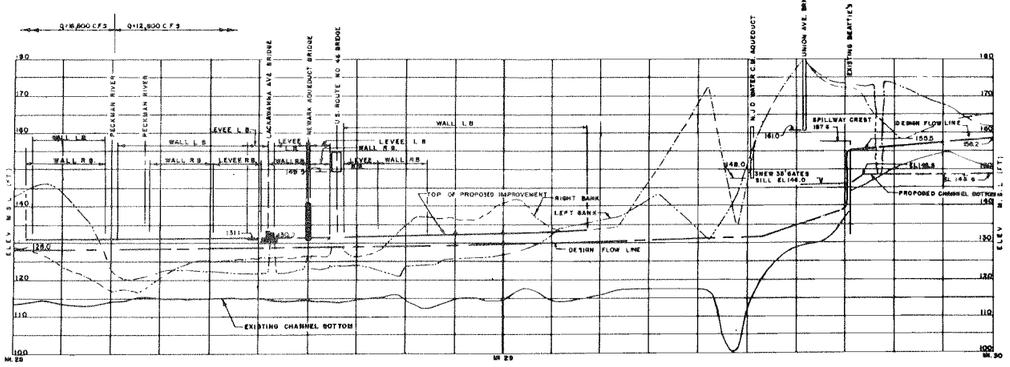
FIGURE 12

CORPS OF ENGINEERS

U. S. ARMY







PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30

SECTION AT MILE 28.38

SECTION AT MILE 29.92

SCALE IN FEET

50 0 50 100

PLAN

SCALE IN FEET

600 0 600 1200

MODIFICATION TO BRIDGES									
Miles Above Mouth	Name Of Bridge	Type	New Or Raised	No Spans	Longest Single Opening (Ft)	Normal To Channel Total Horiz Clear Opening (Ft)	Elev Low Steel M S L	Length Of New Approaches 90°	Remarks
26.42	LINCOLN	Highway, 2 Thru Steel Trusses	Removed						To Be Removed
26.45	GLOVER ST	Highway, 2 Span Cont. Plate Girder							No Work
26.79	HILLERY ST	Hwy., Thru Steel Truss	Raised	4	81.0	323.0	128.2	150	Raise 5.0 Ft.
27.07	INT ROUTE 80	Highway							No Work
27.33	E-L RR								Removed
28.52	LACKAWANNA AVE	Hwy, Thru Steel Truss	Raised	3	97.0	278.0	131.1	70	Raise 1.1 Ft.
28.60	NEWARK AQUEDUCT	Aqueduct, 3 Thru Steel Trusses							No Work
28.66	ROUTE 46	Highway, Concrete Rib Arch							No Work
29.52	N J.D.W.S AQUEDUCT	Aqueduct, Deck Steel Truss							No Work
29.62	UNION AVE	Highway, Deck Steel Truss							No Work
MOLLY ANN'S BROOK									
0.39	UNION AVE	Highway Deck Plate Girder	New	1	60.0	60.0	125.5	50	Steel Beam Raise Rd 0.5'
0.45	BERKSHIRE AVE	Highway Deck Rein Concrete	Raise	1	35.0	35.0	125.5	200	Raise 2.7'

LEGEND

FLOOD WALL

LEVEE

CLOSURE STRUCTURE

FIG 13

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 26.0 TO MILE 30.0

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Fox, CHIEF RIVER BASIN SECTION	Stanley Maisel, CHIEF BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: James W. Bennett, COLONEL, C. E., DISTRICT ENGINEER

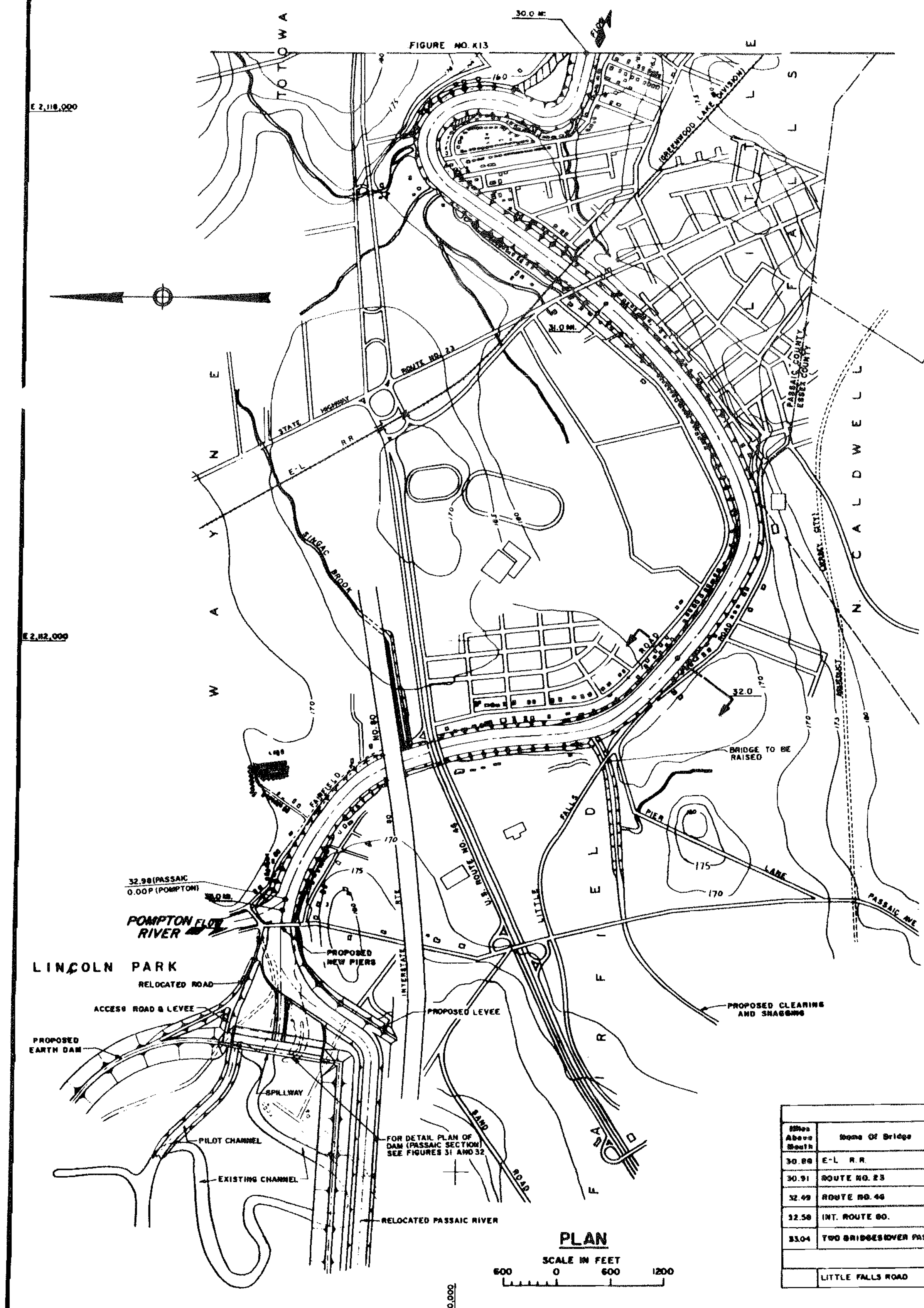
Drawn by

Checked by

DRAWING NUMBER CR-PRB-13

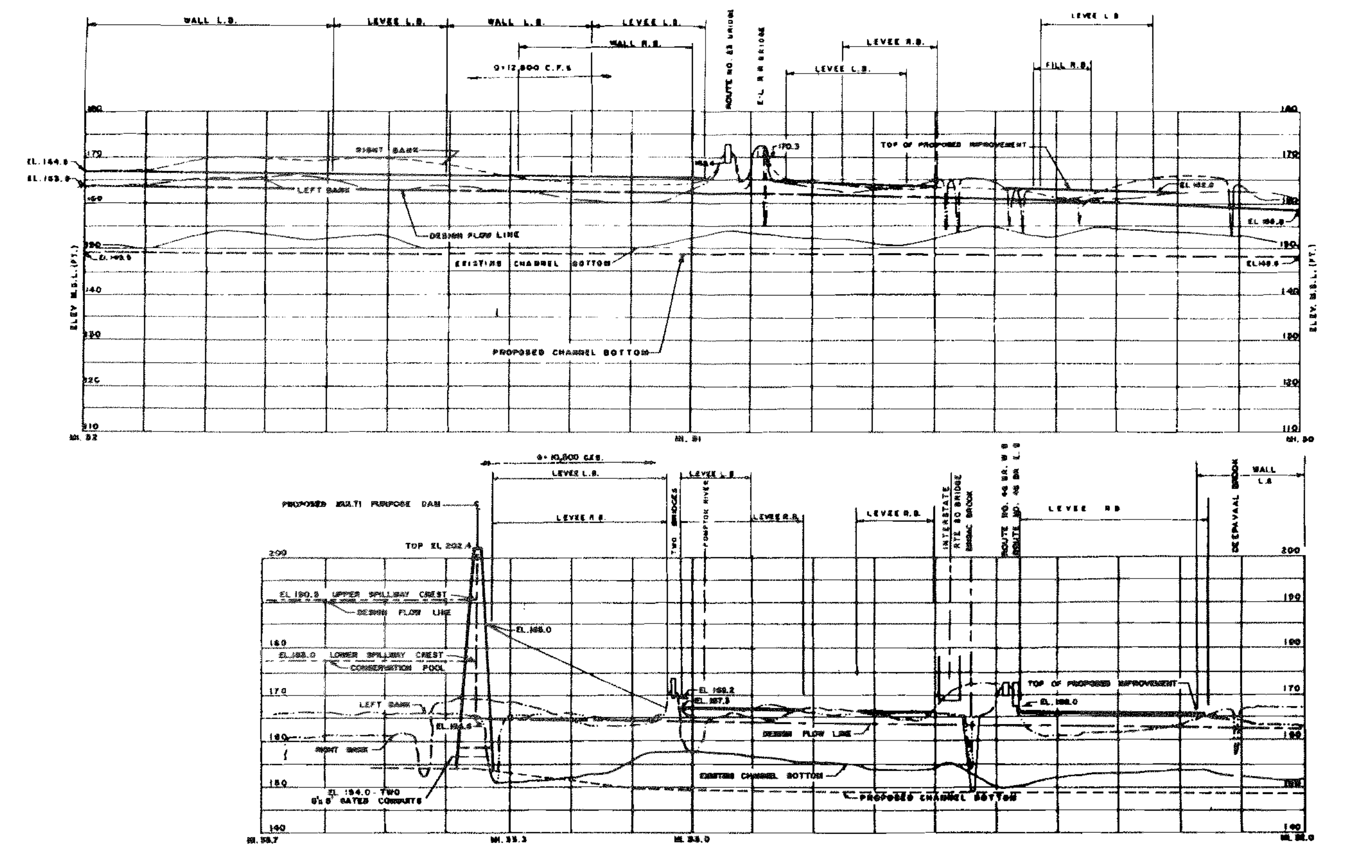
TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 13



PLAN

SCALE IN FEET
600 0 600 1200

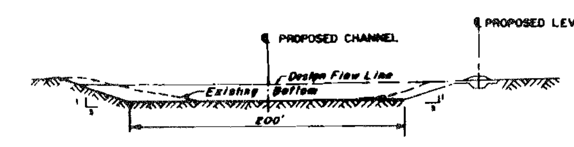


PROFILE

SCALE IN FEET
HOR.: 600 0 600 1200
VERT.: 15 0 15 30

LEGEND

FILL (PLAN)
LEVEE
WALL



SECTION AT MILE 32.0

MODIFICATION TO BRIDGES									
Miles Above Mouth	Name Of Bridge	Type	NEW OR RAISED	No. Spans	Longest Single Opening (Ft.)	Normal To Channel Total Horizontal Clear Opening (Ft.)	Elevation Low Steel M. S. L.	Length of New Approaches	Remarks
30.88	E-L R.R.	R.R., Thru Plate Girder							No Work
30.91	ROUTE NO. 23	Hwy., Deck Conc. Arch							No Work
32.49	ROUTE NO. 46	Hwy., Conc. Encased Thru Steel Girder							No Work
32.58	INT. ROUTE 80.								NO Work
33.04	TWO BRIDGES (OVER PASSAIC)	Hwy., Conc. Encased Thru Steel Girder		3	83.0	247.0	169.2		Underpin 2 Piers
DEEPAVAAL BROOK									
	LITTLE FALLS ROAD	Hwy. Conc. Deck	Raised	1	30.0	30.0	166.0	100	Raise 1.0'

FIG 14

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 30.0 TO MILE 33.3

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

SUBMITTED: Samuel P. Tosi, CHIEF, RIVER BASIN SECTION
REVIEWED: Stanley Marcel, CHIEF BASIN & PROJECT PLANNING BR.
RECOMMENDED: F. C. Pagano, CHIEF ENGINEERING DIVISION

APPROVED: James W. Barnett, COLONEL, C.E. DISTRICT ENGINEER

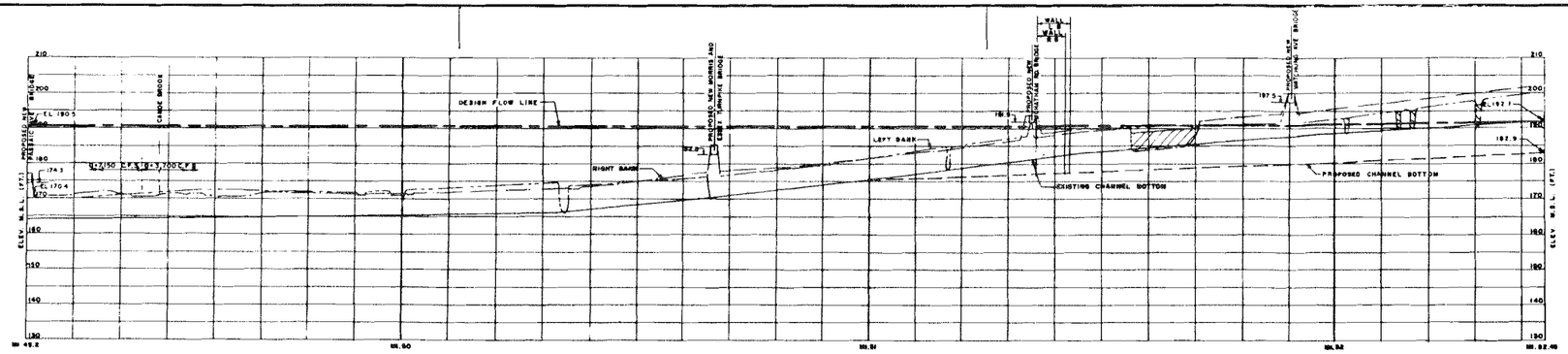
Drawn by
Checked by

DRAWING NUMBER CR-PRB-14

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

CORPS OF ENGINEERS

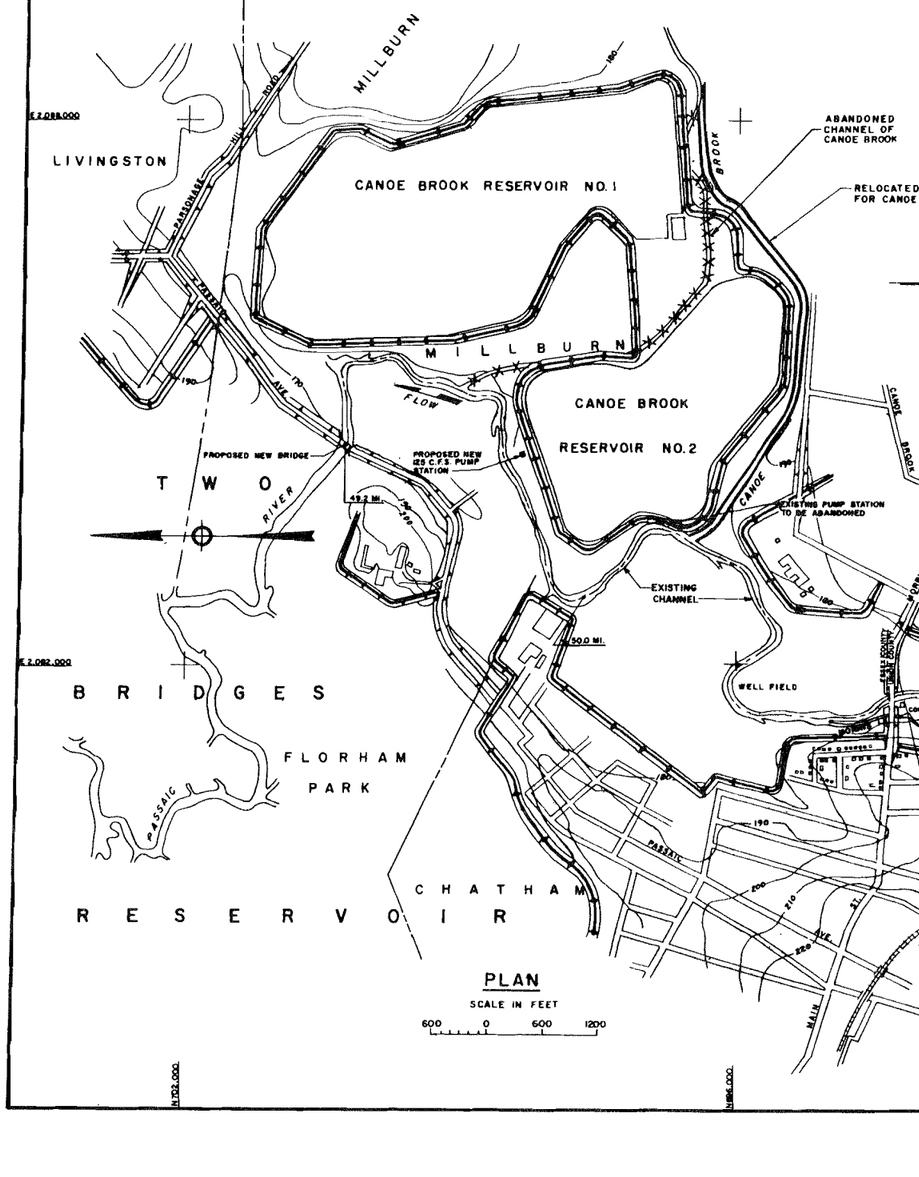
U.S. ARMY



PROFILE

SCALE IN FEET

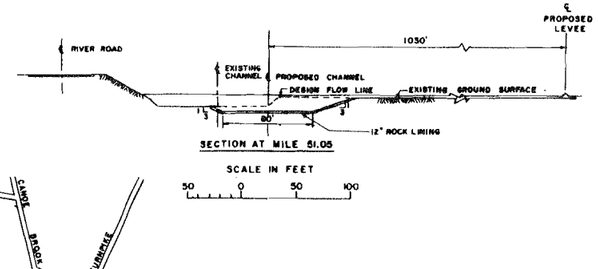
600 0 600 1200



PLAN

SCALE IN FEET

600 0 600 1200



SECTION AT MILE 51.05

SCALE IN FEET

50 0 50 100

LEGEND

- FLOOD WALL
- CHANNEL IMPROVEMENT
- RAISED ROAD
- LEVEE
- ABANDONED CHANNEL XXXXXX

FIG 15

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 49.2 TO MILE 52.45

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, INT'R BASINS SECTION	Stanley Manuel, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED:	Drawn by	DRAWING NUMBER
Thomas W. Brandt, COLONEL, C. E., DISTRICT ENGINEER	Checked by	CR-PRB-15

