US Army Corps
of Engineers
New York District

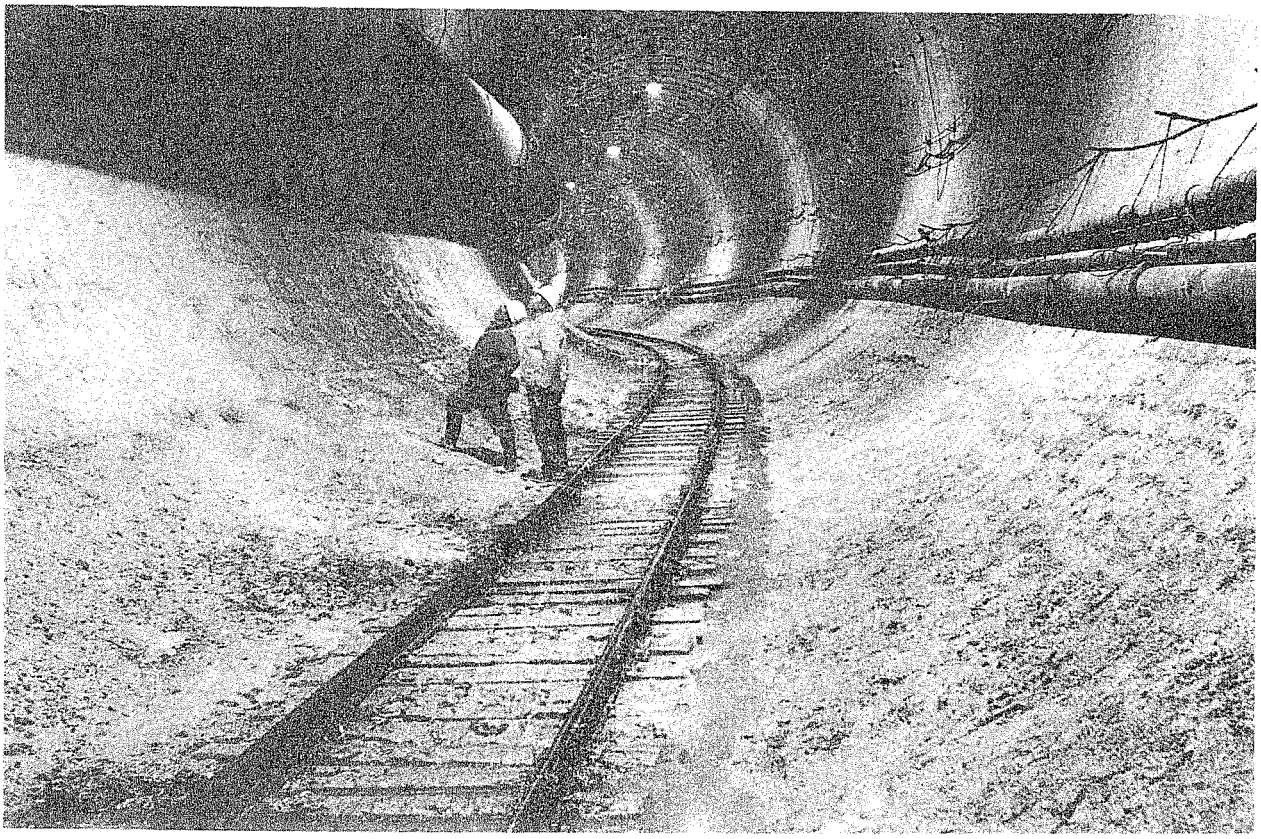
PASSAIC RIVER
PRB
BASIN STUDY

Passaic River Basin, New Jersey and New York
Phase I - General Design Memorandum

Flood Protection Feasibility Main Stem Passaic River

Supporting Documentation

Hydraulics



December 1987

Part II

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PASSAIC RIVER BASIN STUDY
SUPPORTING DOCUMENTATION

PART II - HYDRAULICS

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PART II - HYDRAULICS

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PASSAIC RIVER BASIN STUDY SUPPORTING DOCUMENTATION

PART II - HYDRAULICS

SECTION A - INTRODUCTION

LOCATION

The 935 square mile Passaic River Basin can be subdivided into three distinct topographic and hydrologic regions. According to its physiography, these regions are the Highland Area, the Central Basin and the Lower Valley, as shown on Plate II-1, and as discussed in Section B of Part I, HYDROLOGY.

Recurrent flooding episodes of varying degrees have been reported along the main stem Passaic River in the Lower Valley and Central Basin areas, along the Pompton River, and along the lower Pequannock, Wanaque, Ramapo, Rockaway and Whippany Rivers. Hydraulic studies were conducted along these rivers in order to establish the need and the basis for flood control works to protect the inundated areas. Hydraulic flowlines were developed along the Passaic River in the Lower Valley upstream from Newark Bay for approximately 30 miles to Beatties Dam in the Central Basin, upstream from Beatties Dam for 41.5 miles to the confluence with Dead River in Passaic Township; and along the 6.8 mile Pompton River and the lower reaches of the Rockaway, Whippany, Pequannock, Wanaque and Ramapo Rivers.

OBJECTIVE

This section of the report summarizes the findings of existing and improved conditions hydraulic studies for the main stem Passaic River, including the Pompton River, the lower Pequannock, Wanaque, Ramapo and Whippany Rivers, and the portions of other tributaries within the backwater influence of the main stem. Hydraulic studies for other portions of the watershed which have been treated as potential interim study sites include the Upper Rockaway, Ramapo, Peckman, Saddle, Third and Second Rivers, Molly Ann's Brook and other minor tributaries upstream of the influence of the main stem, and are not included herein.

FLOOD PROBLEM

The Lower Valley flood problem is influenced by several factors. From the mouth to approximately mile 11 of the Passaic River, the flood levels are controlled by tidal stages in Newark Bay. Upstream of mile 11 to Beatties Dam, flooding along the Passaic River is attributed to insufficient channel and bridge

capacities as well as backwater effects of Dundee Dam and the Great Falls. The small tributaries of the Passaic River experience flooding at their mouths from the backwater effect of the Passaic River with upstream flooding caused by insufficient channel and bridge capacities.

The rivers in the Central Basin area basically have mild slopes and extremely large amounts of natural storage volume that tend to dampen the flood peaks from the Highland Area. Due to the large amounts of storage, flooding in the Central Basin tends to be slow peaking and of long duration when compared to the tributary streams of the Highland Area. Flooding in the Central Basin is primarily due to the backwater effect caused by the natural channel constriction occurring along the Passaic River between Two bridges and Beatties Dam in combination with the mild gradients and insufficient channel capacities of the Passaic and Pompton Rivers.

EXISTING CHANNEL CONDITIONS

The conditions of the Passaic River channel have physically changed since the occurrence of the October 1903 flood, due primarily to natural processes and manmade encroachments. The principal physical changes which have occurred in the mainstream channel since October 1903 are: 1) the completion of the Federal Navigation Channel from Newark Bay upstream to Eighth Street Bridge; 2) the reconstruction and addition of a number of bridges across the mainstream and its tributaries; 3) the placing of fill and walls on the banks of the streams; and 4) the removal of the Morris Canal and Pompton River crossing at Mountain View, New Jersey. Construction of bridges since 1903 has, in some cases, has caused constrictions in the channel which tends to increase flood stages.

SECTION B - MODEL ANALYSIS

GENERAL

The channel design and flood protection works in the study areas were based on the accuracy in the hydraulic computations and the flood stage calibration under existing conditions. The hydraulic flowline computations for all the rivers in the Passaic River Basin are based on the laws of continuity and conservation of energy as described in EM 1102-2-1409 "Backwater Curves in River Channels." The HEC-2 computer program "Water Surface Profile," which is based on these principles, was chosen and utilized to compute all of the water surface profiles in this investigation.

REPRODUCTION OF HISTORICAL STORMS

In order to compute and predict the flood stages of the design storm and the other hypothetical frequencies, the reproduction of the existing condition river hydraulics for all channels were calibrated with the selected historical storms by matching published or field surveyed floodmarks. The computation of the hypothetical hydraulic flowlines were based on the incorporation of the discharges generated from the HEC-1 hydrology model into the existing conditions hydraulic model.

The calibrated hydraulic model satisfactorily matches the historical floodmarks of the lower Wanaque, Pequannock and Ramapo Rivers in the Highland Area and along the Passaic River, from its mouth in the Newark Bay upstream to its confluence with the Dead River, and its tributaries in the Lower Valley.

The reproduction of the hydraulic models in the Central Basin, including the Passaic River from Beatties Dam to the Chatham gage, Pompton River, and Lower Rockaway and Whippany River, were accomplished with the aid of a DWOPER model which is discussed below.

Although the existing conditions flowlines presented in this section present the May 1968 storm for all study reaches, the actual historic event used for flowline calibration differed for various streams in the basin depending on the availability of floodmarks. Table II-3 presents a comparison of published and field surveyed floodmarks and HEC-2 computed elevations for the floods actually used in the calibration of various stream reaches.

AID OF DWOPER MODEL

The reproduction of historical storms for the Passaic, lower Whippany, lower Rockaway, and Pompton Rivers in the Central Basin was complicated by the existence of a flow reversal condition in this area. The early peaking flood wave from the Pompton River which merges into the Passaic River at Two Bridges is restricted by the gorge at Little Falls and backs up into the Great Piece Meadows. The flat gradient and wide flood plain storage of the Great Piece Meadows, Troy Meadows and the Hatfield Swamp hinders and attenuates the flood peaks from the Pompton River and the backwater caused by the restriction of the gorge. In order to determine the characteristics of this flow regime, and to ensure that the HEC-1 and HEC-2 models accurately represented flow conditions in the Central Basin, an unsteady flow model was used as an aid to better simulate the flow reversal conditions in the Central Basin.

The unsteady flow program Dynamic Wave Operation Model (DWOPER) was developed by the Hydrologic Research Laboratory of the National Weather Service. It is based on the one-dimensional St. Venant equations that describe gradually varied unsteady flow. A weighted four point non-linear implicit finite difference scheme is used to solve the equations. Irregular cross-sections located at unequal distances along a single river or rivers with first order tributaries can be accommodated. Manning "N" values can vary with location and stage or discharge. A variety of boundary conditions including temporarily varying lateral inflows can be specified. DWOPER study results are documented in the Special Project Memo No. 82-1 entitled "Unsteady Flow Analysis for the Passaic Central Basin" by the Hydrologic Engineering Center, Davis, California (HEC). HEC's study included close coordination with the Passaic River Study Group (PRSG), including providing the PRSG staff with the training for in-house capability to apply DWOPER simulation, which provided a theoretical validation of the HEC-1/HEC-2 results, and it also provided input in the form of rating relationships to be used in the trial allocations of storage and calibration runs of HEC-2. In summary, HEC-2 and HEC-1 were used as final existing conditions models and for plan evaluation, while DWOPER was used as a check for existing and improved conditions.

HEC-2 HYDRAULIC DATA

Cross-section data utilized in the development of the existing conditions HEC-2 hydraulic model were based on stream channel sections field surveyed in 1979 and overbank sections stripped off Passaic Basin topographic mapping (based on aerial photography taken in 1979). Generally, surveyed channel and stripped overbank sections were specified in urban areas with an average distance of approximately 400 feet between sections. In less urbanized areas, distances between sections averaged approximately 800 feet. Cross-sections were always taken immediately at the upstream and downstream faces of bridge and dams, with highlights placed on bridges, waterway openings, piers and dam crests. Detailed cross-sections were also taken of bridges indicating roadway elevations and structural low steel. The number of cross-sections surveyed for each HEC-2 modeled stream and its computation length are shown in Table II-1.

In order to develop accurate storage discharge relationships for use in the existing conditions HEC-1 hydrologic model (for use with the Modified Puls stream routing procedure) overbank sections were extended to a vertical elevation 25 feet greater than the top of channel banks.

Additional hydraulic data were gathered with the help of the local and state governments, and other Federal agencies. Reviews and analyses were performed on all available data to insure accuracy of the information before incorporation into the hydraulic model.

To effectively address the study criteria and current development along the rivers and their overbanks, the 1979 channel cross-sections and overbank sections were used for flowline computations along the following streams: Rockaway River, Whippany River, Ramapo River, Pompton River, Passaic River from Two Bridges to its confluence with Dead River and the tributaries which were treated for potential interim actions. Since flood damages along the Pequannock River were not as extensive, previously available data were used. Flowline computations along the Pequannock River were based on the Corps 1972 field survey of channel cross-sections and the Wanaque River flowline computations were based on field surveyed channel cross-sections prepared for Flood Insurance Studies (FIS). However, for purposes of developing storage discharge relationships, the overbank sections for these two river models were extrapolated from the Corps' 1979 aerial mapping. To improve the hydraulics model simulation of the Pompton River, the 1979 Corps field survey cross-sections were supplemented with FIS and WPA field survey cross-sections.

Along the main stem Passaic River, WPA survey cross-sections were principally used upstream from the mouth to Beatties Dam, while FIS cross-sections were used from Beatties Dam to Two Bridges. WPA bridge sections and plans of new and modified bridges were obtained from the New Jersey State Department of Transportation, encoded, and input in this reach for the flowline computations. A comprehensive list of bridges crossing the Passaic River main stem, Ramapo, Pequannock, Pompton, Rockaway and Whippany Rivers, is included as Table II-2. Additional new cross-sections were surveyed for the Passaic Lower Valley in areas of channel relocation and in locations identified as having potential hydraulic uncertainties. Approximately 30 channel sections were surveyed in 1979 to check the validity of the WPA and FIS sections in the Lower Valley. A comparison of WPA, FIS and Corps 1979 cross-sections for the Lower Valley showed an insignificant change in cross-sectional area (see Plates II-2 and 3 for typical comparison of this data). Test runs were also made with and without these new surveyed cross-sections, with the resulting flowlines indicating an insignificant impact on water surface elevations. The large carrying capacity of the stream in this reach is unaffected by the small amounts of sedimentation deposited through the years.

CHANNEL ROUGHNESS FACTORS

The roughness coefficients (N values) used in the calibration of the existing conditions HEC-2 hydraulic models in the Highland, Central Basin and Lower Valley areas ranged from 0.025 to 0.05 for channel sections for different degrees of vegetation. According to the conditions of the overbanks, N values ranging from 0.06 to 0.2 were used. A contraction value of 0.3 and expansion value of 0.5 were used. Bridge loss coefficients were computed using entrance and exit losses plus a friction loss. The magnitudes of all these coefficients were based on working experience and/or recommended values in the HEC-2 user's manual and Chow's "Open Channel Hydraulics". The roughness coefficients used for calibration of the existing conditions hydraulic model are shown in Table II-4.

EXISTING CONDITIONS WATER SURFACE PROFILES

Lower Valley. The probability of coincidental occurrence of a tidal peak originating from Newark Bay and a fluvial event peak with the same hypothetical frequency is small, based on historical records of storms in the Passaic River Basin as discussed in Part I, HYDROLOGY, of this Report. Hence, the one year tidal stage of 4.9 feet NGVD was used as the starting water surface elevation at the mouth of the lower Passaic River for existing conditions for all frequency events. Annual tidal stages are predicted to be 5.0 in 1990 and 5.5 in 2040 due to the rise in sea level as discussed in Part I, HYDROLOGY. The appropriate tidal elevation was used for all the hypothetical events in the computation of HEC-2 water surface profiles. The starting water surface elevation for the May 1968 storm profile was the recorded tidal elevation of 3.4 feet NGVD.

Since the flooding along the mouth of the Passaic River is subject to tidal influence, the final hydraulic profiles for hypothetical events in the Lower Valley were generated by superimposing peak fluvial water surface profiles, as defined above, on the corresponding frequency peak tide elevations to determine the higher stage. This procedure was followed for each theoretical frequency from the mouth upstream to the point where the computed fluvial stages governed. For the 100-year event, under existing conditions this point of transition from tidal to fluvial hydraulic dominance is at the Route 3 Bridge in Clifton (mile 11.4). The final water surface elevations thus reflect the limits of tidal dominance, under existing conditions for the reference flood, 1, 10, 50, 100, 500 and SPF events, as plotted on Figures II-43 through II-48.

Upstream of the tidal reach to the boundary of the Central Basin (Beatties Dam), the Passaic River was subdivided into two separate hydraulic reaches between Dundee, S.U.M. and Beatties Dams. The backwater of each dam governs the water surface profile immediately upstream. Since there was no recording gages at these dams, the starting water surface elevations at these locations were based on the calibration of historical floodmarks at reaches immediately upstream. The rating curves used for HEC-2 hydraulic runs and information on Dundee, S.U.M. and Beatties Dams are show on Plates II-4, II-5, and II-6, respectively. The reference flood, 1, 10, 50, 100, 500 and SPF event water surface profiles generated with final discharges for these two reaches are shown on Figures II-48 through II-53.

Floodplain delineations of the 100 and 500 year events along the Passaic River main stem from the mouth to the Beatties Dam are shown on Figures II-1 through II-9.

Central Basin. As previously discussed, the flow regime in the Passaic River Central Basin was determined with the aid of the DWOPER model. The DWOPER model was primarily used to derive target storage-discharge relationships, confirm timing relationships between main stem tributary hydrographs, and provide target stages to supplement the available flood marks. Based upon the physical features of the Central Basin and the preliminary HEC-2 runs it was determined that there were eight distinct reaches for which eight hydraulic conditions cases would have to be investigated in order to develop the final existing conditions water surface profiles. The eight cases correspond to the eight different peak flows which could be controlling the water surface elevations in each of the eight reaches, respectively.

These reaches are:

1. The Passaic River between Beatties Dam and its confluence with the Pompton River.

2. The Passaic River between its confluence with the Pompton River and the Horseneck Road Bridge.

3. The Passaic River upstream of Horseneck Road Bridge and downstream from its confluence with the Rockaway River and Pine Brook.

4. The Passaic River upstream from its confluence with the Rockaway River.

5. The Rockaway River downstream from its confluence with the Whippany River.

6. The Rockaway River upstream from its confluence with the Whippany River.

7. The Whippany River upstream from its confluence with Rockaway River.

8. The Pompton River upstream from its confluence with the Passaic River.

Eight multiple frequency HEC-2 runs were performed for the Central Passaic River Basin. Each run considered the peak flows at one of the eight reaches, with the appropriate coincidental flows occurring at the other seven remaining reaches. The peak and coincidental discharge relationships for use in the developing of HEC-2 multiple water surface profiles in these eight locations are indicated on Table II-5.

The controlling elevation for each location resulted from the case with the highest water surface elevation for each event. Through this comparison, the final existing conditions flood profiles were determined. Thus, for example, it was determined that the final 100 year and greater hydraulics profiles along the mouths of the Rockaway and Whippany Rivers, and the Passaic River upstream from its confluence with the Rockaway River, were controlled by the backwater of the peak stage occurring in the reach downstream of the confluence of the Passaic and Pompton Rivers. The final existing conditions water surface profiles for the reference flood, 1, 10, 50, 100, 500 and SPF events, for the Passaic, Rockaway, Whippany and Pompton Rivers are shown on Figures II-53 through II-69. Coincidental discharges on these Figures are indicated by asterisks, as noted. The 100 and 500 year floodplain delineations for these areas are shown on Figures II-9 through II-40.

Pompton Tributaries. A similar analysis was used for the confluence area of the Pequannock, Ramapo and Wanaque Rivers and the final flood profiles of these rivers were also determined by the procedures as described above. The water surface profiles for the reference flood, 1-,10-,50-,100-,500-year and SPF events, for the Pequannock, Ramapo and Wanaque Rivers are shown on Figures II-70, II-71 and II-72, respectively. The 100 and 500 year floodplain delineations of these rivers are shown on Figures II-33, II-40 and II-41.

The existing conditions stage-discharge rating curves for the Passaic, Pompton, Rockaway, Whippany, Pequannock, Ramapo and Wanaque Rivers are plotted on Plates II-7 through II-13, respectively.

The coincidental and peak discharges used in the development of the with-project-conditions hydraulic profiles of the theoretical events developed in this hydraulic study are shown on Table II-6.

SECTION C - PROPOSED PLAN OF IMPROVEMENT

GENERAL

The proposed plan of improvement has been formulated and developed through the combination and integration of the best features of several flood control measures presented in the Stage 2 Report on the Passaic River Basin. This section therefore reports on the hydraulic modeling and design of the Dual Inlet Tunnel Plan. This plan is the most cost-effective design as defined in terms of National Economic Development (NED). Because of the complexity of the Passaic River Basin hydrology and the impacts that future floodplain development will have on the flooding problem, the proposed hydraulic design is also complex. The formulation and evaluation of the proposed plan is presented in the Main Report and in Appendix C, PLAN FORMULATION. Hydraulic results which aided in the understanding of potential plan effects and led to many of the decisions which have shaped the plan are presented in that appendix. These results include data generated for plan alternatives, optimization of plans, and refinement of design of plan components and alternative components. Hydraulic modeling and design was also critical during Stage 2 planning in determining the effectiveness of several measures which are no longer under consideration.

DUAL INLET TUNNEL DIVERSION PLAN

The key feature of the Dual Inlet Tunnel Diversion Plan is a 13.5 mile-long, 39-foot-diameter tunnel from the Pompton River down to the Lower Passaic River. This plan, Plate II-14, includes inlet and diversion works located in Wayne Township on the upper Pompton River below the confluences of the Pequannock, Wanaque and Ramapo Rivers. A second inlet would be provided by means of a 1.2 mile long, 22-foot diameter spur tunnel from Two Bridges to the main tunnel. The tunnel would divert floodwaters from the upper Pompton River and from the central Passaic River area to an outlet near the Third River-Passaic River confluence

at the Clifton-Nutley border. The underground tunnel would be about 125 feet below the Two Bridges inlet, and about 155 feet below the outlet (Plates II-17 and II-18). At its deepest point, under the Watchung Mountains in the area of the Little Falls-Clifton border, the tunnel would be about 450 feet underground.

With the Pompton Inlet located where it will divert the bulk of the flood flows away from the major Pompton Valley flood damage area, no other structural flood control works will be required downstream along the Pompton River. Approximately 3.5 miles of levee, 0.7 miles of floodwall and 4.8 miles of channel modification upstream of the Pompton Inlet would be required to conduct flood flows to the inlet and to protect upstream areas.

A bascule gate structure will be located at the Old Morris Canal Feeder Dam across the transition channel modification upstream of the Pompton Inlet. This structure will be in the raised position under normal conditions to preserve natural flow conditions on the Pequannock and Ramapo Rivers, but lowered during a flood event to open the transition channel through the dam to the Pompton Inlet.

Upstream of the Two Bridges Spur Tunnel Inlet, the Pompton and Passaic River channels would be deepened for 0.3 and 0.8 miles respectively, to divert flood flows to the inlet. Upstream of Two Bridges along the central Passaic River, up to a 500-year level of protection will be provided at intermittent locations by systems of setback levees and floodwalls. These systems would consist of approximately 9.0 miles of levee and 0.5 miles of floodwall. The levees would have average heights ranging from 7 to 10 feet.

Diverting floodwaters through the tunnel from the Central Passaic Basin would significantly reduce the need for structural flood protection along the Passaic River from Beattie's Dam downstream to just above the Saddle River. No measures are proposed in this reach.

From the Saddle River downstream to Newark Bay, the plan calls for 14 levee/floodwall systems, including about 11.2 miles of levee and almost 12.4 miles of floodwall. These levees and floodwalls are required to protect against flooding from tidal events and increased stages due to tunnel discharges. Tidal levees are required from the mouth of the Passaic River to Route 280. They would provide protection against a 500-year tidal flood. Levees to protect against the tunnel discharges are

required from the Second River to the Saddle River. They would provide protection against a 100-year flood. A tunnel diversion plan could not be constructed without the implementation of flood control measures to protect against tides as well as tunnel discharges in the outlet area.

In the Great Piece Meadows, a low weir is to be placed across the Passaic River upstream of Two Bridges to stabilize the upstream channel where it enters the transition channel. This weir will be in the down position at all times, except when it is deemed desirable to flood the 1 year floodplain to preserve wetlands.

A final element of the plan is the preservation of natural floodplain storage in the Central Basin. This component of the plan involves the purchase of 5,350 acres of land within the floodplain along the Passaic and Pompton Rivers for the purpose of preventing future development and filling of floodplain lowland areas which would result in an increase in flood damages. In addition, the preservation of such natural storage areas would also maintain the existing environmental characteristics of the basin by preserving wetlands, open space, and fish and wildlife habitats. This measure is generally applicable throughout the watershed, but is of special significance within the Central Passaic Basin because of the presence of 11 major wetlands and other intermittent pockets of open space floodplain in this area. This measure does not address the existing flood problem, but rather would reduce potential future increases in flooding. Therefore, it is a mechanism to maintain project integrity in terms of level of protection by preventing the loss of floodplain storage. A complete description of this component and the methodology used is described in "Section F-Urbanization and Preservation of Natural Storage, Part I-Hydrology". The selection process for lands to be acquired utilized the HEC-2 model and the HEC-1 hydrology model to determine those areas that contribute most effectively to the storage of floodwaters both with and without the plan.

The Dual Inlet Tunnel Diversion Plan would provide protection up to a 100-year flood event in the Pompton Valley and along the Passaic River from Two Bridges to the Second River. A 500-year level of protection would be provided against tidal flooding on the Passaic River downstream of Route 280. Differing levels of protection, ranging up to 500-year events, would be provided above Two Bridges along the central Passaic River.

SIMILAR PROJECTS AND EXPERIENCE

The use of diversion tunnels for the transport of storm water and flood flows has been accepted and utilized for flood problems around the country. The configuration most similar to the Dual Inlet Tunnel Plan is the Park River auxiliary conduit designed by the New England Division of the U.S. Army Corps of Engineers in Hartford, Connecticut and constructed in 1981. This diversion is a 22-foot diameter tunnel, 9,100 feet in length with a capacity of 5,800 cfs. Its entire length is an inverted siphon constructed underneath downtown Hartford at depths of 100 to 150 feet below sea level with an upshaft and outlet structure on the Connecticut River at sea level. The tunnel remains full of water at all times and will be pumped dry every 10 years for inspection and maintenance. While the tunnel has not been utilized to capacity, the City of Hartford is pleased with its performance to date.

Another New England Division project called the Worcester Diversion, on the Blackstone River in Massachusetts, was built in 1960. This project consists of a control dam across the river with a partial morning glory spillway inlet leading to a tunnel. The tunnel is 16 feet in diameter, 4,205 feet long, and is dry under normal conditions. The design flow is 12,000 cfs with pressure flow occurring at 6,000 cfs and above.

Within the New York District, a diversion tunnel is now in advanced engineering stages for the Sheldrake River in Mamaroneck, New York. This project consists of an uncontrolled ogee drop structure and a 3,550-foot long, 17.5-foot diameter horseshoe shaped tunnel and stilling basin.

As part of the Phoenix Interstate Highway I-10 project, two large pressure tunnels, each 14,000 feet long and 21 feet in diameter, will divert large surface water flows into the Salt River. This project, scheduled for completion in 1987, is an inverted siphon with the crown of the tunnel about 50 feet below downtown Phoenix.

Large tunnels are being utilized or are under construction for urban flood and pollution control in major cities including Chicago, Illinois, Milwaukee, Wisconsin and Rochester, New York. The major portion of the largest of these plans, the Chicago Tunnel and Reservoir Plan (TARP), is now functioning and provides protection against combined sewer overflow and backup that, historically, has occurred for relatively frequent storm events. Principal features of the ultimate project include 120 miles of tunnel 10 to 33 feet in diameter and 150 to 300 feet below ground, which divert wet-weather flows from 640 combined sewer overflow outlets through 320 drop shafts. The largest tunnels include 44,800 feet of 33-foot diameter tunnel and 92,400 feet of 30-foot diameter tunnel, all of which are

completed. During construction, these large tunnels were mined by tunnel boring machines with production rates that exceeded both designer's and manufacturer's expectations.

The projects in both Milwaukee and Rochester are under construction and are similar in function, each including large tunnels up to 30 feet in diameter and several miles in length for the transport of storm water flows. The Chicago, Milwaukee and Rochester projects serve to illustrate the acceptance and use of large and extensive tunnel networks as a practical and reliable measure for handling large storm water flows.

During the course of this study, visits were made to the Park River Tunnel both during construction in 1981 and two years ago, and also to the Rochester tunnels where we observed the concrete lining construction procedures. Discussions were also held with engineers involved in the design of these projects as well as the Chicago, Milwaukee and Phoenix projects. Manufacturers of tunnel boring machines were also consulted. They have advised us that those projects that are functioning are doing so successfully. Tunnel construction on the order of the Passaic Dual Inlet Tunnel is practicable and the technology is available now. The anticipated geologic conditions are not difficult or unusual.

OPERATION OF THE PLAN

The fundamental components of the plan are two tunnels and their inlets and outlet sited in the most cost effective locations. The operation of the tunnels is therefore the basis for the operation of the overall plan. The purpose of the two tunnel diversion inlets is to divert flood flows away from the major Pompton Valley, Passaic Central Basin and Lower Valley damage areas by taking advantage of the differences in timing in the flood flows along the Pompton and Passaic Rivers. This difference permits the most effective use of the tunnel. Priority is given to putting maximum flow into the Pompton Inlet at all times. Because the Pompton peak occurs as much as two days before the Central Basin Passaic River peak, its flow is already well on the receding limb of the hydrograph by the time the Passaic River peak occurs at Two Bridges. Thus, there is adequate capacity to carry these flows through the tunnel. However, while the Pompton Inlet is basically a fixed operation, the gates at the Two Bridges Inlet must be opened and closed during a large flood event to assure that priority is given to Pompton flows. A different operating rule will result in larger bypassed flows from the Pompton arriving at Two Bridges closer to the Passaic River peak, thus adversely affecting areas downstream of the Pompton Inlet, the Great Piece Meadows and the Lower Valley.

To ensure proper operation of the tunnels, there are additional rules that are part of the plan. The tunnel is only to be operated during flood events. A flood event is defined as a condition where river flows are increasing and there is good probability or expectation that flood stages will exceed the one-year level. Gates are to be opened as soon as this is perceived to be the condition and then they are to be closed when this condition has passed. During a flood event the operating rule is sequential. As soon as a flood threat is identified, the inlets are operated so as to minimize the initial bypass flows downstream. During tunnel operation, the required bypass flow at the Pompton Inlet is 500 cfs and at Two Bridges, 100 cfs. Once the downstream flood stages have fallen below the 1 year level and the peak of the flood hydrograph at each inlet has been passed, the one year flow will be bypassed at each inlet. The Great Piece Meadows Weir will also operate at this time, if necessary, to assure reproduction of the 1 year flood stages upstream of the Passaic River in the Great Piece Meadows. It is noted that should flows exceed tunnel design capacity, excess flows are bypassed. Flooding occurs, but flood stages downstream are considerably reduced as the result of the flows carried in the tunnel.

METHODOLOGY FOR PLAN EVALUATION

The overall plan formulation procedure involved several preliminary steps which included hydrology, hydraulic and economic studies. Preliminary designs developed in Stage 2 were used as a starting point to perform sensitivity analyses with the HEC-1 hydrology model. These sensitivity analyses were used to develop plans for different levels of protection utilizing varied tunnel, spur and channel sizes, testing of inlet and outlet locations, testing different operating rules, as well as other hydraulic parameters. Four computer models were utilized including HEC-1, a tunnel simulation model, HEC-2, and the economic EAD (Expected Annual Damages) Model. Appropriate interface programs transferred data from one model to the other. Three models are standard models developed by HEC while the tunnel simulation model was developed by this office. The tunnel simulation model was critical in efficiently calculating the complex hydraulic relationship between the main tunnel and the spur tunnel to determine the balance of flow inputs to the tunnel at each inlet location and then return the balance of flow, the residual in the form of hydrographs, to the HEC-1 model. The model utilizes the Bernoulli equation with losses based on Manning's "n" value and includes bend losses, entrance and exit losses, expansion and contraction losses, junction losses and a back-water starting condition. These sensitivity analyses provided the performance criteria which were the basis

for the design of the proposed plan. The following text explains in further detail the evaluation procedure and the tunnel simulation model.

Initially, the Pompton Tributary HEC-2 models were run with channel and levee improvements to develop storage-discharge relationships to be incorporated into the Pompton River HEC-1 model. The HEC-1 model simulates overland runoff and channel effects downstream to the Pompton River gage, which is also the inlet location. This hydrograph is then input into the tunnel simulation with an assumed hydrograph at Two Bridges. With priority assigned to the Pompton Inlet, the model diverts the maximum possible flow into the tunnel based on the hydraulic capacity of the tunnel. Any residual flow becomes the flow down the Pompton River. This residual flow hydrograph is then input into the Central Basin HEC-1 model and produces a new hydrograph downstream to the Little Falls gage at the mouth of the Central Basin HEC-1 model, which is the location where the Two Bridges inlet is simulated. This hydrograph replaces the earlier assumed hydrograph at Two Bridges and the tunnel simulation model is rerun. This time the revised hydrograph is diverted at Two Bridges and is balanced with the priority Pompton Inlet diversion. Table II-8 shows the Pompton bypass flow for the 100-year flood in the proposed plan. Note that up to the 25th and after the 43rd hour, the bypass flow down the Pompton River is the minimum 500 cfs requirement. The larger discharge between these times indicates that the tunnel is operating at or near its capacity and virtually no flow will be diverted at Two Bridges.

Table II-9 shows hydrographs which are calculated by the model based on the operating rules. This table illustrates the need to open and close the diversion gates at Two Bridges (Column 6) to maintain priority on diverting Pompton River flows, and why the peak bypass flow (column 7) is determined by the flows in the Pompton River tunnel, and not limited by the capacity of the spur tunnel.

At this point (columns 7 and 8), the bypass flows in the Lower Valley and the combined flows in the tunnel from both inlets are input into the Lower Valley HEC-1 model, which completes the HEC-1 simulation. In a final plan run, all frequency flood events are simulated in this manner. The HEC-1 output is then interfaced with the particular HEC-2 improved conditions model. The interface program was developed to rearrange and encode the HEC-1 discharges into the HEC-2 input data files. In the Central Basin, this includes flows for each of the eight cases of peak and coincidental flows for the eight Central Basin hydraulic models as described earlier in Section

B, Existing Conditions Water Surface Profiles. After the HEC-2 runs were completed, these eight cases were merged by another interface program into one profile based on the highest stage of all cases. Then, another interface program was used to compare the resulting HEC-2 stages, discharges, velocities and channel bottom elevations of the entire Passaic River Basin among as many as seven plans and for existing conditions runs. This comparison enabled a quick evaluation of plan effects as well as serving as a tool for locating coding and other errors. Finally, this information was then formatted and encoded for economic analysis in the EAD model. The EAD model provides a measure of the effectiveness of the plan in the form of benefits. By repeating this procedure or portions of this procedure several times, the results eventually led to the design of the recommended plan. Sample comparisons of hydraulic results are shown in Tables II-10, 11, and 12, which show stages, velocities and discharges for the 100 year frequency for existing conditions, 2040 without plan conditions and 2040 improved conditions (Tables II-11 and 12 apply only to the Pequannock River). In addition, delineations and profiles for improved conditions for the entire basin are shown in Figures II-79 through II-136.

SECTION D - HYDRAULIC DESIGN

GENERAL DESIGN CRITERIA

Design Discharges. The design discharges were generated by the 2040 improved conditions HEC-1 model for the Dual Inlet Tunnel Plan. The plan was also run with 1990 development conditions discharges to enable a complete economic analysis. The peak and coincidental discharges used to develop water surface profiles for 2040 improved conditions are shown in Table II-7.

Freeboard and Clearance. Freeboard and clearance for the flood improvement and protection works on the channels are generally in accordance with Paragraph 9, Section VI, of Summary of Discussion, Hydraulic Design Conference, Ohio River Division Office, 8-10 December 1969 and EM 1110-2-1601, "Hydraulic Design of Flood Control Channels," as amended by ER 1110-2-1405. In all cases for (channels only) no freeboard is allowed, in order to minimize impact on wetlands and the loss of floodplain storage.

All bridges were designed to pass the design storm with a 2-foot clearance below the low steel of the improved bridge in order to avoid the possibility of any debris accumulations and any backwater caused by the bridge deck.

The design of levees and floodwalls is in accordance with ER 1110-2-1405 and includes three feet of freeboard above the design storm flood level (the design flood level is different from the existing conditions level for the same frequency because the design level was developed with the incorporation of levee and floodwall encroachments in the HEC-2 hydraulic runs). Walls or levees which are susceptible to wave actions or are used as closures at the upstream ends of improvements have a freeboard clearance of 5 feet.

Levees and Floodwalls. Levees and floodwalls were designed in accordance with current Corps criteria as described in EM 1110-2-2501, "Wall Design," and in EM 1110-2-1913, "Design and Construction of Levees."

In general, the cantilever I-type wall was used only under certain foundation conditions and with a maximum height of 10 feet. The T-type and L-type walls were used for heights ranging from 10 to 30 feet, the difference between the two being the foundation design. When space limitations adjacent to the river edges were critical, the L-type wall was used instead of the T-type wall.

The typical levee sections were designed with a top width of 10 feet and slopes of 3 horizontal to 1 vertical, and tie into existing slopes when practical.

Freeboard and clearance for levees and floodwalls is discussed in the previous section under the subtitle "Freeboard and Clearance."

Channel Protection. Riprap analyses were performed by the local boundary shear and average boundary shear methods as recommended in EM-1110-2-1601, as amended by ETL 1110-22-120. The results of these two methods were compared with the WES Froude Number Analysis, HDC Method and NCSA method. A computer program utilizing these five methods was developed by N.Y. District personnel to perform the riprap analysis. The results from this program have been tested against manual calculations to assure that it adequately predicts the need for and size of riprap. A minimum D50 riprap size of 12 inches is used where riprap was required in accordance with EM 1110-2-1601, paragraph 14i(2). The riprap placed at the toes of side slopes was reinforced by increasing the layer thickness of riprap in order to protect the toe from scouring as recommended by EM 1110-2-1601. Also, an extra thickness of riprap, approximately 6 to 12 inches, would be placed at bends of the improved channels and channel transitions and underneath bridges (bridge stability was analyzed based on proposed excavations) where they are subject to potential scouring, erosional forces and attack by floating

debris. Riprap locations are indicated on Table II-22 and sample calculations using the five methods are shown in Table II-25.

Profile Stability Analysis. The selection of the improved channel widths, slopes, and depths reflect consideration of stream discharges and bed material grain size in order to ensure a stable flow regime. All these improved channels were designed with the permissible bottom width and Froude No. less than 0.3 in accordance with the modified Regime Approach presented in Chapter 6 of the Soil Conservation Service (SCS) Technical Release No 25, entitled "Design of Open Channels," dated October 1977. Flow stability was verified through a section to section examination of the HEC-2 hydraulic outputs of these improved channels. The results of the flow analysis computations indicated stable flows for the improved channels.

Tunnel Design. Several sources of information were used to design the tunnels, inlet structures, gated diversion spillways, and outlet and other structures associated with the tunnels.

The design references for the tunnel system include the following:

1. Hydraulic Design Criteria - prepared by U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi;

2. "Design of Small Dams" - prepared by Bureau of Reclamation, revised second edition, 1977;

3. "Hydraulic Design of Reservoir Outlet Works"- EM 1110-2-1602, 15 October 1980.

4. "Hydraulic Design of Improved Inlets for Culverts", US Department of Transportation.

Standard Engineering Practice. The preceding text has described the technical design criteria. These criteria are applied to develop the project solutions for the flood control problem. Standard engineering practice extends these criteria to include reviewing the plan and assessing the potential for modification of project components in order to minimize changes from normal conditions, particularly in terms of avoiding adverse environmental and cultural impacts, within the achievement of the desired engineering results. Such items include the use of cobble substrate on the modified channel bottoms where there is no riprap requirement. This makes use of residual tunnel excavation materials. Meandering pilot channels are also included where appropriate to concentrate the riverflow

during low flow conditions which benefits the fishery. This controlled irregularity attempts to simulate the existing channel that accomplishes the same purpose.

The Great Piece Meadows Weir functions to stabilize the natural channel at its point of connection to the tunnel inlet transition channel, and includes a gate structure to preserve upstream wetlands for purposes of maintaining environmental attributes and downstream water quality while permitting water stage reductions under flooding conditions. This also serves to preserve the fish and wildlife habitat associated with the wetlands.

The Pequannock River Weir preserves the current function of the old Morris Canal feeder dam while avoiding impacts to fish and wildlife habitats, groundwater resources, and a National Register of Historic Places landmark. The operating rules preserve the inundation of wetlands and also provide downsteam flows up to the annual flood to maintain natural scour of downstream channels. The hydraulic design, effects, and function of these project refinements have all been accomplished within the bounds of standard engineering practice.

POMPTON INLET

The Pompton Inlet has been given priority in operation so as to maximize the diversion of the Pompton River. This priority has been determined to provide the simplest and yet most effective rule based on hydrologic simulation. The inlet consists of a flow restrictor, diversion gates, morning glory, Pequannock Weir, transition channels, and levees.

Flow Restrictor. The function of the flow restrictor is to control flows past the tunnel inlet. Normal flows must be allowed to bypass the tunnel at all times. During a flood event only 500 cfs is bypassed except when the capacity of the tunnel is exceeded. Flows beyond this level must be bypassed without the danger of failure of the restrictor or other structures. Charts, tables and procedures contained in "Hydraulic Design of Improved Inlets for Culverts" by the U.S. Department of Transportation were used in the design of this structure.

The structure was designed with four 16.5' x 28' openings and one 16.5' x 32' center opening, all of which are culverts 30 feet in length. The openings are controlled by roller gates which are withdrawn into the abutments of the flow restrictor.

The restrictor is located on the river downstream of the diversion structure establishing a channel invert of EL. 163.0 feet. The top of the structure is set at EL.181 feet and serves as an emergency spillway (Plate II-15). Embankments extend outward from the structure almost 720 feet on the east bank and 750 feet on the west bank and average 4 to 5 feet in height tying into high ground at El. 182.5 feet.

Under normal conditions, the center gate remains open and is capable of passing the equivalent of the existing 1 year flow during the 100 year design storm event. During a flood event, however, the gate will be closed down to bypass only 500 cfs, a bypass flow to preserve and maintain environmental resources downstream. It will be operated during a flood event to adjust to varying flow conditions in conjunction with the inlet diversion gates to maintain the 500 cfs bypass flow. When tunnel capacity is exceeded, the gate is opened. The remaining roller gates are opened to bypass flows beyond the 100 year design level. For these extreme conditions, the downstream backwater will dominate and submerge the flow restrictor. The stages upstream would be the combined results of pressure and submerged weir flows through the openings and over the emergency spillway and embankments. The rating curve for the flow restrictor was coordinated with that of the inlet diversion spillway to satisfy the operating criteria and was used in determining starting water surface elevations used in HEC-2 profile runs for the tributaries upstream of the inlet.

Diversion Spillways. Bascule gates on top of the diversion spillways were designed to regulate the flow to the tunnel during a flood event and maintain existing Pompton flows during normal conditions. The spillway and gates were designed in accordance with the Corps' "Hydraulic Design Criteria" and recommendations from the gate manufacturer. The ogee-shaped spillways were designed to conform to a trajectory which would eliminate subatmospheric pressure along the crest contact. This design would allow the designed flow to enter effectively at a lower head into the access basin.

Five 5.5'x 75' bascule gates with six 4-foot round-nose supporting piers would be placed on top of the 400-foot Pompton diversion spillway. The crest (EL 169.5 feet) with gates "down" is 5 feet above the channel bottom and 8.7 feet above the access basin bottom. The gates "up" elevation is 175 feet which will allow bypass of the one year flow with no diversion into the tunnel. Flows larger than the one year flood would be diverted into the tunnel.

Morning Glory Spillway. Design of the morning glory spillway is in accordance with Corps "Hydraulic Design Criteria" and the methodology presented in "Design of Small Dams," Bureau of Reclamation, 1977. The morning glory inlet is located behind the diversion spillway in a large semi-circular basin about 320 feet in diameter and 8 feet deep relative to the morning glory crest, Plate II-15. The access basin is designed to provide sufficient space for the flow to distribute around the morning glory spillway and to reduce the velocity head approaching the spillway. The crest of the spillway is at an elevation of 168.8 feet with a radius of 42 feet and a crest length of 264 feet. A crest coefficient of 3.93 was used.

The morning glory spillway transition to the tunnel shaft was designed in a streamlined shape to provide a smooth, gradual change to minimize head losses and to avoid zones where cavitation pressures can develop. Guide piers on top of the morning glory spillways were also designed for anti-vortex action and to maintain converging flow into the drop inlet. Due to the effect of submergence and back pressure incidental to the joining of the converging flows over the morning glory crest, the crest coefficient which relates to the approaching depth (Ho) and crest radius (RS) was carefully selected in the design of the morning glory spillway. In order to avoid the sub-atmospheric pressure on the crest, the ratio of Ho over RS equal to 0.22 was used to determine a conservative crest radius. With this design, the peak flow of 28,709 cfs into the tunnel will be at an elevation of 177.95 feet which is 9.15 feet above the spillway crest.

The advantages of a morning glory spillway under design conditions compared with a side channel spillway include a larger inflow increment for a change in water surface elevation and the compactness of the structure both in terms of a long weir length in a relatively small area and a smooth, short transition from spillway crest to tunnel section. By situating the morning glory in the access basin, flow velocities are considerably reduced, which will prevent objects and heavier sediments from being carried into the tunnel and reduce the possibility of fish being drawn into the tunnel. Finally, the crest of the morning glory spillway is 8 feet above the basin floor making it a secure tunnel inlet in terms of people accidentally walking or falling into the tunnel.

There are also disadvantages to a morning glory inlet that include air entrainment and cavitation. High-head, vertical drop inlets entrain large quantities of air in the flow, which can cause severe surging and/or reduction of capacity. At discharges below throat control, the entrained air is normally

carried through the tunnel by designing the tunnel to flow as an open channel downstream from the throat. An open channel flow design is not possible for the Passaic River tunnel alternatives because the tunnel crown must be located 150 feet below the river level at the downstream exit. Entrained air should be collected and vented or eliminated from the tunnel. Large quantities of air can be prevented from entering the tunnel after the discharge has shifted from crest control to tunnel control by the installation of vortex suppression devices on the crest. Such devices are shown for the proposed inlet in Plate II-15. These devices, however, are effective only at larger flows and venting of the tunnel will be necessary. This is discussed later in this section.

The inner surface of the morning glory spillway is shaped to eliminate cavitation. Construction irregularities in the structure must be limited to gradual offset flatter than 1:25. Although the tunnel can be specified and constructed to the required tolerances, there remains the question of wear and deterioration with time. If spalling or abrasion cause offsets or excessive slopes during the life of the project, cavitation damage could result. Cavitation damage is mitigated by entrainment of air in the water, particularly when the discharge is small.

Recent studies on high velocity structures have shown that cavitation damage can be eliminated by the introduction of small quantities of air into the boundary layer. The morning glory inlet can easily be designed to introduce air into the boundary layer by the venting of the morning glory throat inlet. The exact details of this venting will be determined during the final design stage of the project.

Transition Channels. In order to direct the 100-year design discharge smoothly and effectively to the diversion spillway and into the tunnel, the Pequannock River would be deepened and widened to a 129-foot base width narrowing to 74 feet upstream, with a 1 on 2 side slope channel, Figure II-100. This channel starts at the flow restrictor with a bottom elevation of 163.0 ft. upstream to the Pequannock/Ramapo confluence at an elevation of 163.5 feet. This entire 1800 foot improved section would be protected by a 24-inch layer of riprap. The Pequannock channel would then continue upstream for 2700 feet, 7000 feet and 1950 feet respectively with channel slopes of 0.1%, 0.047% and 0.45% respectively. The average excavated depth would be 6 feet. The channel would then be gradually transitioned back to the grade of the existing channel in the last 500 feet, which is about 3000 feet upstream from the Pequannock/Wanaque confluence. See Figures II-100, II-106, and II-133.

Channelization would also be required and continued upstream from the Pequannock/Ramapo and Pequannock/Wanaque confluences on the Ramapo and Wanaque Rivers, respectively. The Ramapo River, which would be modified to a 100' bottom width and 1 on 2 side slope channel, starts from an elevation of 163.5 ft. for a distance of 3600' to 164.3 ft. NGVD. It would be continued upstream with a 60' bottom width, 1 on 2 side slope, and .023% bottom slope to Pompton Lakes Dam for a distance of 2900 feet. Excavation would deepen the channel an average of 7 feet. See Figures II-100, II-106, and II-135.

On Wanaque River, the modified channel starts with 0.17% bottom slope at an elevation of 169.5 feet and extends 2450 feet upstream. This 100-foot bottom width, 1 on 2 side slope channel would be continued upstream with a 0.26% bottom slope and a 74-foot bottom width channel for another 2500 feet before it transitions to the existing channel. Excavation depths would average 6 feet. See Figures II-106 and II-134.

Pequannock River Weir. This structure is included in the plan to maintain normal river flow stages under normal conditions on the Pequannock and Ramapo Rivers upstream of the Morris Canal Feeder Dam.

The Old Morris Canal Feeder Dam is located upstream of the Pompton Inlet (Figure II-100) where it straddles both the Pequannock and Ramapo Rivers upstream of their natural confluence. Although it was constructed more than a century ago to divert river flows to the no longer existing Morris Canal, it is now used for recreational purposes and is owned by the State of New Jersey. The discharges from the dams are unregulated and naturally balance inflows from both rivers. There are no low level outlets. The structure consists of dams across both the Pequannock and Ramapo Rivers and an earthen dike between and beyond the dams for a total length of almost 3,500 feet. The spillway crest of the dam on the Ramapo River is 175.5 feet NGVD and the dike is between 182 and 183 feet NGVD with a top width varying from 10 to 15 feet. The Ramapo dam, built in 1928 to replace the original structure, is a concrete gravity dam 270 feet long and 22.2 feet high. The Pequannock dam crest is at elevation 177 NGVD, 275 feet long and about 12 feet high. The dams are classified as small because storage behind them is less than 1,000 acre-feet and dam heights are less than 40 feet. However, the Phase I Inspection Report of the National Dam Safety Program gave the structures a "high" hazard potential because of the development located downstream. The findings of the report indicated that the dams and earthen dikes are in good condition but in need of minor repair.

The spillways are considered "inadequate" because a flood equivalent to about 25 to 30 percent of the PMF will overtop the dams. However, they are not considered "seriously inadequate" because dam failure from overtopping would not significantly increase the hazard to loss of life from that which would exist just before overtopping failure. This is confirmed by HEC-2 model runs for this study.

It is noted that the crests of the dams become submerged by downstream backwater in flood events with a 2 to 5 year frequency and that the earthen dike is submerged for floods larger than the 10 year event (Figures II-72 and II-74). This would mean that the dam is submerged by backwater long before the spillway capacity is exceeded (the spillway capacity cited in the dam safety report) and therefore, failure of the structure is inconsequential.

The Pequannock River Weir is to be located in the transition channel at the Morris Canal Feeder Dam at Station 1705 on the Pequannock River. It would consist of two 85-foot wide, 15-foot high bascule gate sections which would be raised under normal conditions and lowered during a flood event. The top elevation of 180 feet NGVD would be about 3 feet higher than the existing dams on the Pequannock and Ramapo Rivers and 3 feet below the non-overflow section. This design would preserve the existing flows conditions over the existing spillways but effectively breach the structure during flood events and direct flows to the Pompton Inlet. In addition, by lowering and raising these gates gradually, it is possible to assure the inundation by the equivalent of the one year flood to satisfy fish and wildlife habitat needs.

Log Booms and Bar Screens. The Pompton Inlet must be protected from large floating debris although this is not expected to be a major concern. The 4.8 miles of channel modification and 4.2 miles of levees and floodwalls result in a relatively stable riverbed condition and containment of floodwaters within floodways, which will minimize debris such as large trees, buildings, etc. Pompton Lake is about 2 miles upstream on the Ramapo River and serves as a natural catchment for debris. To assure that no large debris enters the tunnel, a log boom will be placed across the river upstream of the diversion spillway. In addition, a bar screen (to be designed in engineering studies) with widely spaced bars will be placed in front of the diversion spillway to serve as a second line of protection. The bridge on the diversion spillway will allow equipment to clean the screen during a flood if it is necessary.

TWO BRIDGES INLET

The Two Bridges Inlet is subordinate to the Pompton Inlet and, therefore, must be carefully controlled to support this relationship. The downstream design control of the inlet is not Beatties Dam at elevation 158.2 feet, but the rock ledge about 1,000 feet upstream of Beatties Dam situated at about elevation 153 feet. If Beatties Dam should fail, operation of the tunnel diversion at Two Bridges will still function at its intended capacity. The structures at Two Bridges include the diversion spillway and the morning glory spillway to the 22-foot diameter spur tunnel.

In addition to being designed to function in concert with the Pompton Inlet, this inlet is also designed to function prior to completion of the Pompton Inlet. This would enable the plan to function in the Two Bridges area and provide protection prior to completion of the entire project. Therefore, these facilities are capable of diverting the full 15,800 cfs capacity of the spur tunnel which is a larger flow than the 13,000 cfs maximum diversion anticipated during the hypothetical 100 year storm. This tunnel spur size was determined to be optimum during the formulation of plans.

Diversion Spillway. This structure is similar in appearance, and performs functions similar to the diversion spillway at the Pompton Inlet. There are four 11-foot by 100-foot bascule gates with five 4-foot round nose supporting piers designed for the 420-foot Two Bridges diversion spillway structures (Plate II-16). The crest elevation is 153.2 feet which is 1.7 feet higher than the improved channel bottom and 11.6 feet higher than the access basin bottom at elevation 141.6 feet. The top of gates is El. 168 feet which is 4 feet higher than the existing 1 year flood stage. The crest elevation was determined to be the stage of the 100 year bypass flow when the gates must be closed (approximately elevation 166 feet + 2 feet of freeboard) to maintain the priority of the Pompton Inlet diversion. The design criteria are the same as those described for the Pompton Inlet.

Morning Glory Spillway. The morning glory spillway is designed in accordance with the same hydraulic criteria as the Pompton Inlet structure. Specifically, this structure is situated in a 280-foot diameter semi-circular access basin which widens at its mouth to 412 feet. The 28-foot radius spillway has a crest length of 182 feet, a crest coefficient of 3.93, and a crest elevation of 147 feet, which is 7 feet above the floor of the access basin. At elevation 157 feet, or 10 feet above the spillway crest, the tunnel controls, and the flow into the tunnel is 15,556 cfs.

Transition Channels. The channel work upstream of the inlet is not as extensive as in the Pompton Inlet area because of the reduction of flood discharges resulting from the flow captured by the Pompton Inlet. To direct the flow effectively into the inlet, the channel would be deepened to EL.151.5 feet and widened to 170 feet with 1 on 2 side slopes at the diversion spillway at Station 172300 of the Passaic River. This channel would then be transitioned upstream and downstream to existing grades for 3,090 feet and 1,100 feet to Stations 175390 and 171220, respectively. This channel would continue with a 0.04% gradient upstream from the Passaic/Pompton confluence along the Pompton channel for 1,830 feet. This channel was modified to a 150 foot base width with 1 on 2 side-slopes. Excavation depths range from 3 to 6 feet. See the plan and profiles on Figures II-87, II-119 and II-130.

Great Piece Meadows Weir. This weir is incorporated into the plan for purposes of channel stability near the mouth of the Great Piece Meadows. Inspection of photographs and maps indicate that several oxbows and meanders exist along the Passaic River in the Great Piece Meadows. A berm and opening are provided at the upstream end of the tunnel inlet transition channel upstream of Two Bridges. This measure will serve to train the natural channel to the transition channel and assure the integrity of the tunnel operation on the Passaic River. This structure, along with riprap at the upstream end of the transition channel, will also prevent headcutting or erosion in an upstream direction.

The addition of the gate to the structure will assure appropriate inundation of the wetlands within the one year floodplain upstream of the weir. Appropriate inundation includes duration of flooding as well as stage of flood. Preservation of these wetlands will maintain both the natural water purification function associated with wetlands and the quality of downstream water in the Passaic River. In preserving the wetlands, a large area of fish and wildlife habitat is retained in its present condition.

The normal position of the weir would be open (in the lowered position) so as not to affect normal flows. During a flood event, the weir would remain in the lowered position until the flood peak has passed and flood stages were at, or below, the one year stage. The weir would then be raised to simulate the one year quality, fish and wildlife habitat, and other environmental purposes. The gates could also be used during periods of normal flow should conditions warrant simulation of the one year event.

The weir would consist of one 100-foot wide, 14.7-foot high bascule gate as shown on Plate II-19. It would be founded on the existing channel bottom at Station 175930, which is 3630 feet upstream of Two Bridges Inlet. A 600-foot long embankment would tie the weir into Two Bridges Road on the left bank and a 150-foot embankment would tie into Camp Road on the right bank. The crest elevation would be 164.2 feet, and Camp Road would be raised 1 to 2 feet to that elevation. Culverts along Two Bridges Road would have gates installed to close them off during the periodic floodings.

The structure was coded into the Two Bridges to Pine Brook HEC-2 model and was found to have no significant effect on flood stages when in the lowered position. The weir was also simulated at low flows to determine upstream effects which are shown in Table II-17. The table indicates that up to one half of the Meadows can be flooded to the one year level with a flow of 500 to 1000 cfs.

Log Booms and Bar Screens. A log boom will be placed upstream of the Two Bridges inlet on the Passaic River and a bar screen similar to that described for the Pompton Inlet will be provided across the front of the diversion spillway. Because the Dual Inlet plan will never allow flows to exceed the 1 year flood on the Pompton River (up to the 100 year design event), the waters will be contained, for the most part, within banks with minimum chance for debris to enter the river. On the Passaic River, the Great Piece Meadow is largely a forested wetland and is an extremely flat area with low flow velocities. There was no occurrence of debris jams downstream of this area during the 1984 flood, which indicates that large debris, if it occurs, is naturally screened by the Great Piece Meadows.

TUNNEL SYSTEM

As a system operating under pressure, the design was based on Bernoulli's equation using Manning's equation with a coefficient of 0.013 for friction losses. The energy grade line computations included exit losses and bend losses.

The grade of the tunnel was selected based on maintenance considerations and the need to keep as much of the tunnel above sea level and free of standing water. However, at the lower end of the tunnel it was necessary to lower the invert below sea level to assure that there was adequate rock cover over the crown to allow the use of a tunnel boring machine, which is the most cost effective tunneling method for this plan.

Main Tunnel. The main tunnel is 71,000 feet long and 39 feet in diameter. At the Pompton Inlet the invert is situated at 3.5 feet NGVD (Plates II-17 and 18) and descends at a very flat slope to EL. 0.0 feet at station 19330. From that point on, the slope is one percent almost to the mouth where there is a low point of -192.4 feet at the Third River workshaft. A pump station will be maintained there to periodically pump the tunnel dry for maintenance purposes. At the upshaft, 800 feet farther toward the river, the invert is only slightly higher and the tunnel rises as a vertical shaft to the surface.

From the Pompton Inlet alone, the tunnel has a capacity of 28,709 cfs with backwater at the mouth of 15.4 feet. This backwater would be caused by the discharge during the 100 year flood event being coincident with a one year tide which is El. 5.5 feet under 2040 conditions. This capacity is fully utilized in the 50 and 100 year frequency flood events.

Spur Tunnel. The spur tunnel is 6,500 feet long and 22 feet in diameter (Plate II-18). It consists of a 90 degree bend with a 10 degree flare where it joins the 39 foot diameter main tunnel. Both inverts are at the same elevation of 1.5 feet NGVD. A coefficient of 0.69 was used for bend and expansion losses in calculations.

The spur tunnel has a capacity of 15,800 cfs when there is no Pompton flow in the main tunnel (Table II-14). This capacity would be used in the period before construction completion of the Pompton Inlet to reduce flows downstream of Two Bridges. Once the Pompton Inlet is completed, maximum use at design conditions is 13,000 cfs which is the 100 year peak at Two Bridges (Table II-9).

Venting Shafts. Under low tunnel flow conditions the gradient of the tunnel allows open channel flow in the upper 52,000 feet of tunnel while there is pressure flow in the lower 19,000 feet down to the mouth where the tunnel is below sea level. Air will be entrained by flows through the morning glory spillways and could possibly be trapped by hydraulic jumps below the crown of the tunnel. The depth of the tunnel at the mouth would prohibit air movement to the outlet and it could reduce flow efficiencies in the upper portion of the tunnel by causing vibrations and breaks in the flows, possibly damaging the tunnel lining. Another concern is cavitation at the junction, bends, and zones of slope change, which can set up damaging vibrations. Venting shafts located downstream of both inlets, at the spur-tunnel junction and near station 19330 where there is a change in tunnel slope, will serve both to relieve pressures of entrained air and break the siphonic actions of negative pressures.

The proposed construction work shafts can readily be adapted to this purpose at little extra cost and should serve the purpose well. However, the need for venting will be reviewed in advance design stages to assure adequacy.

Outlet Structure. The outlet structure is located on the Passaic River adjacent to Route 21 and immediately upstream of the mouth of the Third River. There is a Federal navigation channel 12 feet deep which has enlarged the natural channel capacity of the river downstream to the Second River, with larger channels downstream to Newark Bay. The structure begins with a 23-foot long transition section on the tunnel upshaft with an increase in diameter from 39 to 45 feet to the bottom of the outflow sill at EL.-10ft. The stilling basin is 96 feet wide by 81 feet long with a transition section 40 feet long to the river. The channel bottom would be armored with 24-inch riprap for a distance of 250 feet downstream of the structure and flaring out to the 350-foot width of the river. This design is similar to the outlet structure on the Park River Tunnel in Hartford, Connecticut.

SYSTEM OPERATION

Operating the proposed plan will require a central operational facility to manage this complex system of tunnel and local protection works. The sequence of gate operations at both inlets is the key to the successful control of flood events to make certain that flows are diverted to both reduce flood flows and, once the risk has passed, ensure that the needs of environmental resources are satisfied with appropriate bypass flows and retention above the Great Piece Meadows' weir.

Operational Facilities. An operations center will be located near the Two Bridges inlet with supporting facilities at the Pompton inlet and other locations to assure the proper functioning of the plan. Real-time hydrologic data such as reservoir and stream stages, depth of snow on the ground, rainfall, temperature, direction of storm movement, and tide stages are all vital information that will be fed to this center. Some of the information will be available through the flood warning system which is authorized and which will be put into operation in the Spring of 1988 by the Corps of Engineers with the National Oceanic and Atmospheric Administration, the United States Geological Survey, and the State of New Jersey.

The Flood Emergency Preparedness System for the Passaic River Basin consists of a series of enhancements to the present warning system that includes radio reporting rain gages, stream gages, computers and a communications network. The rain and

stream gages will collect data that will be sent for analysis to the National Weather Service via a backbone communications network. Weather forecasts and storm warnings will be issued using all available data, and sent back through the communications backbone network to the counties and local municipalities. Specific improvements in data collection and availability will enhance all existing rainfall and streamflow gages by adding remotely sensed satellite data collection platforms that will gather real time storm information, and by placing 23 new rainfall gages with similar capability within the basin.

Modifications to the system for this plan will allow the operations center to receive rainfall and streamflow data directly. This data will be input into an operational model which, with system forecasts, will be used to determine the operation of the project. Not only will the center assure the proper operation of tunnel components, but it will also issue warnings and orders to make certain that the closure structures and interior drainage facilities are properly tended to and functioning. After the peak of the flood event has passed, the center will also make decisions as to when the Great Piece Meadows weir will be closed to maintain wetlands, and when tunnel diversion gates will be closed to increase downstream bypass flows for stream channel flushing. Finally, in the event of flows in excess of the design (100-year) flood, warnings will be given.

Gate Operation - Pompton Inlet. Gates at both inlets will be operated continuously to maintain downstream requirements for bypass flows, and operation of the gates at Two Bridges will assure the priority of the Pompton Inlet diversion. A scenario for operation of the Pompton Inlet is shown in Tables II-13 and II-15. When a flood event is imminent, the flow restrictor and bascule gates are to be operated to bypass 500 cfs with the balance of flow diverted into the tunnel. Initially, the central roller gate will close to control the 500 cfs bypass and cause ponding to occur behind the restrictor. The Pequannock Weir located upstream across the transition channel, normally in the raised or closed postion, is lowered to open up the channel. At river EL.169.5 feet, the diversion structure bascule gates are lowered and the central roller gate in the flow restrictor is gradually closed with increasing flows and head to maintain the 500 cfs bypass flow. However, once the river elevation reaches 179.5 feet, at which point the tunnel capacity is exceeded, the central roller gate gradually opens to maintain EL.179.5 feet. Beyond the 100 year design flows, the roller gates for the remaining 4 culverts are gradually opened to maintain EL.179.5 feet while bypassing flows in excess of tunnel capacity. The process is reversed as flood flows recede.

However, a modification for maintaining fish and wildlife habitat and other mitigation purposes requires that the tunnel inlet be operated to assure that the equivalent of the one year flood event occurs downstream. This would be effected once the river was under control on the descending limb of the flood hydrograph and when it could be assured that downstream conditions would accommodate these flows without exceeding the one year flood stage. This would be accomplished by partially closing the tunnel inlet gates to bypass these flows sooner than would occur when these gates are operated strictly for flood control purposes.

The primary purpose of the Pequannock River Weir is to close off the transition channel so that normal flows are maintained over the Pequannock and Ramapo dam spillway sections of the Morris Canal Feeder Dam, thus preserving the function of the dams. This structure is therefore opened only for flood events when the Pompton Inlet is functioning. To satisfy fish and wildlife needs, a modification to this rule requires

that the gates be lowered gradually during a flooding event to assure that the one year floodplain and wetlands upstream of the structure are inundated. The gates will be lowered completely at flows approximating the 1 year flood event and for all larger flows. On the descending limb of the flood hydrograph, the gates are to begin to close gradually once flood stages drop to the existing one year level (or approximately the improved 10 year flow), thus reversing the process.

Gate Operation - Two Bridges Inlet. At Two Bridges Inlet, all flows are controlled by regulation of the bascule gates. Table II-14 shows rating curves and Table II-16 lists the gate operation procedure. At the beginning of a flood, the bascule gates are lowered individually but gradually to maintain the 100 cfs flow downstream at Beatties Dam. Note that the rating curve (Table II-14) is established at a starting elevation of 151.5 feet, which is the design condition without Beatties Dam. However, with Beatties Dam, river elevations would be starting about EL.158 feet for a 100 cfs flow. This mode of operation would continue in a flood event until it becomes necessary to close down flows in order to support the priority of diversion at the Pompton Inlet. At the peak of the Pompton flows during the hypothetical 100 year event, the gates would be closed and the flow past the inlet would exceed 9,000 cfs and produce a river stage of about 166.0 feet. As the Pompton flows decrease and capacity becomes available, the gates would again be gradually lowered to begin diverting flows to make use of the full capacity of the tunnel and thereby reduce flows to the Lower Valley and shorten the duration of flooding.

In a rule modification similar to the procedure described for the Pompton Inlet, the Two Bridges Inlet would be operated for fish and wildlife habitat and other mitigation purposes to assure that the equivalent of the one year flood stage occurred both upstream and downstream of the Two Bridges Inlet.

While the Great Piece Meadows Weir functions for channel stabilization, the gate component of the weir is included to provide for inundation of the existing one year floodplain in the Great Piece Meadows during any flood event as part of the operation of the overall Dual Inlet Tunnel Plan. Because backwater elevations from tunnel bypass flows will not completely reproduce existing 1 year stage durations for all flood events in the downstream portion Great Piece Meadows, bascule gates, which are normally in the lowered or open position, would be raised on the descending limb of any flood hydrograph once the flood occurrence was under control and there was no danger from backwaters causing unwanted flooding upstream. These gates would be raised and stages monitored to provide inundation for fish and wildlife purposes. Table II-17 shows existing and improved backwater stages for several discharges up to the one year flow. Once a sufficient period of flood duration had elapsed, the gates would be lowered to their open position until the next flood event.

TUNNEL MAINTENANCE

The proposed tunnel maintenance procedures call for pumping the tunnel dry for the purposes of inspection and cleaning after the first 5 years of operation, and every 10 years thereafter or after a major flood event. Because the upper two-thirds of the tunnel is above sea level, it will be possible to enter that portion of the tunnel more frequently. In the submerged lower third of the tunnel there will be about 180 million gallons of water. Gates at the tunnel outlet would be put in place and a pump with a capacity of 18,000 gpm would be activated for 24 hours a day over 7 days to clear the tunnel. The perimeter grouting placed during construction and the concrete lining will effectively eliminate seepage. However, should there be seepage, it may take longer to clear. Any seepage in the tunnel would be sealed off by grouting during the inspection period. Equipment would be lowered into the tunnel through one of the original workshafts which will be maintained for this purpose. Other workshafts will be utilized for ventilation and other purposes. Any accumulated sediments would be removed at this time. Currently, there is no data available to estimate what this accumulation might amount to. However, this aspect will be evaluated during design, and procedures will be developed further from experience gained during the operation of the

tunnel. There will also be an opportunity to observe the maintenance of the Park River tunnel in Hartford, Connecticut, which will be inspected in the very early 1990's.

RIVERBED COMPOSITION AND SEDIMENT TRANSPORT

In accordance with EM 1110-2-4000 (Draft EC 1110-2-241, 5 November 82), a sediment study (negative study) was performed and confirmed that the recommended channel configurations are not expected to be susceptible to sediment movement. This study followed the five-step sequence recommended in Chapter 6, section 6-11(b), of the above referenced EM. The conclusion that the improvements will not experience any sediment related problems is supported by the following: a) There have been no reports from local interests of channel or streambank erosion in the study area. Field inspection has verified that erosion is not an existing problem. Field inspections and the verification of floodmarks have indicated that no debris jams or large amounts of sediment movement have occurred historically in the study area; b) The channel slopes, both existing and

improved, are shown on Table II-22 which shows little change when compared with the existing channel invert. Channel velocities are compared in Table II-23 which shows no significant change over most of the channel length; c) As discussed above, sections of channel susceptible to erosion will be protected with riprap. This will be provided for the lower end of the Pequannock River where velocities will be variable during tunnel operation, the Ramapo River, and areas where channels transition to the existing channel; d) In the project area, the size distribution of riverbed material will affect the potential for sediment movement. Microscopically fine clays and silt would be susceptible to suspension and transport. Grain size analyses of samples of the riverbed material, however, revealed coarse sands and gravels in the Two Bridges area, providing a stable bottom under improved conditions. The Wanaque and Pequannock Rivers are reported to have silty sands which are to be stabilized where required.

In the Pompton River Basin, Pompton Lake on the Ramapo River is located 2 miles above the Pompton Inlet. This, combined with the fact that the Wanaque and Pequannock Rivers have been heavily developed for water supply with the construction of several reservoirs, may have the effect of controlling sediment transport. In the Two Bridges area, flows coming down the Pompton River would be considerably reduced and contained within banks, while the Passaic River flows at low velocities through flooded wetlands, which naturally accrete soils during flood events. While future studies will model the inlet areas and further investigate sediment transport, an annual maintenance

cost has been included to ensure that the the design channel configuration will be maintained.

OVERTOPPING OF LEVEE AND FLOODWALL RISK ANALYSIS

This section addresses the concern that a rare and infrequent flooding event will occur and result in the overtopping of a levee and floodwall system in the Dual Inlet Tunnel Diversion Plan. Flood overtopping of levee/floodwall structures in a previously protected area is a risk inherent in any levee/floodwall project. This risk varies with the level of protection afforded by the structure. In general, there will be adequate warning time in most areas to evacuate, place sandbags, or take other measures. The tidal flooding in the Lower Valley can be anticipated for northeastern type storms by approximately a day, and hurricanes are constantly monitored for strength and track, so that there can be about a day's warning for an extreme event. In the Central Basin, fluvial peaks take 2 to 4 days to rise while the Ramapo, Pequannock, and Wanaque Rivers, which can rise to peak stages in 30 hours, are reaches where there is most concern. These reaches would have the least warning time after a flood is recognized as having overtopping potential. In all cases, a large volume of river flow and elevated tides could result in severe inundation if these systems were overtopped. In the advanced engineering and design phase of this project, a more detailed hydraulic analysis will be undertaken to minimize the inundation hazard and to manage the overtopping to maximize warning time. A brief analysis of the overtopping potential during the 100 year economic life of the levee/floodwall systems in this plan is shown Table II-24.

In the Lower Valley, there is virtually no probability that the tidal levees will be overtopped. This is because the top of levee elevation of 14.9 feet NGVD is 3.0 feet higher than the hypothetical 500 year tidal event. However, for the mitigation levees which are designed to protect against the 100 year event, six out of seven systems would be overtopped by the 500 year flood or a slightly more frequent event. These systems are at 20 percent or greater risk of being overtopped during the 100 year life of the project. The same is true for most of the remaining systems in the Central Basin and Pompton Valley. The exceptions are Pinch Brook, which is designed to protect against the 500 year flood, and both Stiles Court and Passaic 2C, which are in reaches where the 500 year stage is within the 3 foot freeboard of the 100 year design level of protection.

SECTION E - INTERIOR FLOOD CONTROL

GENERAL

This section presents the basis for the planning and design of the interior flood control facilities for the Pompton-Passaic Dual Inlet Tunnel Diversion Plan for the Passaic River Basin, New Jersey. The project includes 26 systems of levee-floodwalls which total 23.7 miles of levees and 13.7 miles of floodwall as shown on Plate II-14. The interior flood control features proposed as part of these improvements will alleviate flooding behind the levees and floodwalls occurring from interior runoff which cannot pass through the line of protection due to high exterior river stages. The following is a description of the interior flood control studies which were conducted.

BASIS OF DESIGN

The interior flood control for the project was prepared in accordance with EC 1110-2-247 entitled, "Hydrologic Analysis of Interior Areas", dated 23 September 1983.

PLAN ELEMENTS

The 26 levee/floodwall systems can be classified in three categories: fluvial, tidal and systems which are integral to the tunnel diversion itself. The latter category includes those levee/floodwall systems upstream of the Pompton Inlet which are required to safely direct the design flow into the tunnel and also includes levees and floodwalls to protect Lower Valley areas from induced flood stages at the tunnel outlet. There are seven levee/floodwall systems which provide fluvial protection in the Central Basin. Five systems provide tidal protection and there are nine levee/floodwall systems in the Lower Valley which mitigate against induced higher flood stages. Five levee/floodwall systems direct the flood flows into the Pompton inlet. Note that an additional 25 systems have already been screened from further investigation due to economic infeasibility.

FORMULATION OF INTERIOR FLOOD LOSS REDUCTION MEASURES

The hydrologic analysis for interior flood loss reduction measures was accomplished in accordance with EC 1110-2-247. Accordingly, an interdisciplinary study approach was used and the interior drainage analysis was tailored to a level of detail commensurate with the study purpose and other study elements. The premise upon which the hydrologic study strategy was based was that interior facilities were planned and evaluated separately from the line-of-protection project. Hydrologic

analyses addressed the coincidental nature of flooding at the line of protection under both "with" and "without" project conditions. However, in many locations of the watershed, the "without project" conditions reflect exterior flooding that is more significant than the interior problem so that for all practical purposes it was impossible to separate the two occurrences.

As a first step, field reconnaissance of the study areas was performed and State and local governments were contacted to gather available information. These field studies revealed that virtually no information on historic interior events is available. Therefore, the focus of these field investigations was on determining the physical and operational characteristics of existing and planned system components. This survey was used to define the "without project" condition and as a basis for evaluating "minimum" facilities as part of "with project" conditions. Subarea boundaries behind the levees were delineated using topographic mapping at a scale of 1 inch = 200 feet, with 2-foot contour intervals in the floodplain areas. For areas at elevations above the floodplain, USGS mapping at a scale of 1" = 2000 feet with 10-foot contour intervals was used. This mapping was also used to determine the physical characteristics of the subareas such as slope and length.

The 37.3 miles of levees and floodwalls encompass 72 interior subareas with an average size of 0.3 square miles. There are 26 subareas associated with the fluvial systems, 11 subareas corresponding to the tidal systems, and 35 interior subareas associated with either the flood mitigation or tunnel inlet systems.

Exterior stage conditions at existing or potential outlets of interior facilities were determined. The peak exterior stages utilized were obtained from the overall Passaic River Basin HEC-2 models. A study of the timing of exterior and interior events was completed. The results of this study indicate that at most of the proposed levees in the Passaic River Basin the two occurrences would always coincide so that high exterior levels are present in the case of the occurrence of an interior event (see Table II-18). Therefore, in accordance with the EC, since this study indicated that there generally exists complete coincidence, the interior analysis proceeded without exterior analysis (assumed blocked gravity outlets) because the conditions that would exist for interior events were completely known.

Interior runoff hydrographs were generated using rainfall data from U. S. Weather Bureau Technical Report No. 40 and unitgraphs developed using Snyder's method. Snyder's unitgraph coefficients for the interior subareas were obtained from the HEC-1 model for the Passaic River Basin. The actual calculation

of the runoff hydrograph for the design frequency was performed for subbasins which contained the interior subareas using the HEC-1 computer program. Because of the lack of historical event data, and based on the physical and meteorological characteristics of the study area, a conventional hypothetical frequency analysis method was utilized for the hydrologic analysis of interior flood control facilities.

The formulation and evaluation of flood loss reduction measures for interior areas followed planning procedures using a level of detail compatible with those for the line of protection alternatives. Accordingly, the number of alternatives investigated, the range of the hydrologic design frequencies considered, and the extent of the economic evaluation were compatible with the main line planning approach. These procedures were based on technical, economic, social and environmental considerations.

The range of possible solutions considered for reducing flood related losses in interior areas included gravity outlets, detention ponds, pressure interceptors, pumping stations, acquisition of structures (either as a nonstructural measure or to provide area for ponding), and combinations of these measures. During the initial iteration of the planning process, these interior flood loss reduction measures were evaluated with respect to their technical applicability in a given subarea, costs, and social impacts. The results of the first iteration of plan formulation studies are summarized below.

DESIGN CRITERIA

Interior flood control facilities designs included the use of ponds, pump stations, diversion pipes, pressure interceptors, and extending existing storm drains through the levees and/or floodwalls. Swales and ditches draining to drop inlets and culverts were included where necessary to provide for drainage of the interior areas. The designs for such features were based on methods described in the follow paragraphs.

Gravity Drains. For those cases of lower river stage conditions where the exterior stage is lower than the interior stage, the interior runoff was discharged by gravity through outlets constructed through the protection works. All outlets were designed with automatic drainage (AD) gates to protect against backwater flooding from higher exterior stages. Where grades behind the line of protection were lower than the design flowlines in the channel, the outlets were provided with sluice gates to assure protection.

When gravity flow through the outlets was not possible due to high river stages, analyses were performed whereby the interior runoff was stored in ponding areas or pumped through the line of protection until the exterior stage receded to an elevation which permitted gravity discharge.

Ponding Areas. The ponding areas were always designed in low-lying areas to adequately capture the overland runoff from the subdivided drainage area. The depth of the design pond was generally in the range of from 2 to 4 feet. In cases of depths required in excess of 4 feet, protective fences were included around the ponds to meet safety requirements. Ponding area sizes were developed by utilizing the HEC computer program "Interior Drainage Flood Routing" (INTDRA). Input data included calibrated river hydrographs and ponding area inflow hydrographs.

Drainage System Criteria. Hydraulic computations for the outlets and conduits were made in accordance with EM 1110-2-1602, "Hydraulic Design for Reservoir Outlet Structures," dated 10 October 1980, and TM 5-8204-4, "Drainage for Areas Other Than Airfields," dated July 1965. The outlets were designed for gravity flow to discharge the runoff from the design frequency rainfall against the one year frequency flood stage in the river. According to the size of the ponding area and the evacuation time of ponding, one or more 24 inch (minimum) gravity conduits would be installed with:

1) an automatic flap-type service gate to prevent the backwater from a higher river stage and an emergency sluice gate in case of the failure of the service gate.

2) inlet and outlet structures (wingwalls, headwalls, trashracks, stilling basins, etc.) to prevent potential scouring and sedimentation.

3) the outlets of the conduits located with their inverts at the normal river stages for easy maintenance.

The energy losses assumed in the computations are as follows:

Energy Headloss Coefficient (K)
in Terms of Velocity Head ($V^2/2g$)

Type of Energy Loss	Coefficient (K)
Friction	$29.2n^2 L/R^{1.33}$
Entrance	0.50
Manholes	0.10
Trashracks	0.15
Automatic Gates	0.10
Exit	1.00

Note: n=0.013 for concrete and 0.035 for swales and ditches.

Pumping Stations. Pumping stations were utilized to pump the excessive storm runoff from the intercepted area where the inundated flow could neither be discharged into the river by gravity due to a high flood stage, nor be diverted to a downstream ponding area. The design criteria for the storm water pumping stations was in accordance with the Engineering Manuals for Civil Work construction, EM 1110-2-3101 through EM 1110-2-3105. If a combination of ponding area and pumping station was required, the HEC-INTDRA program, with the incorporation of data from the calibrated design river hydrograph, inflow interior drainage hydrograph, rating curves of ponding areas and pump-on and pump-off elevations, was utilized in the computation of a pumping station.

Pressure Interceptors. Pressure interceptors were utilized in congested areas where there was limited vacant land, and in areas with steep contours, to convey the peak interior drainage runoff under pressure to the river side of the line of protection during either high or low river stages. The inlets of the pressure interceptors were located at higher elevations than the peak river stages of the design storm in order to prevent backflows from the river and to discharge the interior flows more efficiently. Inlet and outlet structures (catch basins, wingwalls, headwalls, trashracks, stilling basins, etc.) were also designed to prevent potential scouring and sedimentation.

PLAN FORMULATION

Gravity outlets, as an independent measure, were found to be suitable only for use as part of the minimum facilities due to the volume of the interior runoff and the coincidental nature of the interior and exterior events. This measure was considered further, however, in conjunction with detention ponds.

The acquisition of structures would include many commercial and industrial establishments, especially in the highly urbanized Lower Valley. Since the costs associated with the acquisition of residential, commercial or industrial structures proved to be very high, this measure was determined to be far more costly than other interior flood control measures providing equivalent protection. Therefore, the acquisition of structures was eliminated from further consideration both as nonstructural measures or to provide areas for ponding based on high cost and adverse economic and social impacts.

The evaluation of detention ponds, pressure interceptors and pumping stations compared the cost of each of these measures in providing the same level of protection. To establish a base for the evaluation, and to facilitate a comparison of alternatives, protection against a 100-year interior flood event was the target design level of the plans formulated during the study.

On this basis, it was found that a ponding area where there is sufficient vacant land available to store the runoff from the 100 year rainfall would cost about 50% less than a pump station. On a more general basis, since pump stations have a minimum cost of $125,000, while vacant land averages $55,000/acre, it is more economical to pond an incremental volume of runoff than to pump the equivalent discharge. This is a function of land costs and the inherent inefficiency in sizing a pump station capacity for a design discharge. Since the design discharge only occurs for a portion of the storm duration, during the remainder of the storm, the pump would be operating at less than capacity.

Once it becomes necessary to acquire structures to provide area for ponding, then for the same level of protection, the cost of this measure would be at least three times the cost of a pump station. Therefore, as stated previously, acquisition of structures was eliminated from further consideration.

A comparison of pressure interceptors and ponding areas on vacant land proved that, for the same level of protection, a pressure interceptor would cost approximately 45% less than the ponding area.

Combinations of measures within a given subarea were not usually considered since, in most cases, increasing the scale of a given measure was more cost effective than adding an increment of another alternative.

Therefore, based on this initial evaluation, the remaining measures in order of increasing cost were: (1) pressure interceptors; (2) detention ponds on vacant land; and (3) pumping stations. Generally, the formulation studies for each given subarea focused on the one measure that proved the most cost effective.

RESULTS

For the fourteen levee/floodwall systems which are integral to the tunnel diversion inlet and outlet works, the formulation of interior flood control measures was limited to the scale of the tunnel/levee exterior level of protection. For these levee systems economic studies were focused on developing the least cost interior system. Likewise, the determining economic factor

for the formulation of interior flood control at the remaining fluvial and tidal levee systems was also the cost of implementation. This approach is considered appropriate in light of the planning detail involved in the line of protection works themselves.

Although pressure interceptors are the least costly of the measures considered further, they were eliminated from further investigation in flat, low-lying interior subareas based on coincidental river stages. This was because the inlet to the pressure conduit must be at a higher elevation than the river stage in order to function. It was determined, therefore, that pressure interceptors were feasible at only five subareas along the Rockaway River in the Central Basin.

In those subareas where pressure interceptors were not feasible, ponding was the next measure considered. Detention ponds were utilized only in those interior subareas where there was sufficient vacant or recreational land available. In the Lower Valley, due to the high density of development, this measure was applicable only in limited areas, while in the less urbanized central Passaic and Upper Pompton reaches, detention ponds were the primary measure utilized.

Since pumping stations were determined to be more expensive than pressure interceptors or detention ponds on vacant land, pumping was considered only in those subareas where the other measures had been ruled out. Pumping stations were therefore utilized in the majority of the Lower Valley interior subareas while, in the Central Basin, this measure was utilized in only two subareas along the Rockaway River and one area on the Wanaque River.

The findings of the interior flood control study are presented in Tables II-19 and II-20. The locations of the interior facilities are shown on the recommended plan maps contained in the Main Report. Subarea characteristics for selected interior subareas are shown on Table II-21. Sample ponding area designs for levee/floodwall systems in the fluvial and the tidal flood areas and a system integrally related to the tunnel operation are described in the following text.

Hill Court System. The Hill Court levee system is located on the right bank of the Wanaque River immediately upstream of the Paterson-Hamburg Turnpike in the Borough of Riverdale in Passaic County. It is about 3 miles upstream of the proposed Pompton Inlet and about 1 mile from the Wanaque River confluence with the Pequannock River, Figure II-106 and Main Report Figure 48. The protected area is a suburban residential neighborhood with slight slopes toward the river. In this case the tunnel has no effect

on backwater conditions in the vicinity of the levee system. However, the comparison of interior and exterior runoff patterns for all frequency storms indicate that the interior and exterior peaks occur fairly close in time to each other and therefore are assumed to be coincidental (see Table II-18).

In the vicinity of the system, the channel bottom is at elevation 185 to 186 feet NGVD with a low bank elevation of 190 feet. This area is a low-lying floodplain which results from insufficient channel capacity and constrictions. Damages occur at elevation 195 feet. The ponding area is located in the 1.55 acre vacant low area adjacent to the channel where flood waters rise quickly causing a blocked condition early in the storm event. The proposed ponding area site was measured by planimeter to determine the minimum ponding area size required. However, the area was determined to be inadequate. The pond was therefore designed for additional capacity by means of an additional 4 feet of excavation. Hydrographs displaying pond inflow-outflow relationships and pond stage versus river stage for the 100 year flood event are shown on Plate II-20.

Turnpike System. This system is located underneath the New Jersey Turnpike on the right bank of the Passaic River in Newark, New Jersey about 2 miles upstream from its mouth at Newark Bay and 9 miles downstream of the tunnel outlet at the Third River (Figure II-79 and Figure 24 of the Main Report). Tunnel discharges, however, have no effect in this reach because of large channel capacity created by the 32 foot deep navigation channel located in this section of the Passaic River. The protected area is developed largely as a commercial-industrial area built on fill and is largely very flat. This levee is designed to provide protection from a 500 year tidal surge of 11.9 feet NGVD, which is the 500 year surge elevation projected for the year 2040 based on a projected rise in sea level of 0.1 feet every 10 years (as coordinated with WES). The duration of tidal surges is difficult to predict because the northeaster type of storm can last from several hours to tens of hours, maintaining stages sufficiently high to block interior drainage outflow for extended periods of time. Therefore the design assumption was that the surge would exist for the entire period. This was input into the INTDRA model to produce the results shown in Plate II-21. A 24-inch pipe was utilized as a minimum facility and was found to drain the pond in a reasonable period of time. Hydrographs displaying pond inflow-outflow relationships and pond stage versus river stage for the 100 year flood event are shown on Plate II-21.

Shore Road System. This system is located immediately upstream of the proposed Pompton Inlet and on the left bank of the Ramapo River in Wayne, New Jersey. The system begins at the

flow restrictor embankment and continues 5,700 feet upstream (Figure II-100 and Main Report Figure 49). The modified channel and the tunnel inlet combine to reduce the 100 year flood stages up to 6 feet. The river stages are therefore affected by the backwater conditions at the tunnel inlet and flow restrictor. These stages correlate to river flow hydrographs, and the comparison of interior and exterior runoff hydrographs indicates that both peaks occur near the same point in time and therefore are assumed to be coincidental, see Table II-18. Hydrographs displaying pond inflow-outflow relationships and pond stage versus river stage for the 100 year flow event are shown on Plate II-22.

There are three ponding areas totaling 21.5 acres located on vacant land upstream about midway behind the levee. These were analyzed as one ponding area within the levee system interior drainage area.

SUMMARY

The results developed in this analysis reflect a 100 year design level for interior flood control for all measures. This level of analysis is appropriate for the feasibility level of this study and reflects the level of detail of the planning of line of protection works and the available data on the storm and combined sewer systems in communities where these levee/ floodwall systems are located. In the next phase of study, extensive field surveys will be necessary to refine these systems to enable detailed analysis of the storm water inflow. This data, combined with a more detailed topographic survey, will enable a more detailed design of interior flood control measures, and their response to storm events. Finally, optimization of these systems and determination of residual inundation risks will be performed in these advanced engineering and design studies.

TABLE II-1 Number of Cross-Sections Per River System.

River	Length (Miles)	Number of X-Sections	Average Length Per X-Section (feet)
Passaic River	71.5	400	944
Pompton River	6.8	75	476
Rockaway River	5.8	42	732
Whippany River	6.6	53	660
Pequannock River	3.2	38	449
Lower Ramapo River	1.9	28	366
Wanaque River	1.8	31	299

TABLE II-2 BRIDGE DATA (1of10)

No.	Miles Above Mouth	Community	Locality or Name	Type	# of Spans	Longest Single Opening (Ft.)	Total Hor. Opening (Ft.)	Tot. Clear Bridge Opening (Sq. Ft.)
1	0.76	Newark	C.R.R. of N.J.	R.R. Swing Thru Truss and 5 Deck Girders	6	100	567	*
2	1.42	Newark	Lincoln Highway	Hwy, Vert Lift Truss and 2 Deck Girders	3	300	515	*
3	1.61	Newark	Pulaski Skyway	Hwy, Thru Steel Arch and 2 Wing Spans	1	520	520	*
4	2.16	Newark	Conrail R.R.	R.R. Swing Thru Truss and 5 Deck Girders	6	111	648	*
5	2.23	Newark	N.J. Turnpike	Hwy, Deck Plate Girder	3	390	660	*
6	4.21	Newark	Jackson Ave	Hwy, Swing Thru Truss 1 Fixed Truss, 1 Deck Girder	3	145	295	*
7	4.59	Newark	Amtrak R.R.	R.R. Vert Lift Thru Truss and 2 Plate GirderS	3	200	386	*
8	4.94	Newark	Hudson and Manhattan	R.R. Swing Thru Truss Plus 2 Fixed Trusses	3	115	358	10,824
9	5.23	Newark	Bridge Street	Hwy, Swing Thru Truss	3	80	273	6,840
10	5.41	Newark	Conrail R.R.	R.R. Swing Deck Truss and 2 Deck Trusses	3	75	327	12,450

* Bridge Opening Greater Than 10,000 Sq. Feet.

TABLE II-2 BRIDGE DATA (2 of 10) PASSAIC RIVER

11	5.44	Newark	Route Int. 280	Hwy, Vert. Lift	3	200	545	21,500
12	5.66	Newark	Central Ave	Hwy, Swing Thru Truss and 2 Plate Girders	3	75	211	8,600
13	5.92	Newark	Erie R.R.	R.R., Base, Thru Truss and 3 Deck Girders	4	134	322	7,820
14	7.71	Newark	Conrail R.R.	R.R. Swing Deck Girder Plus 4 Deck Girders	5	70	396	7,530
15	8.40	Belleville	Rutgers Street	Hwy, Base Thru Truss Plus 3 Thru Trusses	4	100	279	7,560
16	10.26	Lyndhurst	Kingsland Ave	Hwy, Swing Thru Truss Plus 2 Thru Trusses	3	99	333	8,290
17	11.31	Clifton	D.L. and W.R.R.	R.R. Swing Deck Girder	4	99	295	10,822
18	11.55	Clifton	Route 3	Hwy, Double Bascule	4	125	418	*
19	12.89	Passaic	Union Avenue	Hwy, Swing Thru Truss and 2 Deck Trusses	3	65	218	5,870
20	13.79	Passaic	Gregory Ave	Hwy, Swing Thru Truss	2	91	166	4,142
21	14.41	Passaic	Second Street	Hwy, Deck Girder Double Base Plus 2 Conc.	3	99	267	5,515
22	14.98	Passaic	West 8th Street	Hwy, Thru Truss Base Plus 2 Thru Trusses	3	108	244	3,945
23	15.74	Passaic	Wall Street	Hwy, Thru Steel Girder	3	73	219	3,220
24	16.04	Passaic	Erie R.R. Spur	Trestle, Wood	23	11	231	3,737

* Bridge Opening Greater Than 10,000 Sq. Feet.

