US Army Corps
of Engineers
New York District

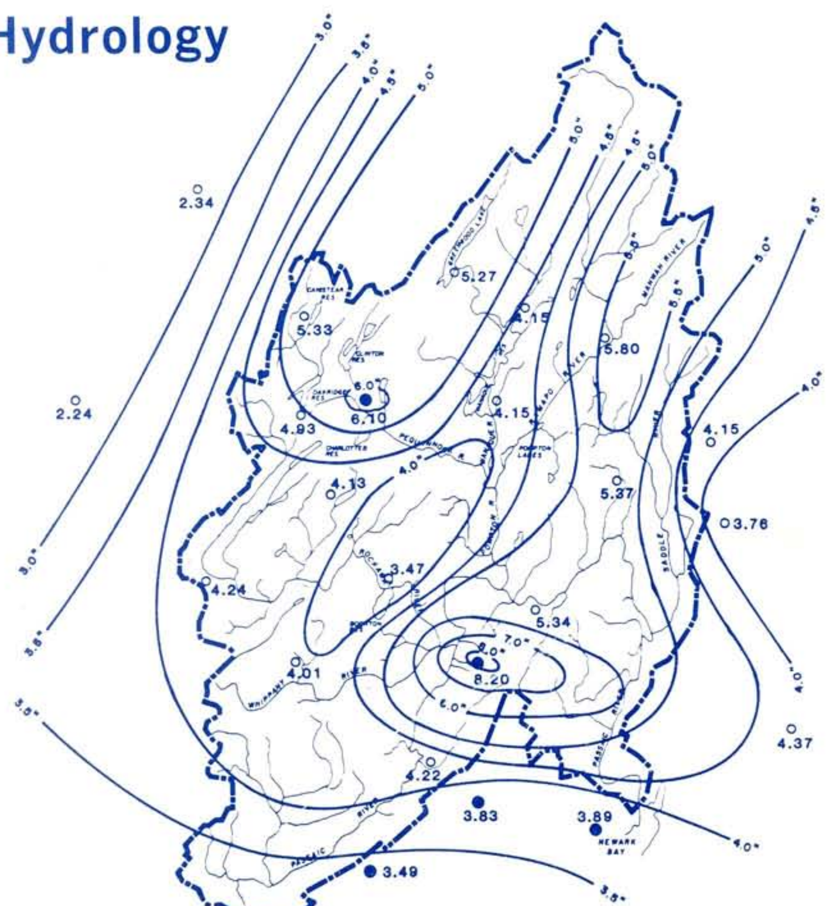
PASSAIC RIVER BASIN STUDY

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

Flood Protection Feasibility
Main Stem Passaic River

Supporting Documentation

Hydrology



December 1987

Part I

PASSAIC RIVER BASIN STUDY
SUPPORTING DOCUMENTATION

PART I - HYDROLOGY

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PART I - HYDROLOGY

SECTION A - GENERAL

INTRODUCTION

This section of Appendix A presents the hydrologic studies that have been undertaken for the Passaic River Basin. These studies involved consideration of both present and future (1990 and 2040) states of upland watershed development, present and future volumes of floodplain storage in the Central Basin area, water resources developments by other (e.g., Monksville Reservoir, which is presently under construction), and various flood protection works, all of which could be expected to have impacts on the extent, duration, frequency and severity of flooding as well as on the environment in general. The results reflect coordination with interested parties both in and outside of the Corps of Engineers.

SECTION B - GEOGRAPHY AND TOPOGRAPHY

WATERSHED DESCRIPTION

The Passaic River empties into Newark Bay, N.J. Its watershed area of 935 square miles lies in northeastern New Jersey and southeastern New York. The roughly elliptical basin is bounded on the north and west by the Appalachian Highlands of New York and New Jersey, on the south by the First Watchung Mountains, and on the east by the Piedmont Plain. The watershed is divided into three distinct topographic and hydrologic regions, designated as the Highland Area, the Central Basin and the Lower Valley (Figure 1).

TOPOGRAPHIC AND HYDROLOGIC FEATURES

The Highland Area contains 500 square miles of the northwesterly portion of the Passaic River Basin. It is a mountainous and heavily wooded section of the Appalachian Mountain Province. This roughly rectangular area is about 13 miles wide and 38 miles long. It is characterized by a series of parallel ridges which are separated by steep-sided, narrow valleys in which flow the Ramapo, Wanaque, Pequannock, Rockaway and Whippany Rivers and in which are contained a large number of natural and artificial lake areas. The first three streams join in a common point near Pompton Plains to form the Pompton River. The elevation of the Highland Area averages about 900 feet m.s.l. (map datum), varying from about 1300 feet m.s.l. at the western rim to 300 feet m.s.l. in the valley at the eastern edge. The average stream slopes vary from 30 to 40 feet per mile (Table 1 and Figure 2).

The Central Basin, containing 262 square miles, is a flat, oval-shaped depression about 10 miles wide and 30 miles long, lying between the foot of the easterly slope of the Highland Area and the crescent-shaped Watchung Mountains to the south and east. Low-lying and marshy lands bordering the various streams form a floodplain that originally extended over 19,000 acres above Little Falls and included the Great Piece Meadows, Hatfield Swamp, Troy Meadows, Black Meadow, and Bog and Vly Meadows.

The Passaic River passes through this floodplain from the southwest and meanders generally to the north and east until it passes out of the area through the gorge at Little Falls. The five major tributaries from the Highland Area discharge into the bottom lands near Fairfield Township and at Two Bridges. The basin elevation averages 300 feet m.s.l., varying from about 500 feet m.s.l. at the rims of the basin to 160 feet m.s.l. at the northeasterly end of the basin. The average stream slope varies from 19.5 feet per mile in the headwaters above Chatham to 1.4 feet per mile through the floodplain downstream of Chatham (Table 1 and Figures 1 and 3).

The Lower Valley, containing 173 square miles of the Passaic River Watershed, lies between Little Falls on the eastern edge of the Central Basin and Newark Bay. This roughly rectangular area, about 8 miles wide and 26 miles long, is largely built up and densely populated. The valley has rolling sides and a comparatively flat, wide bottom which narrows down to about 0.75 mile below Dundee Dam. The average elevation of the area is about 250 feet m.s.l., varying from 500 feet m.s.l. along the westerly edge of the basin to sea level at the mouth of the Passaic River. The main stream has a flat stream slope of 2.9 feet per mile with concentrated falls of 33 feet at Beattie's Dam above Little Falls, 63 feet at the Great Falls above Paterson and 17 feet at Dundee Dam above the City of Passaic. The major tributary in this hydrologic area, the Saddle River, joins the Passaic River 15.5 miles above Newark Bay, and has an average stream slope of 22 feet per mile. Smaller tributaries join the main stream at intervals below Two Bridges and are short and precipitous with average stream slopes varying from 45 to 194 feet per mile. The reach of river downstream from Dundee Dam is affected by tides from Newark Bay (Table 1 and Figures 1 and 2).

As indicated by the topographic features, these three regions of the Passaic River have different flood producing characteristics. The basins of the Highland Area are the greatest flood producers in the Central Basin although they contain a large number of natural and artificial lakes and reservoirs. These impoundments, which tend to dampen the flood peaks to some extent, are used principally for water supply and recreational purposes. The northerly upland tributaries, namely the Ramapo, Wanaque, and Pequannock Rivers, join to form the Pompton River, the greatest producer of extreme floods in the Central Basin. Although the flood peaks are reduced and retarded somewhat due to the lake and reservoir storage on the tributaries and the valley storage between Pompton Lakes and the Passaic River at Two Bridges, the Pompton River peak reaches Two Bridges from 40 to 50 hours earlier than the Passaic River peak during basin-wide floods. The southerly upland tributaries, namely the Whippany and Rockaway Rivers, are as precipitous as the northerly tributaries, but they join the Passaic River at widely separated points in time which results in desynchronization of their peaks. Also, they are greatly affected by the large valley storage in their lower reaches lying wholly or partly in the Central Basin, and they therefore contribute less to flood peaks in the Central Basin.

Flooding upstream of Two Bridges is caused by the restricted river section and control above Little Falls which throttles the flow into the Lower Valley and causes a partial diversion of the Pompton River flood flows upstream into the Great Piece Meadows, part of the Central Basin floodplain. Thus, the combined flow from the total watershed above Two Bridges raises the water level in the meadows until it becomes equal to or greater than that at Two Bridges. As a result, during periods of flood, the floodplain in the Central Basin acts as a natural detention reservoir which significantly retards the peak and reduces the flood intensities in the Lower Valley below Little Falls. The Lower Valley is also subject to floods due to the short, flashy streams below Little Falls, which peak much earlier than the Upper Passaic River. This was indicated by the double-peaked flood of July 1945, the first peak of which, high and of short duration, was mainly from the Lower Valley tributaries while the second peak, low and of long duration, was mostly from the Central Basin outflow. The flood stages in the section of the Passaic River downstream from Dundee Dam are also affected by the tides from Newark Bay. Pertinent watershed data for the Passaic River and its principal tributaries are given in Table 1.

SECTION C - CLIMATOLOGY

CLIMATE

The climate of the Passaic River Basin is characteristic of the entire Middle Atlantic Seaboard. Marked changes of weather are frequent, particularly during the spring and fall. The winters are moderate with moderate snowfall and the summers are moderate with hot, sultry, mid-summer weather and frequent thunderstorms. The rainfall is moderate and well distributed throughout the year. The relative humidity is high. The average annual temperature varies from 49oF. at Charlotteburg to 54oF. at Paterson, with extremes from 26oF. below zero (Canoe Brook) to 106oF. above zero (Paterson). The growing season averages 171 days and the mean annual relative humidity varies from 67 percent to 73 percent. Prevailing winds are from the northwest with an annual average velocity of 9.7 miles per hour. Rainy days average about 121 per year, Climatological data are shown on Figures 3, 4, and 5. Temperature, sunshine and frost data are given in Table 2. Data for wind, humidity, evaporation and rainy days are given in Table 3.

PRECIPITATION STATIONS

The Passaic River Basin is presently served by a network of 41 official U.S. Weather bureau stations. Of these, 14 are equipped with automatic recording rainfall gages and 27 with standard, non-recording gages which are read one or more times daily. The location, period of record, and type of station are shown on Figure 6, which also includes data on pertinent discontinued stations.