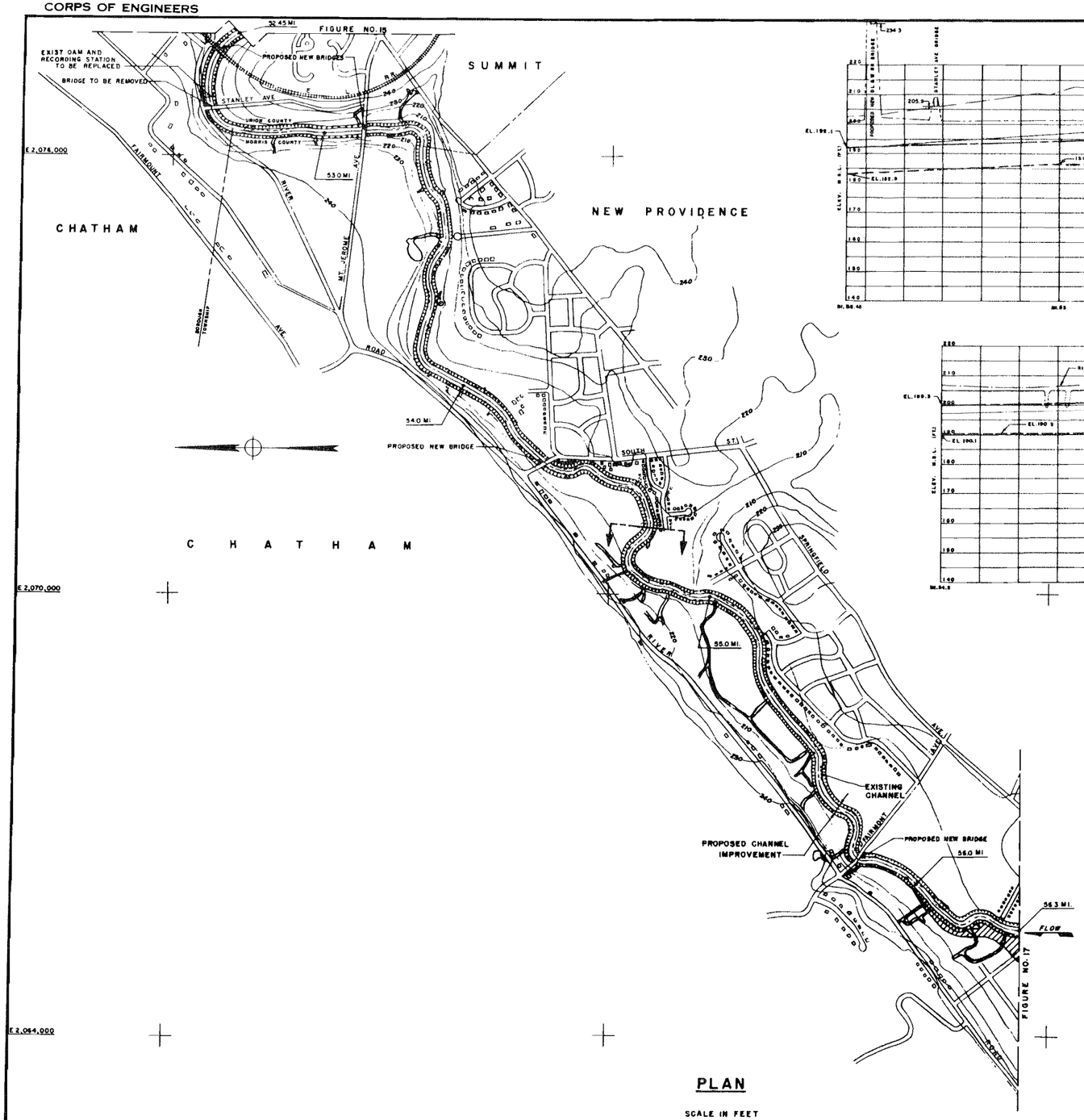
TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 15

CORPS OF ENGINEERS

U.S. ARMY

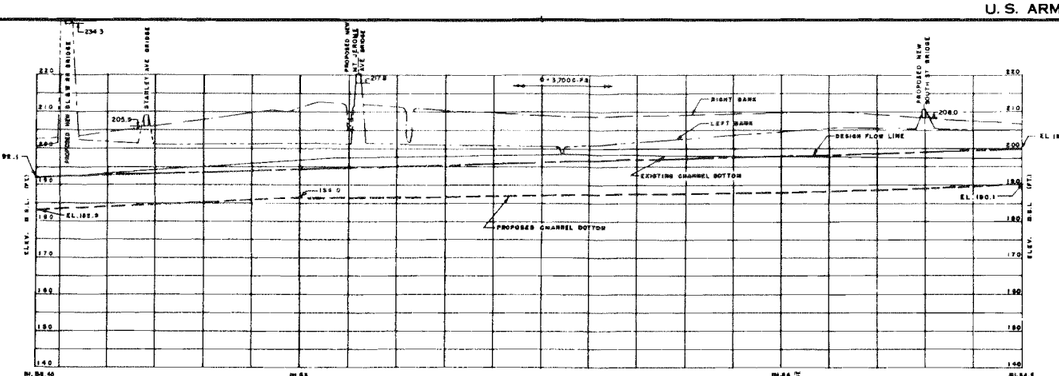
FIGURE NO. 16

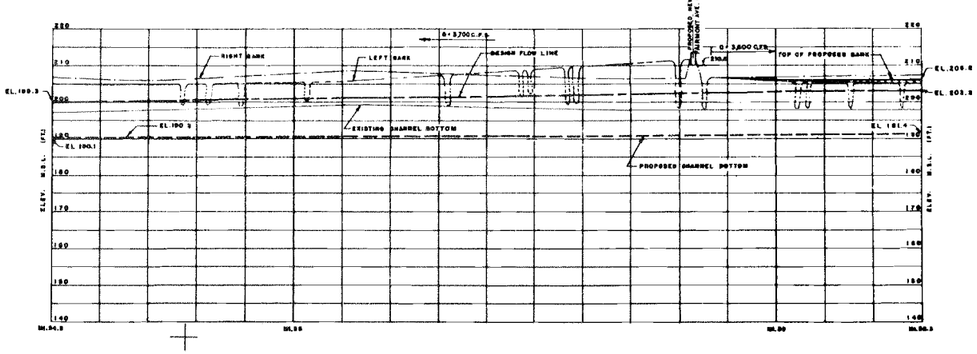


PLAN

SCALE IN FEET

600 0 600 1200



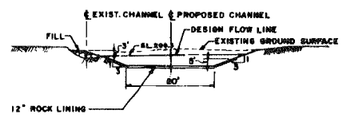


PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30



SECTION AT MILE 54.68

SCALE IN FEET

50 0 50 100

LEGEND

FILL (PLAN)

FILL (PROFILE L.B.)

CHANNEL IMPROVEMENT

FIG 16

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 52.45 TO MILE 56.3

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tros, CHIEF, RIVER BASIN SECTION	Stanley Maisel, CHIEF, RIVERS & HARBORS PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: James W. Benoit, COLONEL, C. E., DISTRICT ENGINEER

Drawn by

Checked by

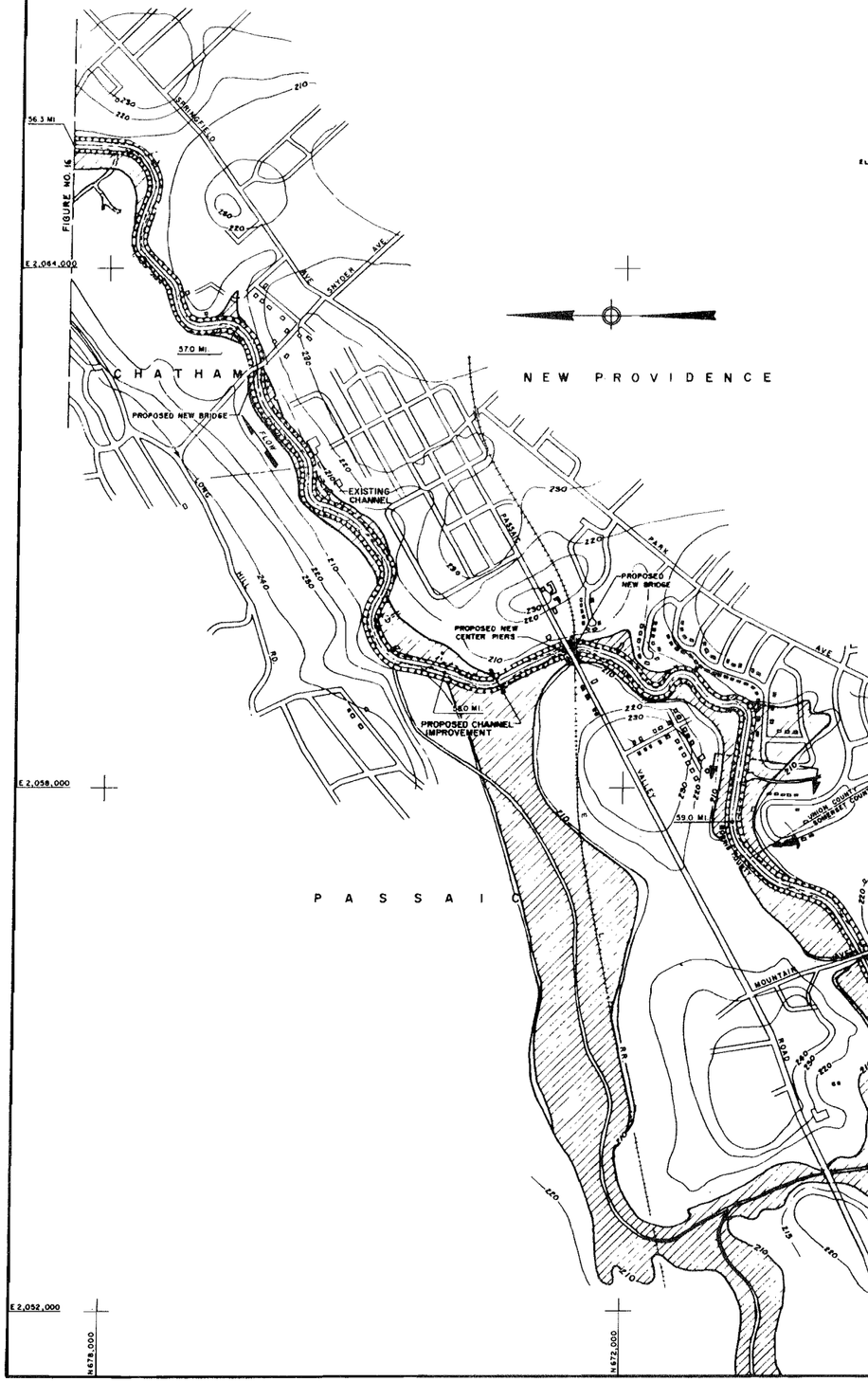
DRAWING NUMBER CR-PRB-16

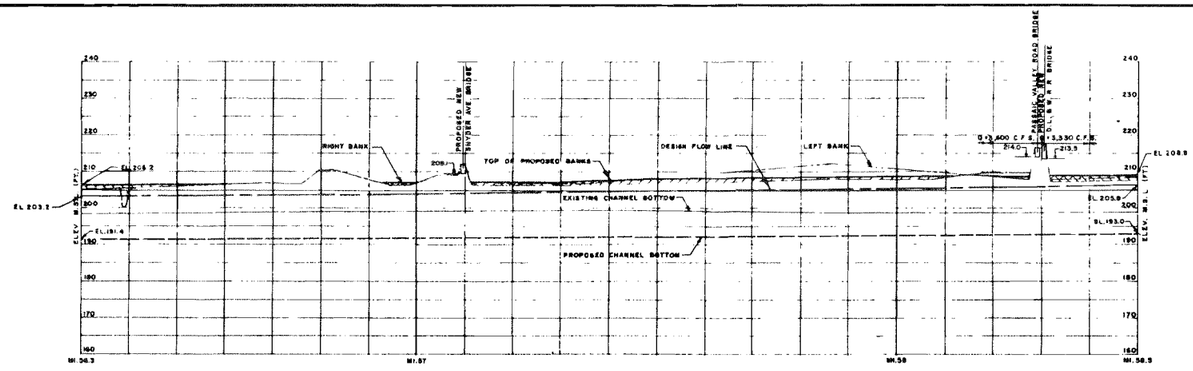
TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

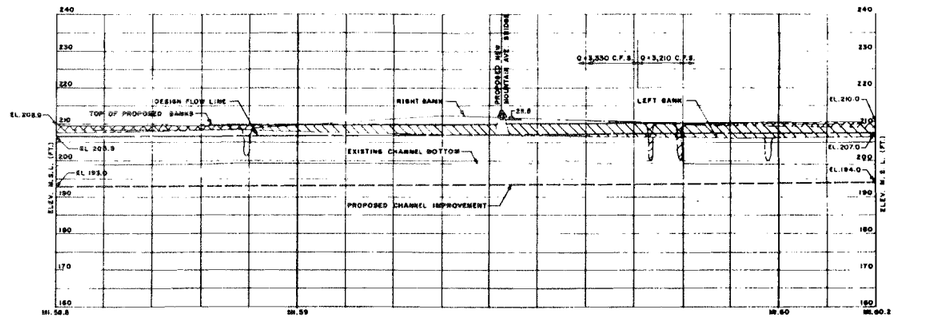
FIGURE 16

CORPS OF ENGINEERS

U. S. ARMY





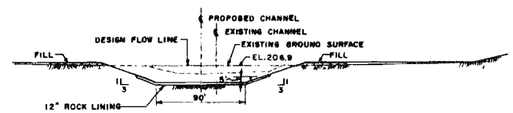


PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30



SECTION AT MILE 58.87

SCALE IN FEET

50 0 50 100

LEGEND

- FILL (PLAN)
- FILL PROFILE (R.B.)
- FILL PROFILE (L.B.)
- FILL PROFILE (BOTH BANKS)
- CHANNEL IMPROVEMENT

PLAN

SCALE IN FEET

500 0 600 1200

FIG 17

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress)

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 56.3 TO MILE 60.2

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tees, CHIEF RIVER BASIN SECTION	Stanley Manuel, CHIEF BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: James W. Sweet, COLONEL, C. E., DISTRICT ENGINEER

Drawn by

Checked by

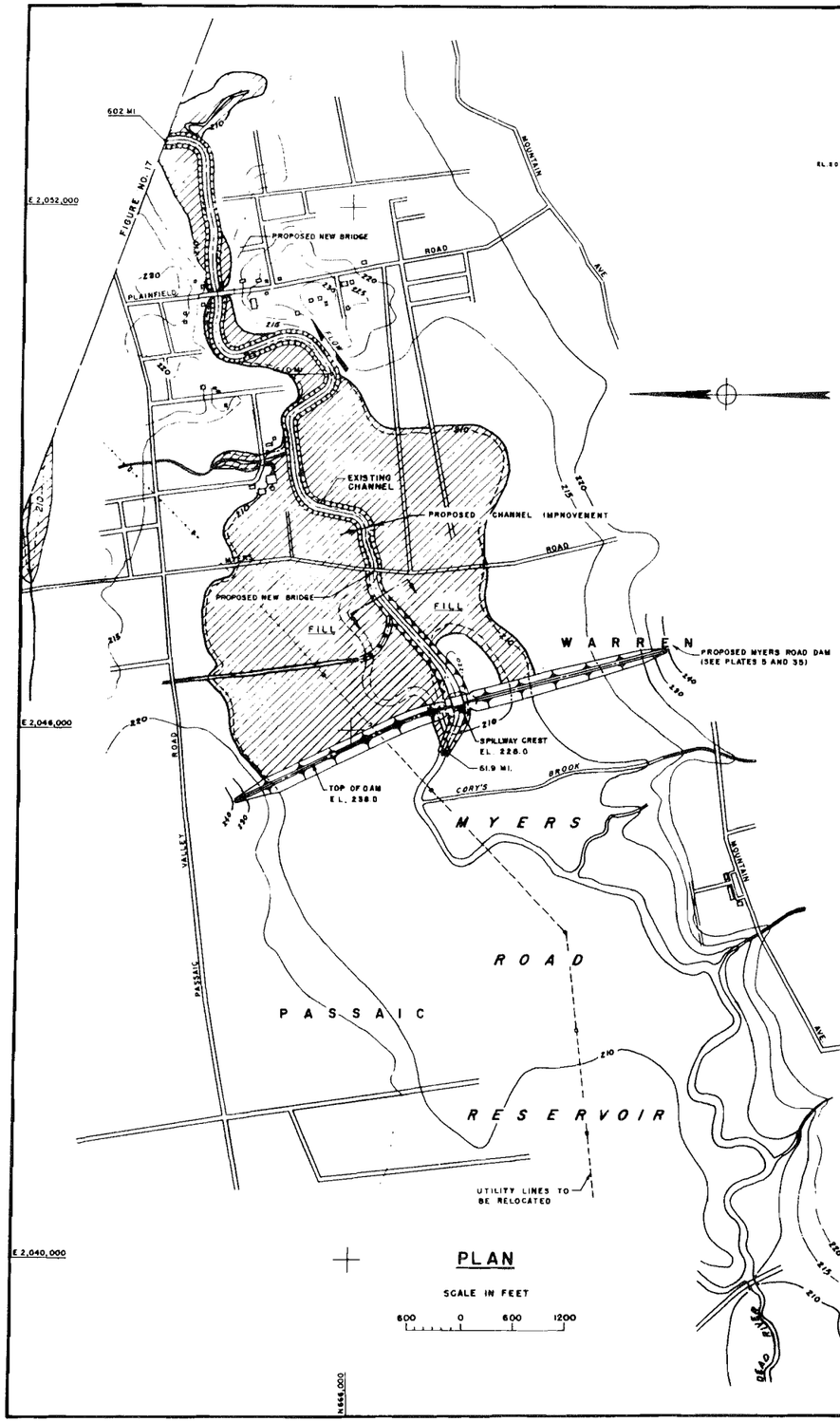
DRAWING NUMBER CR-PRB-17

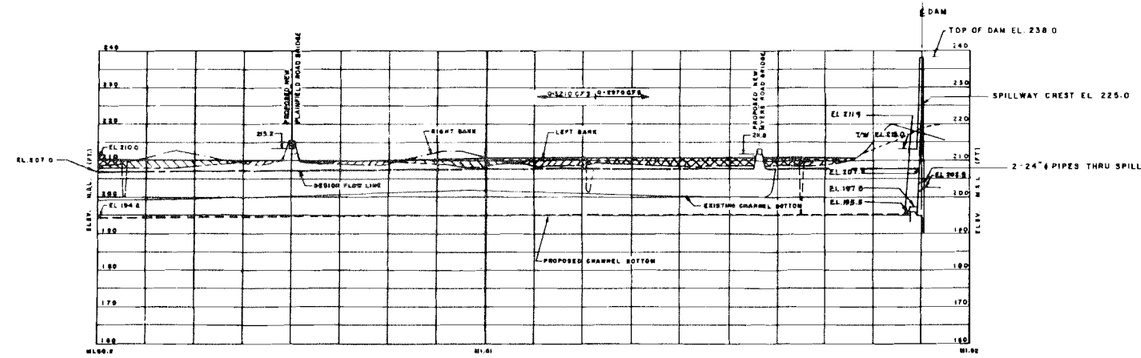
TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 17

CORPS OF ENGINEERS

U.S. ARMY



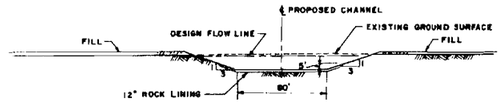


PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30



SECTION AT MILE 61.60

SCALE IN FEET

50 0 50 100

LEGEND

FILL (PLAN)

FILL PROFILE (R.B.)

FILL PROFILE (L.B.)