TABLE II-2 BRIDGE DATA (3 of 10) PASSAIC RIVER

25	16.06	Passaic	Monroe Street	Hwy, Deck Conc. Arch	3	91	247	3,584
26	16.94	Clifton	Ackerman Ave	Hwy Deck Conc. Arch	7	55	379	7,550
27	17.90	Paterson	Garden State Pkwy	Hwy, Deck Steel Girder	7	90	630	8,943
28	18.18	Paterson	Route 46	Hwy, Deck Conc. Rib Arch	5	108	498	7,257
29	18.86	Paterson	Route Int. 80	Hwy, Deck Steel Girder	4	90	360	12,827
30	18.90	Paterson	Market Street	Hwy, Conc. Covered Girder	6	55	323	4,700
31	19.03	Paterson	N.Y.S. and W.R.R.	R.R. Deck Plate Girder	4	95	370	10,826
32	20.07	Paterson	Broadway	Hwy, Open Spandrel Conc. Arch	3	118	301	5,268
33	20.90	Paterson	East 33rd Street	Hwy, Thru Plate Girder	3	80	240	4,100
34	21.66	Paterson	Fifth Ave. Fairlawn	Hwy, Thru Truss	2	128	256	5,050
35	22.16	Paterson	Wagaraw Bridge	Hwy, Conc. Arch	3	106	279	3,461
36	22.44	Paterson	19th Street Bridge	Hwy, Conc. Encased Deck Girder	6	57	315	4,884
37	22.80	Hawthorne	N.Y.S. and W.R.R.	R.R. 3 Plate Girders	3	117	283	10,444
38	22.98	Hawthorne	Erie R.R.	R.R. Truss and 2 Thru Plate Girders	3	125	286	5,368
39	23.53	Paterson	Sixth Avenue	Hwy, Deck, Steel Arch	4	72	207	4,254

TABLE II-2 BRIDGE DATA (4 of 10) PASSAIC RIVER

40	23.88	Paterson	Hillman Street	Hwy, Thru Steel Arch	1	168	168	2,747
41	24.14	Paterson	Straight Street	Hwy, Steel Thru Truss	1	248	248	4,286
42	24.43	Paterson	Arch Street	Hwy, Steel Thru Truss	1	174	174	2,677
43	24.59	Paterson	Main Street	Hwy, Deck Steel Arch	3	71	190	2,355
44	24.71	Paterson	West Broadway	Hwy, Deck Conc Arch	3	93	263	3,233
45	24.75	Paterson	Mulberry Street	Hwy, (Private) Thru Steel Truss	1	100	100	919
46	25.37	Paterson	Spruce Street	Hwy, Deck, Steel and Conc.	5	55	238	4,982
47	25.71	Paterson	Rockland Street	Footbridge, Thru Steel Arch	3	124	252	4,378
48	26.49	W. Paterson	Glover Street	Hwy, 2 Span Conc. Plate Girders	2	138	275	4,280
49	26.84	W. Paterson	Hillery Street	Hwy, Thru Steel Truss	4	81	323	9,570
50	27.37	Totowa	Route Int. 80	Hwy Deck Steel Girder (High Bridge)	6	120	522	13,500
51	28.52	W. Paterson	Lackawanna Ave	Hwy, Thru Steel Truss	3	97	278	4,238
52	28.61	Little Falls	Newark Aqueduct	Aqueduct, 3 Thru Steel Trusses	3	98	326	5,136
53	28.65	Little Falls	Route 46	Hwy, Conc., Rib Arch	5	91.2	442.1	9840.5
54	29.52	Little Falls	N.J.D.W.S.C.	Aqueduct Deck Steel Truss	1	162	162	5,945

TABLE II-2 BRIDGE DATA (5 of 10) PASSAIC RIVER

56	30.83	Little Falls	Erie R.R.	R.R. Thru Plate Girder	3	83	249	4,208
57	30.88	Wayne	Route 23	Hwy, Deck, Conc. Arch	3	99	257	3,436
58	32.40	Caldwell	Route 46 E. & W. Bound	Hwy, Deck, Conc. Encased Steel Girder	3	79	229	3,218
59	32.52	Two Bridges	Route Int. 80	Hwy, Deck, Steel Girder	3	130	380	8,573
60	32.94	Two Bridges	Two Bridges Road	Hwy, Conc. Encased Steel Girder	3	83	247	2,483
61	41.64	Caldwell	Horseneck Road	Hwy, Thru, Steel Girder	5	45	215	2,141
62	43.74	Caldwell	Route Int. 80	Hwy, Deck, Steel Girder	3	127	381	6,042
63	44.44	Pine Brook	Route 46	Hwy, Deck, Conc. Encased I Beam	4	60	240	3,318
64	44.76	Pine Brook	Bloomfield Ave	Hwy, Conc. Encased I Beam	4	46	178	2,530
65	47.48	Pine Brook	Route Int. 280	Hwy, Deck, Steel Girder	3	150	250	2,950
66	47.84	East Hanover	Eagle Rock Road	Hwy, Deck Conc. Encased I Beam	2	70	140	1,812
67	48.54	East Hanover	Morristown & Erie R.R.	R.R. Trestle	12	14	168	3,631
68	50.63	East Hanover	Route 10	Hwy, Deck Conc.	3	36	108	114.2
69	50.67	East Hanover	Mt. Pleasant Ave	Conc. Encased Girder	3	32	90	1157

TABLE II-2 BRIDGE DATA (6 of 10) PASSAIC RIVER

70	52.33	Florham Park	Columbia-S. Orange Ave.	Hwy, Deck Conc.	3	33	99	5,790
71	55.55	Lower Chathem	Passaic Ave	Hwy, Deck Steel Girder	2	50	98	890
72	57.43	Chatham	Route 24	Hwy, Deck Conc. Arch	1	80	80	1310
73	57.73	Chatham	Main Street Connector	Hwy, Desk, Steel & Conc. Arch	1	80	80	764
74	57.75	Chatham	Main Street	Hwy, Deck Steel and Conc. Arch	1	40	40	700
75	58.44	Chatham	Chatham Rd.- Summit Avenue	Hwy, Deck, Conc. Arch	1	74	74	547
76	59.01	Stanley	Watchung Ave.	Hwy, Deck Steel Girder	2	37	73	1819
77	59.61	Stanley	D.L. and W.R.R.	R.R. Stone Masonry Arch	1	46	46	825
78	59.76	Stanley	Stanley Ave.	Hwy, Conc. Encased Girder	2	40	80	859
79	60.21	Mt. Vernon	Mt. Vernon Ave	Hwy, Deck Steel Girder	2	47	94	1739
80	61.40	Mt. Vernon	Passaic Street	Hwy, Steel Thru Truss	1	79	79	1154
81	62.98	New Providence	Central Avenue	Hwy, Conc. Girder	2	40	80	767
82	64.28	Berkeley Heights	Snyder Ave	Hwy, Conc. Girder	2	40	80	655

TABLE II-2 BRIDGE DATA (7 of 10)

PASSAIC RIVER

83	65.52	Berkeley Heights	D.L. and W.R.R.	R.R. Steel Girder	1	64	64	774
84	65.52	Berkeley Heights	Springfield Ave	Hwy, Steel Girder	4	76	145	*
85	66.67	Gillette	Mountain Ave	Hwy, Deck Steel Girder	2	40	80	698.5
86	67.87	Smalley Town	Stirling Road	Hwy, Deck Steel Girder	2	38	76	815
87	68.87	Stirling	Meyers Road	Hwy, Deck Conc. Arch	1	54	54	446

* Bridge Opening Greater Than 10,000 Sq. Feet.

Lower Rockaway River

1	1.79	Rockaway Neck	FootBridge	Steel Truss	1	81.5	81.5	807
2	2.29	Pine Brook	Route 46	Hwy, Conc. Encased I-Beam	3	38.5	115.0	1139
2	2.37	Pine Brook	Old Bloomfield Road	Hwy, Steel Girder	1	69.6	69.6	975
4	2.59	Pine Brook	Route 80	Hwy, Deck, Steel Girder	3	78	22.05	3196
5	3.80	Pine Brook	Vail Road	Hwy, Thru Steel Truss	2	43.3	86.5	817
6	5.83	Mountain Lakes	Knoll Road	Hwy, Steel Thru Truss	1	90	90	676

TABLE II-2 BRIDGE DATA (8 of 10)

Whippany River

1	0.35	Troy Hill	Edward's Road Truss	Hwy, Steel Thru Truss	1	35	35	207
2	0.40	Troy Hill	Route 20	Hwy, Deck Steel Girder	2	50.5	101	2220
3 +	0.45	Troy Hill	Ridgedale Avenue	Hwy, Deck, Steel Girder	2	96	192	1982
4	2.87	Troy Hill	Troy Hill Road	Hwy, Steel Truss	1	60	60	412
5	3.64	East Hanover	Morristown & Erie Railroad	R.R. Steel Beam & Timber Bents	11	11	106.5	1040
6	3.76	East Hanover	Railroad Spur	R.R. Steel Beam & Timber	1	55	55	564
7	4.18	East Hanover	Melanie Lane	Hwy, Steel Girder	2	45.5	91	595
8	4.61	Hanover	Route 10	Hwy, Steel Beam	2	42	84	964
9	6.28	Whippany	Whippany Road	Hwy, Steel Truss	1	60	60	372

TABLE II-2 BRIDGE DATA (9 of 10)

PASSAIC RIVER

No.	Miles Above Mouth	Community	Locality or Name	Type	No.of Spans	Longest Single Opening (Ft.)	Tot. Hr. Clear Opening (Ft.)	Tot. Hr. Clear Bridge Opening (Sq.Ft.)
1	.07	Lincoln Park	Two Bridges	Hwy 2 Steel Thru Trusses	2	80	159.0	1830
2	1.42	Mountain View	Boonton Turnpike	Hwy Deck Steel Girder	2	85	173	2486
3	2.63	Wayne	Lackawanna R.R.	Trestle, 2 Thru Steel Trusses, 2 Steel Deck Plate Girder	5	105	287	3448
4	4.20	Pequannock	Erie Lackawanna R.R.	Trestle, 3 Thru Plate Girder	3	82	171	3010
5	4.66	Pequannock	Newark and Pompton Turnpike	Hwy, Thru Girder Conc. Encased	2	86	152.5	2730
6	4.75	Pequannock	Newark Supply	Aqueduct, Steel Thru Truss	4	77.2	223	3419
7	5.20	Pequannock	Route 23	Hwy, Deck Conc. Encased Girder	5	73.5	224	3463
8	6.60	Pequannock	Pompton Plains Road	Hwy, Thru Steel Plate Girder	2	50.0	78.8	1320

TABLE II-2 BRIDGE DATA (10 of 10)

LOWER RAMAPO RIVER

No.	Miles Above Mouth	Community	Locality or Name	Type	No of Spans	Longest Single Opening (Ft.)	Tot. Hr. Clear Opening (Ft.)	Tot. Clear Bridge Opening (Sq. Ft.)
1	1.38	Pompton	Dawes Hwy	Hwy, Deck, Conc. Arch	1	91	91	937
2	1.87	Pompton	Paterson Hamburg Turnpike	Hwy, Conc. Ream	3	39	114	1172

PEQUANNOCK RIVER

1	0.90	Pompton Plains	Footbridge	Footbridge Steel Suspension	1	108	108	1040
2	1.97	Riverdale	Riverdale Road	Hwy, Steel Truss	2	56.8	11.3	2320
3	2.95	Pompton Lakes	Paterson Hamburg Turnpike	Hwy, Conc. Beam	3	40	11.6	1100
4	3.23	Pompton Lakes	Erie Lackawanna R.R.	R.R. Wood Pile Bents	15	12	176.7	1242

TABLE II-3 FLOODMARK CALIBRATION

LOCATION	DATE	AGENCY	RECORDED ELEVATION (FT.)	CALIBRATED ELEVATION (FT.)
PASSAIC RIVER				
ACKERMAN AVENUE	JULY, 1945	PASSAIC COUNTY	16.5	16.87
5TH AVENUE BRIDGE	MAY, 1968	PASSAIC COUNTY	35.0	35.19
WEST BROADWAY	MAY, 1968	PASSAIC COUNTY	45.3	45.04
LACKAWANNA IN WEST PATERSON	MAY, 1968	PASSAIC COUNTY	127.9	128.19
LITTLE FALLS GAGE	MAY, 1968	U.S.G.S	130.73	130.55
I-80 IN WAYNE	MAY, 1968	PASSAIC COUNTY	168.5	168.15
TWO BRIDGES ROAD	MAY, 1968	PASSAIC COUNTY	168.8	168.79
HORSENECK ROAD	MAY, 1968	PASSAIC COUNTY	170.1	169.49
PINE BROOK GAGE	MAY, 1968	U.S.G.S	170.4	170.36
I-80 IN PINE BROOK	MAY, 1968	PASSAIC COUNTY	170.3	170.00
BLOOMFIELD AVENUE	MAY, 1968	PASSAIC COUNTY	170.6	170.83
CHATHAM GAGE	MAY, 1968	U.S.G.S	201.41	202.31
PASSAIC STREET	AUGUST, 1971	PASSAIC COUNTY	209.3	208.75
SYNDER AVENUE	AUGUST, 1971	PASSAIC COUNTY	213.0	213.0
SPRINGFIELD AVENUE	AUGUST, 1971	PASSAIC COUNTY	213.2	213.0
POMPTON RIVER				
TWO BRIDGE ROAD	MAY, 1968	PASSAIC COUNTY	168.8	168.79
POMPTON PLAINS GAGE	MAY, 1968	U.S.G.S	182.18	181.26

TABLE 3 FLOODMARK CALIBRATION (CONT'D)

LOCATION	DATE	AGENCY	RECORDED ELEVATION (FT.)	CALIBRATED ELEVATION (FT.)
		WHIPPANY RIVER		
EDWARDS ROAD	JANUARY, 1979	NJDEP	171.25	172.5
MORRISTOWN AND ERIE RAILROAD	JANUARY, 1979	NJDEP	176.0	175.0
SPILLWAY	JANUARY, 1979	NJDEP	197.48	197.7
		ROCKAWAY RIVER		
KNOLL ROAD	JANUARY,1979	NJDEP	183.2	183.78
		LOWER RAMAPO RIVER		
DAWES HIGHWAY	MAY, 1968	PASSAIC	185.7	185.29
		PEQUANNOCK RIVER		
HARRIS ROAD (DEMOLISHED)	MAY, 1968	PEQUANNOCK'S CIVIL DEFENSE	186.6	186.6
RIVERDALE ROAD	MAY, 1968	PASSAIC COUNTY	188.7	188.31
		WANAQUE RIVER		
PATERSON - HAMBURG TURNPIKE	MAY, 1968	PASSAIC COUNTY	194.9	193.11
WANAQUE AVENUE	MAY, 1968	PASSAIC COUNTY	201.5	200.62

TABLE II-4 ROUGHNESS COEFFICIENTS

PASSAIC RIVER

FROM	TO	LEFT OVER BANK	RIGHT OVER BANK	CHANNEL
MOUTH	UNION AVENUE BRIDGE	0.06	0.06	.025
UNION AVENUE BRIDGE	DUNDEE DAM	0.10	0.10	.035
DUNDEE DAM	ROUTE 46	0.06	0.06	.025
ROUTE 46	ROUTE 80	0.06	0.06	.03
ROUTE 80	MARLOT AVENUE BRIDGE	0.10	0.10	.03
MARLOT AVENUE BRIDGE	5TH AVENUE BRIDGE	0.06	0.06	.025
5TH AVENUE BRIDGE	WAGARAW BRIDGE	0.08	0.08	.025
WAGARAW BRIDGE	PATERSON FALLS	0.08	0.08	.035
PATERSON FALLS	LACKAWANNA AVENUE BRIDGE	0.08	0.08	.035
LACKAWANNA AVENUE BRIDGE	BEATTIES DAM	0.10	0.10	.035
BEATTIES DAM	ROUTE 23	0.10	0.10	.03
ROUTE 23	TWO BRIDGES	0.10	0.08	.03
TWO BRIDGES	PINE BROOK	0.15	0.15	.035
PINE BROOK	MT. PLEASANT AVENUE	0.08	0.08	.04
MT. PLEASANT AVENUE	MAIN STREET	0.10	0.10	.035
MAIN STREET	WATCHUNG AVENUE	0.10	0.10	.035
WATCHUNG AVENUE	CHATHAM GAGE	0.08	0.08	.035
CHATHAM GAGE	MT. VERNON AVENUE	0.08	0.08	.030
MT. VERNON AVENUE	PASSAIC STREET	0.08	0.08	.03
PASSAIC STREET	CONFLUENCE WITH DEAD RIVER	0.06	0.06	.03

TABLE II-4 ROUGHNESS COEFFICIENTS (CONT'D)

POMPTON RIVER

FROM	TO	LEFT OVER BANK	RIGHT OVER BANK	CHANNEL
CONFLUENCE WITH PASSAIC RIVER	BOONTON TURNPIKE	.12	.12	.025
BOONTON TURNPIKE	NEWARK AQUEDUCT	.15	.15	.035
NEWARK AQUEDUCT	POMPTON PLAINS ROAD	.12	.12	.035
	LOWER ROCKAWAY RIVER			
CONFLUENCE WITH PASSAIC RIVER	FOOTBRIDGE	.10	.10	.03
FOOTBRIDGE	ROUTE 80	.08	.10	.03
ROUTE 80	VAIL ROAD	.08	.10	.035
VAIL ROAD	KNOLL ROAD	.10	.10	.04
	WHIPPANY RIVER			
CONFLUENCE WITH ROCKAWAY RIVER	RIDGEDALE AVENUE	.10	.10	.03
RIDGEDALE AVENUE	TROY HILL ROAD	.09	.09	.03
TROY HILL ROAD	MT. PLEASANT AVENUE	.10	.08	.03
MT. PLEASANT AVENUE	WHIPPANY ROAD	.10	.10	.04
WHIPPANY ROAD	RAILROAD SPUR	.10	.10	.045
	LOWER RAMAPO RIVER			
CONFLUENCE WITH POMPTON RIVER	CONFLUENCE WITH PEQUANNOCK RIVER	.12	.12	.035
CONFLUENCE WITH PEQUANNOCK RIVER	DAWES HIGHWAY	.20	.15	.045
DAWES HIGHWAY	POMPTON LAKES DAM	.10	.10	.035
	PEQUANNOCK RIVER			
CONFLUENCE WITH RAMAPO RIVER	ERIE LACKAWANNA RAILROAD	.12	.12	.045
	WANAQUE RIVER			
CONFLUENCE WITH PEQUANNOCK RIVER	LAKE INEZ	.12	.12	.045

TABLE II-5 Peak and Coincidental Discharges Relationship in Central Basin (for use in HEC-2 multiple water surface profile analyses)

LOCATION / CASE	PASSAIC RIVER				ROCKAWAY RIVER		WHIPPANY RIVER	POMPTON RIVER
	PA-1	PA-2	PA-3	PA-4	RO-1	RO-2	WH	PO
1	P	C	C	C	C	C	C	C
2	C	P	C	C	C	C	C	-
3	C	C	P	C	C	C	C	-
4	C	C	C	P	-	-	-	-
5	C	C	C	-	P	C	C	-
6	C	C	C	-	C	P	C	-
7	C	C	C	-	C	C	P	-
8	C	C	-	-	-	-	-	P

"P" PEAK DISCHARGE AT OBSERVED HYDRAULIC REACH.

"C" COINCIDENTAL DISCHARGES ASSOCIATED WITH PEAK AT RESPECTIVE LOCATION.

"-" LOW COINCIDENTAL DISCHARGES WITH LOW STARTING WATER SURFACE ELEVATION (NOT USED).

HYDRAULIC REACH:

PASSAIC RIVER
- PA-1 - UPSTREAM FROM BEATTIES DAM TO DOWNSTREAM WITH POMPTON CONFLUENCE.
- PA-2 - UPSTREAM FROM POMPTON CONFLUENCE TO HORSENECK ROAD BRIDGE.
- PA-3 - UPSTREAM FROM HORSENECK ROAD BRIDGE TO DOWNSTREAM WITH ROCKAWAY CONFLUENCE.
- PA-4 - UPSTREAM FROM ROCKAWAY CONFLUENCE TO CHATHAM GAGE.

ROCKAWAY RIVER
- RO-1 - UPSTREAM FROM PASSAIC CONFLUENCE TO WHIPPANY CONFLUENCE.
- RO-2 - UPSTREAM FROM WHIPPANY CONFLUENCE TO KNOLL ROAD.

WHIPPANY (WH) - UPSTREAM FROM ROCKAWAY CONFLUENCE TO RAILROAD SPUR.

POMPTON (PO) - UPSTREAM FROM PASSAIC CONFLUENCE TO JACKSON AVENUE BRIDGE.

RECOMMENDED PLAN

POMPTON RIVER/PASSAIC RIVER DUAL INLET TUNNEL

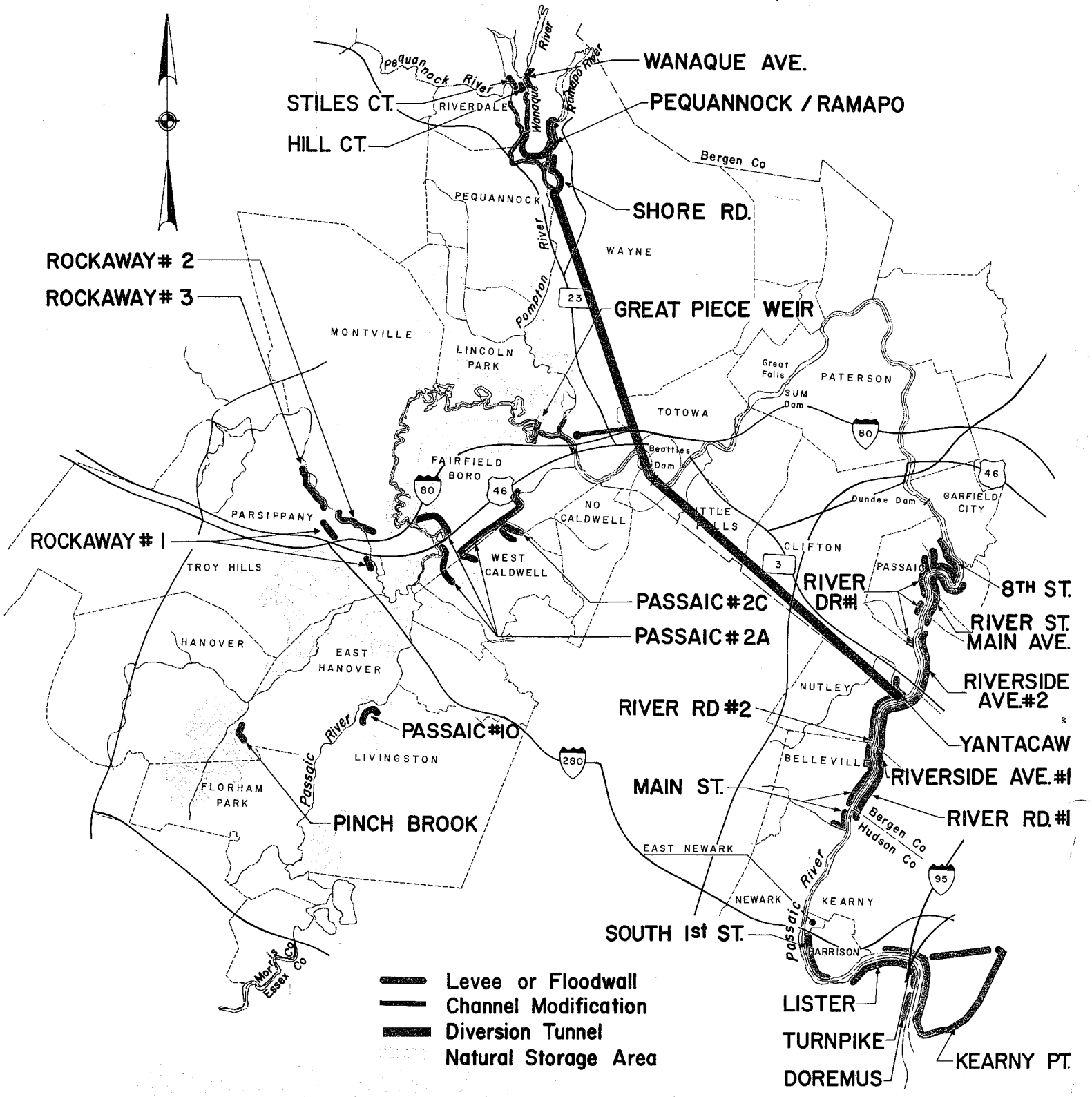


TABLE II-6. HISTORICAL AND THEORETICAL DISCHARGES OF EXISTING CONDITIONS (USED TO DEVELOP PEAK STAGES.)

PASSAIC RIVER --- MOUTH ABOVE NEWARK BAY

STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)	MAY 68 (Q-CFS)
0	5596	7951	10537	13710	23613	28186	46272	45243	13889
42200	5603	7940	10512	13692	23622	28315	46191	45236	13900
58765	5576	7902	10467	13624	23513	28202	45912	45106	13879
74000	5576	7893	10452	13606	23506	28264	45837	45137	13874
DUNDEE DAM									
91785	5514	7821	10386	13443	23098	27676	44817	44509	13550
117020	5517	7817	10371	13429	23096	27758	44801	44533	13535
GREAT FALLS									
133860	5505	7806	10354	13397	23044	27720	44685	44490	13500
149110	5492	7795	10338	13364	22993	27666	44549	44439	13487
BEATTIES DAM									
156816	5479	7787	10319	13344	22836	27407	44437	44406	13753
169300	5454	7775	10243	13293	22969	26966	44033	44326	13759
173500	5200	7535	9965	12850	22288	26843	43071	43244	13326
TWO BRIDGES									
174630	1479	2744	4693	5654	6722*	7522*	9210*	11942*	6492*
219860	2980	4673	5136*	6525	9708*	12029*	18124*	24243	6492*
236330	2885	3822	5001*	6556	10247	12392*	18761	24560	5914*
PINE BROOK									
246395	2360*	2606*	3557	4071*	4977*	5357	6649*	8398*	2276*
266225	2259*	3109*	2203	2732*	3914*	4426	5986	7697	4830
286470	2216	2985	4090	5045	3483*	4133	5299*	6785*	4408*
296650	2054	2795	3751	4636	6701	7829	10415*	14053*	2280*
297845	1205	1732	2101	2601	3880	4512	6112	8099	2686
ROCKAWAY RIVER --- CONFLUENCE WITH PASSAIC RIVER									
STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)	MAY 68 (Q-CFS)
0	427*	595*	3203*	4459	7508*	9313	13576*	19501*	5914*
6715	1577*	1426*	3154*	4390*	7506*	9439	13003*	18953*	3615*
7700	400*	315*	2107*	3082*	5505*	6822*	9372*	14265*	3556
16280	1144*	1582	2158*	3213*	5358*	6602*	10181*	13211*	2414
30752	1109*	1517	2091	3156	5745	7975	12959	10224*	4321
WHIPPANY RIVER --- CONFLUENCE WITH ROCKAWAY RIVER									
STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)	MAY 68 (Q-CFS)
0	1577*	1426*	3154*	4390*	7506*	9439	13003*	18953*	5914*
17375	1596	2043	1994	2447	3481	4075	2612*	4117*	5805
25135	1291	1642	2359	2876	4072	4786	6171	8998	1886
POMPTON RIVER --- CONFLUENCE WITH PASSAIC RIVER									
STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)	MAY 68 (Q-CFS)
0	4092*	5042*	6904*	10729*	22525*	27538*	47090*	46615*	13326*
7940	3590*	4411*	10051	13628	21987*	27533*	46431*	45767*	13324
8510	3528*	4352*	9912	13461	21826*	27333*	46182*	45508*	13177
17420	4288	6808	10521	14308	26216	31455	51801	51688	13706
21810	3997	6449	10014	13696	25437	30575	50709	50454	13151
27555	4021	6493	10089	13952	26543	32105	54228	53813	13188
PEQUANNOCK RIVER --- CONFLUENCE WITH POMPTON RIVER									
STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)	MAY 68 (Q-CFS)
0	3992	6462	10049	13979	26788	32515	55337	54868	14631
2965	1702	3245	5105	7313	13619	16722	27288	30017	6420
10170	1724	3323	5239	7545	14194	17467	28672	31531	7680
10630	793	1617	2463	3523	6418	7647	10329	14546	2596
RAMAPO RIVER --- CONFLUENCE WITH POMPTON RIVER									
STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)	MAY 68 (Q-CFS)
0	3992	6462	10049	13979	26788	32515	55337	54868	14631
3585	2872	4208	6526	8850	17114	20825	36922	36532	8132
WANAQUE RIVER --- CONFLUENCE WITH PEQUANNOCK RIVER									
STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)	MAY 68 (Q-CFS)
0	1121	1882	3056	4394	8416	10581	19633	19610	5093

NOTE: '*'-- PEAK STAGE CAUSED BY COINCIDENTAL FLOW AT RESPECTIVE RIVER.

TABLE II-7. WITH PROJECT (2040) CONDITIONS DISCHARGES.
(USED TO DEVELOP PEAK STAGES.)

PASSAIC RIVER --- MOUTH ABOVE NEWARK BAY

STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)
0	6329	13312	19632	26625	42866	48289	62803	62406
40800	6335	13257	19629	26581	43601	49934	64672	64810
58765	6305	5200	7228	10025	16824	21279	33302	33803
74000	6305	4645	6433	8947	15074	18892	32602	32209
DUNDEE DAM								
91785	6225	3277	4499	6132	9715	12402	28572	28185
117020	6228	3467	4779	6551	10200	12774	28581	28188
GREAT FALLS								
133860	6213	2559	3453	4621	7082	9767	28339	27970
149110	6194	1347	1809	2359	5235	9490	28087	27744
BEATTIES DAM								
156816	6174	100	100	100	4602	9232	27905	27564
173500	5871	4705	6064	7475	10880	12544	27013	26299
TWO BRIDGES								
174630	1405	4119	5423	6834	2873*	4521*	11766*	12859*
236330	3213*	4381*	5274	6551	9502*	11322*	19626*	24907*
240380	3213*	4265*	5683*	7396*	11455*	14338*	20697*	26213*
PINE BROOK								
246395	2578*	2998*	3592*	4187*	5439*	5922*	6668*	8322*
264225	2495*	3030*	1917*	2204*	3395*	3854*	6443*	8285*
284470	2408	3249	4401	5410	7746	9028	5843*	7481*
296650	2242	3057	4058	4999	7156	8335	10996	14785
297845	1317	1890	2298	2832	4187	4834	6581	8707

ROCKAWAY RIVER --- CONFLUENCE WITH PASSAIC RIVER

STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)
0	1213*	1521*	2272*	2786*	4031*	4754*	16110*	21493*
6715	1828*	2413*	2185*	2689*	3837*	4486*	15718*	21126*
7700	1187*	955*	1244	1584	2278*	2674*	11597*	16865*
16280	1368	1843	2650	3809	6661	8461	11853*	16465*
30752	1317	1785	2605	3778	7132	9199	14096	20329

WHIPPANY RIVER --- CONFLUENCE WITH ROCKAWAY RIVER

STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)
0	1828*	1717*	2286*	2512*	3388*	3643*	5944	7847
17375	1781	2278	2168	2639	3728	4353*	3754	8400
25135	1389	1761	2497	3040	4272	5006	6448	9367

POMPTON RIVER --- CONFLUENCE WITH PASSAIC RIVER

STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)
0	4307*	740*	854*	932*	1122*	1505*	23164*	23754*
7940	4783	1799	2444	2933	2929*	5004*	24239*	24280*
8510	4700	1610	2149	2556	2609*	4703*	23938*	23958*
17420	4964	2061	2792	3323	4490	5408*	27461	27677
21810	4659	753	923	1063	1354	4468*	26251	26315
25070	4677	828	991	1132	1371	3863*	27176	27201

PEQUANNOCK RIVER --- CONFLUENCE WITH POMPTON RIVER

STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)
0	4672	7216	11144	15383	27787	33880	57584	57369
2965	2013	3609	5527	7760	13873	17321	28260	30948
10170	2040	3667	5612	7973	14377	17584	29189	31713
10630	900	1741	2609	3705	6649	7912	10553	15079

RAMAPO RIVER --- CONFLUENCE WITH POMPTON RIVER

STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)
0	4672	7216	11144	15383	27787	33880	57584	57369
4630	3385	4856	7316	9795	18064	21819	38367	38025

WANAQUE RIVER --- CONFLUENCE WITH PEQUANNOCK RIVER

STATION (FT.)	1 YR (Q-CFS)	2 YR (Q-CFS)	5 YR (Q-CFS)	10 YR (Q-CFS)	50 YR (Q-CFS)	100 YR (Q-CFS)	500 YR (Q-CFS)	SPF (Q-CFS)
0	1356	2120	3299	4657	8366	10422	19824	19075

NOTE: "*"-- PEAK STAGE CAUSED BY COINCIDENTAL FLOW AT RESPECTIVE RIVER.

TABLE II-8. TUNNEL SIMULATION MODEL -- POMPTON BYPASS FLOW

** ** HYDRGPH (25D) OF HEC1 FILE 'CBM4HAAW ' ---- 100 YR. FLOOD EVENT. ** **

0	60.0	31	4360.0	62	500.0	93	500.0
1	172.0	32	4896.0	63	500.0	94	500.0
2	207.0	33	5171.0	64	500.0	95	500.0
3	220.0	34	5097.0	65	500.0	96	500.0
4	229.0	35	4860.0	66	500.0	97	500.0
5	237.0	36	4608.0	67	500.0	98	500.0
6	247.0	37	4121.0	68	500.0	99	500.0
7	259.0	38	3411.0	69	500.0	100	500.0
8	274.0	39	2639.0	70	500.0	101	500.0
9	294.0	40	2153.0	71	500.0	102	500.0
10	317.0	41	1667.0	72	500.0	103	500.0
11	360.0	42	1181.0	73	500.0	104	500.0
12	455.0	43	670.0	74	500.0	105	500.0
13	500.0	44	500.0	75	500.0	106	500.0
14	500.0	45	500.0	76	500.0	107	500.0
15	500.0	46	500.0	77	500.0	108	500.0
16	500.0	47	500.0	78	500.0	109	500.0
17	500.0	48	500.0	79	500.0	110	500.0
18	500.0	49	500.0	80	500.0	111	500.0
19	500.0	50	500.0	81	500.0	112	500.0
20	500.0	51	500.0	82	500.0	113	500.0
21	500.0	52	500.0	83	500.0	114	500.0
22	500.0	53	500.0	84	500.0	115	500.0
23	500.0	54	500.0	85	500.0	116	500.0
24	500.0	55	500.0	86	500.0	117	500.0
25	500.0	56	500.0	87	500.0	118	500.0
26	1037.0	57	500.0	88	500.0	119	500.0
27	1735.0	58	500.0	89	500.0	120	500.0
28	2306.0	59	500.0	90	500.0	121	0.0
29	2970.0	60	500.0	91	500.0	122	0.0
30	3786.0	61	500.0	92	500.0	123	0.0

PEAK FLOW	TIME
5171.0	33.00

* NOTE: THIS HYDROGRAPH DOES NOT INCLUDE THE ONE YEAR MITIGATION BYPASS FLOW.

TABLE II-9 TUNNEL SIMULATION MODEL --- SUMMARY OUTPUT

** SUMMARY OUTPUT OF HEC1 FILE 'CBM4HAAW ' ** ----- 100.YEAR -----
****
(TUNNEL DIAM.: SPUR = 22.FT. POMPTON = 39.FT. BASE TUNNEL = 39.FT.)

HOUR (1)	HEAD @2BRDGS (2)	HEAD @POMP. (3)	D.HGRPH @POMP. (4)	HYDRGPH @2BRDGS (5)	IN-TNNL @2BRDGS (6)	BYPASS RIVER-Q AT 2BRDGS (7)	TOTAL TNNL-Q AT MOUTH (8)	EXCEED. FLOW AT 2BRDGS (9)	EXCEED. FLOW AT POMP. (10)
0	15.8	15.5	0.0	984.0	884.0	100.0	884.0	0.0	0.0
1	15.8	15.5	0.0	984.0	884.0	100.0	884.0	0.0	0.0
2	15.8	15.5	0.0	984.0	884.0	100.0	884.0	0.0	0.0
3	15.8	15.5	0.0	985.0	885.0	100.0	885.0	0.0	0.0
4	15.8	15.5	0.0	987.0	887.0	100.0	887.0	0.0	0.0
5	15.8	15.5	0.0	989.0	889.0	100.0	889.0	0.0	0.0
6	15.8	15.5	0.0	992.0	892.0	100.0	892.0	0.0	0.0
7	15.8	15.5	0.0	996.0	896.0	100.0	896.0	0.0	0.0
8	15.9	15.5	0.0	1005.0	905.0	100.0	905.0	0.0	0.0
9	15.9	15.5	0.0	1026.0	926.0	100.0	926.0	0.0	0.0
10	15.9	15.5	0.0	1063.0	963.0	100.0	963.0	0.0	0.0
11	16.0	15.5	0.0	1120.0	1020.0	100.0	1020.0	0.0	0.0
12	16.1	15.5	18.0	1202.0	1102.0	100.0	1120.0	0.0	0.0
13	16.3	15.6	222.0	1317.0	1217.0	100.0	1439.0	0.0	0.0
14	16.7	15.9	649.0	1473.0	1373.0	100.0	2022.0	0.0	0.0
15	17.6	16.6	1343.0	1745.0	1645.0	100.0	2988.0	0.0	0.0
16	21.6	19.5	2916.0	2647.0	2547.0	100.0	5463.0	0.0	0.0
17	30.7	27.5	5537.0	3746.0	3646.0	100.0	9183.0	0.0	0.0
18	42.8	40.7	8629.0	4474.0	4374.0	100.0	13003.0	0.0	0.0
19	59.6	59.6	11800.0	5288.0	5188.0	100.0	16988.0	0.0	0.0
20	80.1	81.4	14533.0	6256.0	6156.0	100.0	20689.0	0.0	0.0
21	100.2	103.1	16844.0	7046.0	6946.0	100.0	23790.0	0.0	0.0
22	121.1	126.9	19139.0	7703.0	7603.0	100.0	26742.0	0.0	0.0
23	140.6	150.9	21336.0	8130.0	8030.0	100.0	29366.0	0.0	0.0
24	155.0	173.8	23505.0	8390.0	7999.0	391.0	31504.0	0.0	0.0
25	134.7	178.0	25579.0	8502.0	5286.0	3216.0	30865.0	0.0	0.0
26	120.4	178.0	26946.0	8539.0	3027.0	5512.0	29973.0	0.0	0.0
27	114.1	178.0	27708.0	8518.0	1736.0	6782.0	29444.0	0.0	0.0
28	109.9	178.0	28355.0	8475.0	619.0	7856.0	28974.0	0.0	0.0
29	108.0	178.0	28709.0	8443.0	1.0	8442.0	28710.0	0.0	0.0
30	108.0	178.0	28709.0	8442.0	1.0	8441.0	28710.0	0.0	0.0
31	108.0	178.0	28709.0	8475.0	1.0	8474.0	28710.0	0.0	0.0
32	108.0	178.0	28709.0	8540.0	1.0	8539.0	28710.0	0.0	0.0
33	108.0	178.0	28709.0	8625.0	1.0	8624.0	28710.0	0.0	0.0
34	108.0	178.0	28709.0	8720.0	1.0	8719.0	28710.0	0.0	0.0
35	108.0	178.0	28709.0	8816.0	1.0	8815.0	28710.0	0.0	0.0
36	108.0	178.0	28709.0	8914.0	1.0	8913.0	28710.0	0.0	0.0
37	108.0	178.0	28709.0	9016.0	1.0	9015.0	28710.0	0.0	0.0
38	108.0	178.0	28709.0	9128.0	1.0	9127.0	28710.0	0.0	0.0
39	108.1	178.0	28694.0	9259.0	27.0	9232.0	28721.0	0.0	0.0
40	110.5	178.0	28244.0	9409.0	812.0	8597.0	29056.0	0.0	0.0
41	114.0	178.0	27731.0	9568.0	1696.0	7872.0	29427.0	0.0	0.0
42	118.3	178.0	27177.0	9725.0	2638.0	7087.0	29815.0	0.0	0.0
43	123.2	178.0	26640.0	9882.0	3539.0	6343.0	30179.0	0.0	0.0
44	132.4	178.0	25777.0	10042.0	4964.0	5078.0	30741.0	0.0	0.0
45	145.0	178.0	24768.0	10197.0	6593.0	3604.0	31361.0	0.0	0.0
46	155.0	176.1	23812.0	10340.0	7844.0	2496.0	31656.0	0.0	0.0
47	155.0	169.7	22947.0	10475.0	8277.0	2198.0	31224.0	0.0	0.0
48	155.0	164.0	22182.0	10601.0	8647.0	1954.0	30829.0	0.0	0.0
49	155.0	158.4	21431.0	10714.0	9000.0	1714.0	30431.0	0.0	0.0
50	155.0	153.2	20714.0	10819.0	9329.0	1490.0	30043.0	0.0	0.0
51	155.0	148.2	20008.0	10922.0	9644.0	1278.0	29652.0	0.0	0.0
52	155.0	143.6	19362.0	11017.0	9925.0	1092.0	29287.0	0.0	0.0
53	155.0	139.4	18764.0	11102.0	10179.0	923.0	28943.0	0.0	0.0
54	155.0	135.3	18165.0	11180.0	10429.0	751.0	28594.0	0.0	0.0
55	155.0	131.2	17569.0	11260.0	10672.0	588.0	28241.0	0.0	0.0
56	155.0	127.3	16982.0	11345.0	10907.0	438.0	27889.0	0.0	0.0
57	155.0	123.5	16409.0	11434.0	11131.0	303.0	27540.0	0.0	0.0
58	155.0	119.8	15852.0	11528.0	11345.0	183.0	27197.0	0.0	0.0

TABLE II-9 TUNNEL SIMULATION MODEL --- SUMMARY OUTPUT (CONTD.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
59	154.8	116.3	15315.0	11633.0	11533.0	100.0	26848.0	0.0	0.0
60	153.5	112.6	14797.0	11748.0	11648.0	100.0	26445.0	0.0	0.0
61	152.5	109.1	14299.0	11868.0	11768.0	100.0	26067.0	0.0	0.0
62	151.8	105.9	13822.0	11992.0	11892.0	100.0	25714.0	0.0	0.0
63	151.2	103.0	13364.0	12120.0	12020.0	100.0	25384.0	0.0	0.0
64	150.8	100.2	12922.0	12249.0	12149.0	100.0	25071.0	0.0	0.0
65	150.5	97.6	12498.0	12375.0	12275.0	100.0	24773.0	0.0	0.0
66	150.2	95.2	12092.0	12498.0	12398.0	100.0	24490.0	0.0	0.0
67	150.0	92.9	11704.0	12613.0	12513.0	100.0	24217.0	0.0	0.0
68	149.8	90.8	11333.0	12720.0	12620.0	100.0	23953.0	0.0	0.0
69	149.3	88.7	10978.0	12807.0	12707.0	100.0	23685.0	0.0	0.0
70	148.6	86.6	10641.0	12872.0	12772.0	100.0	23413.0	0.0	0.0
71	147.9	84.7	10318.0	12934.0	12834.0	100.0	23152.0	0.0	0.0
72	147.2	82.7	9992.0	12992.0	12892.0	100.0	22884.0	0.0	0.0
73	146.4	80.7	9661.0	13045.0	12945.0	100.0	22606.0	0.0	0.0
74	145.4	78.9	9353.0	13081.0	12981.0	100.0	22334.0	0.0	0.0
75	144.2	77.0	9062.0	13097.0	12997.0	100.0	22059.0	0.0	0.0
76	142.9	75.3	8787.0	13098.0	12998.0	100.0	21785.0	0.0	0.0
77	141.4	73.5	8518.0	13091.0	12991.0	100.0	21509.0	0.0	0.0
78	139.9	71.8	8245.0	13077.0	12977.0	100.0	21222.0	0.0	0.0
79	138.4	70.1	7991.0	13060.0	12960.0	100.0	20951.0	0.0	0.0
80	137.0	68.6	7754.0	13040.0	12940.0	100.0	20694.0	0.0	0.0
81	135.6	67.2	7530.0	13018.0	12918.0	100.0	20448.0	0.0	0.0
82	134.3	65.9	7318.0	12995.0	12895.0	100.0	20213.0	0.0	0.0
83	133.0	64.6	7117.0	12970.0	12870.0	100.0	19987.0	0.0	0.0
84	131.7	63.4	6925.0	12944.0	12844.0	100.0	19769.0	0.0	0.0
85	130.5	62.2	6743.0	12917.0	12817.0	100.0	19560.0	0.0	0.0
86	129.3	61.2	6569.0	12889.0	12789.0	100.0	19358.0	0.0	0.0
87	128.1	60.1	6401.0	12860.0	12760.0	100.0	19161.0	0.0	0.0
88	126.9	59.1	6239.0	12830.0	12730.0	100.0	18969.0	0.0	0.0
89	125.8	58.2	6083.0	12798.0	12698.0	100.0	18781.0	0.0	0.0
90	124.7	57.2	5932.0	12766.0	12666.0	100.0	18598.0	0.0	0.0
91	123.5	56.4	5786.0	12732.0	12632.0	100.0	18418.0	0.0	0.0
92	122.4	55.5	5645.0	12697.0	12597.0	100.0	18242.0	0.0	0.0
93	121.3	54.7	5508.0	12661.0	12561.0	100.0	18069.0	0.0	0.0
94	120.2	53.8	5375.0	12624.0	12524.0	100.0	17899.0	0.0	0.0
95	119.1	53.1	5245.0	12586.0	12486.0	100.0	17731.0	0.0	0.0
96	118.0	52.3	5119.0	12546.0	12446.0	100.0	17565.0	0.0	0.0
97	117.0	51.5	4996.0	12505.0	12405.0	100.0	17401.0	0.0	0.0
98	115.8	50.8	4875.0	12456.0	12356.0	100.0	17231.0	0.0	0.0
99	114.5	50.0	4758.0	12402.0	12302.0	100.0	17060.0	0.0	0.0
100	113.1	49.2	4644.0	12334.0	12234.0	100.0	16878.0	0.0	0.0
101	111.4	48.4	4532.0	12247.0	12147.0	100.0	16679.0	0.0	0.0
102	109.6	47.5	4423.0	12149.0	12049.0	100.0	16472.0	0.0	0.0
103	107.7	46.7	4317.0	12044.0	11944.0	100.0	16261.0	0.0	0.0
104	105.8	45.8	4213.0	11935.0	11835.0	100.0	16048.0	0.0	0.0
105	103.9	45.0	4111.0	11823.0	11723.0	100.0	15834.0	0.0	0.0
106	102.0	44.2	4012.0	11711.0	11611.0	100.0	15623.0	0.0	0.0
107	100.1	43.4	3916.0	11597.0	11497.0	100.0	15413.0	0.0	0.0
108	98.3	42.6	3822.0	11484.0	11384.0	100.0	15206.0	0.0	0.0
109	96.4	41.9	3730.0	11372.0	11272.0	100.0	15002.0	0.0	0.0
110	94.7	41.1	3640.0	11261.0	11161.0	100.0	14801.0	0.0	0.0
111	93.0	40.4	3552.0	11151.0	11051.0	100.0	14603.0	0.0	0.0
112	91.3	39.7	3467.0	11042.0	10942.0	100.0	14409.0	0.0	0.0
113	89.6	39.1	3383.0	10934.0	10834.0	100.0	14217.0	0.0	0.0
114	88.0	38.4	3302.0	10828.0	10728.0	100.0	14030.0	0.0	0.0
115	86.4	37.8	3222.0	10722.0	10622.0	100.0	13844.0	0.0	0.0
116	84.9	37.2	3145.0	10618.0	10518.0	100.0	13663.0	0.0	0.0
117	83.4	36.6	3069.0	10515.0	10415.0	100.0	13484.0	0.0	0.0
118	82.0	36.1	2995.0	10413.0	10313.0	100.0	13308.0	0.0	0.0
119	80.5	35.5	2922.0	10309.0	10209.0	100.0	13131.0	0.0	0.0
120	79.0	34.9	2852.0	10200.0	10100.0	100.0	12952.0	0.0	0.0

** THIS IS END OF THE SEARCH!! **

NOTES:
COLUMN 1. = TIME IN HOURS.
COLUMN 2. = HEAD IN TUNNEL AT TWO BRIDGES.
COLUMN 3. = HEAD IN TUNNEL AT POMPTON INLET.
COLUMN 4. = TUNNEL INFLOW AT POMPTON INLET.
COLUMN 5. = FLOW AT TWO BRIDGES INLET BEFORE DIVERSION.
COLUMN 6. = TUNNEL INFLOW AT TWO BRIDGES.
COLUMN 7. = BYPASS FLOW INTO LOWER VALLEY AT TWO BRIDGES; THESE HYDROGRAPHS DO NOT INCLUDE THE ONE YEAR MITIGATION BYPASS FLOWS.
COLUMN 8. = COMBINED FLOWS IN TUNNEL AT TUNNEL MOUTH.
COLUMN 9.&10. = USED IN ITERATIVE PROCEDURE TO DETERMINE CAPACITY OF TUNNEL.

TABLE II-10. STAGE COMPARISON --- RIVERS IN PASSAIC RIVER BASIN

** COMPARISON OF PROFILE NO. 7 ** ---100.YEAR ---

PASSAIC RIVER ---- MOUTH

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
3200.00	4.90	5.50	5.50	0.60	0.60
3998.00	4.88	5.47	5.44	0.59	0.56
7000.00	4.90	5.49	5.49	0.59	0.59
7520.00	4.90	5.50	5.49	0.60	0.59
7600.00	4.89	5.49	5.47	0.60	0.58
8471.00	4.92	5.52	5.55	0.60	0.63
8480.00	4.92	5.52	5.55	0.60	0.63
8545.00	4.92	5.52	5.55	0.60	0.63
11000.00	4.93	5.54	5.59	0.61	0.66
11395.00	4.93	5.53	5.58	0.60	0.65
11790.00	4.93	5.55	5.58	0.62	0.65
12025.00	4.94	5.55	5.53	0.61	0.59
15200.00	4.96	5.58	5.73	0.62	0.77
16200.00	4.98	5.60	5.77	0.62	0.79
19200.00	4.99	5.62	5.81	0.63	0.82
22200.00	5.01	5.64	5.85	0.63	0.84
24155.00	5.03	5.68	5.90	0.65	0.87
26013.00	4.98	5.61	5.77	0.63	0.79
26063.00	4.98	5.61	5.78	0.63	0.80
26103.00	5.01	5.65	5.89	0.64	0.88
26153.00	5.01	5.65	5.89	0.64	0.88
27587.00	5.05	5.69	5.98	0.64	0.93
27637.00	5.05	5.69	5.98	0.64	0.93
27697.00	5.13	5.81	6.26	0.68	1.13
27747.00	5.13	5.81	6.26	0.68	1.13
28502.00	5.16	5.85	6.34	0.69	1.18
28552.00	5.16	5.85	6.34	0.69	1.18
28578.00	5.18	5.89	6.43	0.71	1.25
28628.00	5.19	5.89	6.43	0.70	1.24
28643.00	5.18	5.88	6.41	0.70	1.23
28720.00	5.18	5.88	6.42	0.70	1.24
28820.00	5.20	5.91	6.48	0.71	1.28

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

TABLE II-10. STAGE COMPARISON --- RIVERS IN PASSAIC RIVER BASIN(CONTD.)

STATION	(1) STAGE	(2) STAGE	(3) STAGE	(2-1)	(3-1)
29400.00	5.21	5.92	6.50	0.71	1.29
29858.00	5.22	5.93	6.52	0.71	1.30
29908.00	5.22	5.93	6.53	0.71	1.31
29968.00	5.22	5.94	6.54	0.72	1.32
30018.00	5.23	5.94	6.54	0.71	1.31
30600.00	5.28	6.01	6.69	0.73	1.41
31193.00	5.28	6.01	6.69	0.73	1.41
31243.00	5.28	6.02	6.69	0.74	1.41
31273.00	5.31	6.06	6.80	0.75	1.49
31323.00	5.32	6.06	6.80	0.74	1.48
33000.00	5.42	6.20	7.07	0.78	1.65
35400.00	5.41	6.19	7.05	0.78	1.64
37200.00	5.74	6.60	7.81	0.86	2.07
40800.00	5.97	6.79	7.89	0.82	1.92
42200.00	5.98	6.79	7.82	0.81	1.84
44327.00	7.87	9.09	12.05	1.22	4.18
44377.00	7.88	9.10	12.06	1.22	4.18
44433.00	7.88	9.10	12.06	1.22	4.18
44483.00	7.89	9.11	12.08	1.22	4.19
47000.00	8.42	9.72	12.93	1.30	4.51
49600.00	8.66	9.98	13.22	1.32	4.56
52080.00	9.10	10.48	13.87	1.38	4.77
54103.00	9.35	10.76	14.29	1.41	4.94
54153.00	9.36	10.77	14.29	1.41	4.93
54193.00	9.39	10.81	14.65	1.42	5.26
54243.00	9.39	10.81	14.65	1.42	5.26
55980.00	9.44	10.86	14.72	1.42	5.28
58765.00	9.70	11.25	15.39	1.55	5.69
59702.00	9.69	11.14	15.37	1.45	5.68
59706.00	9.75	11.21	15.38	1.46	5.63
59728.00	9.85	11.33	15.41	1.48	5.56
60200.00	9.93	11.45	15.45	1.52	5.52
60800.00	10.04	11.55	15.47	1.51	5.43
60930.00	10.08	11.60	15.48	1.52	5.40
61030.00	10.05	11.57	15.47	1.52	5.42
61900.00	10.07	11.58	15.47	1.51	5.40
63800.00	9.96	11.43	15.40	1.47	5.44
66200.00	10.63	12.18	15.60	1.55	4.97
66800.00	10.81	12.39	15.66	1.58	4.85
67996.00	10.89	12.47	15.68	1.58	4.79
68046.00	10.90	12.48	15.68	1.58	4.78
68072.00	11.02	12.63	15.71	1.61	4.69
68122.00	11.04	12.64	15.72	1.60	4.68
69000.00	11.27	12.92	15.78	1.65	4.51
69800.00	11.46	13.11	15.83	1.65	4.37
72595.00	12.76	14.49	16.22	1.73	3.46

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

TABLE II-10. STAGE COMPARISON --- RIVERS IN PASSAIC RIVER BASIN(CONTD.)

STATION	(1) STAGE	(2) STAGE	(3) STAGE	(2-1)	(3-1)
72835.00	12.96	14.70	16.27	1.74	3.31
72885.00	13.22	15.77	16.35	2.55	3.13
74000.00	13.91	16.40	16.60	2.49	2.69
76010.00	14.59	17.04	16.80	2.45	2.21
76060.00	14.60	17.05	16.81	2.45	2.21
76110.00	14.67	17.46	16.82	2.79	2.15
76160.00	14.68	17.47	16.83	2.79	2.15
78200.00	15.11	17.85	16.96	2.74	1.85
79034.00	15.44	18.14	17.04	2.70	1.60
79084.00	15.44	18.15	17.05	2.71	1.61
79164.00	15.45	18.16	17.06	2.71	1.61
81665.00	15.39	18.08	17.07	2.69	1.68
82200.00	15.68	18.27	17.18	2.59	1.50
83033.00	15.74	18.30	17.19	2.56	1.45
83083.00	15.77	18.33	17.20	2.56	1.43
83131.00	16.23	18.60	17.21	2.37	0.98
83181.00	16.25	18.62	17.22	2.37	0.97
83800.00	16.80	19.22	17.32	2.42	0.52
84631.00	17.09	19.39	17.62	2.30	0.53
84681.00	17.11	19.41	17.63	2.30	0.52
84701.00	17.79	19.92	17.65	2.13	-0.14
84751.00	17.81	19.94	17.66	2.13	-0.15
84773.00	17.81	19.94	17.65	2.13	-0.16
84821.00	18.38	20.44	17.66	2.06	-0.72
84871.00	18.39	20.45	17.67	2.06	-0.72
85800.00	18.95	21.03	17.97	2.08	-0.98
87000.00	19.13	21.19	18.07	2.06	-1.06
87670.00	19.75	21.85	18.37	2.10	-1.38
87800.00	19.85	21.94	18.46	2.09	-1.39
88600.00	19.67	21.74	18.35	2.07	-1.32
89100.00	20.35	22.37	18.78	2.02	-1.57
89400.00	20.70	22.74	18.98	2.04	-1.72
89450.00	20.88	22.93	19.09	2.05	-1.79
89480.00	21.06	23.22	19.10	2.16	-1.96
89561.00	21.00	23.16	19.07	2.16	-1.93
89900.00	21.09	23.24	19.12	2.15	-1.97
90000.00	21.20	23.36	19.18	2.16	-2.02
90650.00	21.33	23.49	19.25	2.16	-2.08
91200.00	21.45	23.53	19.31	2.08	-2.14

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

PASSAIC RIVER ---- DUNDEE DAM ---- 100.YEAR ----

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
91785.00	22.05	24.09	19.82	2.04	-2.23
91790.00	32.41	33.14	30.60	0.73	-1.81
92150.00	32.31	33.02	29.69	0.71	-2.62
92400.00	32.43	33.17	29.73	0.74	-2.70
94089.00	32.56	33.33	29.78	0.77	-2.78
94525.00	32.58	33.35	29.79	0.77	-2.79
94665.00	32.58	33.35	29.79	0.77	-2.79
94930.00	32.59	33.37	29.80	0.78	-2.79
95670.00	32.61	33.39	29.81	0.78	-2.80
96014.00	32.62	33.40	29.82	0.78	-2.80
96096.00	32.67	33.46	29.83	0.79	-2.84
97120.00	32.76	33.59	29.85	0.83	-2.91
98200.00	33.29	34.13	30.18	0.84	-3.11
99583.00	33.73	34.59	30.45	0.86	-3.28
99743.00	33.77	34.64	30.47	0.87	-3.30
99811.00	33.70	34.63	30.44	0.93	-3.26
99920.00	33.93	35.55	30.54	1.62	-3.39
100430.00	34.01	35.63	30.57	1.62	-3.44
100480.00	34.03	35.64	30.58	1.61	-3.45
100492.00	34.19	35.84	30.63	1.65	-3.56
101100.00	34.34	36.02	30.70	1.68	-3.64
102580.00	34.74	36.37	30.92	1.63	-3.82
104800.00	35.65	37.26	31.50	1.61	-4.15
105977.00	36.14	37.72	31.86	1.58	-4.28
106043.00	36.35	37.97	31.93	1.62	-4.42
106376.00	36.48	38.10	32.01	1.62	-4.47
106740.00	36.54	38.16	32.06	1.62	-4.48
108900.00	37.39	38.99	32.70	1.60	-4.69
109370.00	37.52	39.13	32.81	1.61	-4.71
110340.00	37.76	39.40	33.09	1.64	-4.67
110378.00	37.83	39.40	33.12	1.57	-4.71
110960.00	38.51	39.71	33.40	1.20	-5.11
111860.00	38.88	40.10	33.58	1.22	-5.30
112200.00	38.69	39.92	33.57	1.23	-5.12
113750.00	39.18	40.33	34.22	1.15	-4.96
114340.00	39.40	40.52	34.51	1.12	-4.89
114730.00	39.43	40.57	34.52	1.14	-4.91
114800.00	39.65	40.83	34.66	1.18	-4.99
114870.00	39.85	41.07	34.74	1.22	-5.11
116840.00	40.38	41.65	35.22	1.27	-5.16

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

TABLE II-10. STAGE COMPARISON --- RIVERS IN PASSAIC RIVER BASIN(CONTD.)

STATION	(1) STAGE	(2) STAGE	(3) STAGE	(2-1)	(3-1)
117020.00	40.42	41.68	35.25	1.26	-5.17
117056.00	40.68	41.98	35.52	1.30	-5.16
117300.00	41.24	42.62	36.17	1.38	-5.07
117468.00	41.39	42.73	36.38	1.34	-5.01
117940.00	41.62	42.94	36.59	1.32	-5.03
118320.00	42.12	43.51	37.01	1.39	-5.11
118368.00	42.42	44.09	37.05	1.67	-5.37
118600.00	42.74	44.47	37.20	1.73	-5.54
118890.00	42.90	44.62	37.40	1.72	-5.50
119700.00	43.09	44.79	37.63	1.70	-5.46
120374.00	43.36	45.01	37.91	1.65	-5.45
120416.00	43.38	45.04	37.92	1.66	-5.46
121000.00	43.54	45.28	38.02	1.74	-5.52
121350.00	43.61	45.30	38.12	1.69	-5.49
121380.00	43.85	45.76	38.12	1.91	-5.73
122520.00	44.50	46.49	38.69	1.99	-5.81
123400.00	44.92	46.73	39.29	1.81	-5.63
124234.00	45.35	47.14	39.65	1.79	-5.70
124276.00	45.44	47.13	39.68	1.69	-5.76
125000.00	45.72	47.51	39.88	1.79	-5.84
125700.00	46.20	47.94	40.35	1.74	-5.85
126068.00	47.02	48.62	40.84	1.60	-6.18
126122.00	47.06	48.67	40.88	1.61	-6.18
126740.00	47.06	48.67	41.50	1.61	-5.56
127435.00	47.23	48.81	41.78	1.58	-5.45
127485.00	47.24	48.96	41.81	1.72	-5.43
128000.00	48.03	49.52	42.13	1.49	-5.90
128730.00	48.27	49.76	42.39	1.49	-5.88
128995.00	48.83	50.38	42.69	1.55	-6.14
129250.00	49.20	50.68	43.10	1.48	-6.10
129540.00	49.29	50.72	43.25	1.43	-6.04
129836.00	49.45	50.88	43.48	1.43	-5.97
129884.00	50.06	51.13	43.53	1.07	-6.53
130365.00	50.42	51.50	44.02	1.08	-6.40
130474.00	51.07	52.62	44.54	1.55	-6.53
130526.00	52.16	53.70	44.60	1.54	-7.56
130546.00	52.16	53.71	44.62	1.55	-7.54
130700.00	51.72	53.38	44.06	1.66	-7.66
130805.00	51.88	53.55	44.61	1.67	-7.27
130845.00	51.88	53.65	44.97	1.77	-6.91
131250.00	53.91	55.06	47.23	1.15	-6.68
131550.00	53.45	54.43	47.46	0.98	-5.99
132430.00	55.26	56.31	50.86	1.05	-4.40
133030.00	57.96	59.24	53.15	1.28	-4.81
133350.00	61.60	63.51	55.10	1.91	-6.50
133390.00	56.80	59.32	53.45	2.52	-3.35
133520.00	62.30	65.33	54.37	3.03	-7.93

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

PASSAIC RIVER ---- GREAT FALLS ---- 100.YEAR ----

STATION	PR86HEC2 (1) STAGE	PRTFHEC2 (2) STAGE	PRT3TFH2 (3) STAGE	(2-1)	(3-1)
133540.00	113.11	113.69	111.16	0.58	-1.95
133550.00	115.37	116.15	112.75	0.78	-2.62
133800.00	115.62	116.44	112.86	0.82	-2.76
133860.00	115.91	116.77	113.06	0.86	-2.85
133865.00	123.96	124.99	119.49	1.03	-4.47
133885.00	123.84	124.85	119.46	1.01	-4.38
133935.00	123.86	124.87	119.47	1.01	-4.39
133995.00	123.94	124.97	119.48	1.03	-4.46
134220.00	123.78	124.79	119.45	1.01	-4.33
135550.00	125.05	126.31	119.84	1.26	-5.21
135761.00	125.31	126.58	119.95	1.27	-5.36
135769.00	125.34	126.61	119.96	1.27	-5.38
136460.00	125.88	127.22	120.14	1.34	-5.74
139880.00	127.42	128.83	121.11	1.41	-6.31
139940.00	127.46	128.89	121.12	1.43	-6.34
140000.00	127.50	128.96	121.14	1.46	-6.36
140800.00	128.04	129.57	121.36	1.53	-6.68
141723.00	128.49	130.02	121.56	1.53	-6.93
141757.00	129.12	130.80	121.57	1.68	-7.55
142000.00	129.15	130.83	121.62	1.68	-7.53
142320.00	129.19	130.86	121.67	1.67	-7.52
143460.00	129.40	131.04	121.95	1.64	-7.45
143830.00	129.85	131.51	122.27	1.66	-7.58
143920.00	129.87	131.53	122.32	1.66	-7.55
144090.00	129.90	131.55	122.45	1.65	-7.45
144320.00	129.83	131.48	122.45	1.65	-7.38
144490.00	130.16	131.81	122.71	1.65	-7.45
144930.00	130.17	131.83	122.69	1.66	-7.48
145620.00	130.65	132.34	123.11	1.69	-7.54
146140.00	130.85	132.51	123.46	1.66	-7.39
147600.00	131.35	132.93	124.25	1.58	-7.10
149110.00	132.58	133.95	125.58	1.37	-7.00
149470.00	132.84	134.21	125.86	1.37	-6.98
150526.00	133.09	134.43	126.16	1.34	-6.93
150576.00	133.11	134.45	126.18	1.34	-6.93
150596.00	133.64	135.02	126.18	1.38	-7.46
150646.00	133.66	135.04	126.19	1.38	-7.47
150800.00	133.85	135.25	126.28	1.40	-7.57
150951.00	133.88	135.28	126.30	1.40	-7.58
151065.00	133.90	135.31	126.32	1.41	-7.58
151079.00	134.29	135.87	126.32	1.58	-7.97
151270.00	134.34	135.91	126.36	1.57	-7.98
151390.00	134.35	135.92	126.37	1.57	-7.98
151490.00	134.48	136.07	126.43	1.59	-8.05
151630.00	134.45	136.04	126.43	1.59	-8.02
152000.00	134.64	136.24	126.56	1.60	-8.08

NOTE: 1.'PR86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PRTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PRT3TFH2' = 2040 WITH PROJECT CONDITIONS.

STATION	(1) STAGE	(2) STAGE	(3) STAGE	(2-1)	(3-1)
152740.00	134.86	136.47	126.79	1.61	-8.07
152930.00	134.75	136.33	126.84	1.58	-7.91
153350.00	135.65	137.31	127.41	1.66	-8.24
153700.00	135.65	137.27	127.73	1.62	-7.92
154640.00	136.72	138.20	128.38	1.48	-8.34
155130.00	138.37	140.19	129.15	1.82	-9.22
155500.00	138.00	139.72	129.42	1.72	-8.58
155805.00	138.21	139.83	129.95	1.62	-8.26
155855.00	137.41	138.94	129.28	1.53	-8.13
155877.00	137.45	138.99	129.32	1.54	-8.13
155927.00	137.71	139.33	130.16	1.62	-7.55
156330.00	143.05	144.65	135.62	1.60	-7.43
156380.00	143.92	145.53	136.53	1.61	-7.39
156408.00	145.10	145.59	136.57	0.49	-8.53
156458.00	145.06	146.67	137.66	1.61	-7.40
156650.00	148.32	149.93	140.92	1.61	-7.40

PASSAIC RIVER ---- BEATTIES DAM ---- 100.YEAR ----

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
156816.00	158.25	159.24	153.91	0.99	-4.34
156855.00	161.03	162.27	155.67	1.24	-5.36
156865.00	167.06	168.10	162.55	1.04	-4.51
156982.00	166.95	168.02	162.45	1.07	-4.50
157310.00	167.30	168.35	162.67	1.05	-4.63
157600.00	167.85	169.04	162.81	1.19	-5.04
157900.00	167.56	168.72	162.74	1.16	-4.82
158280.00	168.52	169.77	163.11	1.25	-5.41
158710.00	168.76	170.05	163.17	1.29	-5.59
159330.00	168.79	170.05	163.31	1.26	-5.48
160690.00	169.26	170.52	163.72	1.26	-5.54
161470.00	169.67	170.93	163.99	1.26	-5.68
162290.00	169.95	171.24	164.10	1.29	-5.85
162724.00	169.93	171.23	164.12	1.30	-5.81
162774.00	169.61	170.78	164.11	1.17	-5.50
162790.00	169.94	171.22	164.12	1.28	-5.82
162840.00	169.96	171.24	164.13	1.28	-5.83
163043.00	170.36	171.80	164.22	1.44	-6.14
163097.00	170.38	171.84	164.23	1.46	-6.15
163147.00	170.39	171.85	164.24	1.46	-6.15
163620.00	170.59	172.04	164.28	1.45	-6.31
163800.00	170.62	172.06	164.31	1.44	-6.31

NOTE: 1."PB86HEC2" = EXISTING 1986 W/O PROJECT CONDITIONS.
2."PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3."PBT3TFH2" = 2040 WITH PROJECT CONDITIONS.

TABLE II-10. STAGE COMPARISON --- RIVERS IN PASSAIC RIVER BASIN(CONTD.)

STATION	(1) STAGE	(2) STAGE	(3) STAGE	(2-1)	(3-1)
164580.00	170.71	172.15	164.40	1.44	-6.31
165200.00	170.65	172.06	164.45	1.41	-6.20
165600.00	170.73	172.14	164.49	1.41	-6.24
166070.00	170.90	172.29	164.57	1.39	-6.33
167000.00	171.29	172.74	164.78	1.45	-6.51
167420.00	171.10	172.55	164.67	1.45	-6.43
167600.00	171.62	173.09	164.96	1.47	-6.66
168280.00	171.74	173.19	165.06	1.45	-6.68
169300.00	171.84	173.20	165.21	1.36	-6.63
170090.00	172.33	173.74	165.53	1.41	-6.80
170920.00	172.39	173.78	165.81	1.39	-6.58
171050.00	172.15	173.50	165.84	1.35	-6.31
171105.00	172.16	173.50	165.85	1.34	-6.31
171165.00	172.17	173.52	165.85	1.35	-6.32
171220.00	172.18	173.52	165.86	1.34	-6.32
171450.00	172.74	174.14	165.99	1.40	-6.75
171730.00	172.54	173.88	166.04	1.34	-6.50
171790.00	172.55	173.89	166.04	1.34	-6.51
171840.00	172.56	173.91	166.04	1.35	-6.52
172000.00	172.80	174.22	166.07	1.42	-6.73
172860.00	172.76	174.19	166.14	1.43	-6.62
173500.00	173.15	174.56	166.16	1.41	-6.99
173860.00	173.33	174.74	166.33	1.41	-7.00
173940.00	173.36	174.77	166.34	1.41	-7.02
173990.00	173.37	174.81	166.35	1.44	-7.02
174060.00	173.38	174.81	166.36	1.43	-7.02

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

PASSAIC RIVER ---- TWO BRIDGES ---- 100.YEAR ----

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
175390.00	173.52	174.97	166.28	1.45	-7.24
184170.00	173.52	175.00	166.57	1.48	-6.95
187420.00	173.53	175.01	166.80	1.48	-6.73
194000.00	173.53	175.04	167.67	1.51	-5.86
213370.00	173.55	175.13	169.58	1.58	-3.97
217750.00	173.56	175.16	169.89	1.60	-3.67
219860.00	173.58	175.19	170.11	1.61	-3.47
219887.00	173.63	175.23	170.11	1.60	-3.52
220187.00	173.63	175.24	170.17	1.61	-3.46
224000.00	173.66	175.32	170.60	1.66	-3.06
226375.00	173.67	175.37	170.77	1.70	-2.90
230300.00	173.68	175.49	171.24	1.81	-2.44
230950.00	173.65	175.54	171.43	1.89	-2.22
231150.00	173.65	175.55	171.44	1.90	-2.21
231860.00	173.80	175.72	171.61	1.92	-2.19
234650.00	173.83	175.78	171.89	1.95	-1.94
234755.00	174.02	176.11	171.90	2.09	-2.12
235585.00	174.24	176.35	172.11	2.11	-2.13
236330.00	174.26	176.40	172.29	2.14	-1.97
236420.00	174.73	176.68	172.88	1.95	-1.85
238590.00	174.79	176.75	173.11	1.96	-1.68
240380.00	174.80	176.76	173.16	1.96	-1.64

PASSAIC RIVER ---- PINE BROOK ---- 100.YEAR ----

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
246395.00	174.99	176.79	173.30	1.80	-1.69
249565.00	175.02	176.81	173.38	1.79	-1.64
250650.00	175.03	176.80	173.42	1.77	-1.61
250685.00	175.04	176.82	173.44	1.78	-1.60
250730.00	175.05	176.82	173.45	1.77	-1.60
250775.00	175.05	176.82	173.46	1.77	-1.59
250820.00	175.06	176.83	173.47	1.77	-1.59
251930.00	175.25	176.96	173.78	1.71	-1.47
252535.00	175.26	176.97	173.79	1.71	-1.47
252590.00	175.26	176.97	173.78	1.71	-1.48
252650.00	175.29	177.00	173.83	1.71	-1.46
253815.00	175.30	177.00	173.86	1.70	-1.44

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

TABLE II-10. STAGE COMPARISON --- RIVERS IN PASSAIC RIVER BASIN(CONTD.)

STATION	(1) STAGE	(2) STAGE	(3) STAGE	(2-1)	(3-1)
254485.00	175.30	177.00	173.86	1.70	-1.44
255600.00	175.30	177.00	173.87	1.70	-1.43
256225.00	175.36	177.03	173.96	1.67	-1.40
256305.00	175.33	177.01	173.93	1.68	-1.40
256315.00	175.35	177.02	173.96	1.67	-1.39
257245.00	175.49	177.13	174.15	1.64	-1.34
258370.00	175.53	177.16	174.21	1.63	-1.32
259185.00	175.57	177.19	174.28	1.62	-1.29
260190.00	175.58	177.19	174.30	1.61	-1.28
261250.00	175.60	177.20	174.33	1.60	-1.27
261880.00	175.61	177.21	174.36	1.60	-1.25
264410.00	175.63	177.22	174.40	1.59	-1.23
265075.00	175.64	177.23	174.42	1.59	-1.22
265590.00	175.65	177.23	174.44	1.58	-1.21
266225.00	175.68	177.24	174.50	1.56	-1.18
266700.00	175.69	177.25	174.51	1.56	-1.18
267330.00	175.66	177.22	174.48	1.56	-1.18
267380.00	175.83	177.23	174.51	1.40	-1.32
267520.00	175.91	177.27	174.57	1.36	-1.34
267665.00	175.83	177.22	174.38	1.39	-1.45
267695.00	175.85	177.26	174.50	1.41	-1.35
268485.00	176.24	177.54	175.52	1.30	-0.72
269410.00	176.26	177.56	175.56	1.30	-0.70
270395.00	176.27	177.57	175.57	1.30	-0.70
271405.00	176.28	177.57	175.58	1.29	-0.70
272850.00	176.29	177.58	175.60	1.29	-0.69
273840.00	176.30	177.59	175.61	1.29	-0.69
274740.00	176.33	177.61	175.66	1.28	-0.67
275500.00	176.35	177.63	175.68	1.28	-0.67
276320.00	176.36	177.63	175.70	1.27	-0.66
277050.00	176.36	177.63	175.71	1.27	-0.65
277080.00	176.36	177.67	175.71	1.31	-0.65
278390.00	176.49	177.79	175.87	1.30	-0.62
280040.00	176.49	177.79	175.88	1.30	-0.61
281025.00	176.50	177.79	175.88	1.29	-0.62
282180.00	176.50	177.80	175.89	1.30	-0.61
283580.00	176.52	177.81	175.91	1.29	-0.61
285190.00	176.53	177.82	175.93	1.29	-0.60
286470.00	176.54	177.82	175.94	1.28	-0.60
292040.00	176.55	177.83	176.02	1.28	-0.53
293290.00	176.56	177.83	176.06	1.27	-0.50
294120.00	176.56	177.83	175.70	1.27	-0.86
294155.00	176.83	178.83	177.63	2.00	0.80
295200.00	177.98	178.99	177.89	1.01	-0.09

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

STATION	(1) STAGE	(2) STAGE	(3) STAGE	(2-1)	(3-1)
296650.00	178.05	179.04	177.97	0.99	-0.08
297845.00	178.11	179.08	178.04	0.97	-0.07
298720.00	178.11	179.09	178.05	0.98	-0.06
300020.00	178.14	179.11	178.08	0.97	-0.06
300750.00	178.16	179.12	178.10	0.96	-0.06
301720.00	178.19	179.14	178.14	0.95	-0.05
302305.00	178.20	179.15	178.15	0.95	-0.05
303210.00	178.24	179.15	178.20	0.91	-0.04
303270.00	178.26	179.16	178.22	0.90	-0.04
303320.00	178.28	179.18	178.24	0.90	-0.04
303385.00	178.30	179.19	178.26	0.89	-0.04
303870.00	178.60	179.51	178.61	0.91	0.01
304510.00	178.75	179.61	178.77	0.86	0.02
304840.00	178.75	179.53	178.77	0.78	0.02
304870.00	178.81	179.59	178.85	0.78	0.04
304900.00	179.37	180.08	179.49	0.71	0.12
304935.00	179.39	180.11	179.52	0.72	0.13
305490.00	179.71	180.40	179.87	0.69	0.16
306330.00	182.37	182.53	182.54	0.16	0.17
307250.00	185.19	185.38	185.37	0.19	0.18
308425.00	186.63	186.76	186.76	0.13	0.13
308550.00	188.53	188.60	188.60	0.07	0.07
308575.00	188.23	188.48	188.50	0.25	0.27
309145.00	193.19	193.69	193.69	0.50	0.50
309735.00	193.50	193.93	193.93	0.43	0.43
310570.00	193.71	194.10	194.10	0.39	0.39
311400.00	195.31	195.46	195.46	0.15	0.15
311560.00	195.86	196.04	196.04	0.18	0.18
311620.00	197.16	197.44	197.44	0.28	0.28
312120.00	198.37	198.75	198.75	0.38	0.38
312860.00	199.21	199.49	199.49	0.28	0.28
313440.00	199.67	199.94	199.94	0.27	0.27
314400.00	201.71	201.95	201.95	0.24	0.24
314645.00	201.56	201.78	201.78	0.22	0.22
314725.00	200.84	200.90	200.90	0.06	0.06
314740.00	201.67	202.21	202.21	0.54	0.54
315150.00	204.99	205.56	205.56	0.57	0.57
315395.00	204.94	205.50	205.50	0.56	0.56

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

ROCKAWAY R. @ CNFLNCE WITH PSSC R. ---- 100.YEAR ----

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
210.00	174.98	176.78	173.20	1.80	-1.78
2040.00	174.99	176.79	173.20	1.80	-1.79
3160.00	175.01	176.81	173.22	1.80	-1.79
5100.00	175.05	176.83	173.24	1.78	-1.81
6715.00	175.09	176.86	173.26	1.77	-1.83
7700.00	175.11	176.88	173.27	1.77	-1.84
8610.00	175.21	176.92	173.31	1.71	-1.90
9370.00	175.24	176.93	173.36	1.69	-1.88
9470.00	175.24	176.93	173.32	1.69	-1.92
9480.00	175.21	176.92	173.32	1.71	-1.89
9915.00	175.49	177.08	174.07	1.59	-1.42
10890.00	175.54	177.11	174.19	1.57	-1.35
11900.00	175.54	177.11	174.21	1.57	-1.33
12105.00	175.54	177.12	174.28	1.58	-1.26
12215.00	176.04	177.73	174.93	1.69	-1.11
12420.00	176.40	178.04	175.59	1.64	-0.81
12520.00	176.40	178.05	175.61	1.65	-0.79
12560.00	177.32	179.05	176.98	1.73	-0.34
12660.00	177.37	179.06	177.06	1.69	-0.31
13165.00	177.50	179.18	177.29	1.68	-0.21
13400.00	177.49	179.16	177.27	1.67	-0.22
13650.00	177.50	179.17	177.29	1.67	-0.21
13710.00	177.51	179.18	177.30	1.67	-0.21
13760.00	177.52	179.18	177.32	1.66	-0.20
13820.00	177.53	179.19	177.33	1.66	-0.20
14300.00	177.64	179.32	177.51	1.68	-0.13
16280.00	177.85	179.50	177.83	1.65	-0.02
17215.00	177.87	179.52	177.88	1.65	0.01
18100.00	177.90	179.54	177.93	1.64	0.03
19135.00	177.94	179.57	178.00	1.63	0.06
19930.00	178.00	179.62	178.08	1.62	0.08
20065.00	178.01	179.63	178.10	1.62	0.09
20080.00	178.09	179.71	178.20	1.62	0.11
20180.00	178.13	179.72	178.21	1.59	0.08
20840.00	178.17	179.77	178.32	1.60	0.15
21235.00	178.21	179.81	178.39	1.60	0.18
21630.00	178.26	179.84	178.47	1.58	0.21
21935.00	178.28	179.86	178.50	1.58	0.22
22290.00	178.31	179.88	178.54	1.57	0.23
22925.00	178.33	179.90	178.58	1.57	0.25
23435.00	178.35	179.92	178.61	1.57	0.26
24070.00	178.39	179.94	178.66	1.55	0.27
24375.00	178.40	179.95	178.68	1.55	0.28
24377.00	178.52	180.07	178.81	1.55	0.29
24475.00	178.54	180.08	178.85	1.54	0.31
24750.00	178.58	180.11	178.90	1.53	0.32

NOTE: 1."PB86HEC2" = EXISTING 1986 W/O PROJECT CONDITIONS.
2."PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3."PBT3TFH2" = 2040 WITH PROJECT CONDITIONS.

STATION	(1) STAGE	(2) STAGE	(3) STAGE	(2-1)	(3-1)
25260.00	178.59	180.12	178.92	1.53	0.33
26140.00	178.65	180.15	178.99	1.50	0.34
26850.00	178.80	180.24	179.18	1.44	0.38
28647.00	179.29	180.59	179.81	1.30	0.52
30752.00	183.23	181.70	183.48	-1.53	0.25
30806.00	184.79	182.64	184.85	-2.15	0.06

WHIPPANY R. @ CNFLNCE WITH ROCK. R. ---- 100.YEAR ----

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
215.00	175.09	176.86	173.27	1.77	-1.82
1060.00	175.12	176.88	173.28	1.76	-1.84
1625.00	175.14	176.89	173.30	1.75	-1.84
1825.00	175.01	176.82	173.12	1.81	-1.89
1845.00	175.01	176.82	173.13	1.81	-1.88
2100.00	175.36	177.00	173.95	1.64	-1.41
2160.00	175.37	177.00	173.96	1.63	-1.41
2210.00	175.36	177.00	173.94	1.64	-1.42
2270.00	175.37	177.00	173.96	1.63	-1.41
2390.00	175.40	177.02	174.04	1.62	-1.36
2460.00	175.41	177.03	174.06	1.62	-1.35
2840.00	175.56	177.14	174.33	1.58	-1.23
3885.00	175.67	177.23	174.51	1.56	-1.16
5290.00	175.69	177.23	174.54	1.54	-1.15
6090.00	175.70	177.24	174.56	1.54	-1.14
7080.00	175.71	177.25	174.59	1.54	-1.12
8765.00	175.73	177.26	174.63	1.53	-1.10
9690.00	175.75	177.27	174.67	1.52	-1.08
10740.00	175.76	177.28	174.70	1.52	-1.06
12980.00	175.82	177.31	174.83	1.49	-0.99
14060.00	175.87	177.33	174.94	1.46	-0.93
15000.00	176.04	177.42	175.33	1.38	-0.71
15160.00	176.04	177.41	175.33	1.37	-0.71
15180.00	175.53	177.33	175.00	1.80	-0.53
15300.00	177.04	177.60	177.26	0.56	0.22
16080.00	177.20	177.74	177.42	0.54	0.22
17375.00	177.86	178.36	178.09	0.50	0.23
17970.00	177.94	178.44	178.18	0.50	0.24
18935.00	178.05	178.54	178.28	0.49	0.23
19215.00	178.31	178.81	178.55	0.50	0.24
19230.00	178.61	179.17	178.87	0.56	0.26
19500.00	178.45	178.97	178.71	0.52	0.26

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

TABLE II-10. STAGE COMPARISON --- RIVERS IN PASSAIC RIVER BASIN(CONTD.)

STATION	(1) STAGE	(2) STAGE	(3) STAGE	(2-1)	(3-1)
19860.00	178.78	179.57	179.31	0.79	0.53
19875.00	178.62	179.18	178.97	0.56	0.35
20000.00	179.49	180.35	180.00	0.86	0.51
20945.00	179.82	180.66	180.32	0.84	0.50
22090.00	179.81	180.66	180.31	0.85	0.50
22350.00	179.89	180.71	180.37	0.82	0.48
22375.00	179.88	180.71	180.37	0.83	0.49
22475.00	179.92	180.73	180.39	0.81	0.47
23010.00	180.01	180.77	180.45	0.76	0.44
23555.00	180.26	181.00	180.69	0.74	0.43
24185.00	180.54	181.26	180.95	0.72	0.41
24350.00	180.65	181.36	181.06	0.71	0.41
24410.00	180.68	181.42	181.10	0.74	0.42
24610.00	180.89	181.64	181.32	0.75	0.43
25135.00	181.30	181.99	181.69	0.69	0.39
26455.00	181.43	182.10	181.81	0.67	0.38
27490.00	181.50	182.15	181.87	0.65	0.37
28635.00	181.74	182.32	182.08	0.58	0.34
29620.00	182.85	183.10	183.01	0.25	0.16
30735.00	185.56	185.68	185.69	0.12	0.13
31290.00	189.34	189.49	189.49	0.15	0.15
31790.00	190.86	191.01	191.02	0.15	0.16
32590.00	194.06	194.24	194.24	0.18	0.18
33000.00	195.09	195.23	195.24	0.14	0.15
33140.00	196.04	196.20	196.21	0.16	0.17
33200.00	196.58	196.70	196.71	0.12	0.13
33315.00	196.70	196.82	196.82	0.12	0.12
33385.00	197.26	197.39	197.40	0.13	0.14
33386.00	198.37	198.43	198.43	0.06	0.06
33390.00	198.07	198.11	198.11	0.04	0.04
33790.00	199.92	200.03	200.03	0.11	0.11
34490.00	202.15	202.23	202.23	0.08	0.08
34720.00	203.18	203.27	203.27	0.09	0.09
34730.00	206.27	206.38	206.39	0.11	0.12
34975.00	206.31	206.42	206.43	0.11	0.12

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

POMPTON R. @ CNFLNCE WITH PSSC R. ---- 100.YEAR ----

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
830.00	173.38	174.81	166.42	1.43	-6.96
1010.00	173.38	174.82	166.42	1.44	-6.96
1480.00	173.59	174.95	166.43	1.36	-7.16
1835.00	173.79	175.08	166.43	1.29	-7.36
2290.00	174.13	175.32	166.48	1.19	-7.65
2810.00	174.27	175.42	166.53	1.15	-7.74
2950.00	174.31	175.45	166.54	1.14	-7.77
3840.00	174.62	175.66	166.65	1.04	-7.97
3945.00	174.64	175.68	166.67	1.04	-7.97
4130.00	174.68	175.71	166.69	1.03	-7.99
4590.00	174.79	175.78	166.74	0.99	-8.05
4935.00	174.81	175.80	166.75	0.99	-8.06
5540.00	174.89	175.86	166.78	0.97	-8.11
6980.00	175.12	176.03	166.88	0.91	-8.24
7310.00	175.26	176.13	166.96	0.87	-8.30
7470.00	175.29	176.14	166.98	0.85	-8.31
7514.00	175.29	176.14	166.99	0.85	-8.30
7675.00	175.62	176.37	167.10	0.75	-8.52
7940.00	175.91	176.59	167.16	0.68	-8.75
8510.00	175.95	176.62	167.19	0.67	-8.76
8805.00	176.27	176.86	167.29	0.59	-8.98
9320.00	177.01	177.35	167.43	0.34	-9.58
9520.00	177.17	177.46	167.48	0.29	-9.69
9660.00	177.31	177.59	167.53	0.28	-9.78
9940.00	177.63	177.89	167.68	0.26	-9.95
10525.00	177.90	178.16	167.81	0.26	-10.09
11250.00	178.09	178.34	168.08	0.25	-10.01
11780.00	178.40	178.63	168.18	0.23	-10.22
12240.00	178.50	178.72	168.25	0.22	-10.25
12430.00	178.56	178.78	168.29	0.22	-10.27
12720.00	178.82	179.03	168.46	0.21	-10.36
13250.00	178.93	179.13	168.54	0.20	-10.39
13655.00	178.99	179.20	168.60	0.21	-10.39
13890.00	179.10	179.30	168.64	0.20	-10.46
13920.00	179.17	179.30	168.65	0.13	-10.52
14190.00	179.20	179.32	168.73	0.12	-10.47
14445.00	179.86	179.98	168.78	0.12	-11.08
14880.00	180.24	180.36	168.88	0.12	-11.36
15710.00	180.43	180.54	169.09	0.11	-11.34
16480.00	180.56	180.67	169.30	0.11	-11.26
16710.00	180.61	180.72	169.35	0.11	-11.26
17420.00	180.67	180.78	169.50	0.11	-11.17

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

TABLE II-10. STAGE COMPARISON --- RIVERS IN PASSAIC RIVER BASIN(CONTD.)

STATION	(1) STAGE	(2) STAGE	(3) STAGE	(2-1)	(3-1)
18185.00	180.74	180.85	169.66	0.11	-11.08
19190.00	180.87	181.00	170.01	0.13	-10.86
19830.00	180.94	181.07	170.31	0.13	-10.63
20730.00	181.01	181.15	170.52	0.14	-10.49
21810.00	181.06	181.21	170.79	0.15	-10.27
22195.00	181.08	181.22	170.83	0.14	-10.25
22215.00	182.59	182.85	170.84	0.26	-11.75
22445.00	182.60	182.86	170.98	0.26	-11.62
23035.00	182.61	182.88	170.96	0.27	-11.65
24110.00	182.64	182.91	171.18	0.27	-11.46
24605.00	182.63	182.89	171.29	0.26	-11.34
24645.00	182.63	182.89	171.29	0.26	-11.34
24845.00	182.68	182.94	171.32	0.26	-11.36
25060.00	182.73	183.00	171.35	0.27	-11.38
25070.00	182.73	183.00	171.35	0.27	-11.38
25270.00	182.78	183.05	171.38	0.27	-11.40
25585.00	182.84	183.11	171.41	0.27	-11.43
26280.00	183.08	183.35	171.55	0.27	-11.53
26530.00	183.11	183.39	171.55	0.28	-11.56
26700.00	183.15	183.43	171.61	0.28	-11.54
27030.00	183.21	183.50	171.80	0.29	-11.41
27435.00	183.36	183.64	171.99	0.28	-11.37
27555.00	184.32	184.60	172.00	0.28	-12.32
27985.00	184.38	184.65	172.07	0.27	-12.31
28195.00	184.45	184.73	172.13	0.28	-12.32
28530.00	184.50	184.77	172.36	0.27	-12.14
29000.00	184.60	184.87	172.55	0.27	-12.05
29415.00	184.64	184.91	172.67	0.27	-11.97
29820.00	184.69	184.95	172.80	0.26	-11.89
30350.00	184.74	185.01	172.90	0.27	-11.84
30750.00	184.80	185.07	172.98	0.27	-11.82
31500.00	184.88	185.14	173.13	0.26	-11.75
31910.00	184.95	185.21	173.31	0.26	-11.64
32785.00	185.21	185.46	173.91	0.25	-11.30
33780.00	185.37	185.62	174.79	0.25	-10.58
34090.00	185.44	185.68	174.89	0.24	-10.55
34260.00	185.45	185.69	174.98	0.24	-10.47
34840.00	185.87	186.10	175.22	0.23	-10.65
34920.00	185.87	186.10	175.22	0.23	-10.65
34975.00	185.86	186.09	175.23	0.23	-10.63
34985.00	185.86	186.09	175.47	0.23	-10.39
35090.00	185.97	186.20	175.46	0.23	-10.51
35735.00	186.18	186.40	175.82	0.22	-10.36

NOTE: 1."PR86HEC2" = EXISTING 1986 W/O PROJECT CONDITIONS.
2."PRTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3."PRT3TFH2" = 2040 WITH PROJECT CONDITIONS.

PEQUANNOCK R. @ CNFLNCE WITH PMPTN R. ---- 100.YEAR ----

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
320.00	186.78	186.97	179.79	0.19	-6.99
320.10	186.84	187.03	180.08	0.19	-6.76
320.20	186.83	187.03	179.95	0.20	-6.88
320.30	186.84	187.04	180.10	0.20	-6.74
320.40	186.85	187.04	180.42	0.19	-6.43
320.50	186.86	187.05	180.92	0.19	-5.94
1210.00	187.23	187.42	181.84	0.19	-5.39
1695.00	187.47	187.65	182.97	0.18	-4.50
1705.00	187.46	187.64	182.94	0.18	-4.52
1715.00	187.47	187.65	182.91	0.18	-4.56
1765.00	187.50	187.68	182.96	0.18	-4.54
3750.00	188.27	188.42	184.26	0.15	-4.01
4628.00	188.53	188.67	184.79	0.14	-3.74
4728.00	188.57	188.71	184.85	0.14	-3.72
4733.00	188.66	188.79	184.85	0.13	-3.81
4783.00	188.65	188.79	184.88	0.14	-3.77
5040.00	188.82	188.94	185.09	0.12	-3.73
5765.00	188.96	189.09	185.40	0.13	-3.56
7134.00	189.18	189.29	186.11	0.11	-3.07
8436.00	189.66	189.76	186.85	0.10	-2.81
8900.00	189.88	189.97	187.04	0.09	-2.84
9510.00	190.33	190.40	187.64	0.07	-2.69
10170.00	191.14	191.19	188.32	0.05	-2.82
10385.00	191.49	191.53	188.59	0.04	-2.90
10445.00	191.49	191.53	188.61	0.04	-2.88
10630.00	192.10	192.13	189.28	0.03	-2.82
11015.00	192.19	192.22	189.32	0.03	-2.87
11390.00	192.34	192.38	189.38	0.04	-2.96
11710.00	192.48	192.52	189.45	0.04	-3.03
12050.00	192.58	192.63	189.53	0.05	-3.05
12400.00	192.49	192.54	189.49	0.05	-3.00
13030.00	193.72	193.79	189.65	0.07	-4.07
13500.00	195.09	195.17	189.80	0.08	-5.29
14270.00	198.20	198.31	195.16	0.11	-3.04
14700.00	199.84	199.95	198.70	0.11	-1.14
14958.00	201.77	201.90	201.34	0.13	-0.43
15040.00	201.79	201.92	201.27	0.13	-0.52
15100.00	201.97	202.11	201.52	0.14	-0.45
15200.00	202.27	202.42	201.60	0.15	-0.67
15930.00	205.77	205.91	205.05	0.14	-0.72
16535.00	208.32	208.41	207.70	0.09	-0.62
16843.00	210.46	210.51	211.95	0.05	1.49
17040.00	211.64	211.71	212.46	0.07	0.82
17055.00	212.29	212.42	213.23	0.13	0.94

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

TABLE II-10. STAGE COMPARISON --- RIVERS IN PASSAIC RIVER BASIN(CONTD.)

RAMAPO R. @ CNFLNCE WITH PMPTN R. ---- 100.YEAR ----

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
770.00	186.78	186.97	0.00	0.19	0.00
1049.00	186.83	187.03	0.00	0.20	0.00
1050.00	186.83	187.03	0.00	0.20	0.00
1070.00	186.84	187.04	0.00	0.20	0.00
1071.00	186.85	187.04	0.00	0.19	0.00
1430.00	186.85	187.05	0.00	0.20	0.00
2330.00	187.23	187.42	0.00	0.19	0.00
3585.00	187.46	187.64	0.00	0.18	0.00
3595.00	187.46	187.64	0.00	0.18	0.00
3605.00	187.46	187.64	0.00	0.18	0.00
3655.00	187.47	187.65	182.97	0.18	-4.50
4630.00	187.72	187.91	183.66	0.19	-4.06
5465.00	188.42	188.63	184.42	0.21	-4.00
5730.00	188.93	189.15	185.03	0.22	-3.90
6240.00	189.19	189.42	185.70	0.23	-3.49
6630.00	189.41	189.65	185.86	0.24	-3.55
7010.00	189.71	189.95	186.29	0.24	-3.42
7230.00	189.82	190.06	186.02	0.24	-3.80
7290.00	189.86	190.11	186.02	0.25	-3.84
7331.00	190.07	190.35	186.02	0.28	-4.05
7420.00	190.20	190.47	187.13	0.27	-3.07
7805.00	190.52	190.80	188.17	0.28	-2.35
8250.00	190.96	191.24	188.74	0.28	-2.22
8600.00	191.80	192.10	189.98	0.30	-1.82
9130.00	191.81	192.11	190.04	0.30	-1.77
9410.00	191.98	192.27	190.30	0.29	-1.68
9770.00	191.95	192.24	190.44	0.29	-1.51
9865.00	191.82	192.11	190.51	0.29	-1.31
9920.00	191.91	192.12	190.64	0.21	-1.27
10015.00	193.15	193.39	191.13	0.24	-2.02
10245.00	193.93	194.21	191.67	0.28	-2.26

NOTE: 1."PB86HEC2" = EXISTING 1986 W/O PROJECT CONDITIONS.
2."PBTFHEC2" = 2040 W/O PROJECT CONDITIONS.
3."PBT3TFH2" = 2040 WITH PROJECT CONDITIONS.