ANNUAL AND MONTHLY PRECIPITATION

The average annual precipitation for the watershed is approximately 47.3 inches as derived from a compilation of past records at U.S. Weather bureau stations in and adjoining the basin. The observed extreme annual values were 85.99 inches at Paterson (1882) and 25.26 inches at Morristown (1930). The monthly extremes were 25.98 inches in September 1882 at Paterson and 0.02 inches at Plainfield and Jersey City in June 1949. The distribution of precipitation throughout the year is fairly uniform with higher amounts occurring during the summer months (Table 4).

SNOWFALL

The average snowfall of about 34.2 inches for the Passaic River Basin is equivalent to about four inches of rain. The average snow season is longest in the Highland Area where it extends from the middle of October through the middle of April. The variation of average snowfall over the basin is shown on Figure 4. The average snowfall for the different areas and at individual stations is given in Table 5. The depths of snow given are for freshly fallen snow with an approximate water content of one inch of water to 10 inches of snow.

STORM TYPES

Storms affecting the Passaic River Basin are characterized as tropical and extra-tropical events. The tropical storm arises, not surprisingly, in the tropics: a hurricane is the most severe, but not the most common, occurrence of this type. The extra-tropical storm arises from the interaction of a warm and a cold front; thunderstorm activity is the frequent result of such interaction, but storms of much greater areal extent also arise therefrom, for example, the northeaster, so named for the strong northeast winds which accompany it. The season for tropical storms runs from about June to November, that for northeasters from about November to April; thunderstorms are most frequent in the summer months and, due to rapid convective circulations, are generally limited in extent and cause local flooding similarly on flashy streams.

PAST STORMS

A review of great storms which have occurred in the northeastern states (Table 6) reveals that the Passaic River basin is located in the center of the North Atlantic storm belt. Those storms which have resulted in the worst floods in the Passaic River Basin or represented a threat to the basin are shown on isohyetal maps (Figures 7 through 18) and described in the following paragraphs.

Storm of 20-24 September 1882. This storm was the greatest recorded over the Passaic River Watershed prior to the storm of October 1903. An extra-tropical event, it resulted in a total maximum rainfall at Paterson, N.J., of 17.9 inches of which 11.4 inches occurred in 24 hours (Figure 7). The average rainfall over the Passaic River Basin was about 9.2 inches. The storm was preceded by light rainfall during the months of July and August. The ground was reported to be quite dry at the start of the storm, resulting in high losses due to infiltration. This storm was less extensive than that of October 1903, and its destructive effects were generally confined to the Passaic River Basin.

Storms of February and March 1902. This storm, a typical winter event of low intensity, consisted of over six days of heavy snow and sleet in February, followed in early March by moderate rains and a general rise in temperature. It is estimated that a total of 6.2 inches of rain and snow melt occurred over the Passaic River Basin. The maximum (water equivalent) precipitation recorded in 24 hours was 3.30 inches at Hanover, N.J., and 3.03 inches at Paterson, N.J.

Storm of 7-12 October 1903. This storm, one of the worst in the vicinity of the Passaic River Watershed, occurred following three months of excessive rainfall which had saturated the ground and raised groundwater levels throughout the Passaic River Basin. This extra-tropical storm was comparatively widespread but centered over Paterson, N.J., where a total of 15.5 inches of rain was recorded (Figure 8). The greatest intensity occurred during the night of 8 October and morning of 9 October when over 75 percent of the rain fell. A maximum one day rainfall of 11.45 inches was recorded at Paterson. The total average rainfall over the Passaic River Basin was about 11.4 inches.

Storm of 9-22 March 1936. This extra-tropical type storm occurred over the northeastern United States, with separate centers over the Ohio River and Connecticut River watersheds. Intense rainfall on 11 and 12 March and again on 16 to 19 March fell on a heavy snow cover resulting in damaging floods throughout the northeastern states. The average precipitation over the Passaic River Watershed was 11.1 inches of which 6.0 inches was rainfall and 5.1 inches was the water content of the snow cover. A daily maximum rainfall of 2.58 inches was recorded at Paterson, N.J.

Storms of 16-23 September 1938. These storms comprised a complex series of events ending with a major hurricane. They resulted in heavy rainfall over a widespread area with centers of maximum precipitation over Connecticut and Massachusetts. The average total rainfall over the Passaic River Watershed was 7.0 inches. A maximum daily rainfall of 2.32 inches was recorded at Paterson, N.J. Isohyetals are shown on Figure 9.

Storm of 15-23 July 1945. This extra-tropical storm consisted of six days of moderate rains followed by about 15 hours of heavy showers on 22 and 23 July. The storm centered over the eastern edge of the Passaic Basin, with maxima of 14.73 inches at Midland Park, N.J., and 14.64 inches at Suffern, N.Y. (Figure 10). The heavy showers were localized and spotty, resulting in flash floods on many small streams in and near the Passaic River Basin. The maximum daily rainfall recorded in the vicinity was 7.60 inches at Little Falls, N.J.; 2.36 inches of rain fell at Wanaque, N.J. in the last three hours of the storm and 3.51 inches fell at Spring Valley, N.Y. in five hours after midnight of 22 July. An average of 8.5 inches of rain fell on the Passaic River Basin.

Storm of 11-16 August 1955. Hot dry conditions over New Jersey and New York during the summer resulted in drought conditions in early August 1955. On 3 August a tropical low which developed into Hurricane "Connie" was first detected in the Mid-Atlantic Ocean east of the Windward Islands. Moving slowly northwestward, it entered the mainland near Cape Lookout, N.C., on 12 August. The storm then moved up Chesapeake Bay, east of Washington, D.C., and northward through central Pennsylvania. The hurricane winds diminished and the storm passed over Central New York on 14 August. As a low pressure mass, "Connie" deposited 4 to 12 inches of rain over eastern Pennsylvania, southeastern New York and northern New Jersey. During this period, rainfall over the Passaic River Basin ranged from 11.48 inches to 5.64 inches with an average of over 8 inches. These rains filled many small, depleted reservoirs and saturated the soil, resulting in conditions conducive to the disastrous floods following the heavy rains of hurricane Diane which struck the area only five to six days later.

Storm of 17-20 August 1955. Hurricane Diane, with greatly diminished winds, passed about 60 miles west of Washington, D.C. on the morning of 18 August and turned northeastward to pass between Harrisburg and Philadelphia that evening. The center moved eastward across New Jersey during the night, and on the morning of the 19th was centered a short distance south of central Long Island. From there it moved east-north-eastward between Martha's Vineyard and Nantucket. A continued inflow of tropical air and orographic lifting over the foothills of Pennsylvania and southern New England added to the storm rainfall to produce excessive rains over Pennsylvania, New York, New Jersey and New England on the 18th and 19th. The maximum daily rainfalls were 4.25 inches at Paterson, 4.92 inches at Wanaque Dam, 6.24 inches at Canistear Reservoir, and 4.84 inches at Suffern, New York (Figure 11). Average rainfall over the basin was 5 inches.

Storm of 14-18 October 1955. A cold front moved into eastern Pennsylvania and southern New York on the morning of 13 October and became stationary, with a coastal wave moving northward accompanied by moderate to heavy rains on the 14th and 15th of October. The center drifted slowly northward bringing abundant rains which continued in the northeast through the 16th. Concurrently, an extra-tropical storm from the Carolinas to New York brought high winds up to 57 m.p.h. on the 14th of October. These winds were accompanied by heavy rainfall extending through the 17th of October. The system finally drifted eastward and the rains ceased on the 19th. Average rainfall over the Passaic River Basin was about 5.5 inches (Figure 12).

Storm of 11-12 September 1960. Hurricane "Donna," travelling in a northeasterly direction across Long Island, lashed the new Jersey coast on the 12th of September. As "Donna" moved northeastward off the Jersey coast, damaging winds, heavy rains and high tides struck the coastal areas of the state. Winds gusting up to 100 miles per hour swept the coast. Average rainfall over the Passaic River Basin was about 4.5 inches with maximum daily rainfalls of 4.04 inches recorded at Plainfield, N.J., and 3.86 inches recorded at New Milford, N.J., (Figure 13).

Storm of 27-31 May 1968. On 27 and 29 May 1968, two small, low-pressure disturbances formed in the Cape Hatteras area and moved into the Delaware Bay area. The forming of the second low pressure system extended heavy rainfall from north of New York City through the Hudson Valley and into Massachusetts. The maximum recorded precipitation of 7.96 inches in the Passaic River Basin occurred at Canoe Brook, with an average rainfall over the basin of 6.0 inches (Figure 14).

Storm of 27-28 August 1971. The center of tropical storm "Doria" passed from Delaware Bay over the extreme southern portion of Cumberland County, thence northward through the central part of New Jersey in the early morning of the 28th. From New Brunswick, the storm passed over Newark, then across the Hudson River into southeastern New York State and Connecticut. Excessive rainfall occurred over the state for 24 hours just prior to "Doria". The communities hardest hit by "Doria" were Bound Brook, Manville, and Elizabeth, N.J. Three deaths by drowning were attributed to the storm. The average rainfall over the Passaic River Basin was approximately 8 inches. The total rainfall at Newark was 8.01 inches, at Mahwah, 9.25 inches and at Canoe Brook, 9.20 inches (Figure 15).

Storm of 16-23 June 1972. This was a combined tropical and extra-tropical event which, while not a major occurrence with respect to the Passaic River Basin, which it struck only peripherally, was such elsewhere in the same hydrologic region and is therefore indicative of what might be expected over this basin; the storm actually centered near Harrisburg, Pa., which is located approximately 150 miles west-south-west of Paterson. The greatest point rainfall associated with the event exceeded 18 inches, and 12 or more inches of rain was experienced over an area several times that of the Passaic Basin. The greatest 3-hour accumulation at Harrisburg, near the storm center, was 4.55 inches. If this storm had, in fact, centered critically over the Passaic Basin, the isohyetals would have been as shown on Figure 16.

Storm of 6-8 November 1977. An extra-tropical storm travelled into the New Jersey coast on November 6. Strong east winds with speeds of 50 m.p.h. were experienced at the shore on November 7, then decreased on November 8. Rain began on the evening of November 6 and continued into the afternoon of November 8. Heaviest rainfall was in the northeastern part of the state, where 2 inches fell on the 7th followed by 8 inches or more on the 8th. The average rainfall over the Passaic River Basin was approximately 5.5 inches, with 9.25 inches at Newark, 6.04 inches at Mahwah and 4.10 inches at Bernardsville (Figure 17).