FILL PROFILE (BOTH BANKS)

CHANNEL IMPROVEMENT

FIG 18

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PASSAIC RIVER MILE 60.2 TO MILE 61.9

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, BASIN SECTION	Stanley Maisel, CHIEF, BASIN & DISTRICT PLANNING SEC.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: James D. Bennett, COLONEL, C.E., DISTRICT ENGINEER

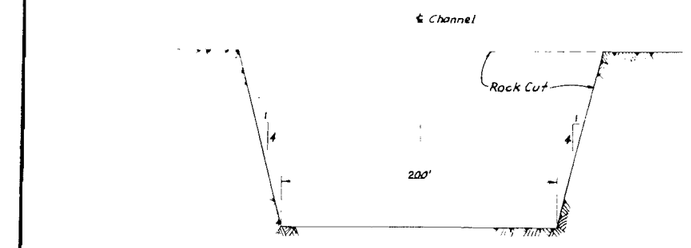
Drawn by

Checked by

DRAWING NUMBER: CR-PRB-18

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

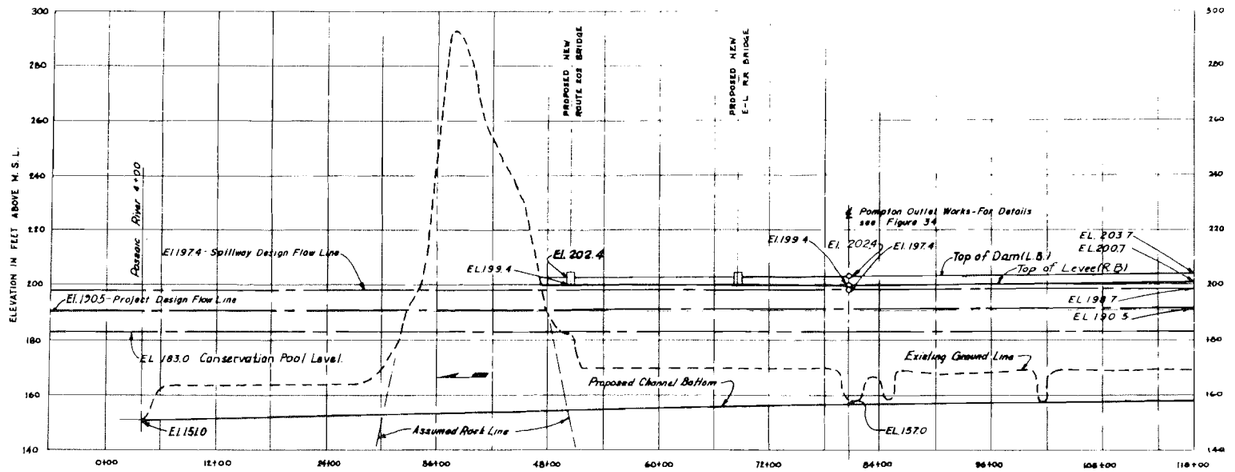
FIGURE 18



SECTION AT STATION 40 + 00

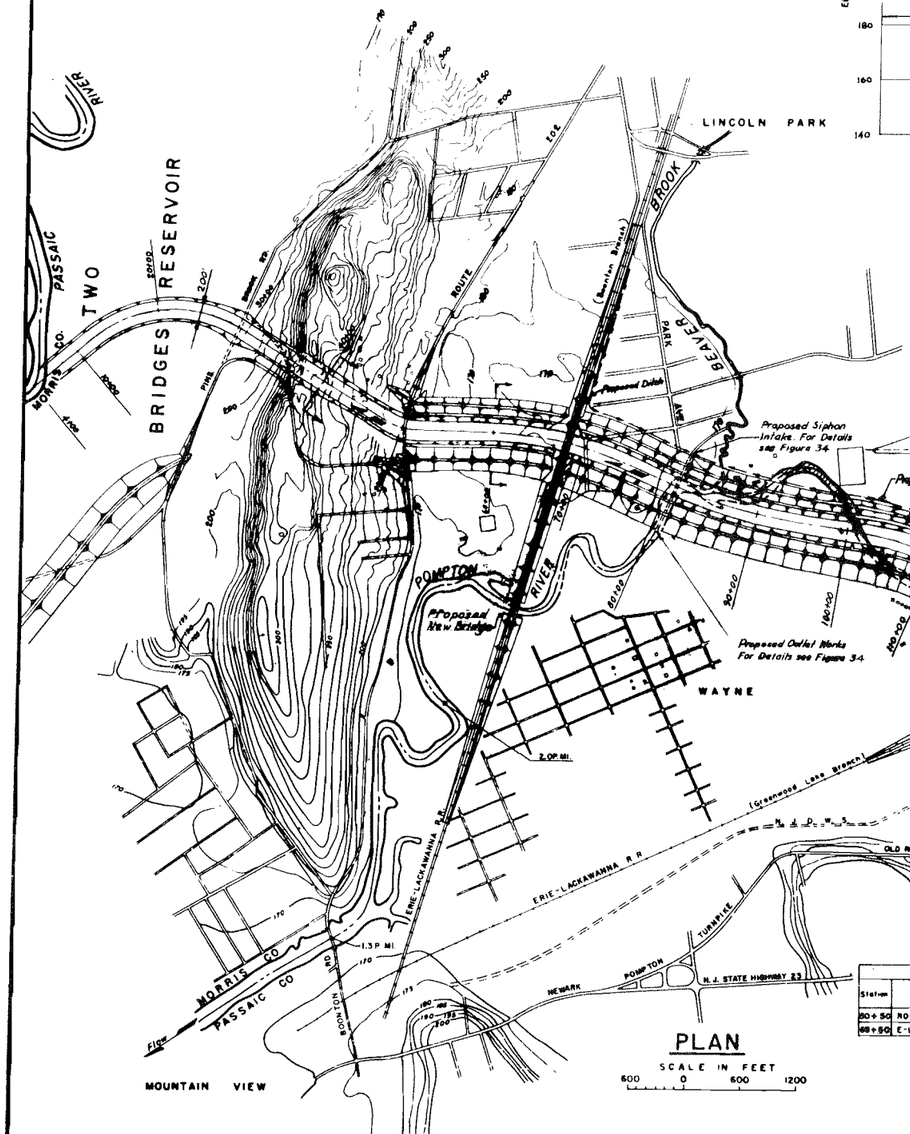
SCALE IN FEET

40 0 40 80



PROFILE

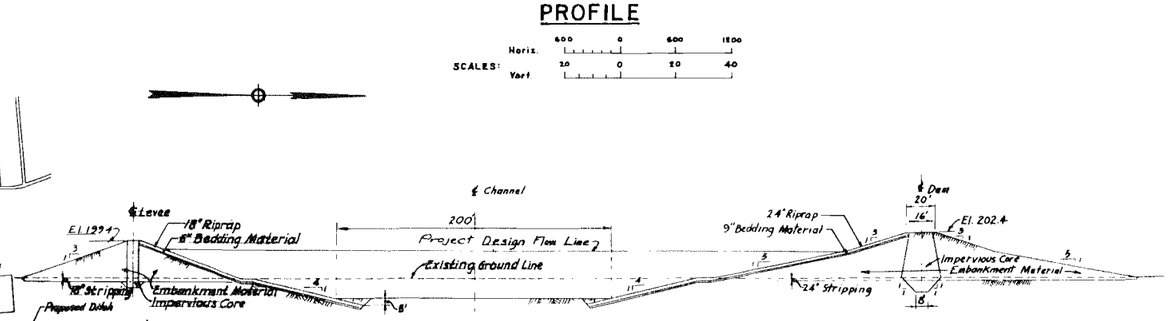
SCALES: Horiz. 600 0 600 1200; Vert. 20 0 20 40



PLAN

SCALE IN FEET

600 0 600 1200



SECTION AT STATION 60 + 00

SCALE IN FEET

40 0 40 80

BRIDGE DATA

Station	Name of Bridge	Type	EXISTING BRIDGES: No Spans	Longest Single Opening (Ft)	Normal to Channel Total Horiz Clear Opening (Ft)	Elev Low Steel M.S.L.	MODIFICATION TO BRIDGES: New or Revised	No Spans	Longest Single Opening (Ft)	Normal to Channel Total Horiz Clear Opening (Ft)	Elev Low Steel M.S.L.	Remarks
50+50	ROUTE 202	—	—	—	—	—	New	2	135.0	260.0	199.4	Steel Truss
68+50	E-L R.R. (Boonton Br)	—	—	—	—	—	New	2	135.0	260.0	199.4	Steel Truss

FIG 19

Submitted with Survey Report in compliance with Sections 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

POMPTON RIVER DIVERSION

MILE 1.3 P TO 3.32 P

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF OPER. MAINT. SECTION	Stanley Mussal, CHIEF PLANS & PROJECT PLANNING SE.	F. L. Pagano, CHIEF ENGINEERING DIVISION

APPROVED: James W. Bennett, COL., C. E., DISTRICT ENGINEER

Drawn by

Checked by

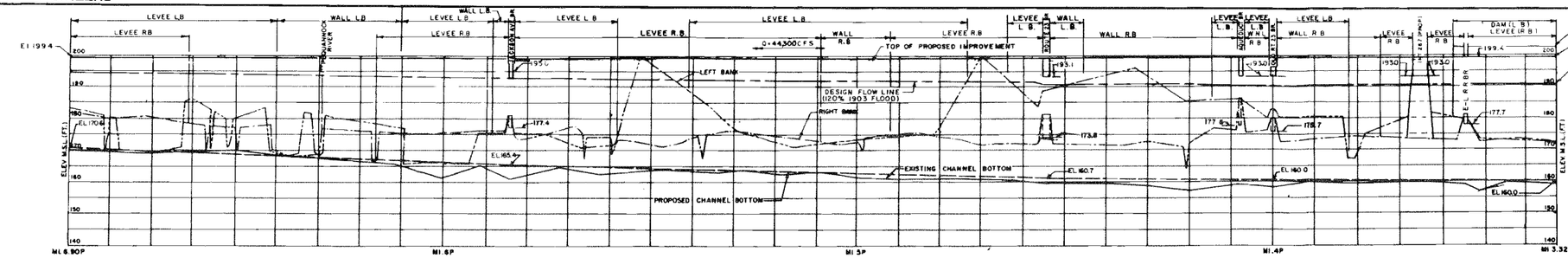
DRAWING NUMBER CR-PRB-19

TO ACCOMPANY SURVEY REPORT DATED 4MAR 1972

FIGURE 19

CORPS OF ENGINEERS

U. S. ARMY

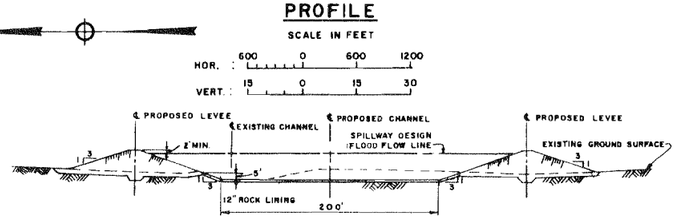


PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

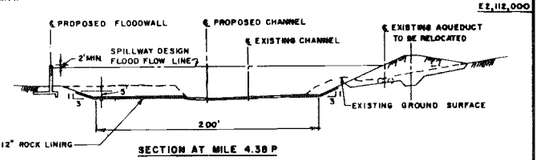
VERT. 15 0 15 30



SECTION AT MILE 4.98 P

SCALE IN FEET

50 0 50 100



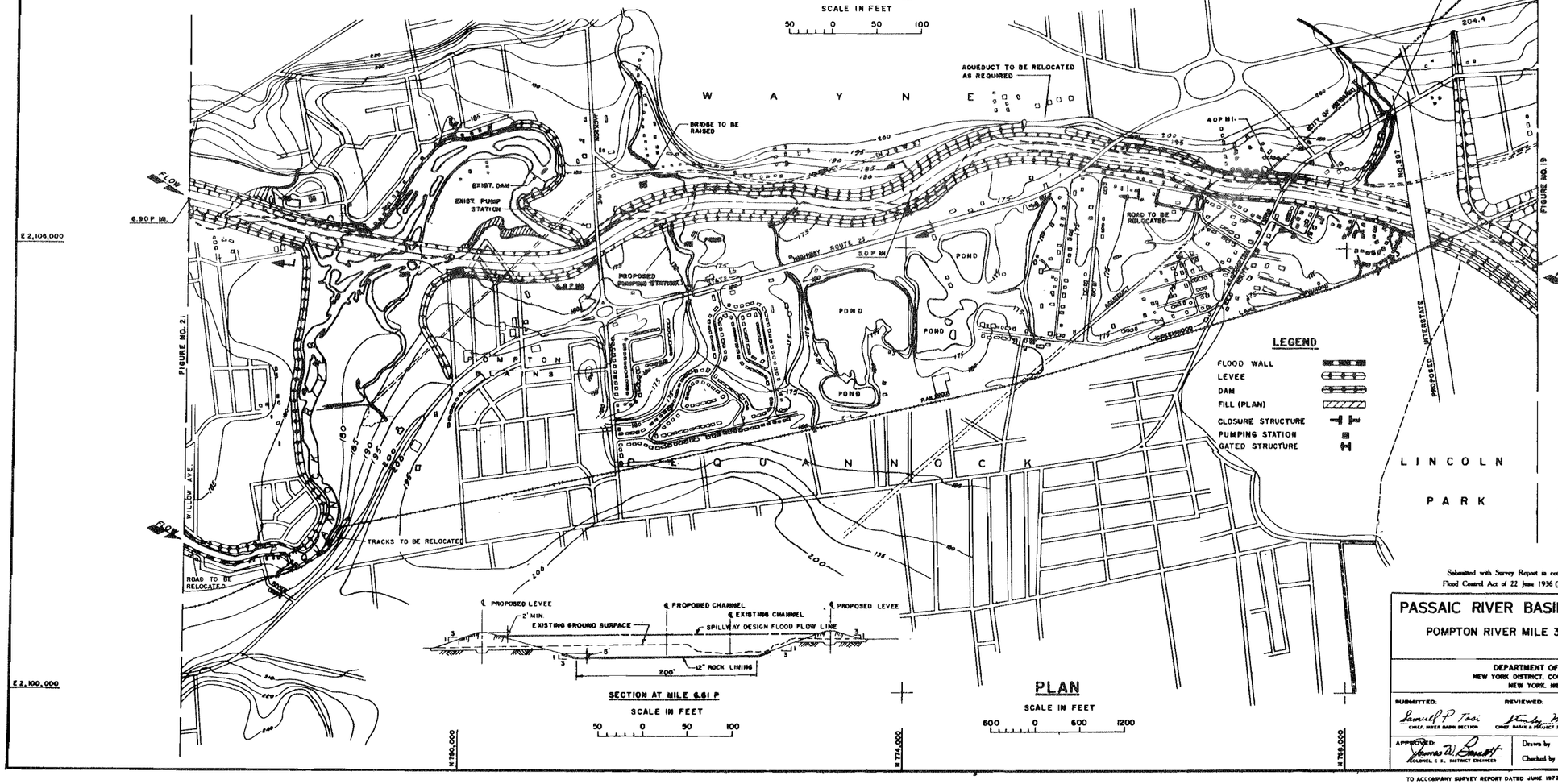
SECTION AT MILE 4.38 P

SCALE IN FEET

50 0 50 100

MODIFICATION TO BRIDGES

Miles Above Mouth	Name of Bridge	Type	New or Raised	No. Spans	Longest Single Opening(Ft.)	Normal to Channel Total Horiz. Clear Opening (Ft.)	Elev. Low Steel M.S.L.	Length of New Approaches(Ft)	Remarks
3.55	GREENWOOD LANE BRANCH E-L.R.R	Trestle 3 Thru Plate Girders	New	2	135.0	260.0	198.4	6000	Steel Truss Raise 2.5 Ft.
3.66	INT. ROUTE 287		New				193.0		
4.00	NEWARK POMPTON TURNPIKE (OLD ROUTE 23)	Hwy., Thru Girder	New	2	135.0	260.0	193.0	1150	Steel Truss Raise 17.3 Ft.
4.08	NEWARK WATER SUPPLY	Aqueduct Steel Thru Truss	New	5	77.2	253.0	188.0	450	Add 1-20' Span Raise 15.6 Ft.
4.84	ROUTE 23	Hwy., Deck Plate Girder	New	6	115.0	253.0	193.1	1900	Add 1-15' Span Raise 19.3 Ft.
5.84	JACKSON AVE.	Hwy., Thru Plate Girder	New	4	100.0	282.0	195.0	880	Add 4-31' Spans Raise 16.8 Ft.



LEGEND

- FLOOD WALL
- LEVEE
- DAM
- FILL (PLAN)
- CLOSURE STRUCTURE
- PUMPING STATION
- GATED STRUCTURE

SECTION AT MILE 6.61 P

SCALE IN FEET

50 0 50 100

PLAN

SCALE IN FEET

600 0 600 1200

FIG 20

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

POMPTON RIVER MILE 3.32 P TO MILE 6.9 P

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Stanley Masuk, CHIEF BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: James W. Bennett, COLONEL, C. E., DISTRICT ENGINEER

Drawn by

Checked by

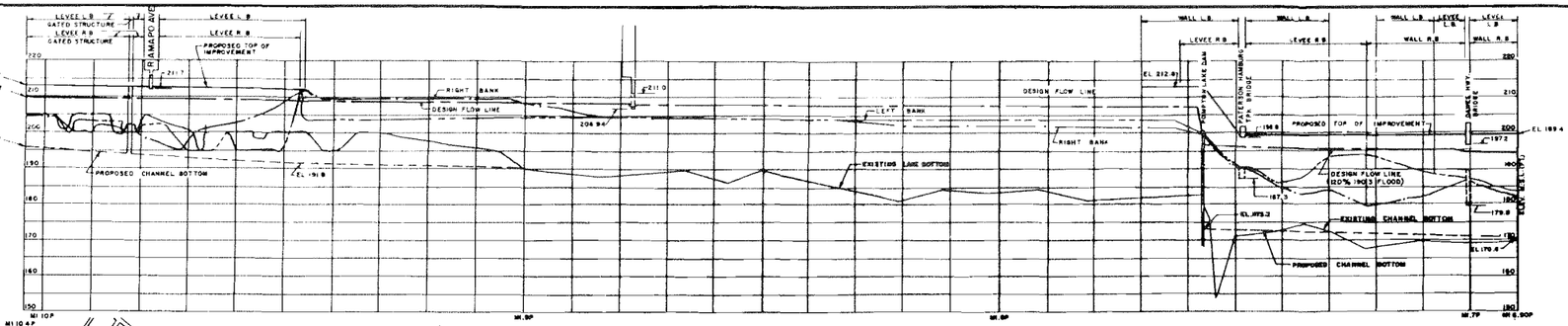
DRAWING NUMBER CR-PRB-20

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 20

CORPS OF ENGINEERS

U.S. ARMY

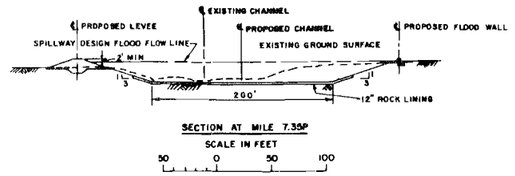


PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30



SECTION AT MILE 7.35P

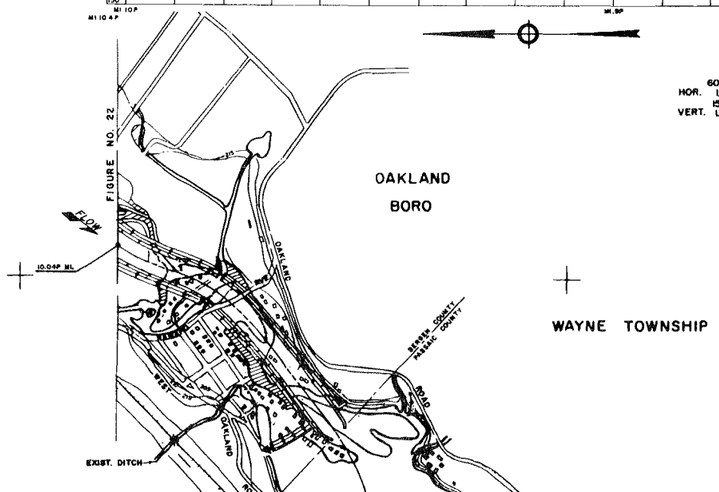
SCALE IN FEET

50 0 50 100

E 2,112,000

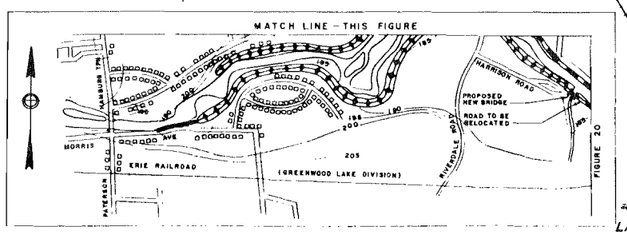
E 2,118,000

E 2,132,000



E 2,108,000

N 736,000



PLAN

SCALE IN FEET

600 0 600 1200

MODIFICATION TO BRIDGES

Miles Above Mouth	Name of Bridge	Type	New or Raised	No Spans	Longest Single Opening (Ft.)	Normal To Channel Total Horiz. Clear Opening (Ft.)	Elev. Low Steel	Length of New Approaches	Remarks
7.00	DAWES HIGHWAY	Hwy. Deck Conc. Arch	New	2	136.0	262.0	197.2	550'	2-136' Spans - Raise 9.47'
7.46	PATERSON - HAMBURG TPK.	Hwy., Concrete Beam	New	4	79.0	194.0	196.7	600'	Add 1-80' Span - Raise 12.3'
8.77	SCHUYLER AVE	Encased Beam	New	3	45.4	135.5	211.0	400'	Raise 4.08'
9.78	RAMAPO AVE.	Composite Steel Beam & Conc. Deck	New	5	80.0	296.6	211.7	4.00	3-82' Spans, 2-30' Spans

LEGEND

CLOSURE STRUCTURE

FLOOD WALL

LEVEE

GATED STRUCTURE M

FIG 21

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

POMPTON AND RAMAPO RIVERS MILE 6.90 P TO MILE 10.04 P

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Fred Merrick, CHIEF BASIN & PROJECT PLANNING BR.	J. R. Pegano, CHIEF, ENGINEERING DIVISION

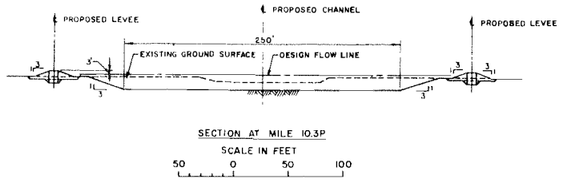
APPROVED:	Drawn by	DRAWING NUMBER
James W. Benoit, COLONEL C.E., DISTRICT ENGINEER	Checked by	CR-PRB-21