WANAQUE R. @ CNFLNCE WITH POMCK R. ---- 100.YEAR ----

STATION	PB86HEC2 (1) STAGE	PBTFHEC2 (2) STAGE	PBT3TFH2 (3) STAGE	(2-1)	(3-1)
255.00	192.12	192.15	189.40	0.03	-2.72
860.00	192.39	192.40	189.58	0.01	-2.81
2110.00	193.01	193.00	190.19	-0.01	-2.82
2350.00	193.22	193.20	190.38	-0.02	-2.84
2450.00	193.34	193.31	190.67	-0.03	-2.67
2615.00	193.38	193.36	190.73	-0.02	-2.65
2645.00	193.40	193.38	190.74	-0.02	-2.66
2655.00	193.40	193.38	190.74	-0.02	-2.66
2755.00	193.52	193.49	190.92	-0.03	-2.60
3220.00	193.82	193.78	191.16	-0.04	-2.66
3975.00	194.65	194.60	191.87	-0.05	-2.78
4525.00	195.25	195.18	192.69	-0.07	-2.56
4880.00	195.53	195.46	193.13	-0.07	-2.40
5135.00	196.12	196.04	194.24	-0.08	-1.88
5215.00	195.72	195.65	193.42	-0.07	-2.30
5270.00	195.72	196.19	195.90	0.47	0.18
5315.00	197.38	197.58	197.43	0.20	0.05
5620.00	197.56	197.74	197.60	0.18	0.04
6230.00	198.11	198.23	198.09	0.12	-0.02
6675.00	198.59	198.65	198.66	0.06	0.07
6780.00	199.03	199.06	199.92	0.03	0.89
6790.00	199.04	199.06	200.00	0.02	0.96
6885.00	199.37	199.37	200.35	0.00	0.98
7230.00	201.06	200.98	202.27	-0.08	1.21
7595.00	201.74	201.66	202.84	-0.08	1.10
7875.00	202.19	202.10	203.40	-0.09	1.21
8050.00	202.24	202.15	203.45	-0.09	1.21
8140.00	202.59	202.48	203.80	-0.11	1.21
8270.00	203.32	203.18	204.39	-0.14	1.07
8690.00	203.97	203.84	204.82	-0.13	0.85
8800.00	204.26	204.11	205.00	-0.15	0.74

***** END OF COMPARISON OF PROFILE NO. 7 *****

---------- THIS IS END OF THE SEARCH! ----------

NOTE: 1.'PB86HEC2' = EXISTING 1986 W/O PROJECT CONDITIONS.
2.'PBTFHEC2' = 2040 W/O PROJECT CONDITIONS.
3.'PBT3TFH2' = 2040 WITH PROJECT CONDITIONS.

TABLE II-11. VELOCITY COMPARISON --- PEQUANNOCK RIVER

PEQUANNOCK R. @ CNFLNCE WITH PMPTN R.

STATION	(1) VLCTY	(2) VLCTY	(3) VLCTY	(4) VLCTY	(5) VLCTY	(2-1)	(3-1)	(4-1)	(5-1)
					---- 100.YEAR ----				
320.00	4.18	4.16	3.13	0.00	0.00	-0.02	-1.05	0.00	0.00
320.10	3.24	3.23	1.87	0.00	0.00	-0.01	-1.37	0.00	0.00
320.20	3.91	3.89	5.83	0.00	0.00	-0.02	1.92	0.00	0.00
320.30	3.91	3.89	5.65	0.00	0.00	-0.02	1.74	0.00	0.00
320.40	3.24	3.23	1.81	0.00	0.00	-0.01	-1.43	0.00	0.00
320.50	4.15	4.12	3.02	0.00	0.00	-0.03	-1.13	0.00	0.00
1210.00	3.43	3.41	6.81	0.00	0.00	-0.02	3.38	0.00	0.00
1695.00	2.48	2.46	3.32	0.00	0.00	-0.02	0.84	0.00	0.00
1705.00	2.84	2.80	4.09	0.00	0.00	-0.04	1.25	0.00	0.00
1715.00	2.79	2.76	4.68	0.00	0.00	-0.03	1.89	0.00	0.00
1765.00	2.78	2.74	4.66	0.00	0.00	-0.04	1.88	0.00	0.00
2965.00	3.49	3.45	4.29	0.00	0.00	-0.04	0.80	0.00	0.00
3750.00	3.04	3.00	4.91	0.00	0.00	-0.04	1.87	0.00	0.00
4628.00	4.02	3.97	4.84	0.00	0.00	-0.05	0.82	0.00	0.00
4728.00	4.01	3.96	4.83	0.00	0.00	-0.05	0.82	0.00	0.00
4733.00	2.30	2.27	4.82	0.00	0.00	-0.03	2.52	0.00	0.00
4783.00	3.97	3.92	4.81	0.00	0.00	-0.05	0.84	0.00	0.00
5040.00	2.89	2.85	4.37	0.00	0.00	-0.04	1.48	0.00	0.00
5765.00	2.76	2.71	4.93	0.00	0.00	-0.05	2.17	0.00	0.00
7134.00	3.45	3.40	4.84	0.00	0.00	-0.05	1.39	0.00	0.00
8436.00	4.46	4.40	4.54	0.00	0.00	-0.06	0.08	0.00	0.00
8900.00	4.81	4.76	6.27	0.00	0.00	-0.05	1.46	0.00	0.00
9510.00	6.11	6.06	6.39	0.00	0.00	-0.05	0.28	0.00	0.00
10170.00	7.24	7.17	6.34	0.00	0.00	-0.07	-0.90	0.00	0.00
10385.00	5.49	5.47	5.88	0.00	0.00	-0.02	0.39	0.00	0.00
10445.00	5.49	5.47	5.88	0.00	0.00	-0.02	0.39	0.00	0.00
10630.00	3.01	3.07	2.49	0.00	0.00	0.06	-0.52	0.00	0.00
11015.00	3.88	3.96	2.68	0.00	0.00	0.08	-1.20	0.00	0.00
11390.00	3.33	3.40	2.72	0.00	0.00	0.07	-0.61	0.00	0.00
11710.00	2.41	2.46	2.37	0.00	0.00	0.05	-0.04	0.00	0.00
12050.00	1.60	1.63	1.82	0.00	0.00	0.03	0.22	0.00	0.00
12400.00	6.07	6.15	3.67	0.00	0.00	0.08	-2.40	0.00	0.00
13030.00	7.76	7.82	4.58	0.00	0.00	0.06	-3.18	0.00	0.00
13500.00	8.02	8.11	6.93	0.00	0.00	0.09	-1.09	0.00	0.00
14270.00	7.06	7.12	12.99	0.00	0.00	0.06	5.93	0.00	0.00
14700.00	10.41	10.52	12.53	0.00	0.00	0.11	2.12	0.00	0.00
14958.00	6.94	7.02	7.54	0.00	0.00	0.08	0.60	0.00	0.00
15040.00	8.54	8.64	9.36	0.00	0.00	0.10	0.82	0.00	0.00
15100.00	8.38	8.48	9.11	0.00	0.00	0.10	0.73	0.00	0.00
15200.00	9.64	9.70	11.06	0.00	0.00	0.06	1.42	0.00	0.00
15930.00	6.70	6.71	8.15	0.00	0.00	0.01	1.45	0.00	0.00

***** END OF COMPARISON OF PROFILE NO. 7 *****

NOTE : (1) -- EXISTING 1984 CONDITIONS PEQUANNOCK RIVER
(2) -- 2040 WITHOUT PROJECT CONDITIONS PEQUANNOCK RIVER
(3) -- 2040 WITH PROJECT CONDITIONS PEQUANNOCK RIVER

TABLE II-12. DISCHARGE COMPARISON --- PEQUANNOCK RIVER

PEQUANNOCK R. @ CNFLNCE WITH PMPTN R. ----- 100.YEAR -----

STATION	(1) DSCHRG	(2) DSCHRG	(3) DSCHRG	(4) DSCHRG	(5) DSCHRG	(2-1)	(3-1)	(4-1)	(5-1)
					** DATAS DIVIDED BY 100. **				
320.00	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
320.10	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
320.20	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
320.30	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
320.40	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
320.50	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
1210.00	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
1695.00	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
1705.00	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
1715.00	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
1765.00	32515.00	32907.00	33880.00	0.00	0.00	3.92	13.65	0.00	0.00
2965.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
3750.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
4628.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
4728.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
4733.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
4783.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
5040.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
5765.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
7134.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
8436.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
8900.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
9510.00	16722.00	16776.00	17321.00	0.00	0.00	0.54	5.99	0.00	0.00
10170.00	17467.00	17445.00	17584.00	0.00	0.00	-0.22	1.17	0.00	0.00
10385.00	17467.00	17445.00	17584.00	0.00	0.00	-0.22	1.17	0.00	0.00
10445.00	17467.00	17445.00	17584.00	0.00	0.00	-0.22	1.17	0.00	0.00
10630.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
11015.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
11390.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
11710.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
12050.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
12400.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
13030.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
13500.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
14270.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
14700.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
14958.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
15040.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
15100.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
15200.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00
15930.00	7647.00	7840.00	7912.00	0.00	0.00	1.93	2.65	0.00	0.00

***** END OF COMPARISON OF PROFILE NO. 7 *****

NOTE : (1) -- EXISTING 1984 CONDITIONS PEQUANNOCK RIVER
(2) -- 2040 WITHOUT PROJECT CONDITIONS PEQUANNOCK RIVER
(3) -- 2040 WITH PROJECT CONDITIONS PEQUANNOCK RIVER

TABLE II-13 DIVERSION SYSTEM RATING CURVES --- POMPTON INLET

POMPTON RIVER CONTROL SECTION					MORNING GLORY SPILLWAY(84' DIAM.)				
RIVER EGL FT.MSL	BOX CULVERT CFS	EMERGENCY-SPILLWAY WEIR-FLOW CFS	EMBKMNT CFS	TOTAL R.BPSS	EGL FT.MSL	Co	Q CFS	COMMENT	TOTAL FLOW
163.0	0	0	0	0	0	0	0		
169.2	0	0	0	500	0	0	0		500
169.5	500	0	0	500	0	0	0		500
170.64	500	0	0	500	170	4.00	1388		1888
171.89	500	0	0	500	171.23	4.0	3971	1-YR	4471
172.75	500	0	0	500	172.0	4.0	6042		6542
175.02	500	0	0	500	174.0	4.0	12517		13017
175.72	500	0	0	500	174.64	4.0	14883	10-YR	15383
178.95	1145	0	0	1145	177.49	3.94	26642	50-YR	27787
179.5	5171	0	0	5171	177.95	3.93	28709	100-YR	33880
188.6	5248	1775	9903	16926	188.09		29587	TNL-CNTRL	46513
188.7	7422	3621	20294	31337	188.2		29596	TNL-CNTRL	60933

NOTE: BY INTERPOLATION, 500-YR W.S. = 188.68 (Q =57584 CFS)
SPF W.S = 188.68 (Q = 57369 CFS)
Co = WEIR COEFFICIENT

TABLE II - 14 DIVERSION SYSTEM RATING CURVES -- TWO BRIDGES INLET

					MORNING GLORY SPILLWAY (56' DIAM.)					
RIVER EGL FT-MSL	DOWN-RIVER FLOW W/DAM	DIVERSION SPILLWAY Cs/Co	DIVERSION SPILLWAY Q-CFS	EGL FT-MSL	Co	Q CFS	COMMENT	TOTAL FLOW CFS W/DAM	DOWN RIVER FLOW W/O DAM	TOTAL FLOW CFS W/O DAM
151.5	0	0	0	0		0		0	0	0
152.6*	0	0	0	0	-	0	-	0	0	0
154.66*	100	1.0	3657	150	4	3657	-	3757	400	4057
156.03*	100	1.0	7868	152	4	7868	-	7968	480	8348
157.3*	100	1.0	12805	154	3.93	12805	-	12905	490	13295
158.02	100	0.985	15446	155	3.88	15446	-	15546	500	15946
158.4	150	0.90	15556	157	-	15556	TNNL-CONTROL	15706	510	16066
159.75	1780	0.66	15665	159	-	15665	TNNL-CONTROL	17445	1800	17465
161.55	3200	0.475	15774	161	-	15774	TNNL-CONTROL	18974	3600	19374
163.33	4602	0.365	15882	163	-	15882	TNNL-CONTROL	20484	5700	21582
165.24	7750	0.28	15989	165	-	24989	TNNL-CONTROL	23739	8500	24489
167.31	10630	0.23	16096	167	-	16096	TNNL-CONTROL	26726	12300	28396
169.24	16186	0.193	16201	169	-	16201	TNNL-CONTROL	32387	16700	32901
171.25	17750	0.163	16306	171	-	16306	TNNL-CONTROL	34056	21400	37706
173.25	27564	0.14	16411	173	-	16411	TNNL-CONTROL	43975	29500	45911

NOTE: Co = DIVERSION SPILLWAY (WEIR) COEFFICIENT (Co=3.1 WITH BASCULE GATE).
Cs = WEIR COEFFICIENT OF SUBMERGENCE.
Cs/Co = SUBMERGENCE CORRECTION FACTOR.

* THE RIVER STAGE IS 158.02 BY CONTROLLING BASCULE GATES TO BYPASS 100 CFS OVER THE BEATTIES DAM.

TABLE II-15 OPERATION PROCEDURE FOR POMPTON INLET DURING 100 YEAR FLOOD 2/

STEP	Water Surface Elev. at River	Control Gate	Operation Condition	Bypass Flow (cfs)	Tunnel Flow (cfs)	Total Pompton R. Flow (cfs)
1.	W.S. El. Reaches 169.5	1-16.5'x 32' Roller Gate	Start Closing	500	0	500
2.	W.S. El. Reaches 169.5	5-5.5'X'75' Bascule Gates	Open Completely 3/	500	1	501
3.	W.S. El. Reaches 179.5	1-16.5'x 32' Roller Gates	Stop Closing	500	28709	29209
4.	W.S. El. Over 179.5	1-16.5'x 32' Roller Gates	Start Opening	501	28709	29210
5.	At Peak Flow Condition 1/	5-15'x'75' Bascule Gates 1-16.5'x,32' Roller Gate	Completely Open Completely Open	5171 5171	28709 28709	33880 33880
6.	W.S. El. Below 179.5	1-16.5'x 32' Roller Gate	Start Close 4/	499	28709	29208
7.	W.S. El. at 169.5	1-16.5'x 32' Roller Gate	Stop Close	500	0	500
8.	W.S. El. Below 169.5	5-5.5' X 75' Bascule Gates	Completely Close	500	0	<500
9.	W.S. El. Below 169.5	1-16.5'x 32' Roller Gate	Completely Open	500	0	<500

NOTE: 1/ When storms larger than the 100 year design storm occur, the emergency spillway gates (4 16.5' X 28' Roller Gates) are operated (opened) to prevent overtopping of the flow restrictor.

2/ This table does not include the rules for bypass flows to be made after flood flow peaks for fish and wildlife and other environmental purposes and operation of the Pequannock Weir.

3/ Operation center has clear indication that 1 year flood event will be exceeded and Pequannock Weir is gradually opened.

4/ The Pequannock Weir starts to close.

TABLE II-16 OPERATION PROCEDURE FOR TWO BRIDGES INLET DURING 100 YEAR FLOOD 5/

STEP	Water Surface Elev. at Beatties Dam	Control Gate	Operation Condition	Bypass Flow (cfs)	Tunnel Flow (cfs)	Total Passaic R. Flow (cfs)
	Normal Flow	4-11'x 100' Basule Gates	Closed	Normal	0	Normal Flow
1.	Start of flood event 1/	4-11'x 100' Basule Gates	Start Open 4/	100	Flood Flow-100	101
2.	W.S. El. >158.0 2/	4-11'x 100' Bascule Gates	Start Close	100+	8030	8131
3.	W.S. El.= 166.0 3/	4-11'x 100' Bascule Gates	Closed	9128	1	9127
4.	W.S. El.= 166.0 2/	4-11'x 100' Bascule Gates	Start Open	9232	27	9259
5.	W.S. El.= 158.0	4-11'x 100' Bascule Gates	Start Close	100	12998	13098
6.	Flood Flow Decreasing	4-11'x 100' Bascule Gates	Start Close	100	Flood Flow-100	Flood Flow
7.	Flood event ended	4-11'x 100' Bascule Gates	Closed	100+	0	Normal Flow

NOTE: 1/ Gates must close to maintain priority diversion at Pompton Inlet.

2/ Gates are closed to allow maximum diversion at Pompton Inlet.

3/ Gates begin opening as Pompton flows decrease and Passaic flows are diverted to make use of available tunnel capacity.

4/ Operations center has clear indication that 1 year flood event will be exceeded.

5/ This table does not include the rules for bypass flows to be made after flood flow peaks for fish and wildlife and other environmental purposes.

TABLE II-17 LOW FLOW COMPARISON - GREAT PIECE MEADOWS WEIR

Station (FT)	Existing Condition 1yr Stage (FT)	Discharge (CFS)	Improved Stage w/Weir (FT)	Difference (FT)
175390	164.17	100	158.02	Downstream of Proposed Weir
		500	158.02	
		1000	158.02	
		1500	158.04	
		2000	158.07	
		2500	158.10	
		3143	158.16	
184170	164.25	100	164.17	-.08
		500	164.19	-.06
		1000	164.23	-.02
		1500	164.31	+.06
		2000	164.41	+.15
		2500	164.52	+.26
		3143	164.68	+.41
187420	164.27	100	164.17	-.10
		500	164.19	-.08
		1000	164.25	-.02
		1500	164.35	+.07
		2000	164.47	+.19
		2500	164.60	+.32
		3143	164.79	+.50
194000	164.40	100	164.17	-.23
		500	164.21	-.19
		1000	164.34	-.06
		1500	164.53	+.13
		2000	164.76	+.36
		2500	165.00	+.60
		3143	165.30	+.90
213370	165.98	100	164.18	-1.80
		500	164.44	-1.54
		1000	165.07	- .91
		1500	165.65	- .33
		2000	166.12	+ .14
		2500	166.50	+ .52
		3143	166.92	+ .94

TABLE II-18

ANALYSIS OF TIMING OF 100 YEAR EXTERIOR AND INTERIOR EVENTS FOR WITHOUT PROJECT CONDITIONS

	Lower Valley Tidal	Lower Valley Mitigation	Central Basin Fluvial	Upper Pompton Tunnel Inlet
Ground Elevation (feet)	6	9	172	180
INTERIOR PEAK				
Interior Peak Time (hour)	18	17	18	18
Interior Peak Discharge (cfs)	5,363	2,455	1,064	513
Exterior Discharge Coincidental to Interior Peak (cfs)	Tidal Surge	Tidal Surge	1,459	6,728
Exterior Stage Coincidental to Interior Peak (feet)	10.0	10.0	174	182.5
Time of Exterior Event Coincidental to Interior Peak (hour)	18	17	18	18
Blocked Gravity Conditions	YES	YES	YES	YES
Exterior Peak				
Exterior Peak Time (hour)	A/	66	47	29
Exterior Peak Discharge (cfs)	Tidal Surge	26,455	6,242	20,241
Exterior Peak Stage (feet)	10.0	9.7	178	188
Interior Discharge Coincidental to Exterior Peak (cfs)	5,363	84	191	98
Time of Interior Event Coincidental to Exterior Peak (hour)	18	66	47	29
Blocked Gravity Conditions	YES	YES	YES	YES

A/ Although the timing of the 100 year tidal stage of 10.0 can not be predicted with certainty, the likelihood of coincidence between tidal surges and interior events is high since tidal surges are caused either by hurricane storms which are intense in rainfall and of short duration, or by northeaster storms which can have a longer duration but more moderate rainfall.

TABLE II-19

SUMMARY OF INTERIOR FLOOD LOSS REDUCTION MEASURES

AREA	HYDRAULIC CONTROL	NUMBER LEVEE SYSTEMS	NUMBER OF SUBAREAS	SUBAREAS WITH ONLY PONDS	SUBAREAS WITH ONLY PRESSURE INTERCEPTORS	SUBAREAS WITH ONLY PUMPING
Lower Valley	Tidal	5	11	2	0	9
Lower Valley	Tunnel Mitigation	9	26	0	0	26
Central Passaic	Fluvial	7	26	19	5	2
Upper Pompton	Integral	5	9	8	0	1
	Total	26	72	29	5	38

TABLE II-20

SUMMARY OF INTERIOR FLOOD CONTROL
FACILITY DESIGN SELECTED FOR EACH LEVEE/FLOODWALL SYSTEM

SYSTEM NAME	SUBAREA	INTERIOR FLOOD CONTROL FACILITY
LOWER VALLEY		
TIDAL:		
KEARNY POINT	3	PUMPING 349 cfs pump 335 cfs pump POND AREA DEPTH 4ft. AREA 50.4 acres
DOREMUS AVE.	2	PUMPING 253cfs pump 253cfs pump
N.J. TURNPIKE	1	POND AREA DEPTH 4ft. AREA 23 acres
LISTER AVE.	3	PUMPING 270cfs pump 255cfs pump 349 cfs pump
SOUTH 1ST	2	PUMPING 200cfs pump 257cfs pump
MITIGATION:		
RIVER ROAD #1	2	PUMPING 299cfs pump 319cfs pump

TABLE II-20 (CONT)

SYSTEM NAME	SUBAREA	INTERIOR FLOOD CONTROL FACILITY
MAIN STREET	4	PUMPING 228cfs pump 253cfs pump 255cfs pump 337cfs pump
RIVER ROAD #2	4	PUMPING 217cfs pump 237cfs pump 297cfs pump 345cfs pump
RIVERSIDE AVE. #1	5	PUMPING 263cfs pump 311cfs pump 318cfs pump 401cfs pump 429cfs pump
YANTACAW	1	PUMPING 299cfs pump
RIVERSIDE AVE #2	5	PUMPING 222cfs pump 228cfs pump 239cfs pump 239cfs pump 355cfs pump
RIVER ST. - MAIN AVE.	2	PUMPING 325cfs pump 62cfs pump
RIVER DRIVE #1	2	PUMPING 358cfs pump 400cfs pump
8TH STREET	1	PUMPING 211cfs pump

TABLE II-20 (CONT)

SYSTEM NAME	SUBAREA	INTERIOR FLOOD CONTROL FACILITY
CENTRAL BASIN		
FLUVIAL:		
PASSAIC 2A	6	POND AREA DEPTH 4ft. AREA 57.62 acres DEPTH 2ft. AREA 100 acres DEPTH 2ft. AREA 133.4 acres DEPTH 4ft. AREA 52.8 acres DEPTH 4ft. AREA 25.0 acres DEPTH 4ft. AREA 20.7 acres
PASSAIC 2C	1	DEPTH 4ft. AREA 6.82 acres
PASSAIC 10	2	POND AREA DEPTH 4ft. AREA 8.55 acres DEPTH 4ft. AREA 10.39 acres
ROCKAWAY 1	6	POND AREA DEPTH 54ft. AREA 3.3 acres DEPTH 5ft. AREA 13.0 acres DEPTH 2ft. AREA 2.4 acres DEPTH 4ft. AREA 28.1 acres DEPTH 6ft. AREA 18.5 acres DEPTH 3.5ft. AREA 18.9 acres

TABLE II-20 (CONT)

SYSTEM NAME	SUBAREA	INTERIOR FLOOD CONTROL FACILITY
ROCKAWAY 2	7	POND AREA DEPTH 4ft. AREA 27.5 acres DEPTH 5ft. AREA 10.5 acres PRESSURE INTERCEPTOR DIAMETER 42in. LENGTH 3,400ft. DIAMETER 48in. LENGTH 3,700ft. DIAMETER 42in. LENGTH 3,800ft. DIAMETER 36in. LENGTH 1,800ft. PUMPING 148cfs pump
ROCKAWAY 3	3	PUMPING 188cfs pump PONDING AREA DEPTH 4ft. AREA 26 acres PRESSURE INTERCEPTOR DIAMETER 6ft. LENGTH 2,800ft.
PINCH BROOK	1	POND AREA DEPTH 5.5ft. AREA 7.23 acres

TABLE II-20 (CONT)

SYSTEM NAME	SUBAREA	INTERIOR FLOOD CONTROL FACILITY
POMPTON VALLEY		
INTEGRAL TO TUNNEL:		
SHORE ROAD	3	POND AREA DEPTH 5ft. AREA 8.38 acres DEPTH 5ft. AREA 4.88acres DEPTH 4ft. AREA 8.21 acres
PEQUANNOCK-RAMAPO	3	POND AREA DEPTH 4ft. AREA 11.76 acres DEPTH 3ft. AREA 25.82 acres DEPTH 4ft. AREA 7.98 acres
STILES COURT	1	POND AREA DEPTH 4ft. AREA 2.07 acres
HILL COURT	1	POND AREA DEPTH 4.5ft. AREA 1.55 acres
WANAQUE AVENUE	1	PUMPING 217cfs pump

TABLE II - 21

SUBAREA CHARACTERISTICS AND SELECTED INTERIOR FLOOD CONTROL FACILITIES

A. LOWER VALLEY SYSTEMS

SUBAREA	DRAINAGE AREA (SQ MILE)	L (MILE)	LCA (MILE)	Cp	Ct	Tp (HOUR)	100 YR PEAK Q (CFS)	TYPE OF FACILITY
Kearny 1	0.35	0.62	0.33	0.44	4.2	2.61	349	Pumping Station
Kearny 2	0.36	0.85	0.38	0.44	4.2	0.99	335	Pumping Station
Lister 1	.23	.625	.375	.76	2.0	1.29	278	Pumping Station
Lister 2	0.20	.5	0.35	0.76	2.0	1.2	225	Pumping Station
Lister 3	0.27	0.69	0.25	0.76	2.0	1.18	349	Pumping Station
8th Street	0.197	1.54	0.91	0.45	0.75	0.826	211	Pumping Station
B. PEQUANNOCK, RAMAPO AND WANAQUE LEVEE SYSTEMS (POMPTON PLAINS)								
Pequannock - Ramapo								
- Pequannock 1a	.07	.34	.23	.31	.51	.24	115	Pond
- Pequannock 1b	.24	492	.3	.31	.51	.287	372	Pond
- Ramapo 1	.03	.227	.075	.38	.284	.084	56	Pond
- Ramapo 2	.15	.594	.133	.38	.284	.129	292	Pond
Wanaque Ave	.11	.24	.24	.306	.44	.226	217	Pumping Station

TABLE II-22. EXISTING AND IMPROVED THALWEG COMPARISON

Station (ft)	Length (ft)	Improved Bottom Width (ft)	Average Existing Slope (%)	Improved Bottom Slope (%)	Channel Protection
Passaic River					
171220 to 17590	4170	170	-0.17	-0.048	18" Riprap Transition
Pompton River					
0-1835	1835	150	-0.19	+.0375	18" Riprap Transition
Pequannock River					
0-1800	1800	129	+.11	+0.03	24" Riprap Channel
1800-4500	2700	100	+.11	-0.1	-
4500-11500	7000	100	+.13	+0.047	24" Riprap Bridges
11500-13450	1950	74	-0.05	+0.45	24" Riprap Transition
Ramapo River					
0-3600	3600	100	-0.01	+.023	18" Riprap Channel
3600-6500	2900	60	+0.023	+.023	18" Riprap Channel
Wanaque River					
0-2450	2450	74	+0.18	+0.17	-
2450-4950	2500	74	-0.16	+0.26	24" Riprap Transition

Note: 2 on 1 side-slopes for all improved channels.

TABLE II-23 VELOCITY COMPARISON --- WITH AND WITHOUT PROJECT(2040) CONDITIONS

PASSAIC RIVER ---- BEATTIE'S DAM ---- 100.YEAR ----

STATION	(1) VLCTY	(2) VLCTY	(3) VLCTY	(4) VLCTY	(5) VLCTY	(2-1)	(3-1)	(4-1)	(5-1)
156816.00	15.83	11.48	0.00	0.00	0.00	-4.35	0.00	0.00	0.00
156855.00	10.31	6.20	0.00	0.00	0.00	-4.11	0.00	0.00	0.00
156865.00	6.75	3.12	0.00	0.00	0.00	-3.63	0.00	0.00	0.00
156982.00	8.00	4.60	0.00	0.00	0.00	-3.40	0.00	0.00	0.00
157310.00	7.24	3.75	0.00	0.00	0.00	-3.49	0.00	0.00	0.00
157600.00	5.53	3.12	0.00	0.00	0.00	-2.41	0.00	0.00	0.00
157900.00	8.26	4.81	0.00	0.00	0.00	-3.45	0.00	0.00	0.00
158280.00	4.32	2.33	0.00	0.00	0.00	-1.99	0.00	0.00	0.00
158710.00	2.87	2.14	0.00	0.00	0.00	-0.73	0.00	0.00	0.00
159330.00	4.74	3.34	0.00	0.00	0.00	-1.40	0.00	0.00	0.00
159900.00	6.63	4.32	0.00	0.00	0.00	-2.31	0.00	0.00	0.00
160690.00	5.83	4.06	0.00	0.00	0.00	-1.77	0.00	0.00	0.00
161470.00	4.69	2.93	0.00	0.00	0.00	-1.76	0.00	0.00	0.00
162290.00	3.35	2.74	0.00	0.00	0.00	-0.61	0.00	0.00	0.00
162724.00	4.37	3.30	0.00	0.00	0.00	-1.07	0.00	0.00	0.00
162774.00	6.50	3.41	0.00	0.00	0.00	-3.09	0.00	0.00	0.00
162790.00	6.38	3.41	0.00	0.00	0.00	-2.97	0.00	0.00	0.00
162840.00	6.37	3.40	0.00	0.00	0.00	-2.97	0.00	0.00	0.00
163043.00	4.84	2.86	0.00	0.00	0.00	-1.98	0.00	0.00	0.00
163097.00	4.75	2.86	0.00	0.00	0.00	-1.89	0.00	0.00	0.00
163147.00	4.75	2.86	0.00	0.00	0.00	-1.89	0.00	0.00	0.00
163620.00	4.41	3.14	0.00	0.00	0.00	-1.27	0.00	0.00	0.00
163800.00	4.32	3.05	0.00	0.00	0.00	-1.27	0.00	0.00	0.00
164580.00	4.45	3.01	0.00	0.00	0.00	-1.44	0.00	0.00	0.00
165200.00	5.76	3.27	0.00	0.00	0.00	-2.49	0.00	0.00	0.00
165600.00	5.98	3.51	0.00	0.00	0.00	-2.47	0.00	0.00	0.00
166070.00	5.70	3.54	0.00	0.00	0.00	-2.16	0.00	0.00	0.00
167000.00	4.35	2.74	0.00	0.00	0.00	-1.61	0.00	0.00	0.00
167420.00	6.89	4.96	0.00	0.00	0.00	-1.93	0.00	0.00	0.00
167600.00	4.38	3.27	0.00	0.00	0.00	-1.11	0.00	0.00	0.00
168280.00	4.42	3.24	0.00	0.00	0.00	-1.18	0.00	0.00	0.00
169300.00	5.18	3.14	0.00	0.00	0.00	-2.04	0.00	0.00	0.00
170090.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
170920.00	4.37	3.51	0.00	0.00	0.00	-0.86	0.00	0.00	0.00
171050.00	6.51	3.37	0.00	0.00	0.00	-3.14	0.00	0.00	0.00
171105.00	6.49	3.37	0.00	0.00	0.00	-3.12	0.00	0.00	0.00
171165.00	6.48	3.37	0.00	0.00	0.00	-3.11	0.00	0.00	0.00
171220.00	6.47	3.37	0.00	0.00	0.00	-3.10	0.00	0.00	0.00
171450.00	2.72	2.37	0.00	0.00	0.00	-0.35	0.00	0.00	0.00
171730.00	5.18	2.33	0.00	0.00	0.00	-2.85	0.00	0.00	0.00
171790.00	5.18	2.33	0.00	0.00	0.00	-2.85	0.00	0.00	0.00
171840.00	5.17	2.32	0.00	0.00	0.00	-2.85	0.00	0.00	0.00
171900.00	5.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
171911.00		2.31	0.00	0.00	0.00				
172000.00	4.08	2.11	0.00	0.00	0.00	-1.97	0.00	0.00	0.00
172860.00	6.18	2.19	0.00	0.00	0.00	-3.99	0.00	0.00	0.00
173500.00	4.74	3.45	0.00	0.00	0.00	-1.29	0.00	0.00	0.00
173860.00	3.04	2.28	0.00	0.00	0.00	-0.76	0.00	0.00	0.00
173940.00	3.44	2.50	0.00	0.00	0.00	-0.94	0.00	0.00	0.00
173990.00	3.61	2.53	0.00	0.00	0.00	-1.08	0.00	0.00	0.00
174060.00	3.43	2.50	0.00	0.00	0.00	-0.93	0.00	0.00	0.00

NOTE : (1) = WITHOUT PROJECT(2040) CONDITIONS
(2) = WITH PROJECT(2040) CONDITIONS

TABLE II-23(CONTD) VELOCITY COMPARISON --- WITH AND WITHOUT PROJECT(2040) CONDITIONS

PASSAIC RIVER ---- TWO BRIDGES ---- 100.YEAR ----

STATION	(1) VLCTY	(2) VLCTY	(3) VLCTY	(4) VLCTY	(5) VLCTY	(2-1)	(3-1)	(4-1)	(5-1)
174630.00	0.80	1.24	0.00	0.00	0.00	0.44	0.00	0.00	0.00
175390.00	0.71	1.42	0.00	0.00	0.00	0.71	0.00	0.00	0.00
184170.00	0.46	1.16	0.00	0.00	0.00	0.70	0.00	0.00	0.00
187420.00	0.52	1.55	0.00	0.00	0.00	1.03	0.00	0.00	0.00
194000.00	0.60	2.15	0.00	0.00	0.00	1.55	0.00	0.00	0.00
213370.00	0.70	2.01	0.00	0.00	0.00	1.31	0.00	0.00	0.00
217750.00	0.68	1.75	0.00	0.00	0.00	1.07	0.00	0.00	0.00
219860.00	1.80	2.13	0.00	0.00	0.00	0.33	0.00	0.00	0.00
219887.00	1.79	2.06	0.00	0.00	0.00	0.27	0.00	0.00	0.00
220187.00	1.78	2.04	0.00	0.00	0.00	0.26	0.00	0.00	0.00
224000.00	1.99	1.82	0.00	0.00	0.00	-0.17	0.00	0.00	0.00
226375.00	2.40	2.32	0.00	0.00	0.00	-0.08	0.00	0.00	0.00
230300.00	3.67	2.69	0.00	0.00	0.00	-0.98	0.00	0.00	0.00
230950.00	2.59	1.45	0.00	0.00	0.00	-1.14	0.00	0.00	0.00
231150.00	2.59	1.37	0.00	0.00	0.00	-1.22	0.00	0.00	0.00
231860.00	1.79	2.07	0.00	0.00	0.00	0.28	0.00	0.00	0.00
234650.00	3.10	1.79	0.00	0.00	0.00	-1.31	0.00	0.00	0.00
234755.00	3.06	1.79	0.00	0.00	0.00	-1.27	0.00	0.00	0.00
235585.00	2.88	3.50	0.00	0.00	0.00	0.62	0.00	0.00	0.00
236330.00	2.72	3.58	0.00	0.00	0.00	0.86	0.00	0.00	0.00
236420.00	2.49	3.56	0.00	0.00	0.00	1.07	0.00	0.00	0.00
238590.00	1.23	2.14	0.00	0.00	0.00	0.91	0.00	0.00	0.00
240380.00	1.09	2.30	0.00	0.00	0.00	1.21	0.00	0.00	0.00

POMPTON R. @ CNFLNCE WITH PASSAIC R. ---- 100.YEAR ----

STATION	(1) VLCTY	(2) VLCTY	(3) VLCTY	(4) VLCTY	(5) VLCTY	(2-1)	(3-1)	(4-1)	(5-1)
830.00	5.58	1.54	0.00	0.00	0.00	-4.04	0.00	0.00	0.00
1010.00	5.65	1.54	0.00	0.00	0.00	-4.11	0.00	0.00	0.00
1480.00	5.79	1.64	0.00	0.00	0.00	-4.15	0.00	0.00	0.00
1835.00	5.21	1.77	0.00	0.00	0.00	-3.44	0.00	0.00	0.00
2290.00	3.47	1.28	0.00	0.00	0.00	-2.19	0.00	0.00	0.00
2810.00	3.72	1.54	0.00	0.00	0.00	-2.18	0.00	0.00	0.00
2950.00	4.11	1.61	0.00	0.00	0.00	-2.50	0.00	0.00	0.00
3840.00	4.36	2.14	0.00	0.00	0.00	-2.22	0.00	0.00	0.00
3945.00	4.26	1.85	0.00	0.00	0.00	-2.41	0.00	0.00	0.00
4130.00	4.25	1.76	0.00	0.00	0.00	-2.49	0.00	0.00	0.00
4590.00	2.77	1.19	0.00	0.00	0.00	-1.58	0.00	0.00	0.00
4935.00	3.62	1.41	0.00	0.00	0.00	-2.21	0.00	0.00	0.00
5540.00	3.63	1.48	0.00	0.00	0.00	-2.15	0.00	0.00	0.00
6980.00	5.97	2.51	0.00	0.00	0.00	-3.46	0.00	0.00	0.00
7310.00	6.26	2.41	0.00	0.00	0.00	-3.85	0.00	0.00	0.00
7470.00	7.47	2.93	0.00	0.00	0.00	-4.54	0.00	0.00	0.00
7514.00	7.47	2.93	0.00	0.00	0.00	-4.54	0.00	0.00	0.00
7675.00	6.11	2.10	0.00	0.00	0.00	-4.01	0.00	0.00	0.00
7940.00	4.83	1.67	0.00	0.00	0.00	-3.16	0.00	0.00	0.00
8510.00	8.52	3.16	0.00	0.00	0.00	-5.36	0.00	0.00	0.00
8805.00	8.22	3.03	0.00	0.00	0.00	-5.19	0.00	0.00	0.00
9320.00	7.19	3.05	0.00	0.00	0.00	-4.14	0.00	0.00	0.00
9520.00	7.15	3.30	0.00	0.00	0.00	-3.85	0.00	0.00	0.00
9660.00	6.89	3.32	0.00	0.00	0.00	-3.57	0.00	0.00	0.00
9940.00	5.75	2.75	0.00	0.00	0.00	-3.00	0.00	0.00	0.00
10525.00	5.82	3.49	0.00	0.00	0.00	-2.33	0.00	0.00	0.00
11250.00	5.72	2.42	0.00	0.00	0.00	-3.30	0.00	0.00	0.00
11780.00	4.75	2.22	0.00	0.00	0.00	-2.53	0.00	0.00	0.00
12240.00	5.89	3.02	0.00	0.00	0.00	-2.87	0.00	0.00	0.00
12430.00	6.17	3.16	0.00	0.00	0.00	-3.01	0.00	0.00	0.00
12720.00	5.52	2.69	0.00	0.00	0.00	-2.83	0.00	0.00	0.00
13250.00	5.61	2.45	0.00	0.00	0.00	-3.16	0.00	0.00	0.00
13655.00	6.42	2.37	0.00	0.00	0.00	-4.05	0.00	0.00	0.00

NOTE : (1) = WITHOUT PROJECT(2040) CONDITIONS
(2) = WITH PROJECT(2040) CONDITIONS

TABLE II-23(CONTD) VELOCITY COMPARISON --- WITH AND WITHOUT PROJECT(2040) CONDITIONS

PEQUANNOCK R. @ CNFLNCE WITH POMPTON R. ---- 100.YEAR ----

STATION	(1) VLCTY	(2) VLCTY	(3) VLCTY	(4) VLCTY	(5) VLCTY	(2-1)	(3-1)	(4-1)	(5-1)
320.00	4.16	3.13	0.00	0.00	0.00	-1.03	0.00	0.00	0.00
320.10	3.23	1.87	0.00	0.00	0.00	-1.36	0.00	0.00	0.00
320.20	3.89	5.83	0.00	0.00	0.00	1.94	0.00	0.00	0.00
320.30	3.89	5.65	0.00	0.00	0.00	1.76	0.00	0.00	0.00
320.40	3.23	1.81	0.00	0.00	0.00	-1.42	0.00	0.00	0.00
320.50	4.12	3.02	0.00	0.00	0.00	-1.10	0.00	0.00	0.00
1210.00	3.41	6.81	0.00	0.00	0.00	3.40	0.00	0.00	0.00
1695.00	2.46	3.32	0.00	0.00	0.00	0.86	0.00	0.00	0.00
1705.00	2.80	4.09	0.00	0.00	0.00	1.29	0.00	0.00	0.00
1715.00	2.76	4.68	0.00	0.00	0.00	1.92	0.00	0.00	0.00
1765.00	2.74	4.66	0.00	0.00	0.00	1.92	0.00	0.00	0.00
2965.00	3.45	4.29	0.00	0.00	0.00	0.84	0.00	0.00	0.00
3750.00	3.00	4.91	0.00	0.00	0.00	1.91	0.00	0.00	0.00
4628.00	3.97	4.84	0.00	0.00	0.00	0.87	0.00	0.00	0.00
4728.00	3.96	4.83	0.00	0.00	0.00	0.87	0.00	0.00	0.00
4733.00	2.27	4.82	0.00	0.00	0.00	2.55	0.00	0.00	0.00
4783.00	3.92	4.81	0.00	0.00	0.00	0.89	0.00	0.00	0.00
5040.00	2.85	4.37	0.00	0.00	0.00	1.52	0.00	0.00	0.00
5765.00	2.71	4.93	0.00	0.00	0.00	2.22	0.00	0.00	0.00
7134.00	3.40	4.84	0.00	0.00	0.00	1.44	0.00	0.00	0.00
8436.00	4.40	4.54	0.00	0.00	0.00	0.14	0.00	0.00	0.00
8900.00	4.76	6.27	0.00	0.00	0.00	1.51	0.00	0.00	0.00
9510.00	6.06	6.39	0.00	0.00	0.00	0.33	0.00	0.00	0.00
10170.00	7.17	6.34	0.00	0.00	0.00	-0.83	0.00	0.00	0.00
10385.00	5.47	5.88	0.00	0.00	0.00	0.41	0.00	0.00	0.00
10445.00	5.47	5.88	0.00	0.00	0.00	0.41	0.00	0.00	0.00
10630.00	3.07	2.49	0.00	0.00	0.00	-0.58	0.00	0.00	0.00
11015.00	3.96	2.68	0.00	0.00	0.00	-1.28	0.00	0.00	0.00
11390.00	3.40	2.72	0.00	0.00	0.00	-0.68	0.00	0.00	0.00
11710.00	2.46	2.37	0.00	0.00	0.00	-0.09	0.00	0.00	0.00
12050.00	1.63	1.82	0.00	0.00	0.00	0.19	0.00	0.00	0.00
12400.00	6.15	3.67	0.00	0.00	0.00	-2.48	0.00	0.00	0.00
13030.00	7.82	4.58	0.00	0.00	0.00	-3.24	0.00	0.00	0.00
13500.00	8.11	6.93	0.00	0.00	0.00	-1.18	0.00	0.00	0.00
14270.00	7.12	12.99	0.00	0.00	0.00	5.87	0.00	0.00	0.00
14700.00	10.52	12.53	0.00	0.00	0.00	2.01	0.00	0.00	0.00
14958.00	7.02	7.54	0.00	0.00	0.00	0.52	0.00	0.00	0.00
15040.00	8.64	9.36	0.00	0.00	0.00	0.72	0.00	0.00	0.00
15100.00	8.48	9.11	0.00	0.00	0.00	0.63	0.00	0.00	0.00
15200.00	9.70	11.06	0.00	0.00	0.00	1.36	0.00	0.00	0.00
15930.00	6.71	8.15	0.00	0.00	0.00	1.44	0.00	0.00	0.00
16535.00	8.25	13.47	0.00	0.00	0.00	5.22	0.00	0.00	0.00
16843.00	8.11	6.64	0.00	0.00	0.00	-1.47	0.00	0.00	0.00
17040.00	5.02	4.43	0.00	0.00	0.00	-0.59	0.00	0.00	0.00
17055.00	4.42	3.91	0.00	0.00	0.00	-0.51	0.00	0.00	0.00

NOTE : (1) = WITHOUT PROJECT(2040) CONDITIONS
(2) = WITH PROJECT(2040) CONDITIONS

TABLE II-23(CONTD) VELOCITY COMPARISON --- WITH AND WITHOUT PROJECT(2040) CONDITIONS

RAMAPO R. @ CNFLNCE WITH POMPTON R. ---- 100.YEAR ----

STATION	(1) VLCTY	(2) VLCTY	(3) VLCTY	(4) VLCTY	(5) VLCTY	(2-1)	(3-1)	(4-1)	(5-1)
770.00	4.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1049.00	3.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1050.00	3.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1070.00	3.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1071.00	3.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1430.00	4.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2330.00	3.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3585.00	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3595.00	1.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3605.00	1.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3655.00	1.83	4.65	0.00	0.00	0.00	2.82	0.00	0.00	0.00
4630.00	5.04	6.48	0.00	0.00	0.00	1.44	0.00	0.00	0.00
5140.00	7.26	7.40	0.00	0.00	0.00	0.14	0.00	0.00	0.00
5465.00	6.42	7.55	0.00	0.00	0.00	1.13	0.00	0.00	0.00
5730.00	4.81	6.70	0.00	0.00	0.00	1.89	0.00	0.00	0.00
6240.00	4.84	5.35	0.00	0.00	0.00	0.51	0.00	0.00	0.00
6630.00	6.05	6.74	0.00	0.00	0.00	0.69	0.00	0.00	0.00
7010.00	6.53	6.45	0.00	0.00	0.00	-0.08	0.00	0.00	0.00
7230.00	7.04	10.76	0.00	0.00	0.00	3.72	0.00	0.00	0.00
7290.00	7.06	11.29	0.00	0.00	0.00	4.23	0.00	0.00	0.00
7331.00	6.70	11.31	0.00	0.00	0.00	4.61	0.00	0.00	0.00
7420.00	6.47	9.10	0.00	0.00	0.00	2.63	0.00	0.00	0.00
7805.00	6.74	7.78	0.00	0.00	0.00	1.04	0.00	0.00	0.00
8250.00	7.70	8.33	0.00	0.00	0.00	0.63	0.00	0.00	0.00
8600.00	2.73	4.62	0.00	0.00	0.00	1.89	0.00	0.00	0.00
9130.00	6.79	7.39	0.00	0.00	0.00	0.60	0.00	0.00	0.00
9410.00	6.36	6.95	0.00	0.00	0.00	0.59	0.00	0.00	0.00
9770.00	8.79	7.66	0.00	0.00	0.00	-1.13	0.00	0.00	0.00
9865.00	10.99	7.69	0.00	0.00	0.00	-3.30	0.00	0.00	0.00
9920.00	10.98	7.64	0.00	0.00	0.00	-3.34	0.00	0.00	0.00
10015.00	7.16	6.13	0.00	0.00	0.00	-1.03	0.00	0.00	0.00
10150.00		5.95	0.00	0.00	0.00				
10245.00	3.54	3.90	0.00	0.00	0.00	0.36	0.00	0.00	0.00
10170.00	7.18	6.69	0.00	0.00	0.00	-0.49	0.00	0.00	0.00
10385.00	5.47	5.83	0.00	0.00	0.00	0.36	0.00	0.00	0.00
10445.00	5.47	5.83	0.00	0.00	0.00	0.36	0.00	0.00	0.00

WANAQUE R. @ CNFLNCE WITH PEQUANNOCK R. ---- 100.YEAR ----

STATION	(1) VLCTY	(2) VLCTY	(3) VLCTY	(4) VLCTY	(5) VLCTY	(2-1)	(3-1)	(4-1)	(5-1)
255.00	3.53	3.49	0.00	0.00	0.00	-0.04	0.00	0.00	0.00
860.00	3.40	4.19	0.00	0.00	0.00	0.79	0.00	0.00	0.00
2110.00	4.53	5.23	0.00	0.00	0.00	0.70	0.00	0.00	0.00
2350.00	4.25	5.24	0.00	0.00	0.00	0.99	0.00	0.00	0.00
2450.00	2.72	3.70	0.00	0.00	0.00	0.98	0.00	0.00	0.00
2615.00	4.02	4.83	0.00	0.00	0.00	0.81	0.00	0.00	0.00
2645.00	3.99	5.06	0.00	0.00	0.00	1.07	0.00	0.00	0.00
2655.00	3.99	5.07	0.00	0.00	0.00	1.08	0.00	0.00	0.00
2755.00	3.68	4.41	0.00	0.00	0.00	0.73	0.00	0.00	0.00
3220.00	5.51	5.70	0.00	0.00	0.00	0.19	0.00	0.00	0.00
3975.00	4.76	5.74	0.00	0.00	0.00	0.98	0.00	0.00	0.00
4525.00	4.83	5.83	0.00	0.00	0.00	1.00	0.00	0.00	0.00
4880.00	5.26	7.30	0.00	0.00	0.00	2.04	0.00	0.00	0.00
5135.00	3.25	3.72	0.00	0.00	0.00	0.47	0.00	0.00	0.00
5215.00	9.13	13.23	0.00	0.00	0.00	4.10	0.00	0.00	0.00
5270.00	8.49	8.88	0.00	0.00	0.00	0.39	0.00	0.00	0.00
5315.00	2.54	2.61	0.00	0.00	0.00	0.07	0.00	0.00	0.00
5620.00	4.12	4.23	0.00	0.00	0.00	0.11	0.00	0.00	0.00
6230.00	5.10	6.38	0.00	0.00	0.00	1.28	0.00	0.00	0.00
6675.00	9.02	11.40	0.00	0.00	0.00	2.38	0.00	0.00	0.00
6780.00	8.88	9.71	0.00	0.00	0.00	0.83	0.00	0.00	0.00
6790.00	8.87	9.62	0.00	0.00	0.00	0.75	0.00	0.00	0.00
6885.00	9.22	9.80	0.00	0.00	0.00	0.58	0.00	0.00	0.00
7230.00	7.33	7.24	0.00	0.00	0.00	-0.09	0.00	0.00	0.00
7595.00	6.55	6.74	0.00	0.00	0.00	0.19	0.00	0.00	0.00
7875.00	6.43	6.17	0.00	0.00	0.00	-0.26	0.00	0.00	0.00
8020.00	7.61	7.02	0.00	0.00	0.00	-0.59	0.00	0.00	0.00
8050.00	8.44	7.93	0.00	0.00	0.00	-0.51	0.00	0.00	0.00
8140.00	8.25	7.44	0.00	0.00	0.00	-0.81	0.00	0.00	0.00
8270.00	6.95	6.18	0.00	0.00	0.00	-0.77	0.00	0.00	0.00
8690.00	8.89	8.06	0.00	0.00	0.00	-0.83	0.00	0.00	0.00
8800.00	9.28	8.53	0.00	0.00	0.00	-0.75	0.00	0.00	0.00

***** END OF COMPARISON OF PROFILE NO. 7 *****

NOTE : (1) = WITHOUT PROJECT(2040) CONDITIONS
(2) = WITH PROJECT(2040) CONDITIONS

TABLE II-24 PROBABILITY OF LEVEE OVERTOPPING IN PASSAIC BASIN

System Name	Average Levee Height (Ft.)	Average 500 Yr Stage (Ft.)	Overtopping Frequency	Approx. % Chance of Overtopping
Lower Valley				
Tidal:				
Kearny Point	14.9	11.9	>500 Yr	Nil
Doremus Ave	14.9	11.9	>500 Yr	Nil
N.J. Turnpike	14.9	11.9	>500 Yr	Nil
Lister Ave	14.9	11.9	>500 Yr	Nil
South 1st Street	14.9	11.9	>500 Yr	Nil
Mitigation:				
Main Street	16.5	15.8	>500 Yr	Nil
River Road #1	16.8	16.7	500 Yr	>20
River Road #2	17.7	16.5	<500 Yr	>20
Riverside Ave #1	17.7	16.5	<500 Yr	>20
Riverside Ave #2	19.4	21.3	<500 Yr	>20
River St-Main Ave	19.4	21.3	<500 Yr	>20
8th Street	20.4	22.8	<500 Yr	>20
CENTRAL BASIN				
Fluvial:				
Passaic 2A	174.5	174.9	<500 Yr	>20
Passaic 2C	175.5	175.2	>500 Yr	<20
Passaic 1D	177.3	177.8	<500 Yr	>20
Rockaway 1	177.3	176.3	>500 Yr	>20
Rockaway 2	180.8	181.4	<500 Yr	>20
Rockaway 3	182.1	182.2	<500 Yr	>20
Pinch Brook	187.8	184.8	<500 Yr	Nil
POMPTON VALLEY				
Integral to Tunnel:				
Shore Road	186	190	<500 Yr	>20
Pequannock-Ramapo	189	191.5	<500 Yr	>20
Stiles Court	210.3	209.2	>500 Yr	Nil
Hill Court	203.7	205.2	<500 Yr	>20
Wanaque Ave	203.7	205.2	<500 Yr	>20

TABLE II-25 SAMPLE OF RIPRAP ANALYSIS -- IMPROVED PEQUANNOCK RIVER.


```
X1  320.    50.0  1267.0  1451.0   350.0   200.0   770.0
CI2400.0  163.09   0.000   2.000   2.000 129.000

 COMPUTED (GR) Y-X POINTS:
      Y       X       Y       X       Y       X       Y       X       Y       X
  179.8  2302.1   163.1  2335.5   163.1  2464.5   179.8  2497.9

 NUMBER OF X-Y POINTS =  4                DISCHARGE = 33880.0 CFS
 WATER SURFACE ELEV.  =  179.8 FT. NGVD
 ROUGHNESS COEFFICIENT : LEFT OVERBANK =0.000  CHANNEL =0.035  RIGHT OVERBANK = 0.000
 LEFT BANK STATION =  2302.1              RIGHT BANK STATION =  2497.9
 GAMMA 50% STONE  =165.0#/CU.FT.          CENTER-LINE RADIUS OF BEND =   0.0 FT.
 WATER-SURFACE WIDTH AT UPSTREAM END OF BEND =   0.0 FT.
 TANGENT OF SIDE SLOPE (IN RADIAN) =  0.50

 SUBSECTION PROPERTIES
 ---------------------
 NO.     DEL X  DEL YAVG        AX        WP         R       (CR**.5)AX      R(CR**.5)AX
   1      33.4       8.3     278.9      34.4       8.1          47760.1         386389.6
   2     129.0      16.7    2154.3     130.1      16.6         594285.7        9842437.5
   3      33.4       8.3     278.9      34.4       8.1          47760.1         386389.6
                  TOTAL = 2712.1                   TOTAL =     689805.8       10616216.8

 C = (1.486/N)(R**.166667)    VX = QX/AX
 QX = Q((CR**.5)AX)/(SUMCR**.5AX)

              NO.  (CR**.5)*AX        QX       AX       VX
                1      47760.1    2345.7   278.9      8.4
                2     594285.7   29188.5  2154.3     13.5
                3      47760.1    2345.7   278.9      8.4
                   ***********************************************
                   *THE MAX. CHANNEL VEL. IS  13.5 FEET/SEC.*
                   ***********************************************
                   ^^^^^THE NORMAL DEPTH IS   16.7 FEET^^^^^

 METHOD 1.--- LOCAL BOUNDARY SHEAR METHOD
 ----------------------------------------

   LAYER        GENERAL GRADATION CRITERIA     SPHERICAL DIA.
 THICKNESS       50%       LIMIT OF WEIGHT        50%   50%
    (T)        STONE           (LBS)             MAX.  MIN.
     21        165.0      205.0   138.0        1.334 1.169

                LOCAL BOUNDARY SHEAR                    PERMISSIBLE SHEAR
          STRAIGHT CHANNEL          CHANNEL BENDS
  (T)     K2     VMAX      TO       R  R/W     TB      50%MIN      T1     K1     T2
   21  0.012     13.5    3.39     0.0  0.0   3.39       1.169    4.80   0.72   3.45
```

TABLE II-25 SAMPLE OF RIPRAP ANALYSIS ---- CONTINUED.


```
          FINAL SELECTION
          ---------------
(T)     ((T1 OR T2)/(T0 OR TB))
 21        3.39/3.45= 1.0

      ***************************************************
      *    THE COMPUTED LAYER THICKNESS IS 21 INCH.    *
      ***************************************************


METHOD 2.  AVERAGE BOUNDARY SHEAR METHOD
----------------------------------------

   CRMEAN = SUM ((CR**.5)*AX)/SUMAX =  254.35

   RMEAN = SUM((CR**.5)*AX)/SUM((CR**.5)*AX)=   15.39FT.

   VAVG =  SUMQ /SUMAX =   12.49 FT/SEC

   SMEAN = VAVG**2.0/CRMEAN =0.0024 FT./FT.

   AVG. STRESS =  62.4* RMEAN*SMEAN

   ** CORRECTION FOR UNIFORM FLOW CONDITIONS **

   AVG. STRESS = 62.4*RMEAN*SMEAN*1.5=  3.47 #/SQ.FT.

   50% STONE = (AVG. STRESS)/.04(165.-62.4)*.718 =     14.1 INCH.

   LAYER THICKNESS =  50 * (SAFETY FACTOR) =21.2 INCHES

      ***********************************************************
      *    THE COMPUTED LAYER THICKNESS IS 21.2 INCH.          *
      ***********************************************************


      ***************************************************
      *THE AVERAGE CHANNEL VELOCITY IS 12.5 FT./SEC. *
      ***************************************************


METHOD 3. FROUDE NO. METHOD
---------------------------

   FROUDE NO.= VAVG/(G*HYDRAULIC DEPTH)**.5=  0.6
   50%  STONE = C*(DEPTH)*(FROUDE NO.)**3.= 12.4 IN.
   LAYER THICKNESS = 50% STONE*SAFETY FACTOR = 18.7 IN.

      ****************************************************
      *    THE COMPUTED LAYER THICKNESS IS 18.7 INCH.    *
      ****************************************************
```

TABLE II-25 SAMPLE OF RIPRAP ANALYSIS ---- CONTINUED.

METHOD 4. HDC 712-1 ISBASH METHOD

50% STONE = .0065*VMAX**2. = 14.3 INCHES.

LAYER THICKNESS = 50% STONE * FS = 21.5 INCHES.

****
* THE COMPUTED LAYER THICKNESS IS 21.5 INCH. *
****

METHOD 5. NATIONAL CRUSHED STONE ASSOC. METHOD

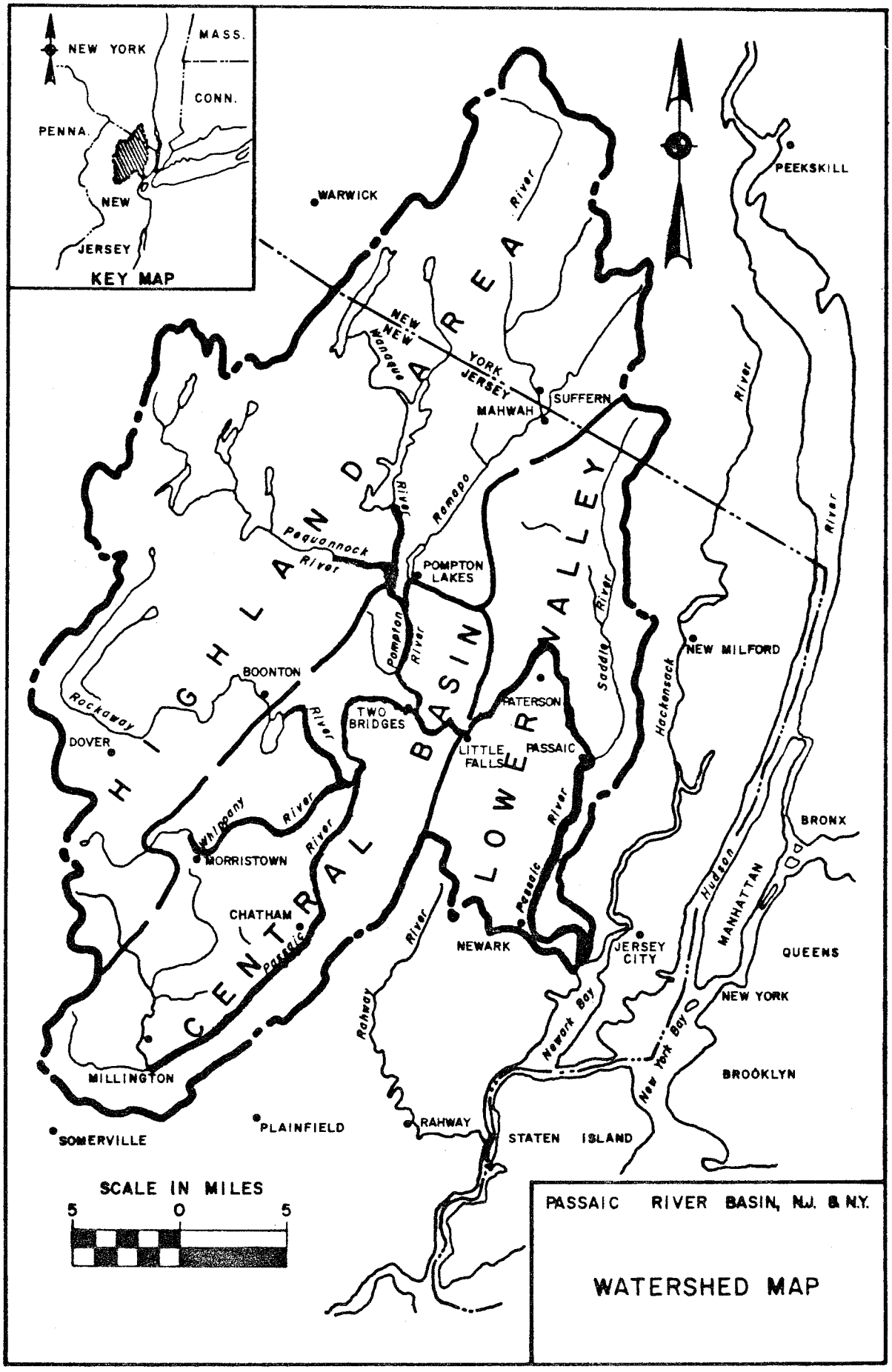
CHANNEL VELOCITY = 12.5 FT/SEC.
FROM THE INTERPOLATION OF NCSA TABLE:
THE 50% STONE = 12.6 INCHES.
THE REQUIRED LAYER THICKNESS = 18.9 INCHES.

****
* THE COMPUTED LAYER THICKNESS IS 18.9 INCH. *
****

SUMMARY TABLE OF RIPRAP ANALYSIS

STATION 320
++++++++++++++

	50% STONE 165.#/CU.FT IN INCHES	LAYER THICKNESS PLACEMENT DRY(INCH.)	WET(INCH.)
1. LOCAL BOUNDARY SHEAR METHOD	14.0	21	31.5
2. AVERAGE BOUNDARY SHEAR METHOD	14.1	21.2	31.8
3. NES MP H-78-7, FROUDE NO. METHOD	12.4	18.7	28.0
4. HDC 712-1 METHOD	14.3	21.5	32.2
5. NATIONAL CRUSHED STONE ASSOC. METHOD	12.6	18.9	28.3


NEW YORK
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CONN.
PENNA.
NEW
JERSEY
KEY MAP
WARWICK
PEEKSKILL
NEW YORK - NEW JERSEY
SUFFERN
MAHWAH
Wanaque River
Ramapo River
Pequannock River
POMPTON LAKES
Pompton River
Saddle River
Hackensack River
NEW MILFORD
BOONTON
Rockaway River
TWO BRIDGES
PATERSON
LITTLE FALLS
PASSAIC
DOVER
Whippany River
MORRISTOWN
CHATHAM
Passaic River
NEWARK
JERSEY CITY
BRONX
MANHATTAN
QUEENS
NEW YORK
BROOKLYN
Rahway River
Newark Bay
New York Bay
RAHWAY
STATEN ISLAND
MILLINGTON
PLAINFIELD
SOMERVILLE
HIGHLAND AREA
CENTRAL BASIN
LOWER VALLEY
SCALE IN MILES
5 0 5
PASSAIC RIVER BASIN, N.J. & N.Y.
WATERSHED MAP

PLATE II-1

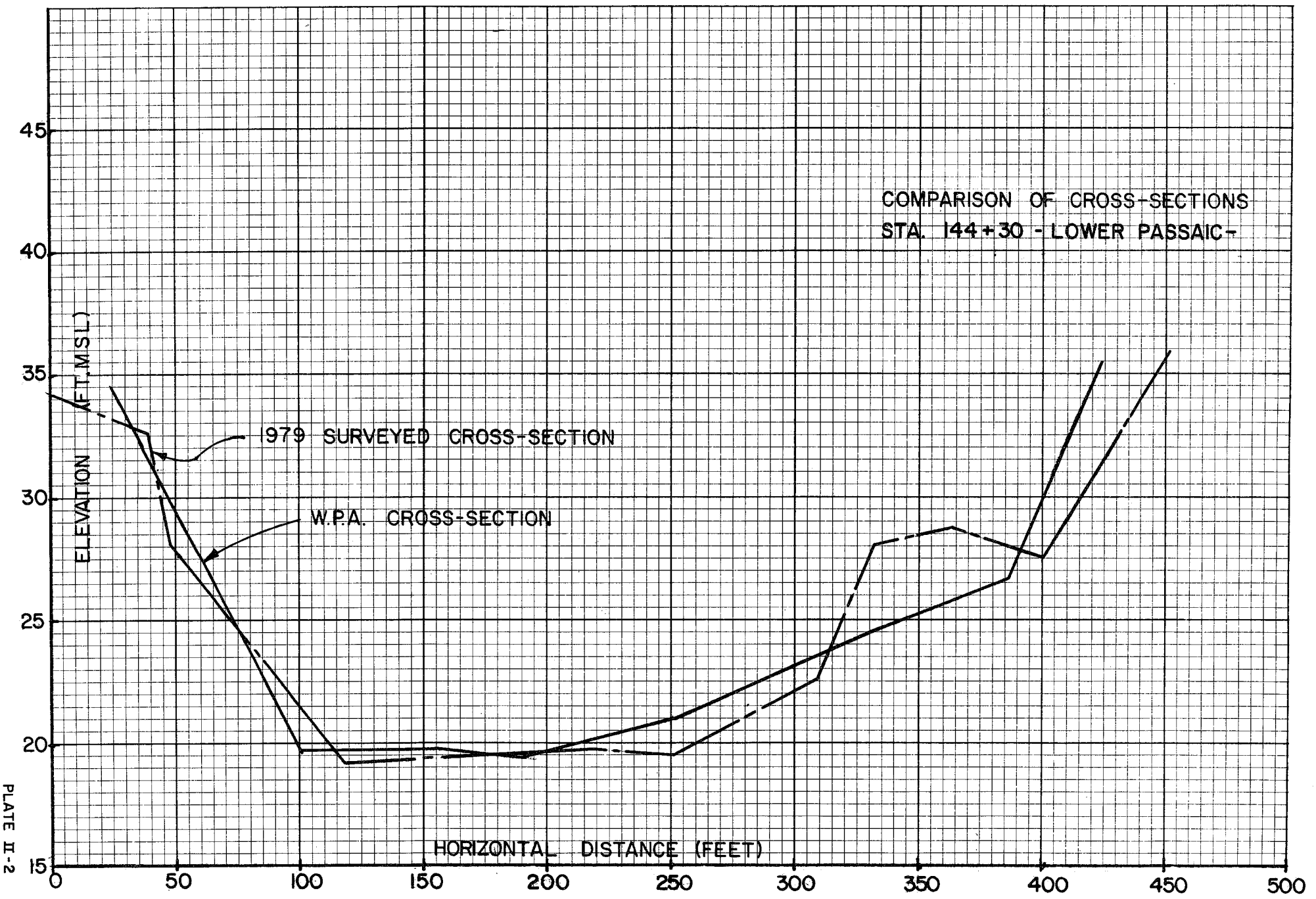

COMPARISON OF CROSS-SECTIONS
STA. 144+30 - LOWER PASSAIC-
1979 SURVEYED CROSS-SECTION
W.P.A. CROSS-SECTION
ELEVATION (FT. MSL)
HORIZONTAL DISTANCE (FEET)
45
40
35
30
25
20
15
0
50
100
150
200
250
300
350
400
450
500

PLATE II-2

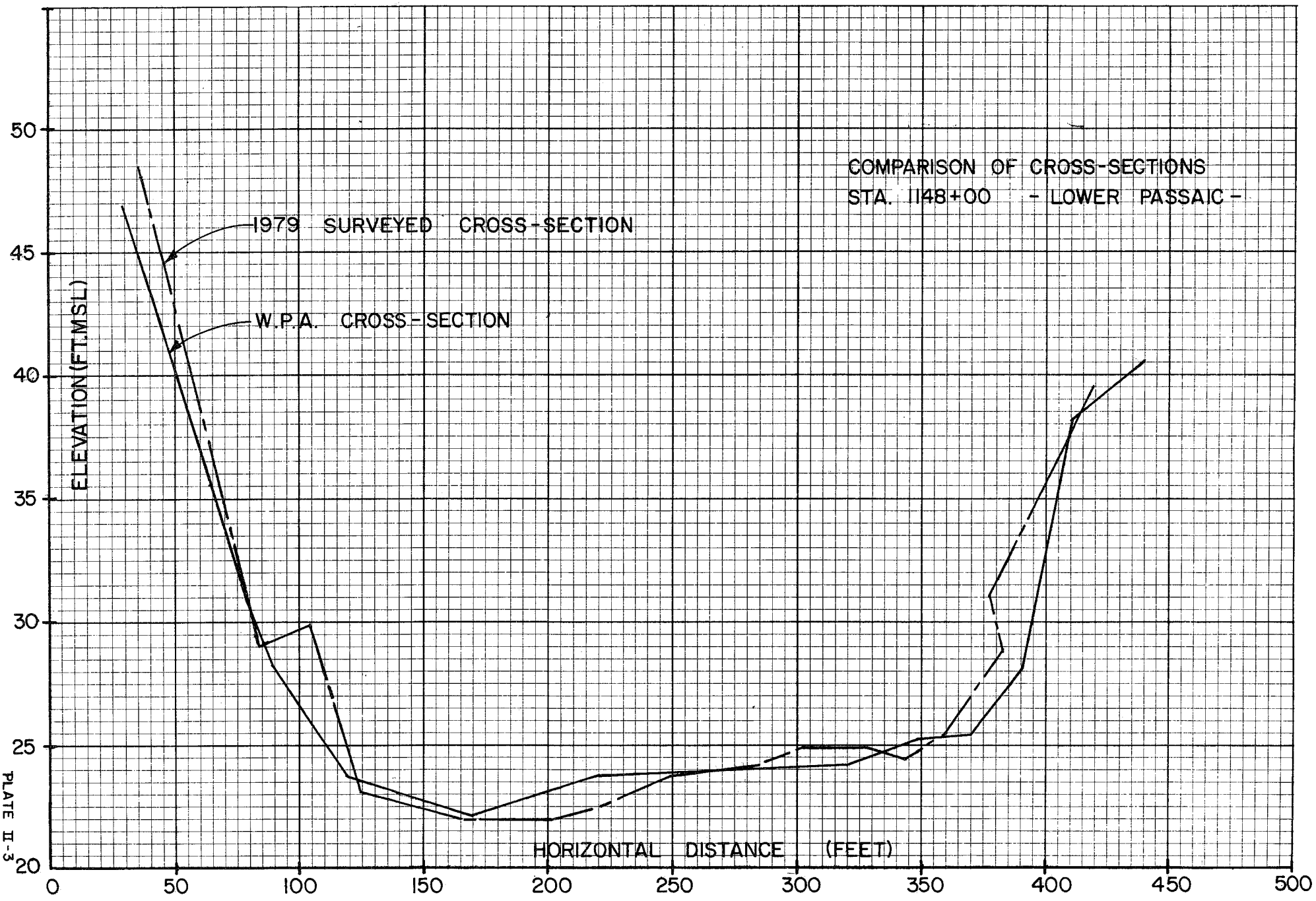

COMPARISON OF CROSS-SECTIONS
STA. 1148+00 - LOWER PASSAIC -
1979 SURVEYED CROSS-SECTION
W.P.A. CROSS-SECTION
ELEVATION (FT. MSL)
HORIZONTAL DISTANCE (FEET)
50
45
40
35
30
25
20
0
50
100
150
200
250
300
350
400
450
500

PLATE II-3

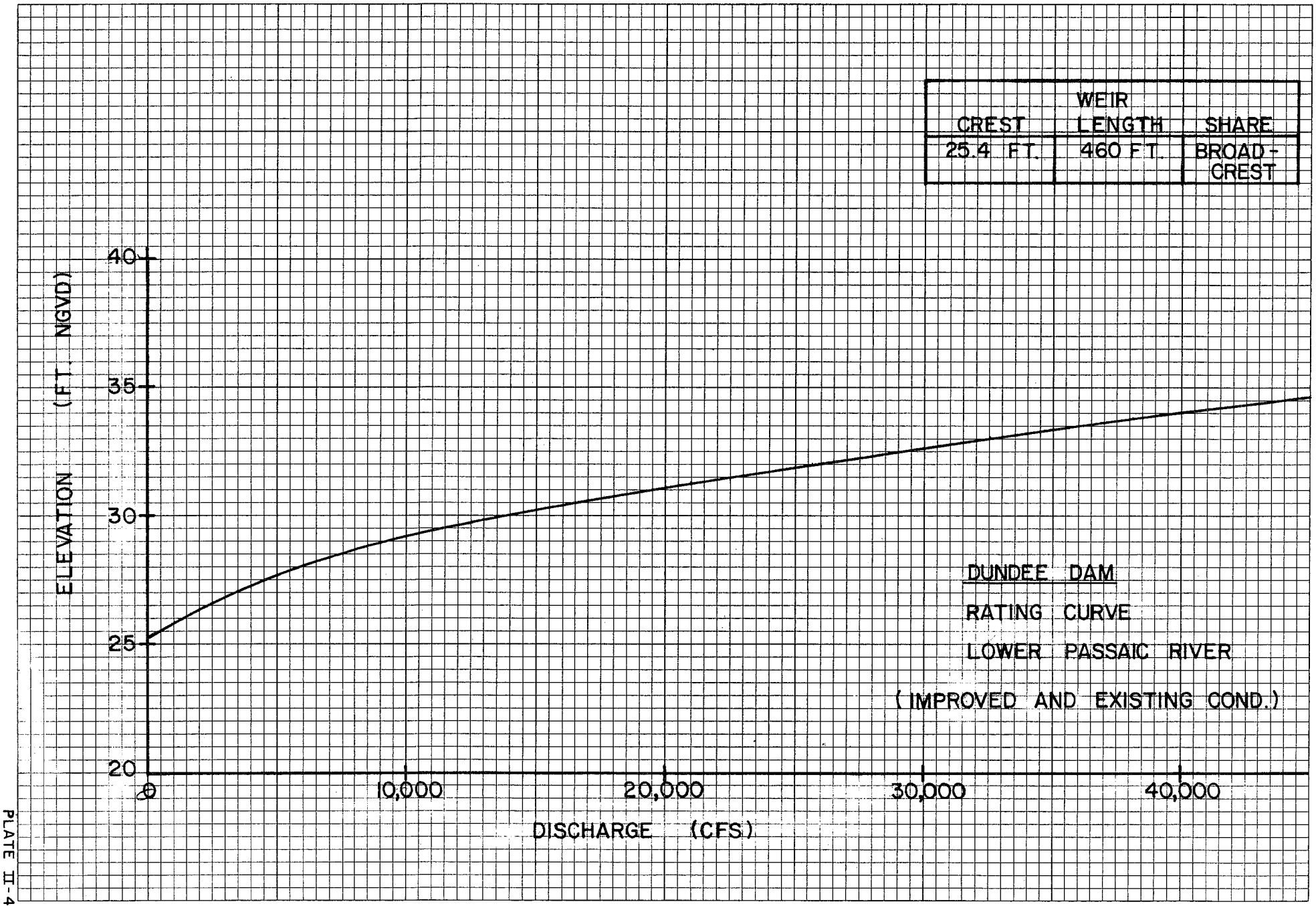

CREST
25.4 FT.
WEIR LENGTH
460 FT.
SHARE
BROAD-CREST
ELEVATION (FT. NGVD)
40
35
30
25
20
0
10,000
20,000
30,000
40,000
DISCHARGE (CFS)
DUNDEE DAM
RATING CURVE
LOWER PASSAIC RIVER
(IMPROVED AND EXISTING COND.)

PLATE II-4

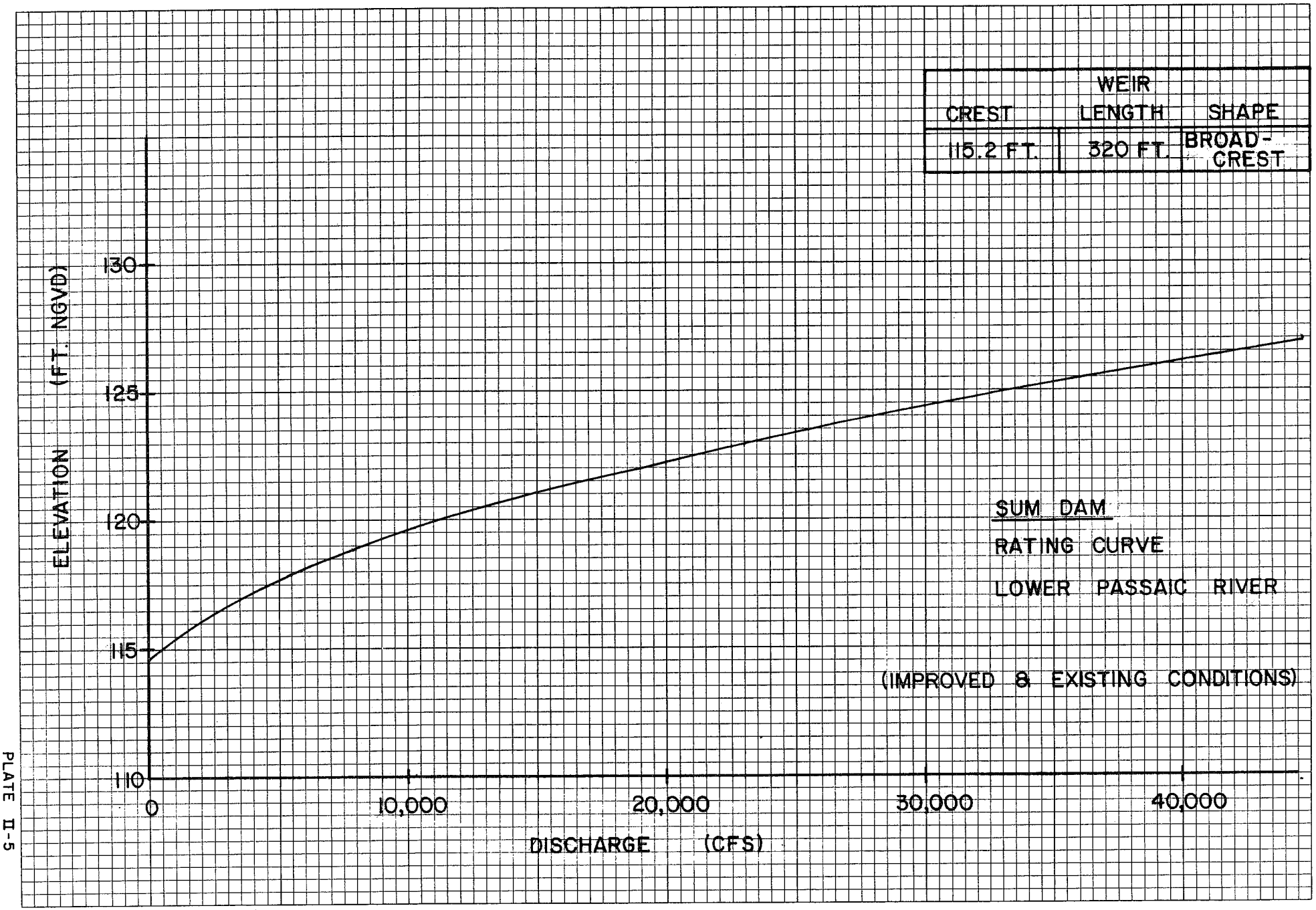

CREST
WEIR LENGTH
SHAPE
115.2 FT.
320 FT.
BROAD-CREST
ELEVATION (FT. NGVD)
130
125
120
115
110
0
10,000
20,000
30,000
40,000
DISCHARGE (CFS)
SUM DAM
RATING CURVE
LOWER PASSAIC RIVER
(IMPROVED & EXISTING CONDITIONS)

PLATE II-5

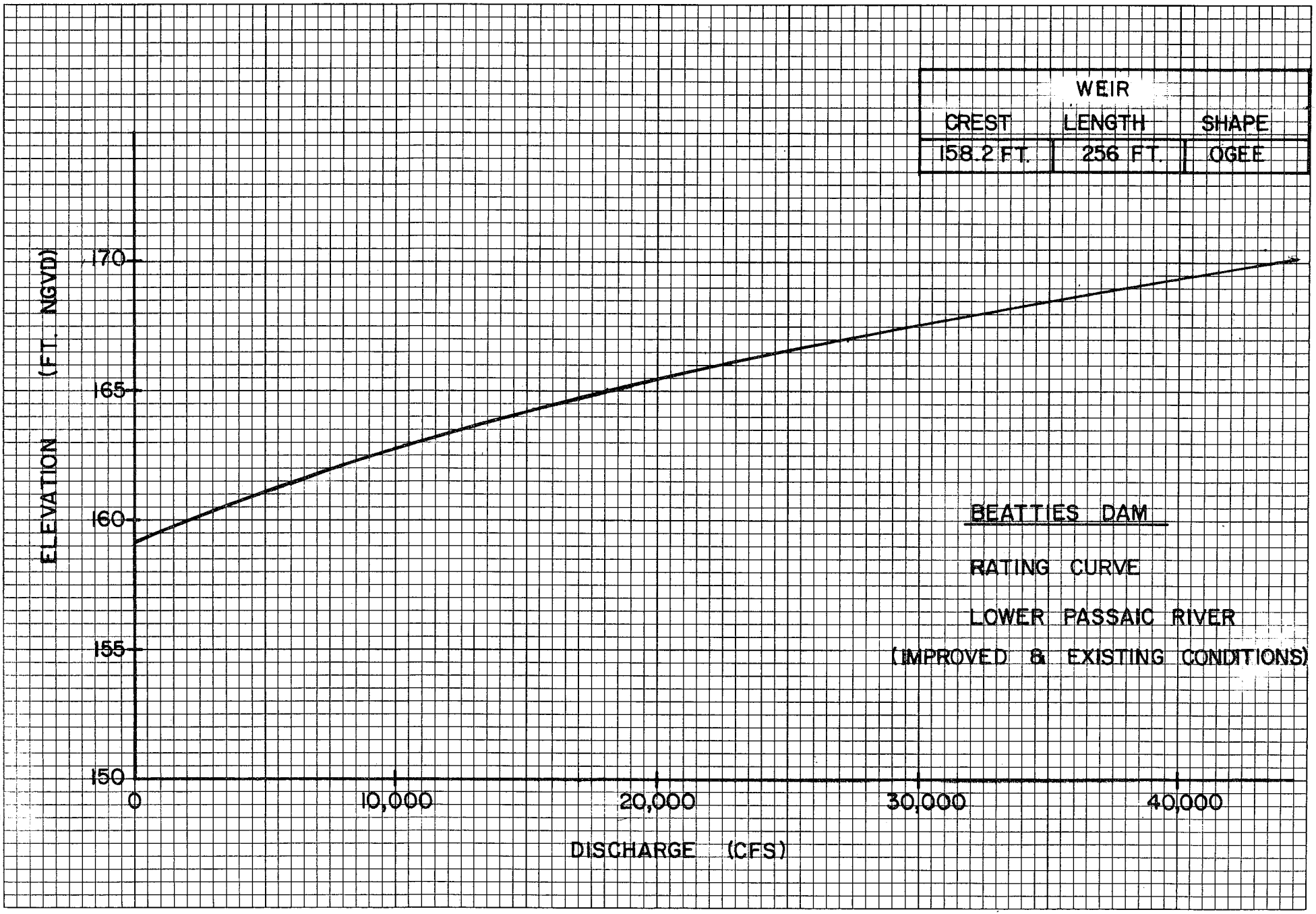

WEIR
CREST
LENGTH
SHAPE
158.2 FT.
256 FT.
OGEE
ELEVATION (FT. NGVD)
170
165
160
155
150
0
10,000
20,000
30,000
40,000
DISCHARGE (CFS)
BEATTIES DAM
RATING CURVE
LOWER PASSAIC RIVER
(IMPROVED & EXISTING CONDITIONS)

PLATE II-6

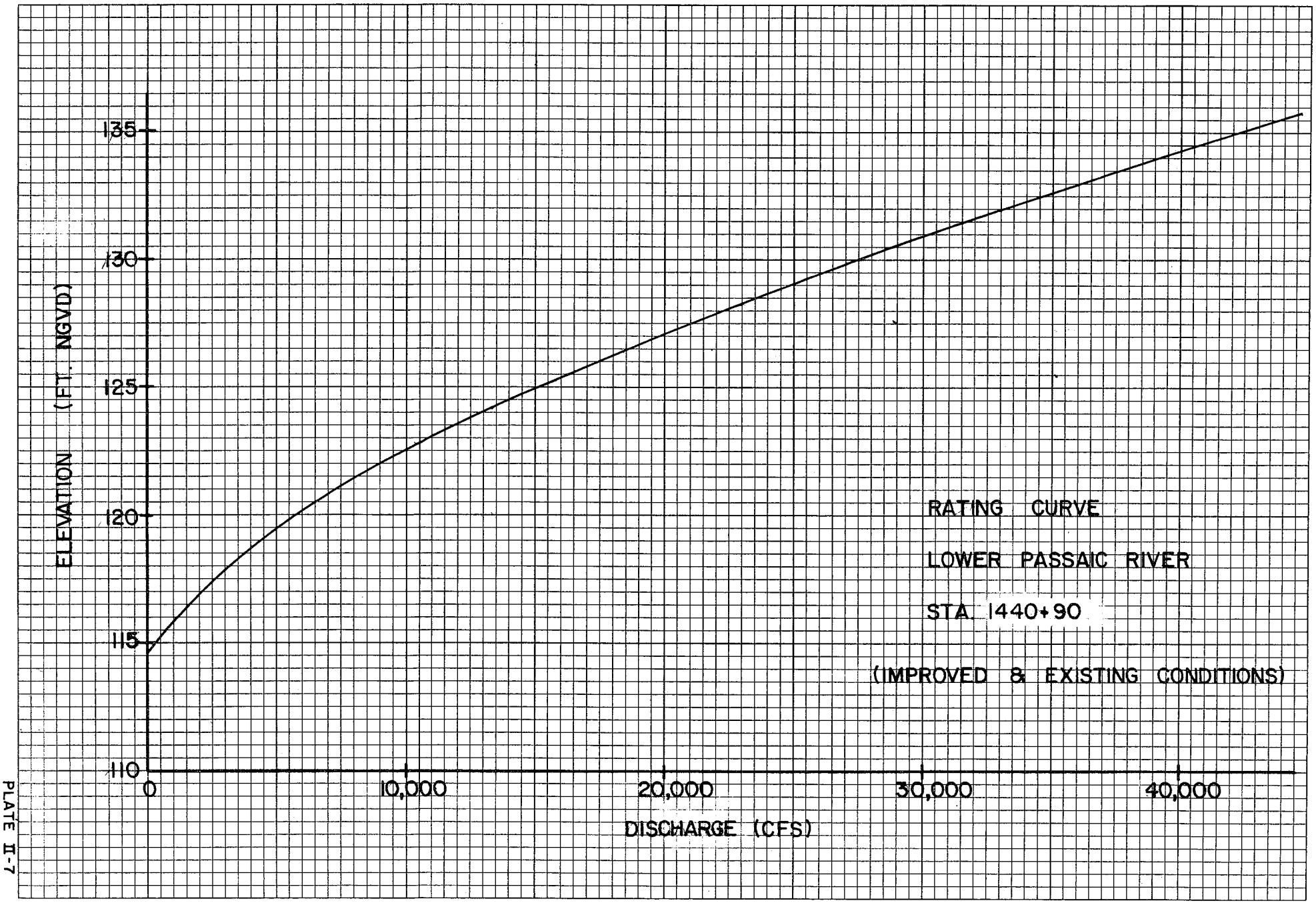

135
130
125
120
115
110
ELEVATION (FT. NGVD)
0
10,000
20,000
30,000
40,000
DISCHARGE (CFS)
RATING CURVE
LOWER PASSAIC RIVER
STA. 1440+90
(IMPROVED & EXISTING CONDITIONS)

PLATE II-7

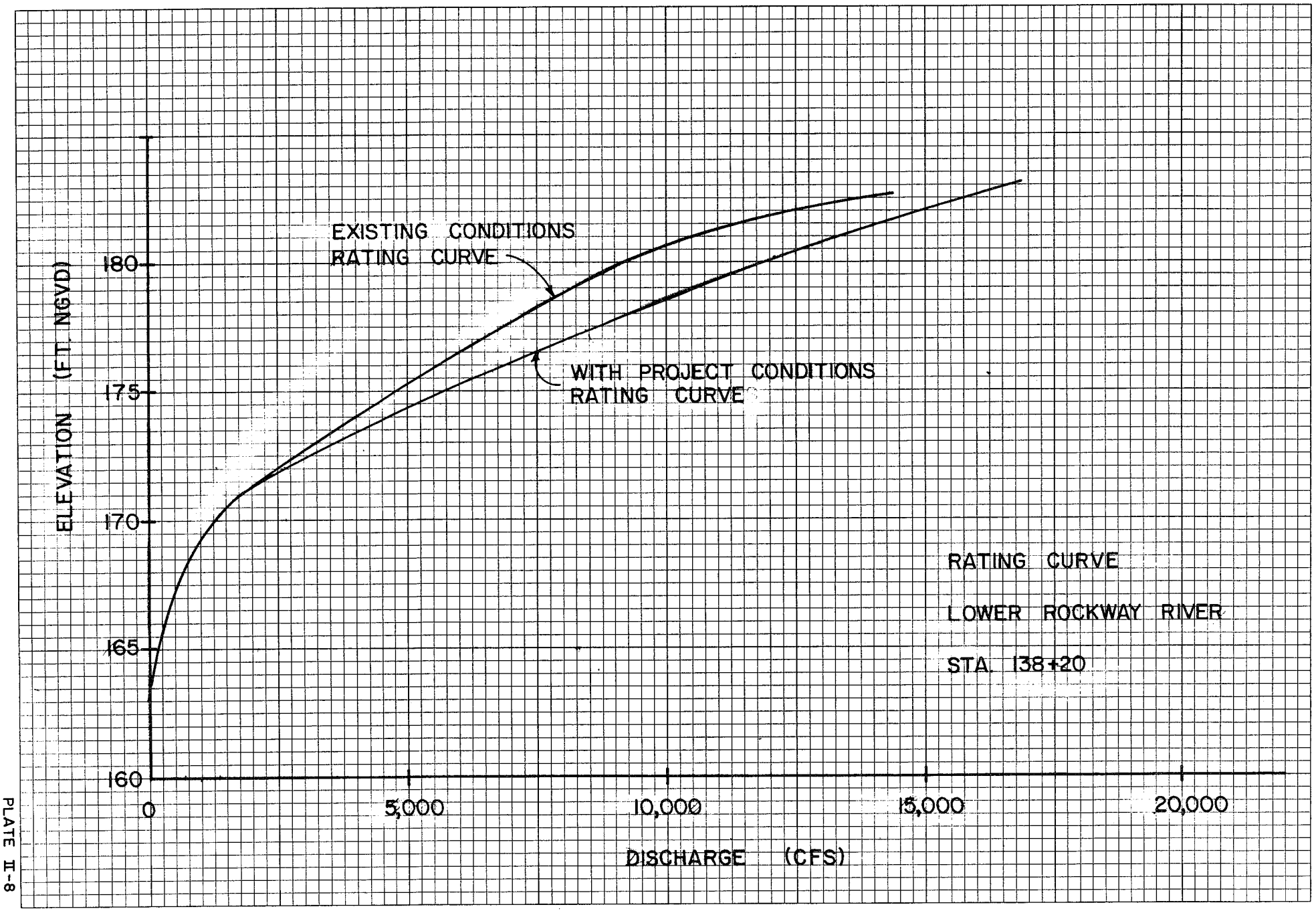

EXISTING CONDITIONS
RATING CURVE
WITH PROJECT CONDITIONS
RATING CURVE
ELEVATION (FT. NGVD)
180
175
170
165
160
0
5,000
10,000
15,000
20,000
DISCHARGE (CFS)
RATING CURVE
LOWER ROCKWAY RIVER
STA. 138+20