Storms of March and April 1984. The storm of 28-30 March 1984 was a northeaster of extra-tropical origin. It brought with it a major tidal surge (March 29th) and significant precipitation in the form of rain, sleet and snow. The maximum known accumulation of such precipitation in the Passaic Basin (water equivalent basis) was 3.87 inches (Little Falls). There was no snow on the ground at the onset of the storm.

The storm of 4-5 April 1984 was of extra-tropical nature arising out of a large, low-pressure system moving out of the Ohio Valley. It entered New Jersey on the 4th where it intensified towards dawn of the 5th with gale force winds and near-record rainfalls (there was no snowfall). Storm totals at the Little Falls, Charlotteburg, and Wanaque gages were, respectively, 5.34, 6.10 and 4.15 inches. Maximum 3-hour accumulations at the Little Falls and Charlotteburg gages were, respectively 1.30 and 1.40 inches. Corresponding 6-hour accumulations were 2.33 and 2.50 inches Sub-24-hour data is unavailable for Wanaque due to the hourly gage malfunctioning. Isohyetals for this event are shown on Figure 18.

Total precipitation for the two storms, extending over a 10-day period and including rain and the water equivalent of sleet and snow, exceeded 9 inches at Little Falls, 8 inches at Mahwah and 7 inches at Charlotteburg, Oak Ridge and Canistear Reservoirs and at Greenwood Lake. For the Passaic Basin as a whole, the total was probably close to 7 inches. Snow on the ground at the start of the second storm was apparently minimal since at those few sites where observations were made, no more than traces were reported for the preceding day (3 April).

MASS CURVES OF STORM RAINFALL

Mass curves of rainfall for selected storms are given in Figures 97 through 101. These data were used to evaluate storm movement across the Passaic watershed.

SECTION D - RUNOFF AND STREAM FLOW

RUNOFF RECORDS

There were, as of September 1984, 33 active gaging stations in the Passaic River Basin providing records of flood runoff. Eleven of these were crest-stage gages which establish only the peak discharges of flood events. The remainder were recording gages which establish not only peak discharges but also the discharge-time relations of such events. Record lengths for the crest stage gages vary from 4 to 48 years; those for the recording gages vary from 2 to 63 years. The locations and periods of record of the various stations are given on Figure 6. Peaks at selected stations are given in Tables 7 and 8. Responsibility for publishing the data collected lies with the U.S. Geological Survey.

A number of gaging stations have been discontinued over the years since the program of systematic gaging began. Where feasible, data from these gages (which are also included on Figure 6) were used to supplement that from stations still in service.

ANNUAL RUNOFF

The average runoff from the Passaic River watershed is affected to a considerable extent by diversions for water supply from the Rockaway, Pequannock, Wanaque and Ramapo Rivers, Canoe Brook, and the Passaic River itself. Average runoff from the 785 square-mile watershed above Paterson, N.J., is 1.55 cfs per square mile exclusive of average water supply diversions amounting to about 0.35 cfs per square mile, which brings the total corrected runoff to 1.90 cfs per square mile. This runoff is equivalent to 25.7 inches per year or 53 percent of the rainfall. Comparative runoff data for the principal gaging stations in the watershed are given in Table 8. Seasonal variation in runoff occurs, with over 50 percent of the annual amount taking place in the months December through April.

FLOOD RUNOFF

The flood runoff from this watershed is affected by its topographic and hydraulic features. The great natural storage that occurs during flood periods over the flat swamps and meadows above Little Falls has a great effect on the runoff of the watershed, especially into the Lower Valley. Because of the variable flood runoff characteristics, each hydrologic division of the watershed requires a different treatment for the analysis of flood runoff such as the unit hydrograph method in the Highland Area and the Lower Valley, and a combination of the unit hydrograph and flood routing methods in the Central Basin.

FLOODS OF RECORD

Significant Passaic Basin floods are on record as having occurred in calendar years 1811, 1865, 1882, 1896, 1902, 1903, 1936, 1945, 1968, 1977, and 1984 (Table 7). Little is known of the earlier events beyond the fact that the first two were, respectively, the second and fourth largest at Little Falls, discounting any changes in ranking that might arise from adjustments for watershed development. Of the more recent events, it can be said that some were of basin-wide consequence while others were of interest only in specific subareas. Descriptions of selected floods are given in the following paragraphs.

Flood of March 1902. This was a major winter flood in the Passaic River Basin. Heavy rains falling on a deep snow cover and a rise in temperature caused a sudden increase in stream flow. The estimated peak discharge on the Passaic River at the S.U.M. (Society for Useful Manufactures) Dam located just upstream of the Great Falls at Paterson, N.J., was 22,500 cfs on 2 March 1902. A runoff volume of 5.20 inches was reported during this flood, equivalent to about 83 percent of the total rainfall and accumulated snow over the watershed. Maximum discharges for this flood at two other locations in the basin, as estimated by other agencies, are listed in Table 9.

Flood of October 1903. This flood was the maximum of record in the Passaic River watershed. The beginning of the sudden flood rise was almost simultaneous on all branches of the Passaic River at about 6:00 P.M. on Thursday, 8 October. The Pompton River reached a maximum at 4:30 P.M. on Friday, 9 October, and continued at a high rate of discharge until noon of Saturday, 10 October. The peak on the Passaic River reached a maximum at about 12:00 P.M. at Two Bridges, 4:00 P.M. at Little Falls and 9:00 P.M. at Dundee Dam on Saturday, 10 October. The Whippany River at Whippany reached its peak at 5:00 P.M. on Friday, 9 October. On the same day the upper Passaic River at Chatham reached a maximum at midnight. Maximum discharges at various locations in the Passaic River watershed, as estimated or recorded by various agencies, are listed in Tables 7 and 9. The peak discharges on the Passaic River were 31,700 cfs at Little Falls and 35,800 cfs at Dundee dam. The total volume of runoff at Dundee Dam was 6.50 inches, approximately 56 percent of the average rainfall over the basin.

Flood of March 1936. This was the worst winter flood occurring between March 1902 and April 1984. The peak discharge recorded at the S.U.M Dam was 19,700 c.f.s. on 13 March. The peak flow on the Pompton River occurred about 24 hours before the peak on the Passaic River. The total runoff volume was 5.99 inches, equivalent to about 67 percent of the total rainfall and accumulated snow cover (water equivalent).

Flood of September 1938. The storm of September 1938 caused severe flooding throughout the New England States. In the Passaic River Basin, this flood was only moderate, with a peak flow of 8,350 cfs on the Passaic River at S.U.M Dam above Paterson on 23 September 1938. The runoff volume was 1.9 inches, equivalent to about 27 percent of the average rainfall over the basin.

Flood of July 1945. This was a major flood in the Lower Valley of the Passaic River. Flash flooding occurred on all small streams tributary to the Passaic River below Two Bridges. The peak on the main stem was due to the simultaneous high flows from the short tributaries, as indicated by the shape of the flood hydrograph at the S.U.M. Dam. The first peak of 19,500 cfs. was caused primarily by the flow from the small tributaries below Two Bridges while the second peak of 11,600 cfs occurred more than 24 hours later and can be attributed to the flow from the Great Piece Meadows area above Two Bridges. The retardation and reduction of flood peak effected by this natural reservoir was clearly shown during this flood. The peak flow on the Pompton River at Pompton Plains, which has a drainage area equal to about one-half that just below Two Bridges, was estimated at 9,690 cfs and the peak time was estimated at one hour after the first peak in the lower Valley of the Passaic River at S.U.M. Dam, and 18 hours before the second peak of 11,600 cfs attributed to the Great Piece Meadows area. The runoff volume was 5.0 inches, equivalent to 59 percent of the average rainfall over the basin.

Flood of August 1955. The storm of August 1955 was not as severe as some of the previous storms described. There was some flooding along the mainstream from Two Bridges to Paterson, but most of the flooding occurred on the tributaries, including the Ramapo, Pompton and Pequannock Rivers and Goffle and Molly Ann's Brooks. A peak flow of 9,850 cfs was recorded at S.U.M. Dam above Paterson on 20 August 1955. The runoff volume was 1.2 inches, equivalent to about 36 percent of the average rainfall over the basin.

Flood of October 1955. The storm of October 1955 caused flooding which was most severe on the Pompton, Ramapo and Wanaque Rivers, equalling or exceeding the March 1936 flood.

The other tributaries were not as severely affected. Peak flow at Little Falls above Paterson was 11,600 cfs on 18 October 1955. The runoff volume was 3.01 inches, equivalent to about 55 percent of the average rainfall over the basin.

Flood of May 1968. The flooding of May 1968 caused widespread damage over the Passaic River Basin. Flooding occurred on the main stream and all major and most minor tributaries from the headwaters to the City of Passaic, about 12 miles upstream of the mouth. Flooding was most severe on the Pompton, Ramapo, Wanaque and Pequannock River equalling or exceeding the March 1936 flood. Peak flow at Little Falls was 13,500 cfs on 31 May 1968. The peak flow on the Pompton River at Pompton Plains occurred on 30 May 1968 and was estimated at 13,100 cfs.

Flood of August 1971. The storm of August 1971 caused extensive flooding on the tributary system of the Passaic River. There was relatively little flood flow at Little Falls on the Passaic main stem in relation to past floods; however, tributaries such as the Pompton River were flooded. The Pompton River at Pompton Plains had a peak discharge of 8,480 cfs. The Rockaway River above Boonton Reservoir had a peak flow of 3,086 cfs. On the Pompton River at Pompton Plains, the volume was 1.75 inches out of a basin average rainfall of 7.40 inches, or approximately 24%. This low percentage of runoff is accounted for by the very long dry period prior to the storm.

Flood of June 1972. Consistent with the location of the Passaic Basin at the periphery of the storm of June 1972, the associated flood was a relatively minor event. The peak flow at Little Falls was 10,300 cfs, which has a return period of 4 years. Had the storm centered over the basin, the peak at Little Falls would, intuitively, have been many times larger. Given the fact that the Passaic Basin lies within the same hydrologic region as the watersheds severely impacted by the storm of 16-23 June 1972, the decision was made to attempt to determine the probable flows attendant upon the centering of that storm over this basin. This work is discussed below under the general heading "SIMULATION OF RUNOFF FROM OTHER HYPOTHETICAL STORMS" and specific heading "Transposed Agnes."