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 21

CORPS OF ENGINEERS

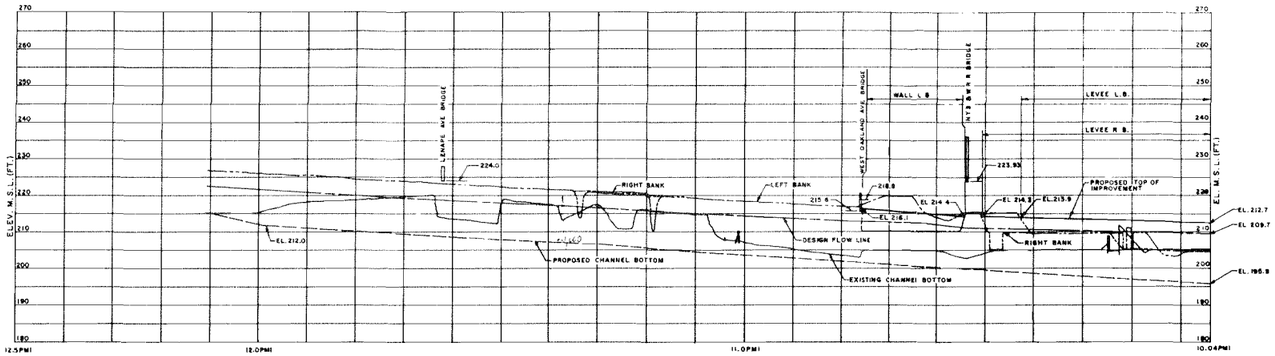
U. S. ARMY



SECTION AT MILE 10.3P

SCALE IN FEET

50 0 50 100

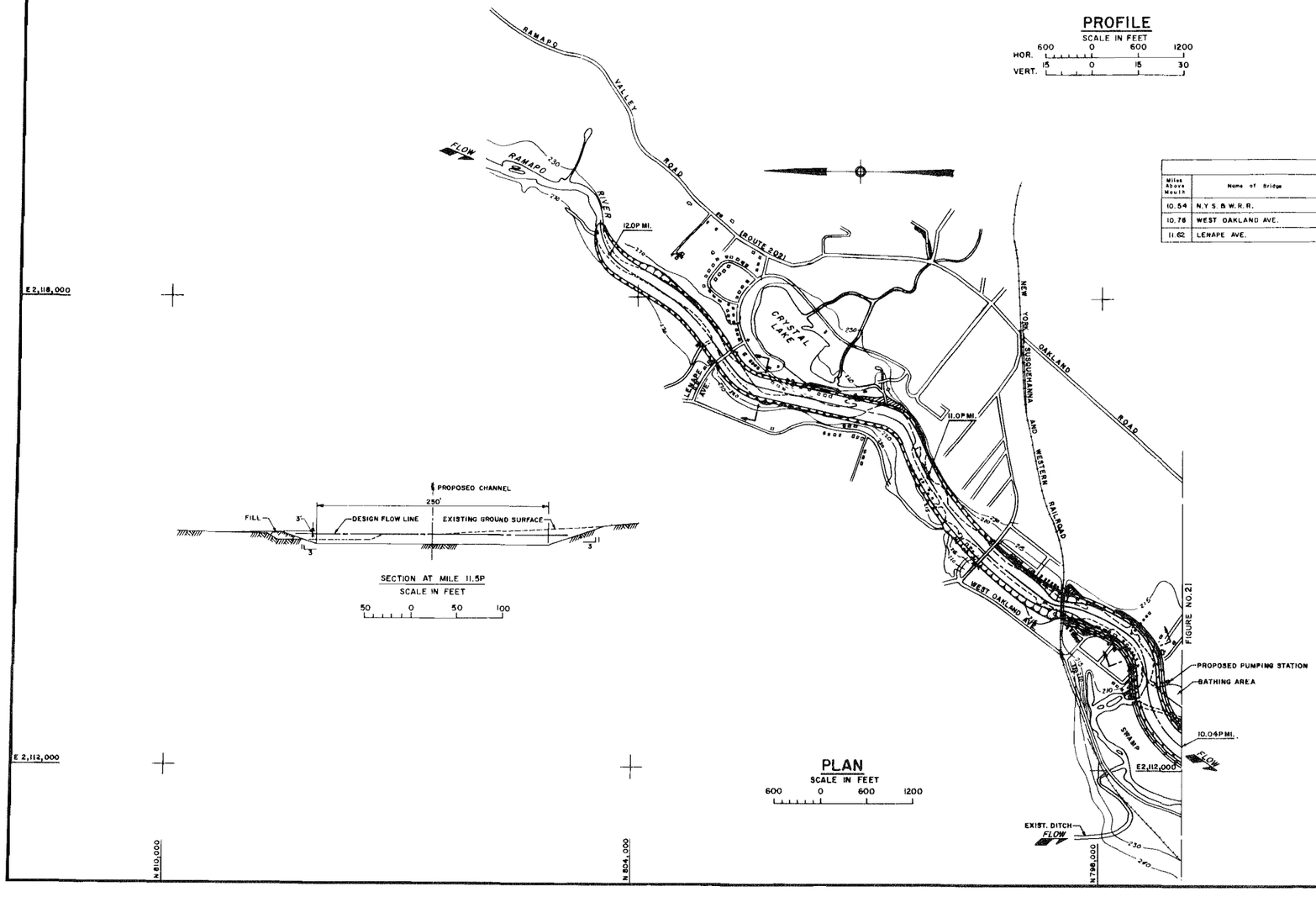


PROFILE

SCALE IN FEET

HOR. 600 0 600 1200

VERT. 15 0 15 30



PLAN

SCALE IN FEET

600 0 600 1200

SECTION AT MILE 11.5P

SCALE IN FEET

50 0 50 100

MODIFICATION TO BRIDGES

Miles Above Mouth	Name of Bridge	Type	New Or Raised	No. Spans	Longest Single Opening (Ft.)	Normal To Channel Total Horiz. Clear Opening (Ft.)	Elev. Low Steel M.S.L.	Length Of New Approaches	Remarks
10.54	N.Y.S.&W.R.R.	Deck Truss	—	3	95.2	284.8	223.93	—	New Piers & Abutments
10.76	WEST OAKLAND AVE.	Comp. Steel Beam & Conc. Deck	New	5	80.0	296.6	215.6	300'	3-80' Spans 2-30' Spans
11.62	LENAPE AVE.	Comp. Steel Beam & Conc. Deck	New	5	80.0	296.6	224.0	300'	3-80' Spans 2-30' Spans

FIG 22

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

LOCAL PROTECTION

RAMAPO RIVER MILE 10.04P TO MILE 12.1 P

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Stanley Manuel, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: Thomas D. Bennett, COLONEL, C. E. DISTRICT ENGINEER

Drawn by

Checked by

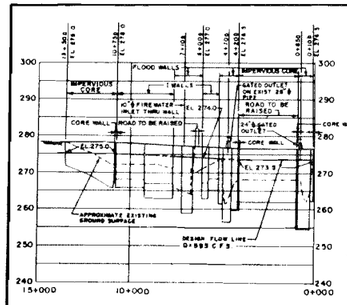
DRAWING NUMBER CR-PRB-22

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

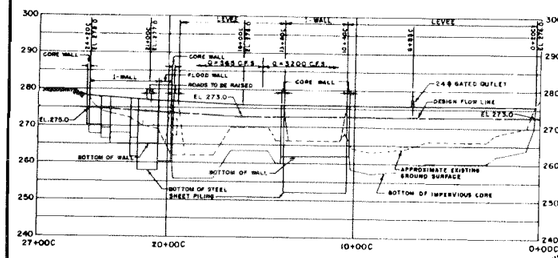
FIGURE 22

CORPS OF ENGINEERS

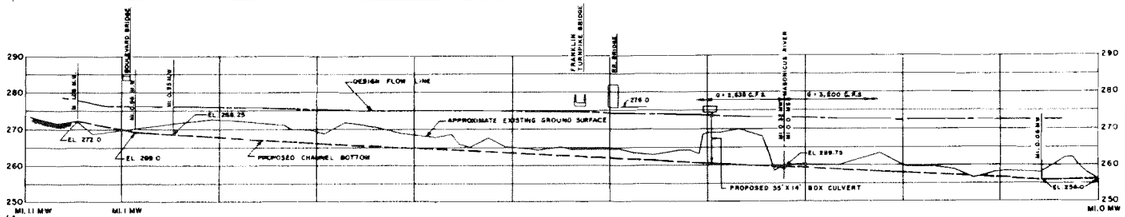
U. S. ARMY



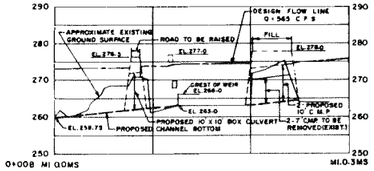
PROFILE ALONG ℄-PROTECTION "D"



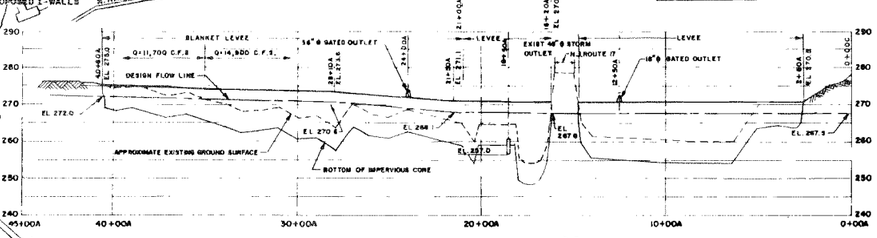
PROFILE ALONG ℄-PROTECTION "C"



PROFILE ALONG ℄ MAHWAH RIVER RELOCATION



PROFILE ALONG ℄ MASONICUS RIVER RELOCATION



PROFILE ALONG ℄-PROTECTION "A"

PLAN

SCALE IN FEET

300 0 300 600

PROFILE ALONG ℄-PROTECTION "B"

PROFILES

SCALE IN FEET

HOR. 300 0 300 600

VERT. 15 0 15 30

LEGEND

PROPOSED LEVEE

PROPOSED WALL

FIG 23

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.
LOCAL PROTECTION
MAHWAH, NEW JERSEY AND SUFFERN, NEW YORK

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tate, CHIEF, RIVER BASIN SECTION	Stanley Mussal, CHIEF, BASIN & PROJECT PLANNING BR.	J. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: James W. Bartlett, COLONEL, C. E., DISTRICT ENGINEER

Drawn by

Checked by

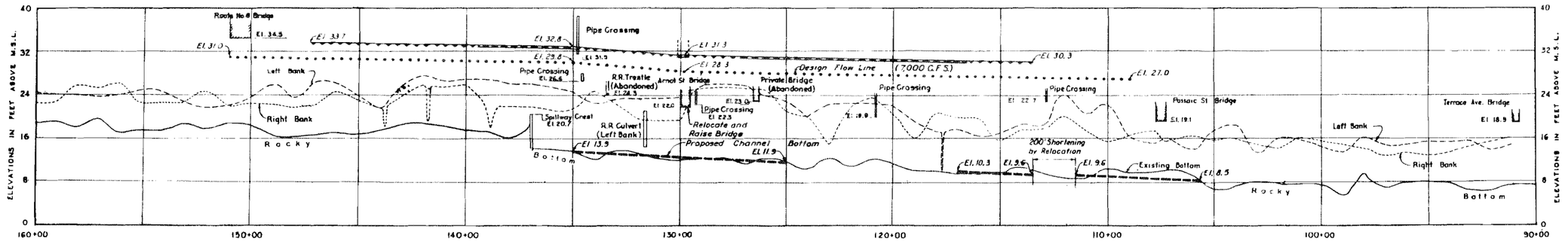
DRAWING NUMBER CR-PRB-23

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 23

CORPS OF ENGINEERS

U. S. ARMY

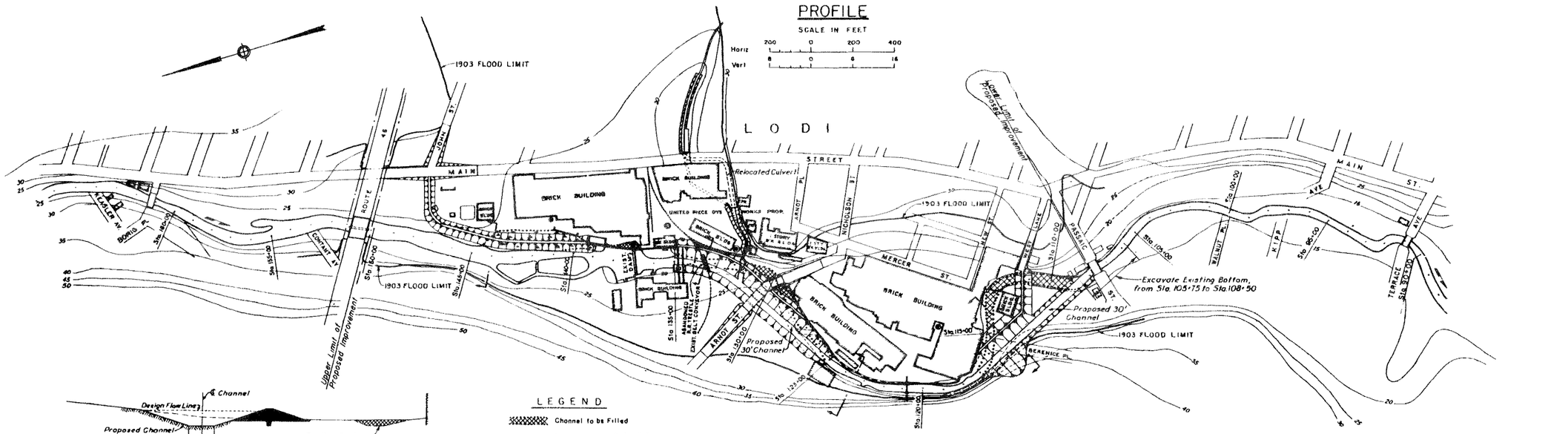


PROFILE

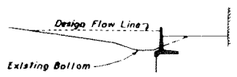
SCALE IN FEET

Horiz 200 0 200 400

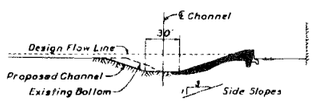
Vert 8 0 8 16



SECTION AT STA. 114+00



SECTION AT STA. 123+50



SECTION AT STA. 133+50

SECTION AT STA. 144+00

SCALE IN FEET

50 0 50 100

LEGEND

- Channel to be Filled
- Proposed Wall ("L" or "T")
- Proposed Levee (On Plan)
- Proposed Levee (On Profile)
- Proposed Pumping Plant

PLAN

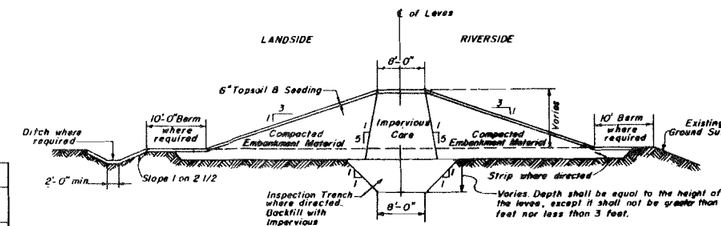
SCALE IN FEET

200 0 200 400

BRIDGE DATA

EXISTING BRIDGES

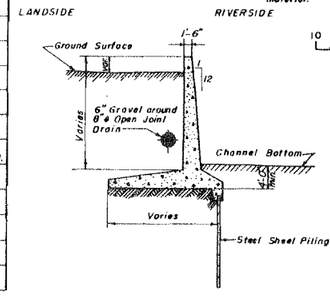
Station	Name of Bridge	Type	Number Spans	Longest Single Opening (Ft.)	Normal to Channel Total Horizontal Clear Opening (Ft)	Clear Elevation M.S.L.	Remarks
107+50	PASSAIC ST.	Highway Thru Girder	1	52.5	52.5	19.1	No Work
112+90	PRIVATE	Pipe Crossing Steel Beam	3	22.0	60.0	22.7	No Work. Channel Relocated
120+80	PRIVATE	Pipe Crossing Steel & Timber	3	33.5	56.5	19.9	Raise 11 Feet
126+70	PRIVATE	Abandoned Timber Trestle	7	15.0	92.0	23.0	Remove
129+30	PRIVATE	Pipe Crossing Self Supporting	2	35.0	70.0	22.3	Raise 9 Feet. Support on Relocated Arnot St. Bridge
129+70	ARNOT ST.	Highway Deck Girder	2	33.5	67.0	22.0	Relocate, Raise 9.5 Feet. Add Two 30 Ft Approach Spans.
133+50	RAILROAD	Abandoned Timber Trestle	5	15.0	71.0	24.3	Remove. Raise Belt Conveyor Crossing. Construct New Support.
134+60	PRIVATE	Pipe Crossing Self Supporting	1	60.0	60.0	26.6	Raise 6 Feet.
134+80	PRIVATE	Pipe Crossing Steel Truss	1	60.0	60.0	31.5	No Work
150+60	ROUTE 46	Highway Conc. Encased Girder	2	47.5	95.0	34.5	No Work
131+70 Left Bank	RAILROAD	Concrete Box Culvert	1	14.0	14.0	21.2	Extend 65 Ft. Thru Levee, Install Flood Gates



LEVEE SECTION

SCALE IN FEET

10 0 10 20



I-WALL SECTION

SCALE IN FEET

10 0 10 20

FIG 24

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

LOCAL PROTECTION

SADDLE RIVER AT LODI, NEW JERSEY

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Stanley Muscal, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

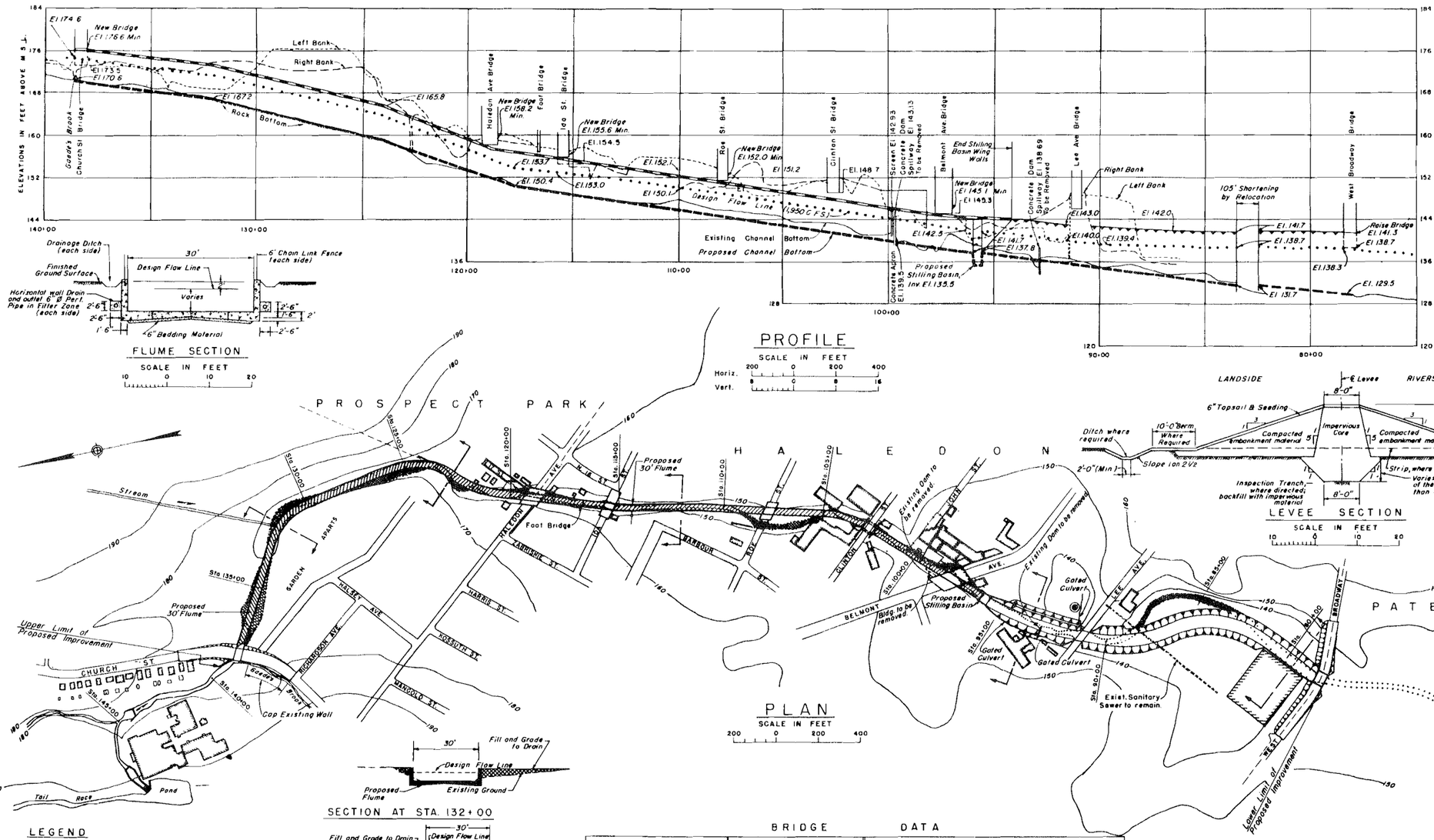
APPROVED:	Drawn by	DRAWING NUMBER
James W. Bennett, COLONEL, C.E. DISTRICT ENGINEER	Checked by	CR-PRB-24

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 24

CORPS OF ENGINEERS

U.S. ARMY



BRIDGE DATA

			EXISTING BRIDGES				MODIFICATION TO BRIDGES					
Station	Name of Bridge	Type	No Spans	Longest Single Opening (Ft)	Normal to Channel-Total Horiz. Clear Opening (Ft.)	Elev Low Steel M.S.L.	New or Raised	No. Spans	Longest Single Opening (Ft.)	Normal to Channel-Total Horiz. Clear Opening (Ft.)	Elev. Low Steel M.S.L.	Remarks
76+20	West Broadway	Hwy.-Thru Plate Girder	1	59.9	59.9	138.7	Raise	1	59.9	59.9	141.3	Raise 2.6 Ft.
91+15	Lee Ave.	Hwy.-Conc. Slab On Steel Beams	1	45.0	45.0	145.7	--	--	--	--	--	No Work
97+45	Belmont Ave.	Hwy.-Conc. Enc. Deck Girder	1	33.2	33.2	145.3	New	1	30.0	30.0	146.1	Steel Beam-Conc. Deck Raise 0.8 Ft.
102+60	Clinton St.	Hwy.-Thru Plate Girder	1	50.0	50.0	148.7	--	--	--	--	--	No Work
107+95	Roe St.	Hwy.-Reinf. Conc. Beam	1	30.0	30.0	151.2	New	1	30.0	30.0	152.0	Steel Beam-Conc. Deck Raise 0.8 Ft
115+40	Ida S.	Hwy.-Conc. Slab On Steel Beams	1	24.0	24.0	154.5	New	1	30.0	30.0	156.4	Steel Beam-Conc. Deck Raise 1.9 Ft
116+70	Private	Foot Bridge Timber	1	25.0	25.0	156.6	--	--	--	--	--	Remove
118+90	Haledon Ave	Hwy.-I Beam & Brick Arch	2	17.0	34.0	(a)159.2 (b)157.2	New	1	30.0	30.0	159.5	Steel Beam-Conc. Deck Raise 2.5 Ft.
138+30	Church St.	Hwy.-Reinf. Conc. Beam	1	22.6	22.6	173.5	New	1	60.0	60.0	177.6	Steel Beam-Conc. Deck Raise 4.1 Ft.