PLATE II-8

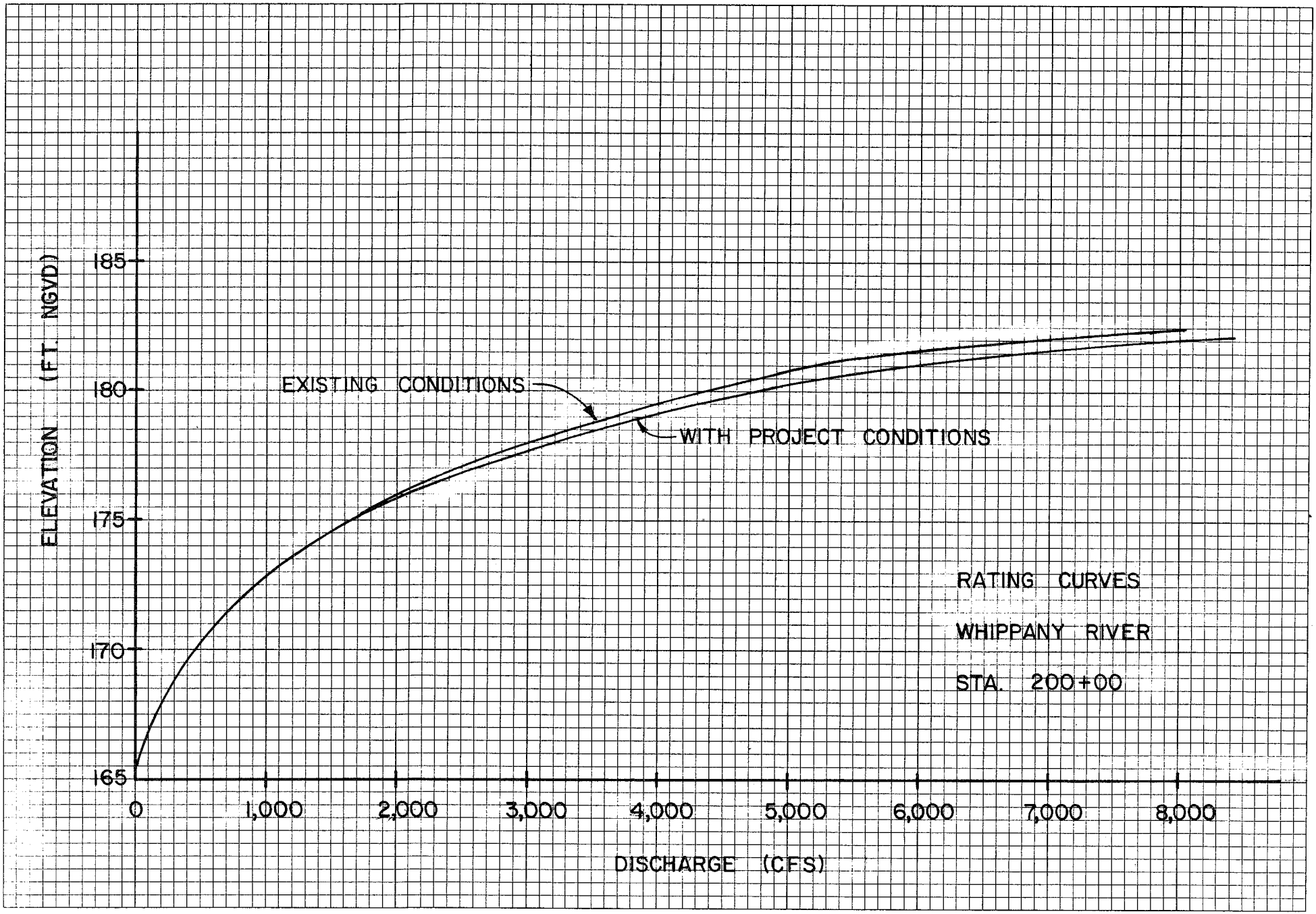

ELEVATION (FT. NGVD)
185
180
175
170
165
EXISTING CONDITIONS
WITH PROJECT CONDITIONS
RATING CURVES
WHIPPANY RIVER
STA. 200+00
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
DISCHARGE (CFS)

PLATE II-9

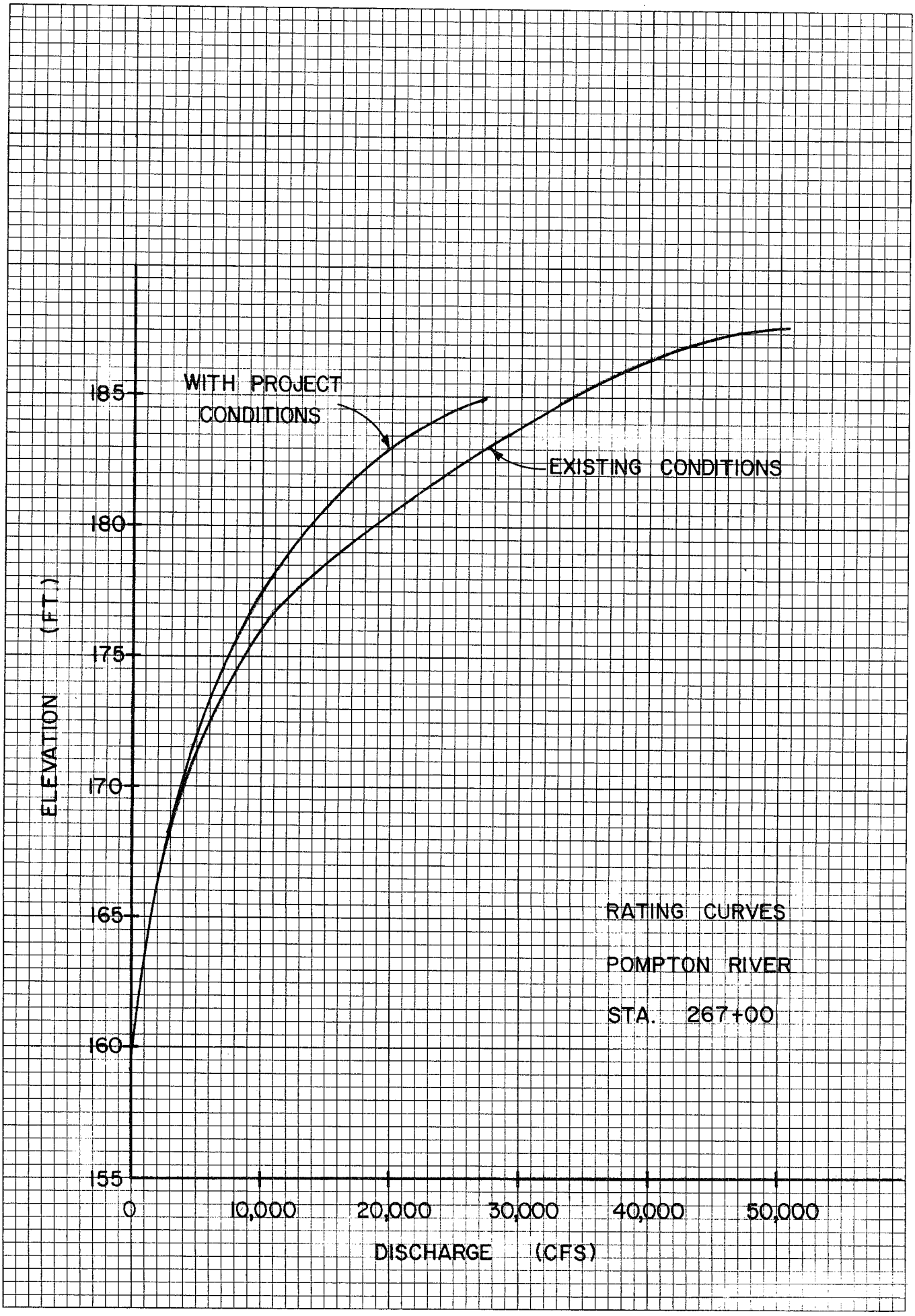

WITH PROJECT CONDITIONS
EXISTING CONDITIONS
185
180
175
170
165
160
155
ELEVATION (FT.)
0
10,000
20,000
30,000
40,000
50,000
DISCHARGE (CFS)
RATING CURVES
POMPTON RIVER
STA. 267+00

PLATE II-10

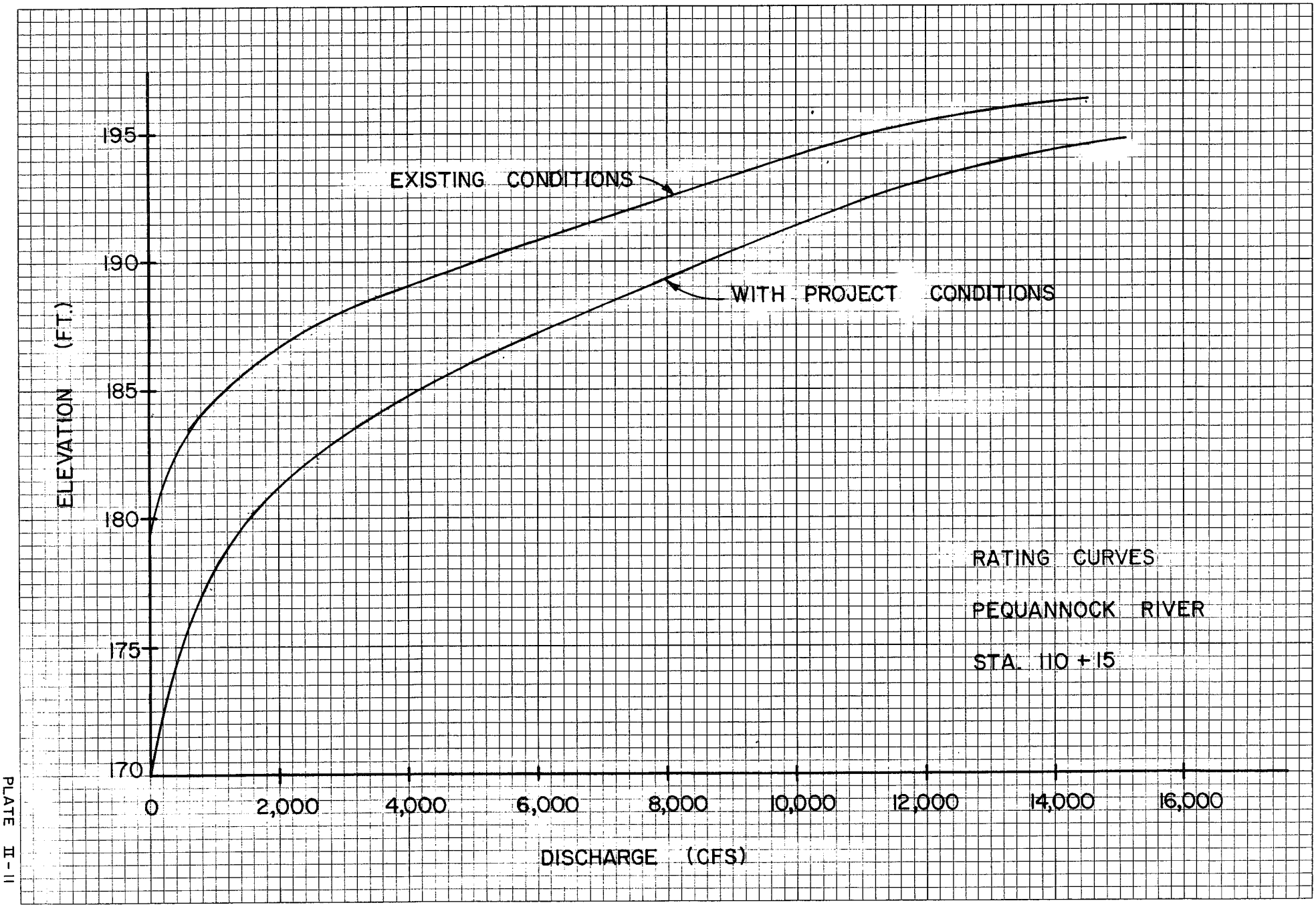

195
190
185
180
175
170
ELEVATION (FT.)
EXISTING CONDITIONS
WITH PROJECT CONDITIONS
RATING CURVES
PEQUANNOCK RIVER
STA. 110 + 15
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
DISCHARGE (CFS)

PLATE II-11

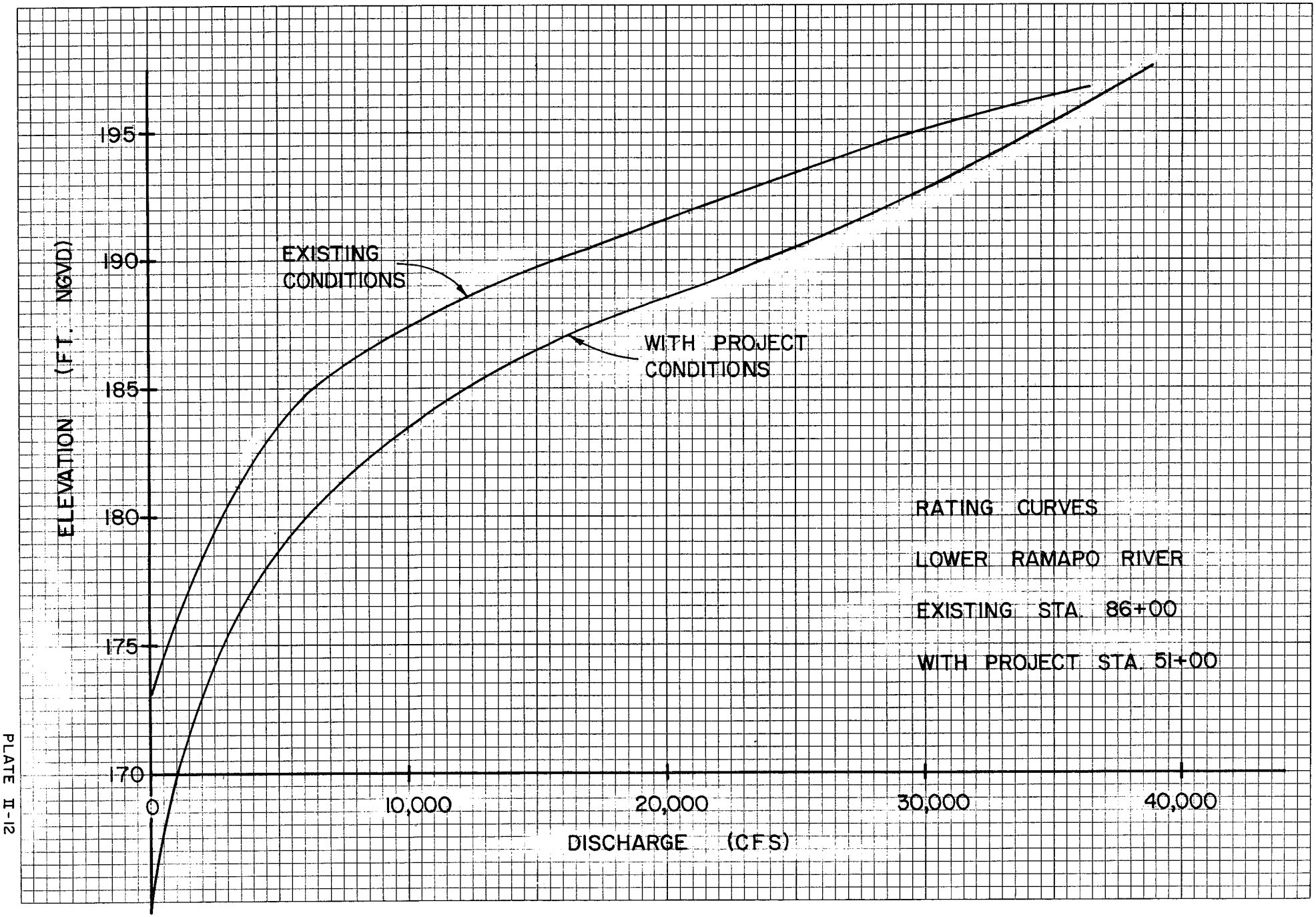

195
190
185
180
175
170
ELEVATION (FT. NGVD)
EXISTING CONDITIONS
WITH PROJECT CONDITIONS
RATING CURVES
LOWER RAMAPO RIVER
EXISTING STA. 86+00
WITH PROJECT STA. 51+00
0
10,000
20,000
30,000
40,000
DISCHARGE (CFS)

PLATE II-12

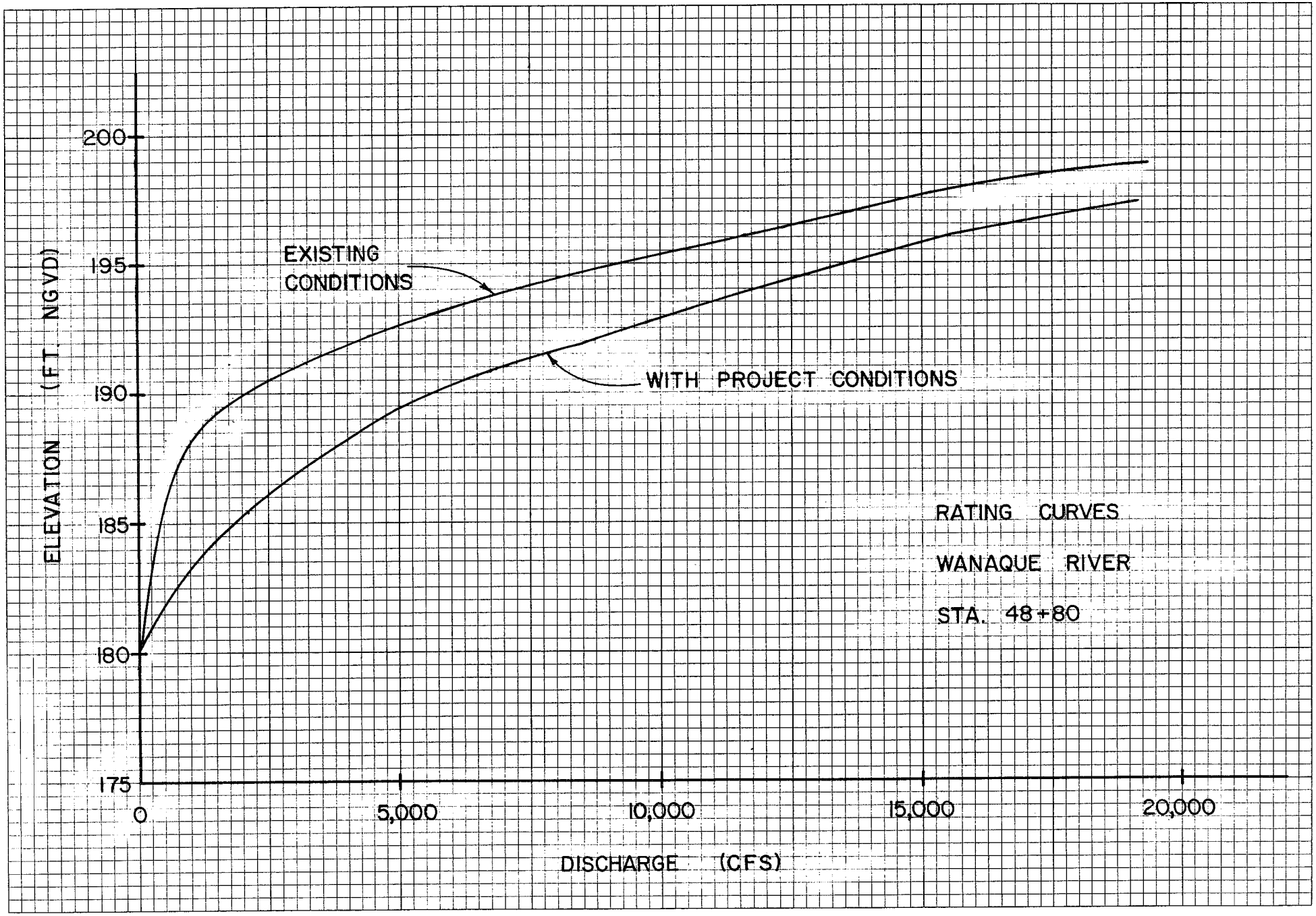

200
195
190
185
180
175
ELEVATION (FT. NGVD)
EXISTING CONDITIONS
WITH PROJECT CONDITIONS
RATING CURVES
WANAQUE RIVER
STA. 48+80
0
5,000
10,000
15,000
20,000
DISCHARGE (CFS)

PLATE II-13

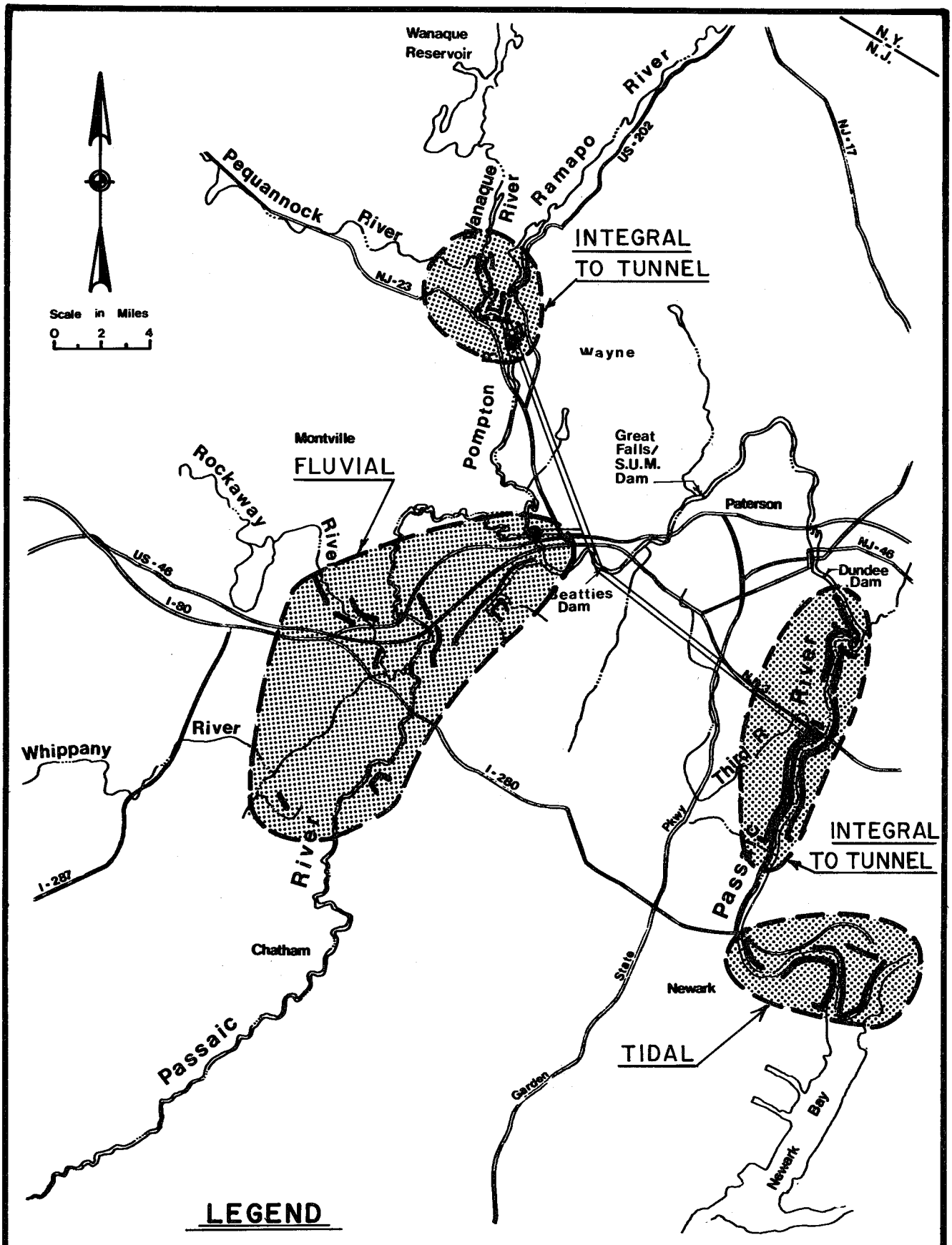
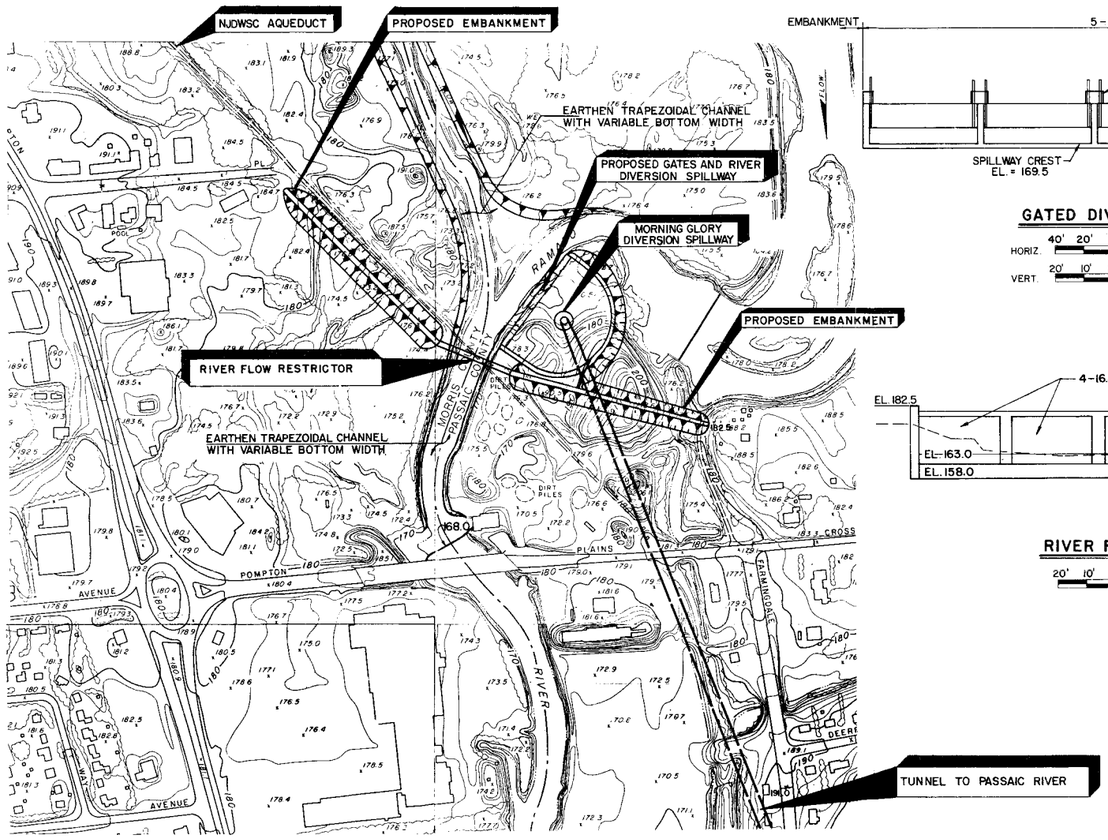
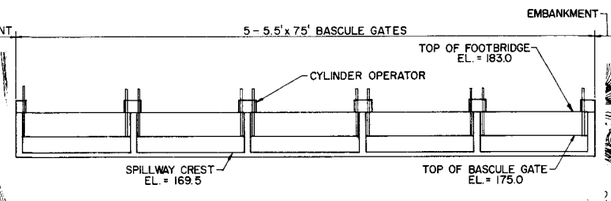

Wanaque Reservoir
Wanaque River
Ramapo River
Pequannock River
N.Y.
N.J.
NJ-17
US-202
NJ-23
INTEGRAL TO TUNNEL
Scale in Miles
0 2 4
Wayne
Pompton
Montville
FLUVIAL
Rockaway River
Great Falls/ S.U.M. Dam
Paterson
US-46
I-80
Beatties Dam
NJ-46
Dundee Dam
Whippany River
Third R.
Passaic River
I-280
Pkwy
INTEGRAL TO TUNNEL
I-287
Chatham
State
Newark
TIDAL
Passaic River
Garden
Newark Bay
LEGEND
LEVEE OR FLOODWALL
CHANNEL MODIFICATION
DIVERSION TUNNEL
Passaic River Study N.J. & N.Y.
DUAL INLET TUNNEL DIVERSION PLAN

PLATE II-14



INLET LOCATION

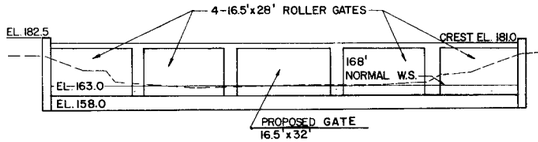
200' 100' 0 200' 400'



GATED DIVERSION SPILLWAY

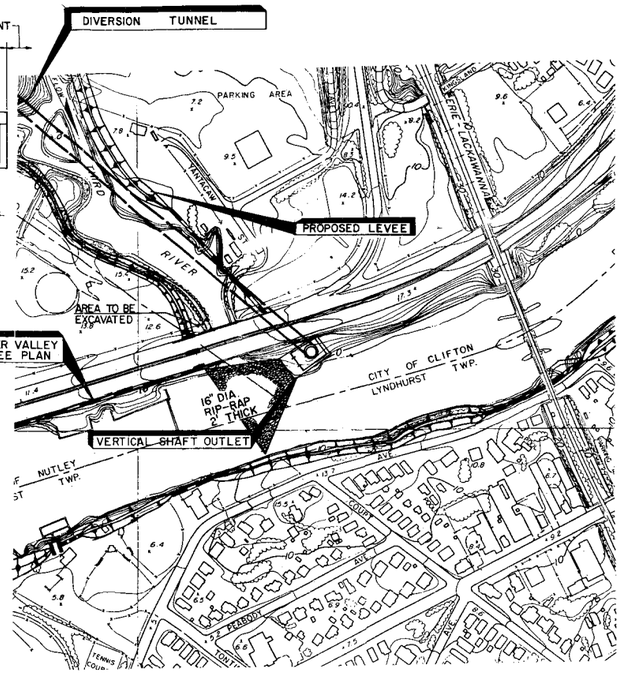
HORIZ. 40' 20' 0 40' 80'

VERT. 20' 10' 0 20' 40'



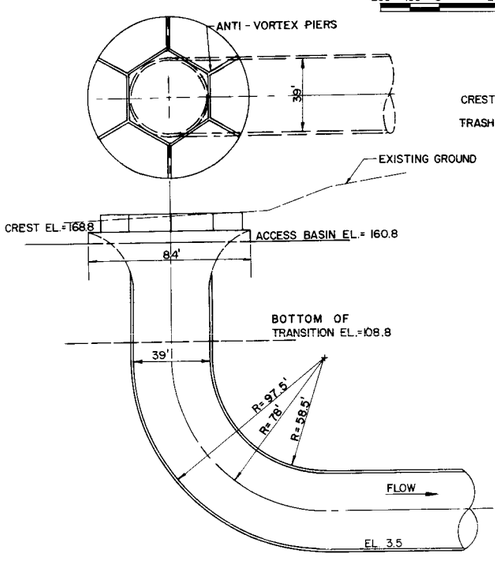
RIVER FLOW RESTRICTOR

20' 10' 0' 20' 40'



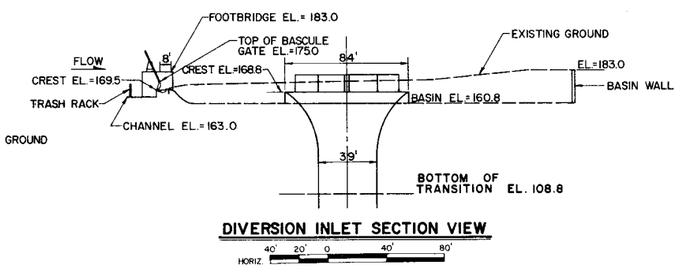
OUTLET LOCATION

200' 100' 0' 200' 400'



MORNING GLORY SPILLWAY

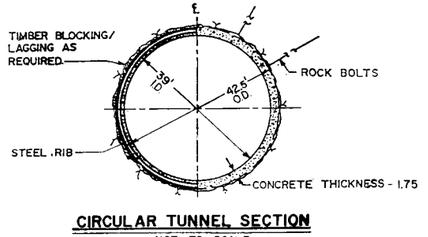
30' 20' 10' 0 30' 60'



DIVERSION INLET SECTION VIEW

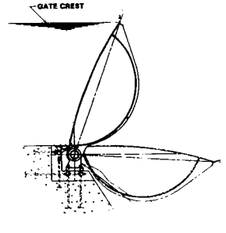
40' 20' 0 40' 80'

HORIZ.



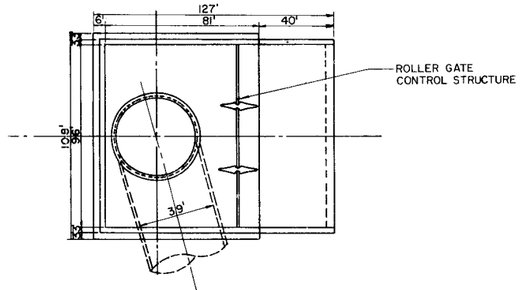
CIRCULAR TUNNEL SECTION

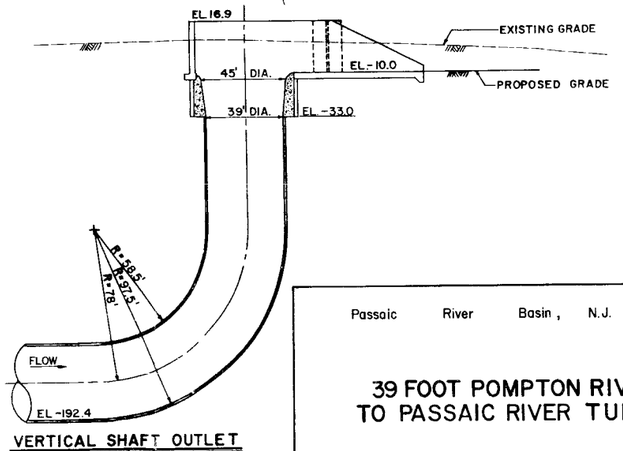
NOT TO SCALE



BASCULE GATE

N.T.S.





VERTICAL SHAFT OUTLET

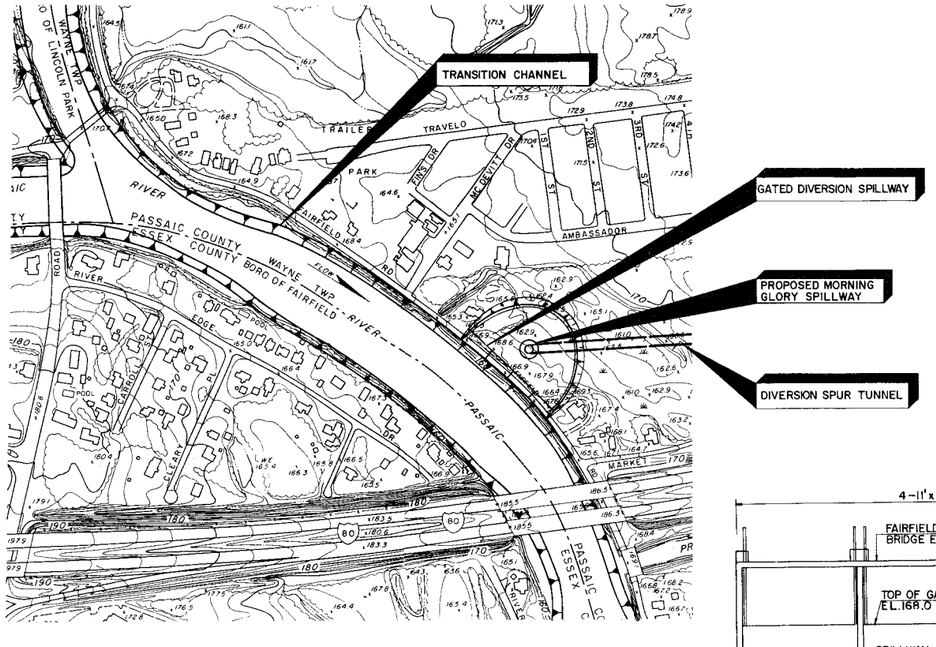
30' 20' 10' 0 30' 60'

Passaic River Basin, N.J. & N.Y.

39 FOOT POMPTON RIVER TO PASSAIC RIVER TUNNEL

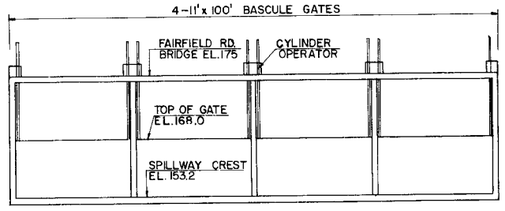
INLET & OUTLET SKETCHES

PLATE II-15



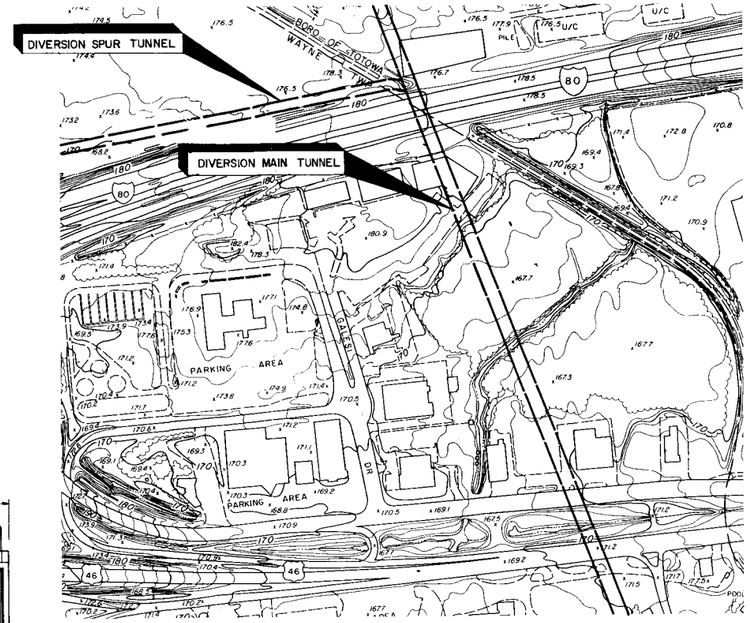
INLET LOCATION

200' 100' 0 200' 400'



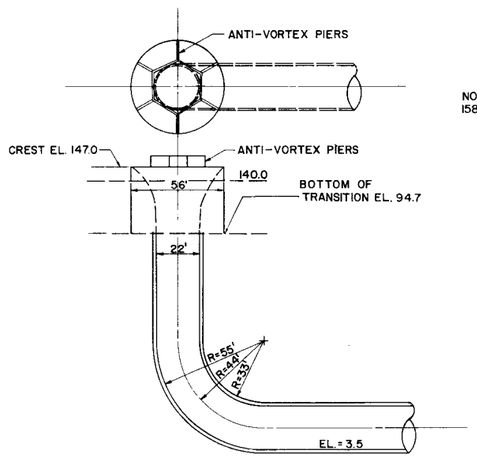
GATED DIVERSION SPILLWAY

NOT TO SCALE



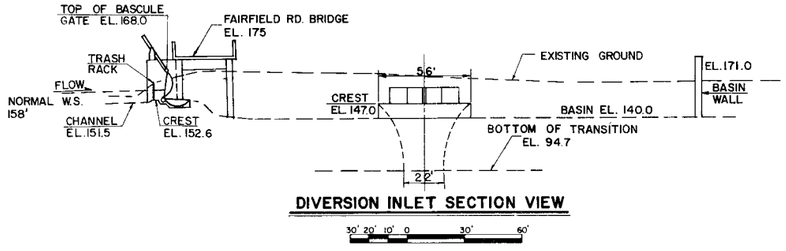
DIVERSION SPUR TUNNEL JUNCTION LOCATION

200' 100' 0 200' 400'



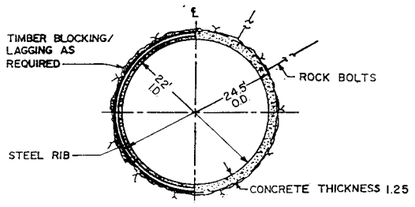
MORNING GLORY SPILLWAY

30' 20' 10' 0 30' 60'



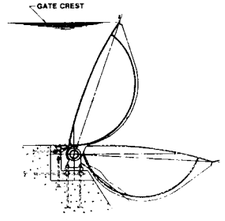
DIVERSION INLET SECTION VIEW

30' 20' 10' 0 30' 60'



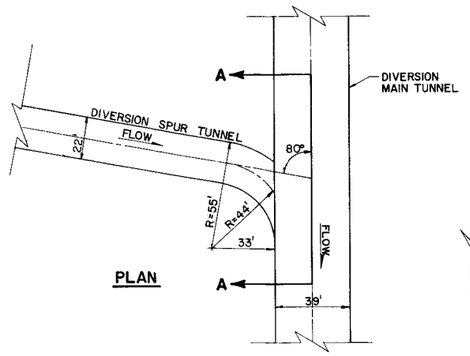
CIRCULAR TUNNEL SECTION

NOT TO SCALE

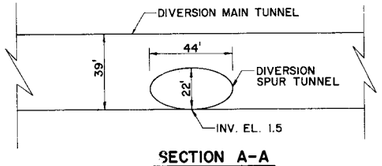


BASCULE GATE

NOT TO SCALE



PLAN



SECTION A-A

DIVERSION SPUR TUNNEL JUNCTION

30' 20' 10' 0 30' 60'

Passaic River Basin, N.J. & N.Y.

22 FOOT SPUR TUNNEL

INLET, JUNCTION DETAILS

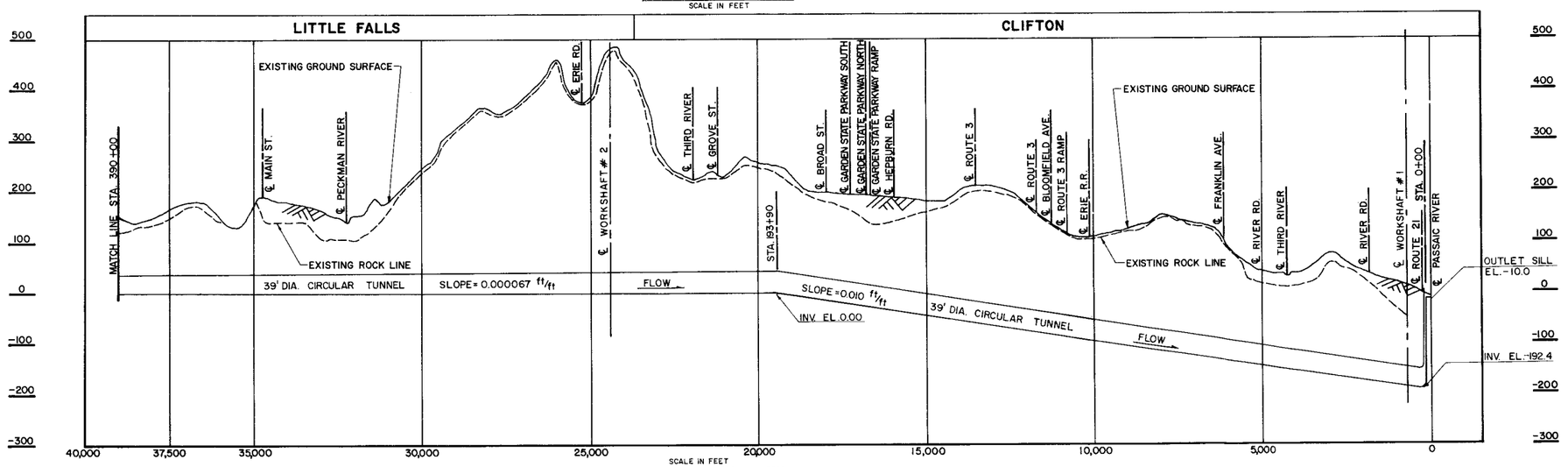
PLATE II-16



PLAN

1500 0 1500 3000

SCALE IN FEET

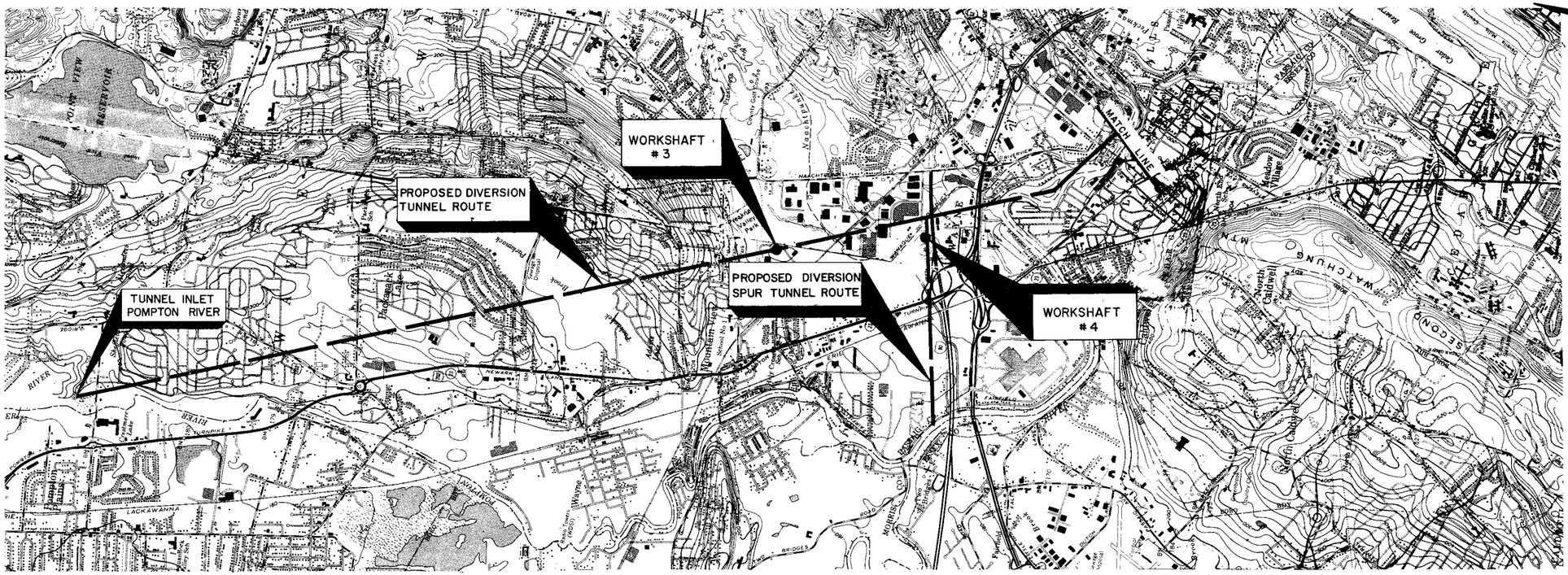


PROFILE OF DIVERSION TUNNEL

Passaic River Basin, N.J. & N.Y.

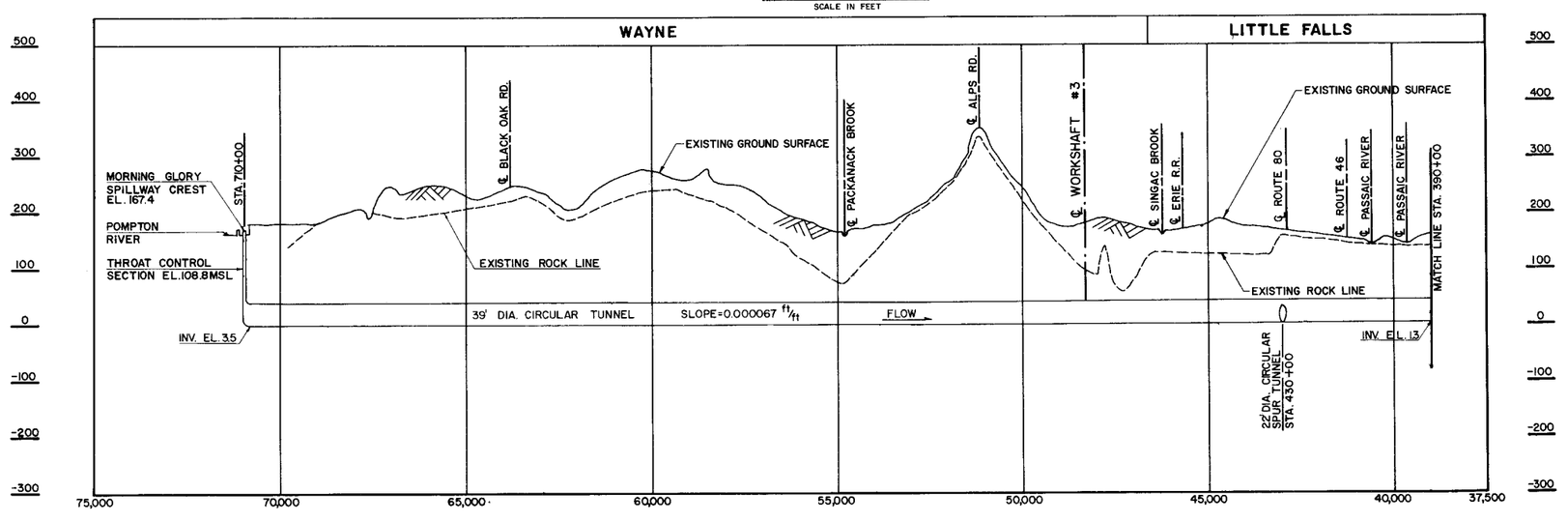
39 FOOT POMPTON RIVER TO PASSAIC RIVER TUNNEL PLAN & PROFILE (1 OF 2)

PLATE II-17



PLAN

1500 0 1500 3000
SCALE IN FEET

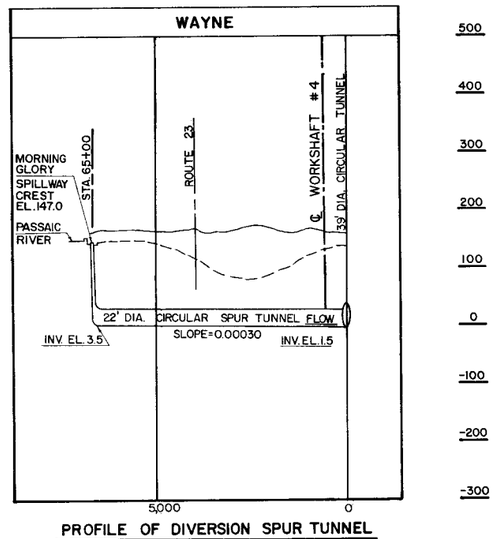


SCALE IN FEET

HORIZ. 1500 0 1500 3000

VERT. 100 0 100 200

PROFILE OF DIVERSION TUNNEL

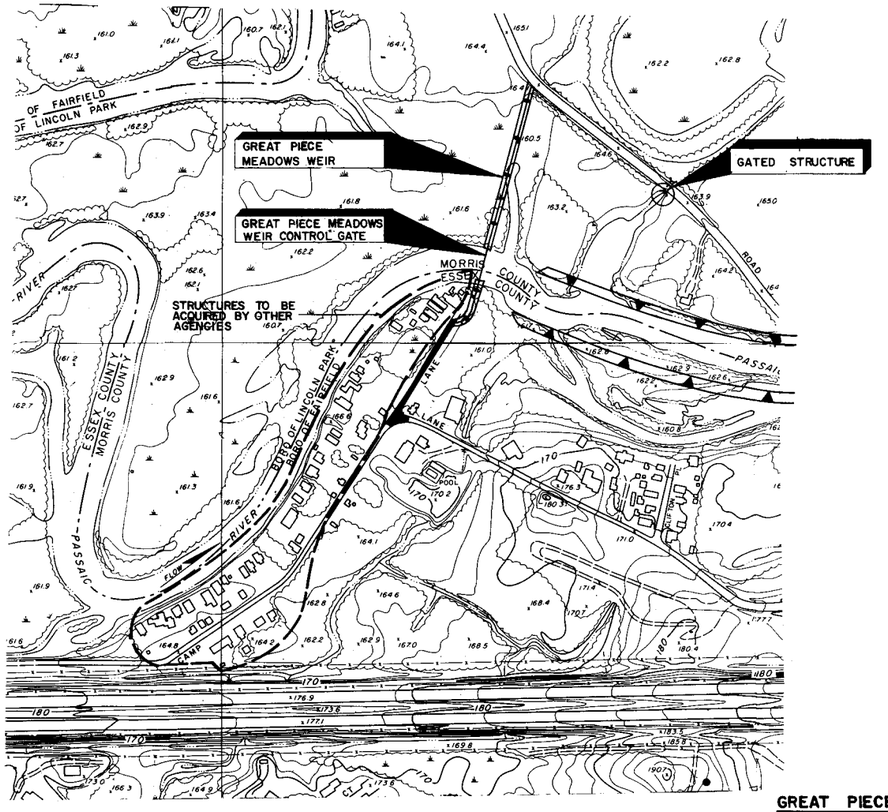


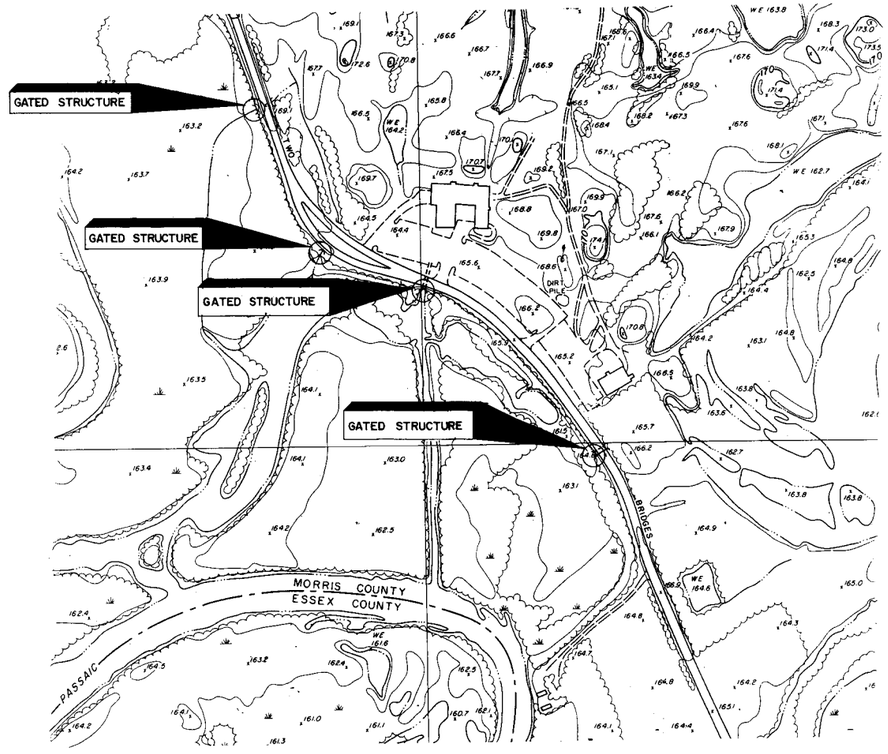
PROFILE OF DIVERSION SPUR TUNNEL

Passaic River Basin, N.J. & N.Y.

39 FOOT POMPTON RIVER TO PASSAIC RIVER TUNNEL, 22' SPUR TUNNEL PLAN & PROFILE (2 OF 2)

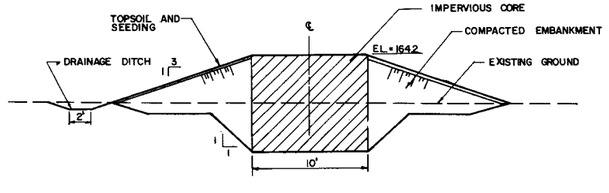
PLATE II-18





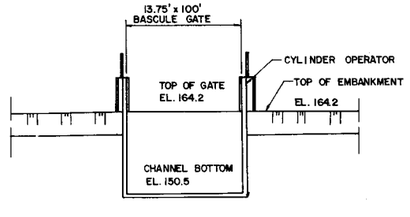
GREAT PIECE MEADOWS WEIR LOCATION

200' 100' 0 200' 400'



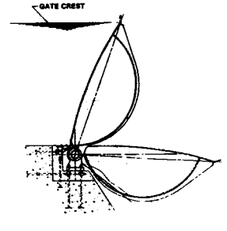
GREAT PIECE MEADOWS WEIR

SCALE = 1" = 5'



GREAT PIECE MEADOWS WEIR CONTROL GATE

SCALE: HORZ = 1" = 50'
VERT = 1" = 10'



BASCULE GATE

NOT TO SCALE

Passaic River Basin, N.J. & N.Y.

GREAT PIECE MEADOWS WEIR DETAILS

PLATE II-19

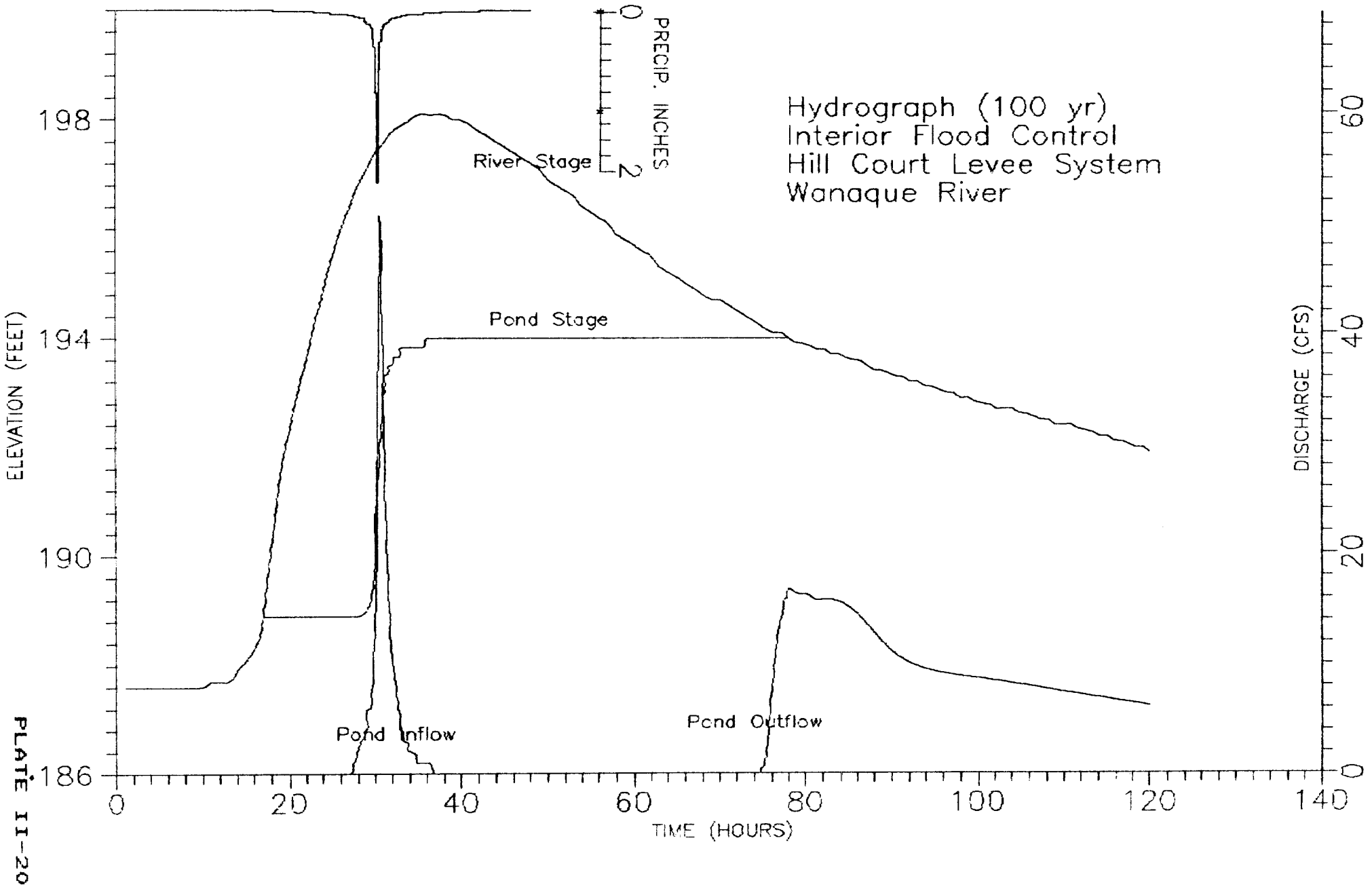

Hydrograph (100 yr)
Interior Flood Control
Hill Court Levee System
Wanaque River
PRECIP. INCHES
0
2
River Stage
Pond Stage
Pond Inflow
Pond Outflow
ELEVATION (FEET)
198
194
190
186
DISCHARGE (CFS)
60
40
20
0
0
20
40
60
80
100
120
140
TIME (HOURS)

PLATE II-20

HYDROGAPH (100 YR)
INTERIOR FLOOD CONTROL
TURNPIKE LEVEE SYSTEM
LOWER PASSAIC RIVER

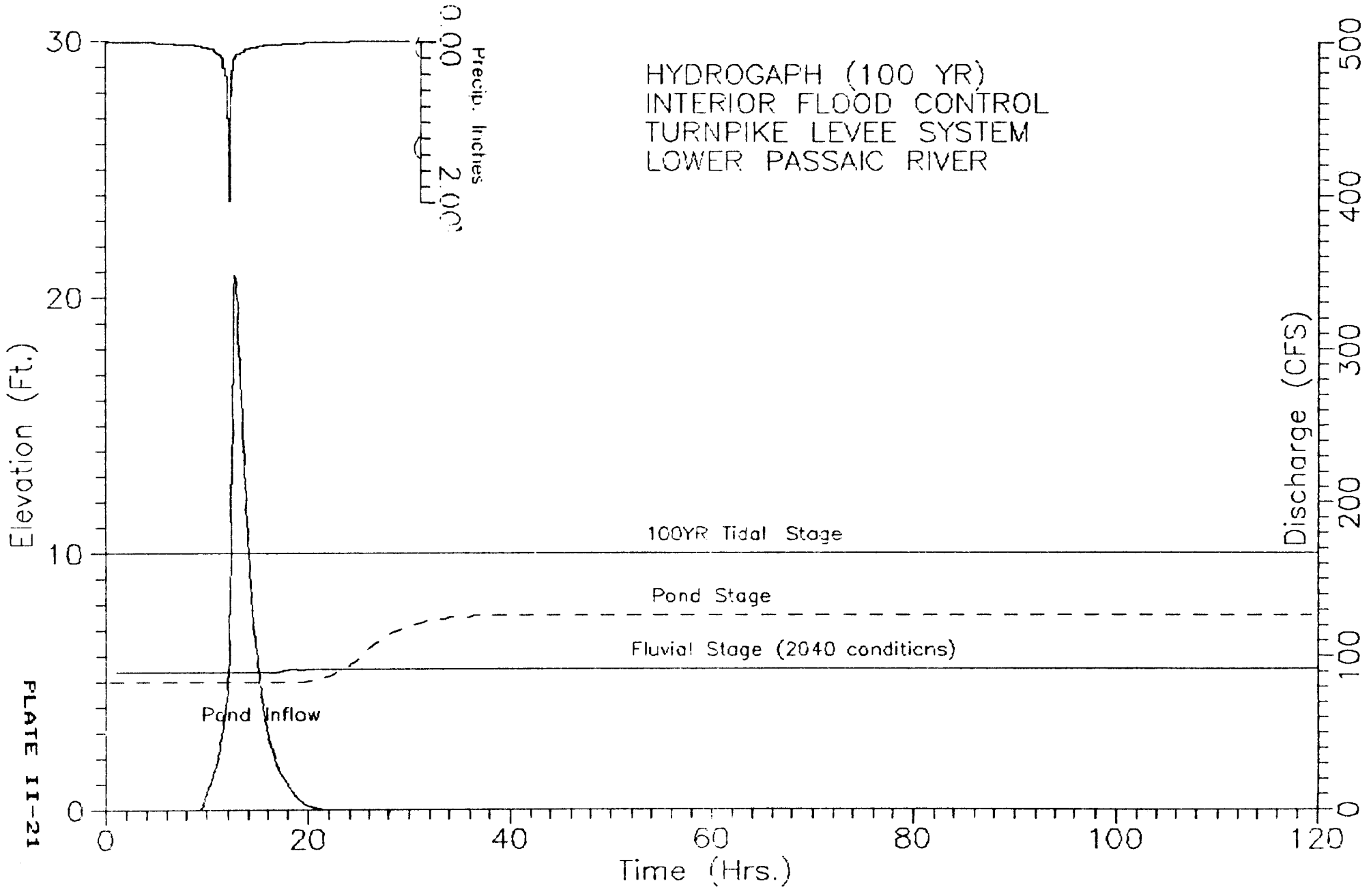


PLATE II-21

PASSAIC RIVER
NINE BROOK TO MOUTH
EXISTING VS BEATTIES ACT. 2

OK
07 FEB 89

STA	NODE	D.A.	ONE YEAR	TWO YEAR	FIVE YEAR	TEN YEAR	25 YEAR	50 YEAR	100 YEAR	500 YEAR	SPEC
0	800	934.46	5954	8306	11015	14174	19141	24070	28822	47172	45567
			(5895)	(8178)	(10858)	(14060)	(19024)	(23971)	(28682)	(46996)	(45815)
42200	700	921.46	5961	8295	10996	14150	19137	24042	28682	47027	45720
			(5902)	(8167)	(10834)	(14037)	(19027)	(23979)	(28982)	(46852)	(45775)
58765	600	897.74	5934	8261	10935	14069	19046	23954	28754	46705	45747
			(5874)	(8133)	(10779)	(13963)	(18946)	(23868)	(28542)	(46532)	(45611)
74000	500	878.71	5936	8253	10919	14043	19033	23937	28731	46577	45742
			(5876)	(8128)	(10762)	(13940)	(18939)	(23856)	(28523)	(46403)	(45609)
91755	400	858.14	5870	8187	10773	13840	18735	23507	28143	45419	45028
			(5812)	(8063)	(10674)	(13762)	(18665)	(23424)	(27954)	(45262)	(44908)
111020	300	800.19	5874	8183	10758	13815	18724	23504	28131	45413	45036
			(5816)	(8061)	(10656)	(13739)	(18659)	(23424)	(27947)	(45244)	(44922)
133860	200	784.78	5863	8173	10726	13775	18678	23449	28082	45274	44987
			(5805)	(8050)	(10640)	(13705)	(18622)	(23369)	(27874)	(45108)	(44869)
149110	100	772.53	5848	8161	10703	13735	18631	23387	27985	45125	44914
			(5792)	(8038)	(10622)	(13668)	(18579)	(23308)	(27804)	(44953)	(44805)
156816											
169300											
173500	35	739.47	5539	7879	10316	13172	17920	22622	27159	44157	43831
			(5489)	(7773)	(10253)	(13148)	(17919)	(22522)	(27042)	(43980)	(43745)
194630											
219863	ADD20	360.36	3091	4103	5437	6920	9161	10838	13088	19423	25230
			(3091)	(4103)	(5437)	(6920)	(9161)	(10838)	(13088)	(19423)	(25230)
236330	12	343.08	2962	3989	5285	6869	9124	10796	13081	19509	25212
			(2962)	(3989)	(5285)	(6869)	(9124)	(10796)	(13081)	(19509)	(25212)

* - VALUES IN THESE ARE - WAS COVER

Hydrograph (100 yr)
Interior Flood Control
Shore Road Levee System
Ramapo River

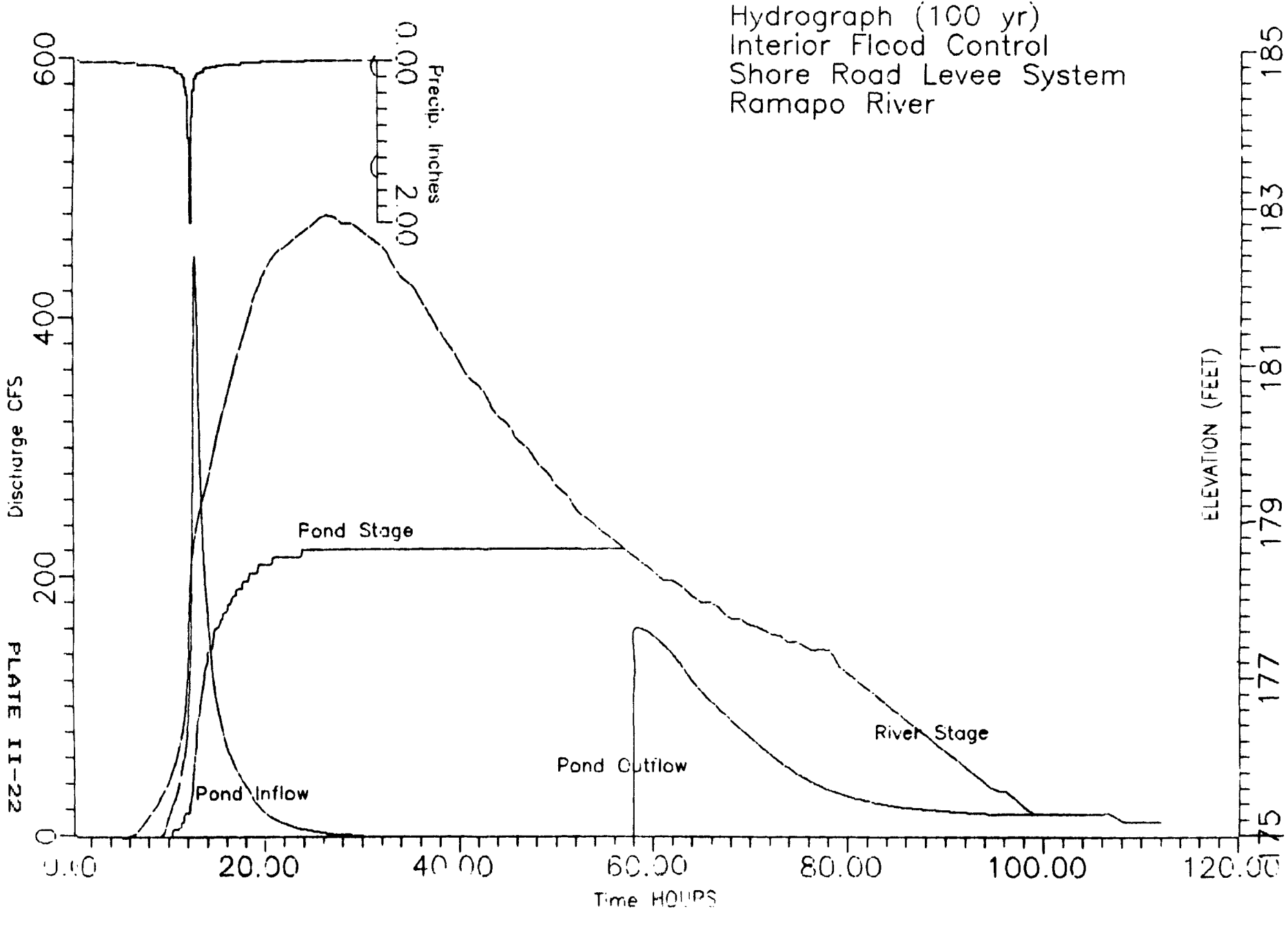


PLATE II-22

LEGEND:
100 YEAR
500 YEAR

MATCH TO SHEET II-2

STA. 166+65

150+00

100+00

50+00

HACKENSACK RIVER

SCALE IN FEET
500 250 0 500 1000'

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA: 0+00 TO STA. 166+65

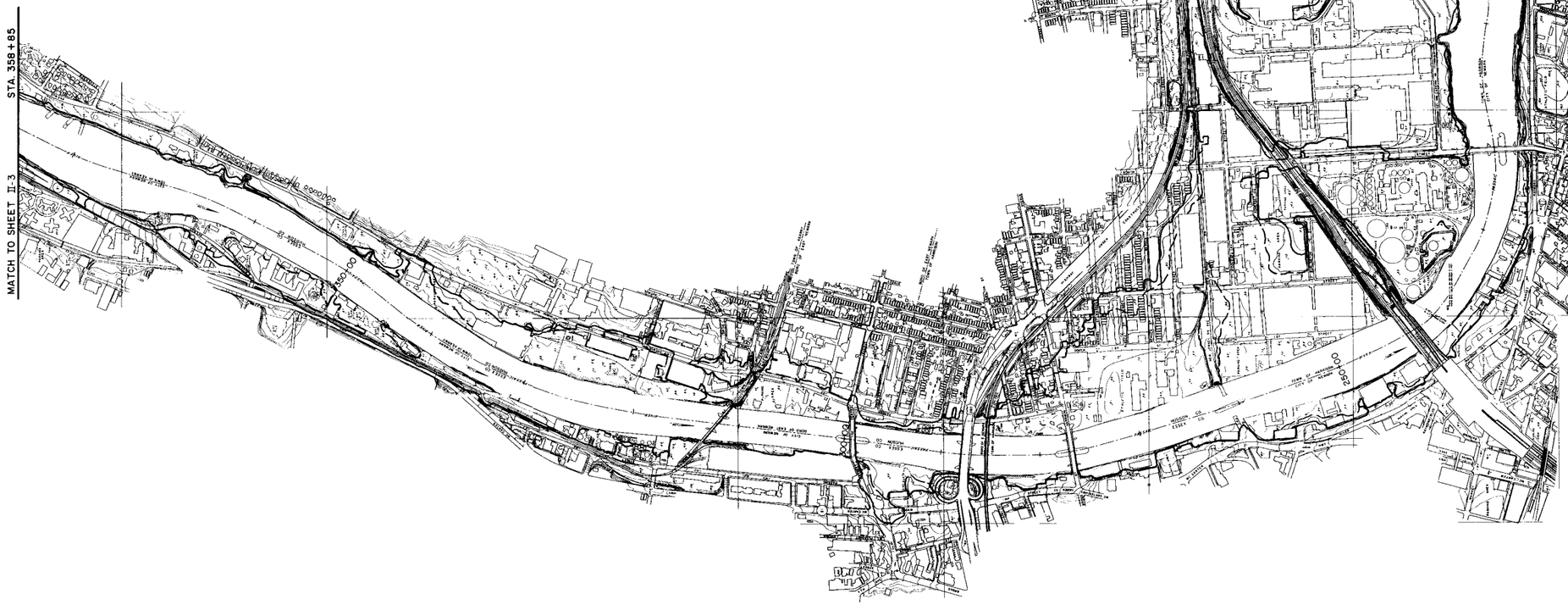
HACKENSACK RIVER

FLOOD LIMITS

NEWARK
KEARNY
HARRISON

FIGURE NO. II-1

LEGEND:
100 YEAR — — —
500 YEAR ———



SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

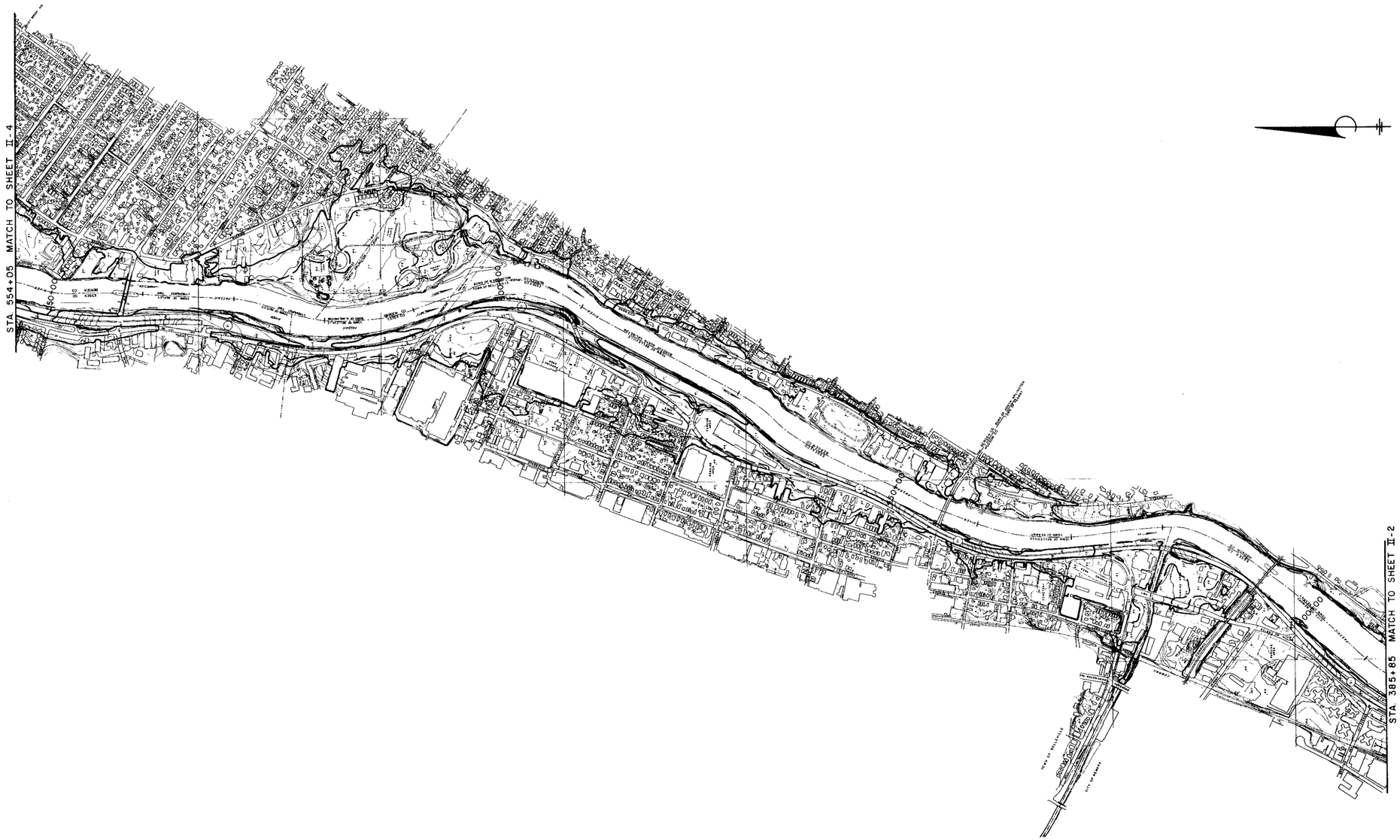
STA. 166+65 TO STA. 358+85

FLOOD LIMITS

NEWARK **KEARNY**
HARRISON **EAST NEWARK**

FIGURE NO. II-2

LEGEND:
100 YEAR — — —
500 YEAR ———



SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 385+85 TO STA. 554+05

FLOOD LIMITS

NEWARK KEARNY
BELLEVILLE NORTH ARLINGTON
NUTLEY LYNDHURST

FIGURE NO. II-3

LEGEND:
100 YEAR
500 YEAR



SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.
PASSAIC RIVER
STA. 554+05 TO STA. 733+05

FLOOD LIMITS
EAST RUTHERFORD
NUTLEY LYNDHURST RUTHERFORD
PASSAIC CLIFTON WALLINGTON

FIGURE NO. II-4

LEGEND:
100 YEAR — — —
500 YEAR ———

MATCH TO SHEET II-4 STA. 733+05

MATCH TO SHEET II-6 STA. 974+55

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 733+05 TO STA. 974+55

FLOOD LIMITS

PASSAIC WALLINGTON GARFIELD
SOUTH HACKENSACK LODI CLIFTON
ELMWOOD PARK PATERSON

FIGURE NO. II - 5

MATCH TO SHEET II-7 STA. 1220+55

LEGEND:
100 YEAR
500 YEAR

MATCH TO SHEET II-5 STA 974+55

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 974+55 TO STA. 1220+55

FLOOD LIMITS

PATERSON
FAIRLAWN
ELMWOOD PARK
HAWTHORNE

FIGURE NO. II-6

LEGEND:
100 YEAR — — —
500 YEAR ———

MATCH TO SHEET II-8

STA. 1387+25

STA 1220+55

MATCH TO SHEET II-6

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

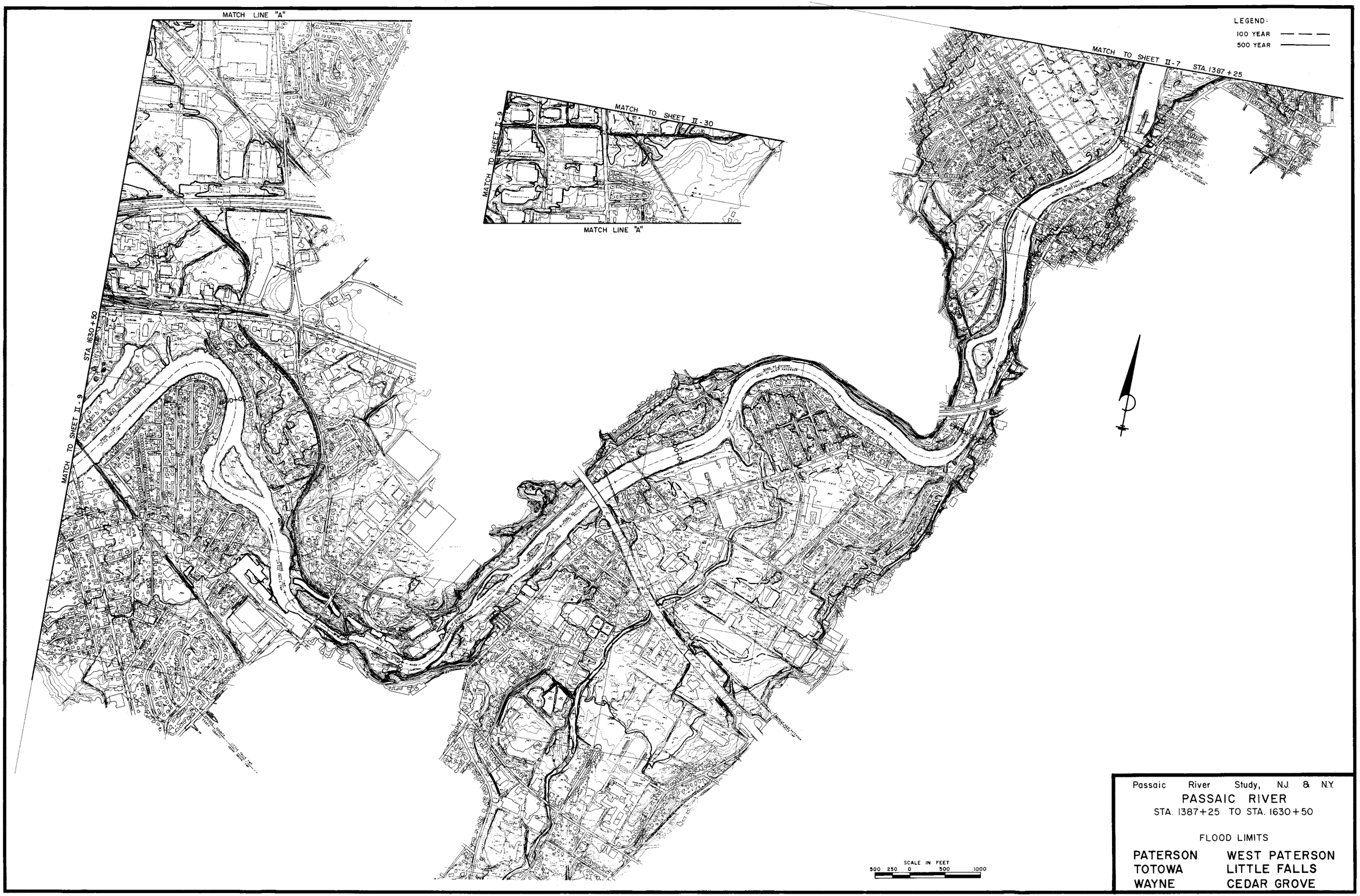
PASSAIC RIVER

STA. 1220+55 TO STA. 1387+25

FLOOD LIMITS

PATERSON
HAWTHORNE
TOTOWA
PROSPECT PARK
HALEDON

FIGURE NO. II-7



Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

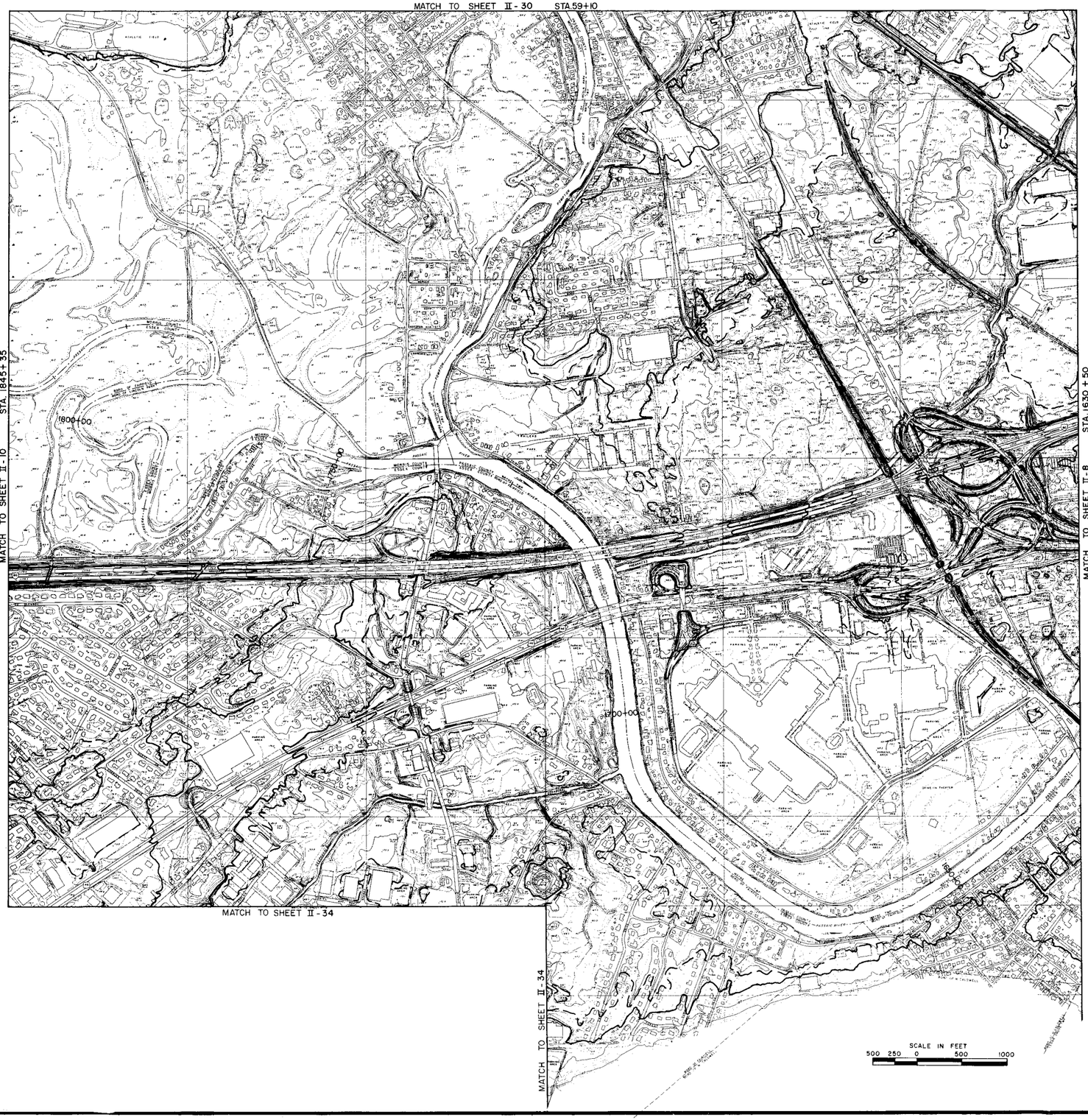
STA. 1387+25 TO STA. 1630+50

FLOOD LIMITS

PATERSON	WEST PATERSON
TOTOWA	LITTLE FALLS
WAYNE	CEDAR GROVE

FIGURE NO. II-8

MATCH TO SHEET II - 30 STA.59+10



LEGEND:
100 YEAR — — — —
500 YEAR ————

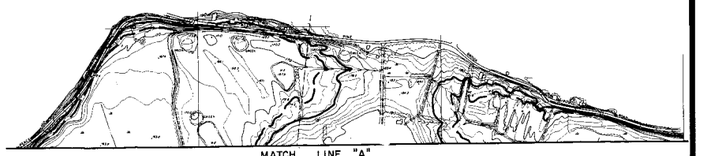
Passaic River Study, N.J. & N.Y.

PASSAIC RIVER
STA. 1630+50 TO STA. 1845+35
POMPTON RIVER
FLOOD LIMITS

LITTLE FALLS
CEDAR GROVE
NORTH CALDWELL
LINCOLN PARK
FAIRFIELD
WAYNE

FIGURE NO. II-9

MATCH LINE "A"



MATCH LINE "A"

LEGEND:
100 YEAR
500 YEAR

MATCH TO SHEET II-9

STA. 1845+35

MATCH TO SHEET II-11 STA. 2192+95

MATCH TO SHEET II-34

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 1845+35 TO STA. 2192+95

FLOOD LIMITS

FAIRFIELD
MONTVILLE
LINCOLN PARK

FIGURE NO. II-10

MATCH TO SHEET II-36

MATCH TO SHEET II-21

STA. 169+10

STA. 42+20

MATCH TO SHEET II-12

STA. 2453+55

MATCH TO SHEET II-10

STA. 2192+95

MATCH TO SHEET II-35

MATCH TO SHEET II-34

LEGEND:

100 YEAR

500 YEAR

SCALE IN FEET

500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 2192+95 TO STA. 2453+55

ROCKAWAY RIVER & WHIPPANY RIVER

FLOOD LIMITS

PARSIPPANY TROY-HILLS

WEST CALDWELL EAST HANOVER

FAIRFIELD MONTVILLE

FIGURE NO. II-11

MATCH TO SHEET II-13 STA. 2657+30

MATCH TO SHEET II-36 STA. 51+25

MATCH TO SHEET II-39

STA. 42+20

MATCH TO SHEET II-11

STA. 2453+55

2650+00

2600+00

2550+00

2500+00

LEGEND:

100 YEAR

500 YEAR

SCALE IN FEET

500 250 0 500 1000

MATCH TO SHEET II-35

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 2453+55 TO STA. 2657+30

FLOOD LIMITS

WEST CALDWELL ROSELAND

EAST HANOVER LIVINGSTON

FIGURE NO. II-12

LEGEND:
100 YEAR — — —
500 YEAR ————

MATCH TO SHEET II-15

MATCH TO SHEET II-14 STA. 2800+70

MATCH TO SHEET II-12 STA. 2657+30

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 2657+30 TO STA. 2800+70

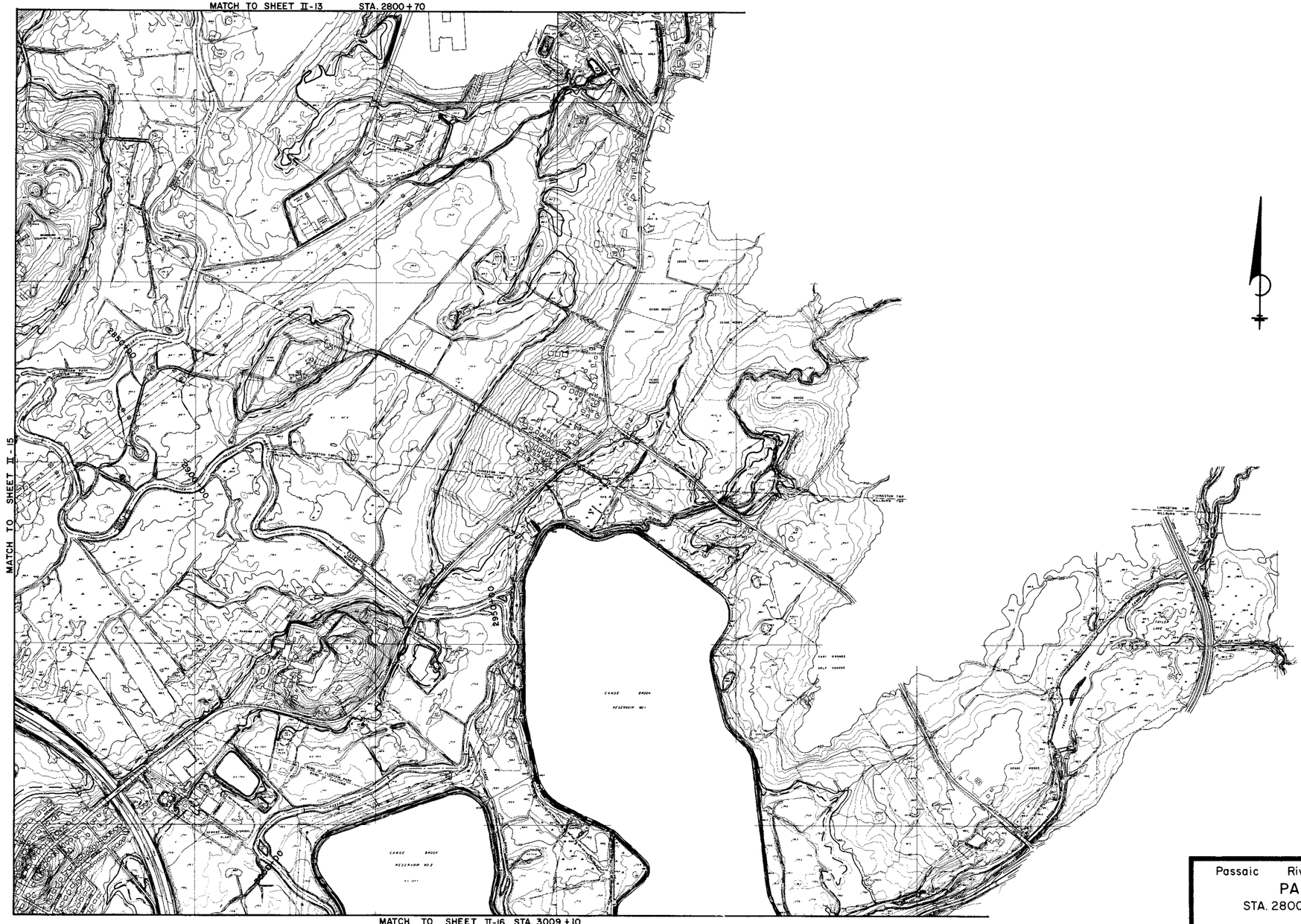
FLOOD LIMITS

LIVINGSTON
EAST HANOVER
FLORHAM PARK

FIGURE NO. II-13

LEGEND:
100 YEAR — — —
500 YEAR ———

MATCH TO SHEET II-13 STA. 2800+70



MATCH TO SHEET II-15

MATCH TO SHEET II-16 STA. 3009+10

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.
PASSAIC RIVER
STA. 2800+70 TO STA. 3009+10

FLOOD LIMITS

LIVINGSTON FLORHAM PARK
MILLBURN CHATHAM

FIGURE NO. II-14

LEGEND:

100 YEAR — — —

500 YEAR ————



SCALE IN FEET

500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

FLOOD LIMITS

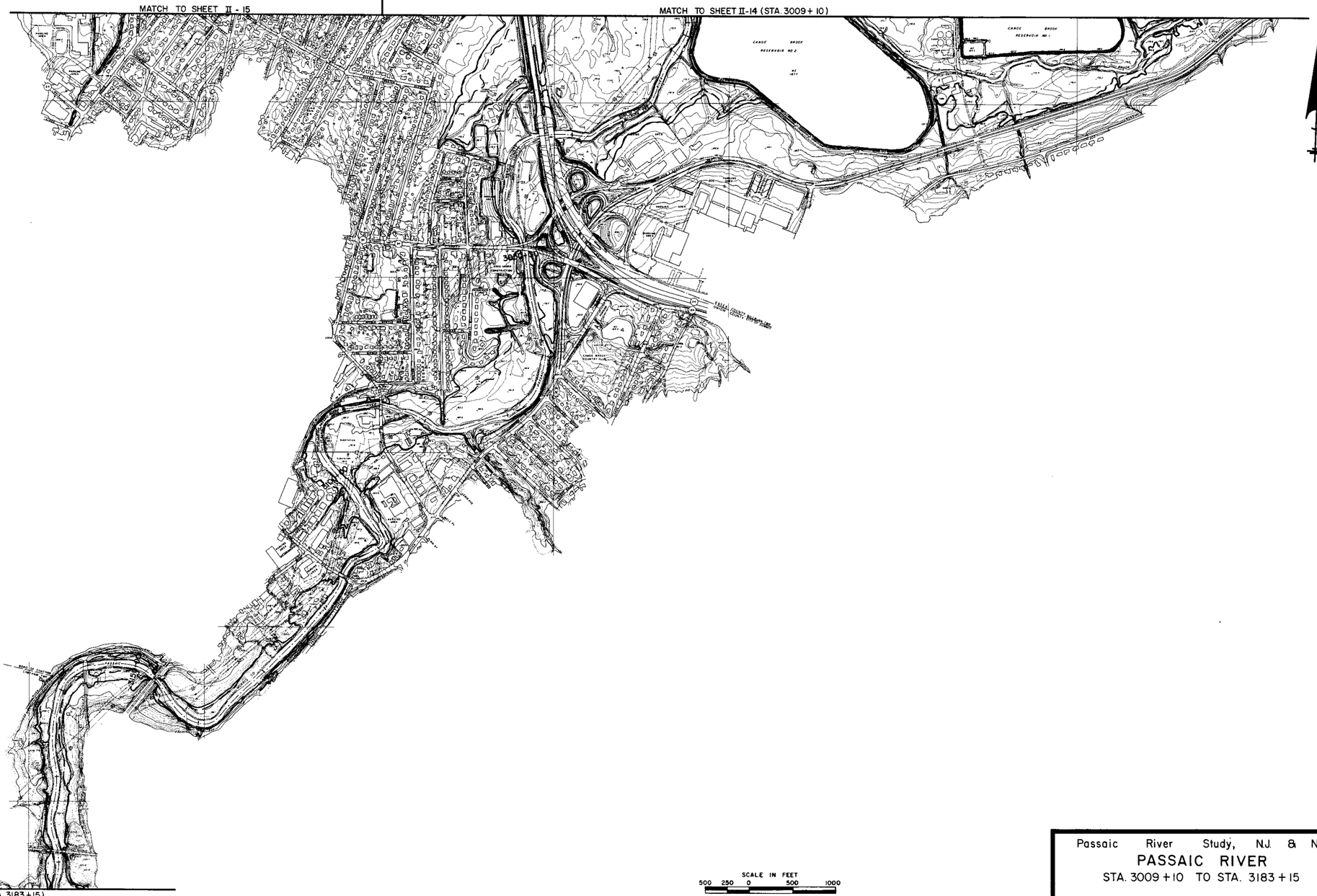
CHATHAM FLORHAM PARK

FIGURE NO. II-15

LEGEND:
100 YEAR
500 YEAR

MATCH TO SHEET II - 15

MATCH TO SHEET II-14 (STA. 3009+10)



MATCH TO SHEET II-17(STA 3183+15)

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 3009+10 TO STA. 3183+15

FLOOD LIMITS

MILLBURN BOROUGH OF CHATHAM
SUMMIT CHATHAM TOWNSHIP

FIGURE NO. II-16

LEGEND:
100 YEAR — — —
500 YEAR ———

MATCH TO SHEET II-16 (STA. 3183+15)



MATCH TO SHEET II-18 (STA. 3383+65)

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.
PASSAIC RIVER
STA. 3183 + 15 TO STA. 3383 + 65

FLOOD LIMITS
CHATHAM TOWNSHIP
SUMMIT NEW PROVIDENCE
BERKELY HEIGHTS

FIGURE NO. II-17

MATCH TO SHEET II-17 (STA 3383+65)



Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 3383+65 TO STA. 3520+00

FLOOD LIMITS

BERKLEY HEIGHTS PASSAIC TOWNSHIP

CHATHAM TOWNSHIP WARREN

FIGURE NO. II-18



Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

STA. 3520+00 TO STA. 3709+60

FLOOD LIMITS

PASSAIC TOWNSHIP
WARREN

FIGURE NO. II-19

LEGEND:
100 YEAR — — —
500 YEAR ———



SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.
PASSAIC RIVER
STA. 3709+60 TO LIMIT OF STUDY

FLOOD LIMITS
PASSAIC TOWNSHIP
WARREN
BERNARDS

FIGURE NO. II-20

LEGEND:
100 YEAR — — —
500 YEAR ———



SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.
ROCKAWAY RIVER
STA. 169+10 TO STA. 273+30

FLOOD LIMITS

MONTVILLE
PARSIPPANY-TROY HILLS

FIGURE NO. II-21



LEGEND:
100 YEAR — — —
500 YEAR ————

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, NJ & NY.