Flood of November 1977. The storm of November 1977 caused extensive flooding throughout northeastern New Jersey, particularly in Bergen County. In the Passaic River Basin, the main tributaries of the basin, which included the Saddle, Ramapo and Pompton Rivers, were hardest hit. The peak discharges for various locations include: Ramapo River at Pompton Lakes = 11,000 cfs; Pompton River at Pompton Plains = 11,000 cfs; Ho-ho-kus Brook at Ho-ho-kus = 6,600 cfs The volume of runoff for the Third River during the peak rainfall period was equal to 1.94 inches versus a rainfall total of 3.39 inches, approximately 57% of runoff versus rainfall over this tributary's basin.

Flood of April 1984. The flood of April 1984 resulted, in part, from high antecedent flows due to the precipitation in late March. At a number of gaging stations in the northern and western subareas of the Passaic Basin with 40 or more years of record, the peaks were the highest or second highest recorded (Table 9A). Estimated frequencies of the peaks ranged from 25 years at Little Falls to 50 years at Pompton Plains. Discharges at selected stations are given in Table 7.

SECTION E - ANALYTICAL APPROACH

BASIN SUBDIVISION

Several factors were considered during the development of the basin subdivisions to be used for the complex 935 square mile Passaic River hydrologic model. These factors included: (1), maintaining the logic of the watershed; (2), locations of damage areas; (3), locations of potential interim study sites; (4) types of basin-wide flood management measures under consideration; (5), stream gage locations; and (6), study scheduling constraints. To adequately address these items it was necessary to divide the Passaic River Basin into the following eight main hydrologic subbasins:

a) Ramapo Subbasin: Ramapo River from Pompton Lakes gage upstream to the basin's headwaters;

b) Saddle Subbasin: Saddle River from mouth to headwaters;

c) Passaic Lower Valley: Passaic River from Beattie's Dam downstream to the mouth at Newark Bay, including secondary subbasins such as the Peckman River, Molly Ann's Brook, and Second and Third Rivers;

d) Passaic Central Basin: Passaic River from Beattie's Dam upstream to the Chatham gage; Pompton River downstream of the Pompton Plains gage; Whippany River downstream of the Morristown gage; and the Rockaway River downstream of the gage above Boonton Reservoir;

e) Passaic Highlands: Passaic River from the Chatham gage upstream to the basin's headwaters;

f) Whippany Subbasin: Whippany River from the Morristown gage upstream to the basin's headwaters;

g) Rockaway Subbasin: Rockaway River from the gage above Boonton reservoir upstream to the basin's headwaters;

h) Pompton Subbasin: Pompton River upstream of the Pompton Plains gage; Pequannock and Wanaque Rivers.

Of these eight subbasins, those within the highland area and Saddle River watershed were modeled independently with a consistent analytical approach. The subbasins within the highland area included the Ramapo, Pompton, Rockaway, Whippany and Passaic Highland Subbasins. The analyses of the Passaic Central Basin and Passaic Lower Valley Subbasins were contingent upon the establishment of boundary conditions resulting from the completion of the highland area subbasins and Saddle River models. To permit adequate calibration of the subbasin models to historical flooding events, each subbasin has its outlet located at a U.S.G.S. stream gage station (except for the Passaic Lower Valley which discharges into Newark Bay), as listed below:

a) Ramapo Subbasin - USGS gage No. 0138800 - Ramapo River at Pompton Lakes.

b) Saddle Subbasin - USGS gage No. 0139150 - Saddle River at Lodi.

c) Passaic Lower Valley - No gages located on Passaic River downstream of Little Falls.

d) Passaic Central Basin - USGS gage No. 0138950 - Passaic at Little Falls.

e) Passaic Highlands -USGS gage No. 0137950 - Passaic River at Chatham.

f) Whippany Subbasin - USGS gage No. 0138150 - Whippany River at Morristown.

g) Rockaway Subbasin - USGS gage No 0138050 - Rockaway River above Boonton Reservoir.

h) Pompton Subbasin - USGS gage No. 0138850 - Pompton River at Pompton Plains.

Each of the subbasins in the highland area and Saddle River models are therefore calibrated to a gage, insuring viable boundary conditions for the modeling of the Central Basin and the Lower Valley. Having each subbasin model calibrated to a gage also precludes the perpetuation of potential calibration errors from upstream to downstream subbasins.

After the division of the Passaic Basin into 8 subbasins, the next step in the development of the hydrologic model was to further divide each of the subbasins into a number of subareas which would serve to define specific Points of Interest (POI) along various stream reaches. The number of subareas was fixed by the requirement that subarea boundaries occur at least at each of the following points of interest:

a. primary stream confluences

b. damage areas

c. stream gage locations

d. potential reservoir and detention sites.

e. potential tunnel inlet and outlet sites.

The Passaic Basin hydrologic model has a total of 190 subareas. These range in size from 0.3 to 50 square miles. Figure 19 shows the 8 main subbasins and their respective subareas. The basin physiographic data for each of the subareas is shown in Table 10. These data include: drainage area, watercourse length, length to center gravity, slope, impervious area and point of interest identifier on the river system.

In addition to physiographic characteristics of the basin, there are many man-made influences on the existing conditions hydrology. Three main types are existing reservoirs, water supply diversions and urbanization. Urbanization is fully described later in the report. Water supply diversions have little or no effect when calibrating major historic flood peaks (except insofar as they contribute cumulatively to reservoir draw-downs) or reproducing hypothetical storms (reservoirs assumed full). There are 9 reservoirs (10, under post-base-year conditions) which are considered in the hydrologic models as possibly having a downstream impact in reducing flood waves. The reservoirs are: Splitrock and Boonton Reservoirs in the Rockaway River Subbasin; Canistear, Oak Ridge, Clinton, Charlotteburg and Echo Lake Reservoirs in the Pequannock River Subbasin; and Greenwood Lake and Wanaque Reservoir in the Wanaque River Subbasin (plus, for future conditions, Monksville Reservoir, which is now under construction). Only the Boonton and Wanaque reservoirs have significant downstream attenuation effects. The remaining reservoirs have either too little volume for flood control storage on top of the water supply storage or their locations are at the headwaters on tributaries to the main river system. The Boonton, Charlotteburg and Wanaque Reservoirs would have an impact on the reproduction of the October 1903 flood since they were not in operation at that time, This flood interrupted the construction of Boonton Dam, which was completed in 1904, and the Wanaque Reservoir site was a huge detention area without the present series of dams containing the reservoir. Details on the reproduction of the October 1903 flood are discussed later in the report.

MODELING PROCEDURE

The hydrologic analysis of the Passaic Basin utilized the HEC-1 Flood Hydrograph Package. The generalized stream system and diversion options were utilized to determine the rainfall-runoff interrelationships.

The hydrologic parameters used in the hypothetical storm runoff simulations are the parameter values determined in the calibration process. These include TC, R, QRCSN and RTIOR. The starting discharge (STRTQ) adopted for each subbasin ranged from 1.00 cfs/sq.mi. to 7.5 cfs/sq.mi. Storage-discharge relationships were used for stream routing with the Modified Puls method where this data was available and the Muskingum routing technique was applied in the reaches where no storage information was available.

The computer model, HEC-1, has a mechanism for ensuring that the runoff from each subarea of a given basin is consistent in terms of rainfall with the runoff contributed by other subareas forming part of that basin. This is accomplished by generating hydrographs for every downstream location from rainfall totals that correspond to a specific drainage area size. Precipitation-depth-drainage area relationships developed for each of the 24-hr. duration hypothetical storm events to be evaluated are presented in Table 18. The values in Table 18 are determined using Figure 15, T.P. 40 (drainage area vs percent of point rainfall) for the hypothetical events and also using Plate 9 of EM 1110-20-1411 for the SPS. Based on these data and discussion with the Hydrologic Engineering Center, a composite precipitation depth area drainage relationship was developed for the Passaic Basin Model (Figure 51).

The methodology for computing a hypothetical event flood hydrograph for a particular subarea involved the initial computation of five index runoff hydrographs corresponding to five precipitation depth-drainage area values. A consistent flood hydrograph is then determined by interpolating between the two index hydrographs which bracket the subarea's drainage area. Consistent hydrographs at confluences are determined by interpolation of the combined index hydrographs of the two streams for the combined drainage area. Additional information for the index hydrograph computation is presented in the HEC-1 User's Manual.

In the Passaic Highlands, Lower Valley and the tributary subbasins, the generalized stream system procedure was used to develop rainfall runoff interrelationships. However, as noted previously in Section B, and as discussed in detail in the calibration results from the Central Basin, in the vicinity of Two Bridges an unsteady flow condition results in the diversion of Pompton River flow upstream along the Passaic River. Due to the occurrence of this flow reversal, the Central Basin modeling procedure was more involved and required the use of the diversion option of HEC-1 in addition to the stream system procedure. Since HEC-1 cannot model unsteady flow behavior directly, an aid was utilized in the modeling of complex flood wave routing in the Central Basin. An unsteady flow model, "DWOPER," was used to gain insight into how flood waves move through the Central Basin and to provide a basis for determining lagging and diversion functions, thereby improving the HEC-1 representation of a flood wave movement.

The "DWOPER" model was prepared by HEC (The Hydrologic Engineering Center, Corps of Engineers, Davis, California) and documented in it's Special Projects Memo No. 81 and a revised Memo No. 82-1 "Unsteady Flow Analysis For the Passaic Central Basin", which is included as an attachment to this appendix. "DWOPER" was not used as the final model analyzing the Passaic Central Basin because: 1), "DWOPER" cannot interface with the family of HEC Programs used in this investigation; 2), modifying "DWOPER" to analyze alternative plans is extremely difficult, requiring detailed modeling changes; 3), "DWOPER" cannot be readily modified to evaluate future land use changes; 4) utilizing "DWOPER" for all necessary analyses would be too costly; and 5) a final product which consists of one modeling technique (HEC-1) for the entire basin was highly desirable.

Therefore, diversion and lagging functions were used to simulate the dynamics of flood routing reflected in the "DWOPER" trial runs for the Central Basin. Diversion was accomplished with the option in the HEC-1 program which permits the amounts of flow to be diverted to be specified. Details of these diversions will subsequently be discussed.