(a) Crown -
(b) Spring Line

FIG 25

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.
LOCAL PROTECTION
MOLLY ANN'S BROOK AT HALEDON, NEW JERSEY

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Frida Musial, CHIEF BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

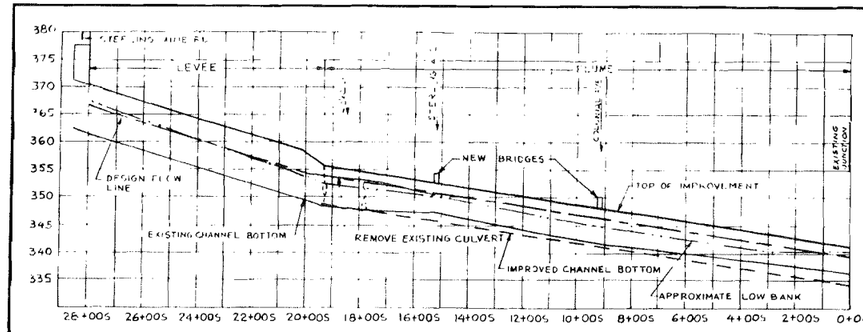
APPROVED: James W. Bennett, COLONEL, C.E. DISTRICT ENGINEER

Drawn by
Checked by

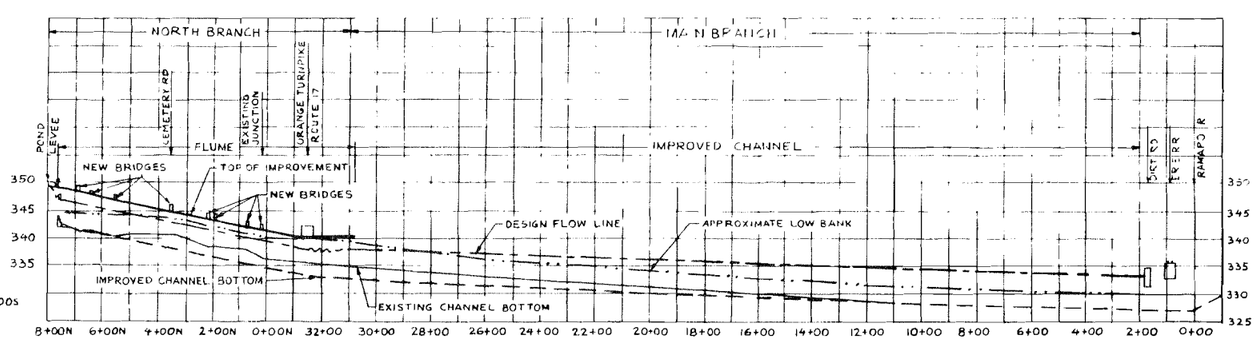
DRAWING NUMBER CR-PRB-25

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 25

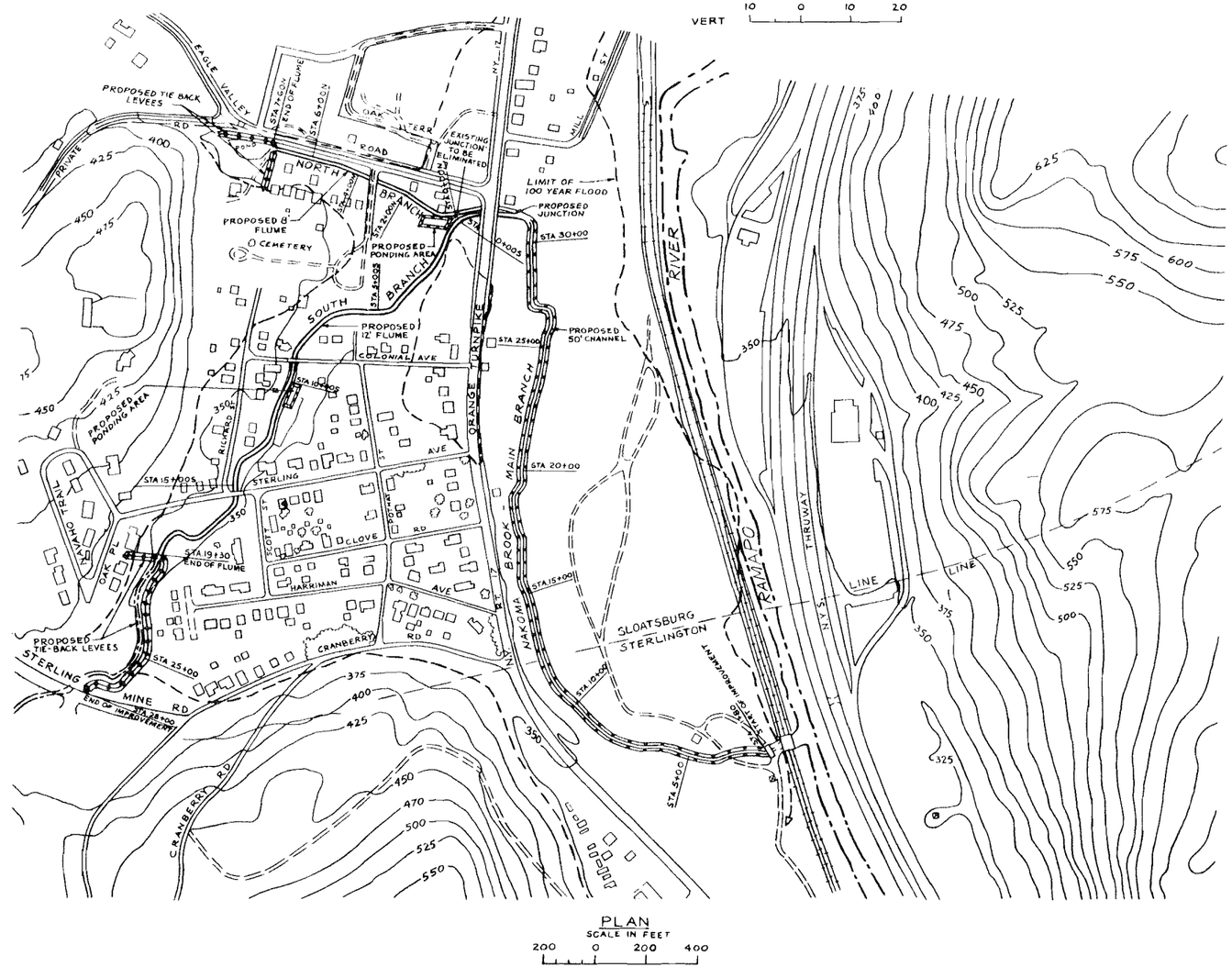


SOUTH BRANCH



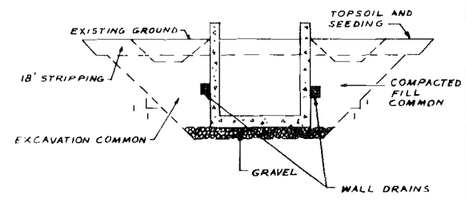
NORTH BRANCH & MAIN BRANCH

PROFILE
SCALE IN FEET
HORIZ 200 0 200 400
VERT 10 0 10 20

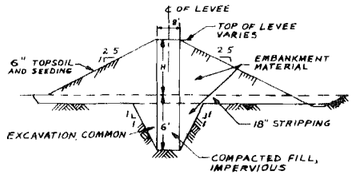


PLAN
SCALE IN FEET
200 0 200 400

LEGEND
- FLUME
- CHANNEL IMPROVEMENT
- LEVEE
- APPROXIMATE LIMIT OF 100 YEAR FLOOD



TYPICAL FLUME CROSS SECTION
NOT TO SCALE



TYPICAL LEVEE CROSS-SECTION
NOT TO SCALE

FIG 26

PASSAIC RIVER BASIN N.J. AND N.Y.
LOCAL PROTECTION
NAKOMA BROOK AT SLOATSBURG, NEW YORK

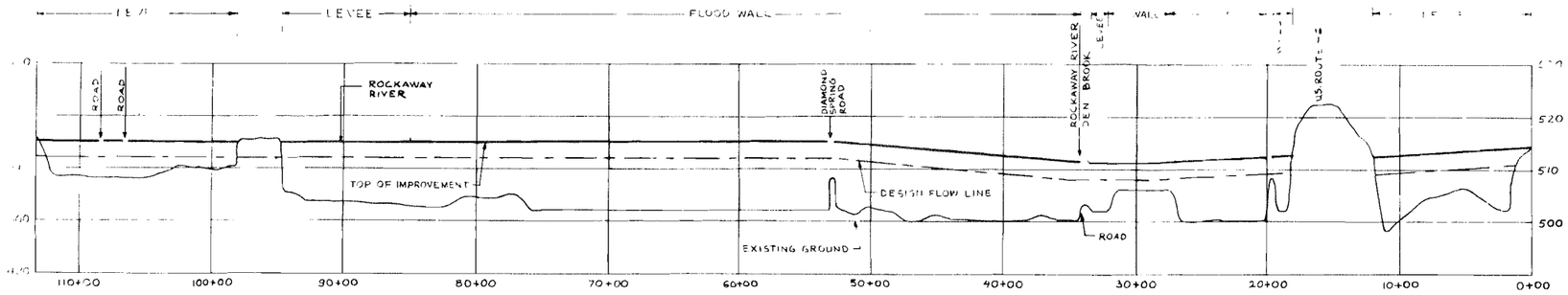
DEPARTMENT OF THE ARMY
NEW YORK DISTRICT, CORPS OF ENGINEERS
NEW YORK, NEW YORK

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P Tosi, CHIEF, RIVER BASIN SECTION	Stanley Maisel, CHIEF, BRANCH PROJECT PLANNING DIV.	F R Pagano, CHIEF, ENGINEERING DIVISION

APPROVED:	Drawn by S.H.	DRAWING NUMBER
James W Barrett, COLONEL, C. E., DISTRICT ENGINEER	Checked by	CR-PRB 26

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE: 26



PROFILE ALONG ℄ IMPROVEMENT

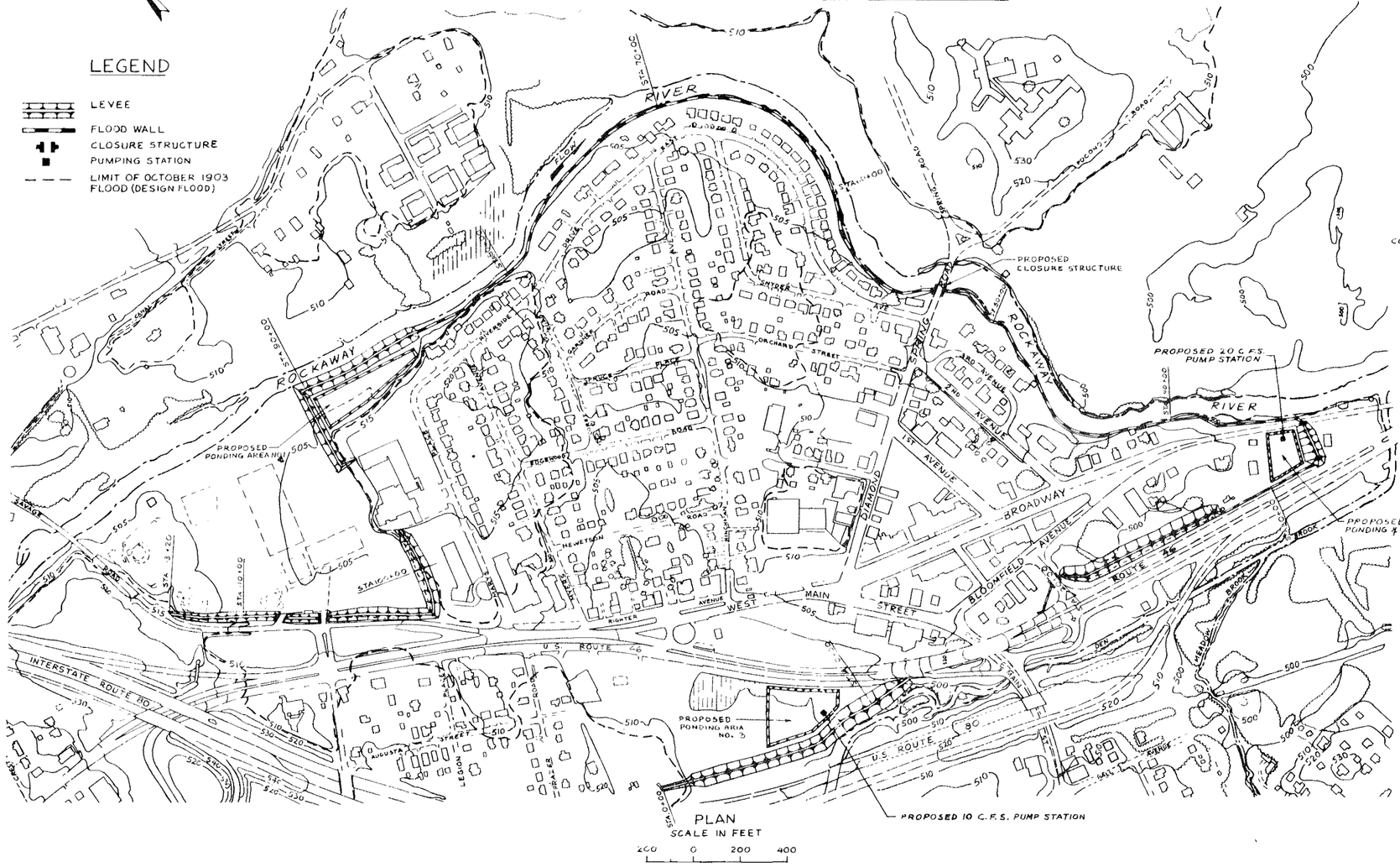
SCALE IN FEET

HORIZ. 400 0 400 800

VERT. 10 0 10 20

LEGEND

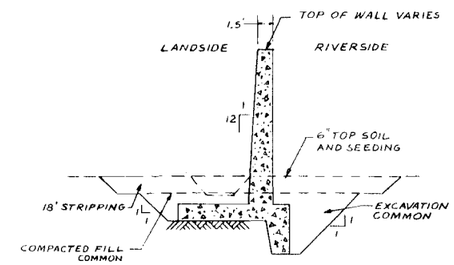
- LEVEE
- FLOOD WALL
- CLOSURE STRUCTURE
- PUMPING STATION
- LIMIT OF OCTOBER 1903 FLOOD (DESIGN FLOOD)



PLAN

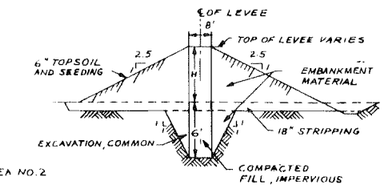
SCALE IN FEET

200 0 200 400



TYPICAL WALL SECTION

NOT TO SCALE



TYPICAL LEVEE CROSS-SECTION

NOT TO SCALE

FIG 27

PASSAIC RIVER BASIN N.J. AND N.Y.

LOCAL PROTECTION

ROCKAWAY RIVER AT DENVILLE, NEW JERSEY

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

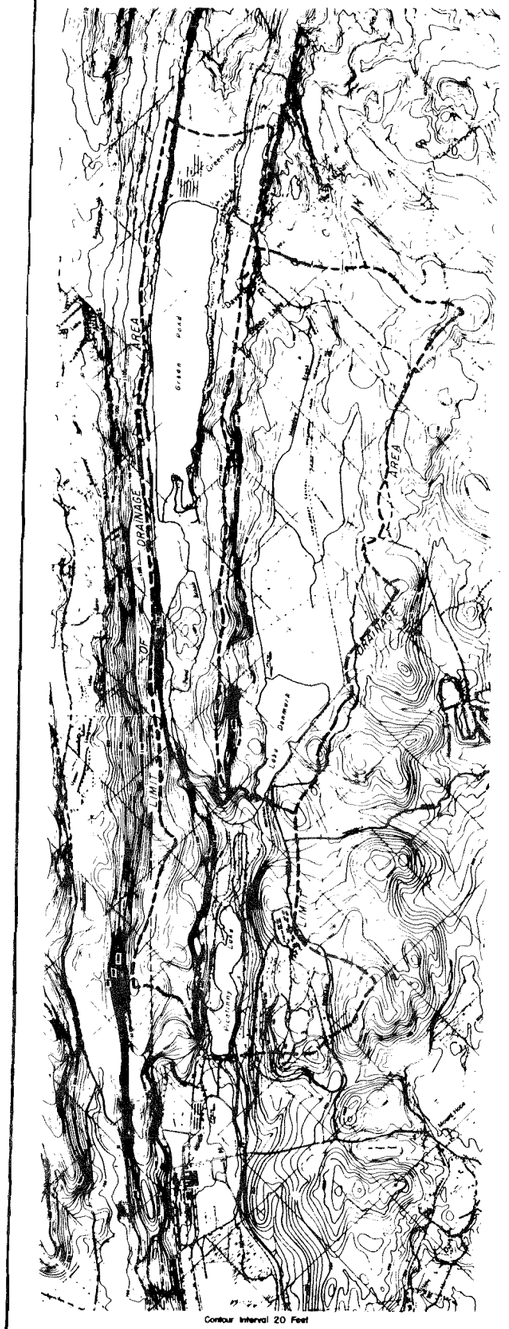
SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Stanley Maisel, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION
APPROVED: Thomas W. Benner, COLONEL, C. E., DISTRICT ENGINEER	Drawn by S.H. Checked by	DRAWING NUMBER CR-PRB-27