ROCKAWAY RIVER

STA. 273+30 TO LIMIT OF STUDY

FLOOD LIMITS

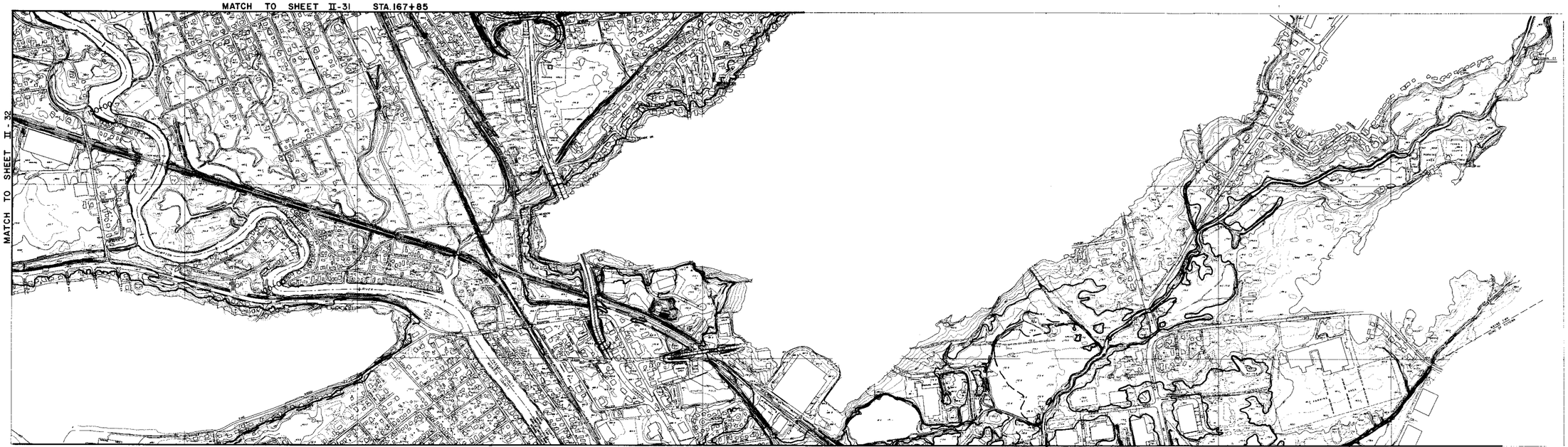
BOONTON
MONTVILLE
PARSIPPANY-TROY HILLS

FIGURE NO. II-22

LEGEND:
100 YEAR — — —
500 YEAR ———

MATCH TO SHEET II-31 STA. 167+85

MATCH TO SHEET II-32



MATCH TO SHEET II-9 STA. 59+10

MATCH TO SHEET II-8

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.
POMPTON RIVER
STA. 59+10 TO STA. 167+85

FLOOD LIMITS
WAYNE
LINCOLN PARK
TOTOWA

FIGURE NO. II-30

LEGEND:
100 YEAR — — —
500 YEAR ————



Passaic River Study, N.J. & N.Y.

POMPTON RIVER

STA. 167+85 TO STA. 278+35

FLOOD LIMITS

WAYNE
LINCOLN PARK
PEQUANNOCK

FIGURE NO. II-31

MATCH TO SHEET II-33

LEGEND:
100 YEAR — — —
500 YEAR ———

MATCH TO SHEET II-31

MATCH LINE "A"

MATCH TO SHEET II-30

SCALE IN FEET
500 250 0 500 1000

MATCH LINE "A"

MATCH TO SHEET II-30

Passaic River Study, N.J. & N.Y.

POMPTON RIVER

FLOOD LIMITS
LINCOLN PARK
PEQUANNOCK
MONTVILLE

FIGURE NO. II-32

STA. 69+10

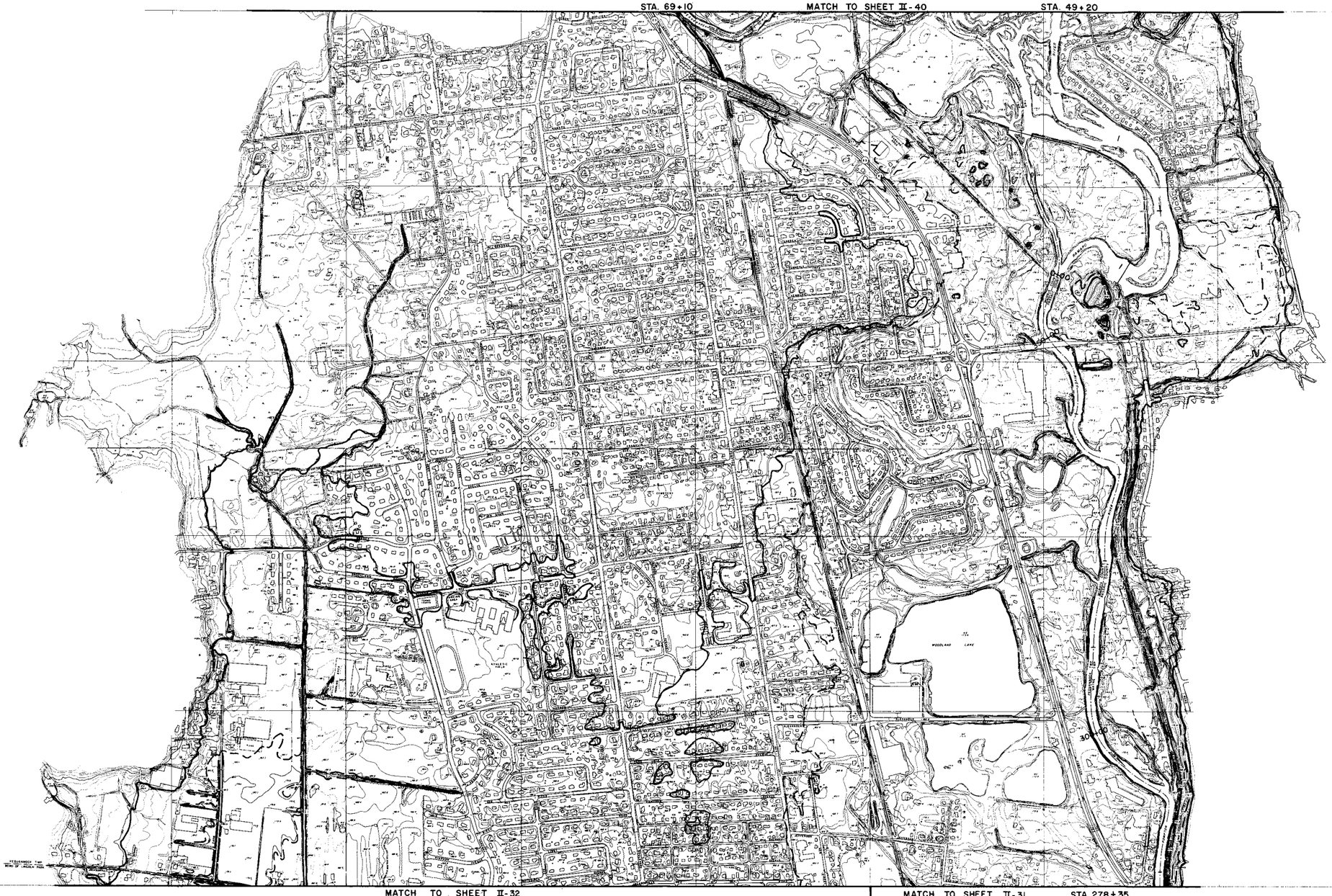
MATCH TO SHEET II-40

STA. 49+20

LEGEND:

100 YEAR

500 YEAR



MATCH TO SHEET II-32

MATCH TO SHEET II-31

STA. 278+35

SCALE IN FEET

500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

POMPTON RIVER

STA. 278+35 TO CONFLUENCE OF PEQUANNOCK & RAMAPO RIVERS

FLOOD LIMITS

POMPTON LAKES WAYNE

PEQUANNOCK LINCOLN PARK

FIGURE NO. II-33

LEGEND:
100 YEAR — — —
500 YEAR ———

MATCH TO SHEET II-10

MATCH TO SHEET II-9

MATCH TO SHEET II-11

MATCH TO SHEET II-9

MATCH TO SHEET II-35

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

FLOOD LIMITS

FAIRFIELD WEST CALDWELL

FIGURE NO. II-34

LEGEND:
100 YEAR — — —
500 YEAR ———



SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

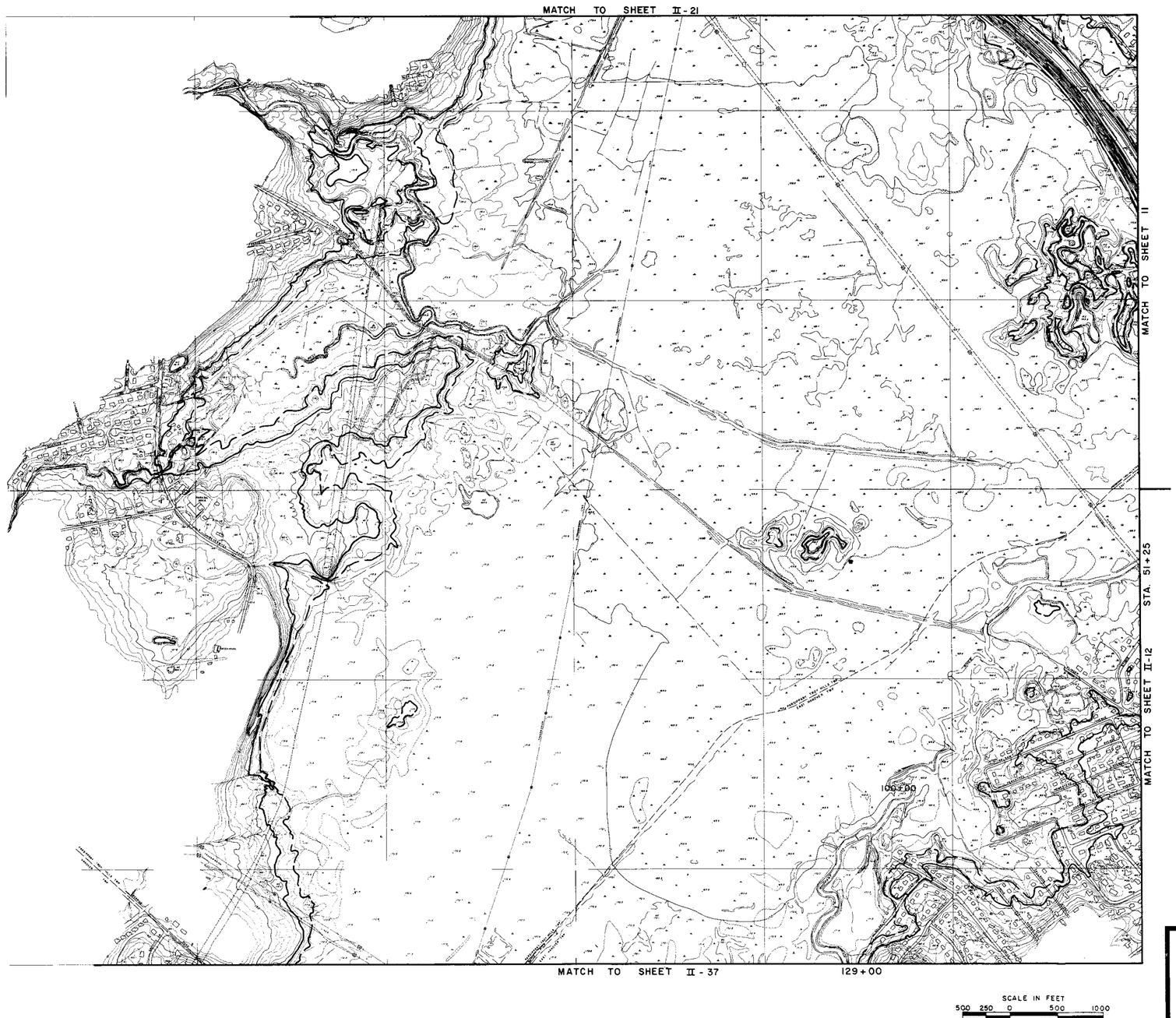
PASSAIC RIVER

FLOOD LIMITS

WEST CALDWELL

FIGURE NO. II-35

LEGEND:
100 YEAR — — —
500 YEAR ———



Passaic River Study, N.J. & N.Y.

WHIPPANY RIVER

STA. 51+25 TO STA. 129+00

FLOOD LIMITS

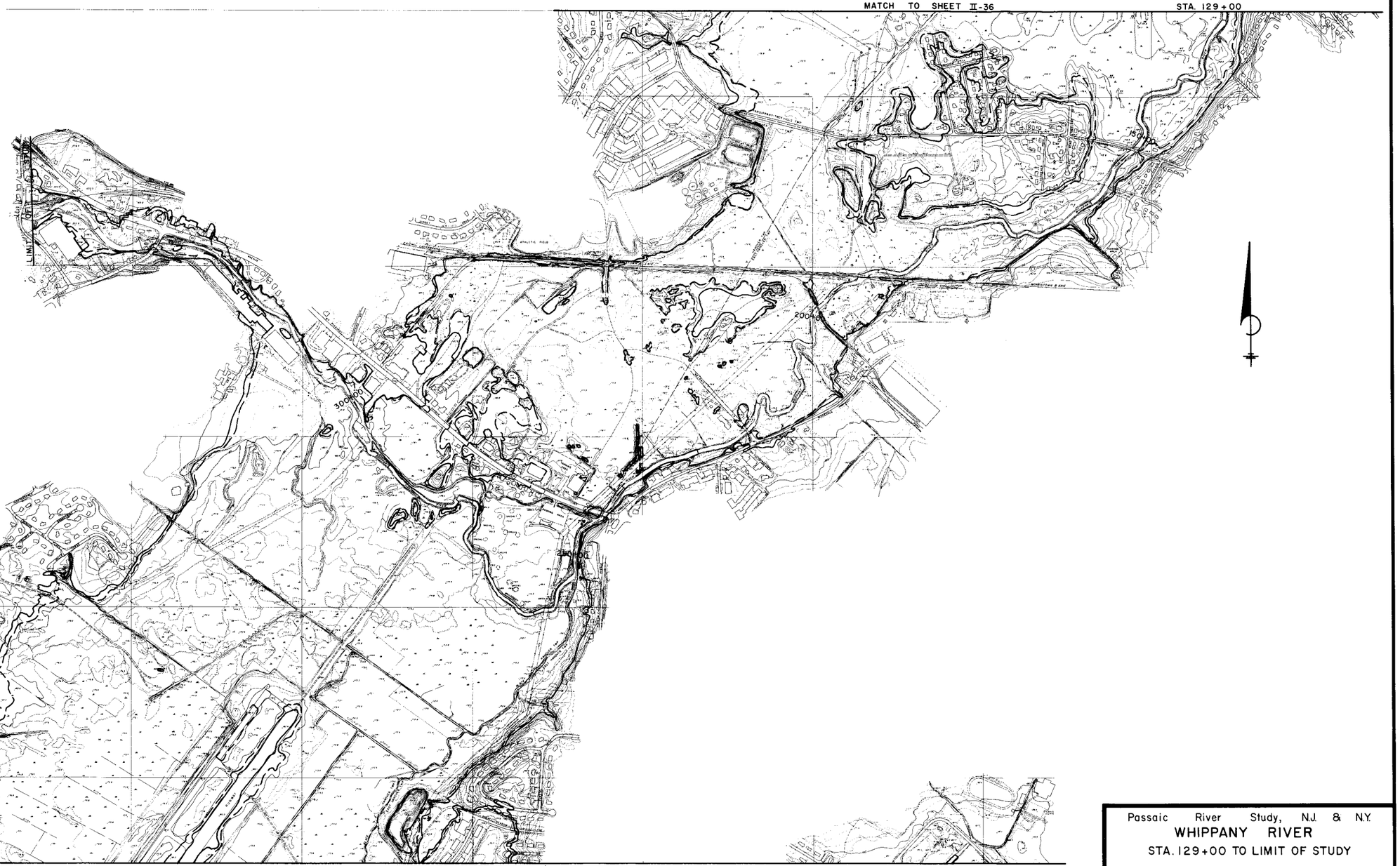
EAST HANOVER
HANOVER
PARSIPPANY - TROY HILLS

FIGURE NO. II-36

LEGEND:
100 YEAR — — —
500 YEAR ———

MATCH TO SHEET II-36

STA. 129+00



MATCH TO SHEET II-38

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.
WHIPPANY RIVER
STA. 129+00 TO LIMIT OF STUDY

FLOOD LIMITS
FAIRFIELD
HANOVER EAST HANOVER
PARSIPPANY - TROY HILLS

FIGURE NO. II-37

LEGEND:
100 YEAR
500 YEAR

MATCH TO SHEET II-37



SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.

WHIPPANY RIVER

FLOOD LIMITS

HANOVER
EAST HANOVER
FLORHAM PARK

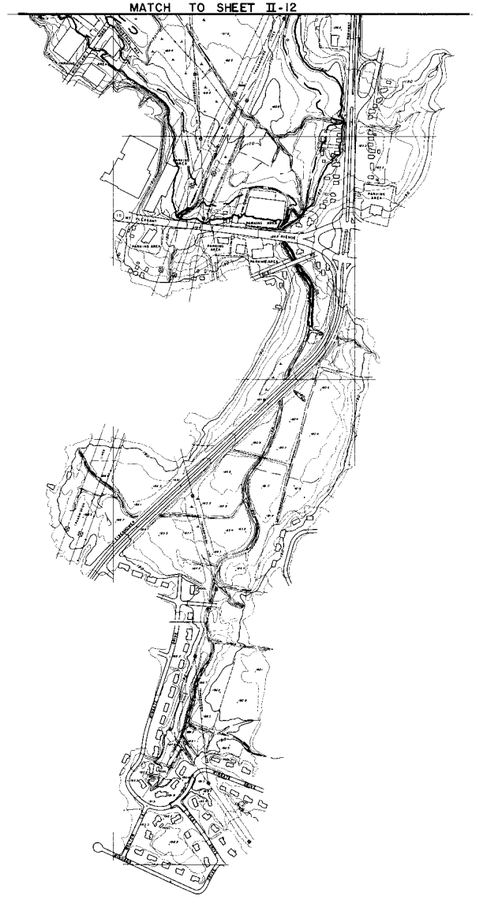
FIGURE NO. II-38

LEGEND:

100 YEAR — — —

500 YEAR ———

MATCH TO SHEET II-12





SCALE IN FEET

500 250 0 500 1000

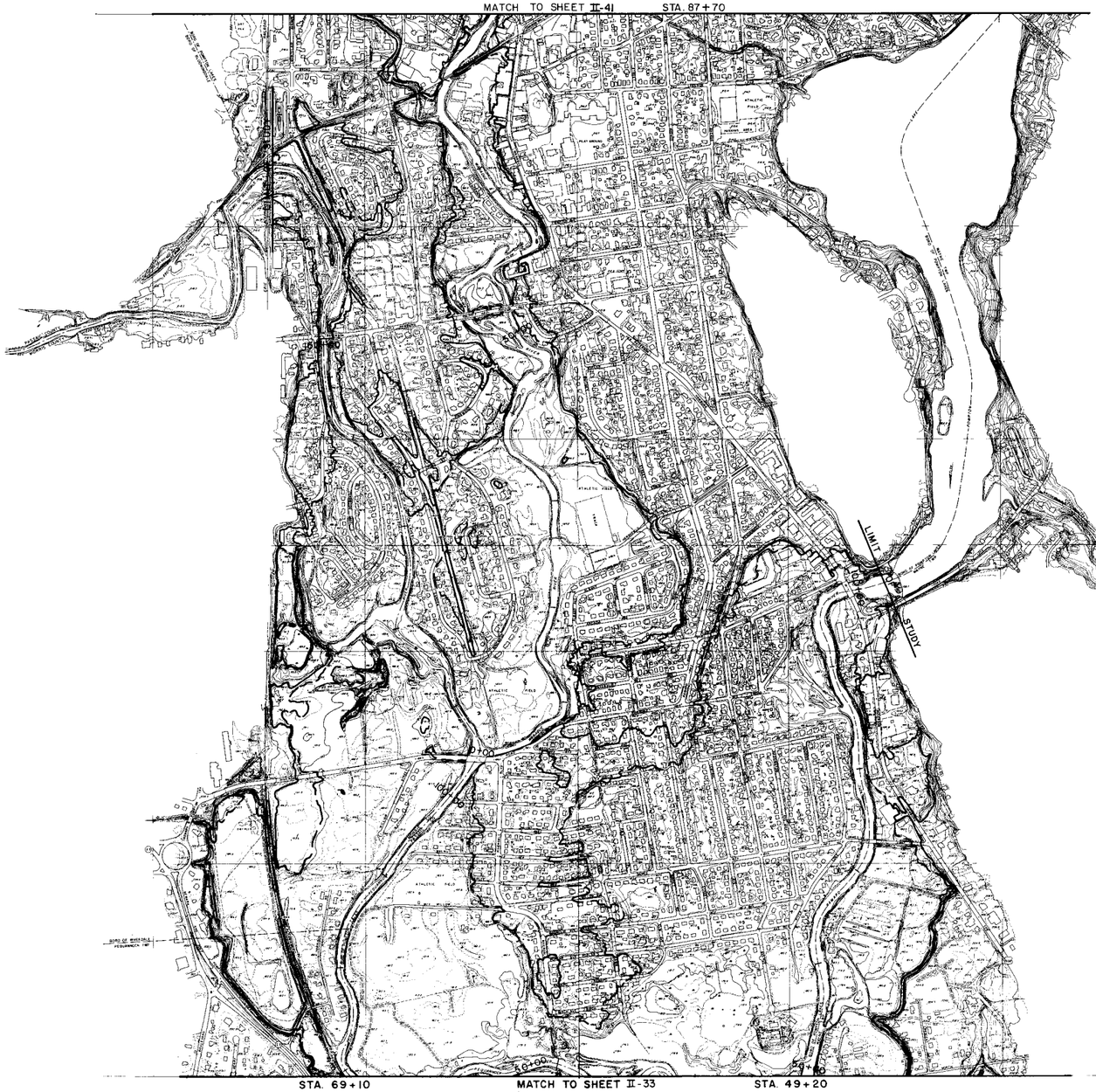
Passaic River Study, N.J. & N.Y.

PASSAIC RIVER

FLOOD LIMITS

LIVINGSTON

FIGURE NO. II-39



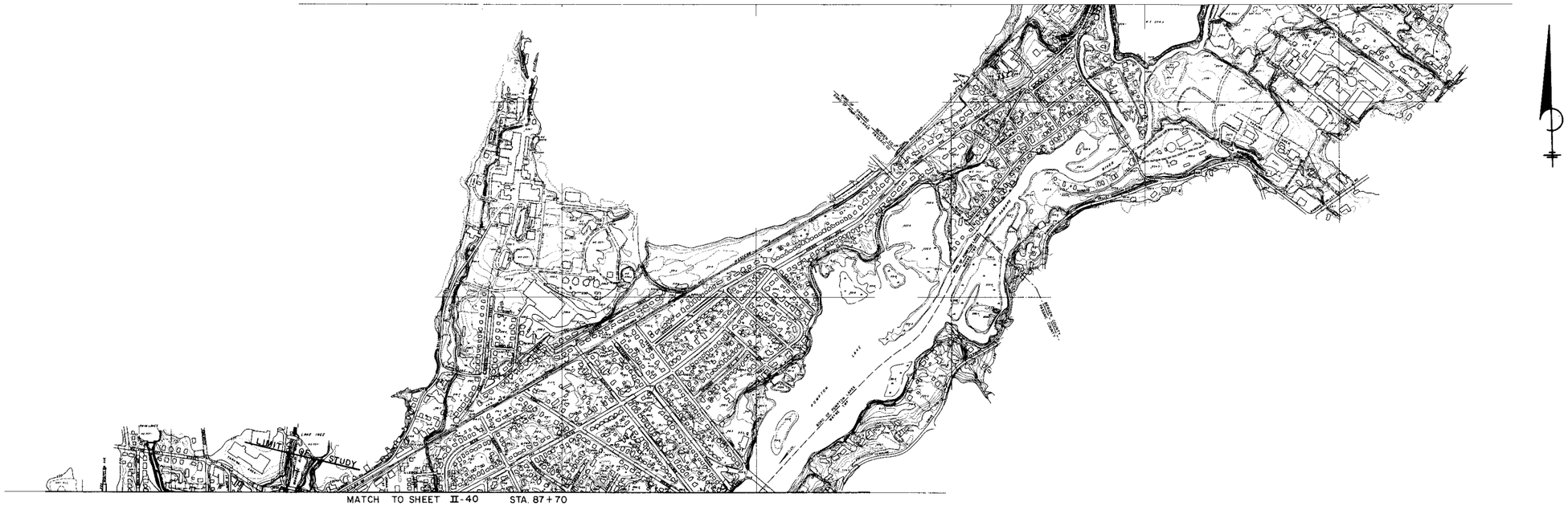
LEGEND:
100 YEAR — — — —
500 YEAR ————

SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.
RAMAPO RIVER
STA. 49+20 TO LIMIT OF STUDY
PEQUANNOCK & WANAQUE RIVERS
FLOOD LIMITS
POMPTON LAKES
PEQUANNOCK RIVERDALE
BLOOMINGDALE WAYNE

FIGURE NO. II-40

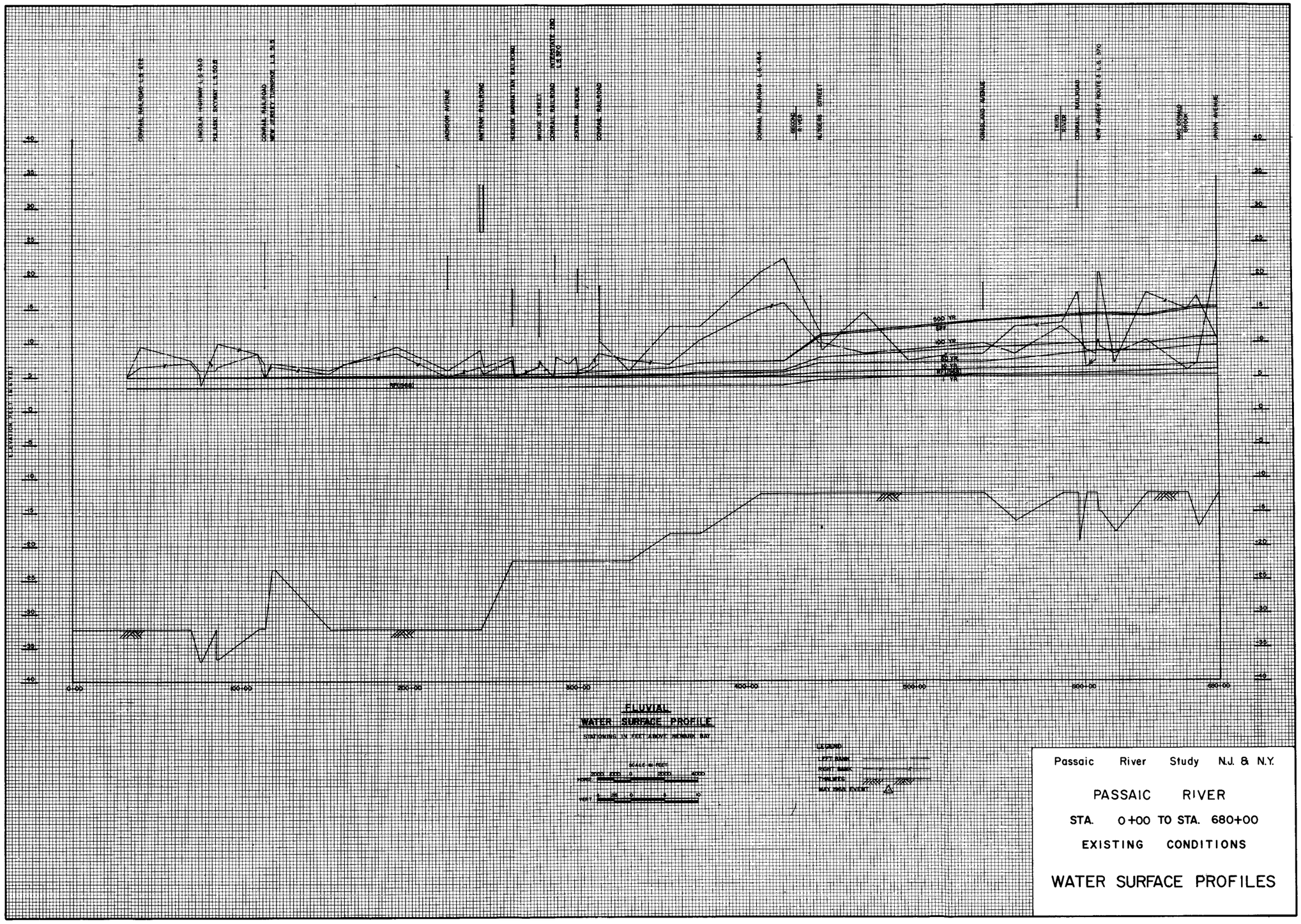
LEGEND:
100 YEAR — — — —
500 YEAR ————



SCALE IN FEET
500 250 0 500 1000

Passaic River Study, N.J. & N.Y.
WANAQUE RIVER
STA. 87+70 TO LIMIT OF STUDY
FLOOD LIMITS
WAYNE
OAKLAND
POMPTON LAKES

FIGURE NO. II-41



Passaic River Study N.J. & N.Y.

PASSAIC RIVER

STA. 0+00 TO STA. 680+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-42

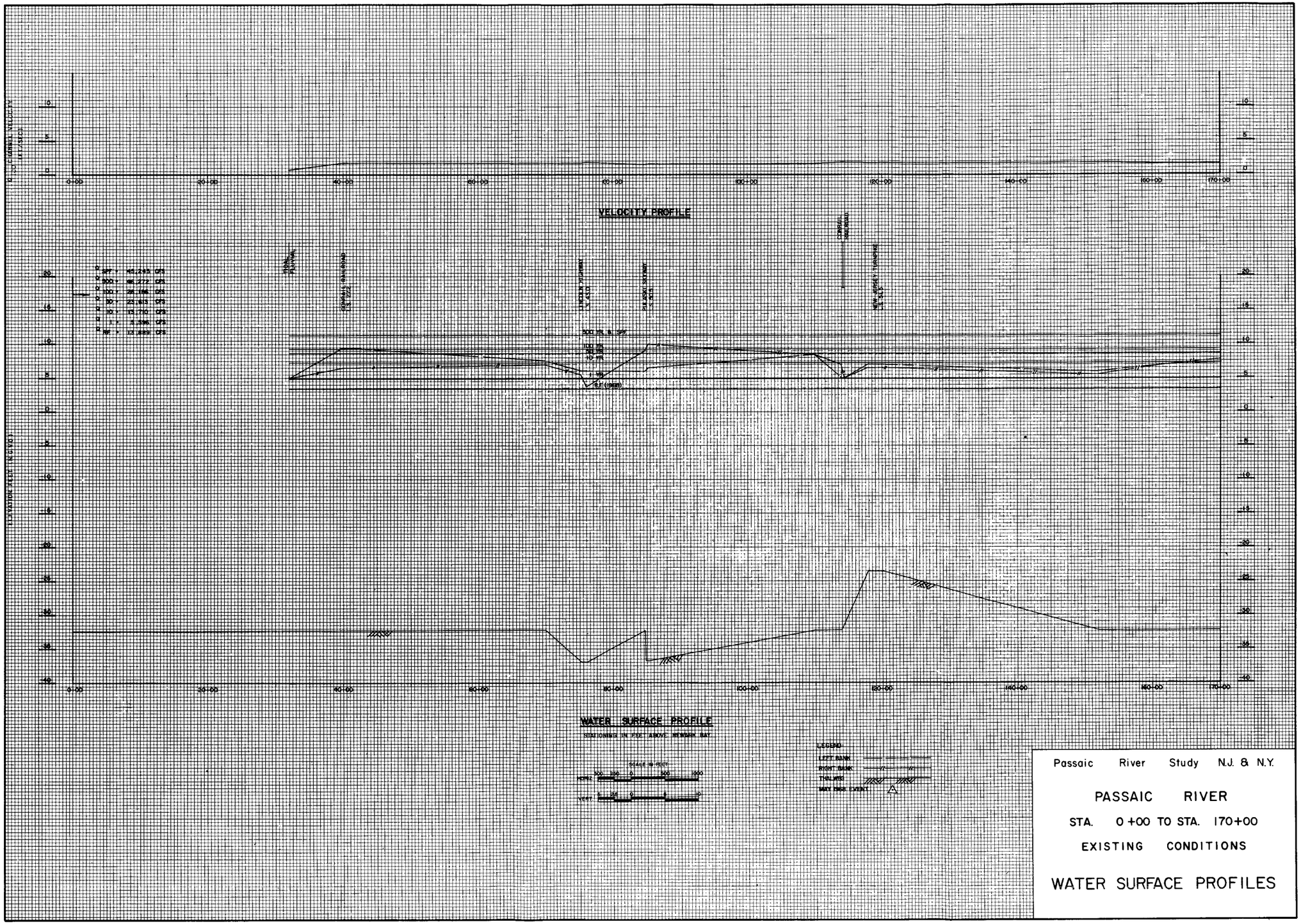


FIGURE NO. II-43

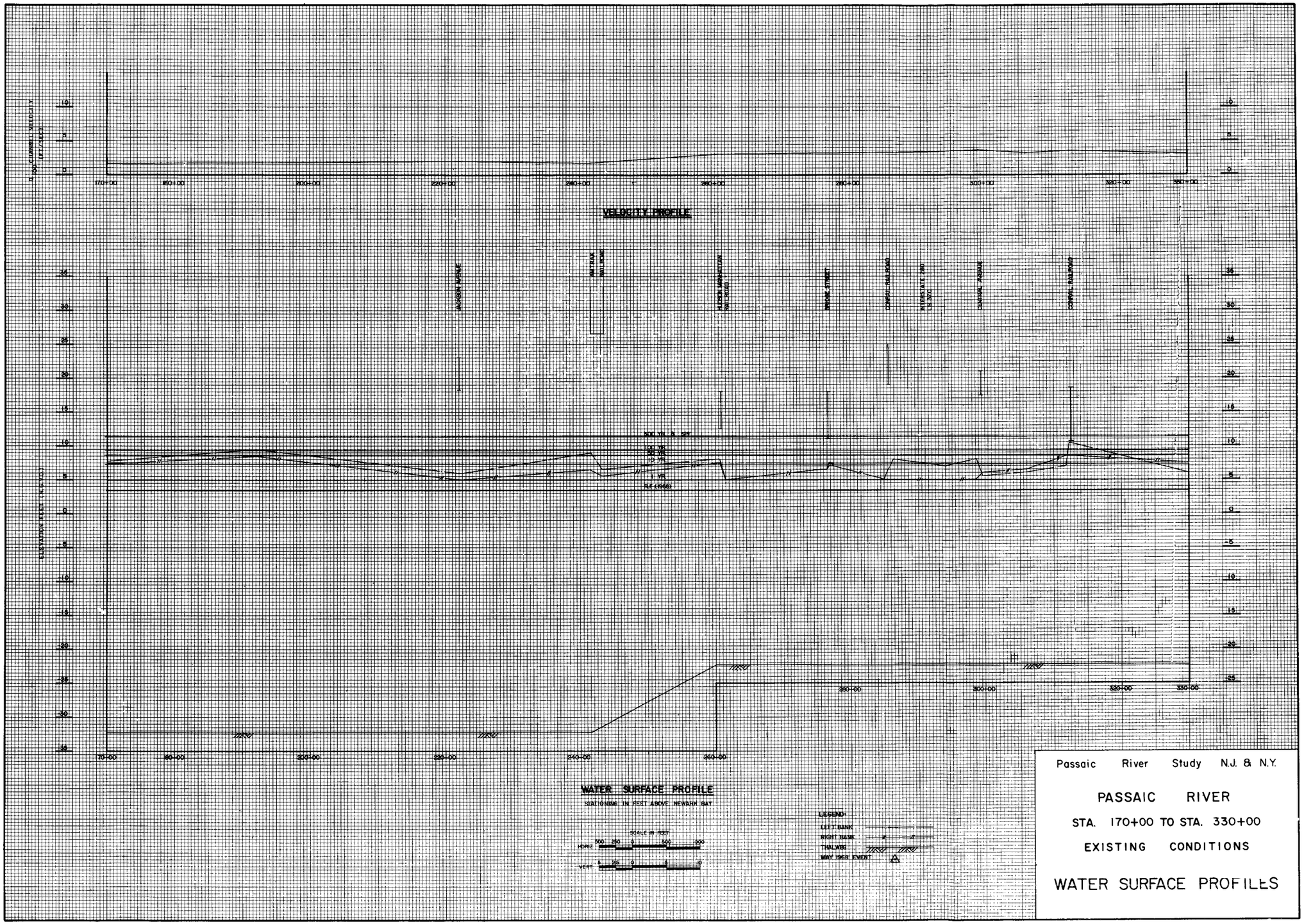


FIGURE NO. II-44

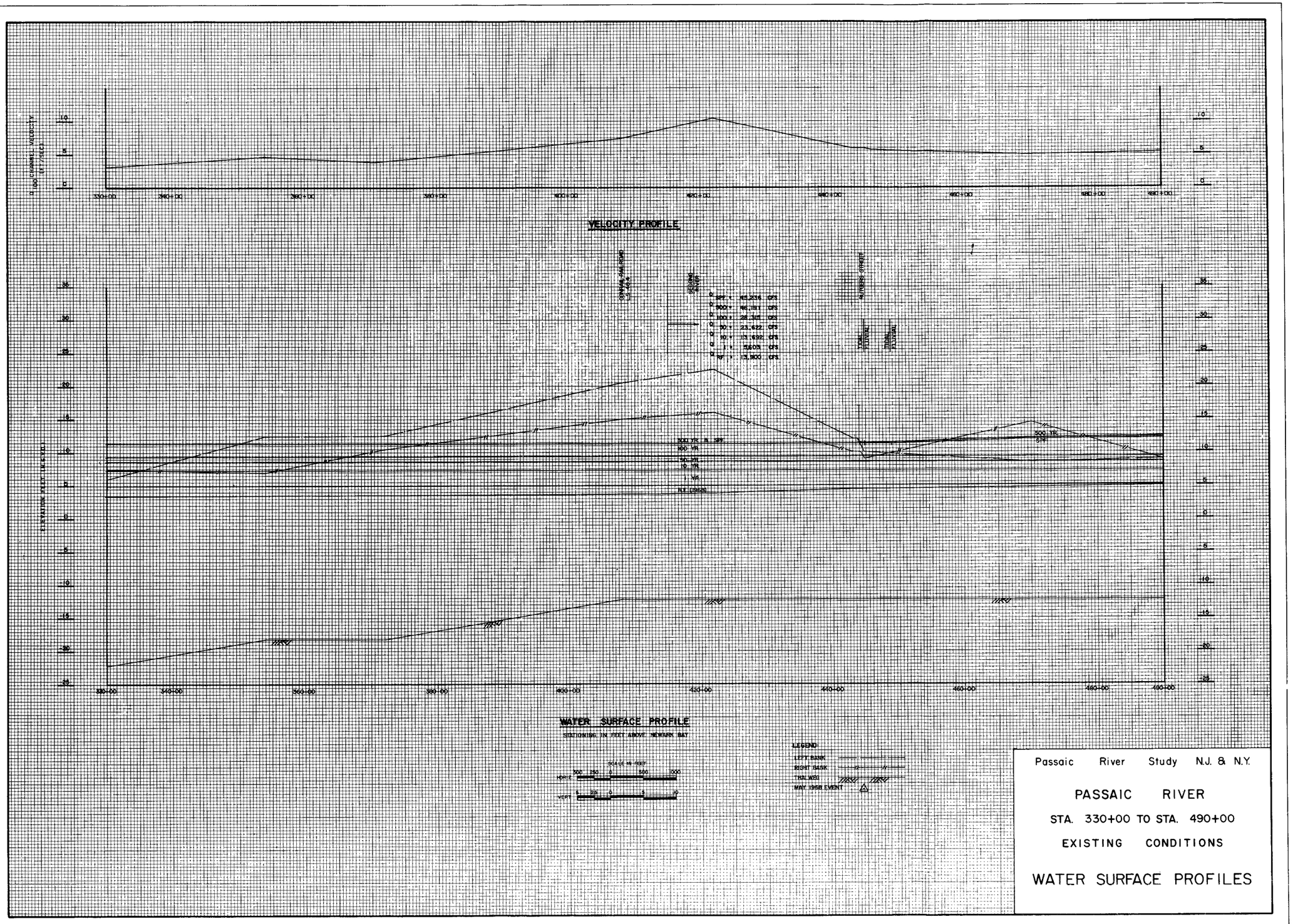


FIGURE NO. II-45

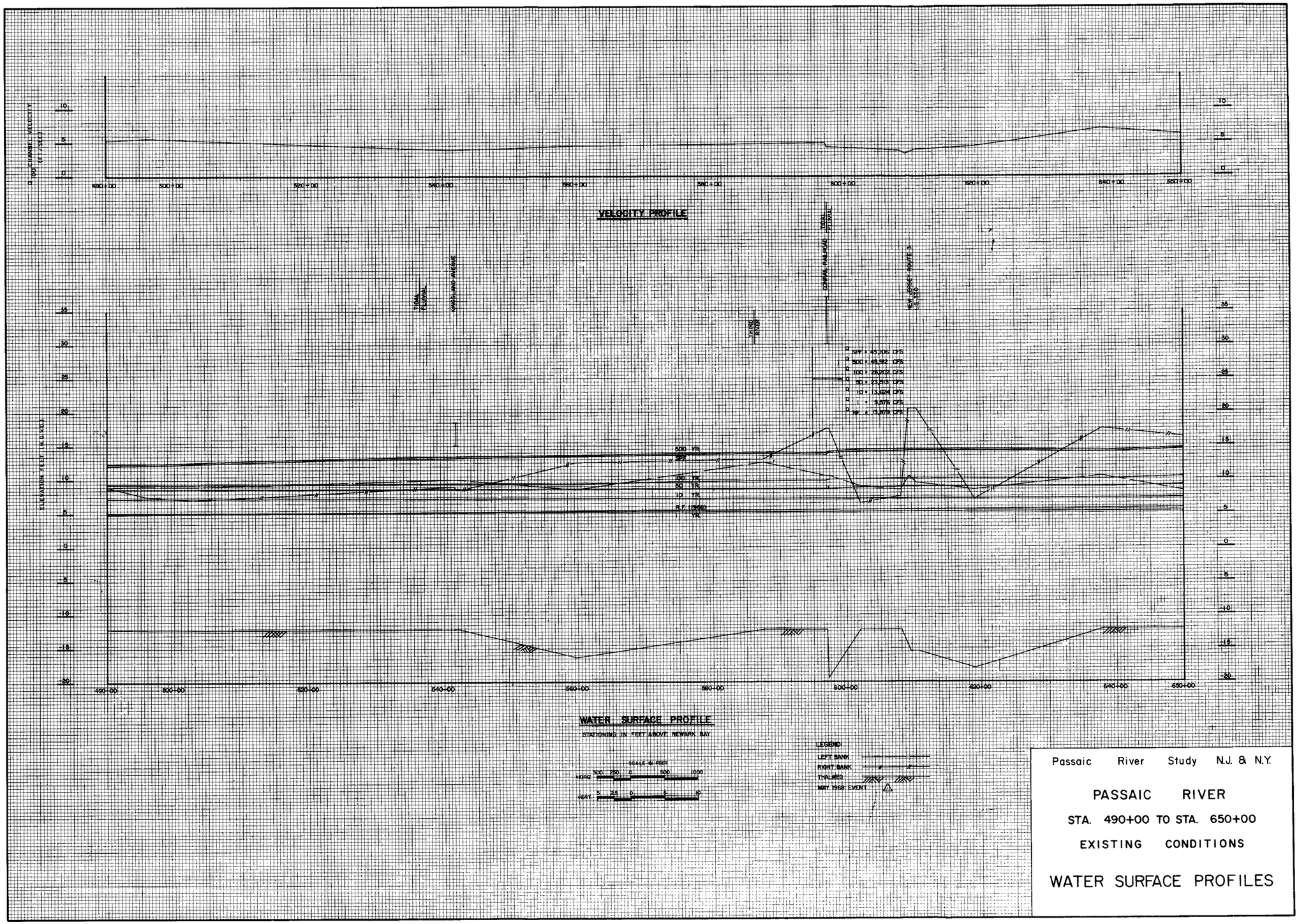
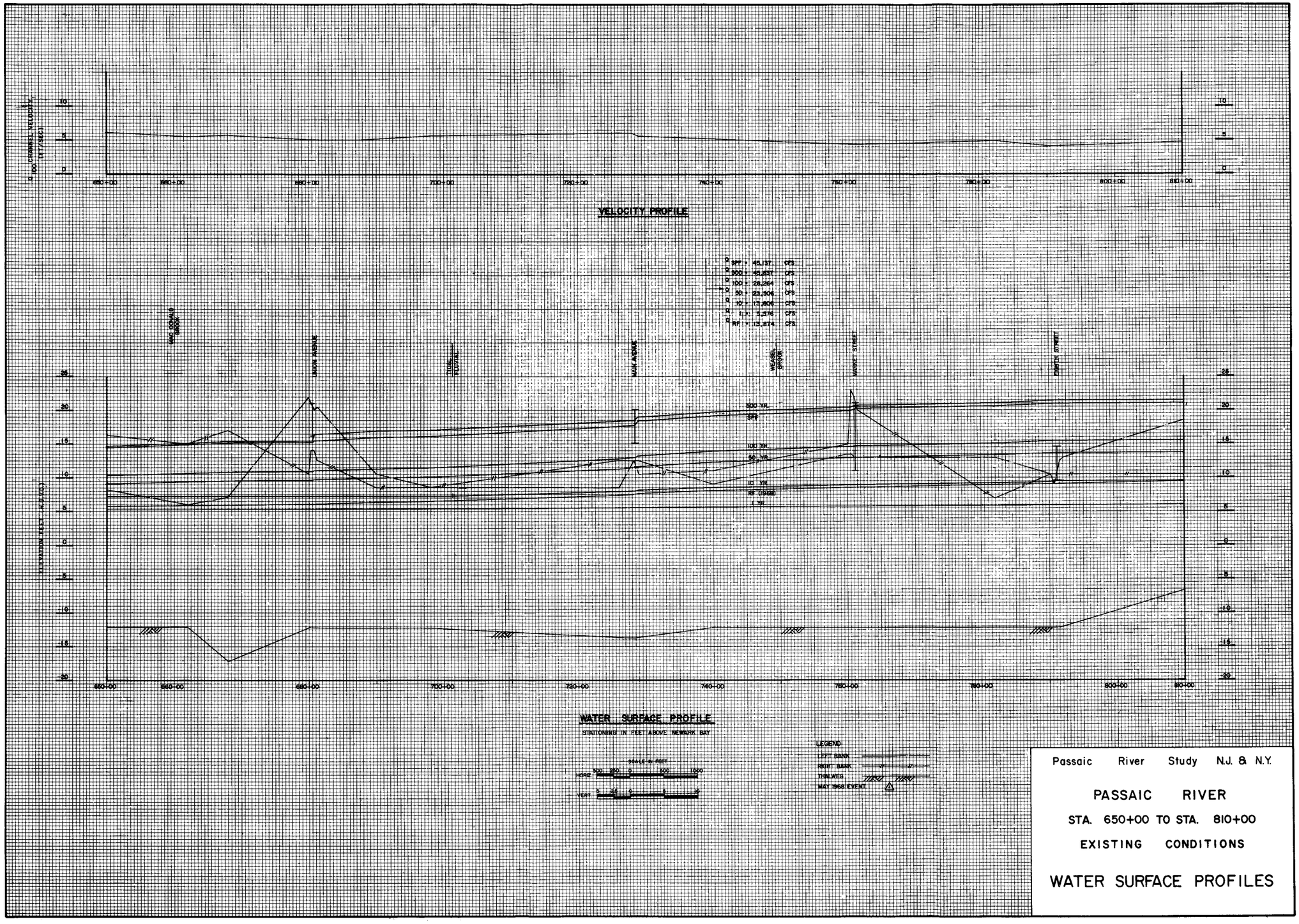


FIGURE NO. II-46



Passaic River Study N.J. & N.Y.

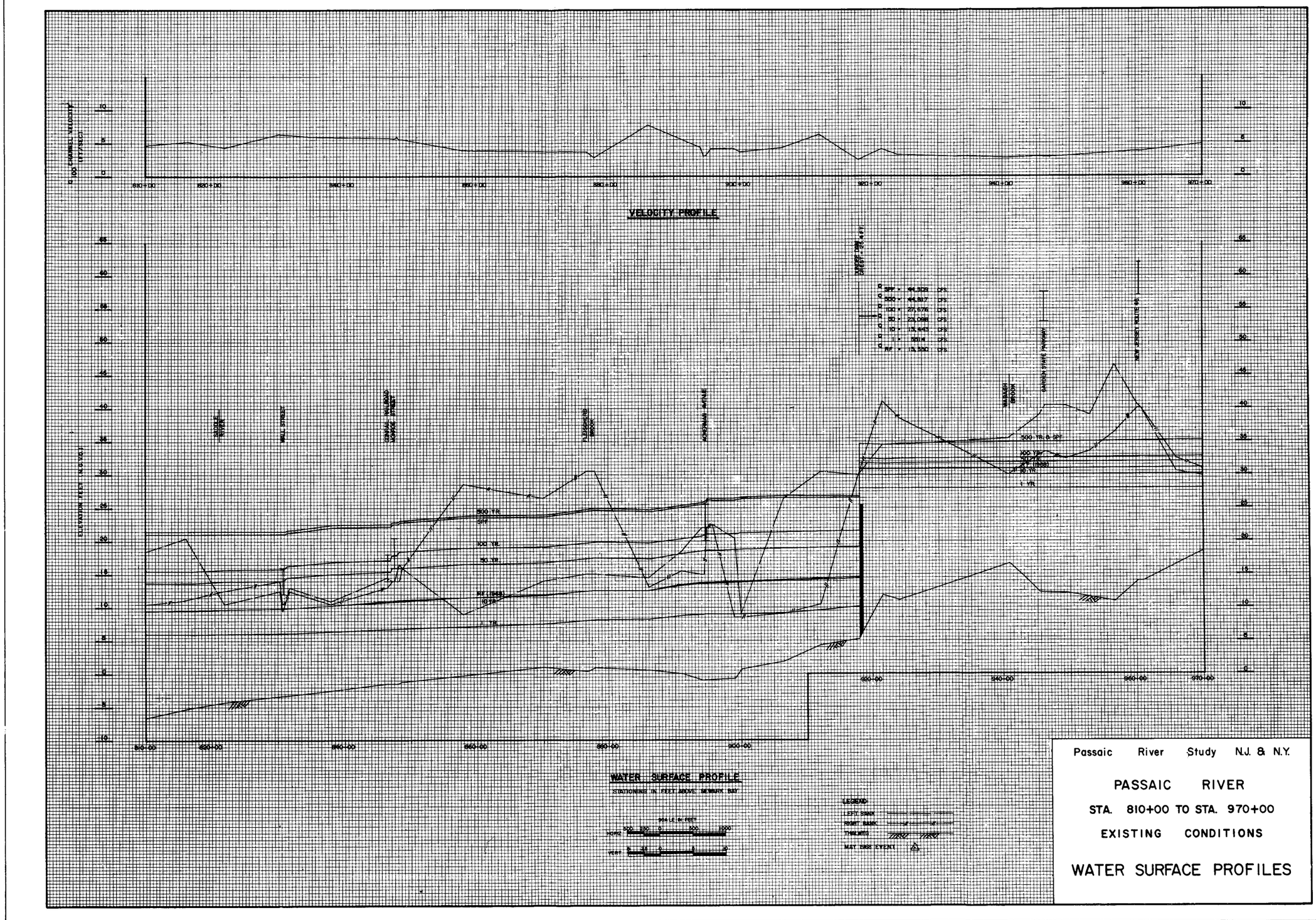
PASSAIC RIVER

STA. 650+00 TO STA. 810+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-47



Passaic River Study N.J. & N.Y.

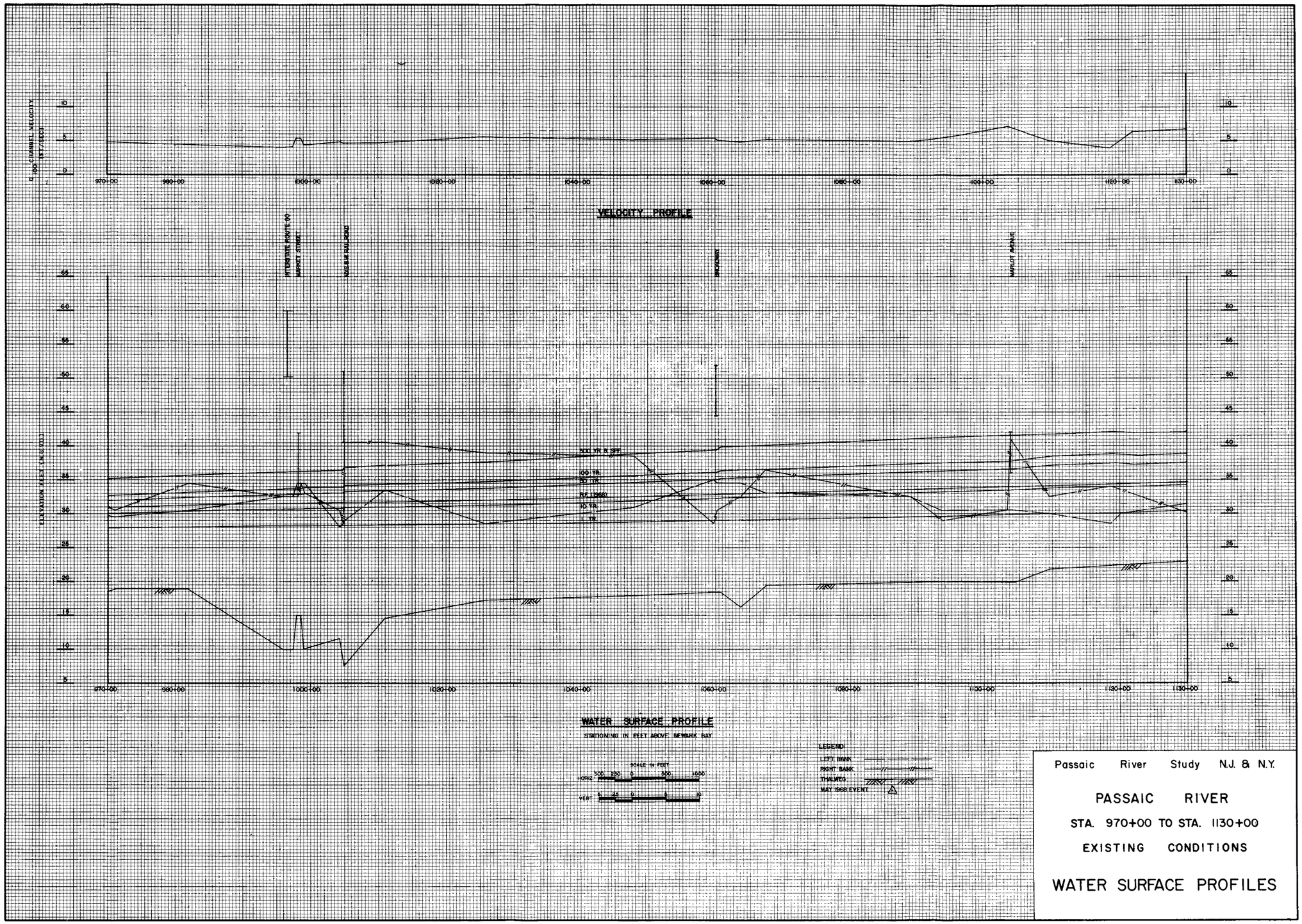
PASSAIC RIVER

STA. 810+00 TO STA. 970+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-48



Passaic River Study N.J. & N.Y.

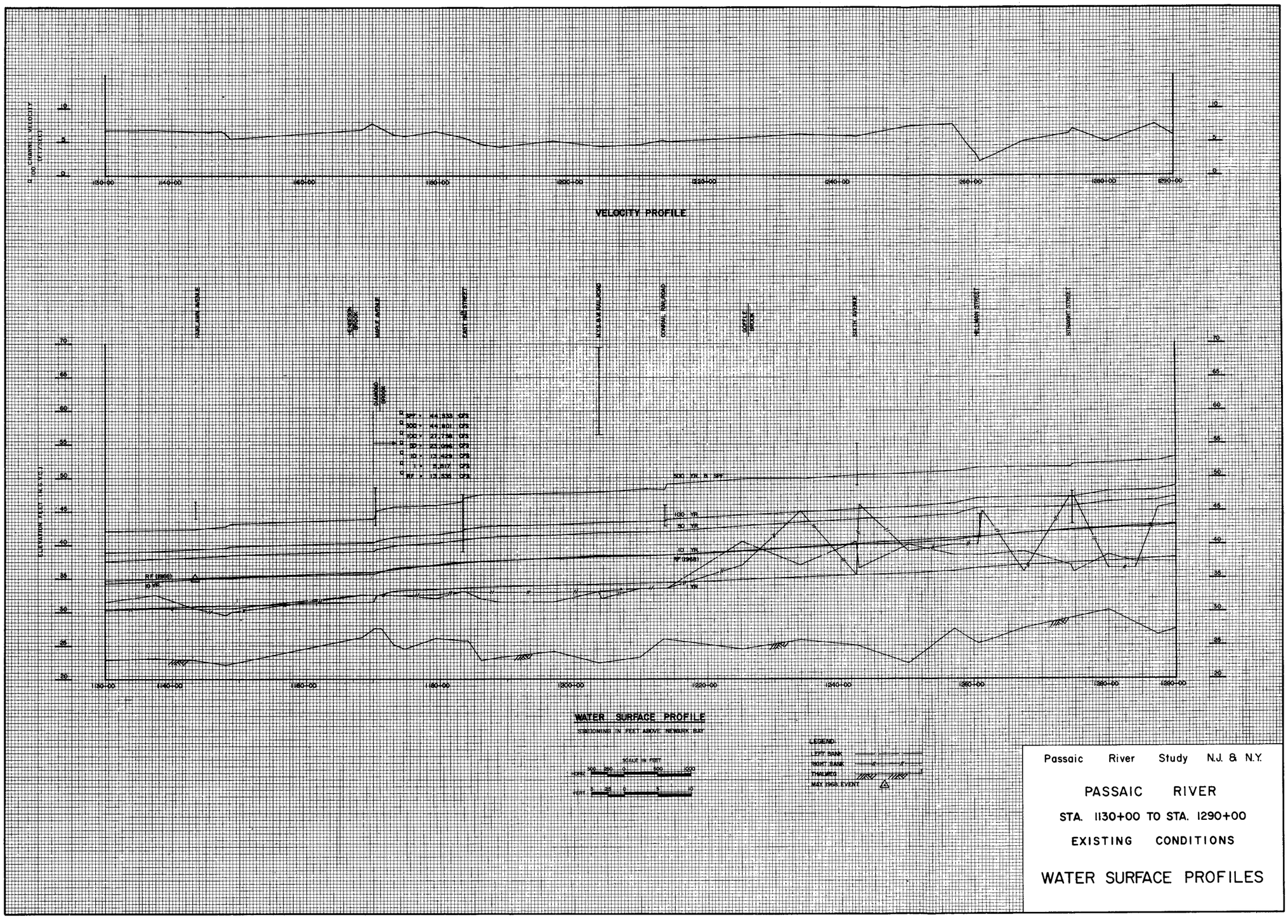
PASSAIC RIVER

STA. 970+00 TO STA. 1130+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-49



Passaic River Study N.J. & N.Y.

PASSAIC RIVER

STA. 1130+00 TO STA. 1290+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-50

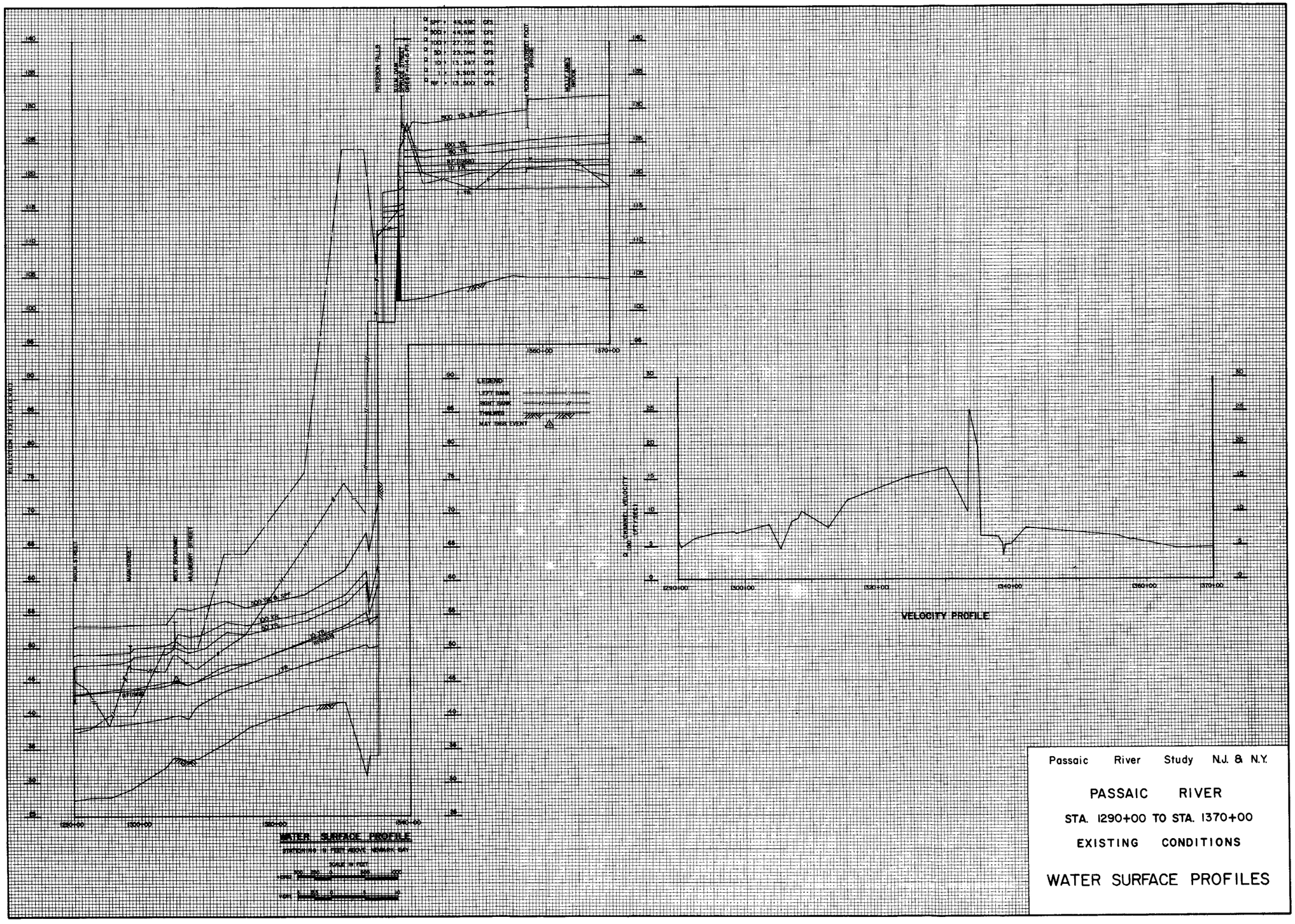
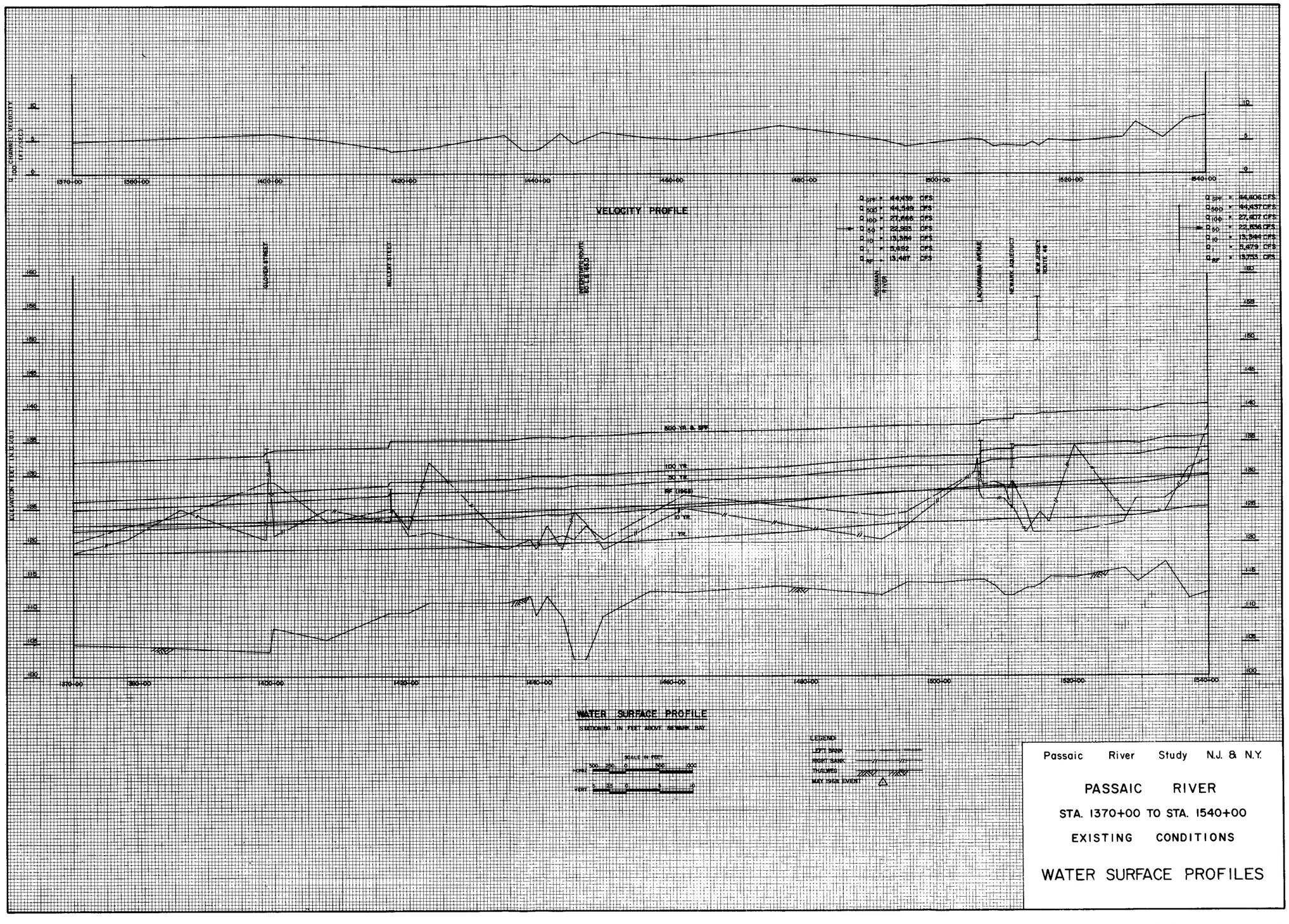


FIGURE NO. II-51



Passaic River Study N.J. & N.Y.

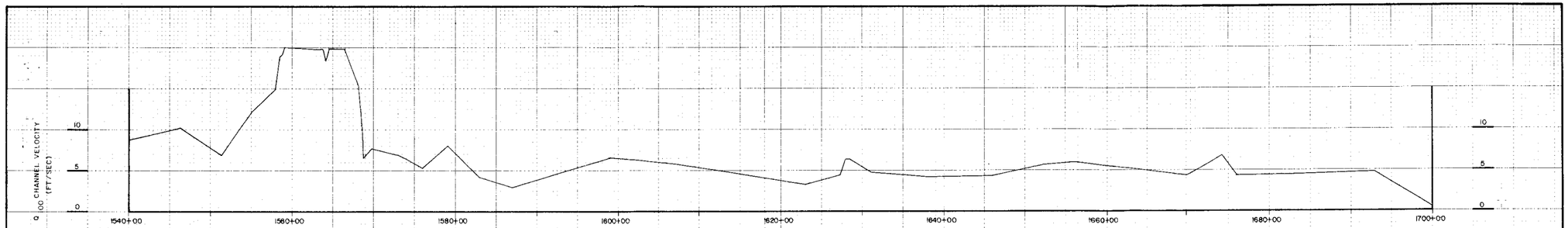
PASSAIC RIVER

STA. 1370+00 TO STA. 1540+00

EXISTING CONDITIONS

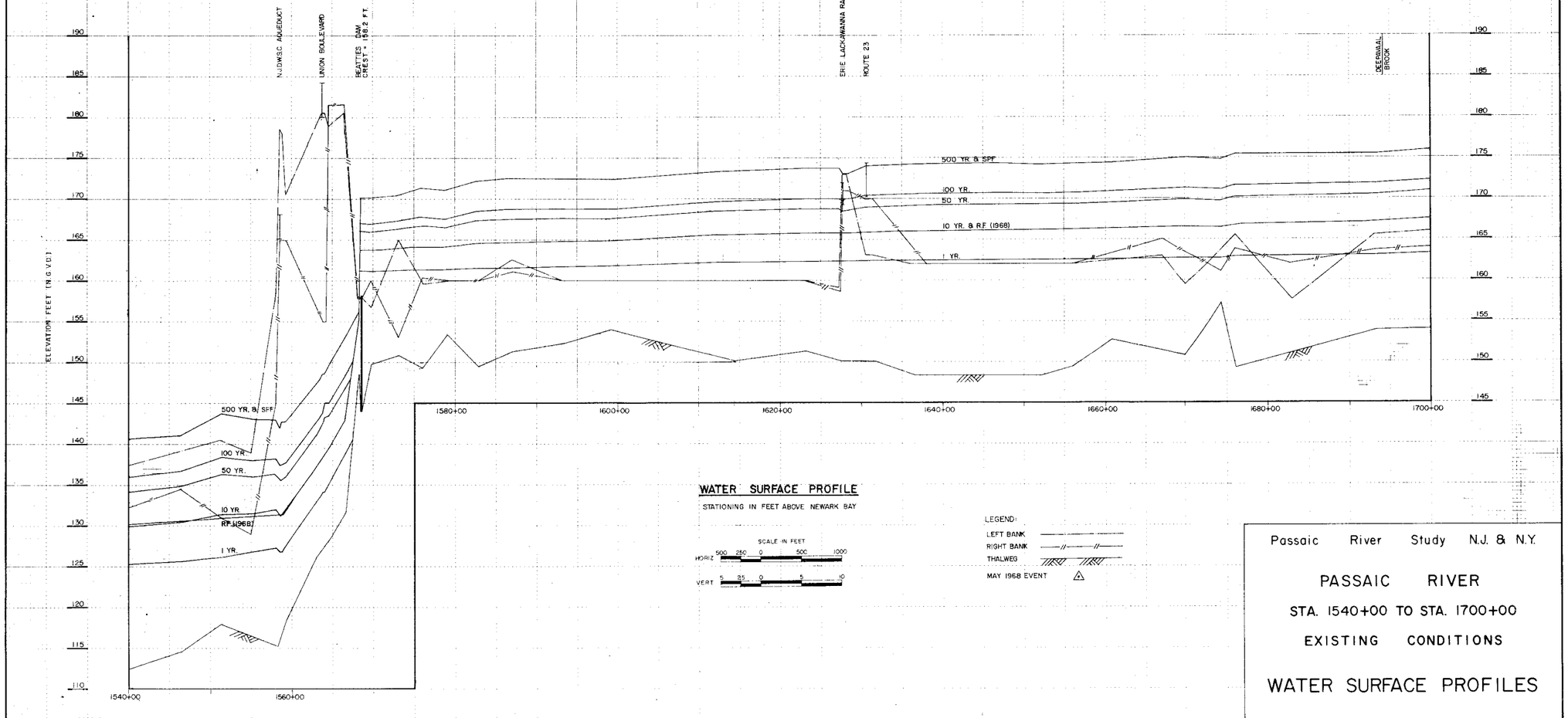
WATER SURFACE PROFILES

FIGURE NO. II-52



VELOCITY PROFILE

Q_{SPF} = 44,326 CFS
Q_{500} = 44,033 CFS
Q_{100} = 26,966 CFS
Q_{50} = 22,969 CFS
Q_{10} = 13,293 CFS
Q_{1} = 5,454 CFS
Q_{RF} = 13,759 CFS



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET
HORIZ 500 250 0 500 1000
VERT 5 25 0 5 10

LEGEND:
LEFT BANK
RIGHT BANK
THALWEG
MAY 1968 EVENT

Passaic River Study N.J. & N.Y.

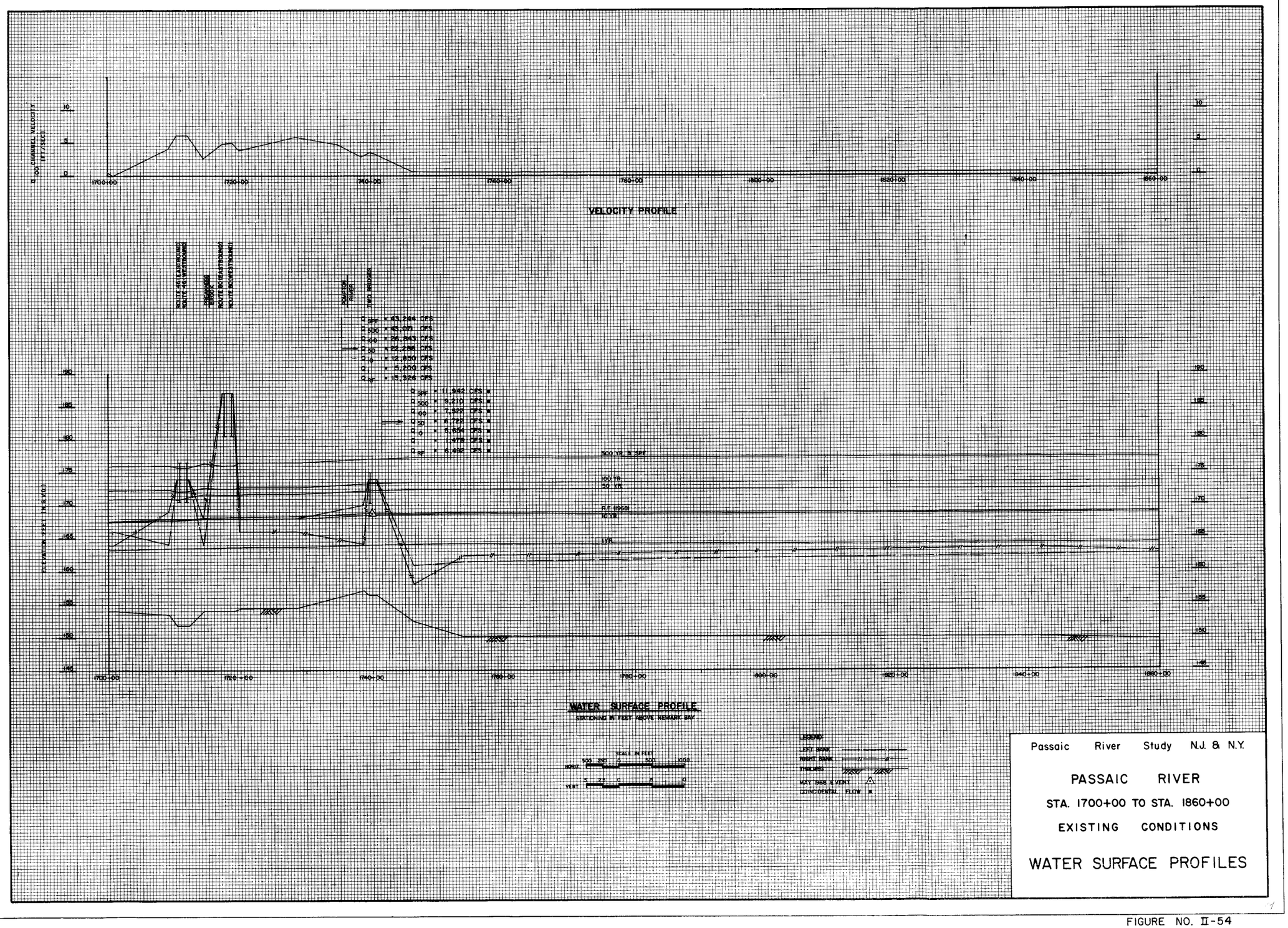
PASSAIC RIVER

STA. 1540+00 TO STA. 1700+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-53



Passaic River Study N.J. & N.Y.

PASSAIC RIVER

STA. 1700+00 TO STA. 1860+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-54

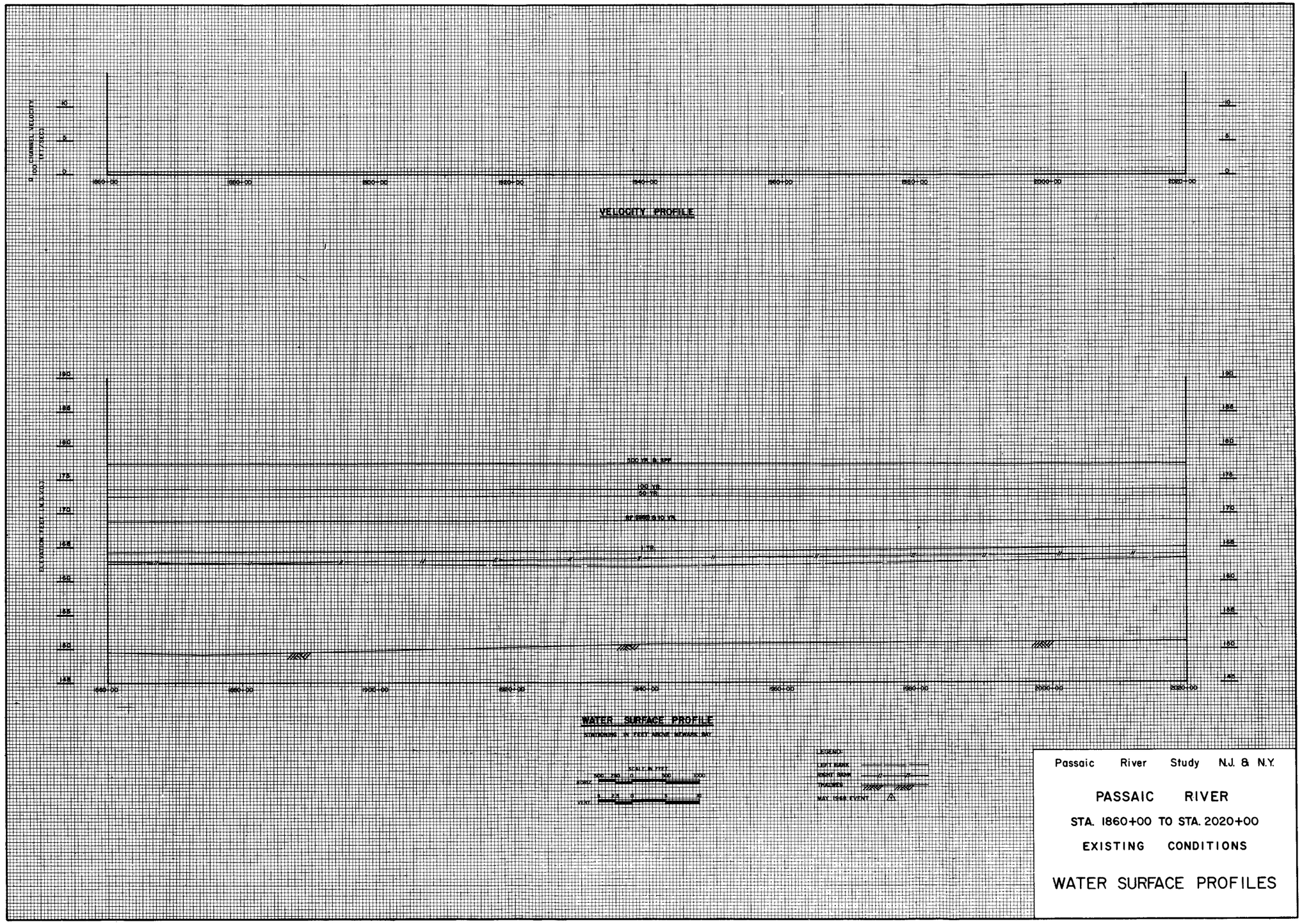


FIGURE NO. II-55

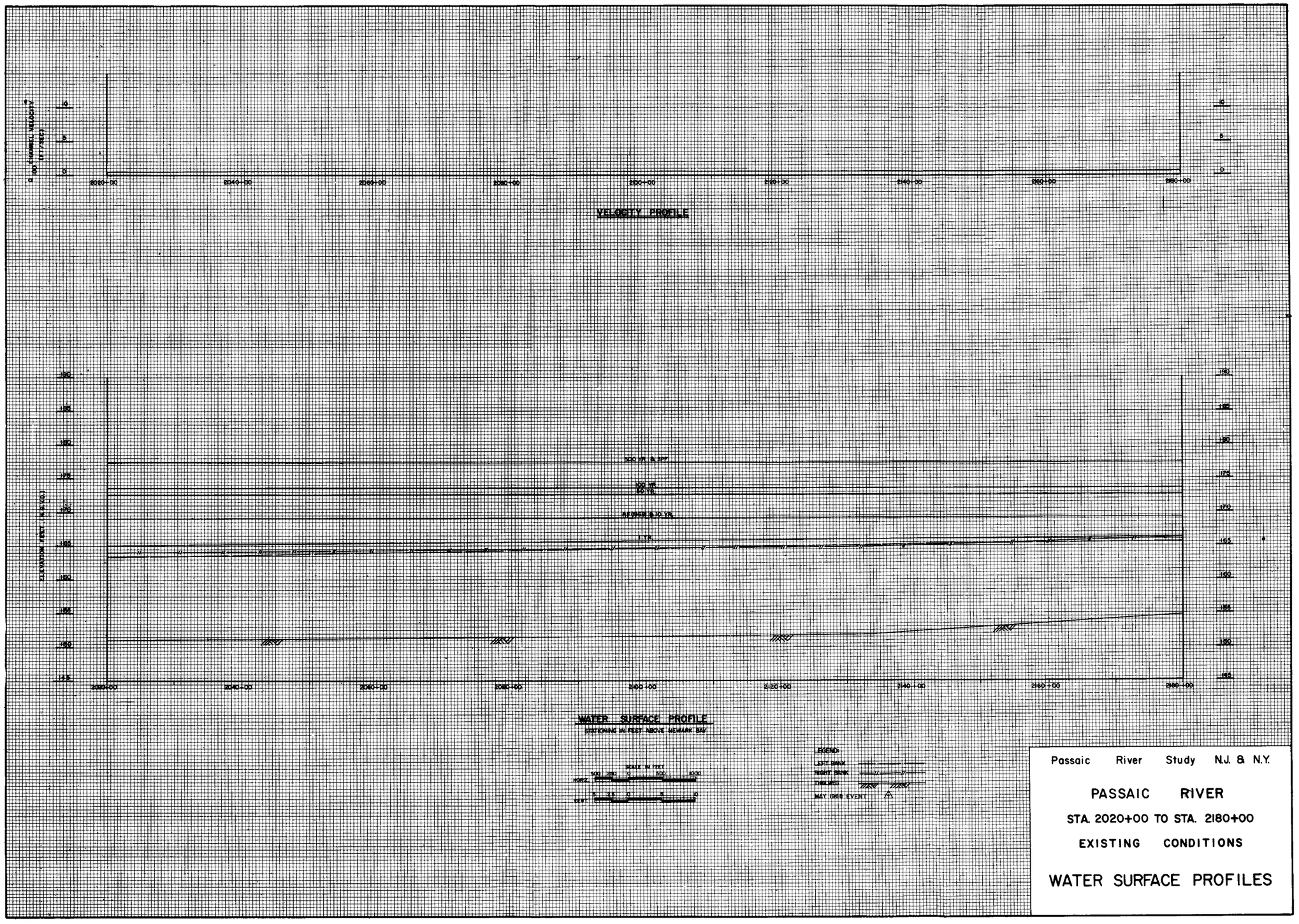
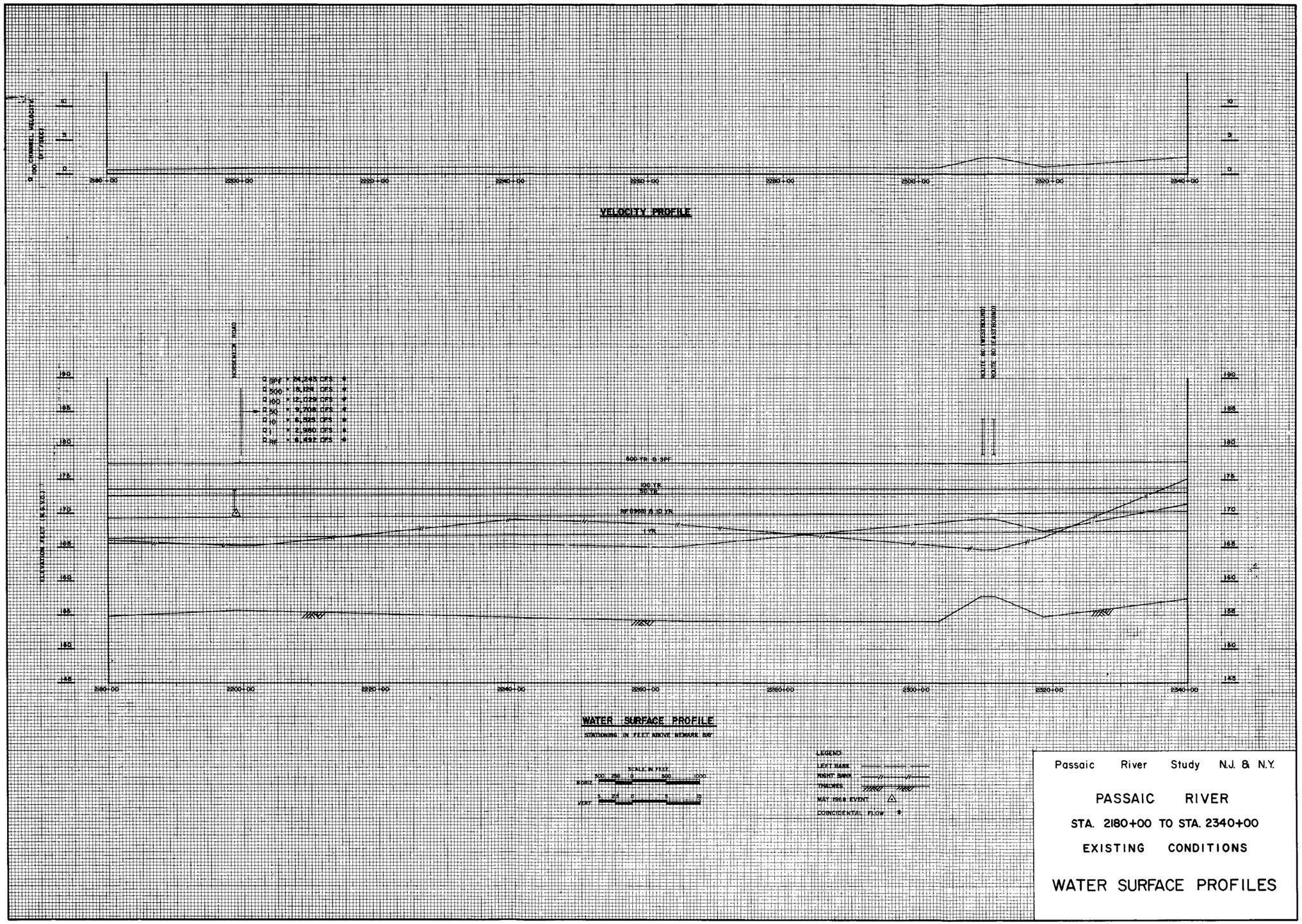


FIGURE NO. II-56



Passaic River Study N.J. & N.Y.