A sample "DWOPER" hydrograph illustrating flow reversal on the Passaic River upstream of the Pompton River confluence is shown on Figure 36. Additional discussion of the "DWOPER" model is also presented in Section B of the hydraulics documentation.

Reservoir Routings. All reservoir routings were done using the Modified Puls option of HEC1. Where hypothetical floods were involved, the reservoirs were assumed full at the start of runoff. There are no outflow constraints for any of the reservoirs so that no flows are held back because of downstream considerations (the only operable spillway in the basin, that of Charlotteburg Reservoir, is intended to control headwater, not tailwater, levels).

One-hour HEC1 Model Time Step. The adopted model time-step was one hour. This is short enough to adequately define the peaks of hydrographs that are pertinent to the non-interior-drainage designs of the considered plan of improvement, but not so short as to preclude generation of a complete hydrograph given the 300-step limit of HEC1. The smallest drainage area tributary to plan provisions is about 80 sq. miles (upper end of improvement on the Pequannock River), for which a one-hour model time step is appropriate. It is noted that the model time step cannot change when the "JD" card option of HEC1 is specified, precluding adjustment with drainage area. Data on the time steps appropriate to interior drainage design are given in Part II of this report entitled "HYDRAULICS".

One-hour time-step models of the many small component areas of the Passaic River Basin may fail to define the peaks of their individual hydrographs. However, this is not significant in the context of the larger basin model because of the number of such areas involved, the ranges of their size and unitgraph parameters, and the dissimilar routings and/or laggings to which they are subject before they are combined to obtain a main stream hydrograph.

MODEL CALIBRATIONS - HISTORICAL EVENTS

Once all of the physical parameters describing the basin had been defined, the rainfall-runoff response had to be calibrated such that the runoff approximates the observed results at the USGS gages. A starting point in the calibration process was to establish regionalized Clark's unitgraph parameters, TC and R. These values were optimized for 18 unregulated watershed gaging stations. The method of optimization followed the derivation sequence guidelines outlined in Addendum 1 of the HEC-1 Users Manual. The regionalized values of TC and R were used to develop plots and regression equations of TC, R and TC+R versus various combinations of basin characteristics. Regional

R/(TC+R) ratios were used as a guide in maintaining subarea hydrograph responses for a particular subbasin when calibration adjustments to TC's and R's were required.

The first areas calibrated in the Passaic Basin were the Highland area subbasins. The initial ungaged subarea estimates for TC and R were established from the plots of R vs DA and TC vs DA which were developed using data from the thirteen USGS gages within the Passaic Basin and five gages outside the Basin. However, even with these plots being the major sources for the relationships, large variance in the TC's and R's occurred during the calibration procedure. Table 12, which shows the hydrologic model subarea parameters, gives R/(TC+R) values for each subarea. The standard time-area curve is used in the Clark method of unitgraph determination.

Consider Figures 20 and 21 which show plots of TC vs DA and R vs DA. There is some scatter in the TC vs DA plot; however, between 10 and 50 square miles, a fairly good fit can be seen. The large variances from this fit occur at the extreme ends. Many of the subareas developed for the Passaic Basin existing conditions HEC-1 model are less than 10 square miles where adequate data are not available to produce a good relationship. The R vs DA plot shows much more scatter than the plot of TC vs DA, and there is no apparent fit from the data. Limited data, as in the TC vs DA plots, restrict the development of a good estimate of R for the smaller drainage areas.

Figures 20 and 21 show original estimates of envelope curves, A and C, for the data and also a "best" fit by eye curve, B, based on the data points which lie between 10 and 50 square miles. Initial calibration estimates of TC's and R's were determined using the B curves. However, as the process to reconstitute the historical events continued, it was evident that the initially selected unit hydrograph parameters would require modification to achieve reasonable calibration results. Consequently, necessary adjustments were made to the TC's and R's. These adjustments were based on detailed analyses of the subbasins and the physiographic characteristics of the individual subareas. The following characteristics were evaluated from USGS quadrangle maps, aerial photographs, and pictures and notes taken during site visits: stream length, slope, general basin shape, number of lakes and ponds, swamp land (including large wetland areas and smaller areas contiguous to the channel), park land and general urban or rural land use types. TC's and R's were increased especially for those subbasins which had numerous ponds and swampy regions in areas along the downstream reaches of the subbasin. The general trend was larger TC's and R's than originally estimated using the B curves on Figures 20 and 21.

The increases in TC's and R's were more pronounced for the subareas which had smaller drainage areas (i.e., less than 5 square miles). About one-half of the final TC's adopted lie in the region between curves A and B on Figure 20, and the others lie above curve A. The maximum envelope of the final subarea TC's is shown on Figure 20 by the dashed curve A. The majority of the final R values lie between the curve A and B or just slightly above curve A on Figure 21. All but two of the R values which lie above curve A are in the Rockaway River Basin.

The development of the unit hydrograph parameters for the Lower Valley tributaries was not as difficult as in the Highland area subbasins because of the fully urbanized nature of the lower Valley. The initial estimates of TC's and R's were obtained from Figures 20 and 21, curve D. These D curves were drawn with more emphasis placed on the urban gaged data than the "best" fit curves (B curves) drawn for the Highland area.

Regression equations developed as part of a unit hydrograph parameter analysis for urban areas were not successful. Mathematical curve fitting or multiple regression analysis applied to the available data gave unreasonably low TC's and R's for the smaller drainage areas. As an example, consider the simple plots of TC vs DA and R vs DA. A regression analysis would fit the points such that the drainage areas less than 10 square miles would have very small TC's and R's. This is a result of the lack of data plots in the lower drainage area.

The majority of the final unit hydrograph parameters were unchanged from the initial estimates adopted during the calibration of the Lower Valley tributaries. However, for a few subareas, the TC's were increased to more accurately simulate the observed events or the trend of observed events at gaged subareas were applied to ungaged subareas.

The ultimate purpose of calibrating each subbasin with selected storms was to obtain values of subarea unitgraph parameters, loss rates, and base flow which would be used to model hypothetical or specific-frequency floods. This is discussed in detail below in the "FREQUENCY ANALYSIS" section.

Regionalization of Loss Rates. Once the unitgraph parameters were determined for each subarea, a regionalized analysis of loss rates was made for every observed event investigated. For each of the eight subbasins and for all calibration storms, the first computer simulation maintained initial and constant loss rates (STRTL = 1.0 in, CNSTL = 0.10 in/hr) for every subarea within a particular subbasin for a given storm. Subsequent iterations of calibration included the adjustment of individual loss rates within each subarea through an iterative testing and tuning process. In many cases, the loss rates initially selected were too small and were increased to reconstitute the observed hydrographs.

Recession Parameters. The recession parameters, QRCSN and RTIOR, were determined from the observed hydrographs at the gages for the calibration storms. For each observed hydrograph, the ratio of QRCSN to the peak flow was computed for application to ungaged subareas. The initial QRCSN ratio and RTIOR for each ungaged subarea in the Whippany and Rockaway subbasins were set equal to the values obtained from the measured hydrograph at the downstream gage. The initial recession values of the ungaged subbasins for the Passaic above Chatham and the Ramapo subbasins were set equal to the values computed from the measured hydrograph at the first downstream gage. Some recession parameter values for the ungaged subareas were altered during the calibration procedure. The adjustment were not only made based on the observed hydrographs but they were also adjusted based on the characteristics of the subarea. For example, for an area such as the Central Basin the original recession parameter value for QRCSN ratio was increased and the RTIOR decreased (flatter recession slope) to reflect the predominantly swamp or marsh land of the Great Piece Meadows. For areas that are highly urbanized the QRCSN ratio was reduced and the RTIOR was increased.

Flood Routing Procedures. The selected routing procedures used were dependent upon the availability of accurate storage vs. outflow discharge relationships. The Modified Puls method was used in all the routing reaches where HEC-2 computed flowlines were developed; this includes approximately 140 miles of the HEC-2 modeled Passaic River main stem and tributary streams. The Muskingum method was used primarily in the upstream reaches where further routing was necessary. Additional iterations of the calibration process were undertaken when revised storage vs outflow curves from HEC-2 results based on HEC-1 discharges deviated from HEC-2 storage results based on Q's from the previous iteration. This was evident in the reaches where the comparisons between the HEC-1 computed discharges and preliminary discharges and/or the resulting storage vs outflow curves were not in agreement.

Calibration Hydrographs. Each subbasin outlet (located at a USGS gage except for the Lower Valley subbasin) was investigated with at least 4 storms for an acceptable historical calibration of their respective subarea parameters; that is, the computed hydrographs for historical events were calibrated against the observed hydrograph in terms of peak flow, time to peak and runoff volume. By matching these 3 criteria, an acceptable overall shape and visual compatibility between computed and observed hydrographs was generally obtained. However, as will be discussed in the calibration results section, not all subbasins were calibrated with all 4 historical storms selected. Some subbasins were calibrated by averaging the results of only 3 storms. This was necessary because not all recording streamflow gages had complete data for all historical storms investigated. Another problem was that in some cases available data was irregular or inconsistent with computed results, with no valid explanation for the differences. Additionally, many tributary areas, especially those in the Pompton Subbasin, are influenced by reservoirs which, depending on their stage at the start of a flood event, can have varying impact on stream flow behavior.

Storm Rainfall Records. The rainfall gages used in the Passaic Basin model are shown on Figure 6. This figure includes the location of the gage, and an "R" to indicate recording or "NR" to indicate non-recording. Table 11 lists the total storm rainfall by gage for the calibration periods investigated. The storms cover the following days: 8/17-20/55, 10/14-18/55, 5/28-31/68, 4/1-3/70, 8/27-29/71, 12/20-22/73, and 11/7-10/77. Both the recording and non-recording gages were used to construct isohyetal maps for the entire watershed for each of the calibration events. The rainfalls for the calibration storms were determined from the isohyetal maps for each of the subbasins. To determine the historical storm rainfall distribution patterns for each of the eight subbasin's subareas, only recording gages were used. The recording gages assigned to develop the rainfall distribution for each subarea are subsequently documented in the calibration discussions for the eight subbasins.