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 27

CORPS OF ENGINEERS

U. S. ARMY

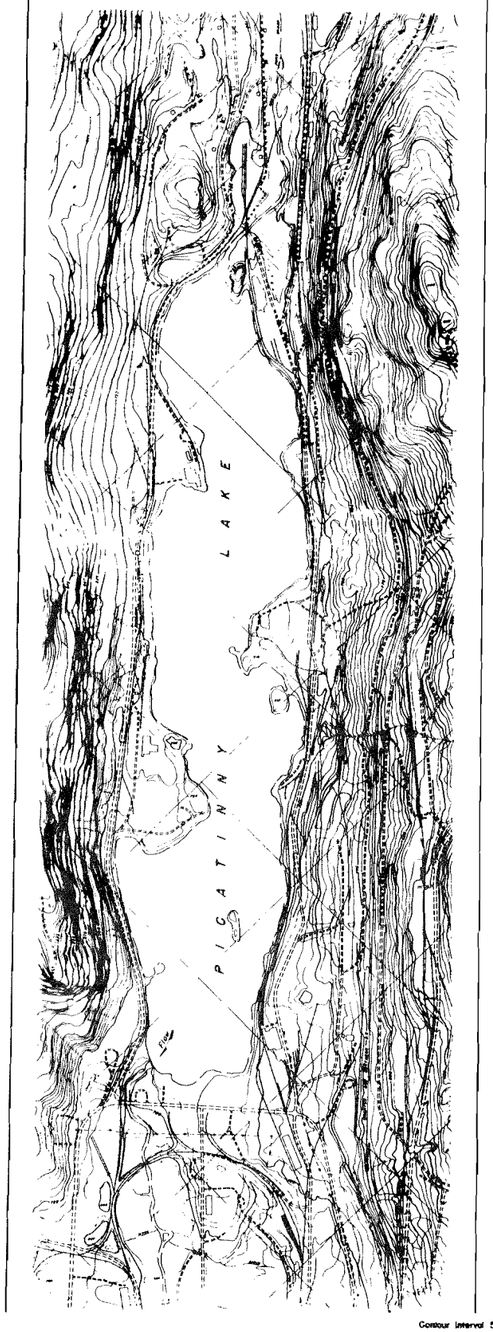


Contour Interval 20 Feet

WATERSHED MAP

SCALE IN MILES

0 1



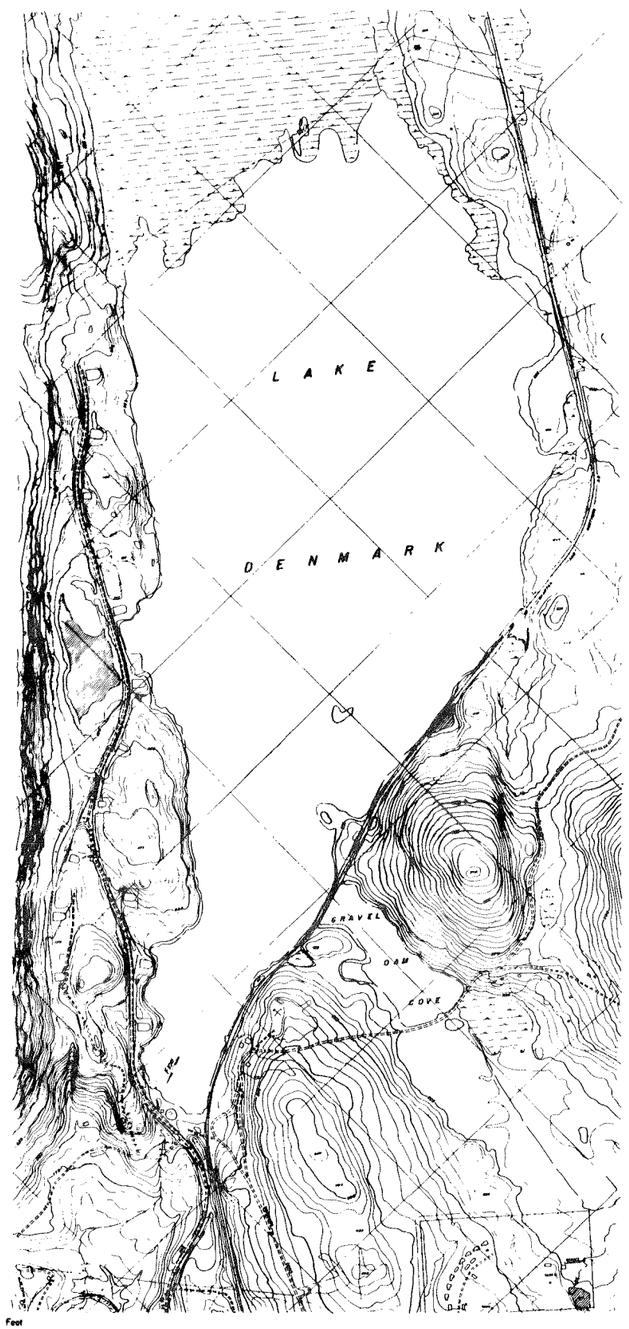
Contour Interval 5 Feet

RESERVOIR AREA

PICATINNY LAKE

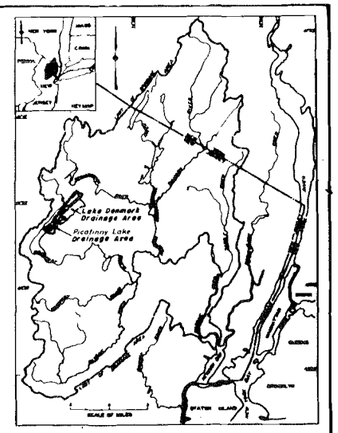
SCALE IN FEET

400 0 400 800 1200

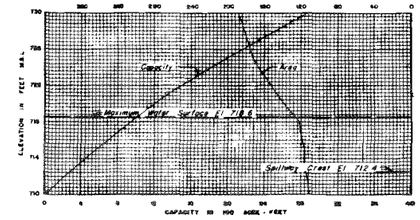


RESERVOIR AREA

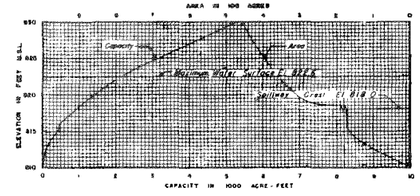
LAKE DENMARK



INDEX MAP



AREA - CAPACITY CURVE
PICATINNY LAKE



AREA - CAPACITY CURVE
LAKE DENMARK

NOTE:
Datum Plane is Mean Sea Level

FIG 28

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738 - 74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PICATINNY AND DENMARK LAKES WATERSHED MAP

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

SUBMITTED:	REVIEWED	RECOMMENDED:
Samuel P. Fox, CHIEF, RIVER BASIN SECTION	Stanley Mussel, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

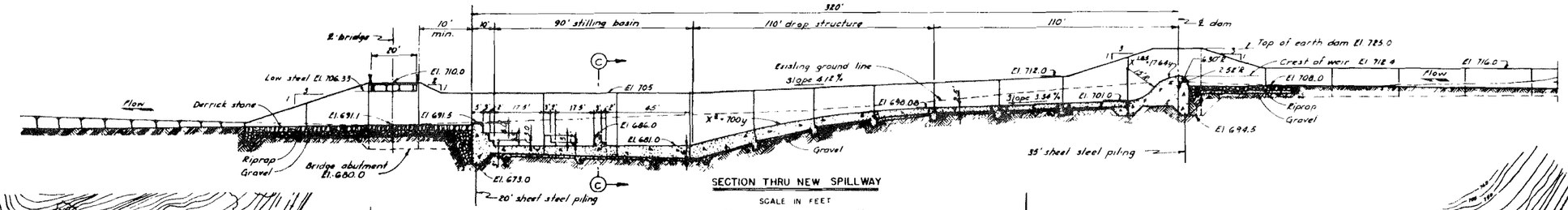
APPROVED:	Drawn by	DRAWING NUMBER
James W. Benhart, COLONEL, C. E. DISTRICT ENGINEER	Checked by	CR-PRB. 28

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 28

CORPS OF ENGINEERS

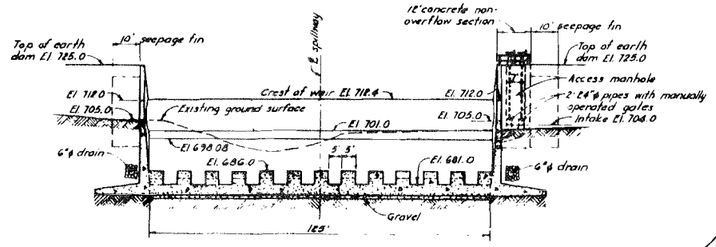
U. S. ARMY



SECTION THRU NEW SPILLWAY

SCALE IN FEET

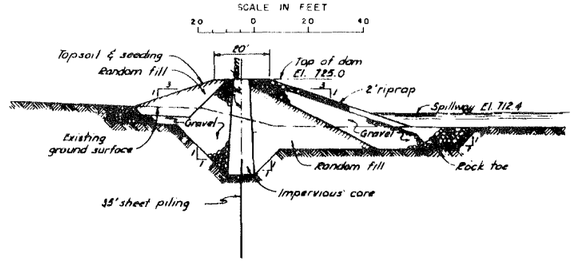
20 0 20 40



SECTION C-C

SCALE IN FEET

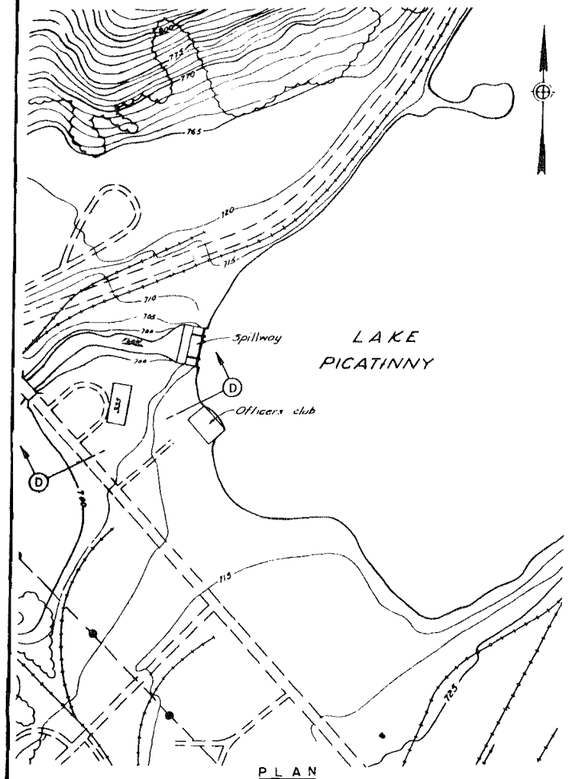
20 0 20 40



SECTION E-E

SCALE IN FEET

20 0 20 40

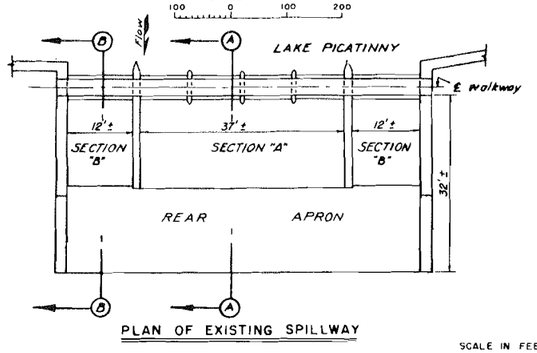


PLAN

EXISTING CONDITIONS

SCALE IN FEET

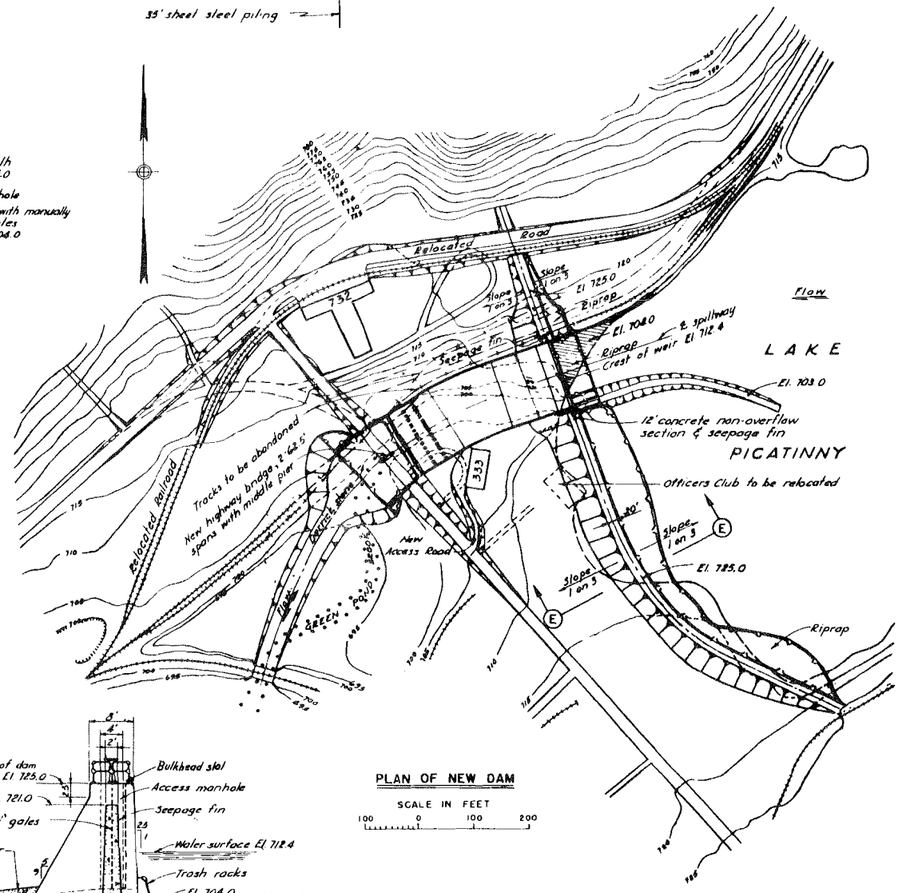
100 0 100 200



PLAN OF EXISTING SPILLWAY

SCALE IN FEET

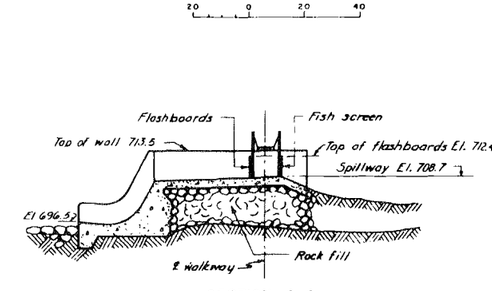
10 0 10 20



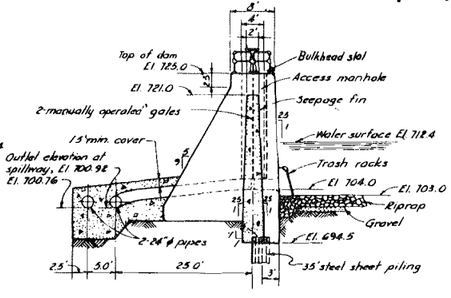
PLAN OF NEW DAM

SCALE IN FEET

100 0 100 200



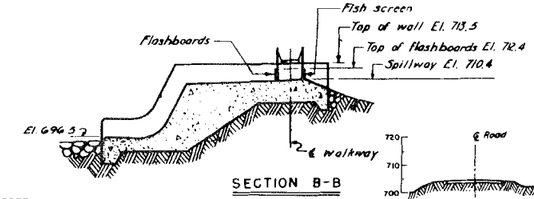
SECTION A-A



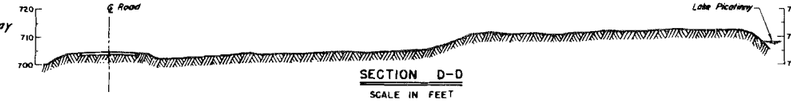
SECTION THRU SEEPAGE FIN & NON-OVERFLOW SECTION

SCALE IN FEET

10 0 10 20



SECTION B-B



SECTION D-D

SCALE IN FEET

20 0 20 40

FIG 29

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

PICATINNY LAKE DAM
PLAN, SECTIONS AND DETAILS

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Stanley Mussel, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: Lawrence W. Bennett, COLONEL, C. E., DISTRICT ENGINEER

Drawn by

Checked by

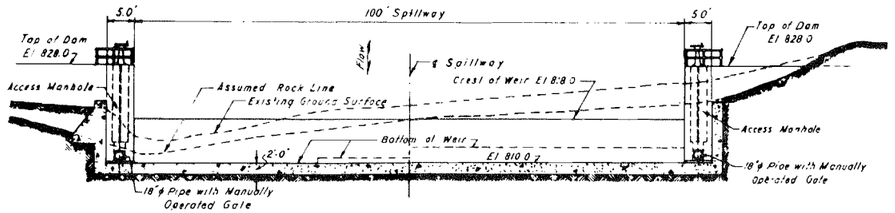
DRAWING NUMBER CR-PRB-29

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 29

CORPS OF ENGINEERS

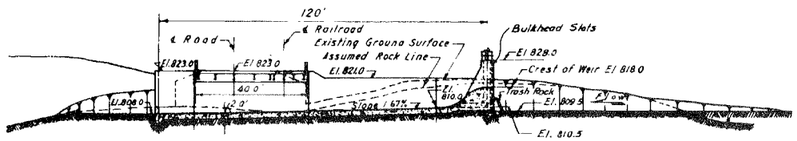
U. S. ARMY



SECTION THRU NEW SPILLWAY

SCALE IN FEET

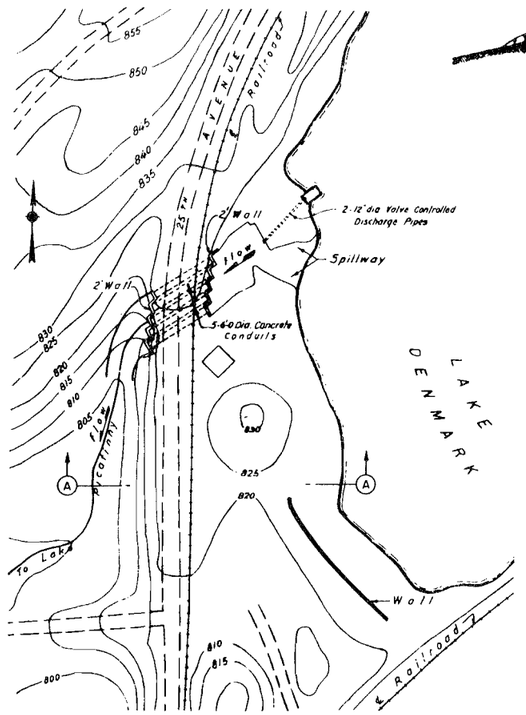
10 0 10 20



PROFILE THRU NEW SPILLWAY

SCALE IN FEET

20 0 20 40

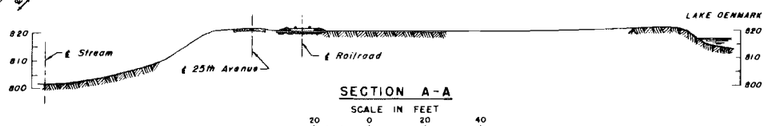


PLAN

EXISTING CONDITIONS

SCALE IN FEET

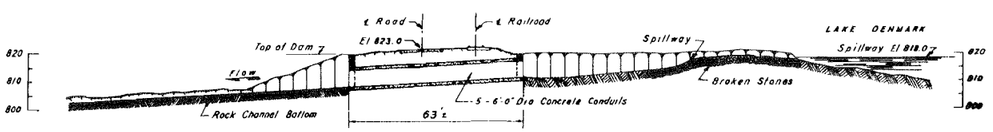
30 0 30 100



SECTION A-A

SCALE IN FEET

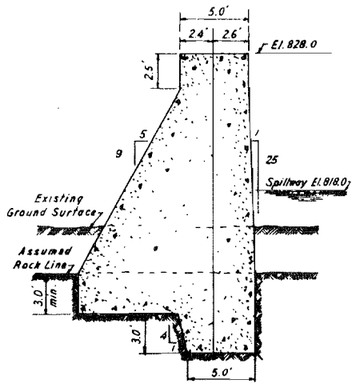
20 0 20 40



PROFILE THRU EXISTING SPILLWAY

SCALE IN FEET

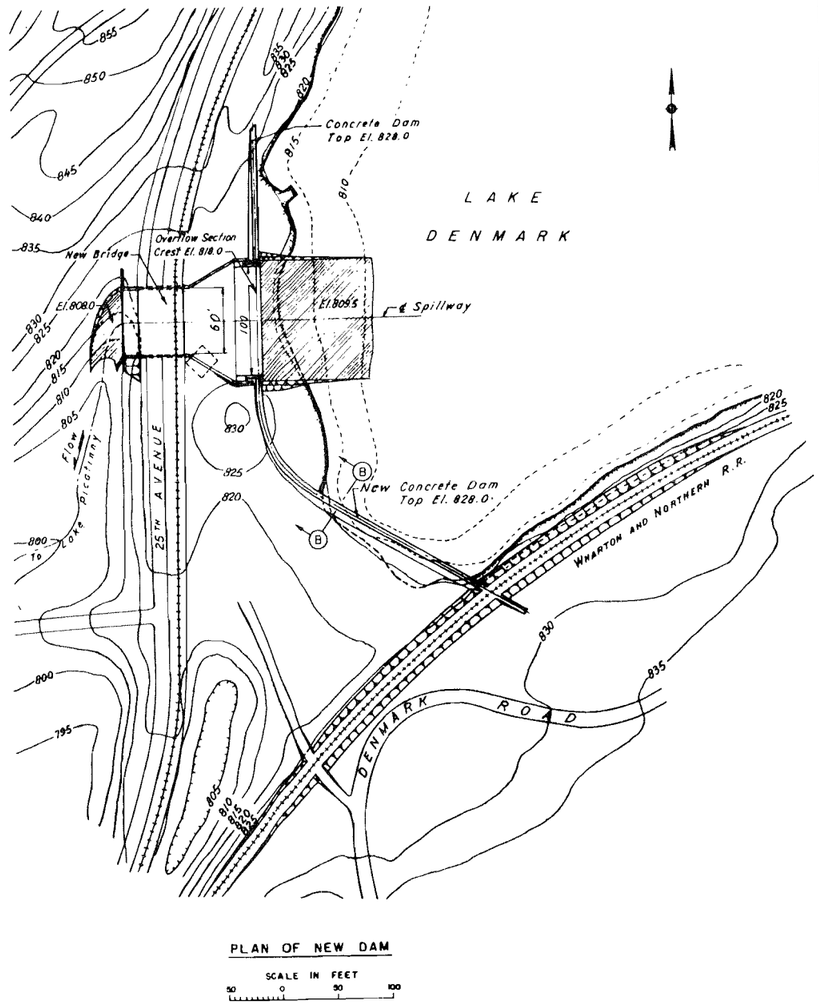
20 0 20 40



SECTION B-B

SCALE IN FEET

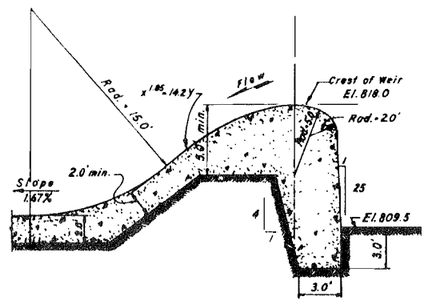
4 0 4 8



PLAN OF NEW DAM

SCALE IN FEET

50 0 50 100



WEIR SECTION

SCALE IN FEET

4 0 4 8

FIG 30

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

LAKE DENMARK DAM

PLAN SECTIONS AND DETAILS

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASINS SECTION	Stanley Massel, CHIEF BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF ENGINEERING BRANCH