PASSAIC RIVER

STA. 2180+00 TO STA. 2340+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-57

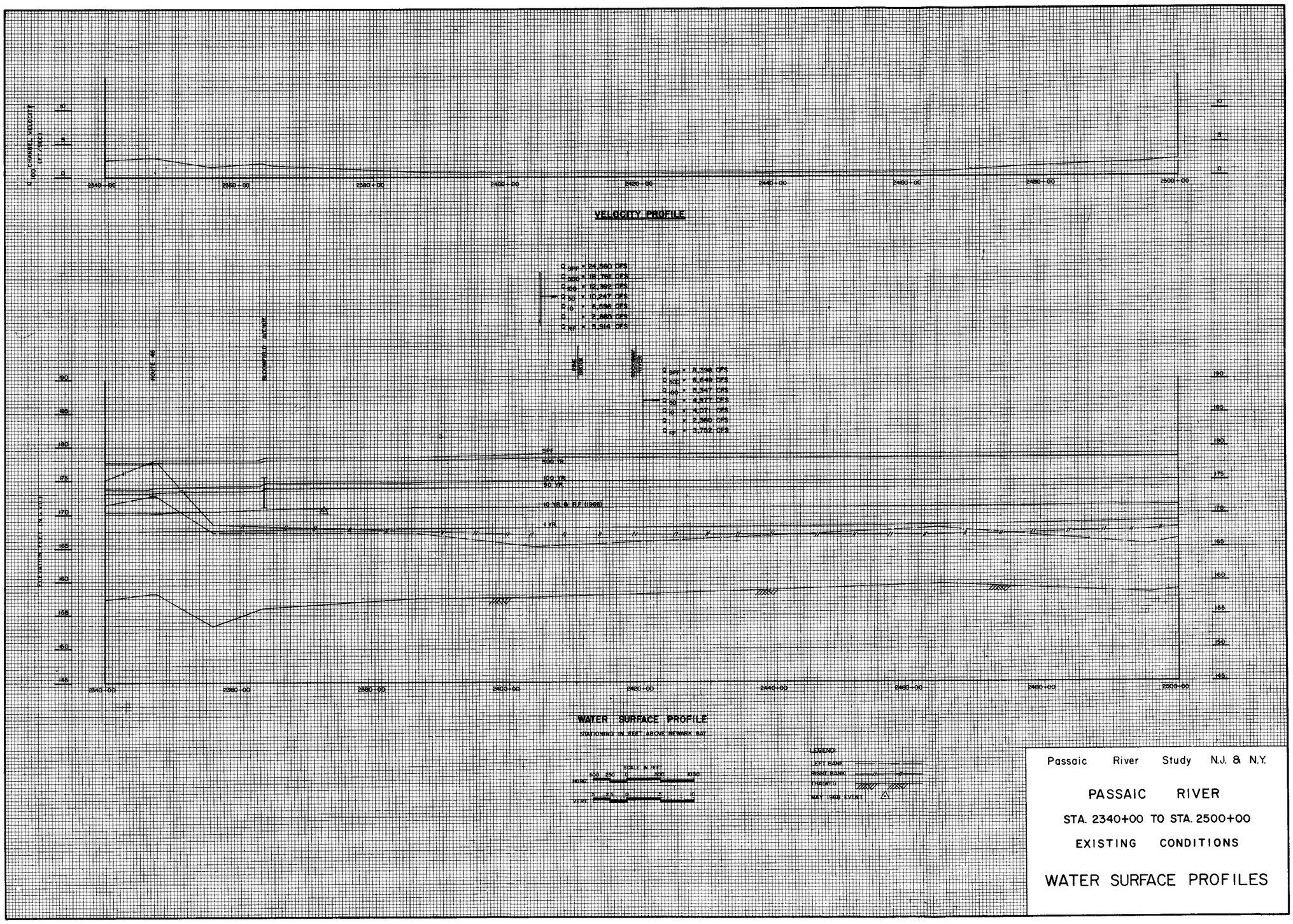
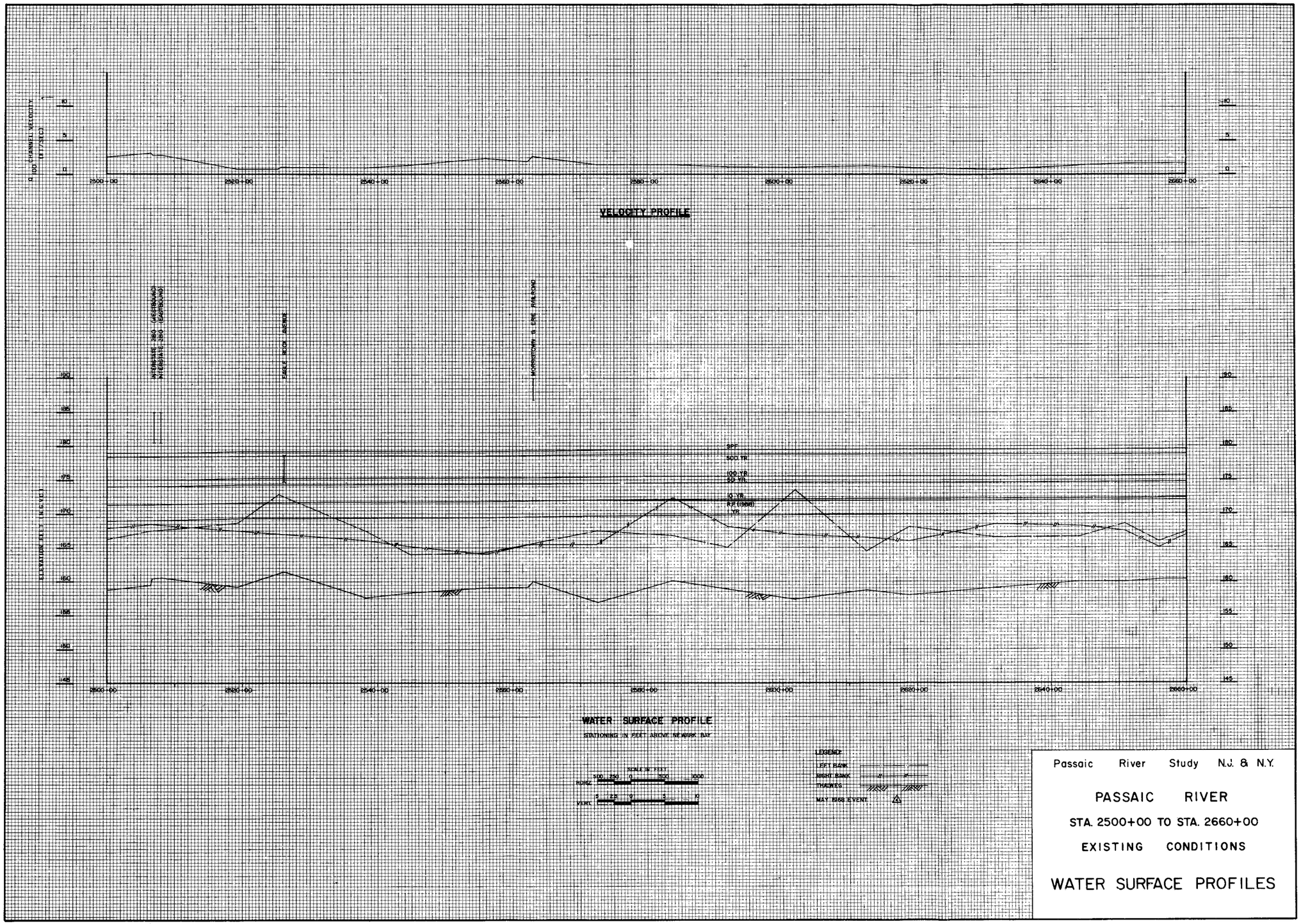


FIGURE NO. II-58



Passaic River Study N.J. & N.Y.

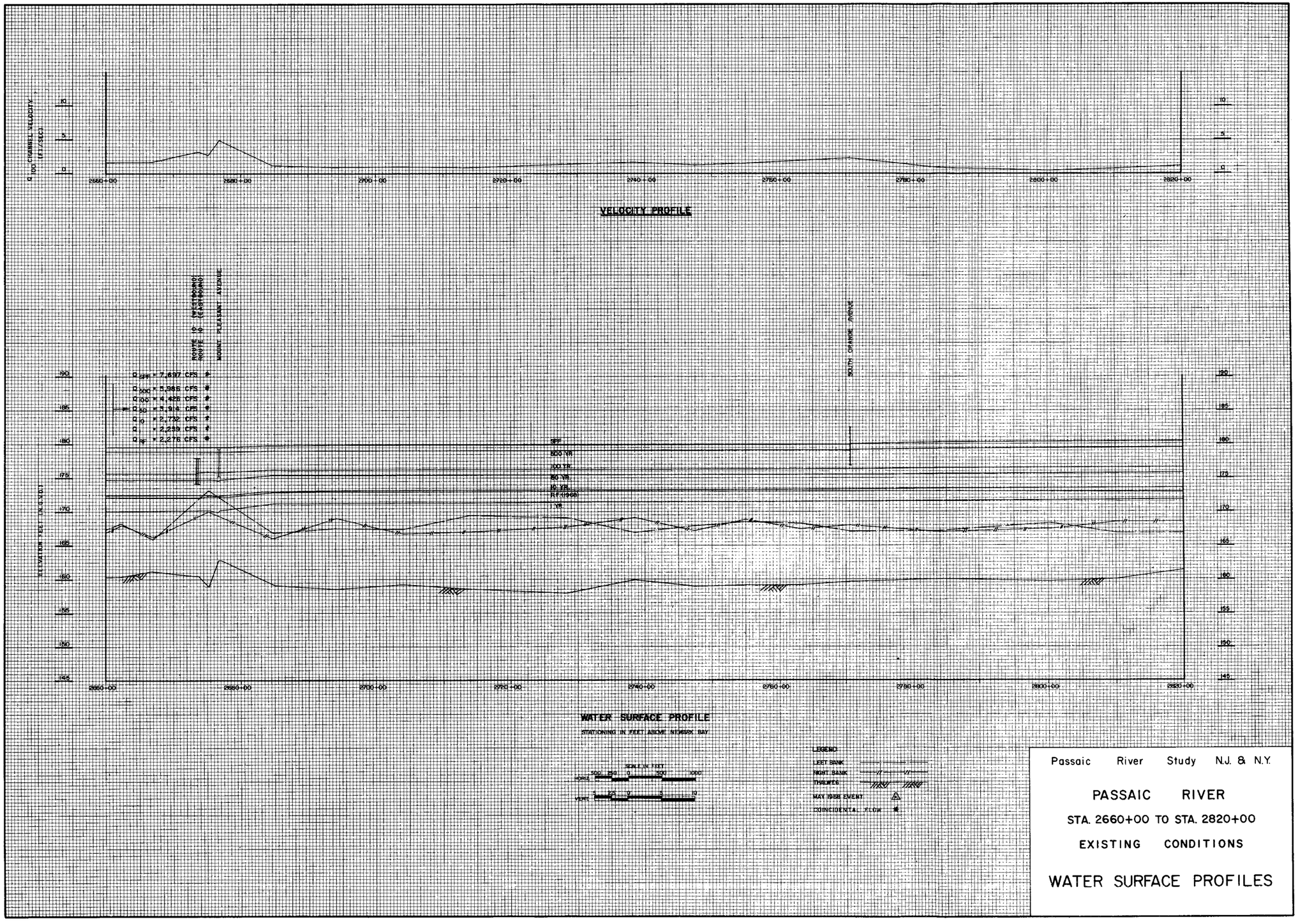
PASSAIC RIVER

STA. 2500+00 TO STA. 2660+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-59



Passaic River Study N.J. & N.Y.

PASSAIC RIVER

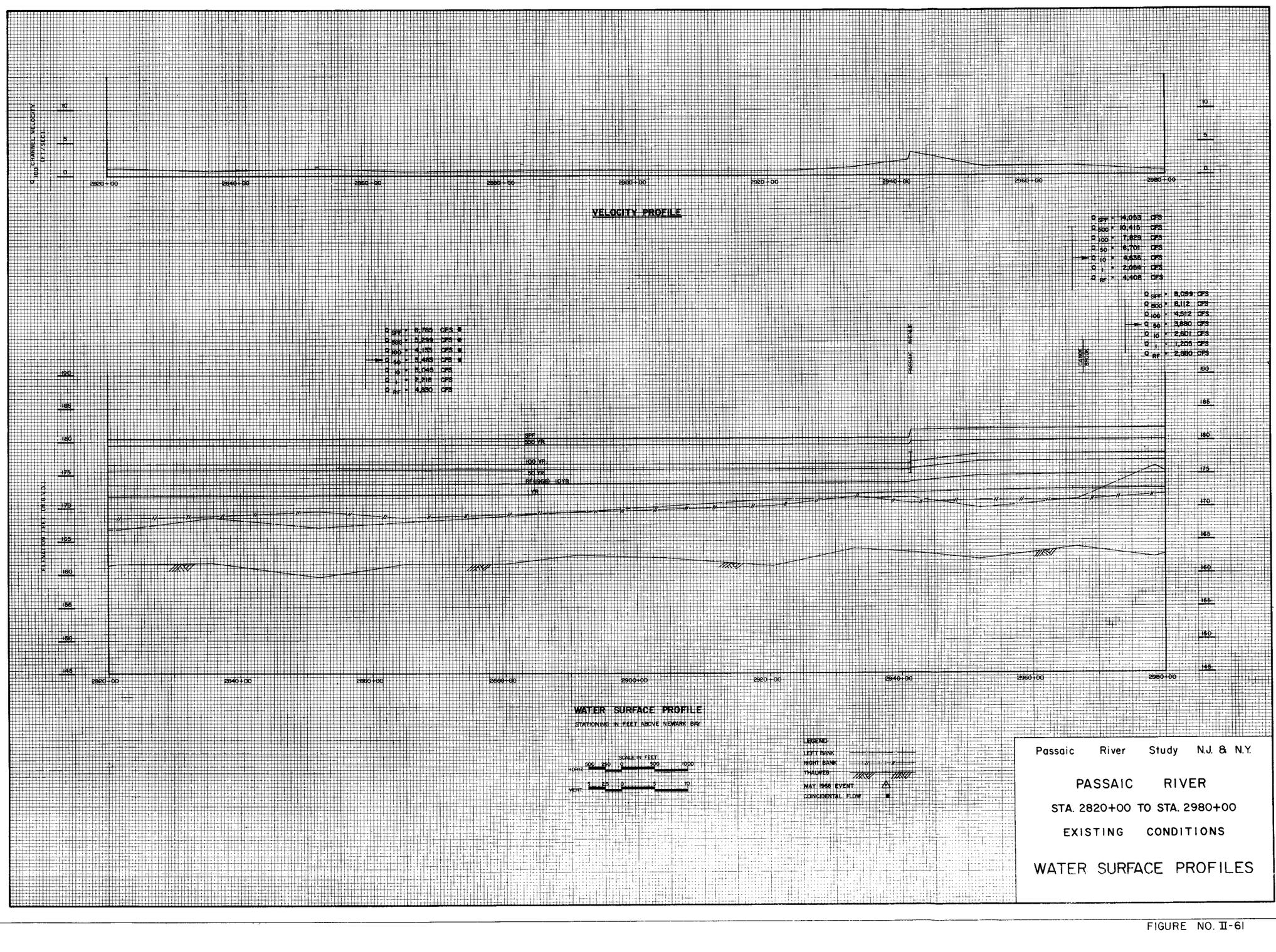
STA. 2660+00 TO STA. 2820+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-60

VELOCITY PROFILE



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET

HORIZ. 500 250 0 500 1000

VERT. 5 2.5 0 5 10

LEGEND:

LEFT BANK

RIGHT BANK

THALWEG

MAY 1968 EVENT

COINCIDENTAL FLOW

Passaic River Study N.J. & N.Y.

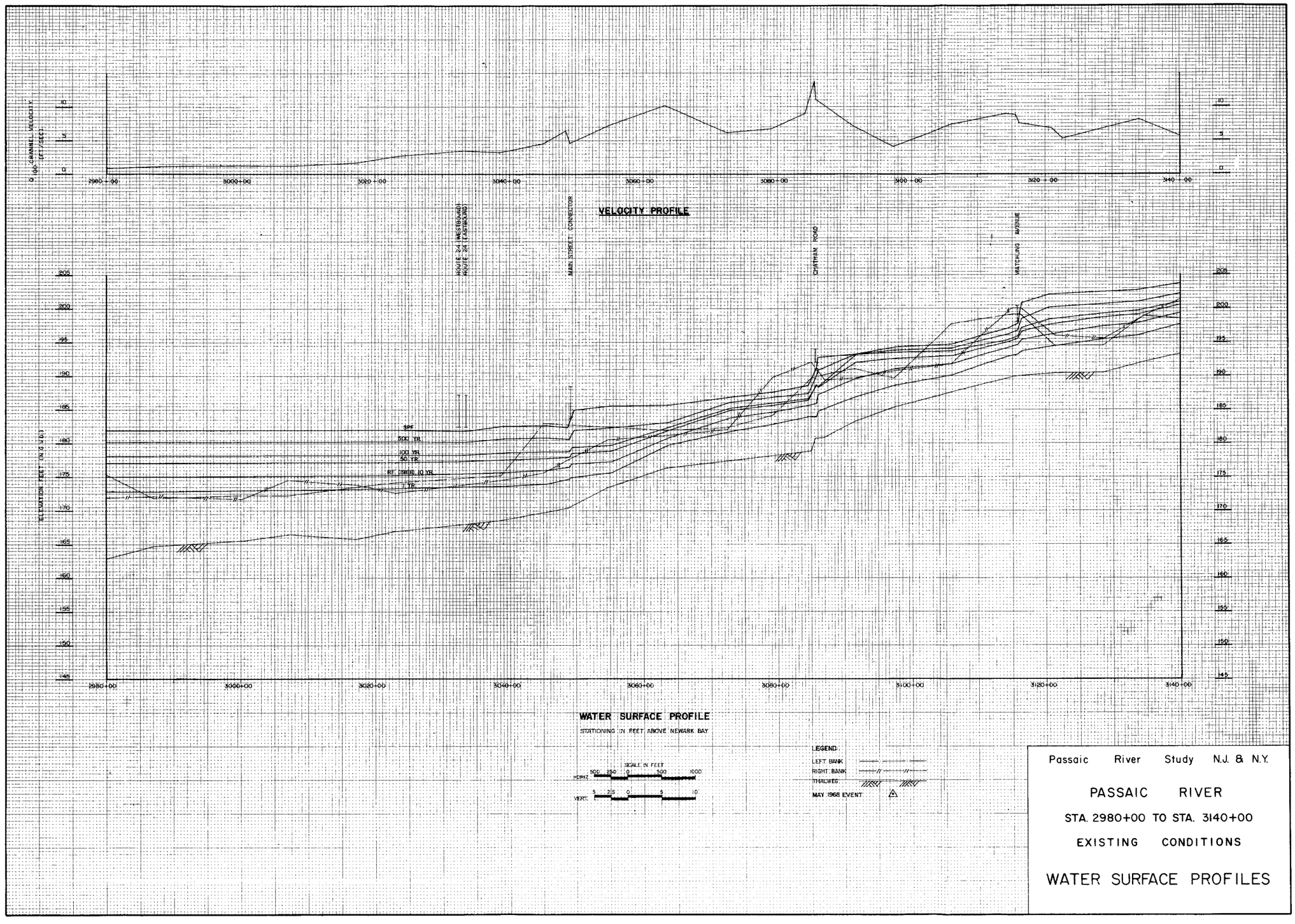
PASSAIC RIVER

STA. 2820+00 TO STA. 2980+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-61



Passaic River Study N.J. & N.Y.

PASSAIC RIVER

STA. 2980+00 TO STA. 3140+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-62

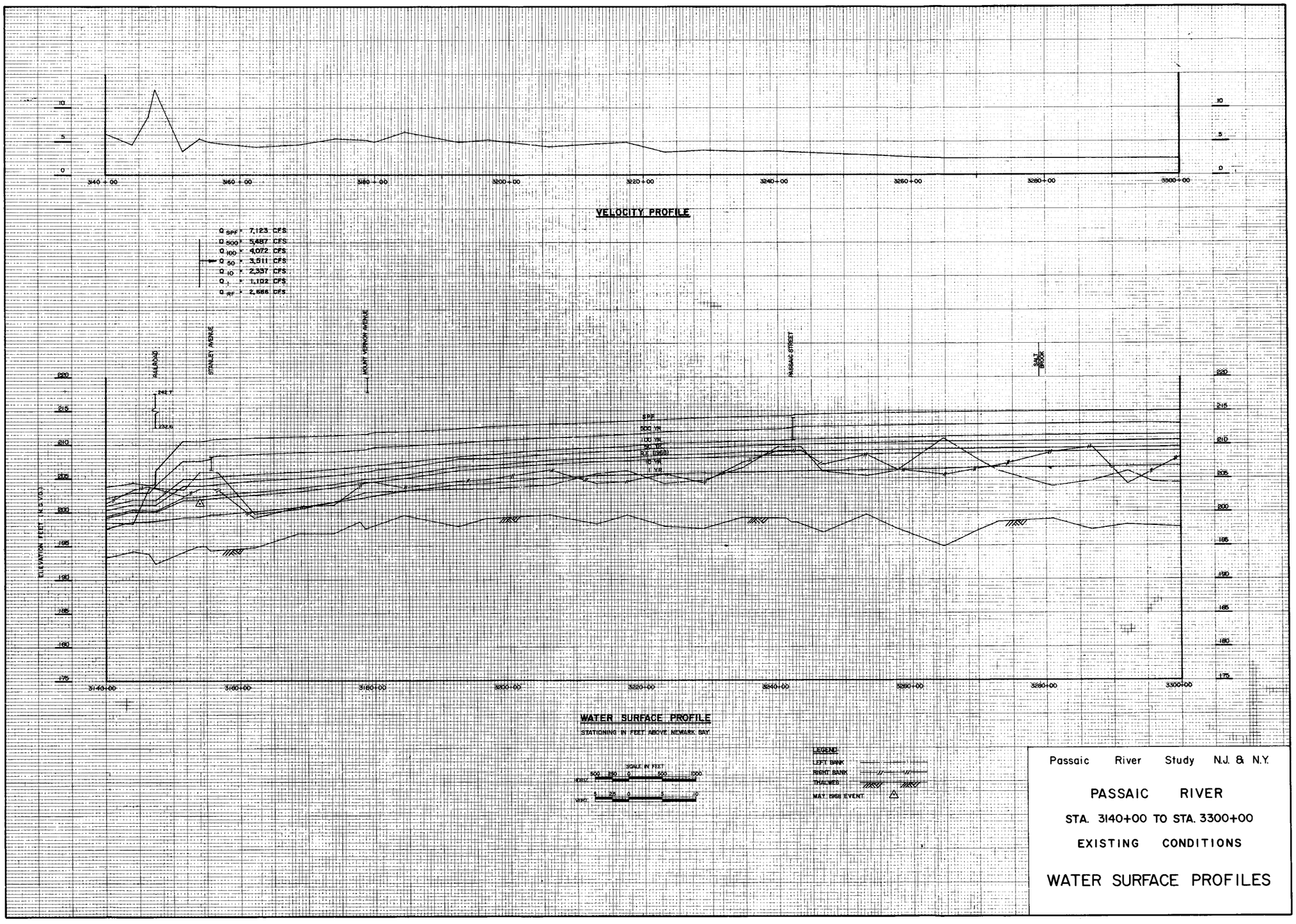
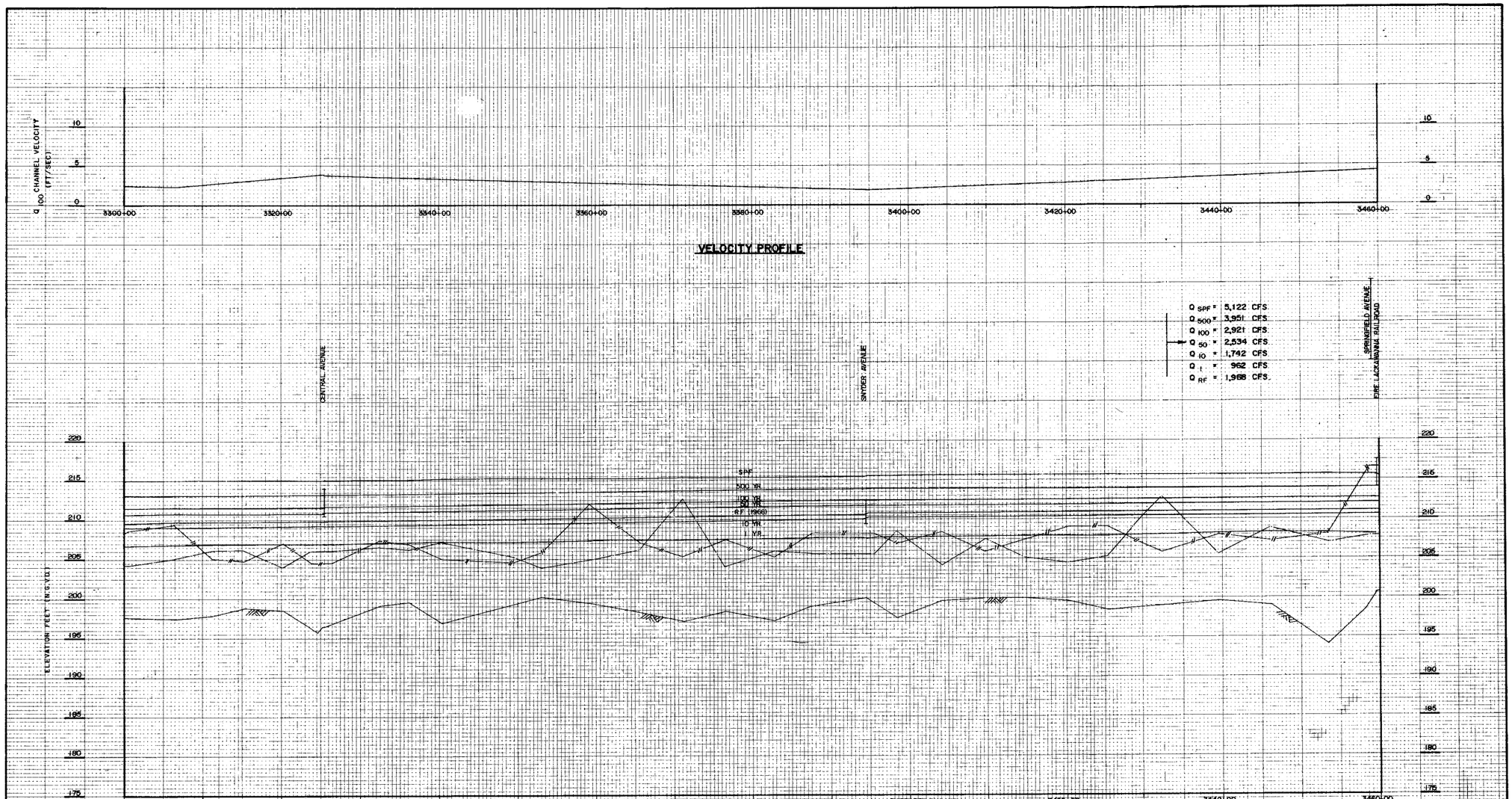


FIGURE NO. II-63

VELOCITY PROFILE



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET

HORIZ. 500 250 0 500 1000

VERT. 5 25 0 5 10

LEGEND

LEFT BANK

RIGHT BANK

THALWEG

MAY 1968 EVENT

Passaic River Study N.J. & N.Y.

PASSAIC RIVER

STA. 3300+00 TO STA. 3460+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-64

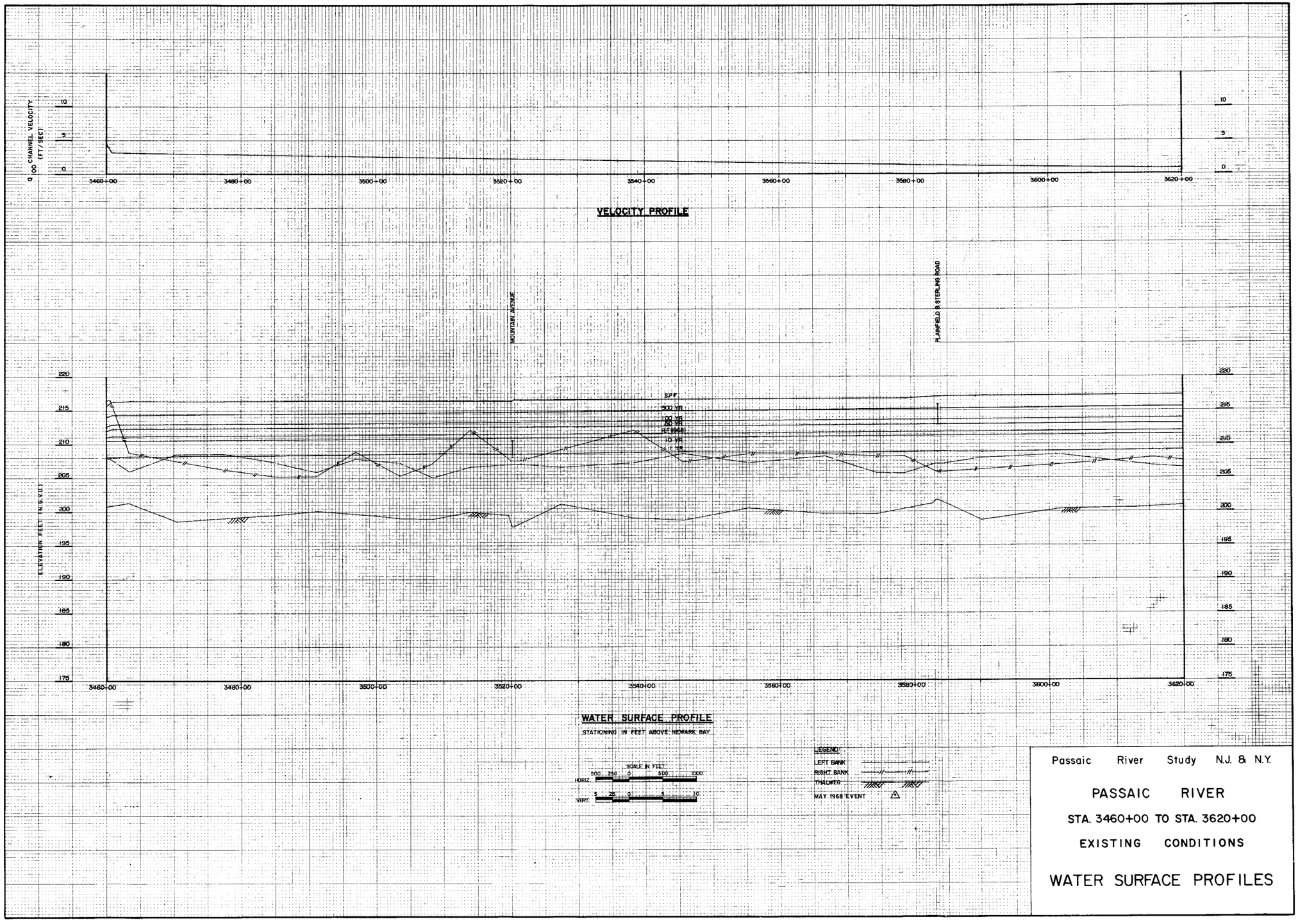
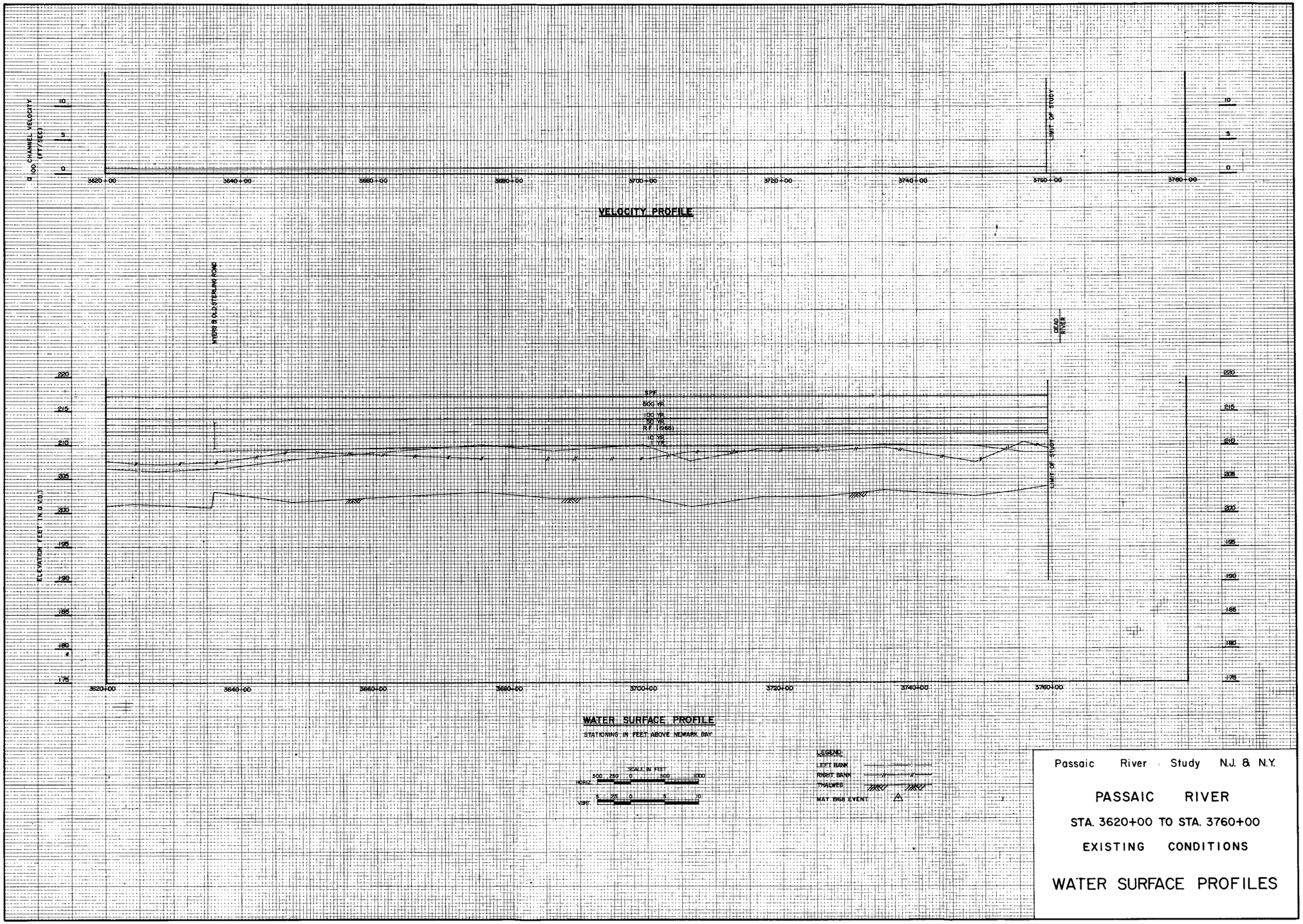


FIGURE NO. II-65



Passaic River Study N.J. & N.Y.

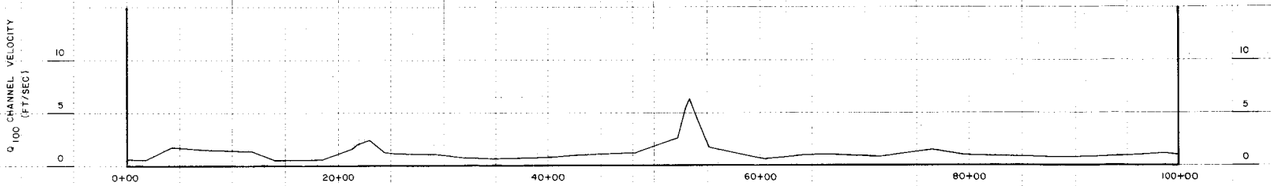
PASSAIC RIVER

STA. 3620+00 TO STA. 3760+00

EXISTING CONDITIONS

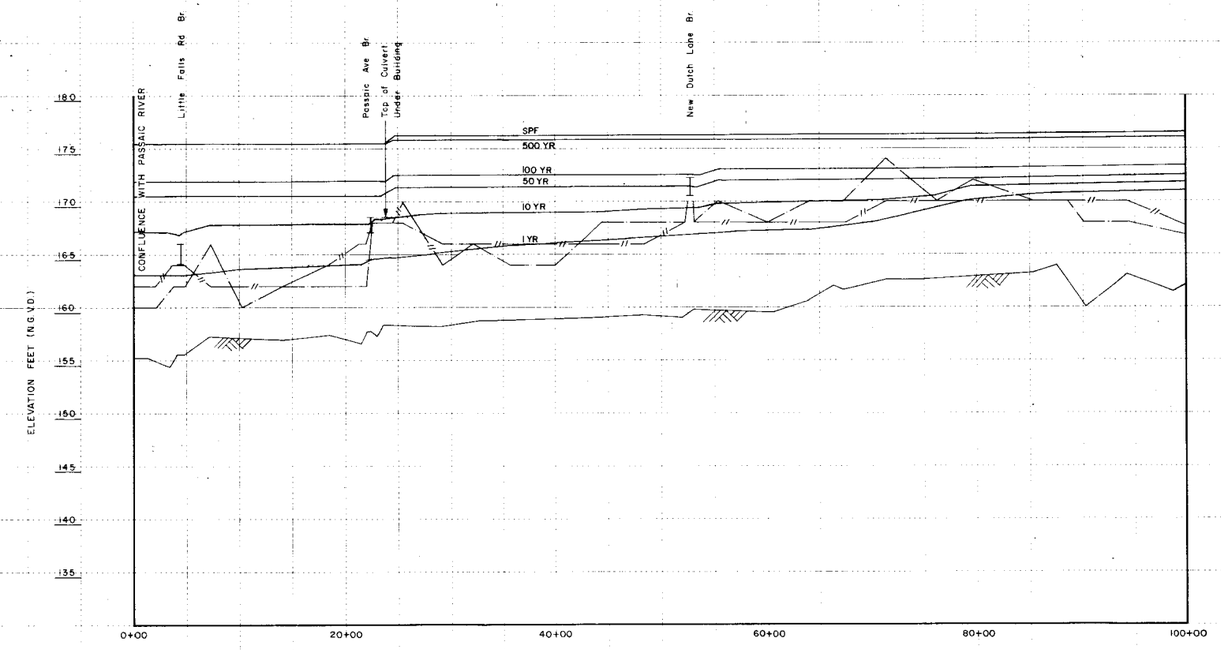
WATER SURFACE PROFILES

FIGURE NO. II-66



VELOCITY PROFILE

Q_{SPF} = 4,548 CFS
Q_{500} = 3,148 CFS
Q_{100} = 2,502 CFS
Q_{50} = 2,143 CFS
Q_{10} = 1,541 CFS
Q_{1} = 684 CFS



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE PASSAIC RIVER

SCALE IN FEET

HORIZ 500 0 500 1000

VERT. 5 0 5 10

LEGEND

LEFT BANK

RIGHT BANK

THALWEG

Passaic River Study N.J. & N.Y.

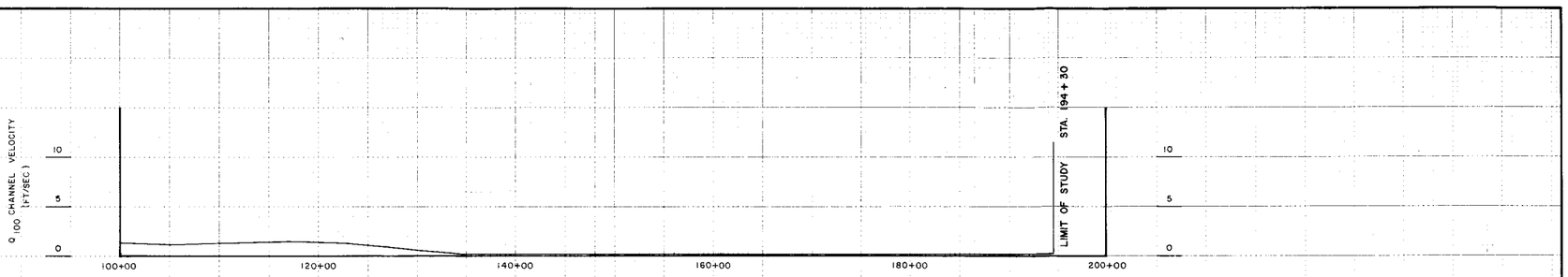
DEEPAVAAL BROOK

STA. 0+00 TO STA. 100+00

EXISTING CONDITIONS

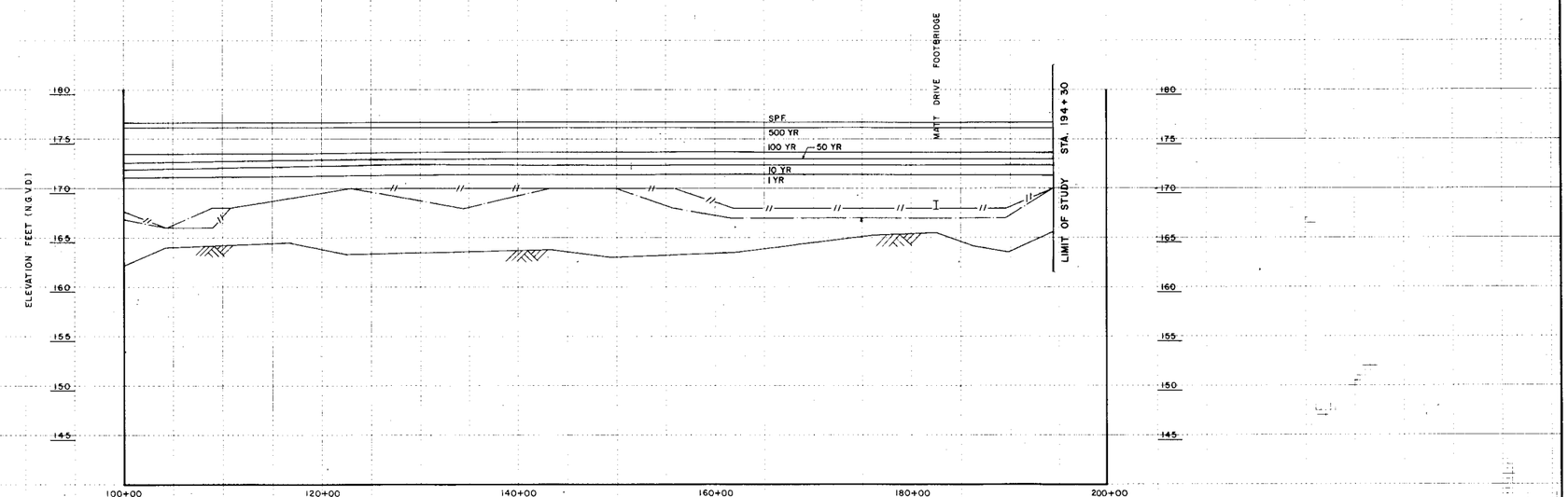
WATER SURFACE PROFILES

FIGURE NO. II-67



VELOCITY PROFILE

Q_{SPF} = 953 CFS
Q_{500} = 692 CFS
Q_{100} = 551 CFS
Q_{50} = 474 CFS
Q_{10} = 344 CFS
Q_{1} = 154 CFS



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE PASSAIC RIVER

SCALE IN FEET
HORIZ 400 0 500 1000
VERT. 5 0 5 10

LEGEND
LEFT BANK
RIGHT BANK
THALWEG

Passaic River Study N.J. & N.Y.

DEEPAVAAL BROOK

STA. 100+00 TO STA. 182+50

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO II-68

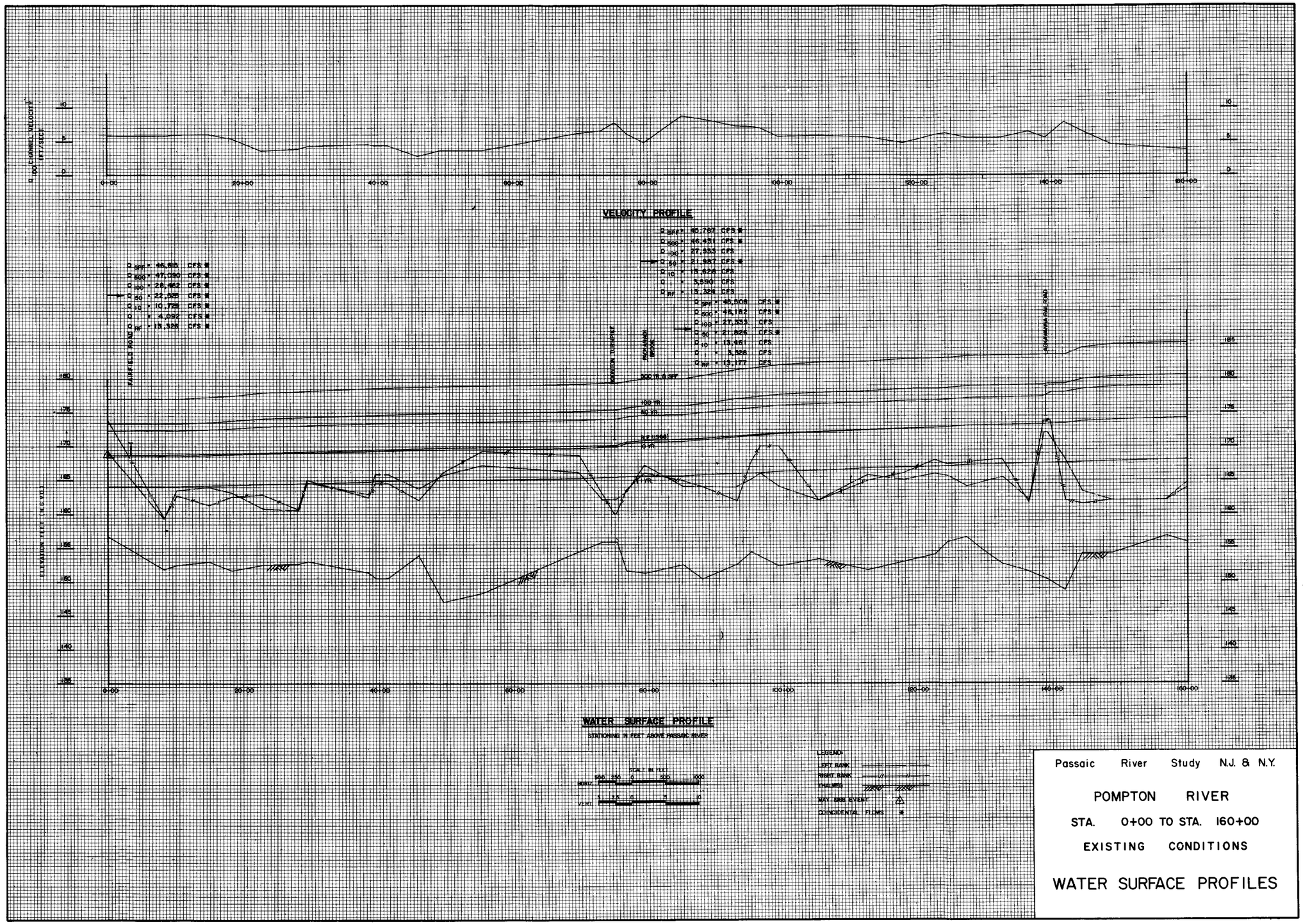
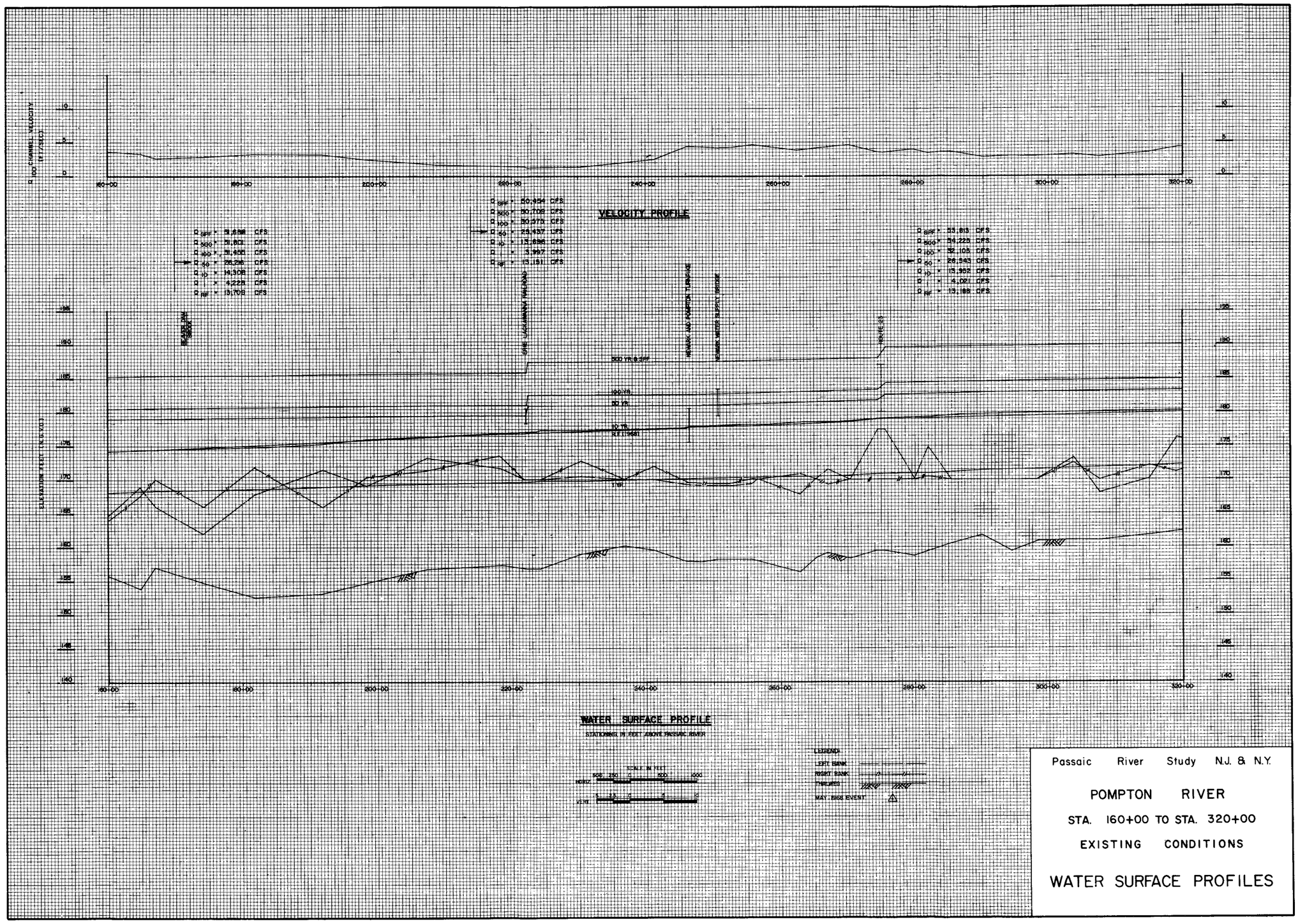


FIGURE NO. II-69



Passaic River Study N.J. & N.Y.

POMPTON RIVER

STA. 160+00 TO STA. 320+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-70

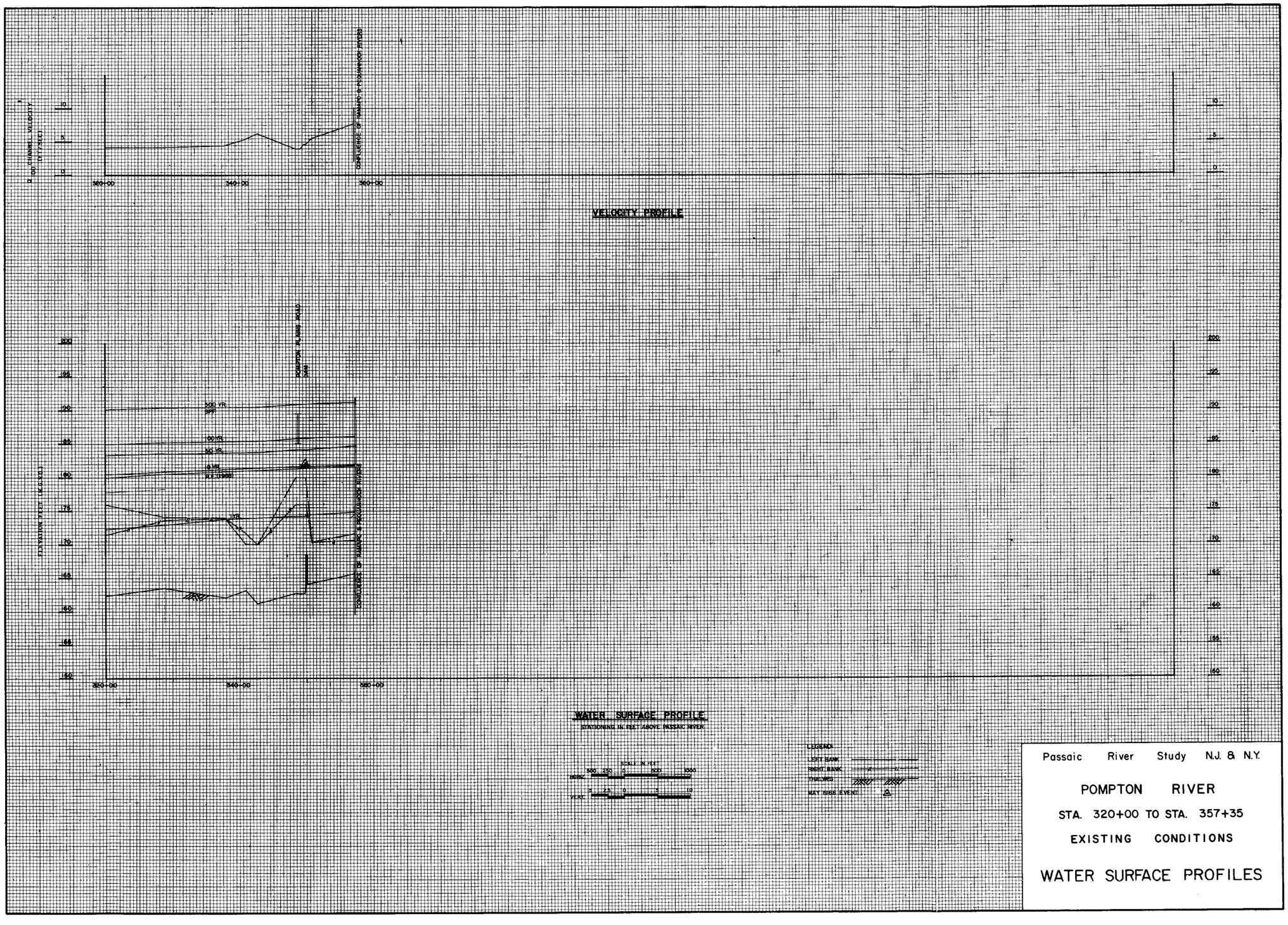


FIGURE NO. II-71

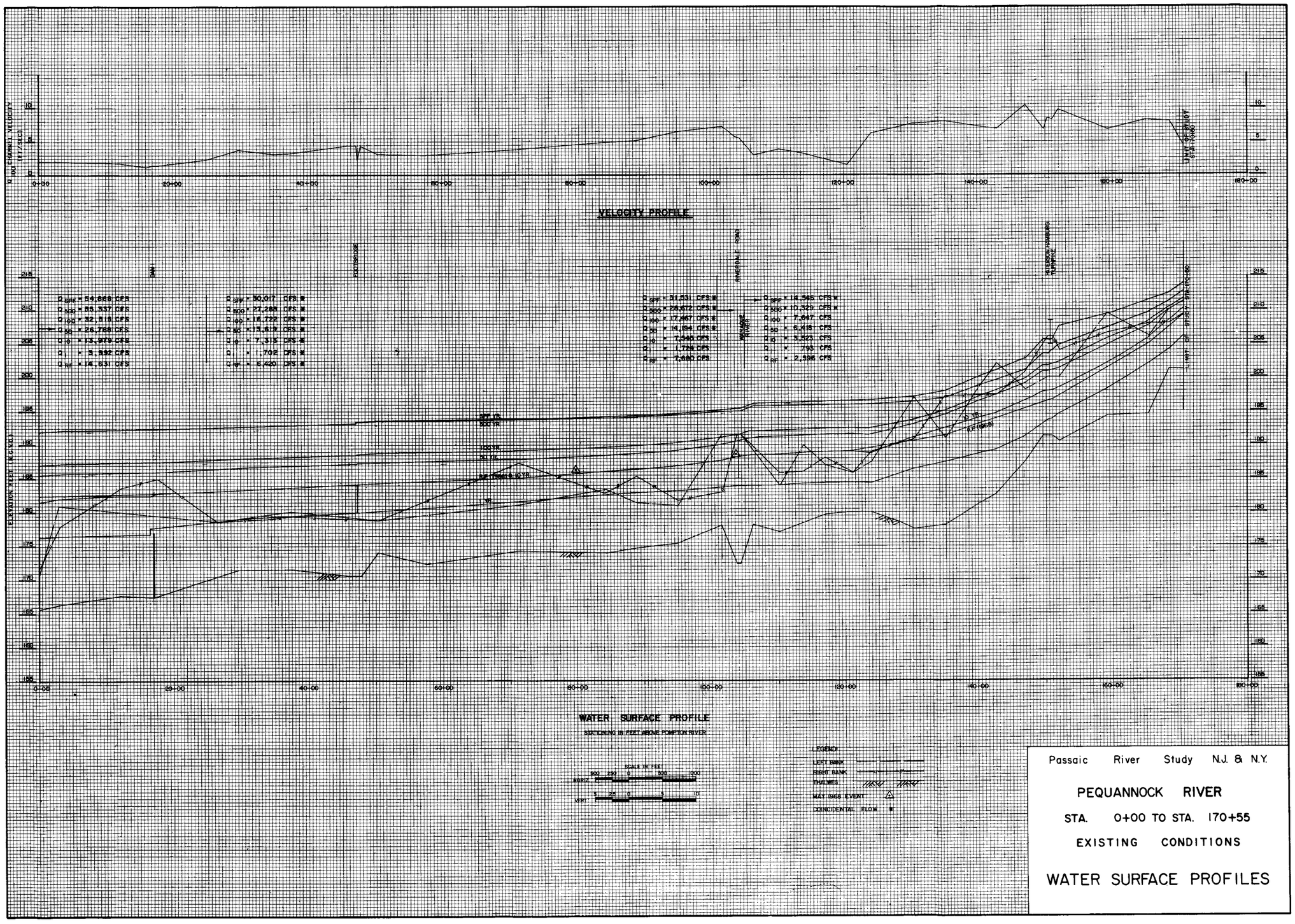
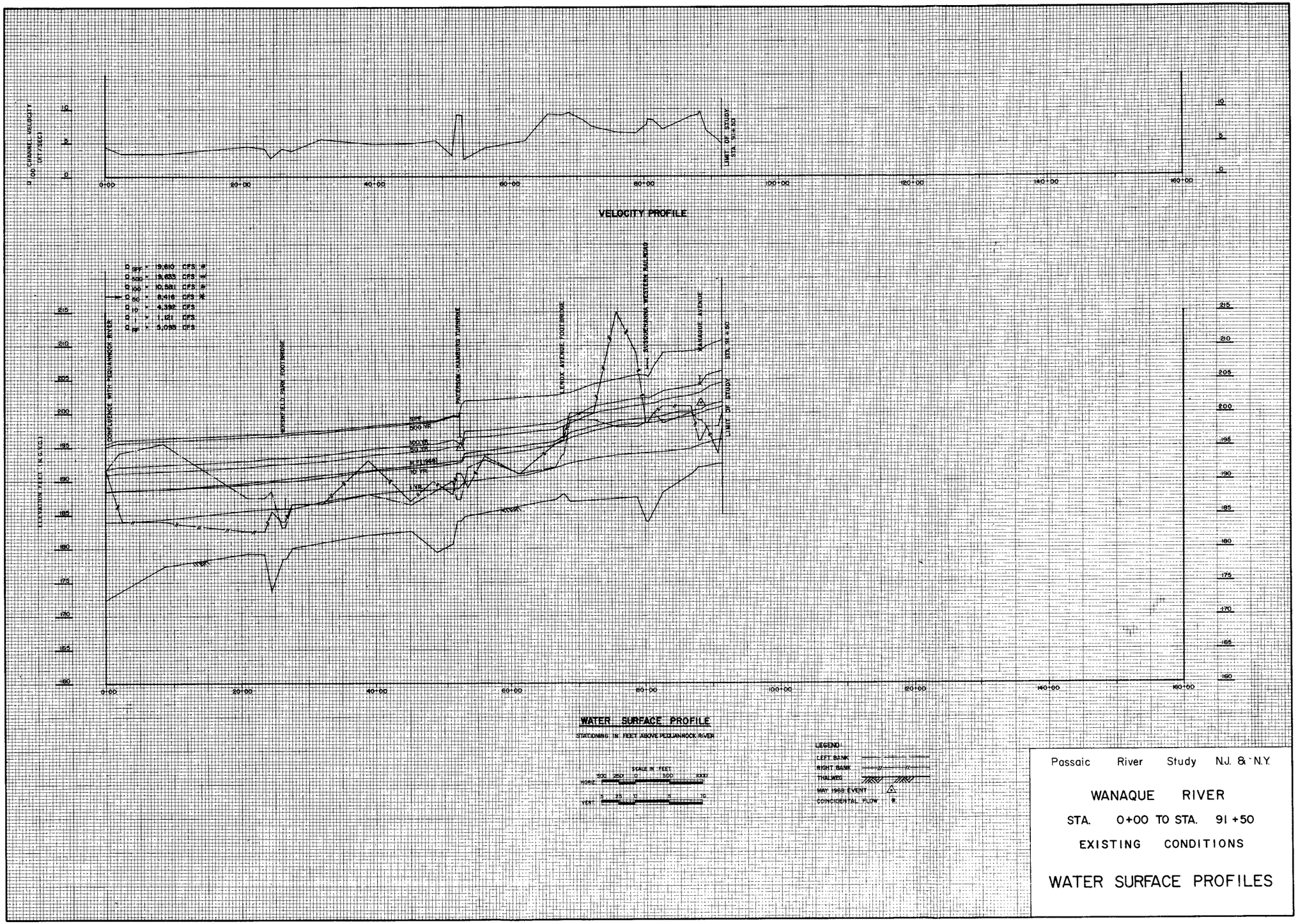


FIGURE NO. II-72



Passaic River Study N.J. & N.Y.

WANAQUE RIVER

STA. 0+00 TO STA. 91+50

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-73

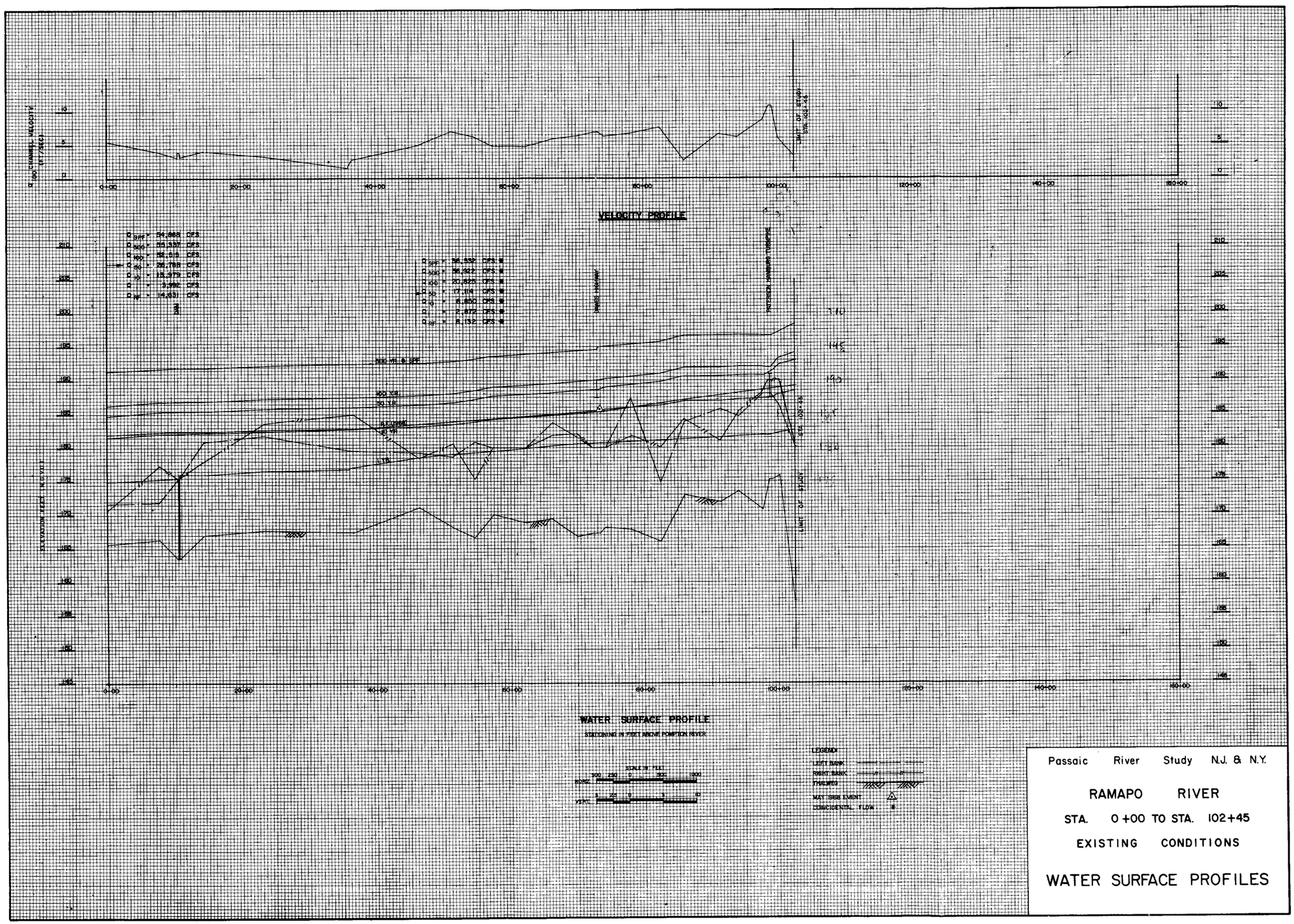


FIGURE NO. II-74

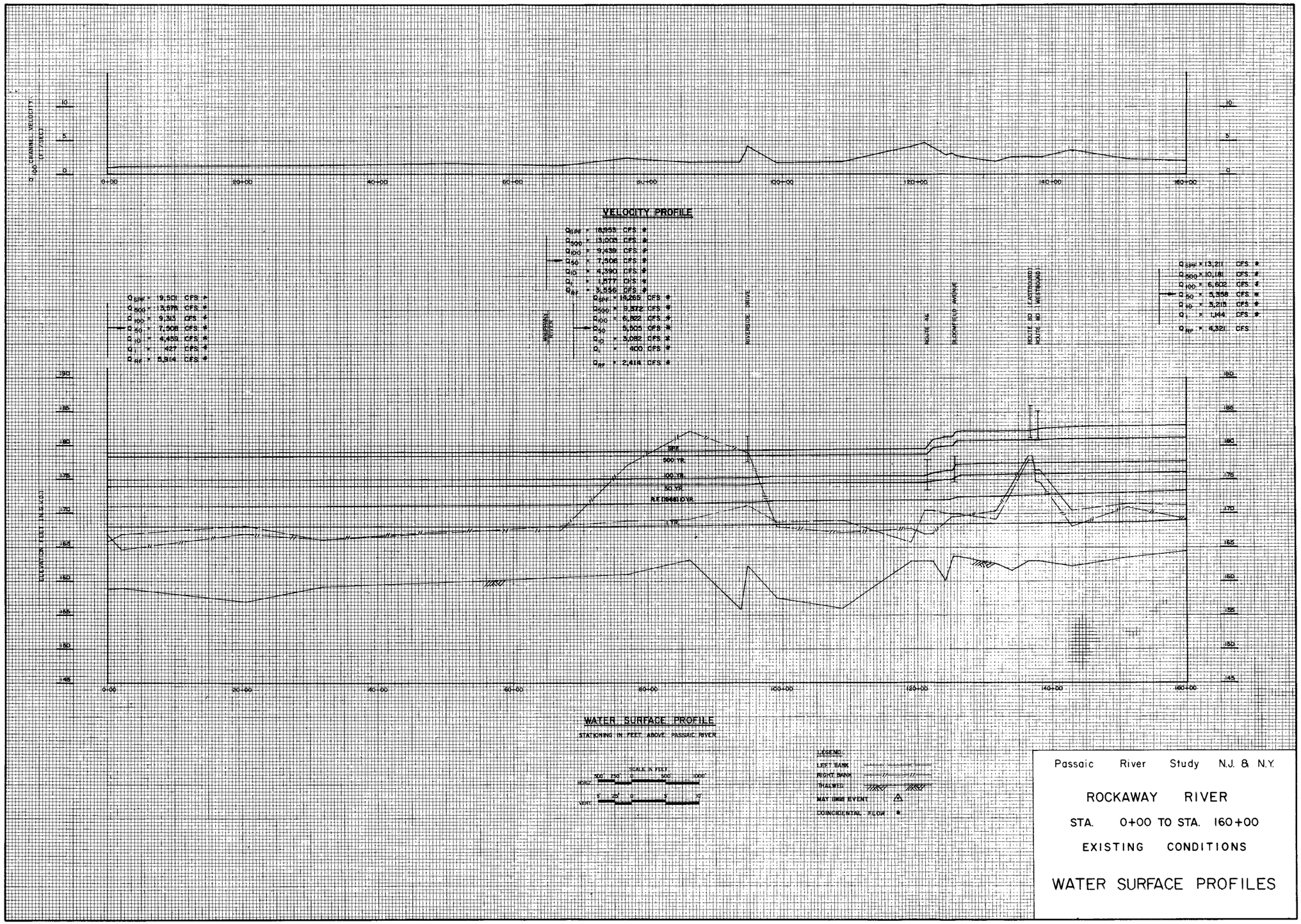
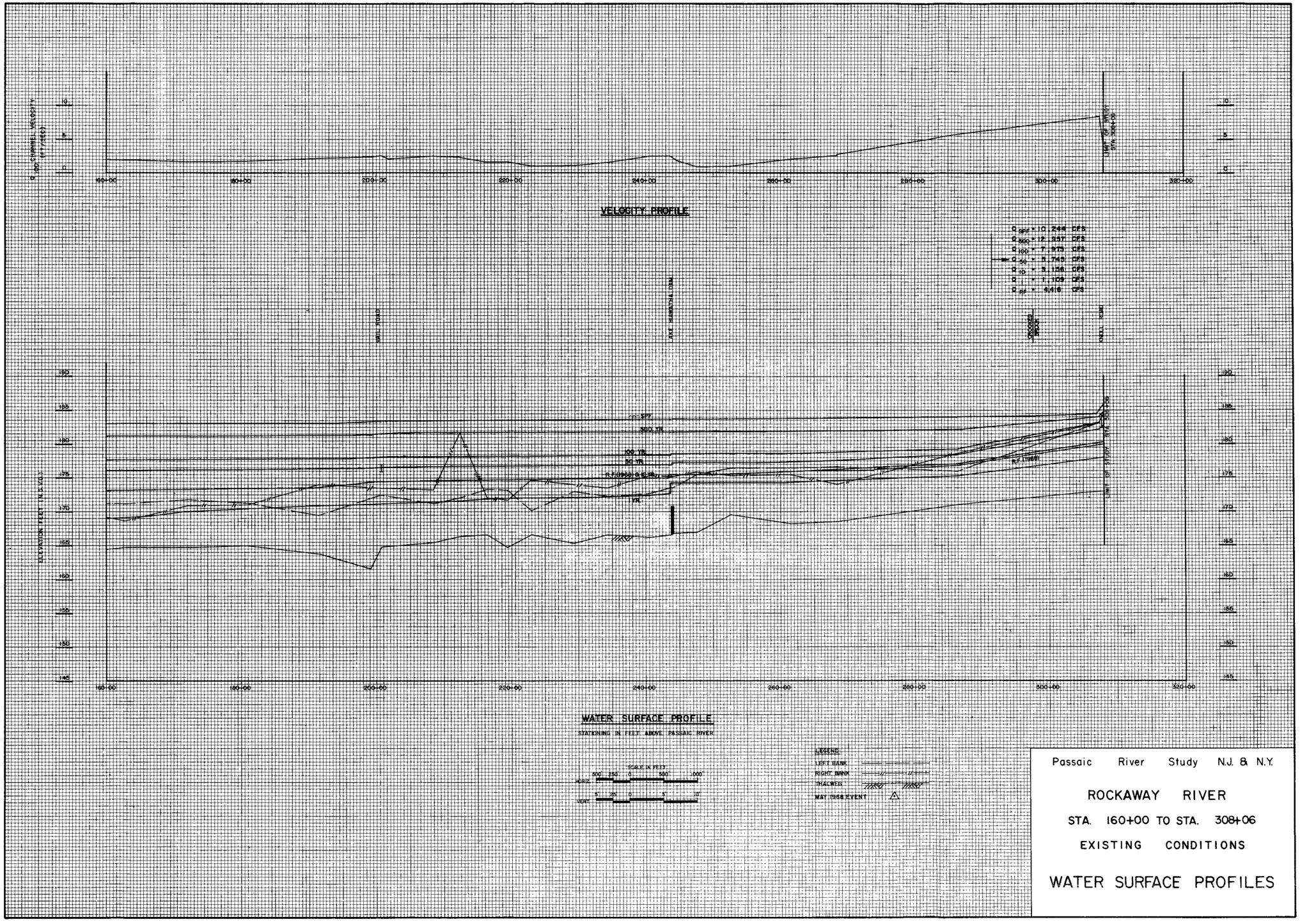


FIGURE NO. II-75



Passaic River Study N.J. & N.Y.

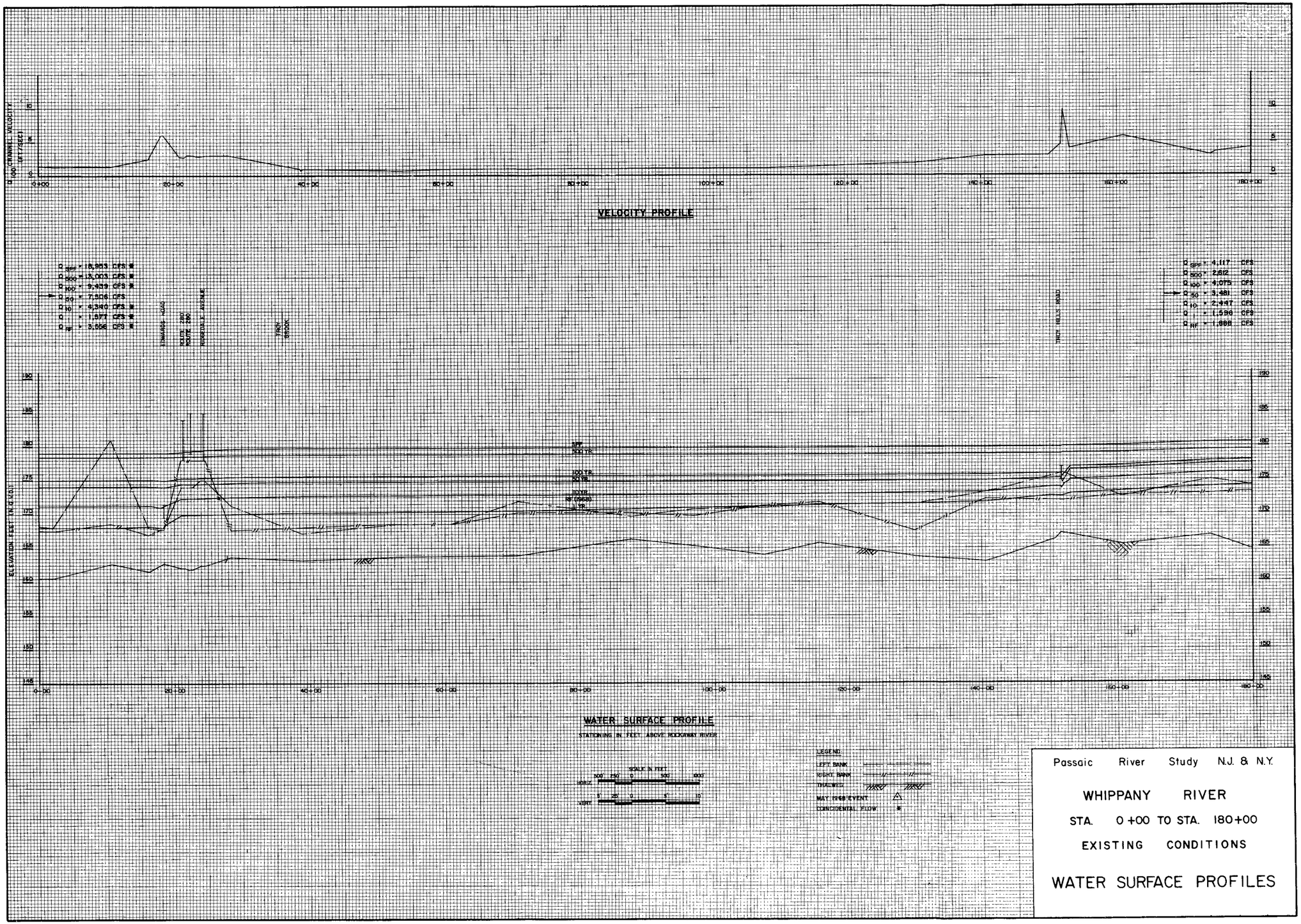
ROCKAWAY RIVER

STA. 160+00 TO STA. 308+06

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-76



Passaic River Study N.J. & N.Y.

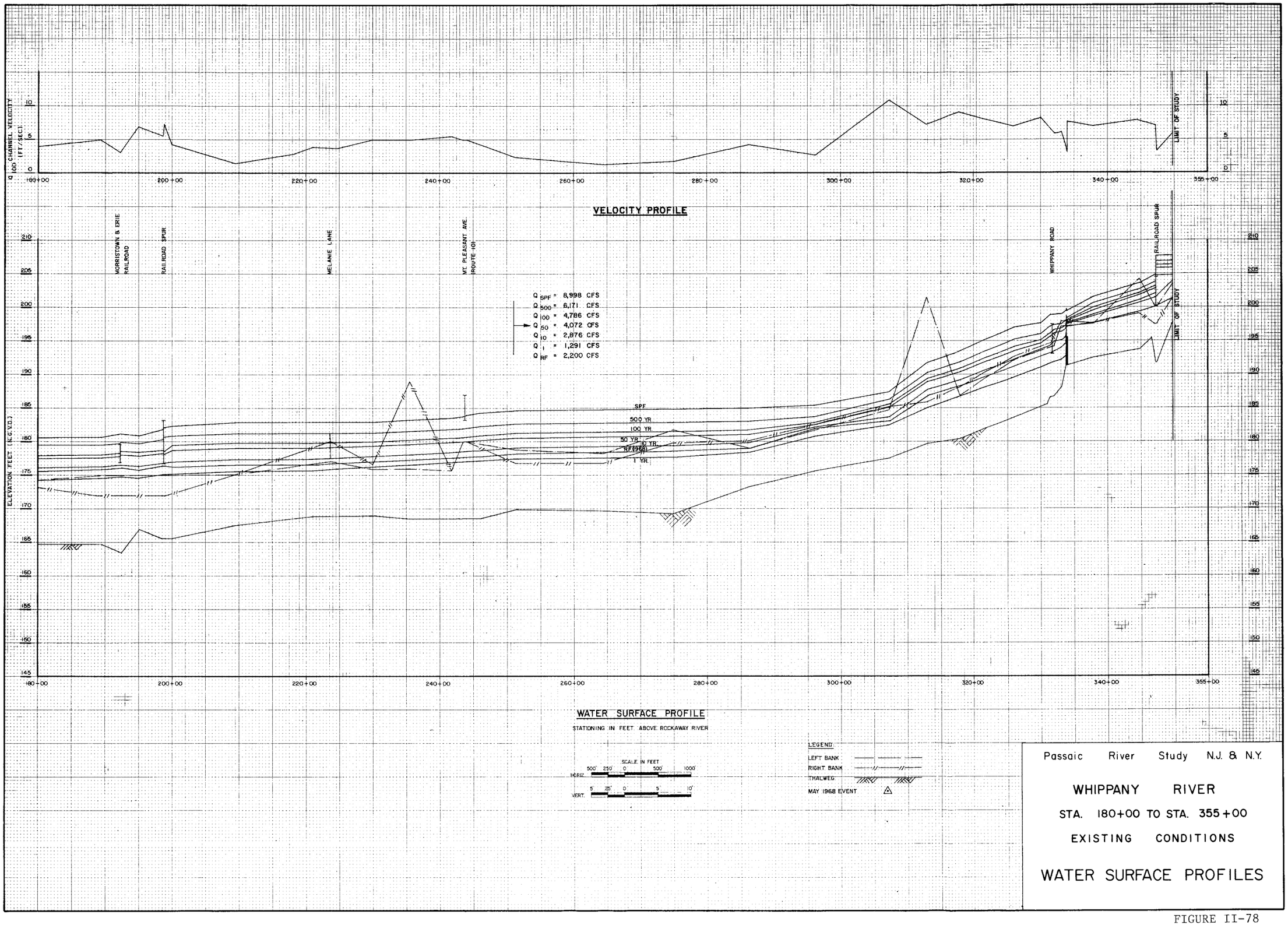
WHIPPANY RIVER

STA. 0+00 TO STA. 180+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II-77



Passaic River Study N.J. & N.Y.

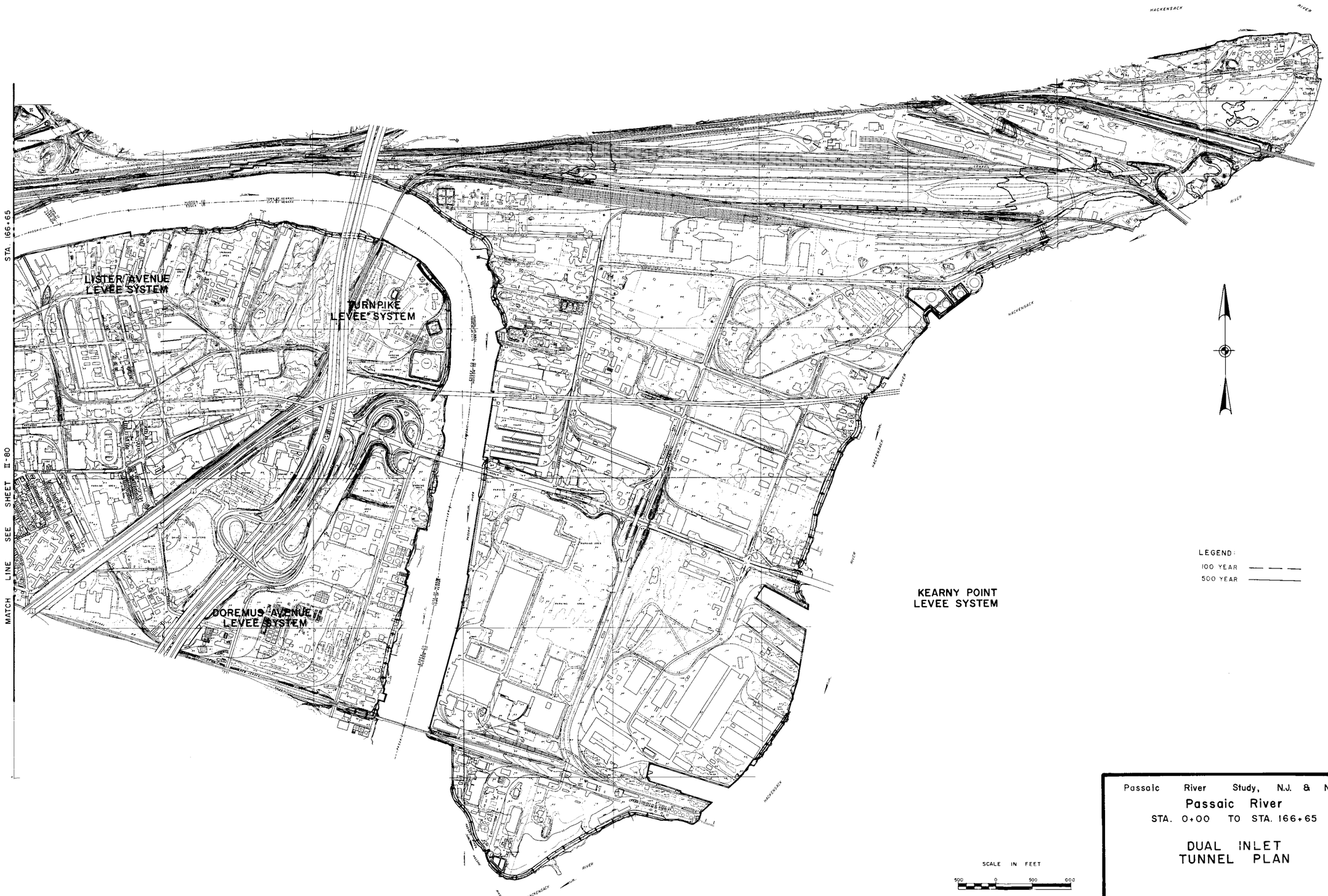
WHIPPANY RIVER

STA. 180+00 TO STA. 355+00

EXISTING CONDITIONS

WATER SURFACE PROFILES

FIGURE II-78



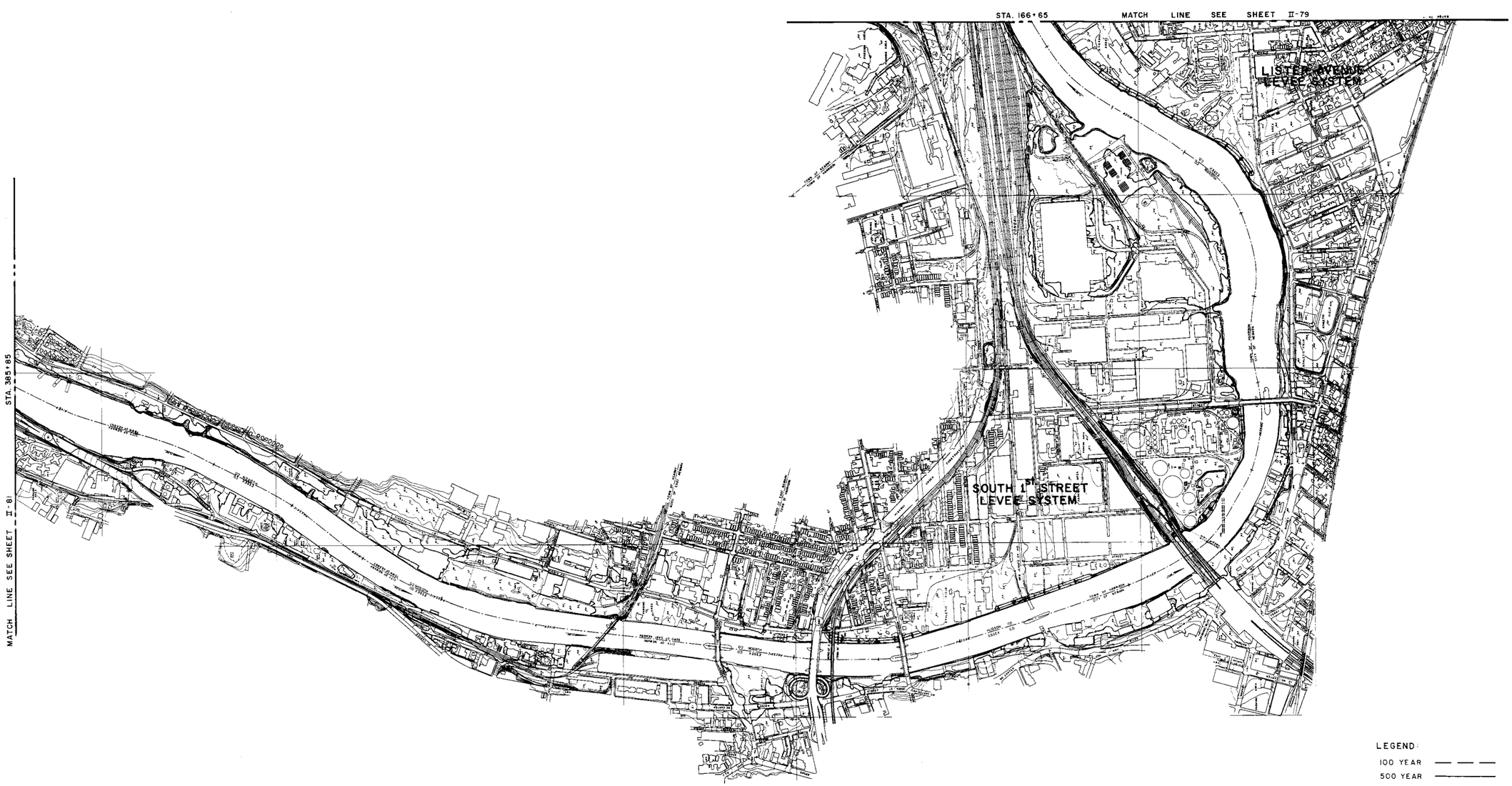
Passaic River Study, N.J. & N.Y.

Passaic River

STA. 0+00 TO STA. 166+65

DUAL INLET TUNNEL PLAN

FIGURE NO. II-79



LEGEND:
100 YEAR — — —
500 YEAR ————

SCALE IN FEET
500 0 500 1000

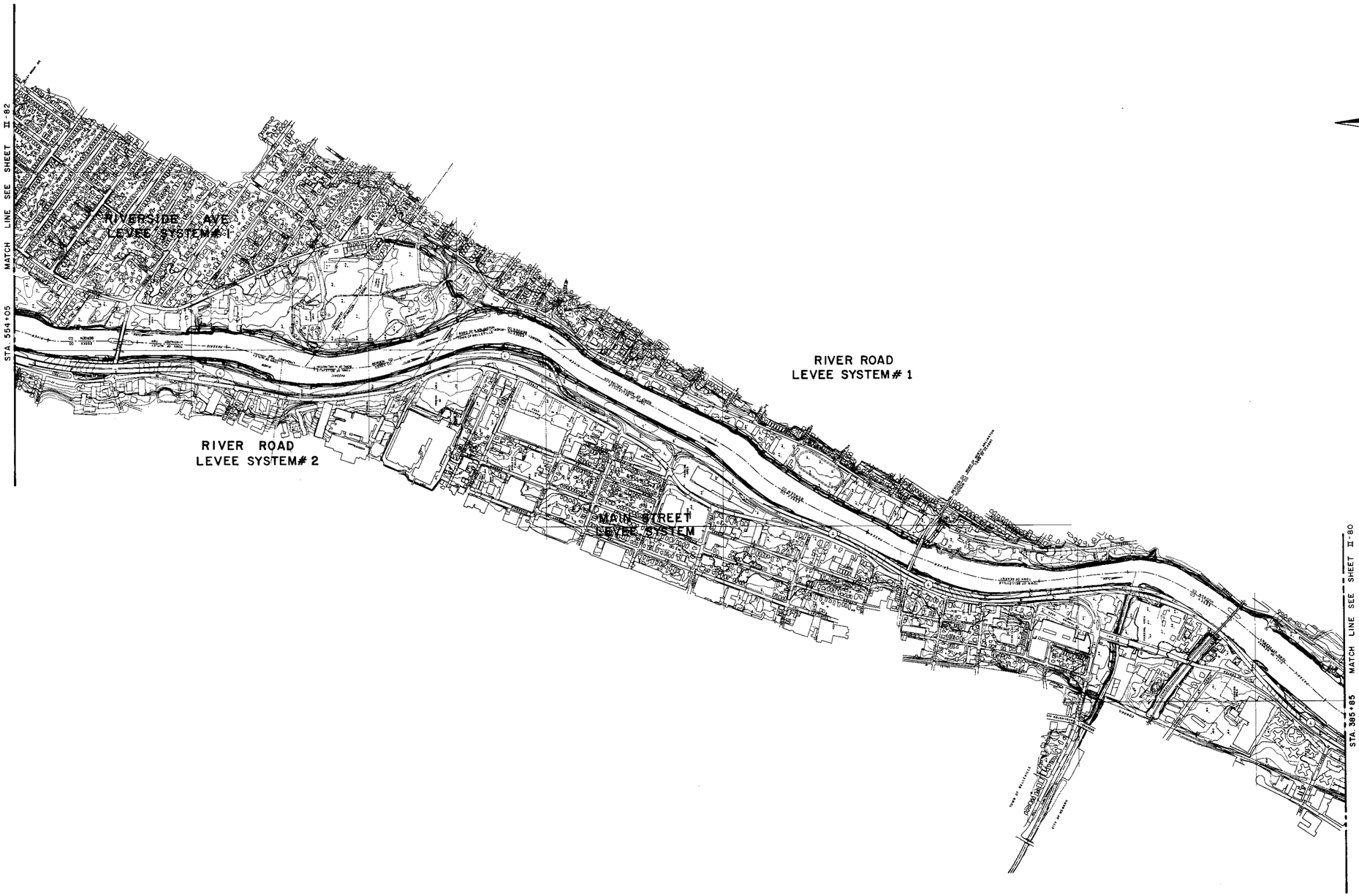
Passaic River Study, N.J. & N.Y.

Passaic River

STA. 166+65 TO STA. 385+85

DUAL INLET TUNNEL PLAN

FIGURE NO. II-80



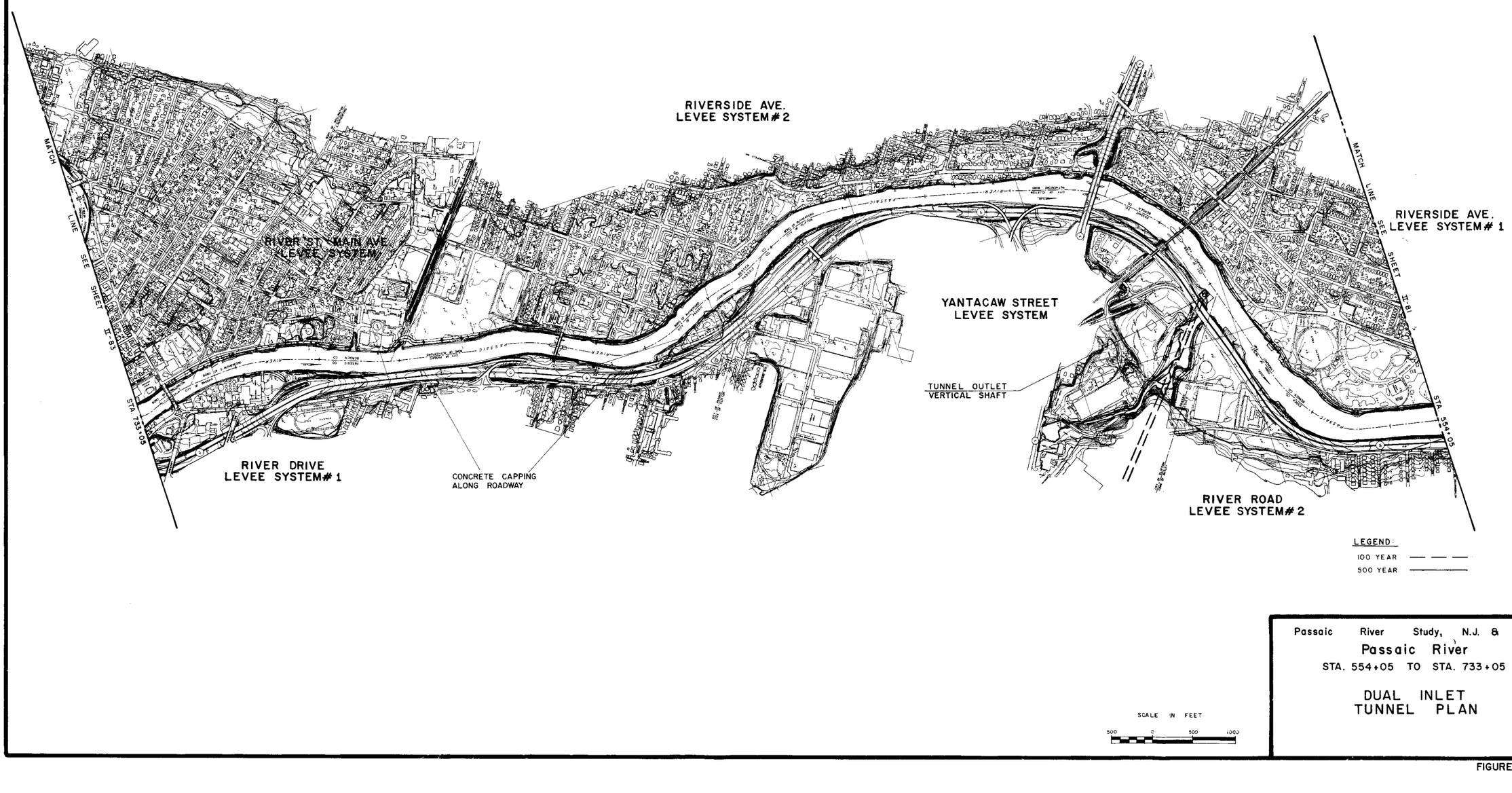
Passaic River Study, N.J. & N.Y.