Ramapo River Subbasin (May 1968 Event). The Ramapo Subbasin model is calibrated with Clark unitgraph parameters optimized to reproduce the 5/68, 4/70 and 11/77 storms at the Ramapo River at Pompton Lakes USGS streamflow gage No.0138800 (see Figure 22 for HEC-1 subarea delineations and network model diagram). As noted above, initial R values were determined from plots of R vs DA. To maintain similar hydrograph responses in the subbasin's subareas, initial values of TC's chosen were determined from regional values of R/(TC+R) based on the optimization results for the 13 unregulated watershed gaging stations. For this subbasin the value of R/(TC+R) determined was 0.60. Once initial values of TC and R were selected for each of the subareas it was necessary to make adjustments to these parameters to reconstitute the historical events investigated. Adjustments to the hydrograph parameters, which are held constant for each calibration storm, were based on a thorough analysis of the subareas' physiographic characteristics, as previously discussed in the "MODELING PROCEDURE" section. With the adjusted parameters, the subarea R/(TC+R) ratios resulting from calibration of the subbasin ranged from 0.57 to 0.73. Adopted values of unitgraph parameters are shown in Table 12. Table 13 shows the routing parameters used in calibration. The Modified Puls method was used where storage discharge relationships were available and the Muskingum method was used where it was felt that further routing was necessary. For this subbasin, rainfall gage #15 was used for all subareas for the 4/70, and 11/77 storms. For the 5/68 storm, data were also available for rainfall gage #44. For this storm, gage #15 distribution was applied to subareas 930, 950, 960, 1040, 1050, 1060, 1070, and 1080 and gage #44 distribution was applied to subareas 935, 940, 970, 870, 985, 990, 1000, 1010, 1015, 1020, and 1030. It should be noted that both gages #15 and #44 are located outside the limits of the Ramapo River Subbasin.

The results of the three (3) storm calibrations indicate that hydrograph peaks for the 5/68, 4/70, and 11/77 storms reproduced observed values within acceptable limits. A comparison of the computed versus observed events at gage No. 0138800 is shown in Table 15. A detailed discussion of the calibration results for the 5/68 storm follows:

The reconstituted hydrograph is calibrated to the Pompton Lakes gage (HEC-1 POI 59) with reasonable losses to duplicate the observed hydrograph peak (Figure 33). The subarea values of STRTL and CNSTL ranged from 0.5 to 1.3 and 0.17 to 0.38, respectively. The observed peak discharge of 9,530 cfs was recorded at 10 P.M. on 29 May 1968. The HEC-1 model reconstitution of the event yielded a flood hydrograph of comparable magnitude and timing. The computed peak discharge was 9,171 cfs at 9 p.m. on 29 May. The peak difference of less than 4%, volume difference of 6% and timing difference of 1 hour are indicative of the reliability of the model and the assumptions made concerning loss rates and unitgraph parameters for the subbasin's 19 subareas.

Saddle River Subbasin (August 1971 Event). The Saddle River Subbasin model is calibrated with Clark unitgraph parameters optimized to reproduce the 8/71, 9/71, 12/73 and 11/77 storms at the Saddle River at Lodi USGS streamflow gage No. 0139150 (see Figure 23 for HEC-1 subarea delineation and network nodal diagram). The sixteen subarea TC's and R's, which are held constant for each calibration storm, were derived initially by graphical means based on plots of R vs DA and TC vs DA, as discussed in the "MODELING PROCEDURE" section. Adjustments to the parameters were based on thorough analysis of the subbasin's physiographic characteristics as previously discussed. Adopted values of unitgraph parameters are shown in Table 12. Table 13 shows the routing parameters used in calibration. Modified Puls routing was used in the 5 reaches where storage discharge relationships were available and the Muskingum Method was used in 6 reaches were it was felt that further routing was necessary. For this subbasin for the August 1971 storm, rainfall gage #5 recordings were applied to subareas 1410, 1413, 1415, 1417, 1420 and gage #44 was used for subareas 1400, 1430, 1440, 1445, 1450, 1460, 1475, 1480, 1490, and 1500; for the December 1973 storm, rainfall gage #4 was used for subareas 1440, 1410, 1430, 1440,1445, 1450, 1460, 1470, 1475, 1480, 1480, 1490, and 1500 and rainfall gage #44 was applied to subareas 1413, 1415, 1417, and 1420; for the September 1971 and November 1977 storms, rainfall gage #4 was used for subareas 1430, 1440, 1445, 1450, 1460, 1470, 1475, 1480, 1490 and 1500 and rainfall gage #5 was used for subareas 1400, 1410, 1413, 1415, 1417 and 1420. The results of the four (4) storm calibrations at gage No. 0139150 (shown on Table 15) indicate that hydrograph peaks for all events reproduced observed values within acceptable limits. A detailed discussion of the calibration results for the 28 August 1971 storm follows:

The reconstituted hydrograph is calibrated to the Lodi gage (HEC-1 POI 95) with reasonable losses to duplicate the observed hydrograph peak (Figure 25). The subarea STRTL and CNSTL variables ranged from 1.5 to 3 inches and 0.1 to 0.73 in/hr respectively. The observed peak discharge of 3,535 cfs was recorded at 7 p.m. on 28 August 1971. The HEC-1 model reconstitution of the event yielded a flood hydrograph of comparable magnitude and timing. The computed peak was 3,350 cfs at 7 P.M. on 28 August. The peak difference of 5%, volume difference of 5% and no timing difference are illustrative of the reliability of the model and the assumptions made concerning unitgraph parameters and loss rates for the 16 subareas.

<u>Passaic River Lower Valley (May 1968 Event)</u>. The Passaic River Lower Valley is structured for HEC-1 by combining previously analyzed subbasins with additional subareas. The Subbasin's subarea delineation and its schematic representation are shown on Figure 24. Since there are no streamflow gages along the Passaic River in this subbasin, the system was examined by simulating the May 1968 storm. Observed inflow hydrographs were input for the mainstream Passaic at Little Falls and for the Saddle River at Lodi. Recording rain gages used to determine the rainfall distribution patterns were selected for each subarea by constructing Thiessen polygons for each rain gage operating at the time of the storm. For this storm, rainfall gage #1 applied to subareas 1540, 1580, 1600, 1610, 1620,; rainfall gage #8 applied to subareas 1270, 1290,

1300, 1320, 1350, 1380, 1370, 1385, 1390, 1505, 1510, 1570, 1520, 1525, 1530, 1550, and 1560; rainfall gage #44 applied to subareas 1310, 1315, 1417; rainfall gage #46 applied to subarea 1280; and rainfall gage #5 applied to subareas 1360 and 1500. The total rainfall for each subarea was then based on the isohyetal map constructed for the May 1968 storm. Losses were assigned based on previously calibrated losses for gaged Lower Valley subareas. The subarea characteristics are listed in Table 12 and the routing criteria are given in Table 13. The TC and R values were obtained graphically from R vs DA and TC vs DA plots with more emphasis placed on the urban gaged data.

The final outflow response at the mouth of the Passaic for the May 1968 storm is a triple-peaked hydrograph (Figure 35). Each peak can be associated with a definable source. The predominant source of flooding in the Lower Valley results from the Little Falls observed peak of 13,500 cfs which occurred on May 31 at 12 noon. This inflow accounts for 762 square miles or 81.6 percent of the entire drainage basin. The wave smooths somewhat with passage down the Passaic River but attains a higher peak of 13,900 cfs due to additional runoff. This wave peak reached the mouth on 1 June at 4:00 a.m. as the final or third peak on the hydrograph.

The second peak is caused by the Saddle River which has a contributing area of 59 square miles or 6.3 percent of the entire drainage basin. The peak, having been routed to the Passaic, enters on May 30 at 2 p.m. with a peak flow of 3,350 cfs. The wave tends to smooth without diminishing until reaching the mouth on May 30 at 10 p.m.

The first peak corresponds to flooding from the remainder of the basin. The timing is earlier than the other peaks due to relatively little routing taking place before entering the Passaic River. Therefore, this peak enters the mainstream on May 29 at approximately midnight. Downstream lag causes the hydrograph to widen during tributary contributions but without attenuation.

Passaic River Central Basin (May 1968 Event). The 46 subareas of the Passaic River Central Basin are calibrated with Clark unitgraph parameters optimized to reproduce the 8/55, 10/55, 5/68, and 4/70 storms at the Beattie's Dam USGS streamflow gage No. 0138950 giving due consideration to the balance of the watershed above the dam. See Figure 25 for the HEC-1 subarea delineations and network nodal diagram. Initially selected R and TC values for the 46 subareas were determined from plots of R vs DA and TC vs DA. The TC and R values were then further adjusted to reflect the effects of slope, percent water area, percent swampland and other subarea physical characteristics as determined from inspection of USGS quad sheets and aerial photos. The final values of the unitgraph parameters adopted for the Central Basin, shown in Table 12, are held constant for each calibration storm. In this subbasin, rainfall gage #15 was used for subareas 1100, 1110, 1120, 1130, 1140 and 1150; rainfall gage #8 was used for subareas 1155, 1160, 1170, 1180, 1190, 1200, 1210, 1220, 1230, 1240, 1250 and 1260; rainfall gage #46 was used for subareas 390, 400, 410, 420, 430, 440, 510, 520, 530, 540, 560, 570, 580, 140, 150, 210, 220, 230, 590, 600, 610 and 620; and rainfall gage #54 was used for subareas 130, 160, 170, 180, 190 and 200. The respective gage recordings were used for all the calibration storms: 8/55, 10/55, 5/68 and 4/70.

Following is a detailed discussion of flow behavior and the HEC-1 modeling procedure adopted to simulate the flood routing due to the unique flood wave movement in the Central Basin.

Without an understanding of flood wave routing in the Central Basin, it might be expected that, under existing conditions, peak discharges occurring at Beattie's Dam would be larger than those on the Pompton River at Pompton Plains given the differences in drainage areas (762 vs 355 sq.mi.). However, this is not the situation , as illustrated by the fact that the 100 year peak at Pompton Plains is in excess of 32,000 cfs while the corresponding peak at Little Falls is less than 28,000 cfs. Thus, the peak for the larger watershed is significantly lower than that for the smaller one. Also note that flood peaks on the Pompton at its confluence with the Passaic occur 40-50 hours prior to the Passaic peaks at this confluence during basin-wide floods of substantial magnitude.