APPROVED: Thomas W. Bennett, COLONEL, C. E. DISTRICT ENGINEER

Drawn by

Checked by

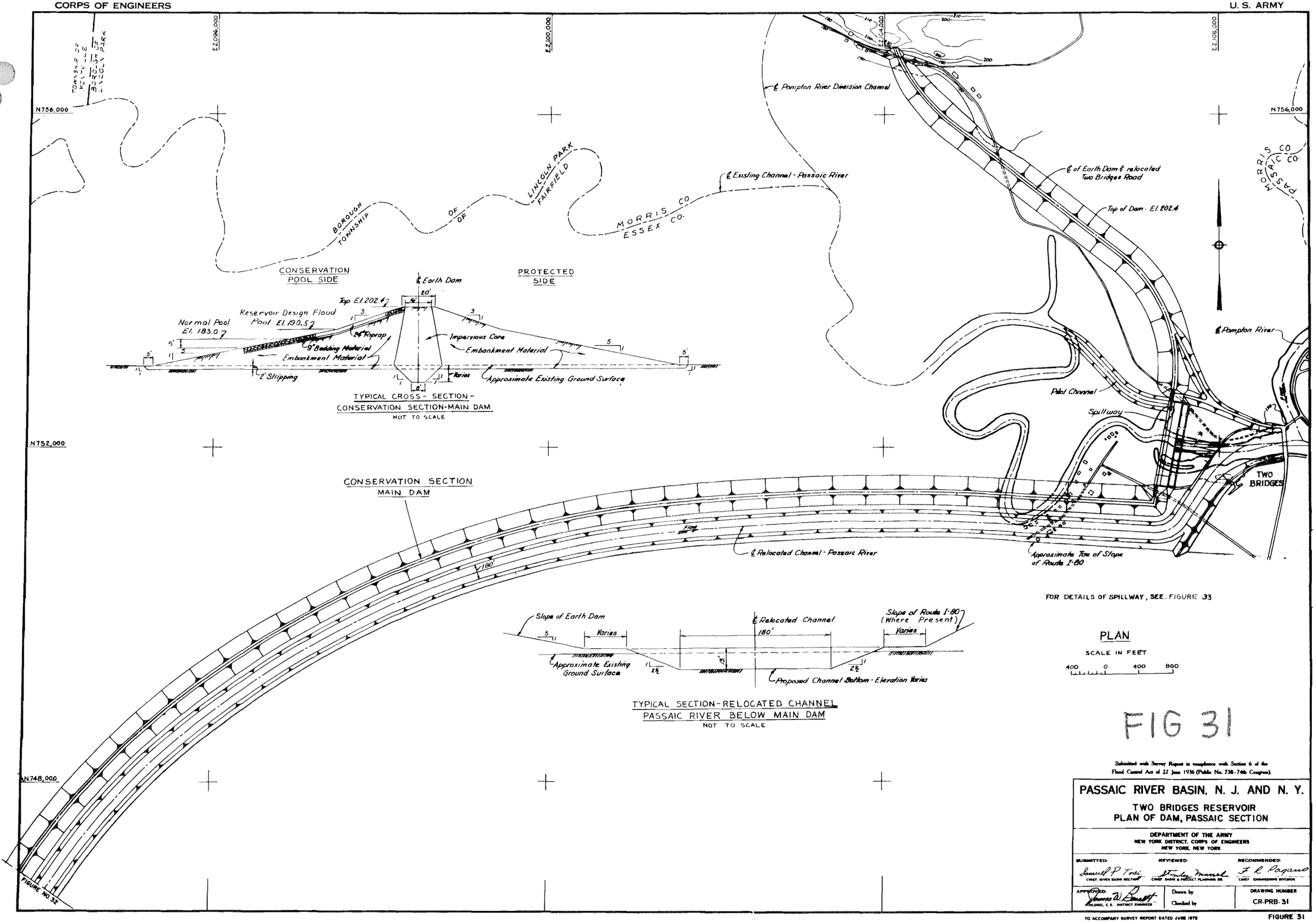
DRAWING NUMBER CR-PRB-30

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 30

CORPS OF ENGINEERS

U. S. ARMY



TYPICAL CROSS - SECTION - CONSERVATION SECTION-MAIN DAM
NOT TO SCALE

TYPICAL SECTION - RELOCATED CHANNEL PASSAIC RIVER BELOW MAIN DAM
NOT TO SCALE

FOR DETAILS OF SPILLWAY, SEE FIGURE 33

PLAN
SCALE IN FEET
400 0 400 800

FIG 31

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

TWO BRIDGES RESERVOIR PLAN OF DAM, PASSAIC SECTION

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Arthur Maund, CHIEF BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF ENGINEERING DIVISION

APPROVED:		
Lawrence W. Bradley, COLONEL, C.E. DISTRICT ENGINEER	Drawn by Checked by	DRAWING NUMBER CR-PRB-31

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 31

CORPS OF ENGINEERS

U. S. ARMY

DETENTION POOL SIDE

PROTECTED SIDE

℄ Earth Dam

Reservoir Design Flood Stage El. 190.5

Top El 202.4

20'

16'

3

3

5

5

5'

5'

2' Riprap

9' Bedding Material

Embankment Material

Impervious Core

Embankment Material

2' Stripping

Varies

Approximate Existing Ground Surface

TYPICAL CROSS-SECTION
DETENTION SECTION - MAIN DAM

℄ Relocated Channel
240'

Approximate Existing Ground Surface Elevation Varies

2 1/2

2 1/2

Proposed Channel Bottom-Elevation Varies

TYPICAL SECTION - RELOCATED CHANNEL
PASSAIC RIVER ABOVE DAM
NOT TO SCALE

N744,000

N740,000

N736,000

N732,000

E2,100,000

E2,096,000

E2,092,000

E2,096,000

E2,092,000

PROTECTED

AREA

OF

WEST

POOL

℄ Relocated Channel - Passaic River For X-Section See Figure NO. 31

Outlet Works - For details, see Fig. 34

DETENTION SECTION MAIN DAM

Viaduct (Rt. 506)

Viaduct (Rt. 46)

℄ Relocated Channel - Passaic River

FLOOD

DETEN-

TION

5 Weirs, Top of Crest El 183.0; Length each Crest 240' For details, see Fig. 34

Existing Route I-80 (To be modified as required)

Existing Bridge to be Removed

Existing Bridge (Route I-80 over Horseneck Road) to be removed.

CONSERVATION SECTION MAIN DAM

CONSERVATION DAM

CONSERVATION

POOL

PROPOSED LEVEE

U.S. Route 46

U.S. Route 46

County Route 506

BOROUGH OF TOWNSHIP

B&G PIKE ROAD

Bridge over relocated channel

FIGURE NO. 31

HORSENECK ROAD

MAPLE AVE.

ESSEX COUNTY

MORRIS COUNTY

ESSEX COUNTY

MORRIS COUNTY

TOWNSHIP OF FAIRFIELD

TOWNSHIP OF FAIRFIELD

MONTVILLE

CALDWELL

FAIRFIELD

TWP. OF E. HANOVER

℄ Existing Channel - Rockaway River

℄ Existing Channel - Passaic River

PLAN

SCALE IN FEET

400 0 400 800

CONSERVATION POOL

℄ Conservation Dam

20'

16'

Normal Pool El. 183.0'

Top El. 193.4'

Embankment Material

2' Riprap

9' Bedding Material

Impervious Core

2' Stripping

Embankment Material

Varies

Approximate Existing Ground Surface

TYPICAL SECTION - CONSERVATION DAM
(EXCL. I-80 SECTION)
NOT TO SCALE

FIG 32

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

TWO BRIDGES RESERVOIR
PLAN OF DAM, PASSAIC SECTION

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Stanley Maisel, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: James W. Benoit, COLONEL, C. E., DISTRICT ENGINEER

Drawn by

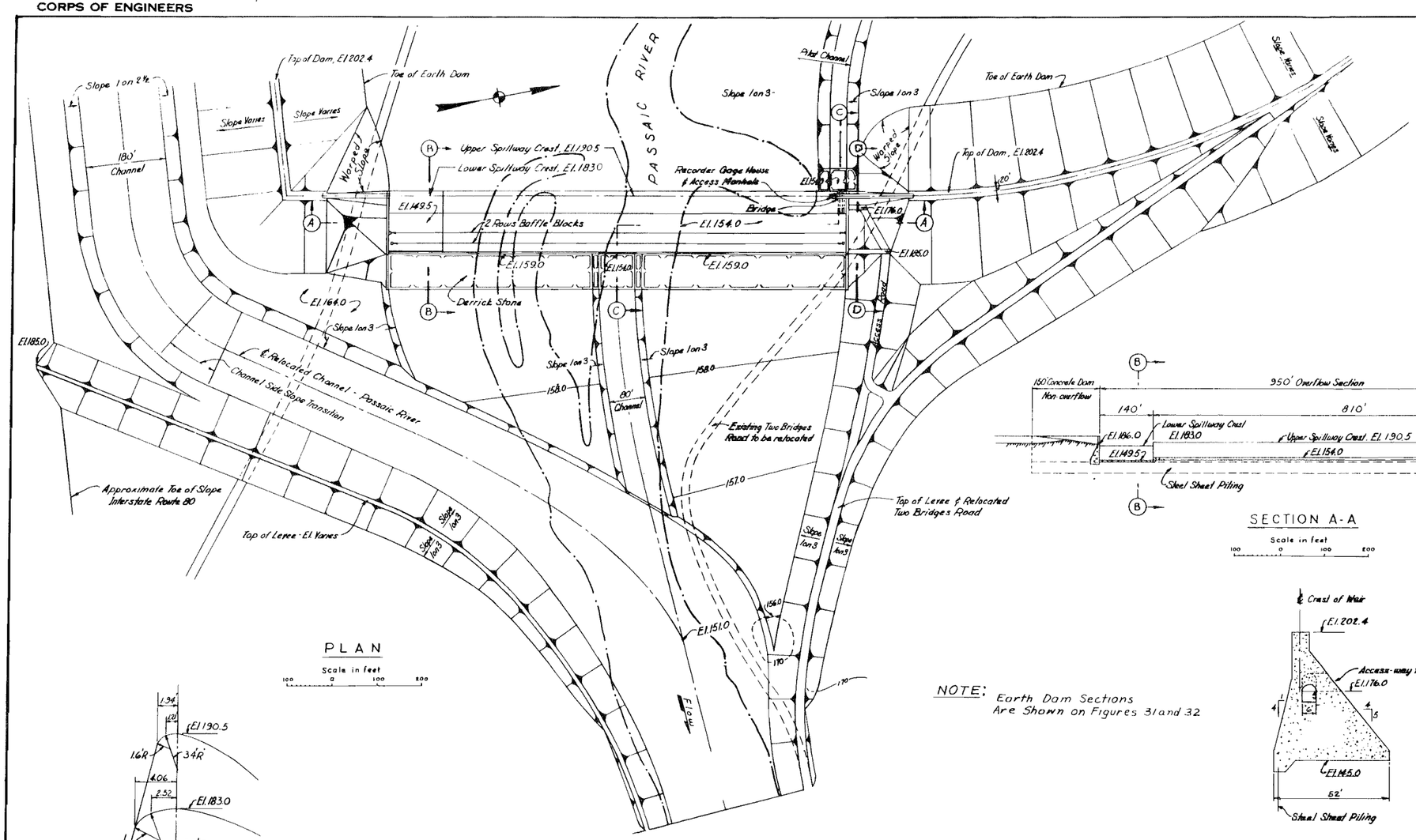
Checked by

DRAWING NUMBER
CR-PRB-32

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 32

CORPS OF ENGINEERS U. S. ARMY



PLAN

Scale in feet
100 0 100 200

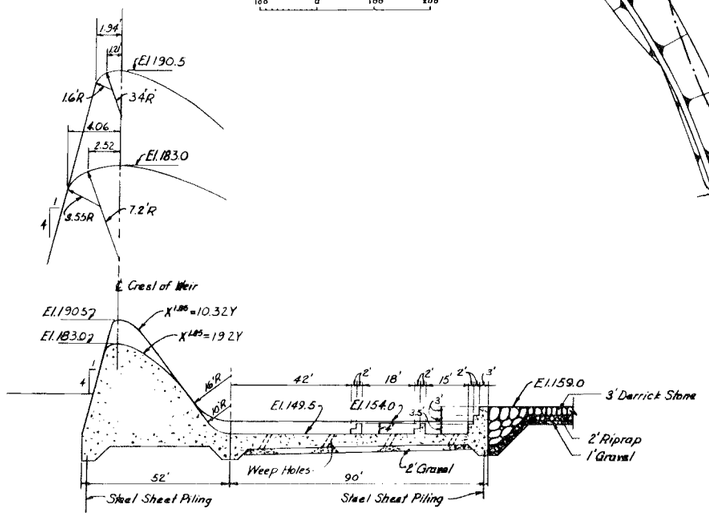
SECTION A-A

Scale in feet
100 0 100 200

NOTE: Earth Dam Sections Are Shown on Figures 31 and 32

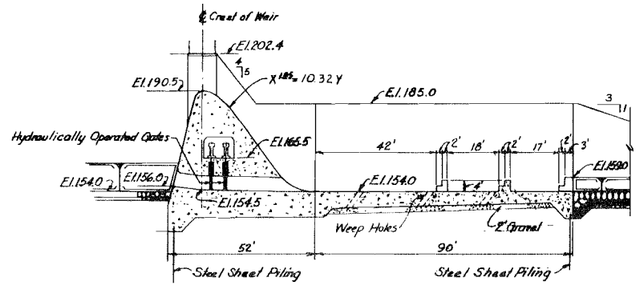
SECTION D-D

Scale in feet
20 0 20 40



SECTION B-B

Scale in feet
20 0 20 40



SECTION C-C

Scale in feet
20 0 20 40

FIG 33

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 736-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.
TWO BRIDGES DAM
PLAN, SECTION AND DETAILS

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tosi, CHIEF, RIVER BASIN SECTION	Stanley Manuel, CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED: Lawrence W. Bennett, COLONEL, C.E., DISTRICT ENGINEER

Drawn by
Checked by

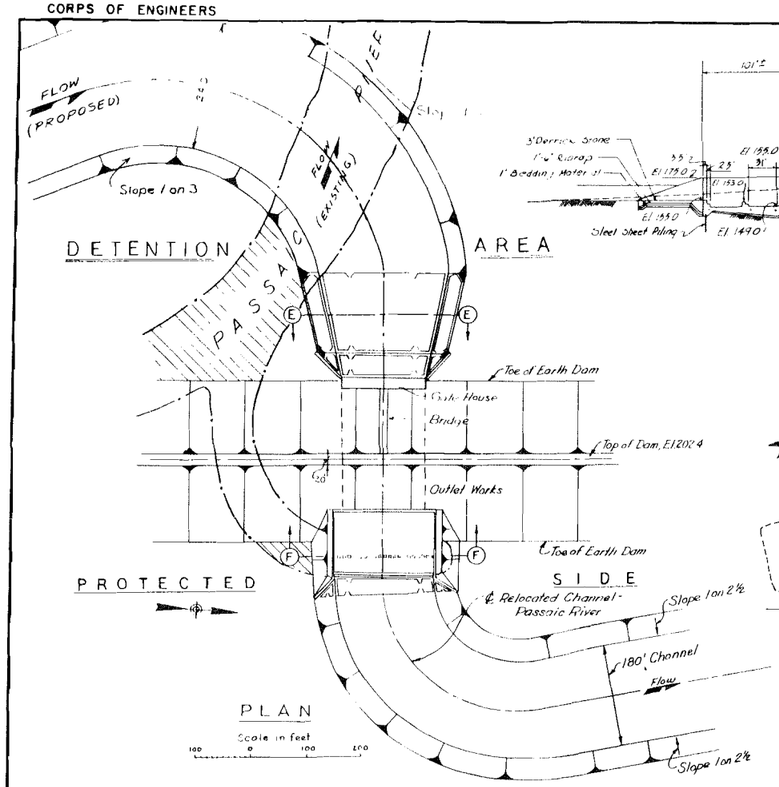
DRAWING NUMBER
CR-PRB-33

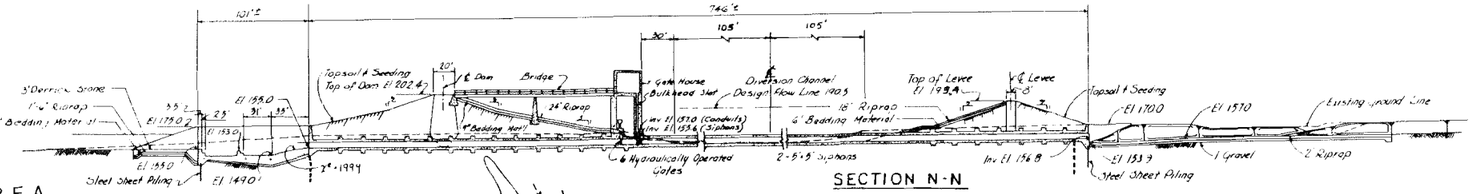
TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 33

CORPS OF ENGINEERS

U.S. ARMY

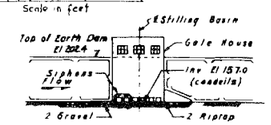




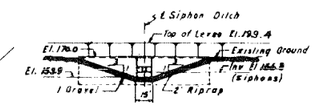
SECTION N-N

Scale in feet

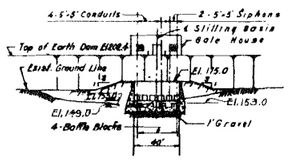
50 0 50 100



SECTION J-J



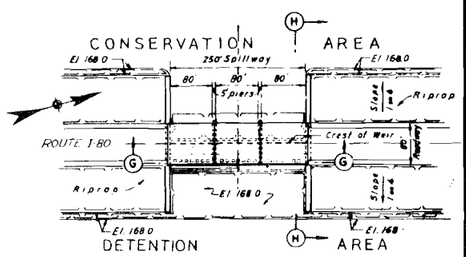
SECTION K-K



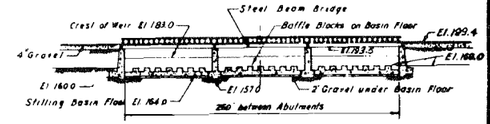
SECTION L-L

Scale in feet

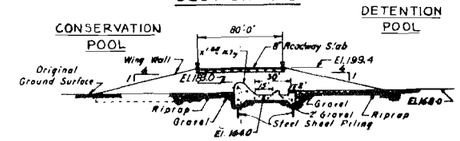
50 0 50 100



PLAN



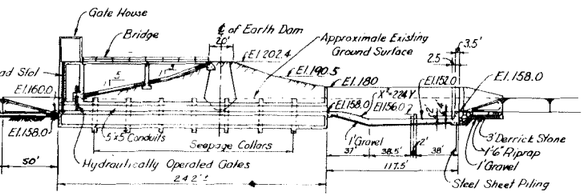
SECTION G-G



SECTION H-H

Scale in feet

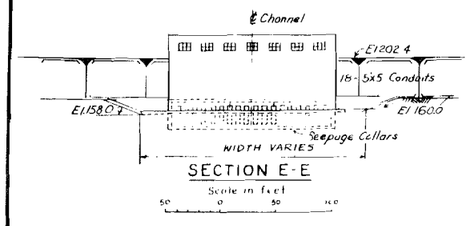
50 0 50 100



SECTION THRU CONDUITS

Scale in feet

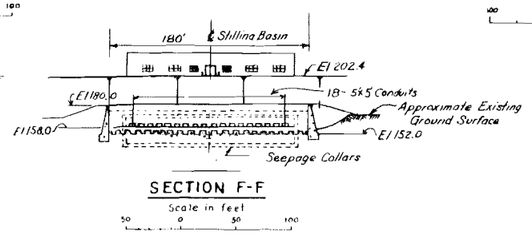
50 0 50 100



SECTION E-E

Scale in feet

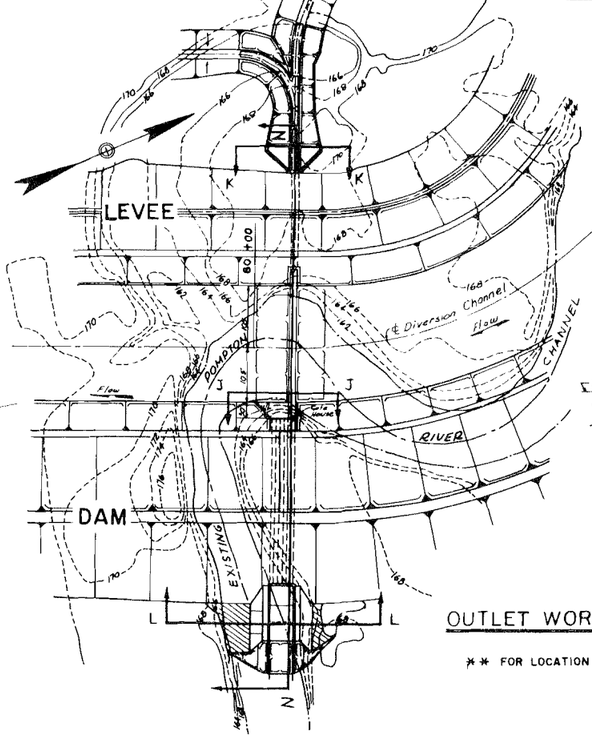
50 0 50 100



SECTION F-F

Scale in feet

50 0 50 100



PLAN

Scale in feet

100 0 100 200

OUTLET WORKS - POMPTON SECTION **

** FOR LOCATION OF STRUCTURES, SEE FIGURE 20.

SPILLWAY WEIRS (EACH)