Passaic River

STA. 385+85 TO STA. 554+05

DUAL INLET TUNNEL PLAN

FIGURE NO. II-81



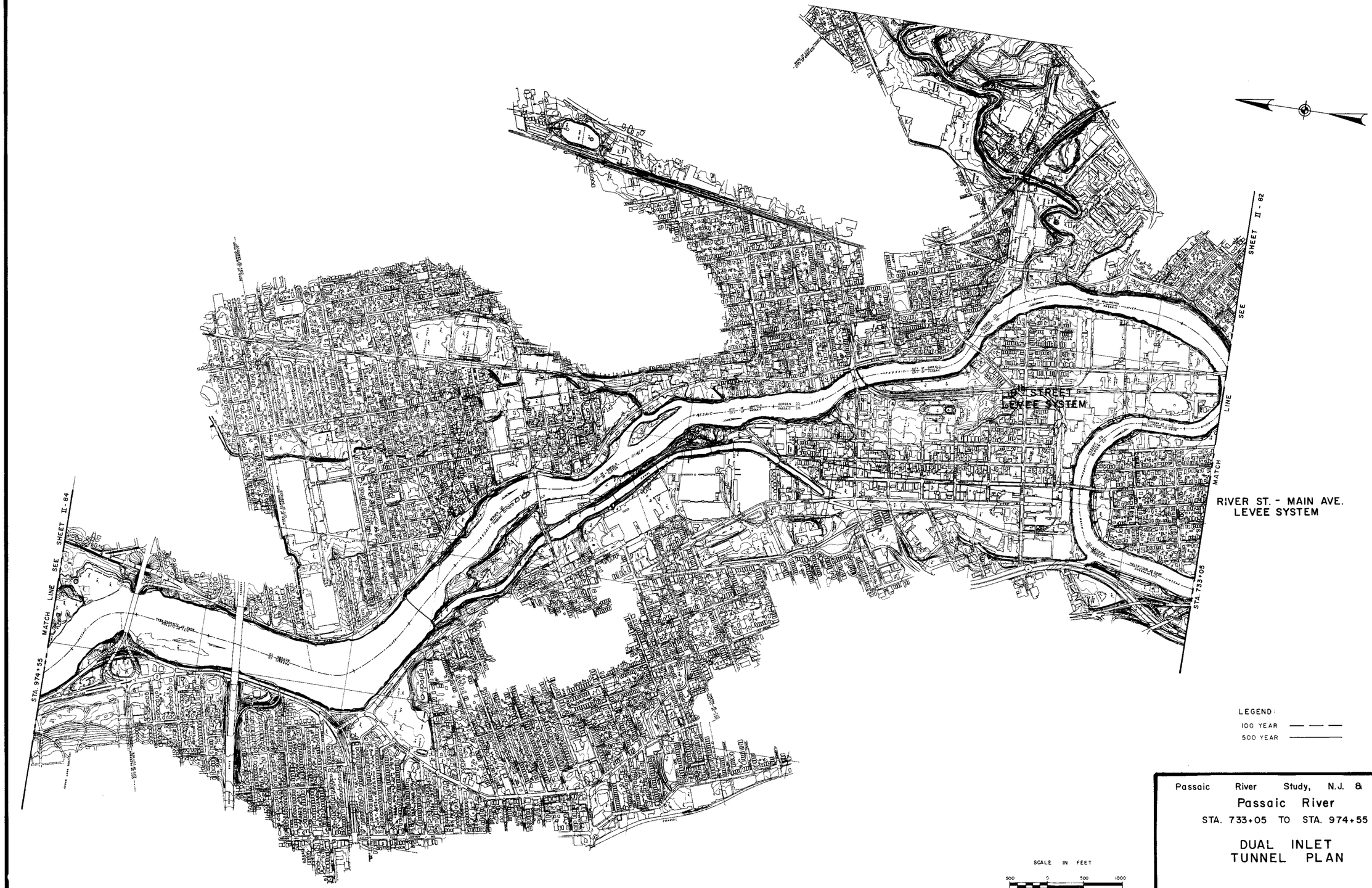
Passaic River Study, N.J. & N.Y.

Passaic River

STA. 554+05 TO STA. 733+05

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-82



Passaic River Study, N.J. & N.Y.

Passaic River

STA. 733+05 TO STA. 974+55

DUAL INLET TUNNEL PLAN

FIGURE NO. II-83

STA 1220+55 MATCH LINE SEE SHEET II - 85

MATCH LINE SEE SHEET II - 83 STA 974+55

LEGEND

100 YEAR — — —

500 YEAR ———

SCALE IN FEET

500 0 500 1000

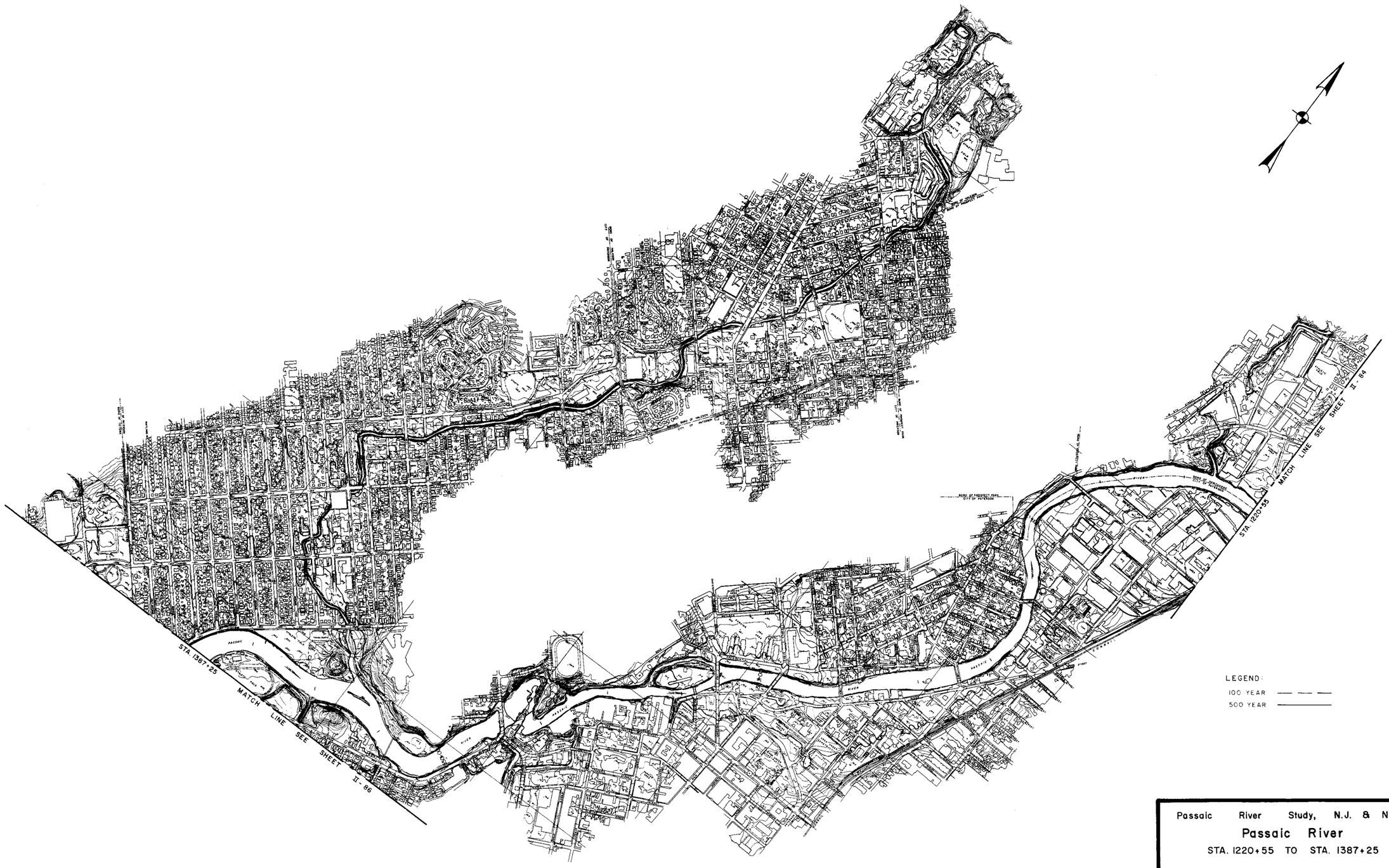
Passaic River Study, N.J. & N.Y.

Passaic River

STA. 974+55 TO STA. 1220+55

DUAL INLET TUNNEL PLAN

FIGURE NO. II-84



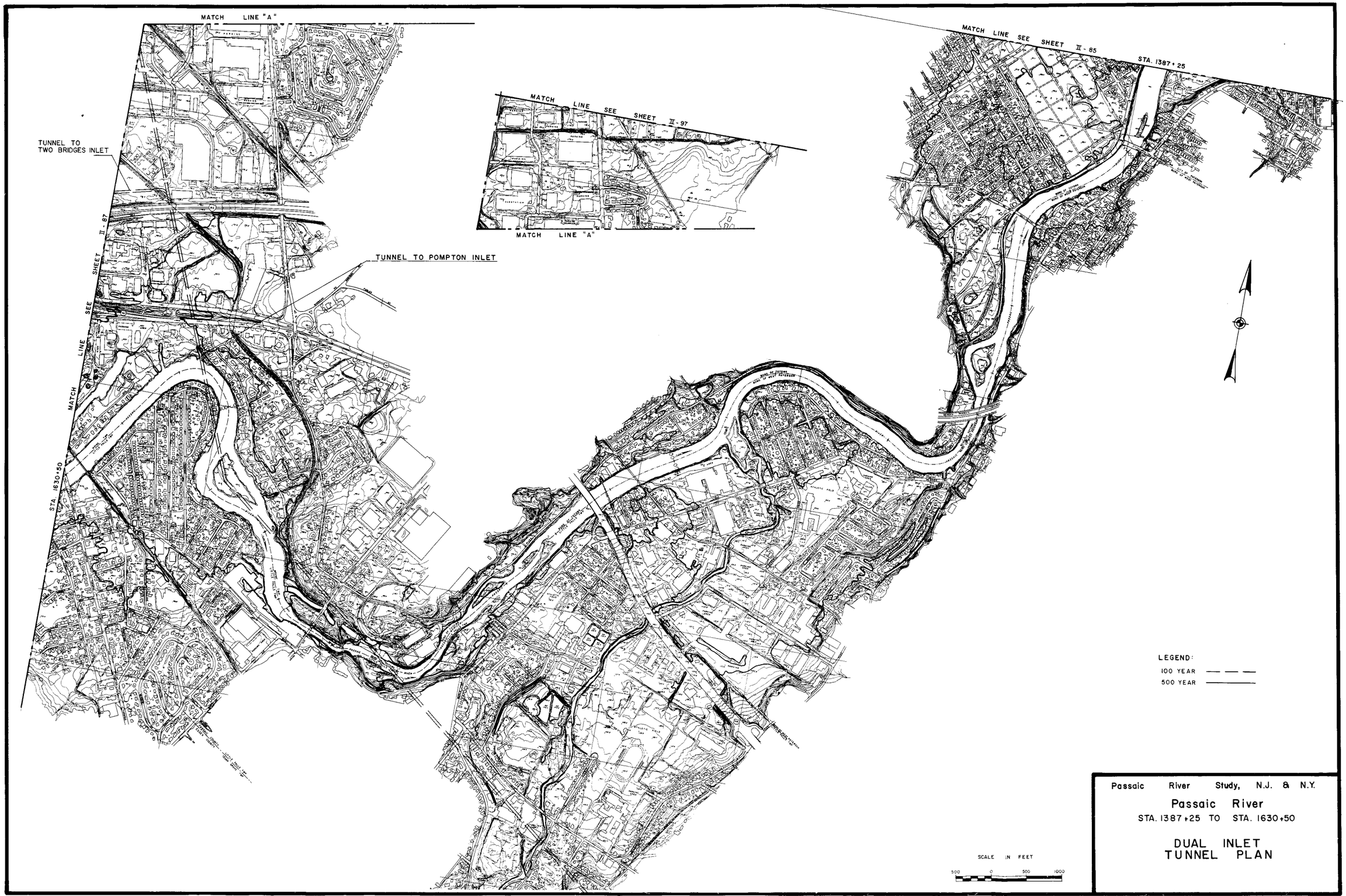
Passaic River Study, N.J. & N.Y.

Passaic River

STA. 1220+55 TO STA. 1387+25

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-85



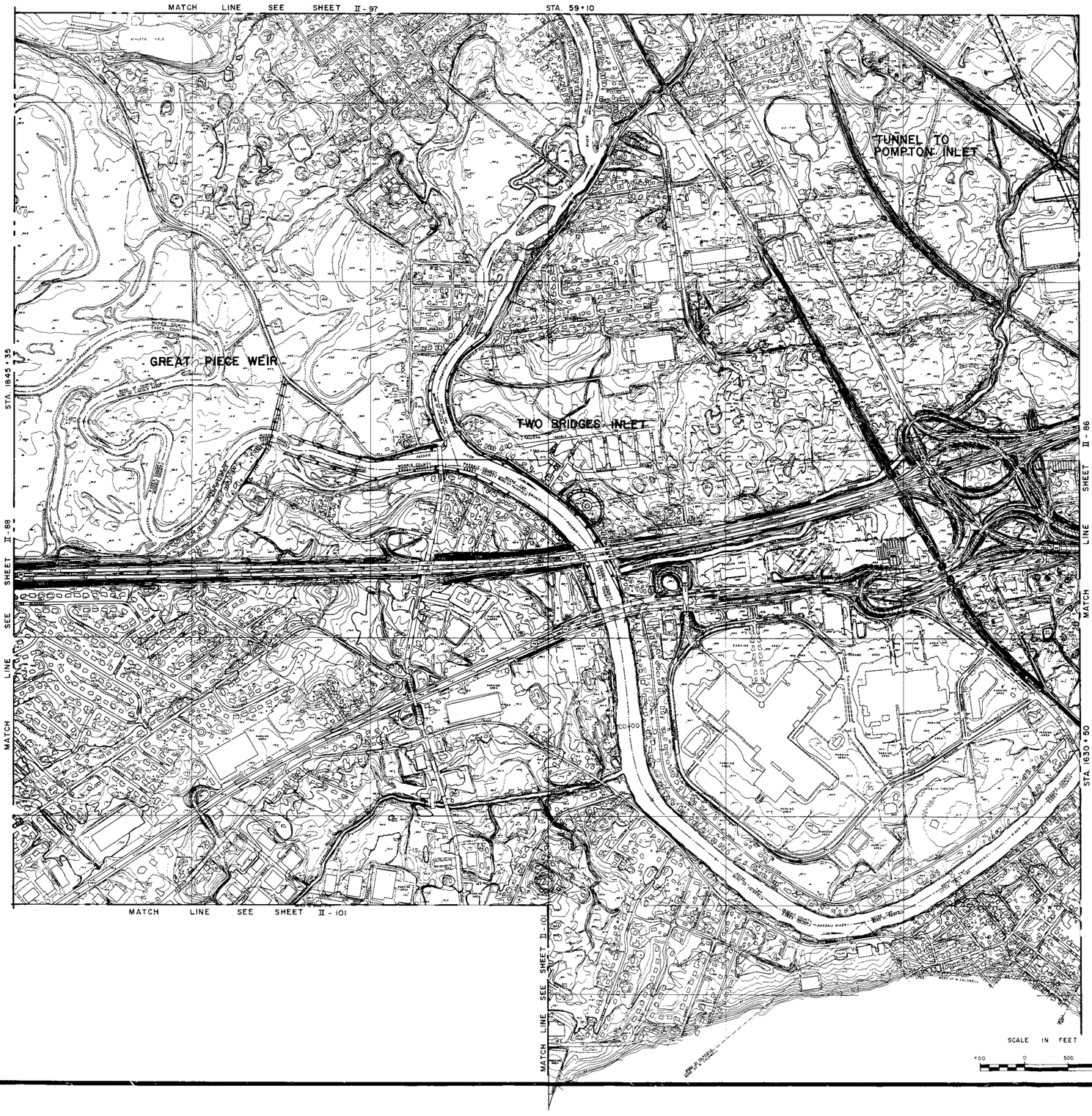
Passaic River Study, N.J. & N.Y.

Passaic River

STA. 1387+25 TO STA. 1630+50

DUAL INLET TUNNEL PLAN

FIGURE NO. II-86



LEGEND:

100 YEAR — — —

500 YEAR ————

Passaic River Study, N.J. & N.Y.

Passaic River

STA. 1630+50 TO STA. 1845+35

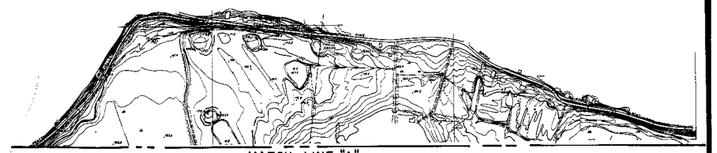
Pompton River

STA. 0+00 TO STA. 59+10

DUAL INLET TUNNEL PLAN

FIGURE NO. II-87

MATCH LINE "A"



MATCH LINE "A"

GATED STRUCTURE

GATED STRUCTURE

PASSAIC RIVER 42A
LEVEE SYSTEM

STA. 1845+35

SEE SHEET II-87 MATCH LINE

STA. 2192+95

MATCH LINE SEE SHEET II-89

MATCH LINE SEE SHEET II-101

LEGEND:
100 YEAR — — —
500 YEAR ———

SCALE IN FEET
500 0 500 1000

Passaic River Study, N.J. & N.Y.

Passaic River
STA. 1845+35 TO STA. 2192+95

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-88

MATCH LINE SEE SHEET II-103

STA. 169+10 MATCH LINE SEE SHEET II-95

STA. 42+20

SHEET II-90 SEE LINE MATCH

ROCKAWAY RIVER #1
LEVEE SYSTEM

ROCKAWAY RIVER #2
LEVEE SYSTEM

STA. 2192+95

SHEET II-88 SEE LINE MATCH

GATED STRUCTURE

STA. 2453+55

PASSAIC RIVER #2A
LEVEE SYSTEM

MATCH LINE SEE SHEET II-101

LEGEND:

100 YEAR — — —

500 YEAR ———

SCALE IN FEET

500 0 500 1000

Passaic River Study, N.J. & N.Y.

Passaic River

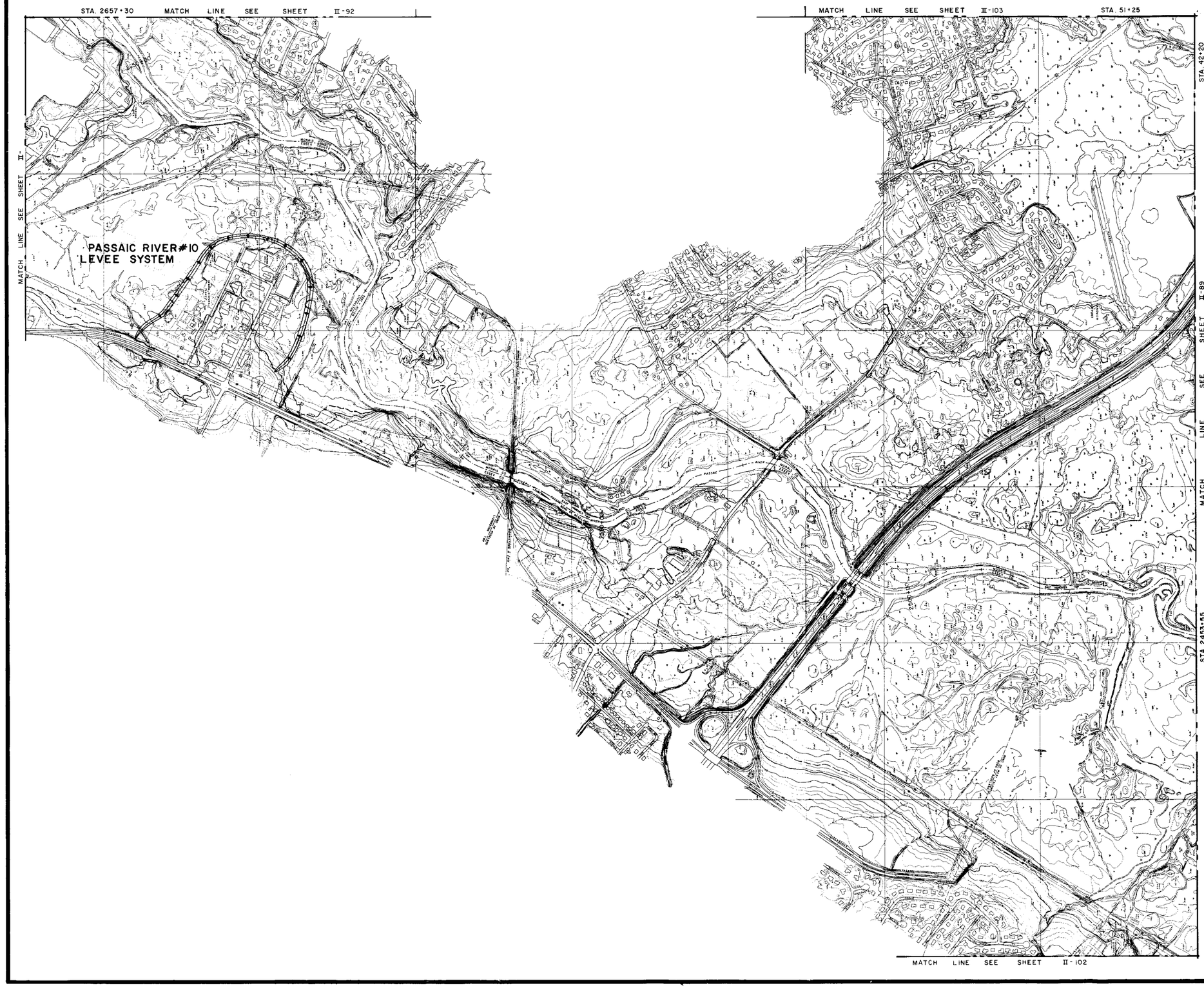
STA. 2192+95 TO STA. 2453+55

Rockaway River & Whippany River

0+00 TO 169+10 0+00 TO 42+20

DUAL INLET TUNNEL PLAN

FIGURE NO. II-89



LEGEND:

100 YEAR — — —

500 YEAR ———

SCALE IN FEET

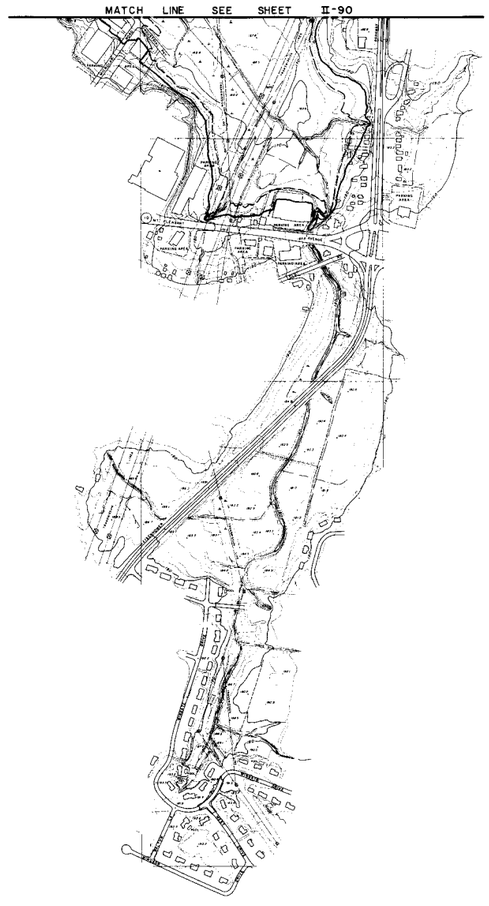
500 0 500 1000

Passaic River Study, N.J. & N.Y.

Passaic River
STA. 2453+55 TO STA. 2657+30

DUAL INLET TUNNEL PLAN

FIGURE NO. II-90



LEGEND:

100 YEAR — — —

500 YEAR ————

SCALE IN FEET

500 0 500 1000

Passaic River Study, N.J. & N.Y.

Passaic River

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-91

STA. 2657+30 MATCH LINE SEE SHEET II-90

STA. 2800+70 MATCH LINE SEE SHEET II-93

LEGEND:
100 YEAR — — —
500 YEAR ————

SCALE IN FEET
500 0 500 1000

Passaic River Study, N.J. & N.Y.

Passaic River
STA. 2657+30 TO STA. 2800+70

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-92

STA. 2800+75 MATCH LINE SEE SHEET II-92

SEE SHEET II-94 MATCH LINE

STA. 3009+10 MATCH LINE SEE SHEET

LEGEND:
100 YEAR
500 YEAR

SCALE IN FEET
500 0 500 1000

Passaic River Study, N.J. & N.Y.

Passaic River
STA. 2800+70 TO STA. 3009+10

DUAL INLET TUNNEL PLAN

FIGURE NO. II-93



LEGEND:
100 YEAR — — —
500 YEAR ———

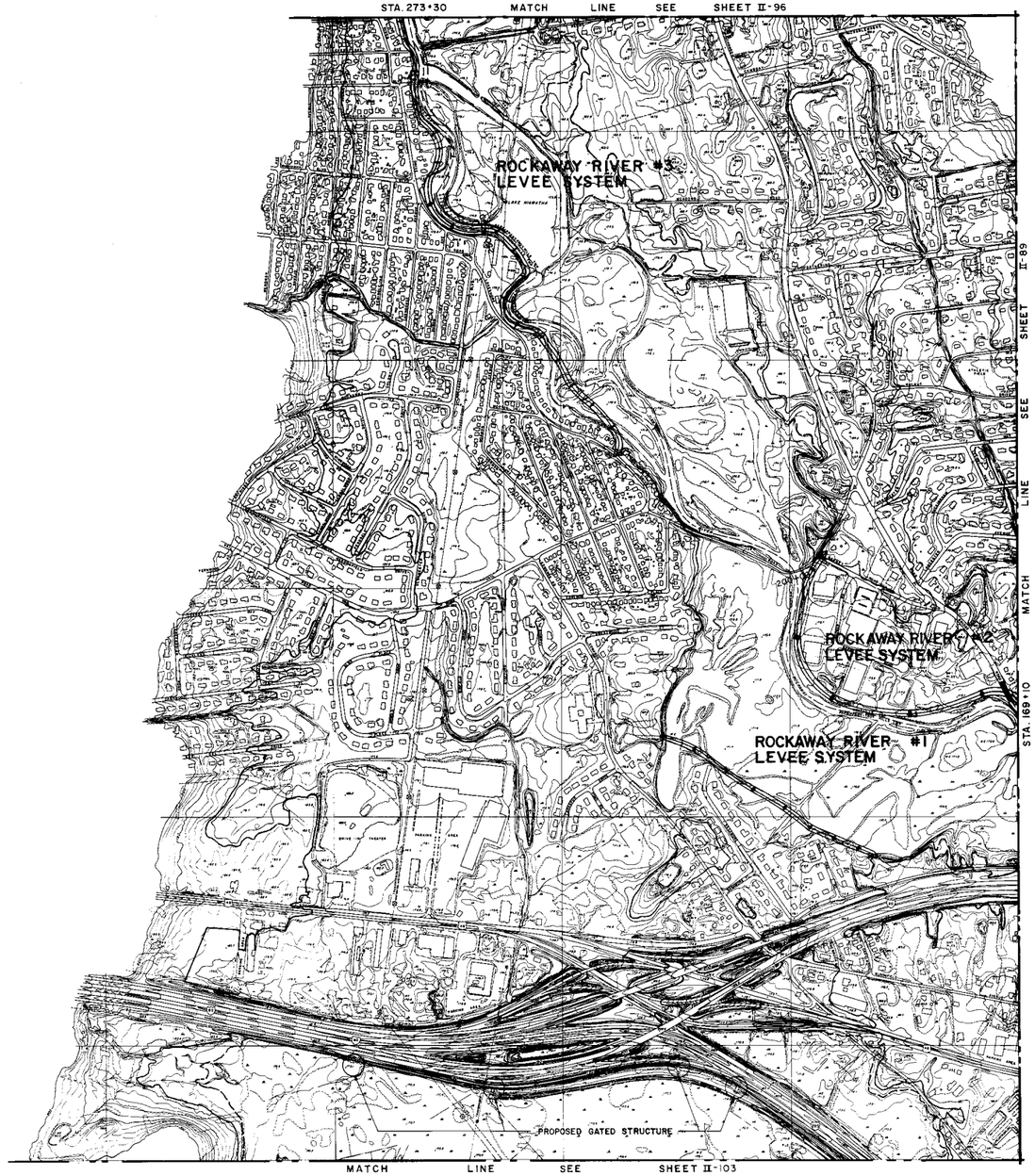
SCALE IN FEET
1000 0 500 1000

Passaic River Study, N.J. & N.Y.

Passaic River

OVERBANK STA. 2860 +00
TO STA. 2940 +00

FIGURE NO. II-94



LEGEND:
100 YEAR — — —
500 YEAR ————

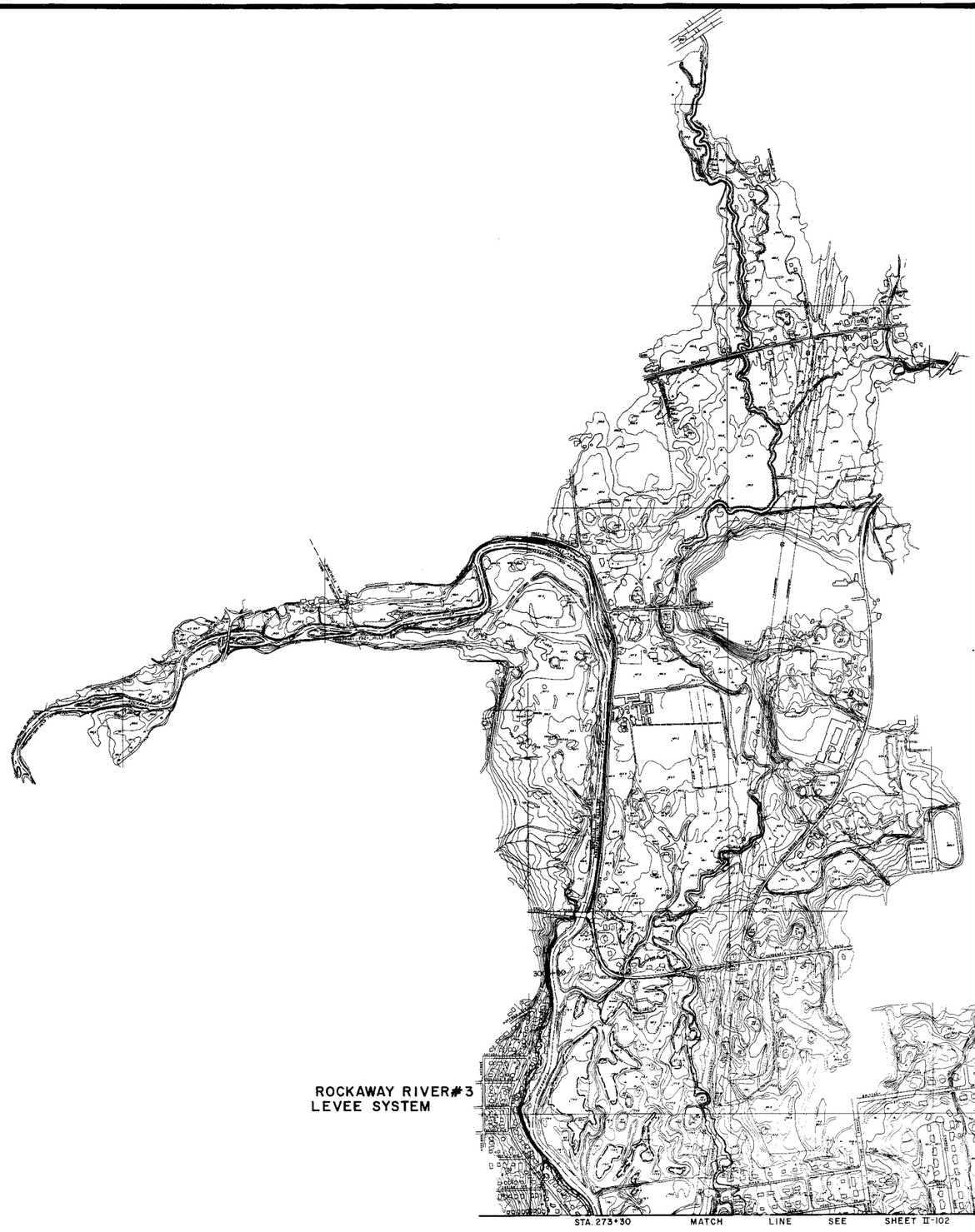
SCALE IN FEET
500 0 500 1000

Passaic River Study, N.J. & N.Y.

Rockaway River
STA. 169+10 TO STA. 273+30

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-95





LEGEND:
100 YEAR — — —
500 YEAR ———

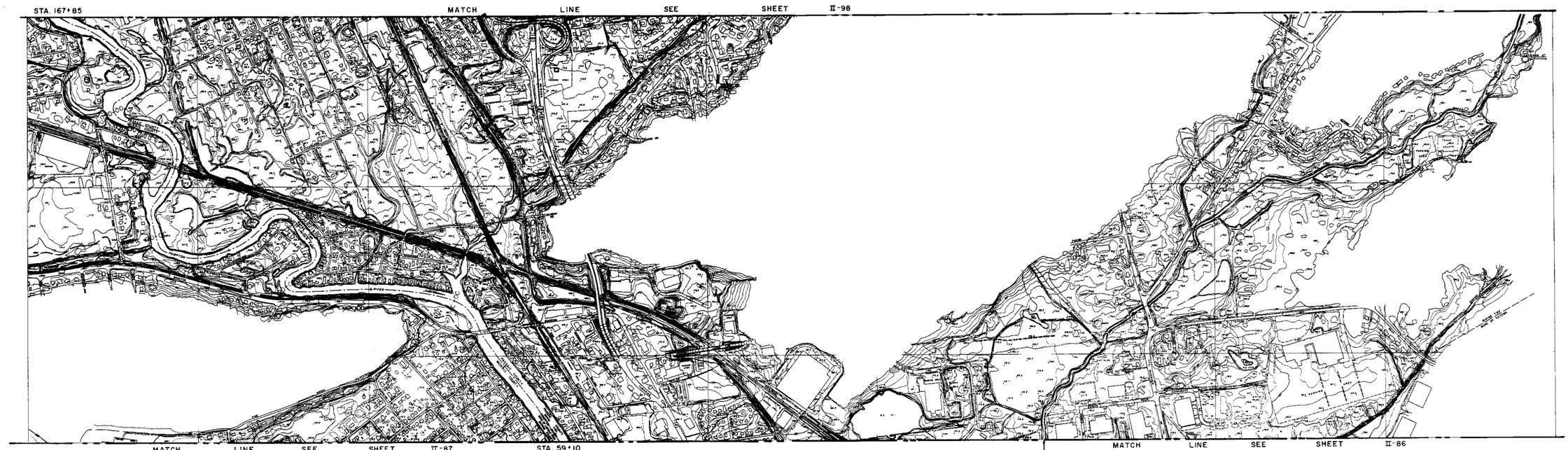
SCALE IN FEET
500 0 500 1000

Passaic River Study, N.J. & N.Y.

Rockaway River
STA. 273+30 TO END OF PROJECT

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-96



Passaic River Study, N.J. & N.Y.

Pompton River
STA. 59+10 TO STA. 167+85

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-97



LEGEND:
100 YEAR — — —
500 YEAR ———

SCALE IN FEET
500 0 500 1000

Passaic River Study, N.J. & N.Y.

Pompton River
STA. 167+85 TO STA. 278+35

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-98

MATCH LINE SEE SHEET II-100

SEE SHEET II-98 LINE MATCH

INSERT A

MATCH LINE

MATCH LINE SEE INSERT A

500 0 500 1000

LEGEND:

100 YEAR — — —

500 YEAR ———

Passaic River Study, N.J. & N.Y.

Pompton River

OVERBANK STA. 85+50

TO STA. 278+00

DUAL INLET

TUNNEL PLAN

FIGURE NO. II-99

MATCH LINE SEE SHEET II-106

STA. 69+10

STA. 49+20

SHORE ROAD
LEVEE SYSTEM

EARTHEN TRAPEZOIDAL
CHANNEL 129' BOTTOM WIDTH

POMPTON RIVER INLET

MATCH LINE SEE SHEET II-99

MATCH LINE SEE SHEET II-98

STA. 278+35

LEGEND:

100 YEAR — — —

500 YEAR ———

SCALE IN FEET

500 0 500 1000

Passaic River Study, N.J. & N.Y.

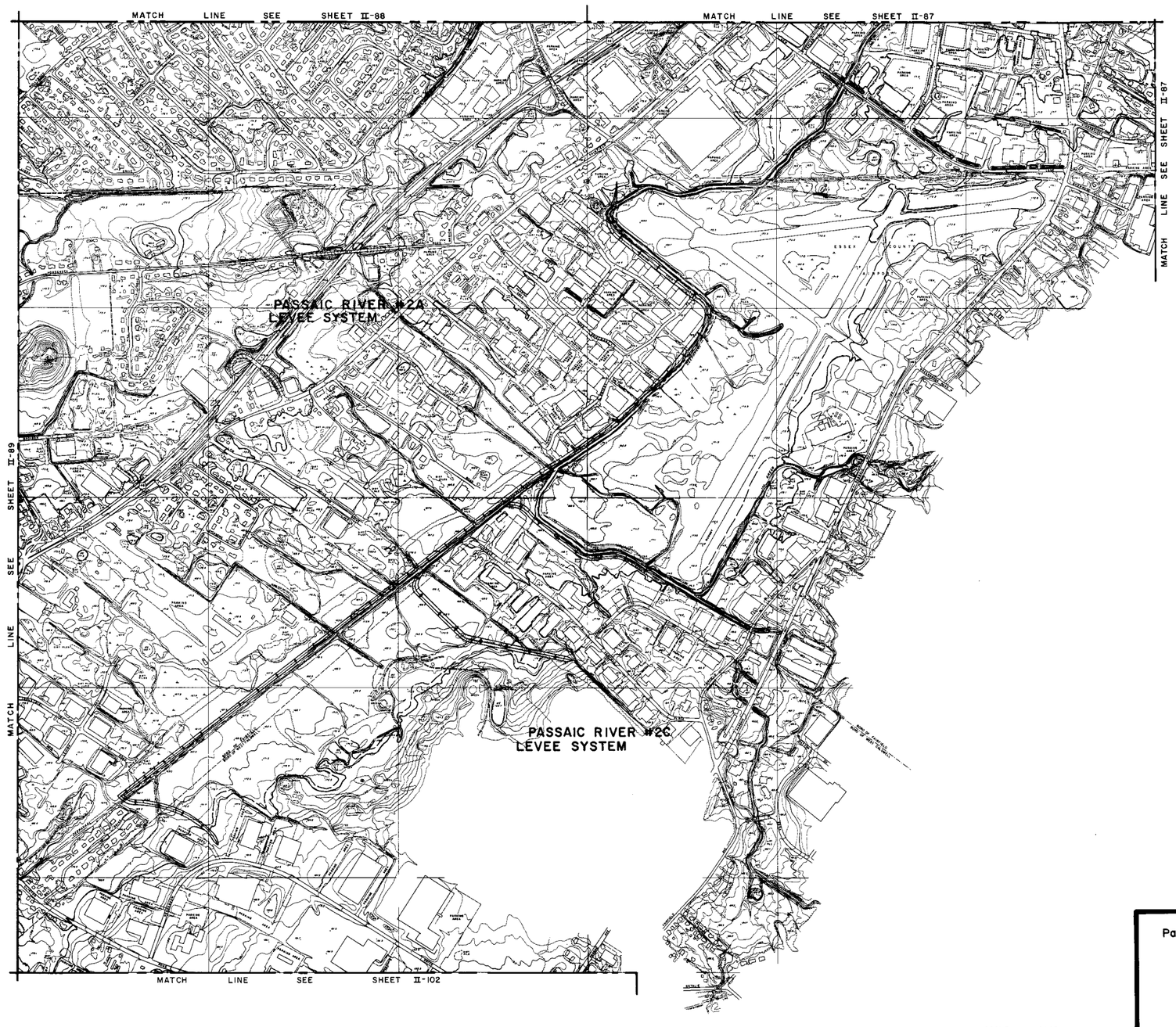
Pompton River

STA. 278+35 TO CONFLUENCE
OF
PEQUANNOCK & RAMAPO RIVERS

0+00 To 69+10 0+00 To 49+20

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-100



LEGEND:

100 YEAR — — —

500 YEAR ——— —

SCALE IN FEET

500 0 500 1000

Passaic River Study, N.J. & N.Y.

Passaic River

DUAL INLET TUNNEL PLAN

FIGURE NO. II-101



SCALE IN FEET
500 0 500 1000

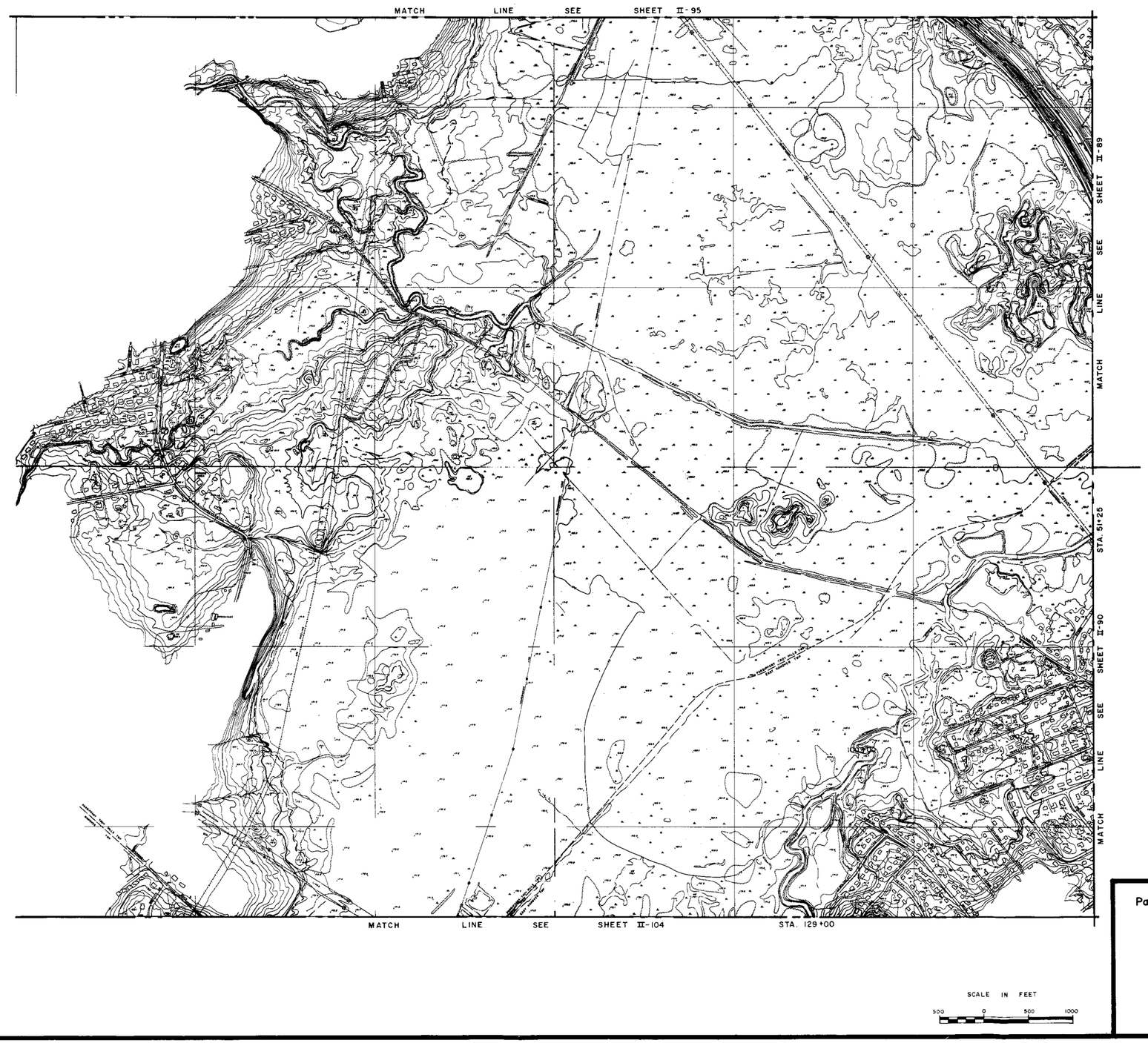
Passaic River Study, N.J. & N.Y.

Passaic River

OVERBANK
STA. 2386+00 TO STA. 2494+00

DUAL INLET
TUNNEL PLAN

FIGURE NO.-102



LEGEND:
100 YEAR — — —
500 YEAR ———

Passaic River Study, N.J. & N.Y.

Whippany River

STA. 51+25 TO STA. 129+00

DUAL INLET
TUNNEL PLAN

FIGURE NO. II-103

MATCH LINE SEE SHEET II-103

STA. 129+00

PINCH BROOK LEVEE SYSTEM

MATCH LINE SEE SHEET II-105

LEGEND:

100 YEAR — — —

500 YEAR ———

SCALE IN FEET

500 0 500 1000

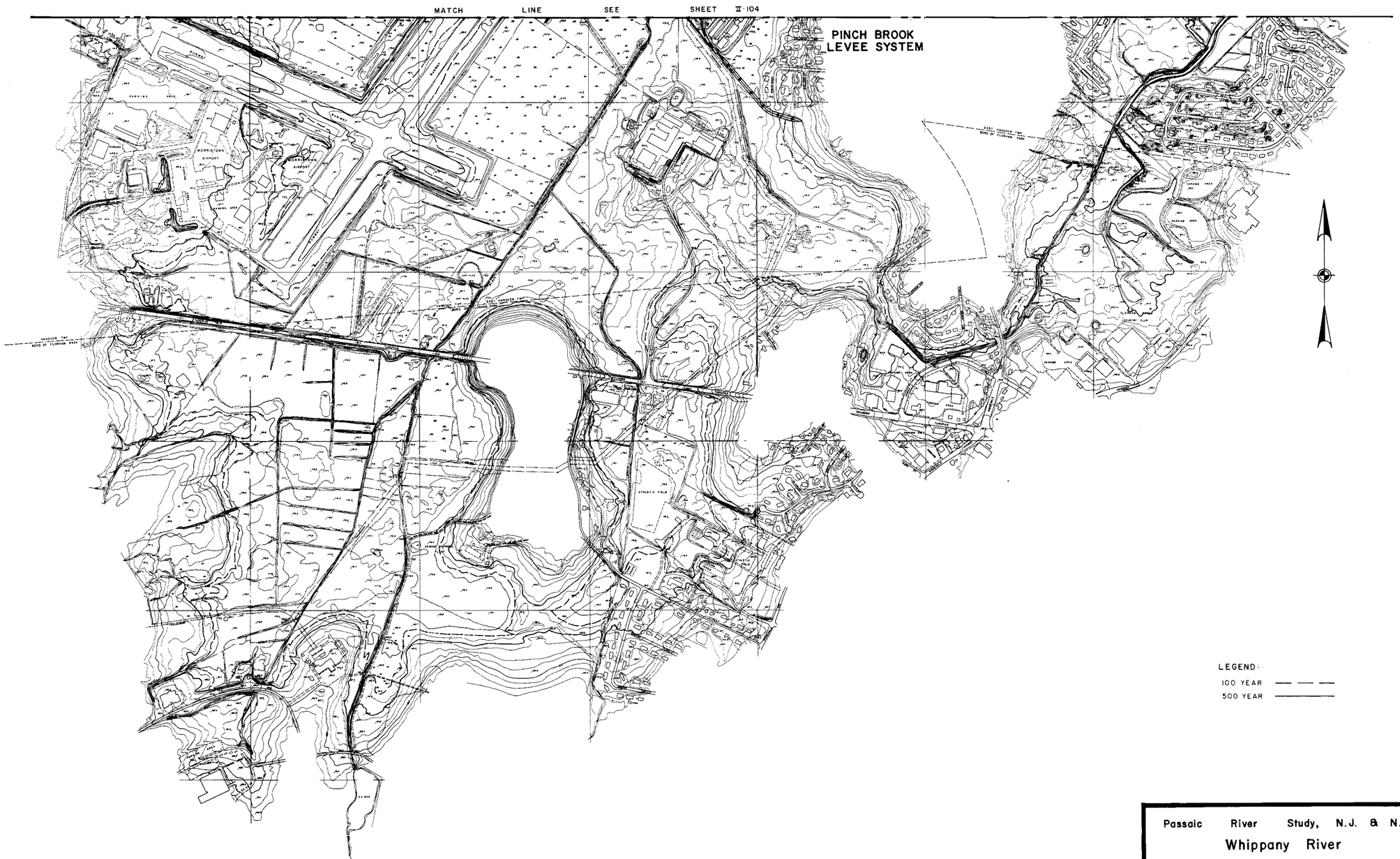
Passaic River Study, N.J. & N.Y.

Whippany River

STA. 129+00 TO END OF PROJECT

DUAL INLET TUNNEL PLAN

FIGURE NO. II-104

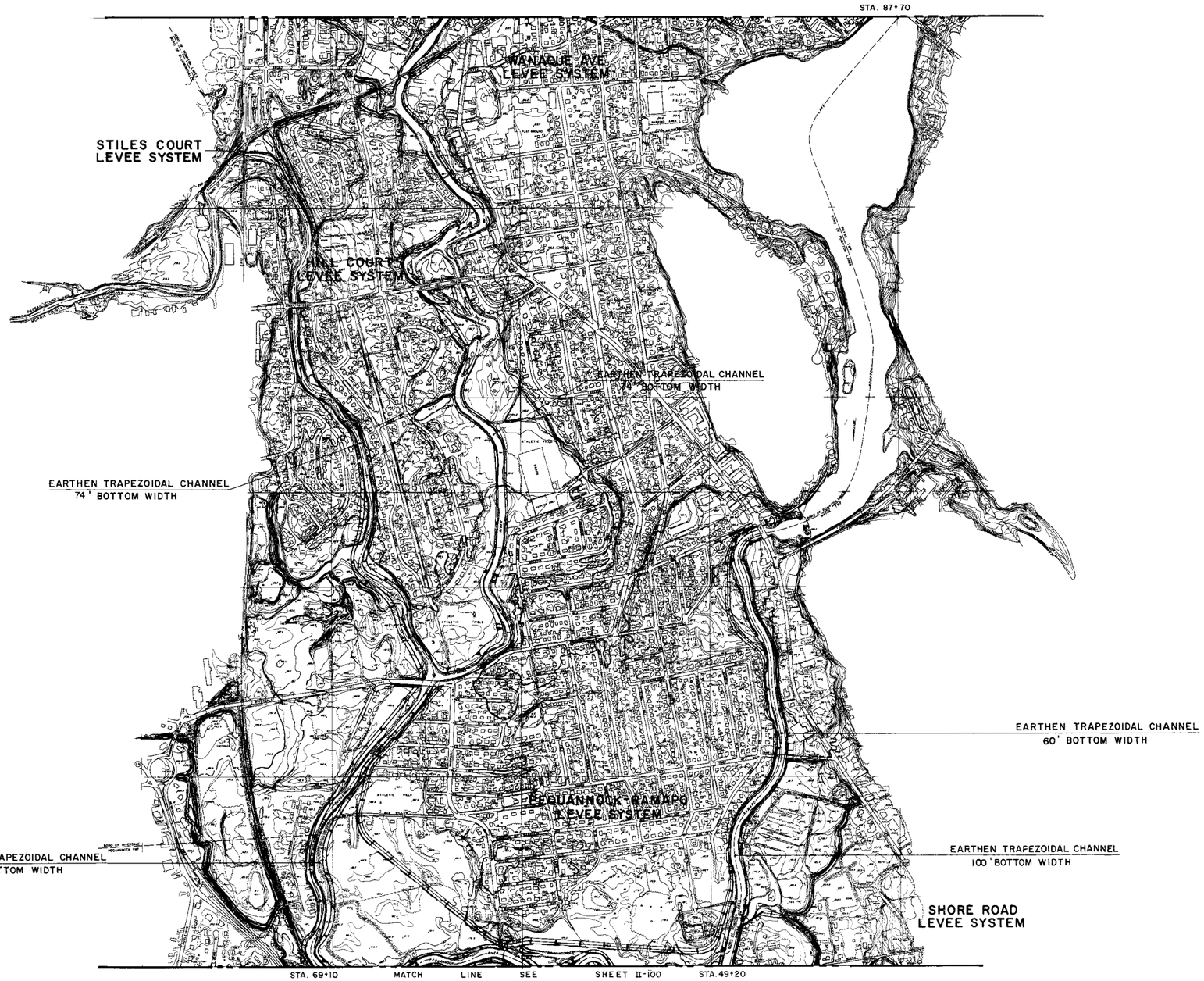


Passaic River Study, N.J. & N.Y.

Whippany River

DUAL INLET
TUNNEL PLAN

FIGURE NO.II-105

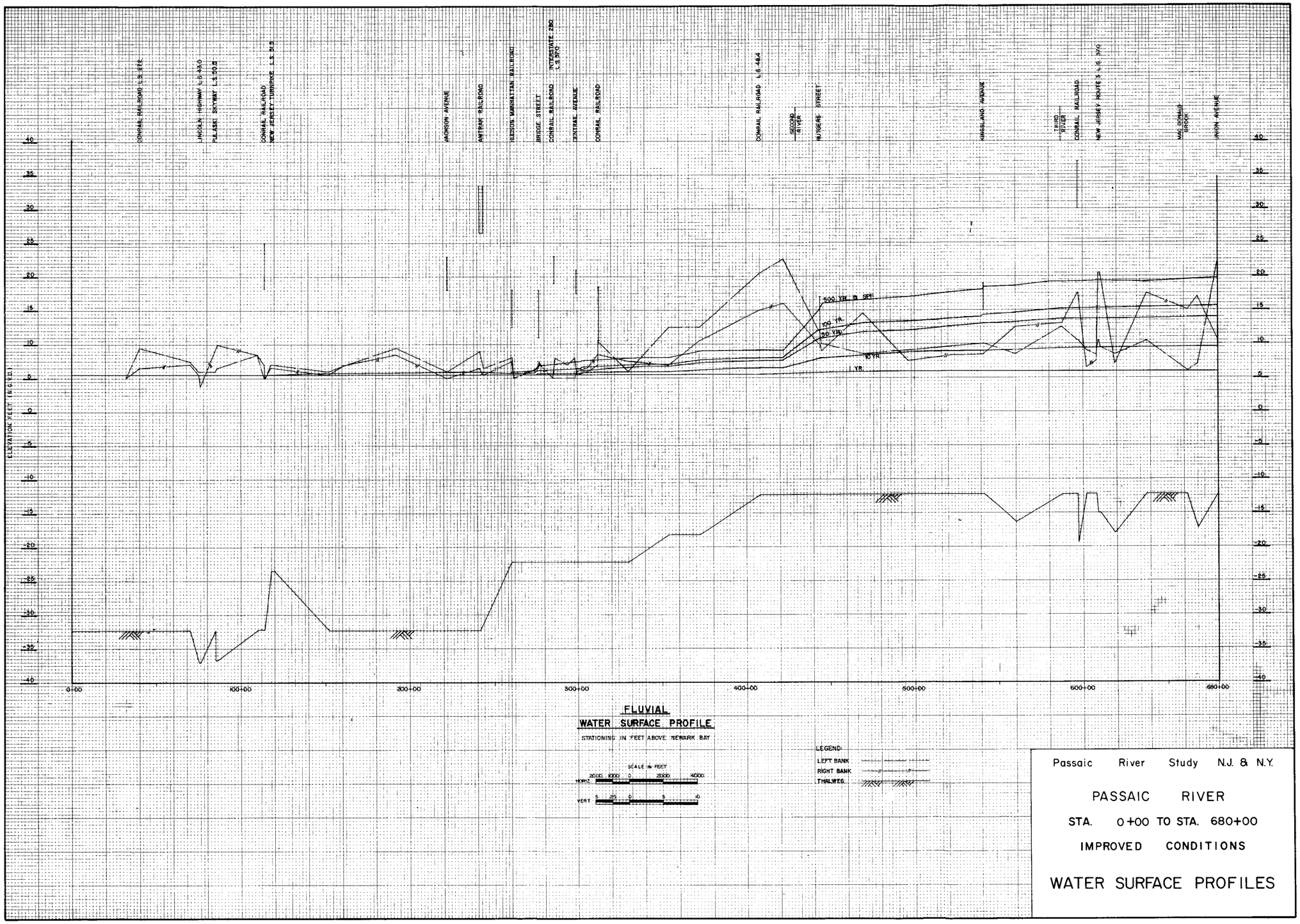


LEGEND:
100 YEAR — — —
500 YEAR ———

SCALE IN FEET
500 0 500 1000

Passaic River Study, N.J. & N.Y.
PEQUANNOCK RIVER
69+10 To End of Project
WANAQUE RIVER
0+00 To End of Project
RAMAPO RIVER
49+20 To End of Project
DUAL INLET
TUNNEL PLAN

FIGURE NO. II-106



FLUVIAL
WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET

HORIZ. 2000 1000 0 2000 4000

VERT. 5 .25 0 5 10

LEGEND:
LEFT BANK
RIGHT BANK
THALWEG

Passaic River Study N.J. & N.Y.

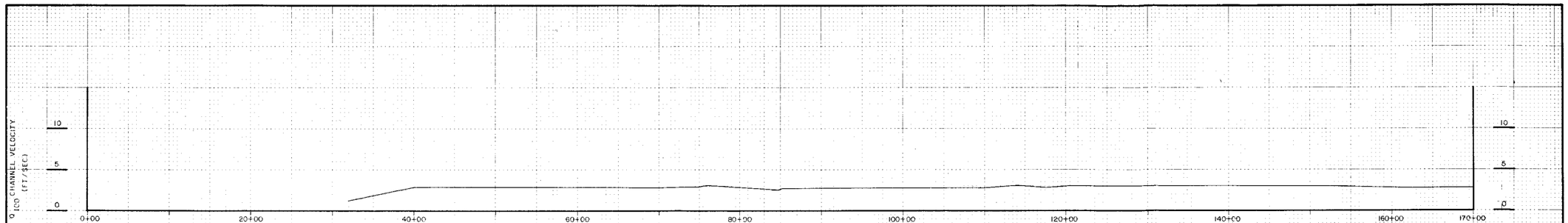
PASSAIC RIVER

STA. 0+00 TO STA. 680+00

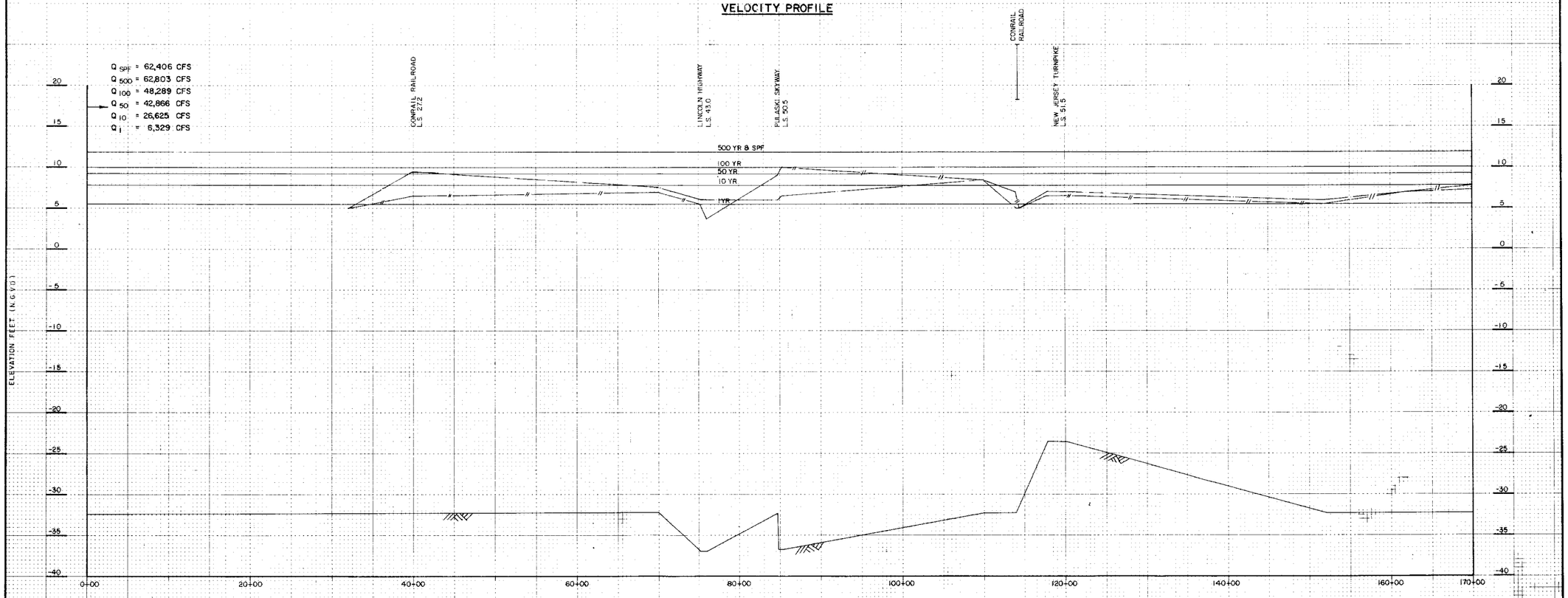
IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II 107



VELOCITY PROFILE



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET

HORIZ 500 250 0 500 1000

VERT 5 2.5 0 5 10

LEGEND:

LEFT BANK

RIGHT BANK

THALWEG

Passaic River Study N.J. & N.Y.

PASSAIC RIVER

STA. 0+00 TO STA. 170+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II.108

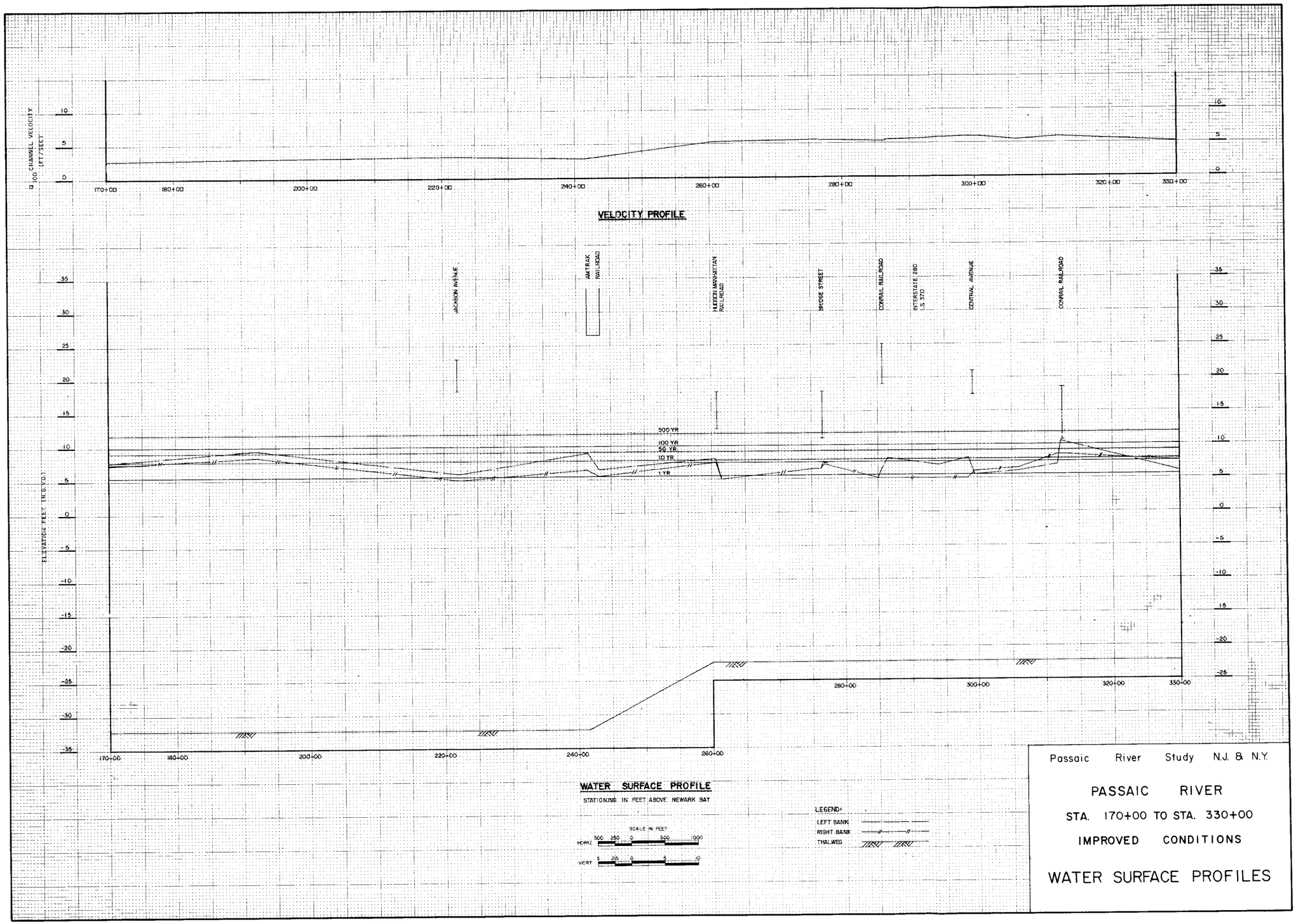
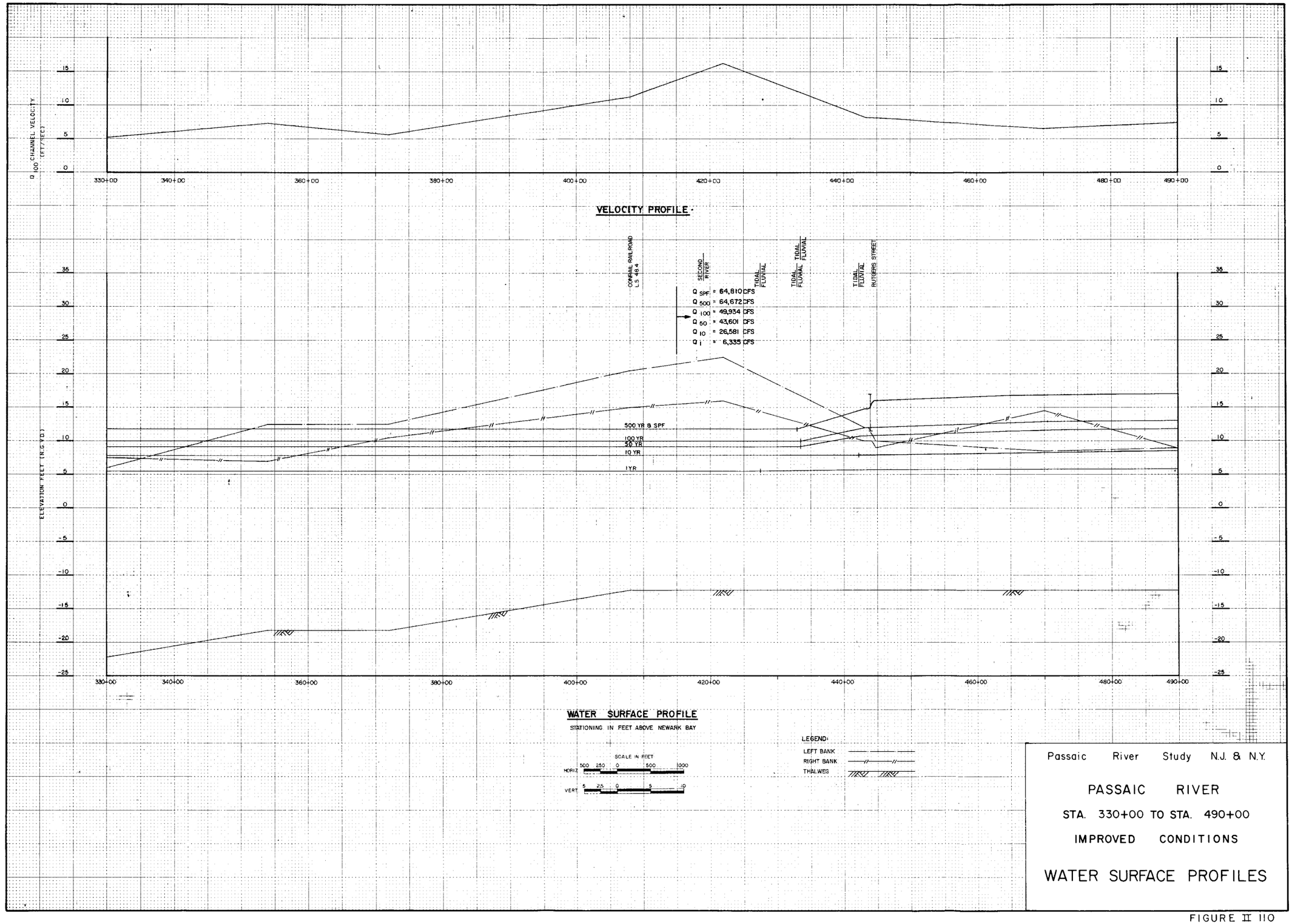


FIGURE NO. II 109



Passaic River Study N.J. & N.Y.

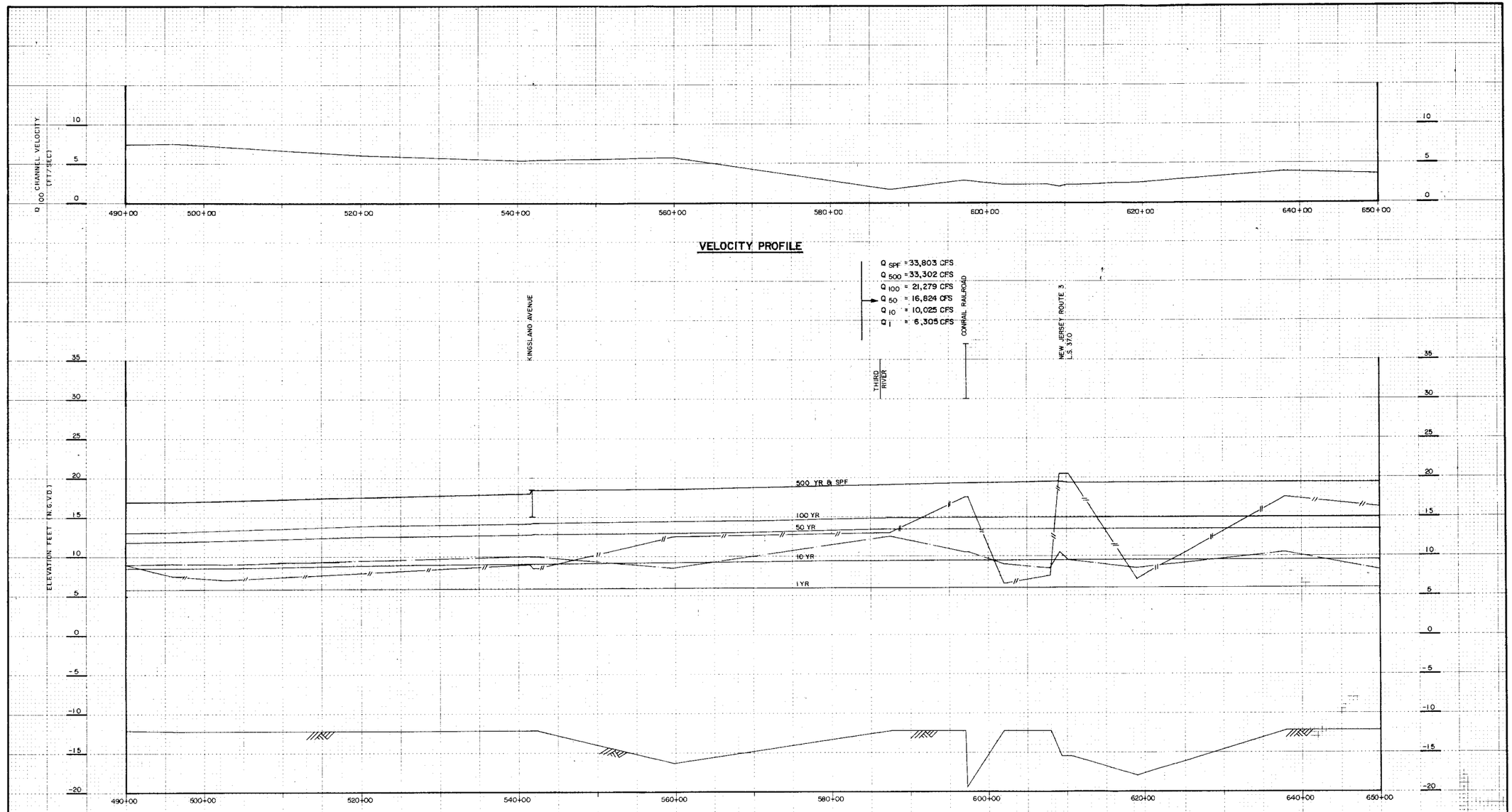
PASSAIC RIVER

STA. 330+00 TO STA. 490+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 110



VELOCITY PROFILE

Q_{SPF} = 33,803 CFS
Q_{500} = 33,302 CFS
Q_{100} = 21,279 CFS
Q_{50} = 16,824 CFS
Q_{10} = 10,025 CFS
Q_{1} = 6,305 CFS

WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET

HORIZ 500 250 0 500 1000

VERT 5 2.5 0 5 10

LEGEND:
LEFT BANK
RIGHT BANK
THALWEG

Passaic River Study N.J. & N.Y.

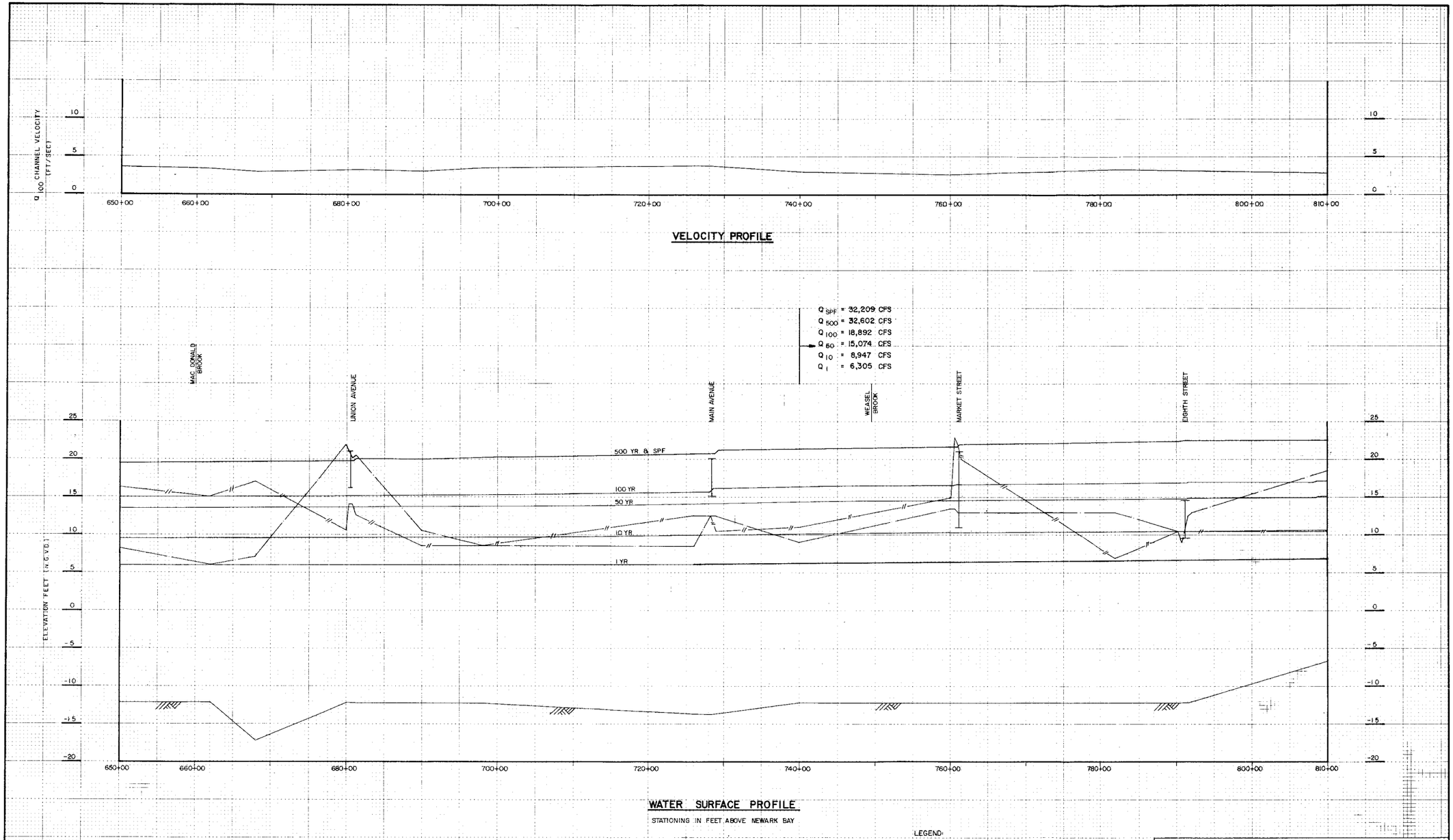
PASSAIC RIVER

STA. 490+00 TO STA. 650+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II III



VELOCITY PROFILE

Q_{SPF} = 32,209 CFS
Q_{500} = 32,602 CFS
Q_{100} = 18,892 CFS
Q_{50} = 15,074 CFS
Q_{10} = 8,947 CFS
Q_{1} = 6,305 CFS

WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET

HORIZ 500 250 0 500 1000

VERT 5 2.5 0 5 10

LEGEND:
LEFT BANK
RIGHT BANK
THALWEG

Passaic River Study N.J. & N.Y.

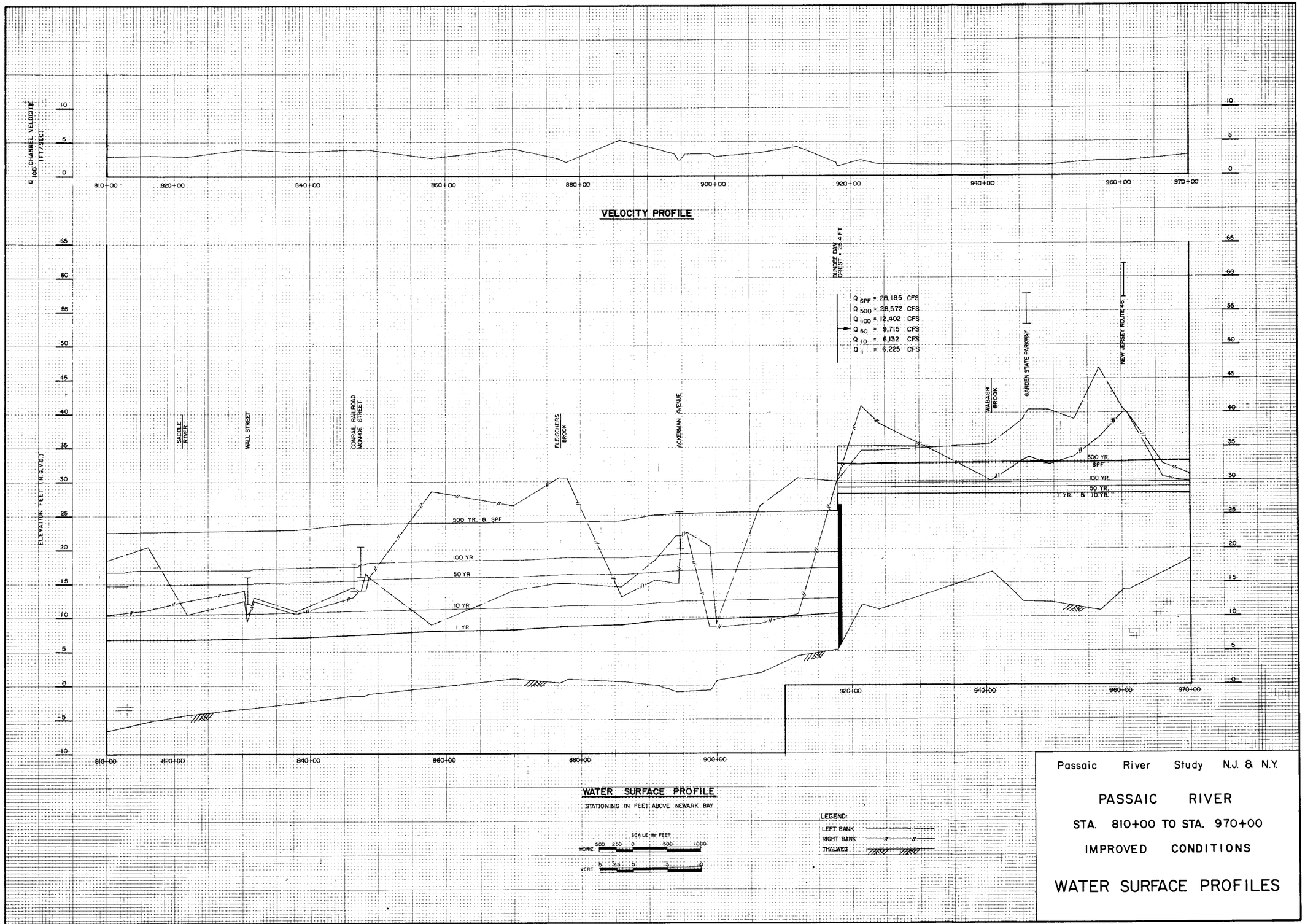
PASSAIC RIVER

STA. 650+00 TO STA. 810+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 112



Passaic River Study N.J. & N.Y.

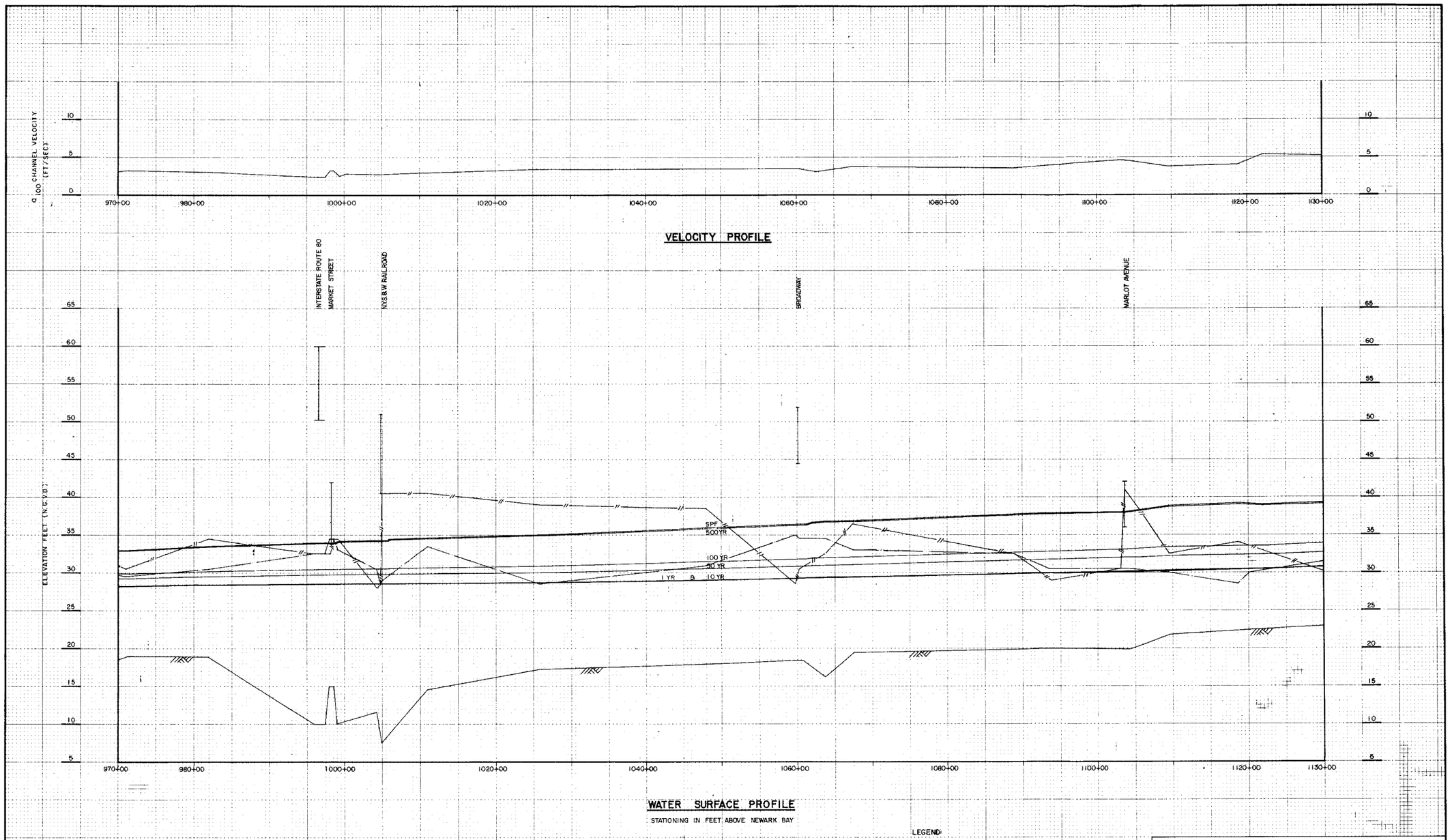
PASSAIC RIVER

STA. 810+00 TO STA. 970+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 113



VELOCITY PROFILE

WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET

HORIZ 500 250 0 500 1000

VERT 5 25 0 5 10

LEGEND:

LEFT BANK

RIGHT BANK

THALWEG

Passaic River Study N.J. & N.Y.

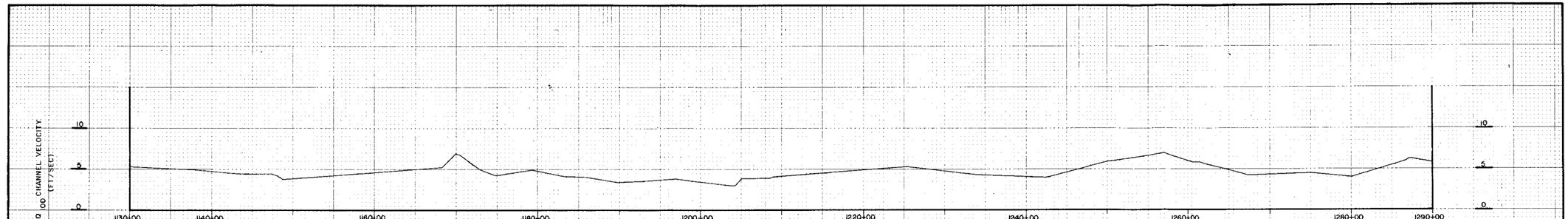
PASSAIC RIVER

STA. 970+00 TO STA. 1130+00

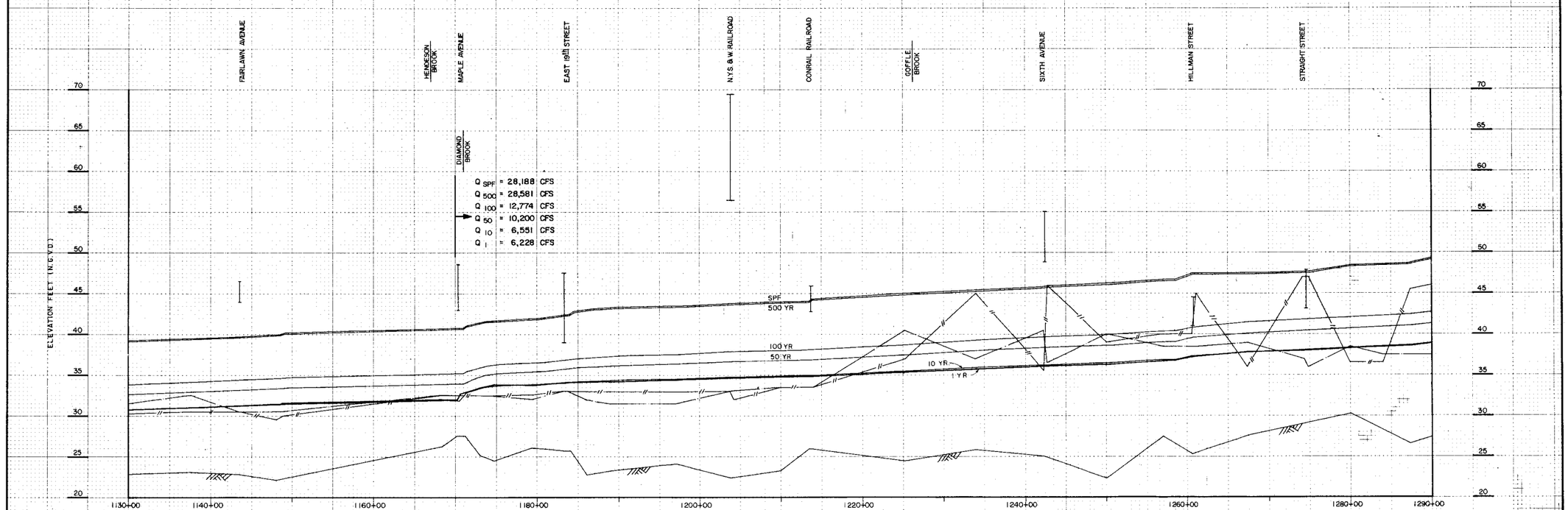
IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 114



VELOCITY PROFILE



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET

HORIZ 500 250 0 500 1000

VERT 5 25 0 5 10

LEGEND:

LEFT BANK

RIGHT BANK

THALWEG

Passaic River Study N.J. & N.Y.

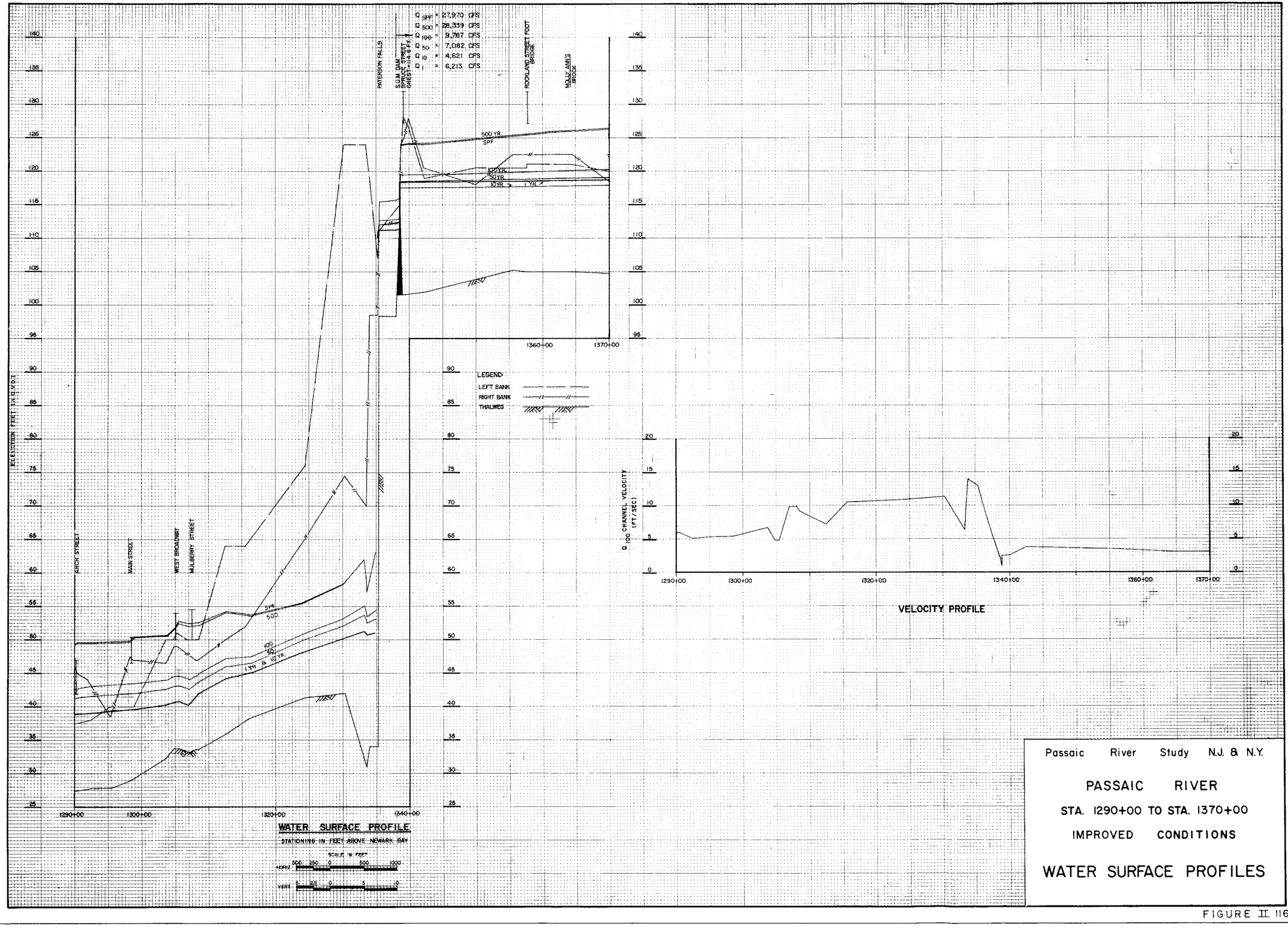
PASSAIC RIVER

STA. 1130+00 TO STA. 1290+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 115



Passaic River Study N.J. & N.Y.