This phenomenon occurs because downstream of Two Bridges the Passaic River channel is very constricted, in part because of the presence of a narrow gorge and Beattie's Dam. This constraint tends to limit the flow out of the Two Bridges confluence to Beattie's Dam and the Lower Valley and creates a backwater effect which influences flows upstream. This backwater causes an energy imbalance which forces the Pompton River to reverse and flow upstream along the Passaic River into the Central Basin floodplain as well as downstream towards Beattie's Dam. The resulting combined flow from the total watershed above Two Bridges (Pompton plus Passaic) begins to fill up the natural storage areas of the Central Basin including the Great Piece Meadows. Flooding in the Passaic River reach upstream of Two Bridges is thus caused by both the Pompton and Passaic River floodwaters. This flow reversal continues until the water level at Two Bridges becomes equal to or less than that upstream. In addition to the initial flow reversal there is a second phase to this phenomenon. This second phase takes place when the peak stage along the Passaic River upstream of Two Bridges occurs 6-12 hours following the Pompton River peak discharge at Two Bridges. This peak stage results from the flow coming down the Passaic and reversed flow of the Pompton River. This combination produces a higher stage along the Passaic and lower Pompton Rivers than the individual peaks of the two streams do. This is due to the decreasing availability of storage in the Great Piece Meadows and the high coincidental flows on the Pompton River. Once again, the constrictive channel downstream of Two Bridges aggravates this flooding problem. Understanding this concept of flow reversal is important in order to comprehend the nature of flooding (in terms of peak discharges and stages) in the Central Basin, and to allow for a complete evaluation of flood management measures.

Due to the unsteady flow conditions in the Central Basin, several iterations in the calibration process were required to simulate this behavior. The preliminary, conventional calibration of the Central Basin consisted of an HEC-1 model based on simply adjusting the storage outflow relationships determined from initial HEC-2 runs. It was found necessary to increase storages generated with HEC-2 for the lower Pompton River to produce sufficient delay and attenuation of Pompton flows to calibrate to the Little Falls streamflow gage. This was considered unacceptable since such an adjustment of the storages does not accurately portray flow behavior in the Central Basin. Therefore, it was determined, through consultation with HEC, that an unsteady flow program ("DWOPER") be used to provide insight into the complex flood wave movement in the basin and to use the "DWOPER" model findings as a tool to improve the HEC-1 and HEC-2 calibration results and flow simulation.

Under request by NANPL-P, HEC prepared a "DWOPER" model for the Passaic Central Basin. The results of this model along with HEC recommendations towards improving the HEC-1 simulation of flow reversals are contained in HEC Special Projects Memo No.82-1 (attached).

HEC simulated the May 1968 event, SPF and an intermediate flooding event to determine the nature and extent of flow reversals in the Central Basin. Figure 36 is a typical flood discharge hydrograph produced with "DWOPER." Other outputs of the model include flood stage hydrographs. HEC's recommendation for the final HEC-1/HEC-2 calibration included the use of diversion functions, revised storage vs discharge relationships, and revised stage-discharge curves to guide development of HEC-2 rating relationships. Upon analysis of these findings, rating relationships were developed from the "DWOPER" results to be used as a guide in the second iteration of developing flow lines with the HEC-2 model. This iteration of HEC-2 model results was then used to develop revised storage outflow relationships for the HEC-1 model. These revised storage vs outflow relationships, along with the "DWOPER" hydrographs for the 3 storms were used as an aid in the final HEC-1 calibration. However, as indicated previously, it was found necessary in the preliminary calibration of HEC-1 to further increase storage in the lower Pompton and Passaic Rivers to enable reproduction of the observed hydrograph at Beattie's Dam. The additional storage provided the required delay and attenuation of Pompton flows. In reality the storage occurs primarily on the Passaic River upstream of Two Bridges rather than on the lower Pompton. An alternative to this adjustment was to divert (conceptually) a portion of the Pompton River flow to a location on the Passaic River upstream of the Great Piece Meadows. The diversion option of HEC-1 allows for the diversion of a portion of stream flow and it also permits the establishment of a threshold flow at which diversion begins. The diversion flow is withdrawn from one node location and applied as an input hydrograph at another node location. The diversion locations are displayed on the schematic nodal diagram shown in Figure 25.

The "DWOPER" simulated hydrographs were used to develop the diversion and lagging functions which gave the best reconstituted flows on the Passaic River at Little Falls and at the confluence of the Rockaway River for the three storm events investigated with the "DWOPER" model.

The first diversion simulates the flow reversal in the Whippany River occasioned by the backup of Rockaway River flow into Troy Meadows through which the Whippany River flows. Water is transferred by the hydrologic model from Node 13 on the Rockaway River to Node 15 on the Whippany where it is combined with the flow in the latter stream for subsequent routing through the meadows to the Whippany-Rockaway confluence. A schematic of the diversion is shown on Figure 27 and the diversion relationship is given in Table 14.

The second diversion simulates the flow reversal in the Passaic River above its confluence with the Rockaway and Whippany Rivers. The stage above this junction is controlled by the joint discharge of these tributaries which peaks much earlier and substantially higher than does the Passaic discharge. Water is transferred by the hydrologic model from Node 20 at the mouth of the joint tributary watershed to Node 6 on the Passaic where it is combined with the flow in that stream for subsequent routing downstream to the confluence. Again, see Figure 27 and Table 14.

The third diversion simulates the flow reversal in the Passaic River above Two Bridges. A detailed schematic of this area is shown in Figure 28. A Muskingum lagging without attenuation is applied to the Pompton outflow at Node 34 to simulate velocity decreases caused by the junction. The amount of lagging varies with frequency. A diversion of part of the lagged hydrograph to the Passaic River above Great Piece Meadows (Node 34 to Node 23), through which it will be routed following combination with the Passaic flow, is intended to simulate the Pompton flow into and out of the meadows; the inflow vs diversion relationship is shown in Table 14.

The movement into the Great Piece Meadows of Pompton flow delays the runoff of the joint Passaic-Whippany-Rockaway flow. The HEC-1 model attempts to account for this delay by lagging the joint flow without attenuation before it is combined with the diverted Pompton hydrograph for subsequent routing through the Great Piece Meadows. This lag does not vary with frequency (as does that at the mouth of the Pompton) since there was little noticeable dependency on flood magnitude under basin-wide flood events.

Two methods of routing are used in the Central Basin; Muskingum and Modified Puls. The Muskingum method is used for reaches where storage discharge relations were not developed. The Muskingum number of routing steps, K coefficient and X coefficient are presented in Table 13 for eleven reaches defined by the node or subarea extremities of the reach. The storage-discharge relationships used in the Modified Puls routing for seventeen reaches are also given in Table 13. The storage-discharge relationships were based on HEC-2 modeling and HEC's analysis using "DWOPER."

NOTE: The recorded flows from gage No. 0137950 Passaic River at Chatham, gage No. 0138050 Rockaway River above Reservoir at Boonton, gage No. 0138150 Whippany River at Morristown, and gage No. 0138850 Pompton River at Pompton Plains were input as given hydrographs into the Passaic River Central Basin model for each historic storm immediately upstream of nodes 1 (Passaic River), 9 (Rockaway River), 14 (Whippany River) and 25 (Pompton River), respectively.

The results of the four (4) storm calibrations shown on Table 15, indicate hydrograph peaks for the 8/55, 10/55, 5/68 and 4/70 events reproduced observed values that were within acceptable limits. A detailed discussion of the calibration results for the May 1968 storm follows:

The reconstituted hydrograph is calibrated into the Little Falls gage (HEC-1 POI 76) with the use of reasonable loss rates to duplicate the observed hydrograph peaks (Figure 37). The losses were 1.0 inch for STRTL and 0.30 in/hr for CNSTL. The observed peak discharge of 13,500 cfs was recorded at 12 noon on 31 May 1968. The HEC-1 model reconstitution of the eventyielded a flood hydrograph of comparable magnitude and timing. The computed peak discharge was 13,753 cfs at 6 a.m. on 31 May 1968. The peak difference of less than 1.9%, volume difference of 2.3% and the timing difference of 6 hours are good indicators of the reliability of the model and the assumptions made concerning the 3 diversion functions which simulate the flow reversals, and the hydrograph parameters and loss rates for the 46 subareas.

The results of the existing conditions hydrologic model calibration for the Passaic Central Basin are considered very good in light of the extremely difficult modeling procedures required. A comparison of computed versus the observed events at gage No. 0138950 is shown on Table 15. It will be noted that peak discharges are within 4%, 11% and 7% for the May 1968, intermediate flood and SPF events, respectively. The timing of runoff is also in close agreement. The agreement is to be expected for the May 1968 event because both models were calibrated to produce the observed hydrograph for that event. The fact that agreement is maintained for the intermediate flood and SPF events indicates that the HEC-1/HEC-2 approach should provide reliable estimates for outflow from the Central Basin, which is essential for evaluation of flood damages downstream from Beattie's Dam.

Passaic Highlands Subbasin (August 1971 Event). The Passaic Highlands is calibrated using Clark unitgraph parameters optimized to reproduce the 5/68, 4/70, 8/71 and 12/73 storms at the Passaic River USGS streamflow gage No. 0137950 at Chatham (see Figure 29 for the HEC-1 subarea delineations and network nodal diagram). The rainfall distribution patterns for each subbasin were developed using rainfall gage #51 for all storms. This rain gage, located outside the Passaic Basin in Watchung, is the nearest recording station and is situated about 10 miles southeast of subareas 10 and 15. The thirteen subarea TC's and R's, which are held constant for each calibration storm, were derived graphically from plots of R vs. DA and (TC+R) vs DA, as discussed in the "MODELING PROCEDURE" section. Adjustments were made to these values during the calibration to reflect the impact of the swampland in the subbasin. This subbasin has two major wetlands which greatly affect the flows. The Great Swamp, which encompasses part of subareas 20, 30, 50, 60 and most of subarea 40 causes the peak flow at USGS gage No. 0137900 Passaic

River near Millington to often be smaller than flows at gage No. 0137869 near Bernardsville, even though the drainage area is over six times larger.

Since all points of interest are located downstream from this swamp, the outflow of the Great Swamp area is modeled using a storage-discharge relationship located between nodes 104 and 105. Storage-discharge relationships were derived for each storm using the modeled flows from subareas 10, 15, 20, 30, 40 and 50 as the inflow and the observed flow at gage No. 0137900 minus the flow from subarea 60 as the outflow. An average relationship were obtained from these calibrations which reconstituted the flows at gage No. 0137900 satisfactorily for all storms. The final values of the unitgraph parameters adopted for the Passaic Highlands are shown on Table 12.