CONSERVATION DAM *

* FOR LOCATION OF STRUCTURES, SEE FIGURE 32

OUTLET WORKS - RELOCATED CHANNEL - PASSAIC RIVER

FIG 34

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

CONSERVATION SPILLWAY, POMPTON AND PASSAIC DIVERSIONS PLANS, SECTIONS AND DETAILS

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tate, CHIEF, RIVER BASIN SECTION	CHIEF, BASIN & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING BRANCH

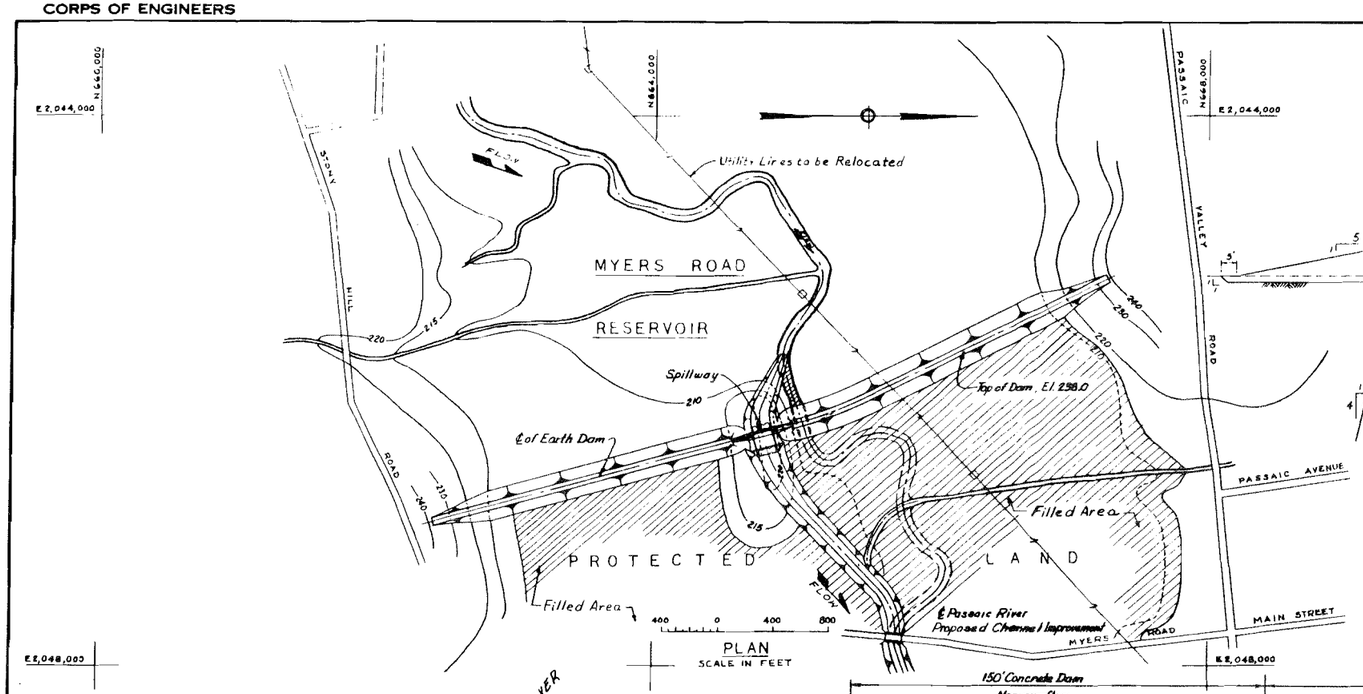
APPROVED:	Drawn by	DRAWING NUMBER
Thomas W. Sweet, COLONEL, C.E., DISTRICT ENGINEER	Checked by	CR-PRB-34

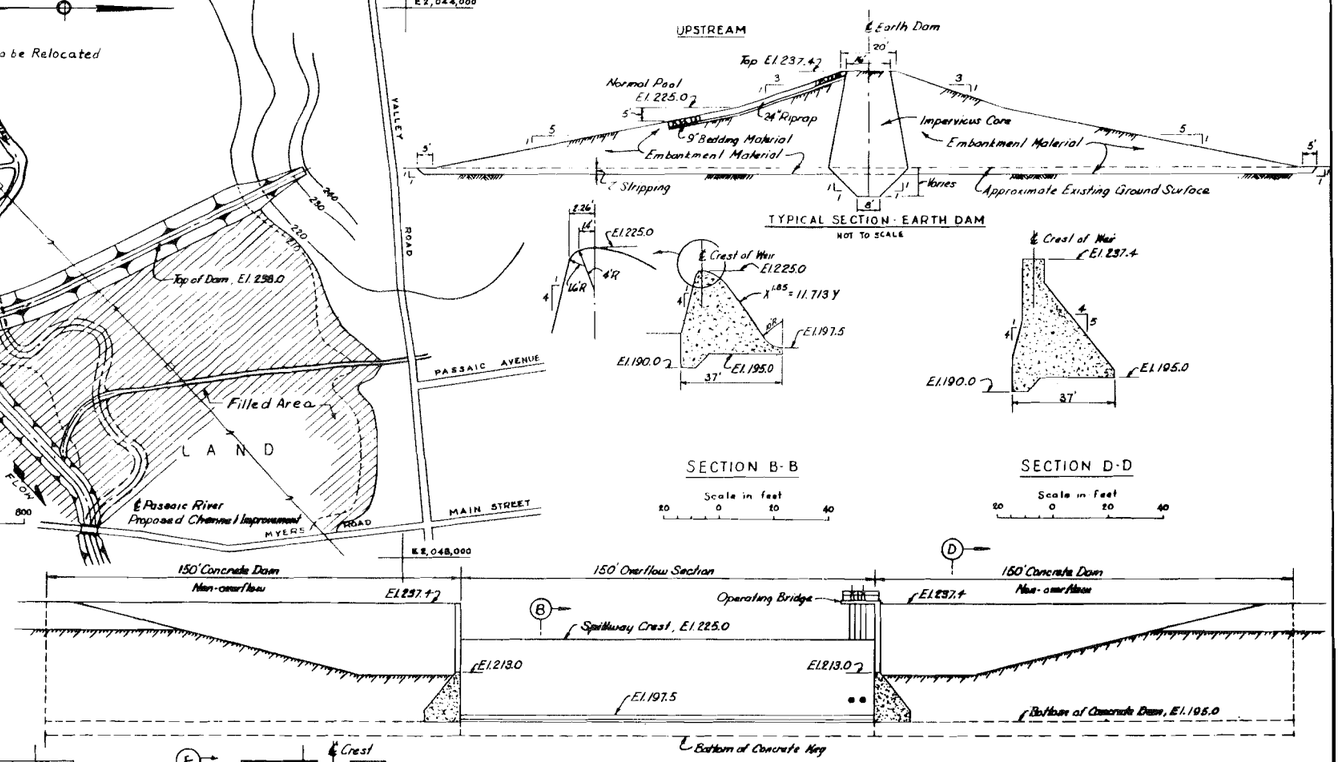
TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 34

CORPS OF ENGINEERS

U. S. ARMY





SECTION B-B

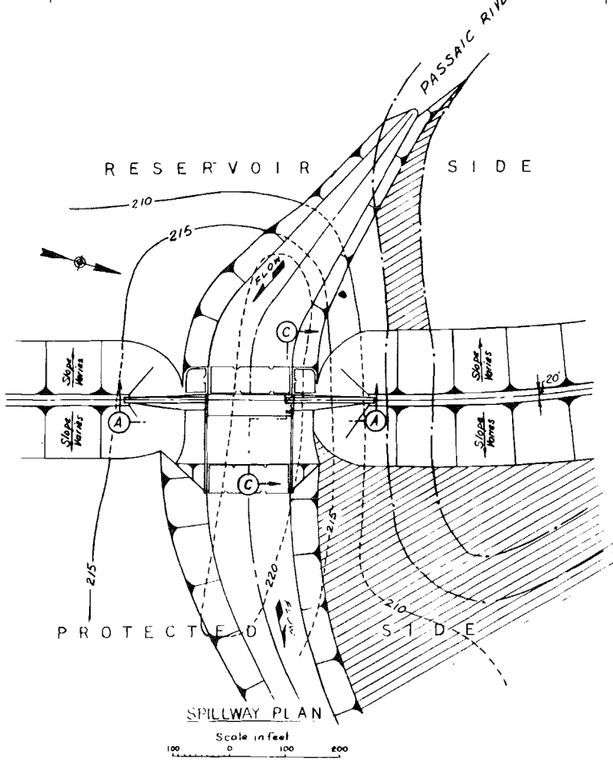
Scale in feet

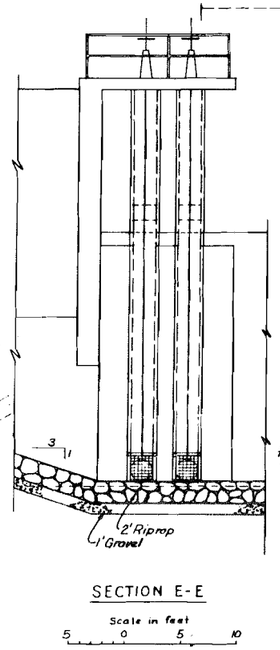
20 0 20 40

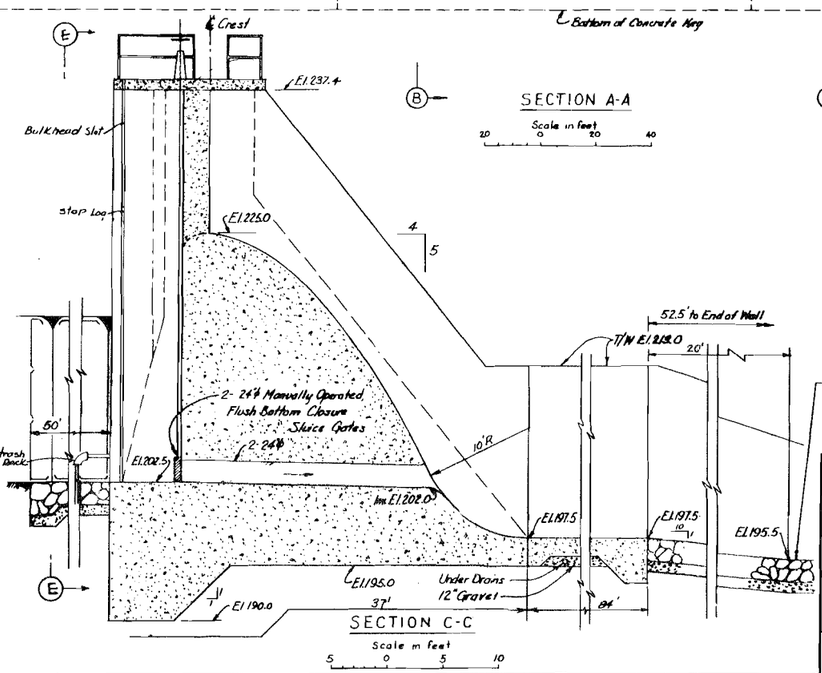
SECTION D-D

Scale in Feet

20 0 20 40







SECTION A-A

Scale in feet

20 0 20 40

FIG 35

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

MYERS ROAD DAM

SPILLWAY PLAN, SECTION AND DETAILS

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Tate, CHIEF, MYERS ROAD SECTION	Stanley Maisel, CHIEF, HYDRO & HYDRAULIC PLANNING SEC.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

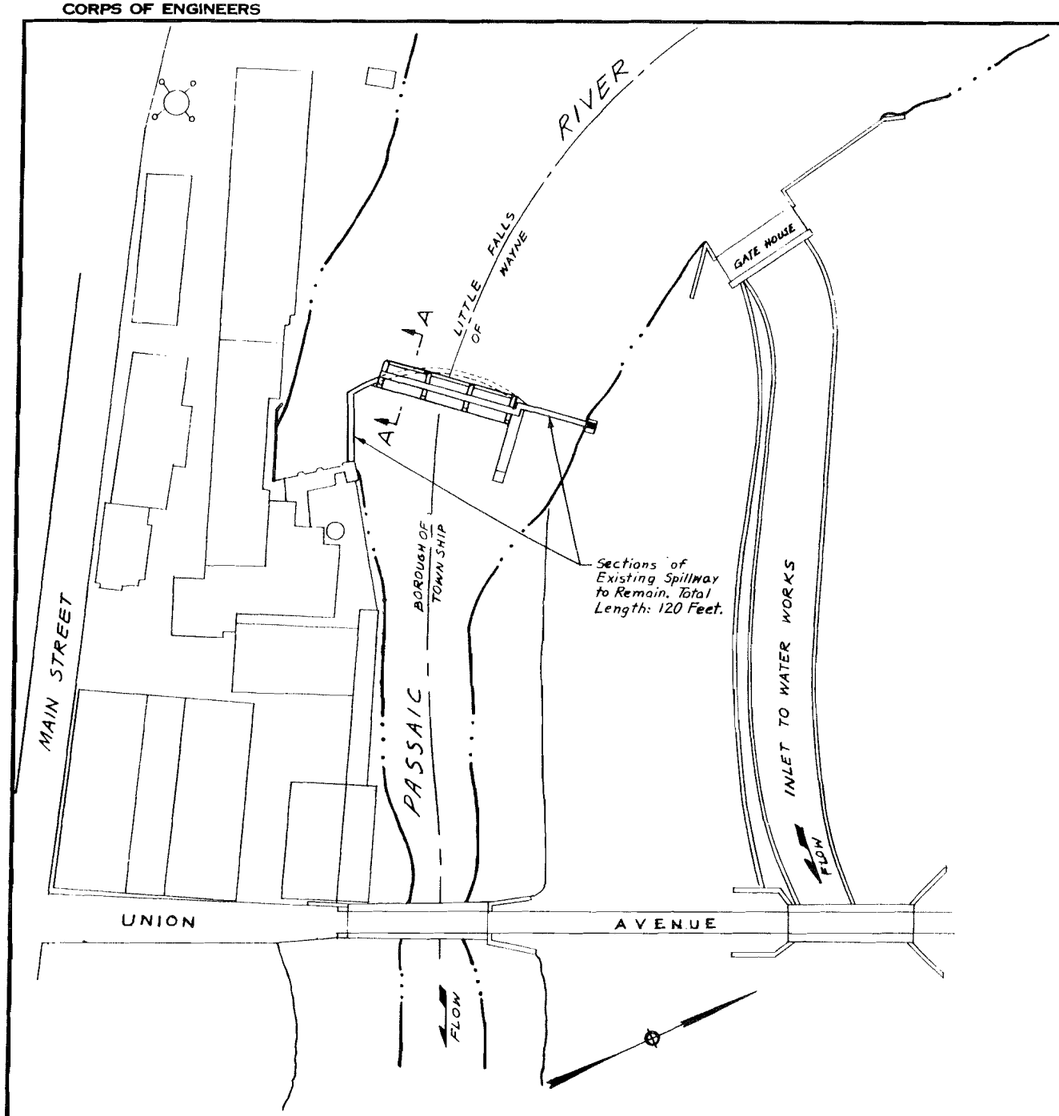
APPROVED:	Drawn by	DRAWING NUMBER
Thomas M. Sweitzer, COLONEL, C.E., DISTRICT ENGINEER	Checked by	CR-PRB-35

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 35

CORPS OF ENGINEERS

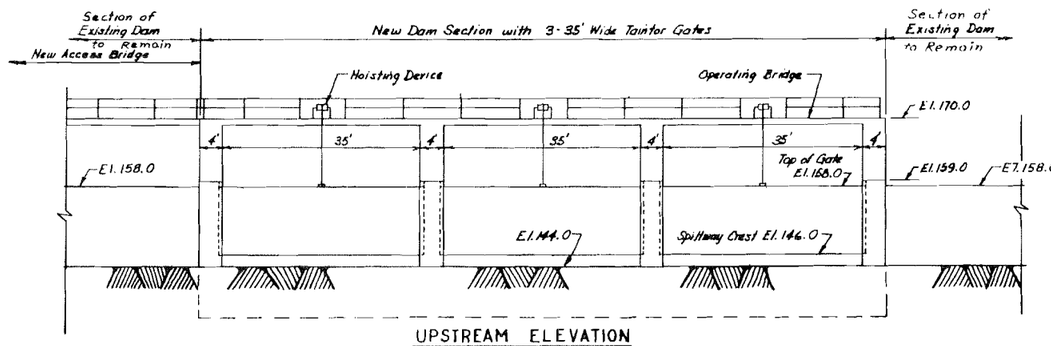
U. S. ARMY



PLAN

SCALE IN FEET

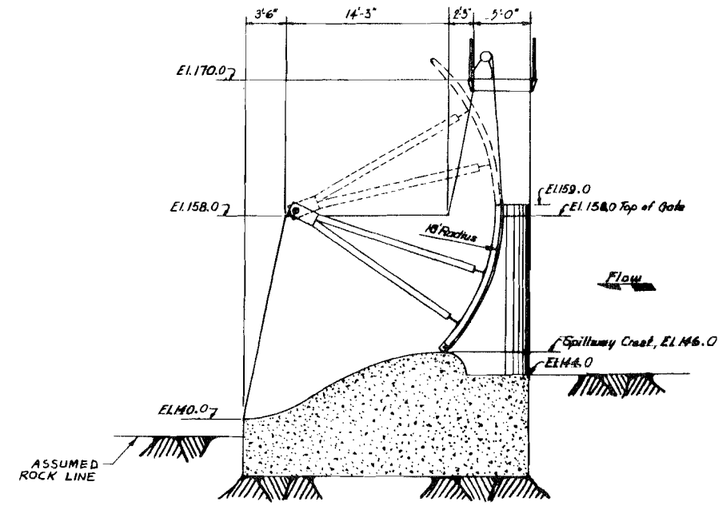
50' 0 50' 100'



UPSTREAM ELEVATION

SCALE IN FEET

10' 0 10' 20'



SECTION A-A

SCALE IN FEET

5' 0 5' 10'

FIG 36

Submitted with Survey Report in compliance with Section 6 of the Flood Control Act of 22 June 1936 (Public No. 738-74th Congress).

PASSAIC RIVER BASIN, N. J. AND N. Y.

BEATTIES DAM
PLAN, SECTION AND DETAILS

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

SUBMITTED:	REVIEWED:	RECOMMENDED:
Samuel P. Trani, CHIEF, RIVER BASIN SECTION	Stanley Maisel, CHIEF, PLANS & PROJECT PLANNING BR.	F. R. Pagano, CHIEF, ENGINEERING DIVISION

APPROVED:	Drawn by	DRAWING NUMBER
James W. Bennett, COL., C.E., DISTRICT ENGINEER	Checked by	CR-PRB-36

TO ACCOMPANY SURVEY REPORT DATED JUNE 1972

FIGURE 36