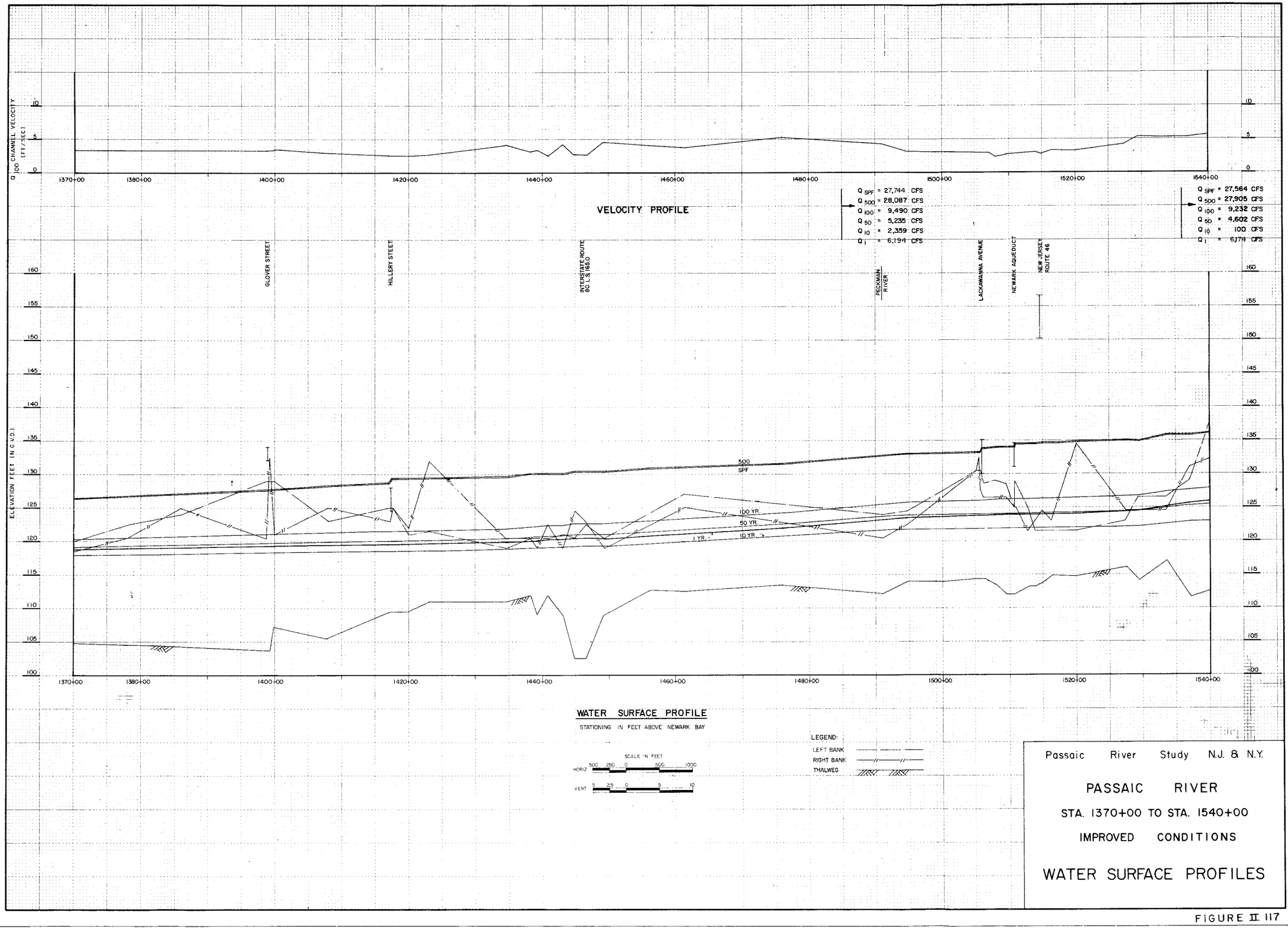
PASSAIC RIVER

STA. 1290+00 TO STA. 1370+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 116



Passaic River Study N.J. & N.Y.

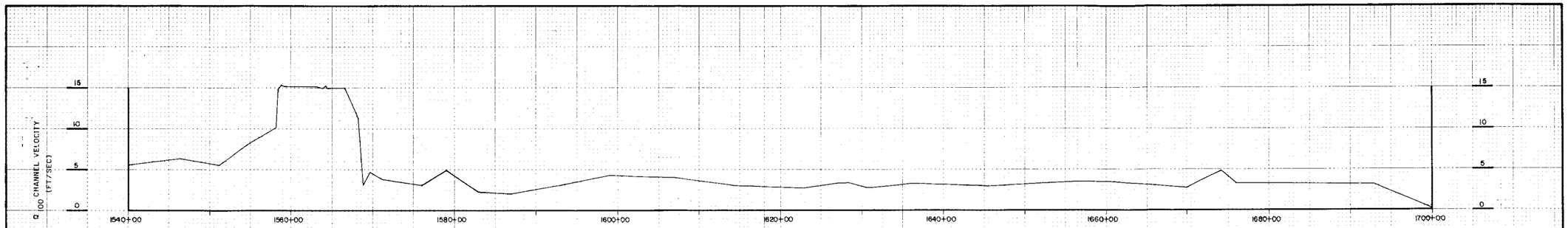
PASSAIC RIVER

STA. 1370+00 TO STA. 1540+00

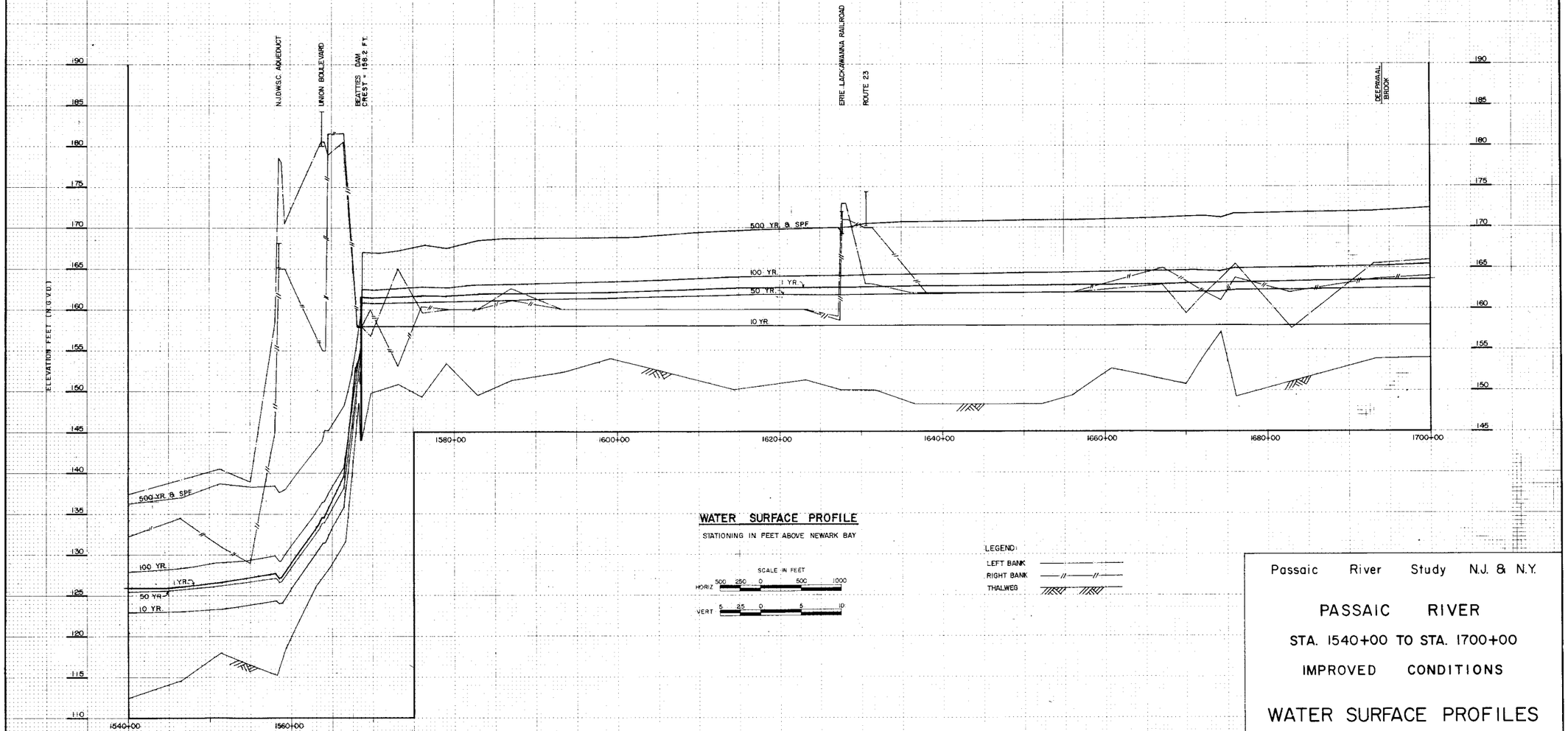
IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 117



VELOCITY PROFILE



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET

HORIZ 500 250 0 500 1000

VERT 5 2.5 0 5 10

LEGEND:

LEFT BANK

RIGHT BANK

THALWEG

Passaic River Study N.J. & N.Y.

PASSAIC RIVER

STA. 1540+00 TO STA. 1700+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 118

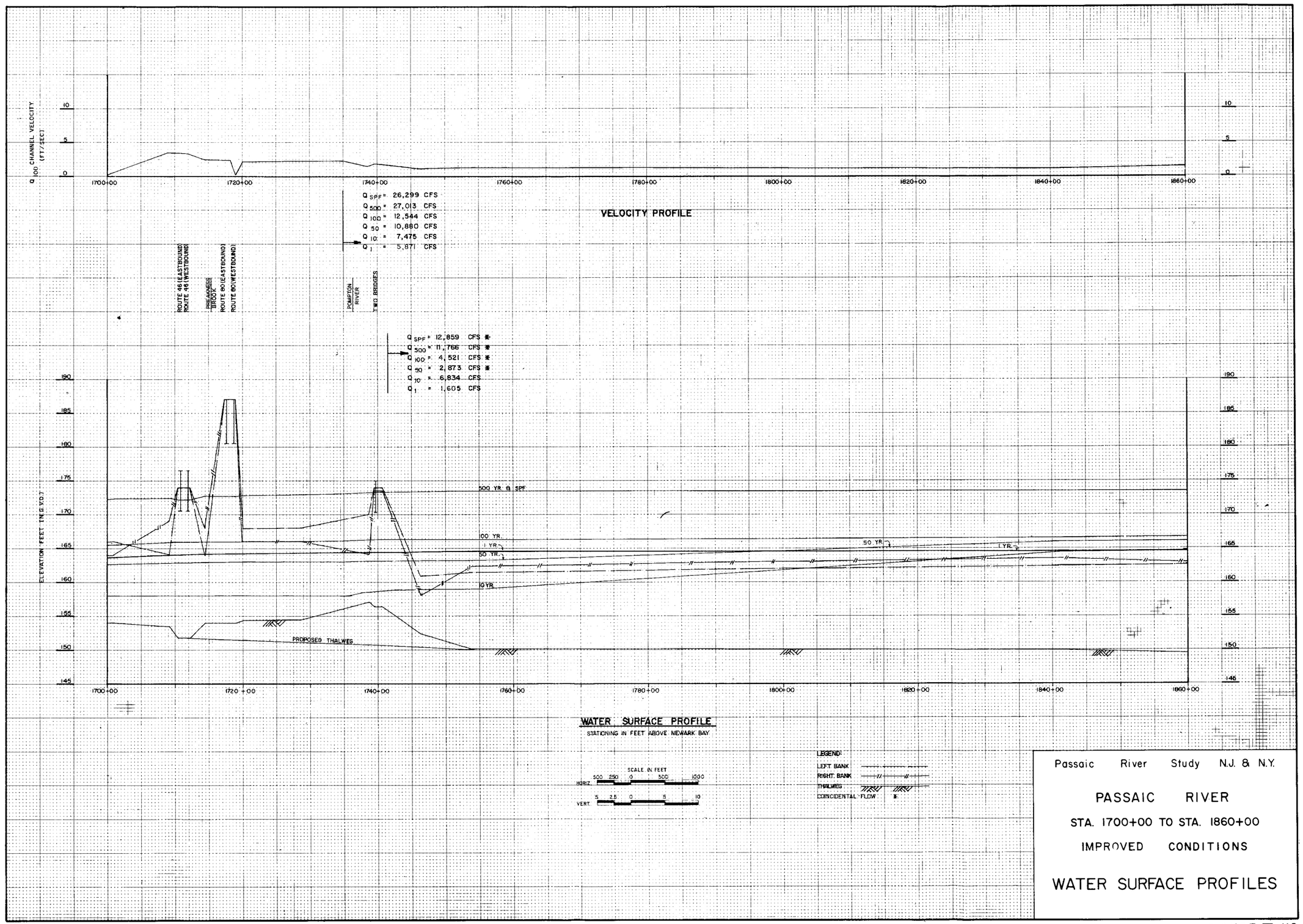
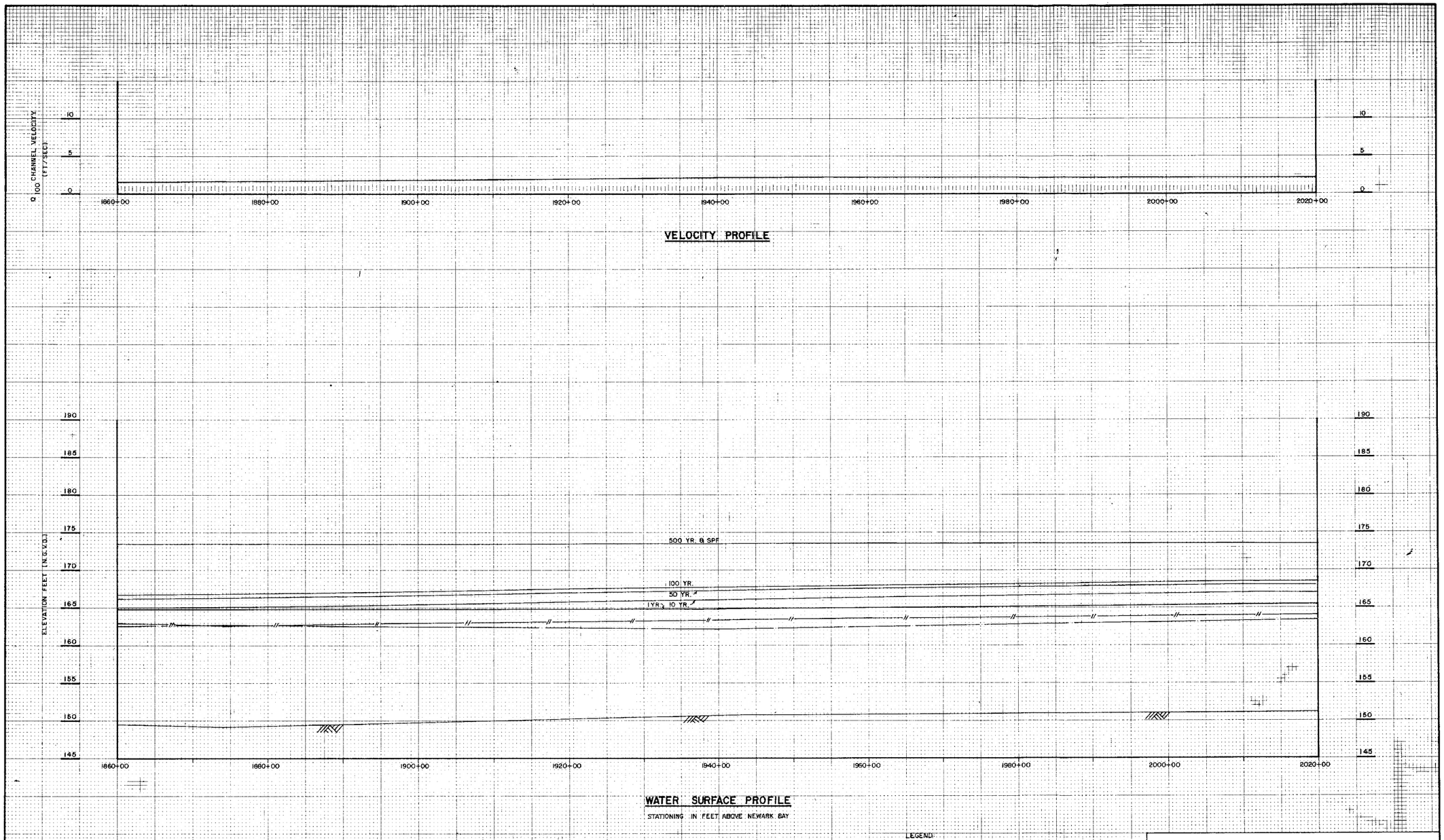


FIGURE II 119



Passaic River Study N.J. & N.Y.

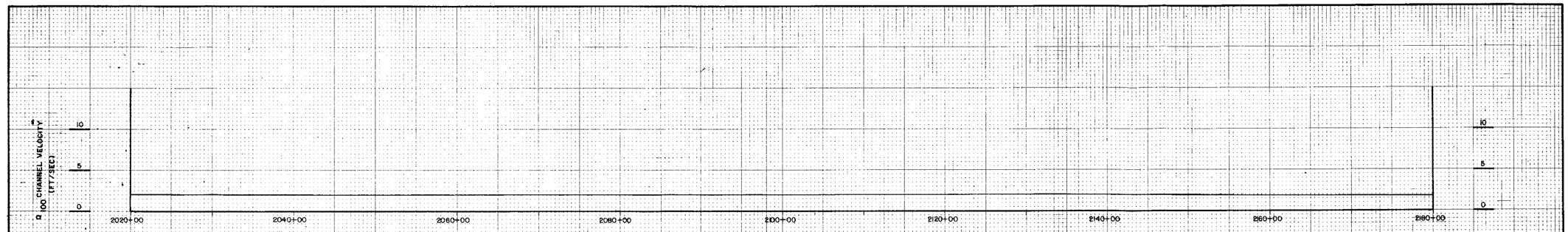
PASSAIC RIVER

STA. 1860+00 TO STA. 2020+00

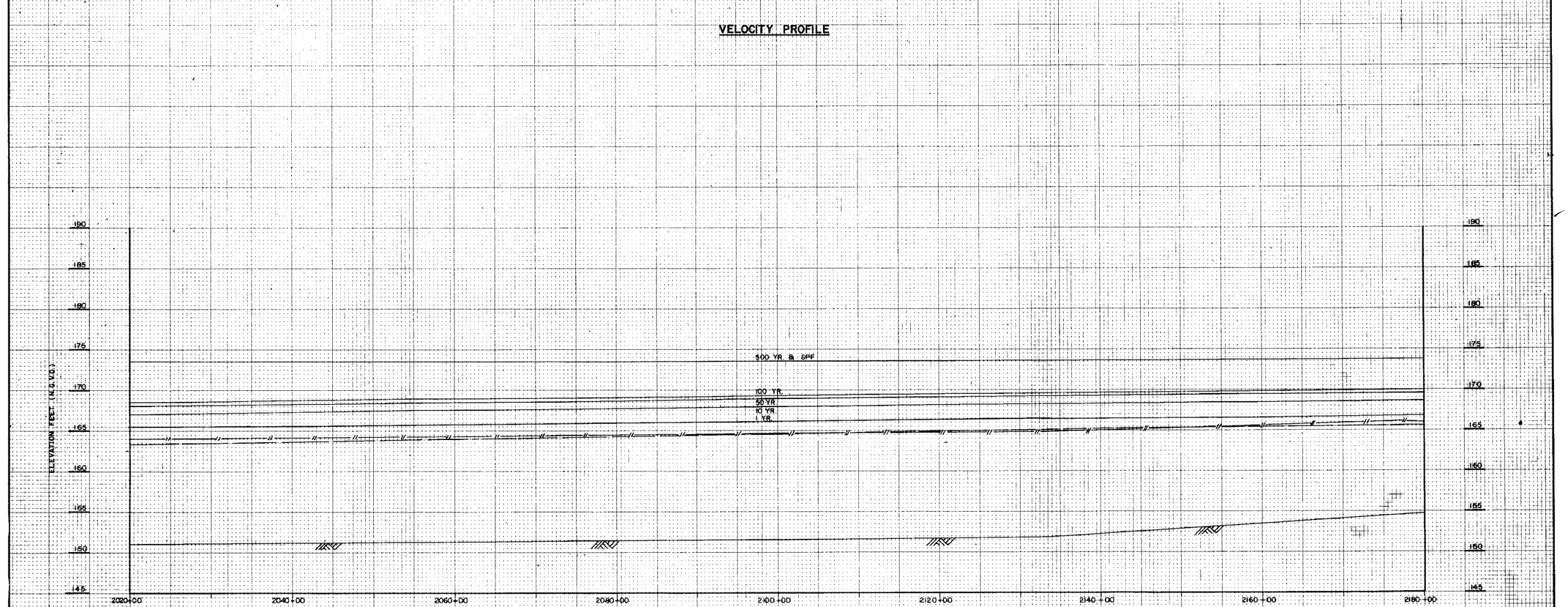
IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 120



VELOCITY PROFILE



WATER SURFACE PROFILE

STATIONING IN FEET, ABOVE NEWARK BAY

SCALE IN FEET

HORIZ. 500 250 0 500 1000

VERT. 5 2.5 0 5 10

LEGEND:

LEFT BANK

RIGHT BANK

THALWEG

Passaic River Study N.J. & N.Y.

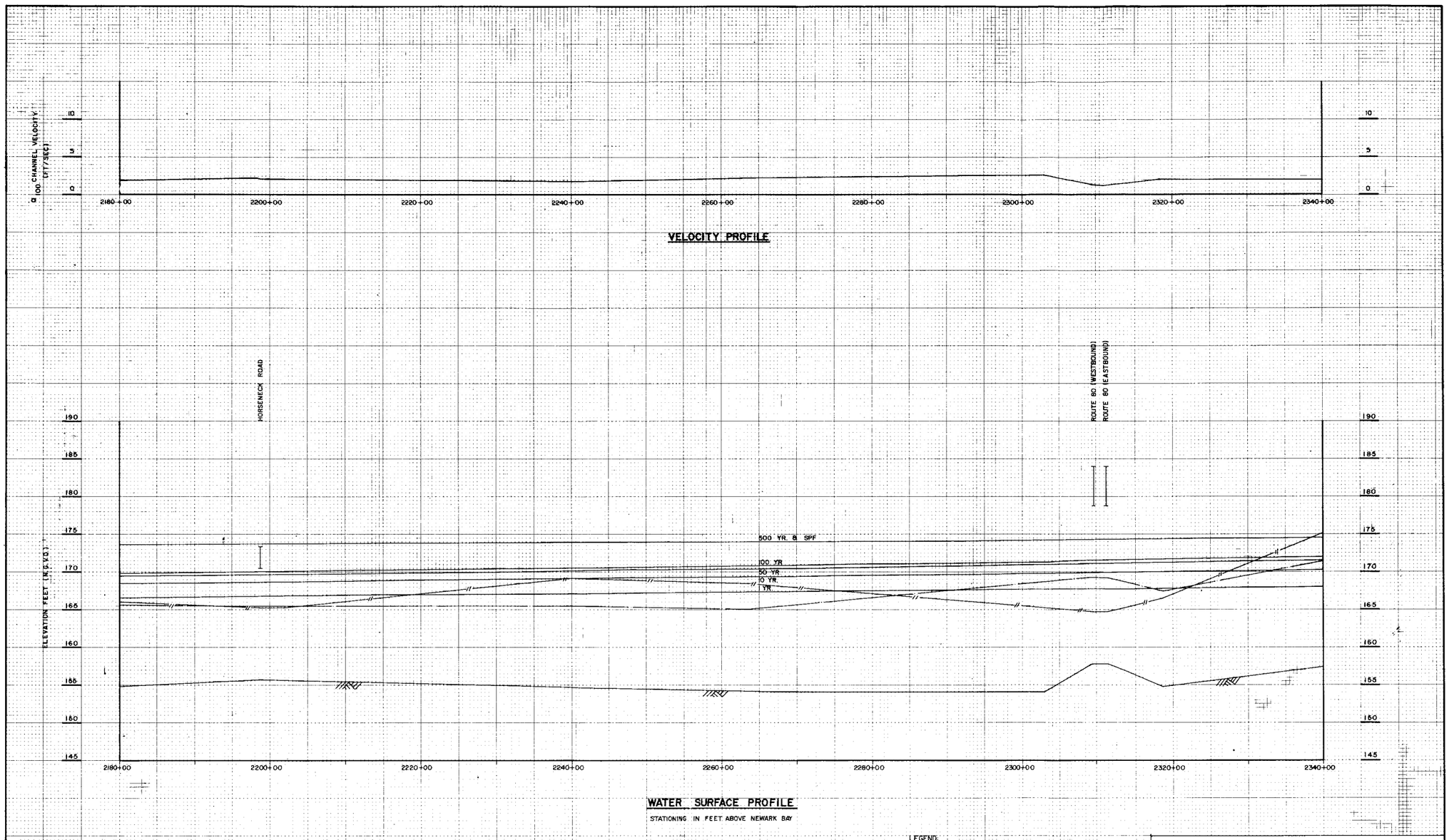
PASSAIC RIVER

STA. 2020+00 TO STA. 2180+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 121



Passaic River Study N.J. & N.Y.

PASSAIC RIVER

STA. 2180+00 TO STA. 2340+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II 122

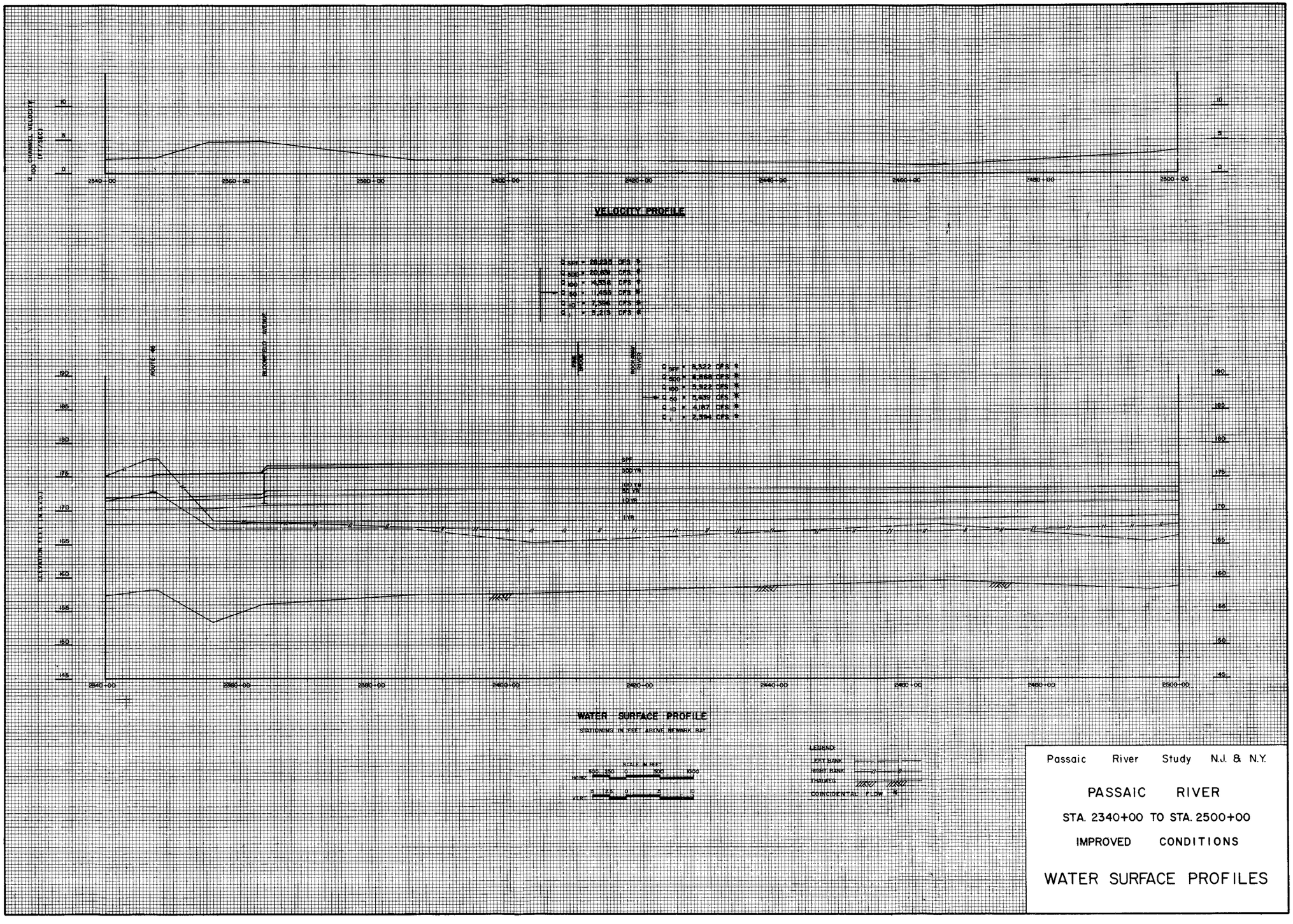
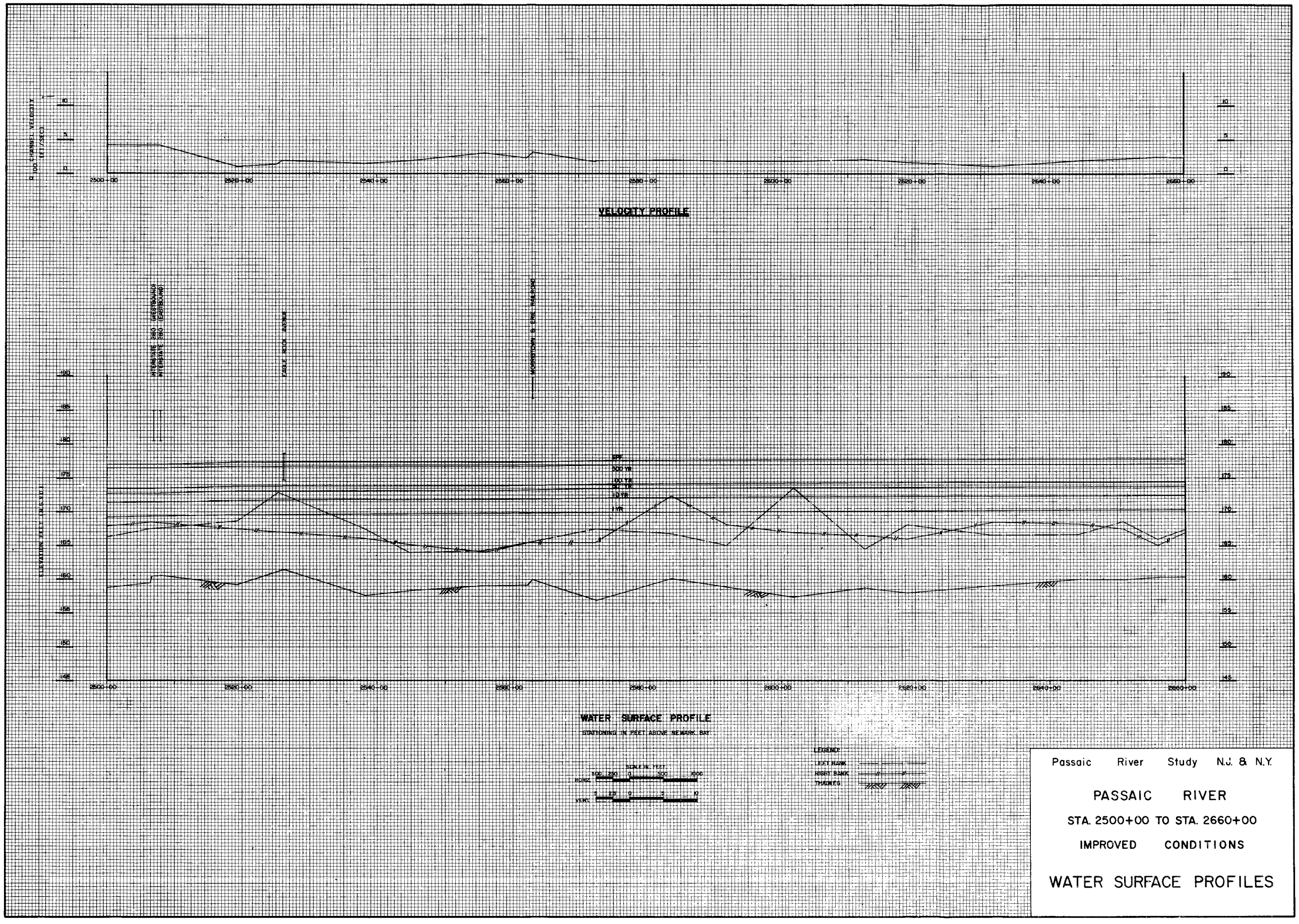


FIGURE NO. II 123



Passaic River Study N.J. & N.Y.

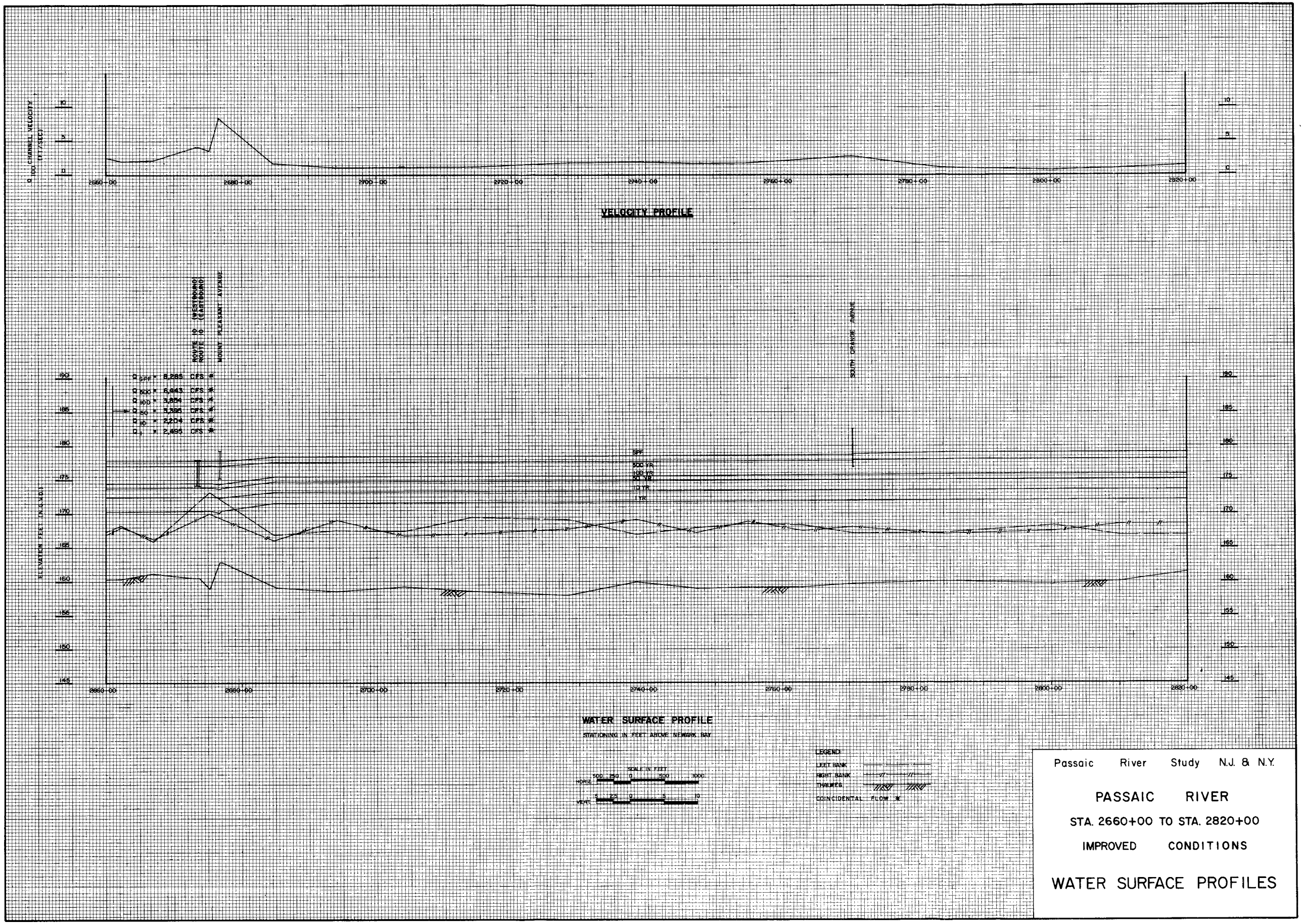
PASSAIC RIVER

STA. 2500+00 TO STA. 2660+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II 124



VELOCITY PROFILE

WATER SURFACE PROFILE

STATIONING IN FEET ABOVE NEWARK BAY

SCALE IN FEET

HORIZ. 500 250 0 500 1000

VERT. 5 2.5 0 5 10

LEGEND:

LEFT BANK

RIGHT BANK

THALWEG

COINCIDENTAL FLOW *

Passaic River Study N.J. & N.Y.

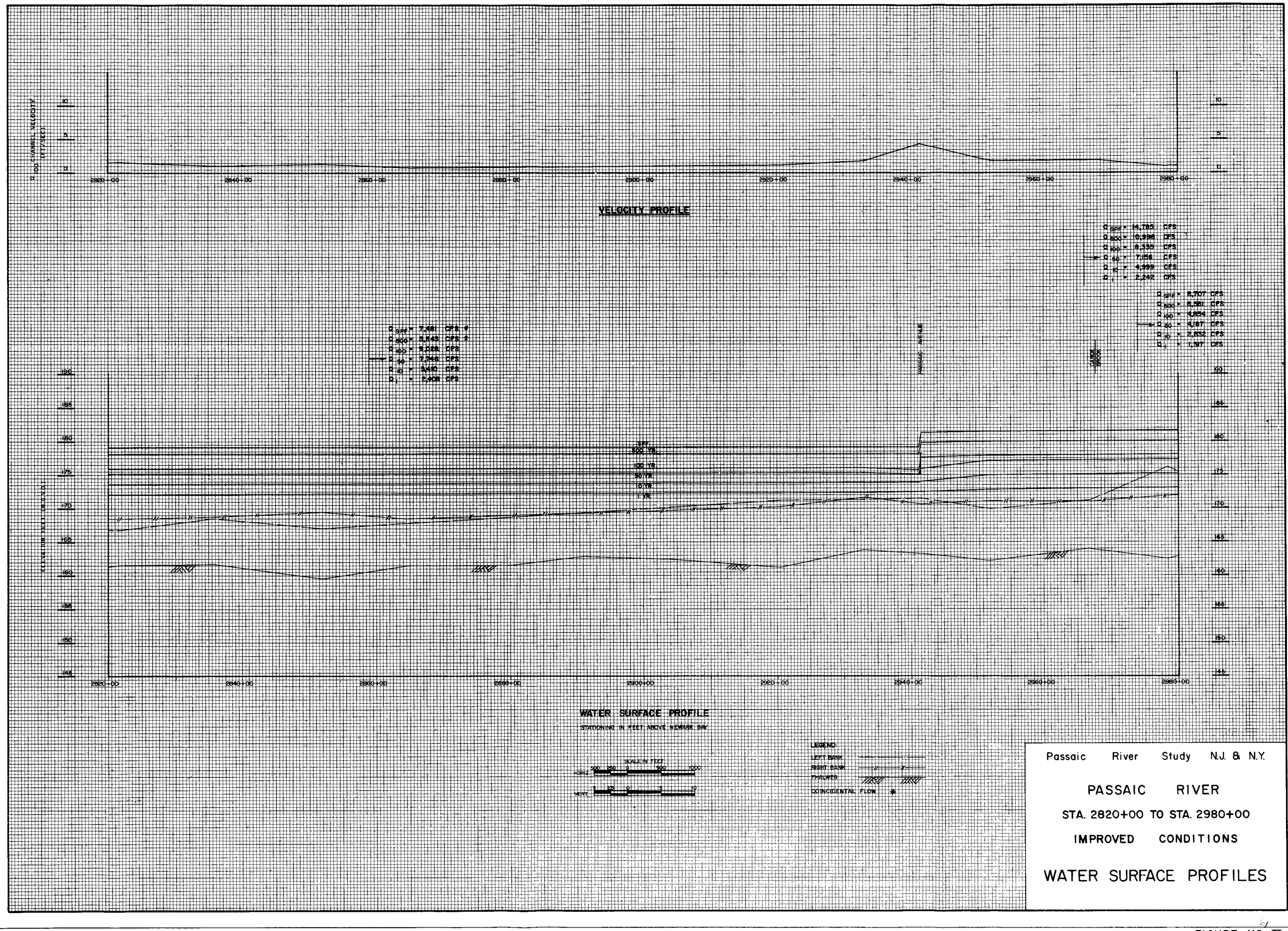
PASSAIC RIVER

STA. 2660+00 TO STA. 2820+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II 125



Passaic River Study N.J. & N.Y.

PASSAIC RIVER

STA. 2820+00 TO STA. 2980+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II 126

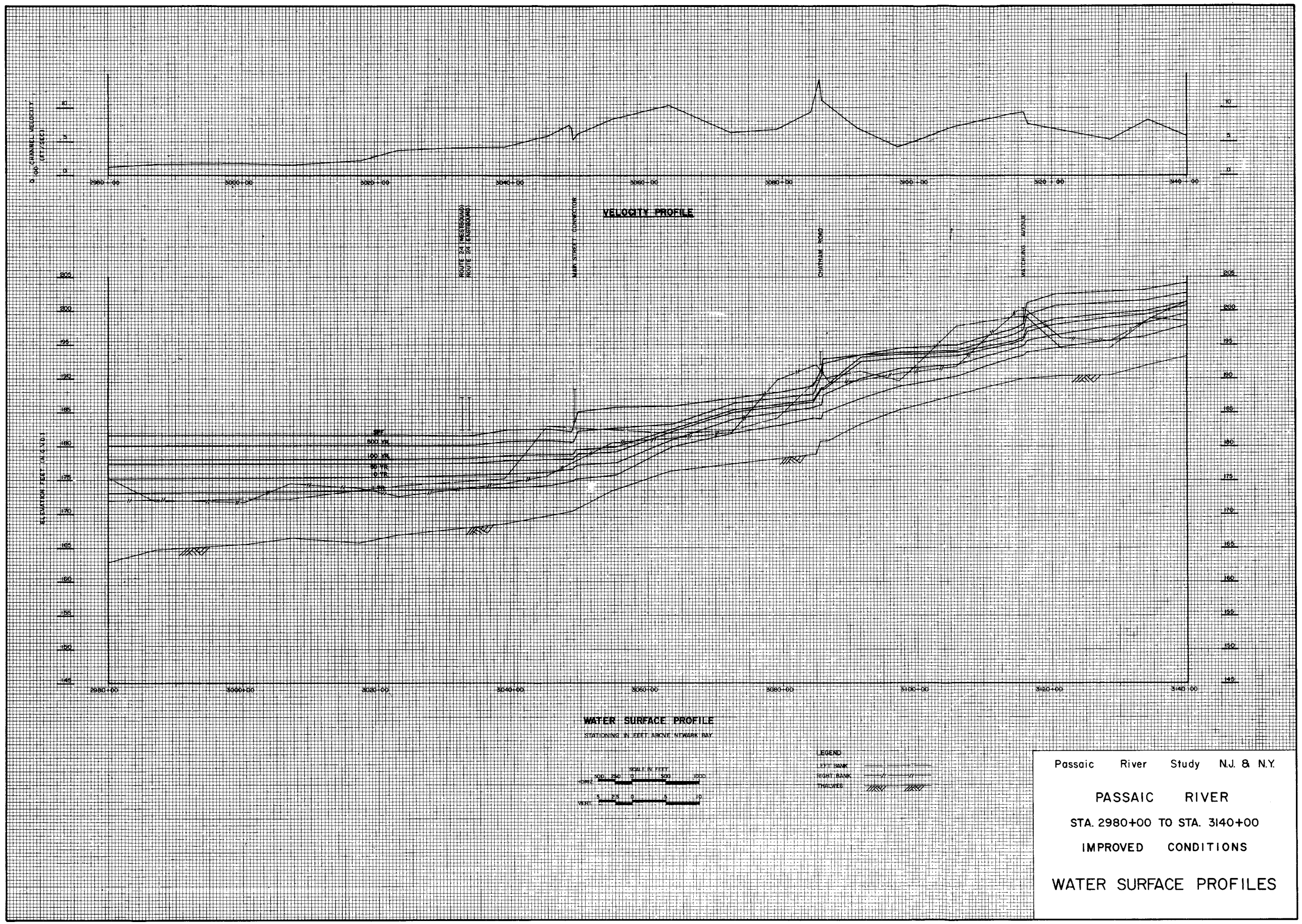
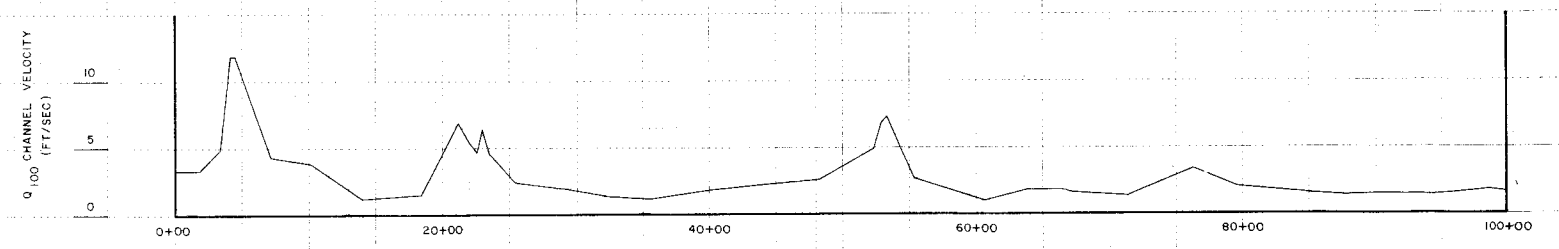
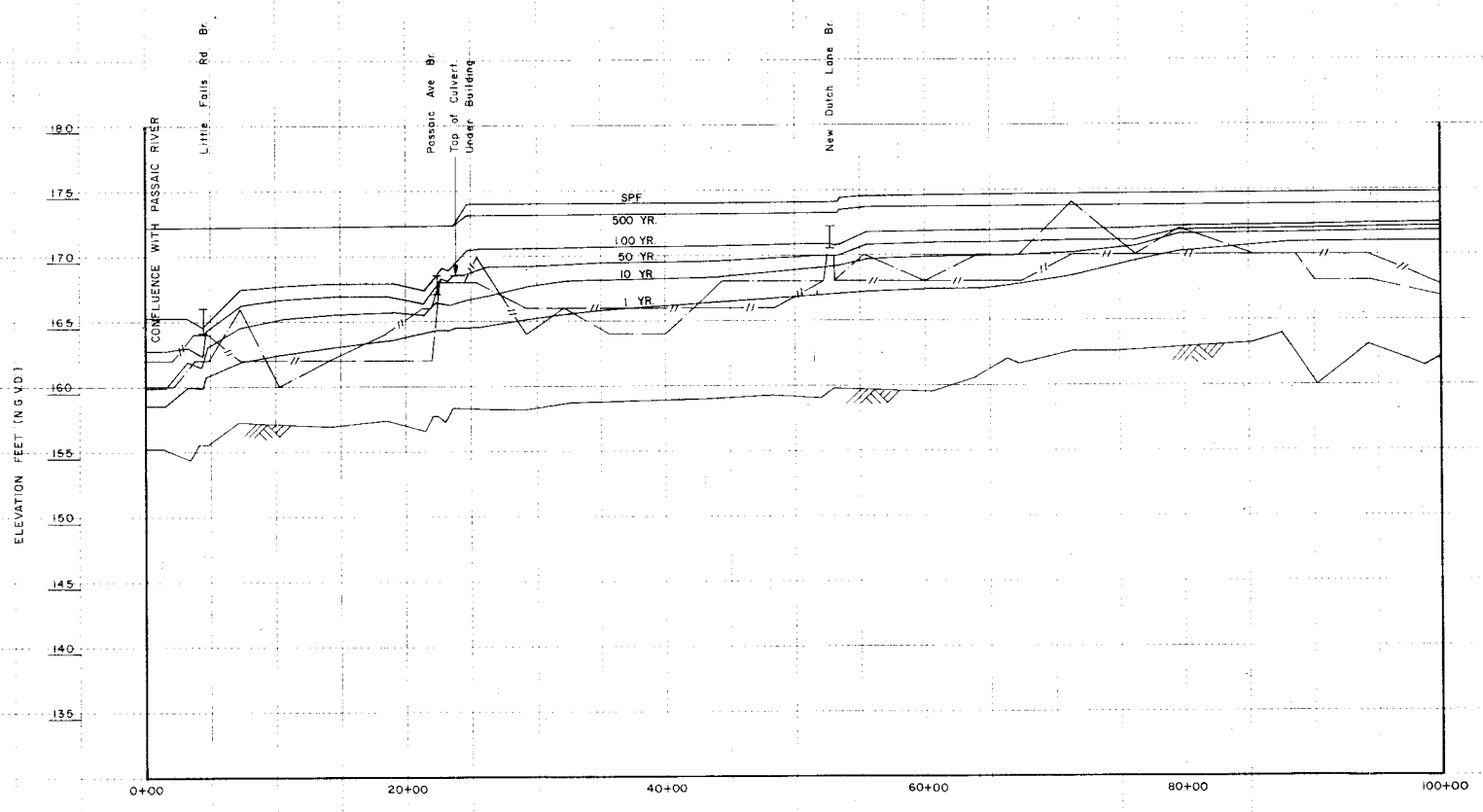


FIGURE NO II 127



Q_{SPF} = 4,616 CFS
Q_{500} = 3,204 CFS
Q_{100} = 2,553 CFS
Q_{50} = 2,191 CFS
Q_{10} = 1,587 CFS
Q_{1} = 716 CFS

VELOCITY PROFILE



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE PASSAIC RIVER

SCALE IN FEET

HORIZ 500 0 500 1000

VERT 5 0 5 10

LEGEND

LEFT BANK

RIGHT BANK

THALWEG

Passaic River Study N.J. & N.Y.

DEEPAVAAL BROOK

STA. 0+00 TO STA. 100+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE NO II 128

WATER SURFACE PROFILES

Passaic River Study N.J. & N.Y.

DEEPAVAAL BROOK

STA. 100+00 TO STA. 194+30

IMPROVED CONDITIONS

LEGEND

LEFT BANK

RIGHT BANK

THALWEG

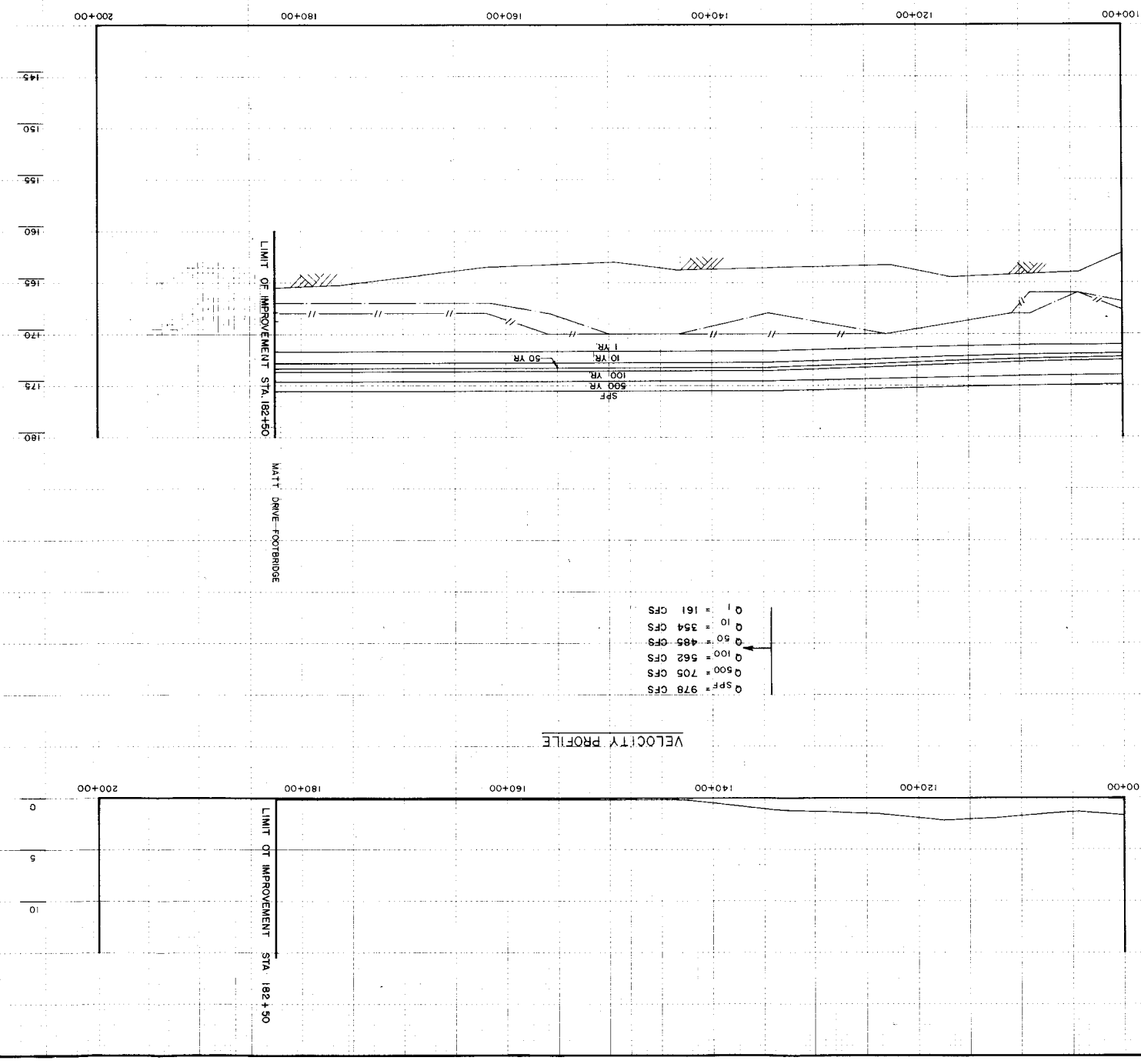
SCALE IN FEET

HOR'Z 400 0 400 1000

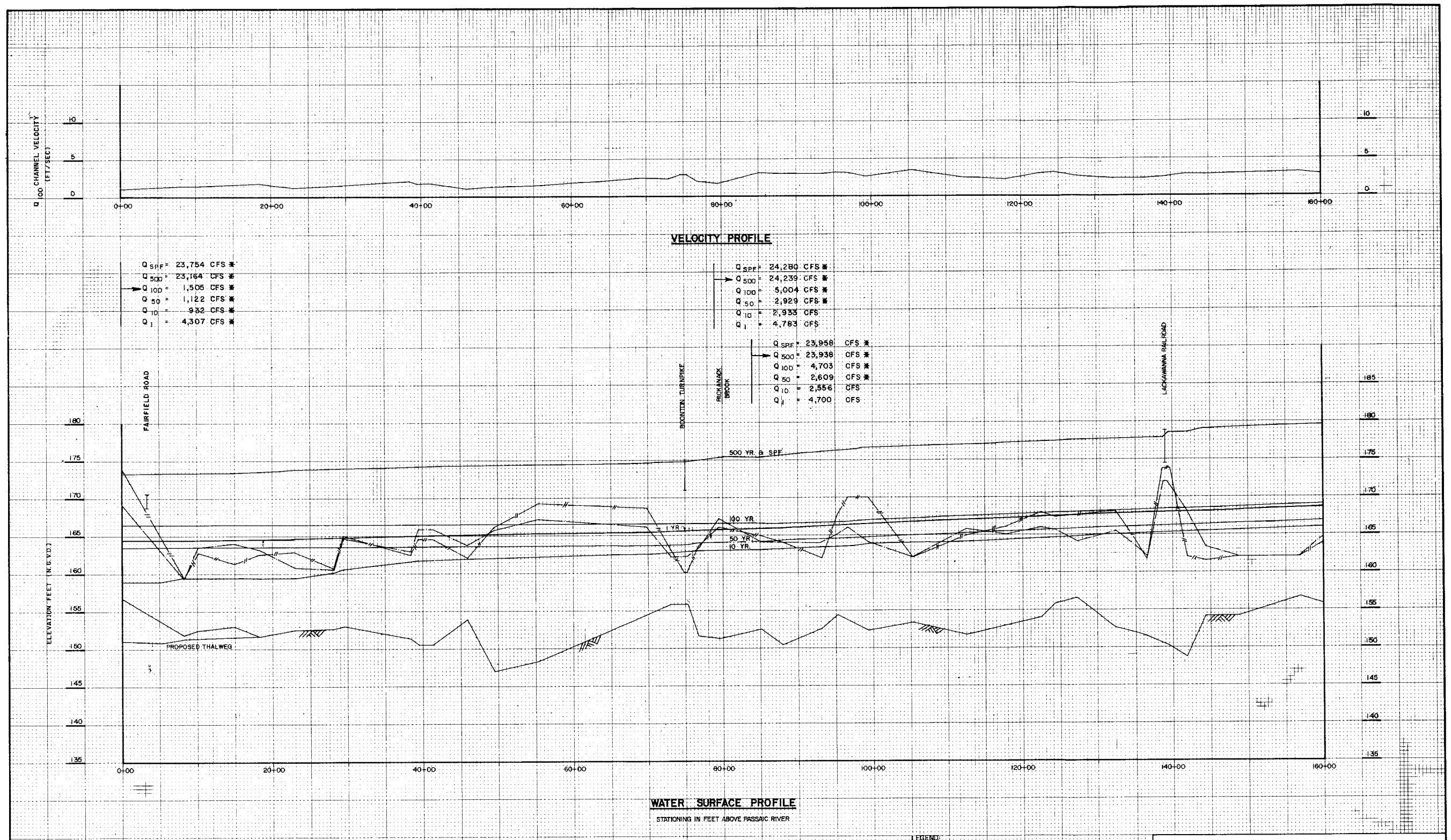
VERT 10 5 0 5 10

WATER SURFACE PROFILE

STATIONING IN FEET ABOVE PASSAIC RIVER



VELOCITY PROFILE



Passaic River Study N.J. & N.Y.

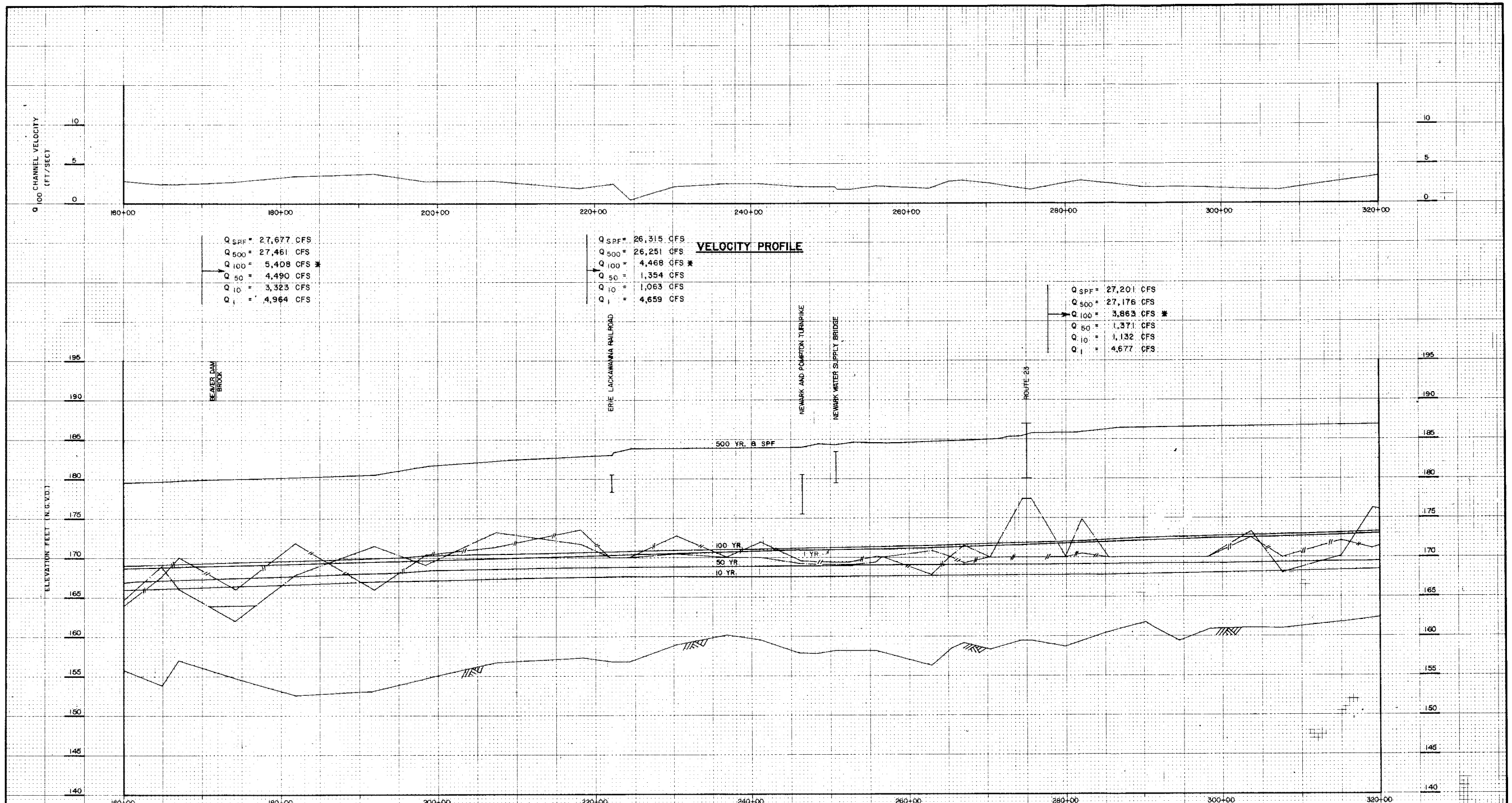
POMPTON RIVER

STA. 0+00 TO STA. 160+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 130



Passaic River Study N.J. & N.Y.

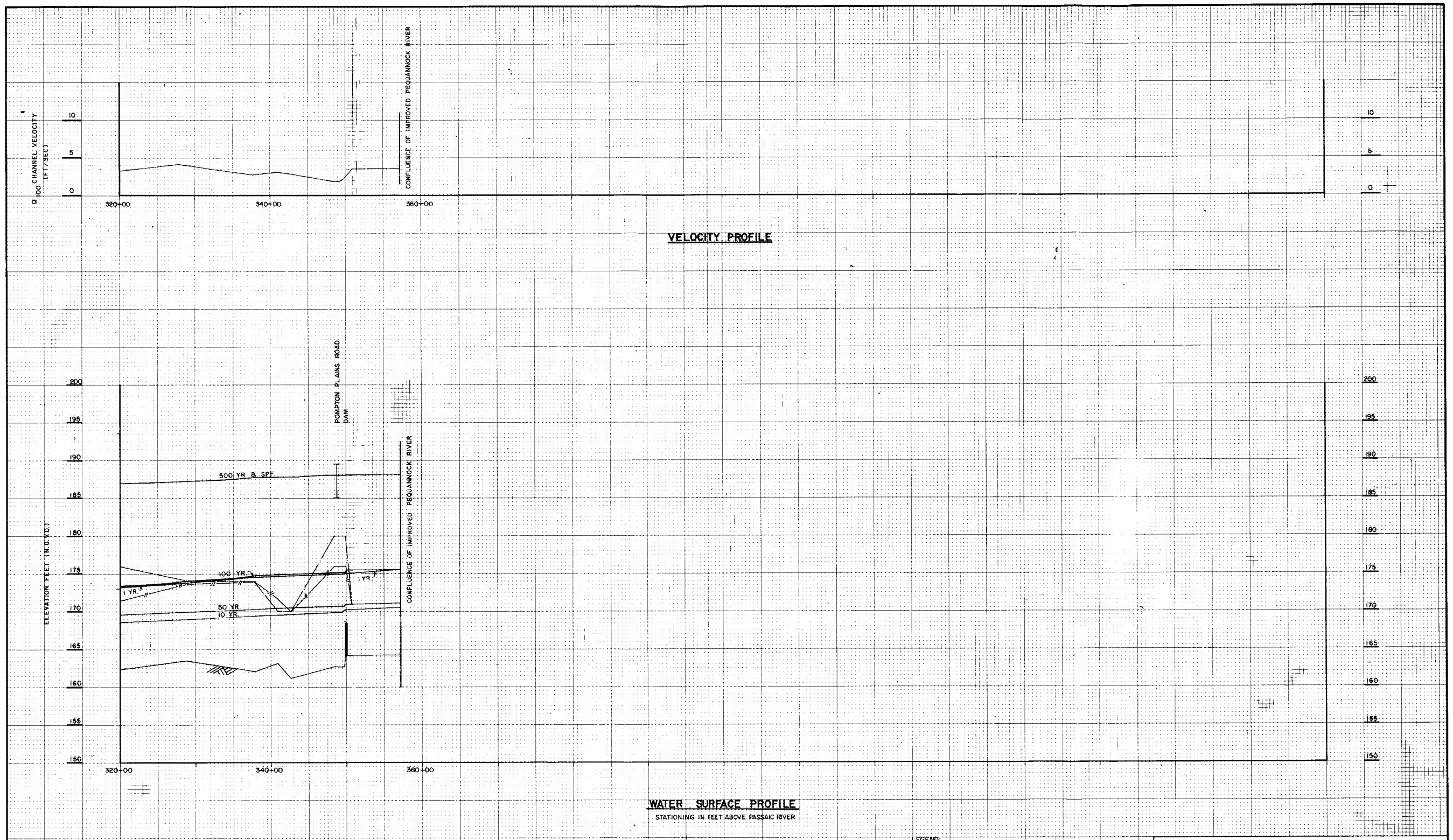
POMPTON RIVER

STA. 160+00 TO STA. 320+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 131



VELOCITY PROFILE

WATER SURFACE PROFILE

STATIONING IN FEET ABOVE PASSAIC RIVER

SCALE IN FEET

HORIZ. 500 250 0 500 1000

VERT. 5 2.5 0 5 10

LEGEND:

LEFT BANK

RIGHT BANK

THALWEG

Passaic River Study N.J. & N.Y.

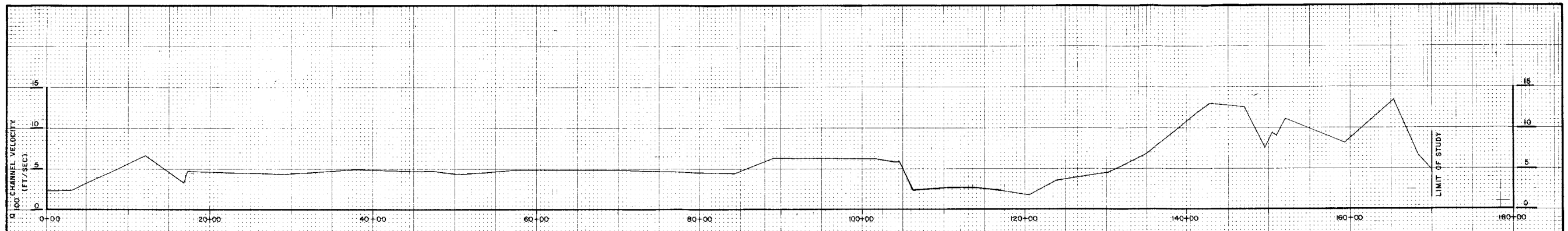
POMPTON RIVER

STA. 320+00 TO STA. 357+35

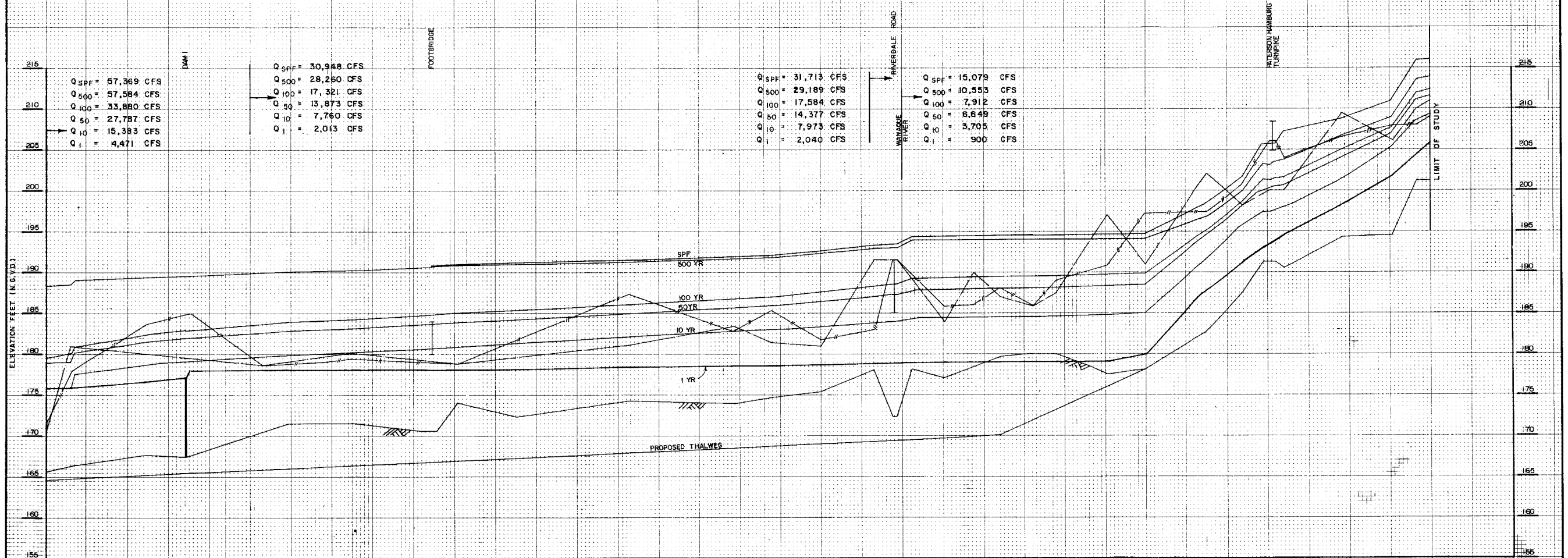
IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 132



VELOCITY PROFILE



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE POMPTON RIVER

SCALE IN FEET

HORIZ. 500 250 0 500 1000

VERT. 5 2.5 0 5 10

LEGEND:
LEFT BANK
RIGHT BANK
THALWEG

Passaic River Study N.J. & N.Y.

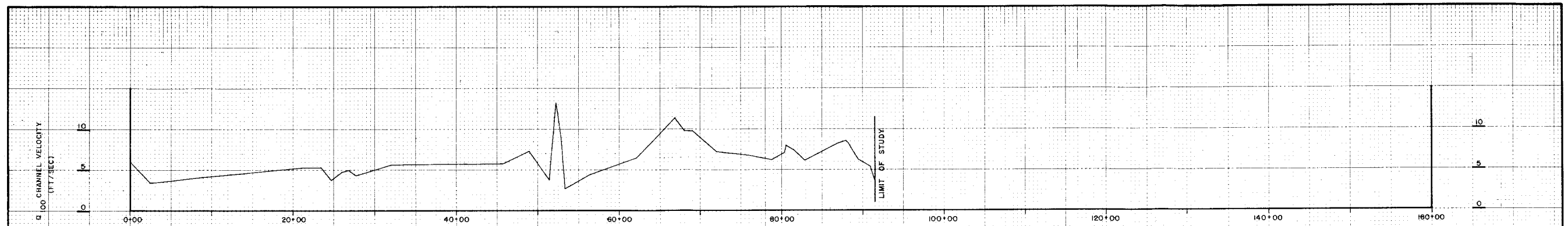
PEQUANNOCK RIVER

STA. 0+00 TO STA. 170+55

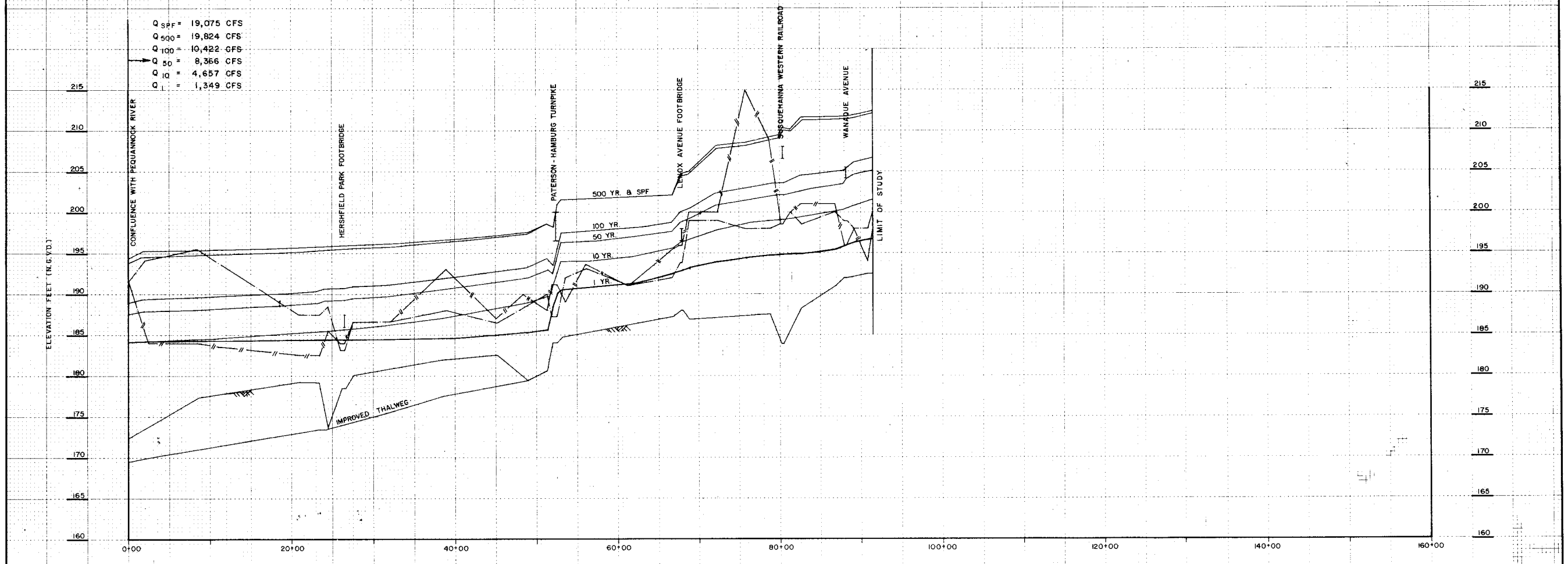
IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 133



VELOCITY PROFILE



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE PEQUANNOCK RIVER

SCALE IN FEET

HORIZ. 500 250 0 500 1000

VERT. 5 2.5 0 5 10

LEGEND:

LEFT BANK

RIGHT BANK

THALWEG

Passaic River Study N.J. & N.Y.

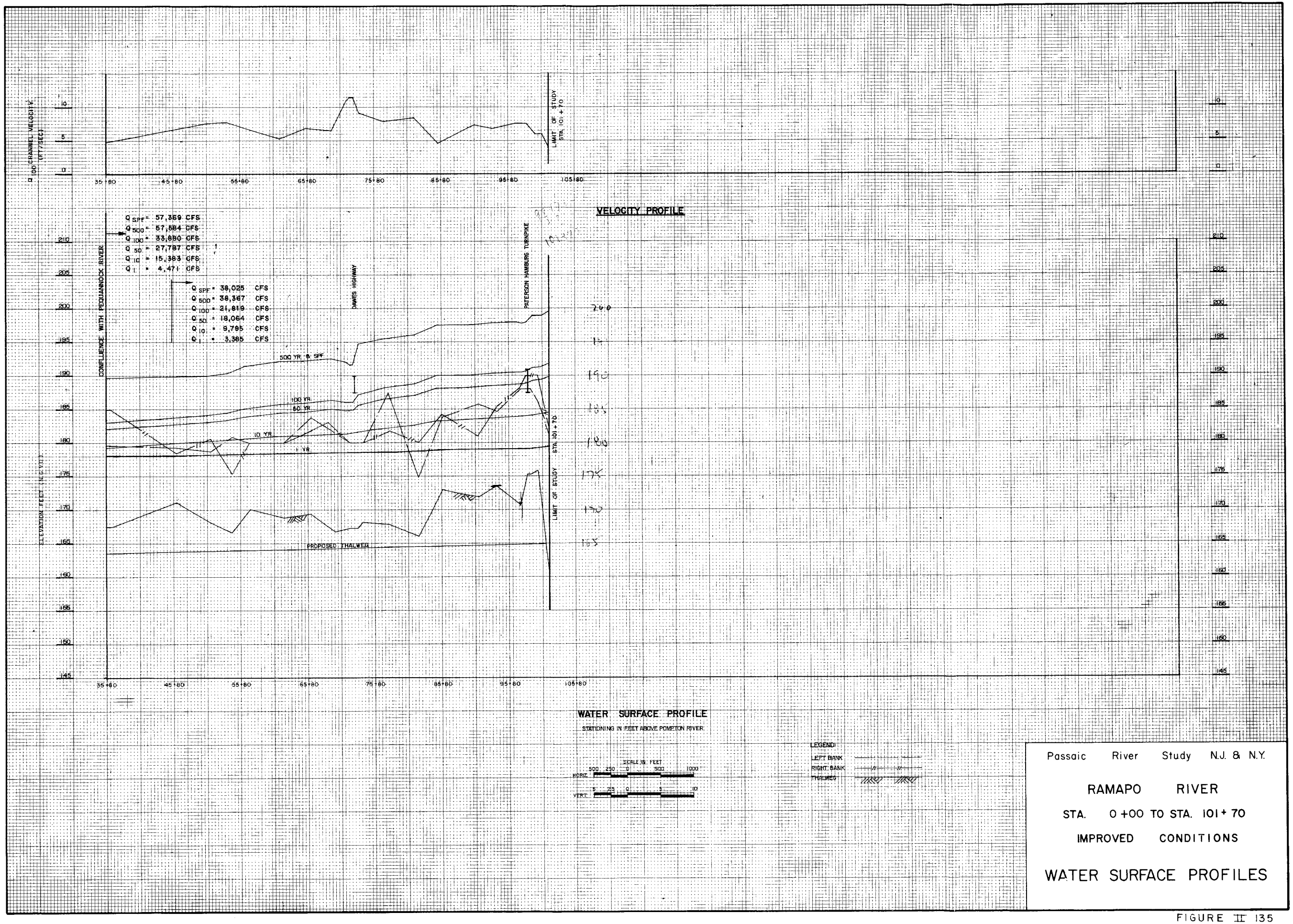
WANAQUE RIVER

STA. 0+00 TO STA. 91+50

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 134



Passaic River Study N.J. & N.Y.

RAMAPO RIVER

STA. 0+00 TO STA. 101+70

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE II 135

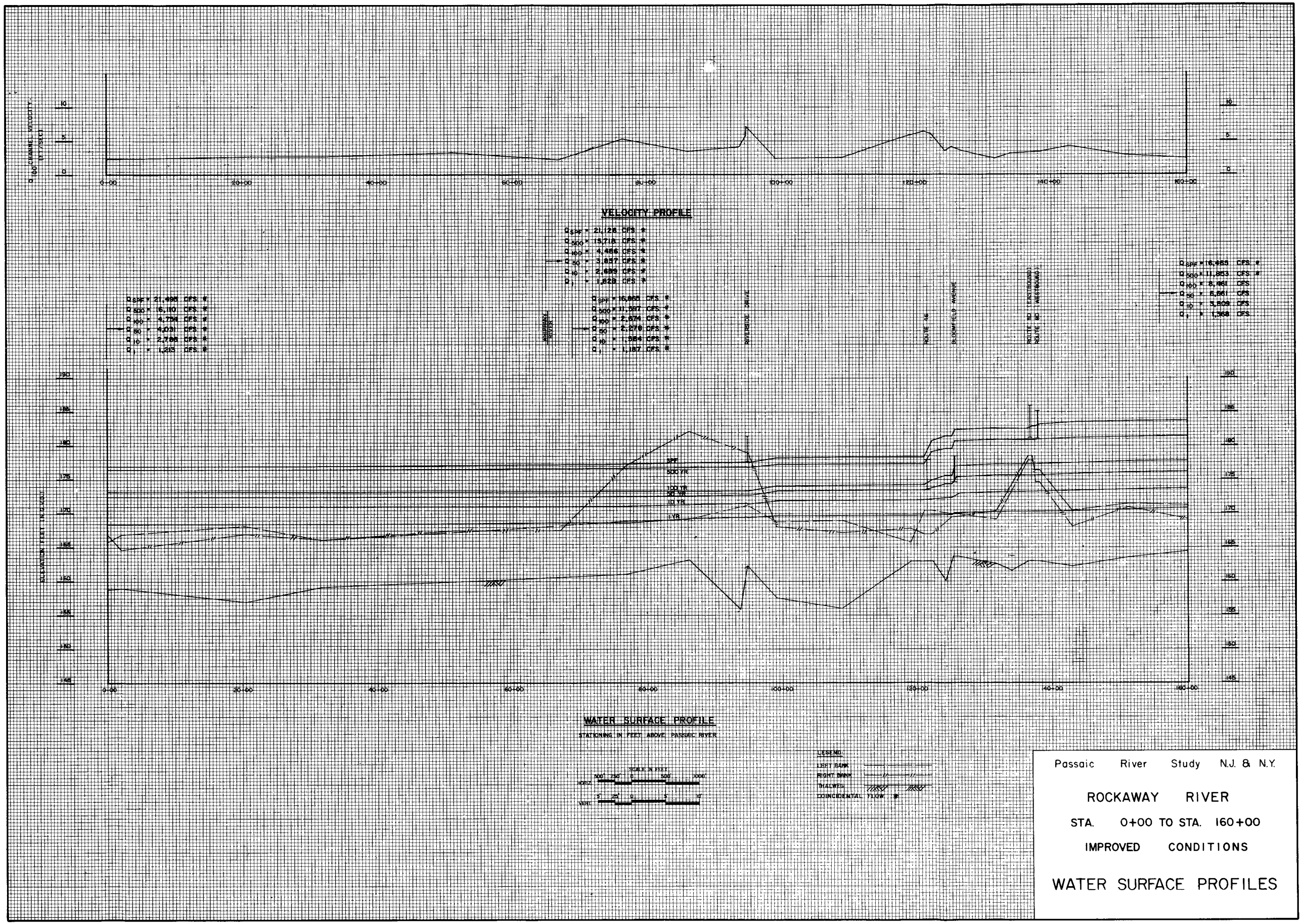
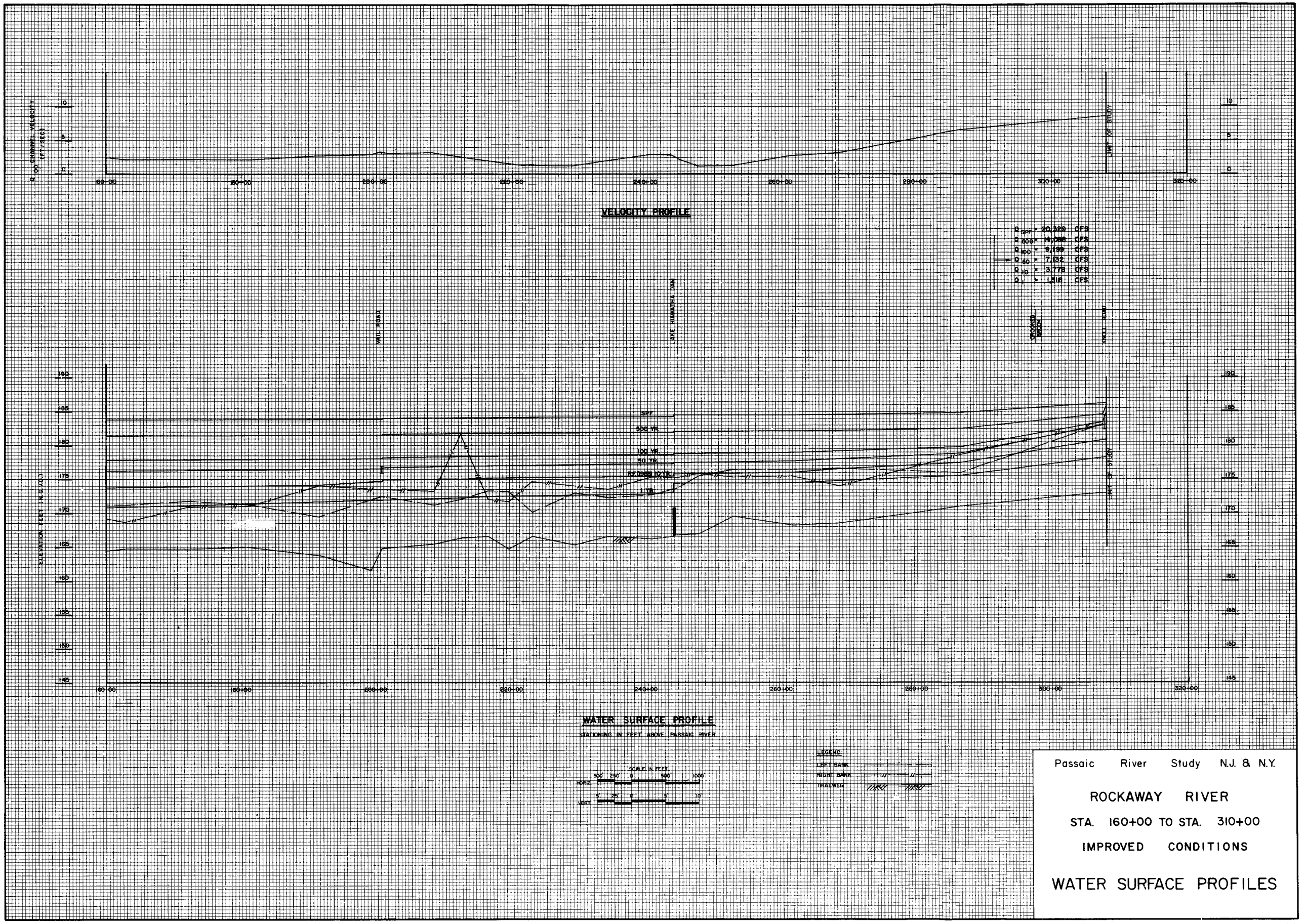


FIGURE NO. II 136



Passaic River Study N.J. & N.Y.

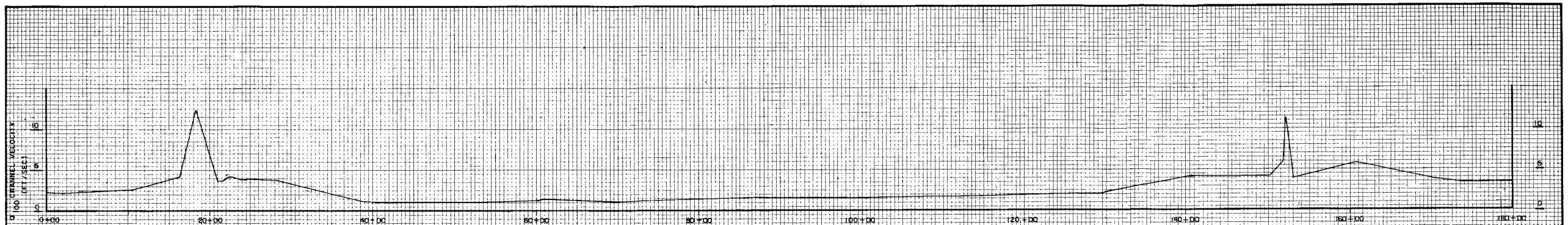
ROCKAWAY RIVER

STA. 160+00 TO STA. 310+00

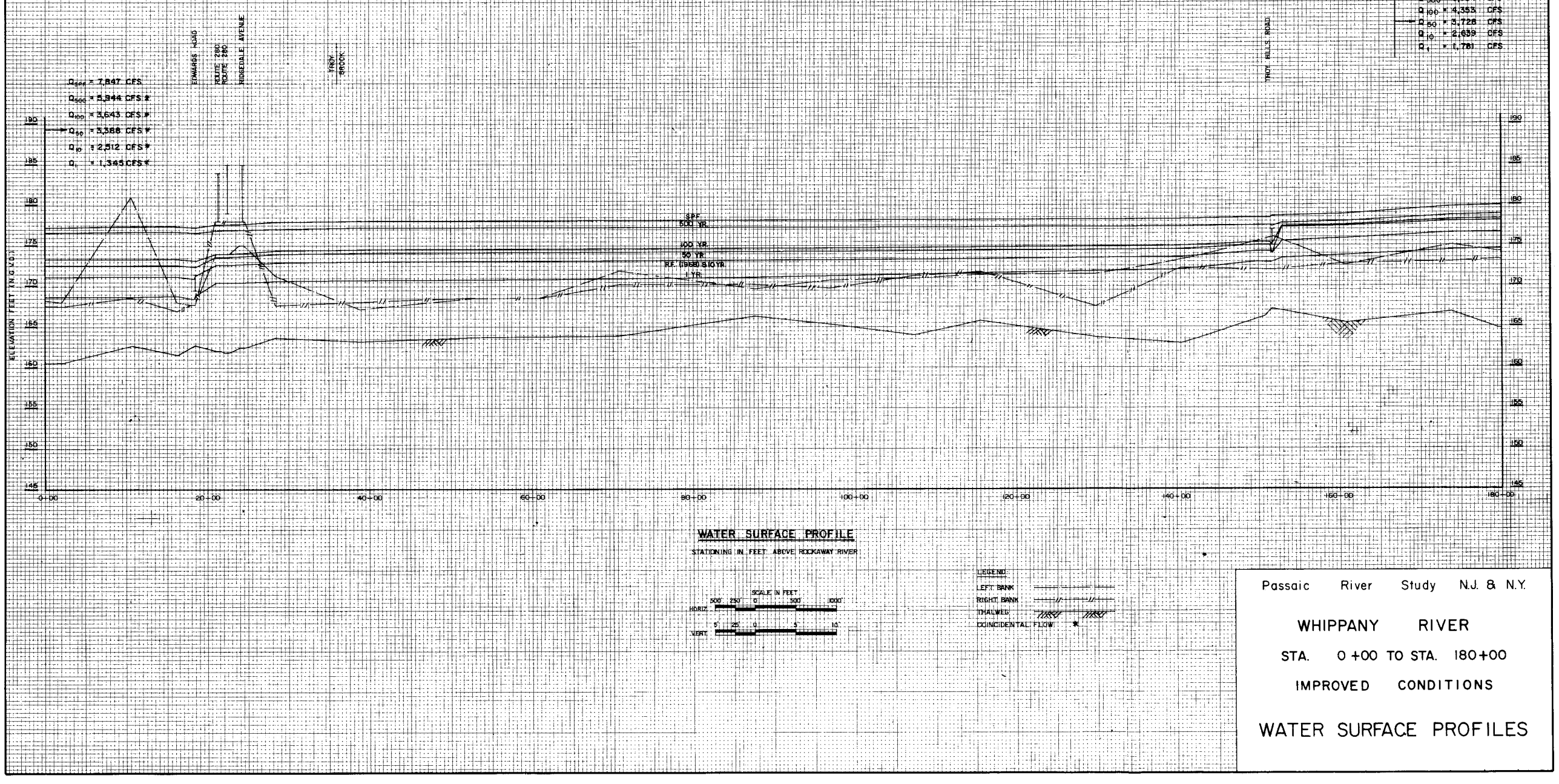
IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II 137



VELOCITY PROFILE



WATER SURFACE PROFILE

STATIONING IN FEET ABOVE ROCKAWAY RIVER

SCALE IN FEET

HORIZ. 500' 250' 0 500' 1000'

VERT. 5' 2½ 0 5' 10'

LEGEND

LEFT BANK

RIGHT BANK

THALWEG

COINCIDENTAL FLOW

Passaic River Study N.J. & N.Y.

WHIPPANY RIVER

STA. 0 +00 TO STA. 180+00

IMPROVED CONDITIONS

WATER SURFACE PROFILES

FIGURE NO. II 138

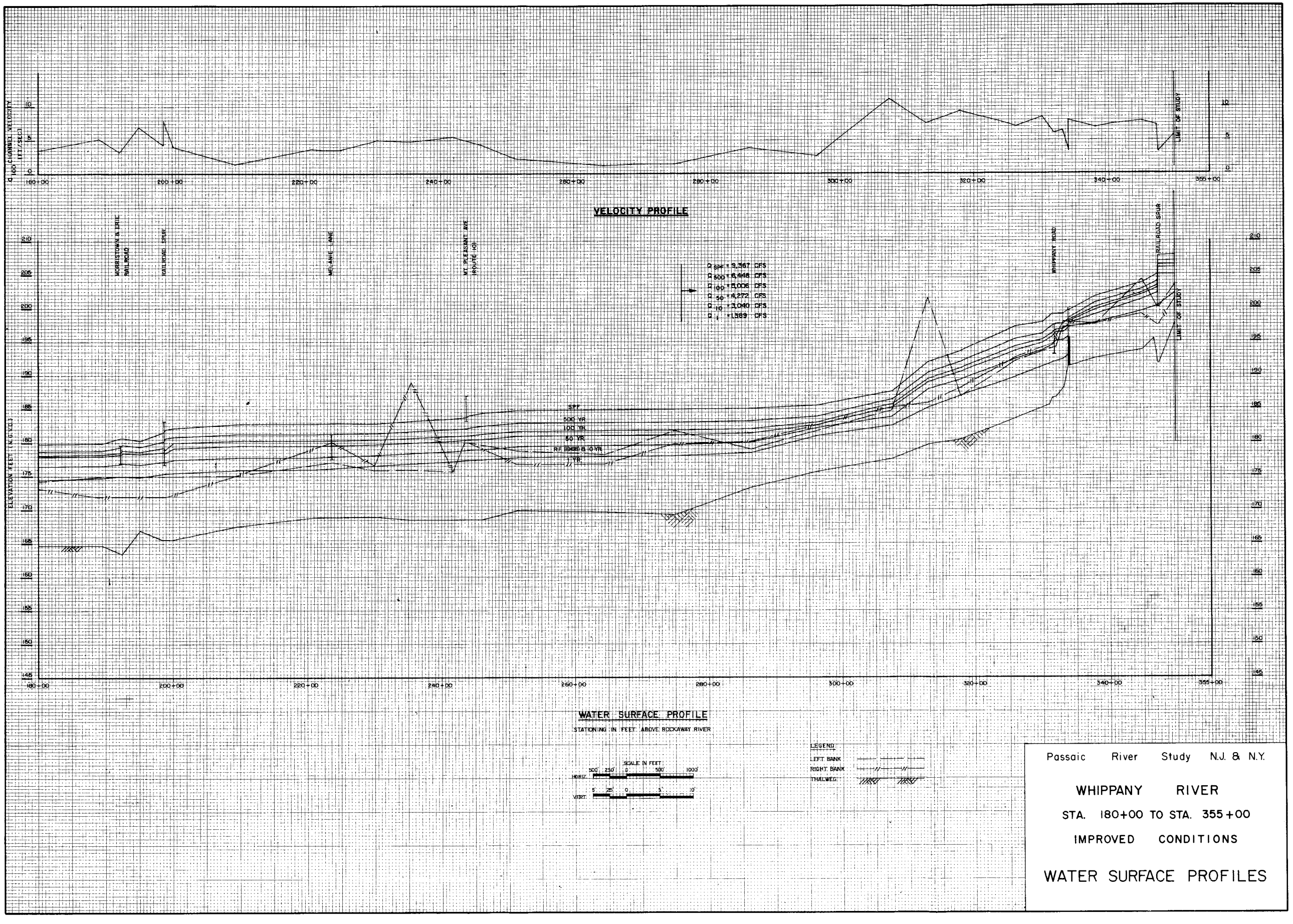


FIGURE NO. II 139