The second region of swamp (Dead River - Passaic wetland complex) covers parts of subareas 70, 80 and 90. This region, when modeled using storage discharge relationships, causes the peak flows to decrease between Points of Interest 3 and 4. The travel times between nodes 107 and 108 with the storage-discharge relationships were used as a guide for estimating the Muskingum variable AMSKK for the reach between nodes 105 and 106 and for the routing of subarea 80 to node 107. The Muskingum routing coefficients and the storage discharge relationships are given in Table 13 for each of the routing reaches.

The results of the four (4) storm calibrations shown in Table 15 indicated that hydrograph peaks for the 5/68, 8/71, 12/73 and 4/70 storms at gage No. 0137950 reproduced observed values within acceptable limits. A detailed discussion of the calibration results for the August 1971 storm follows:

The reconstituted hydrograph is calibrated to the Passaic River at Chatham streamflow gage (HEC-1 POI 6) with reasonable loss rates to duplicate the observed hydrograph peak (Figure 38). The loss rates ranged from 1.29 to 4 inches for STRTL and 0.98 to 0.26 in/hr for CNSTL. The observed peak discharge of 2,540 cfs was recorded at 8 a.m. on 28 August 1971. The HEC-1 model reconstitution of the event produced a flood hydrograph of comparable magnitude and timing. The computed peak discharge was 2,498 cfs at 7 a.m. on 28 August. The peak difference of 2%, volume difference of 4%, and 1 hour timing difference are indicative of the reliability of the model and the assumptions made concerning unitgraph parameters and loss rates for the 13 subareas.

Whippany River Subbasin (August 1955 Event). This model is calibrated with Clark Unitgraph parameters optimized to reproduce the 8/55, 10/55, and 4/70 storms at the Whippany River at Morristown USGS streamflow gage No. 0138150 (see Figure 30 for HEC-1 subarea delineations and network nodal diagram). As noted in the "MODEL CALIBRATION" section, initial R values for the 8 subareas were determined from plots of R vs DA. To maintain similar hydrograph responses in the subbasin, the initial values of TC chosen for the subareas were based on maintaining the regional values of R/(TC+R). For this subbasin the value of R/(TC+R) determined was 0.70 to reconstitute the historical events. Adjustments made to TC's and R's were based on the procedures previously discussed in the "MODELING PROCEDURE" section. With the adjusted parameters the subarea R/(TC+R) ratios ranged from 0.77 to 0.82. Final adopted unitgraph parameters are shown on Table 12. Due to lack of storage-- discharge relationships, the Muskingum routing method was used exclusively in this subbasin. The routing criteria applied between model nodes for the Whippany River Subbasin are shown in Table 13. For this subbasin, rainfall gage, #51 was used for subarea 450 and rainfall gage #46 was used for all other subareas, except during the 8/71 storm for which no data were available for gage #46 and gage #51 was used.

The results of the three (3) storm calibration indicate that hydrograph peaks for the 8/55, 10/55 and 4/70 storms reproduced observed values well within acceptable limits. A comparison of the computed vs observed event for gage No. 0138150 is shown in Table 15. A detailed discussion of the calibration results for the 8/55 storm follows:

The reconstituted hydrograph is calibrated to the Morristown gage (HEC-1 POI 30) with reasonable losses to duplicate the observed hydrograph peak (Figure 39). The subarea values of STRTL and CNSTL are 0.5 inch and 0.25 in/hr, respectively. The observed peak discharge of 1,160 cfs was recorded at 10 a.m. on 18 August 1955. The HEC-1 model reconstitution of the event yielded a flood hydrograph of comparable magnitude and timing. The computed peak discharge was 1,162 cfs at 9 a.m. on 18 August. The peak difference of an exceptionally low 0.1%, volume difference of 10% and timing difference of 1 hour demonstrate the reliability of the model and the assumptions made concerning loss rates and unitgraph parameters for the subbasin's 8 subareas.

Rockaway River Subbasin (December 1973 Event). The Rockaway River Subbasin is calibrated with Clark unitgraph parameters optimized to reproduce the 5/68, 4/70, 8/71 and 12/73 storms at the Rockaway River USGS stream flow gage No. 0138050 upstream of

Boonton Reservoir. The twenty-five subarea TC's and R's, which are held constant for each calibration storm, were derived from plots of R vs DA and TC vs DA, as discussed in the "MODELING PROCEDURE" section. Adjustments were made to R based on the number and magnitude of lakes in each particular subarea. The subareas with increased R values due to the existence of lakes are 240, 250, 315, 325, 330, 340, 350, 370 and 377. Final unitgraph parameters adopted for the Rockaway Subbasin are shown in Table 12. The routing parameters used in calibration are shown in Table 13. Modified Puls routing was applied throughout the main stem of the Rockaway River, while the Muskingum method routings are restricted to the tributaries. For this subbasin, rainfall gage #15 was used for all subareas for the 8/71 and 4/70 storms. Data were also available at rainfall gage #46 for the 5/68 and 12/73 storms. For these two storms, gage #13 distribution was applied to subareas 240, 250, 315, 320, 370, and 375 and gage #46 distribution was applied to subareas 245, 260, 270, 280, 290, 300, 310, 322, 340, 342, 350, 360, 380 and 385.

The results of the four (4) storm calibrations indicate that hydrograph peaks for the 5/68, 4/70, 8/71 and 12/73 events reproduced observed values within acceptable limits. A comparison of the computed versus observed events at gage No. 0138050 is shown in Table 15. A detailed discussion of the calibration results for the December 1973 storm follows:

The reconstituted hydrograph is calibrated to the Rockaway River above Boonton Reservoir gage (HEC-1 POI 20) with reasonable losses (considering the seasonal factor) to duplicate the observed hydrograph peak (Figure 40). The subarea STRTL and CNSTL values were 0.22 inches and 0.06 inches/hours, respectively. The observed peak discharge of 4,280 cfs was recorded at 11 p.m. on 21 December. The peak difference of 3%, volume difference of 5%, and no timing difference are good indicators of the reliability of the model and the assumptions made concerning unitgraph parameters and loss rates for the 25 subareas.

Pompton River Subbasin (April 1970 Event). The Pompton River Subbasin is calibrated for 4 historical storms. The Clark unitgraph parameters were optimized to reproduce the 8/55, 10/55 5/68, and 4/70 storms at the Pompton River at Pompton Plains USGS streamflow gage No. 0138850 (see Figure 32 for HEC-1 subarea delineation and network nodal diagram). The subbasin is separated into 3 main channels 2 of which, the Pequannock and Wanaque Rivers, have many water supply reservoirs on them; the third channel, the Ramapo River, was previously calibrated (see earlier text). The subbasin is divided into 31 subareas of which many are well calibrated due to the fact that there exist nine USGS gages within the subbasin.

Initial estimates of TC and R for the ungaged subareas are based on the analyses which were discussed in the "MODEL CALIBRATION" section. The initial R's were determined as a function of drainage area from points obtained from the gages in the Pequannock-Wanaque River watershed. The initial TC's were calculated from the value of (TC+R) which was determined as a function of drainage area using a straight line on a plot of (TC+R) vs DA for the same gages used in the determination of R. Slight adjustments were made to TC and R during the calibration process. To develop similar hydrograph responses in the subbasin's 31 subareas, the adjusted TC's attempted to maintain the determined regional value of R/(TC+R). For this subbasin, the value of R/(TC+R) is 0.94. With the adjusted parameters the final subarea R/(TC+R) ratios ranged from 0.53 to 0.94. Final values for TC and R, which are held constant for each calibration storm, and STRTL, CNSTL, QRCSN ratio and RTIOR are given in Table 15 for each of the subareas.

The routing criteria for this subbasin, shown in Table 13, were based primarily on using the Muskingum method for stream reaches and the Modified Puls method for reservoirs. One exception to the latter is the Greenwood Lake routing where the Muskingum method was used because the Modified Puls data supplied by the reservoir operator proved unsuccessful in reproducing observed hydrographs at the downstream gage. Also, there is an absence of Muskingum routing parameters in Table 13 for the reach between nodes 8 and 9 during the 5/68 and 4/70 storms, since the Charlotteburg Reservoir was in use during these events. However, during the 8/55 and 10/55 storms, the Charlotteburg reservoir was not yet constructed and the Muskingum routing method was used. In all of the reservoir routes, data such as the storage-discharge relationships and starting elevations were obtained from the various reservoir operators or from Dam Safety Inspection reports. The storage-discharge relationships for the reservoirs are given in Table 13.

The recorded flows from Gage No. 0138800, Ramapo River at Pompton Lakes, were input as given hydrographs into the model for each storm immediately upstream of subarea 1090. For this subbasin, the rainfall distribution patterns were developed using rainfall gage #15 for all subareas for all calibration storms.

The results of the four (4) storm calibrations indicate that hydrograph peaks for the 8/55, 10/55, 5/68 and 4/70 events reproduced observed values within acceptable limits. A comparison of the computed vs observed event at gage No. 0138850 is shown in Table 15. It should be noted that, for this subbasin, there was a scarcity of accurate rainfall measurements in the northwest portion of the Pequannock-Wanaque watershed for the April 1970 storm and it was necessary to use a rain gage recording in New York to complete the isohyetals. Recording gage #15 (Wanaque-Raymond Dam) was used for all four calibration storm distributions. A detailed discussion of the calibration results for the 4/70 storm follows:

The reconstituted hydrograph is calibrated into the Pompton Plains gage (HEC-1 POI 61) with reasonable losses to duplicate the observed hydrograph peak (Figure 41). The losses ranged from 0.1 to 1.5 inches for the STRTL variable and 0.02 to 0.30 in/hr for CNSTL variable. These losses are low but reasonable because of the antecedent runoff of a prior storm. The observed peak discharge of 8,630 cfs was recorded at 7 a.m. on 2 April 1970. The HEC-1 model reconstitution of the event yielded a flood hydrograph of comparable magnitude and timing. The computed peak discharge was 8,728 cfs at 8 a.m. on 2 April 1970. The peak difference of less than 1%, volume difference of 5% and timing difference of 1 hour are indicative of the reliability of the model and the assumptions made concerning loss rates and unitgraph parameters for the subbasin's 31 subareas.

RESULTS OF CALIBRATION TO HISTORIC EVENTS

Based on the successful calibration results of the eight subbasins as previously described, the Passaic River Basin existing conditions hydrologic model was deemed capable of satisfactorily synthesizing hypothetical or other historical flooding events.

HYPOTHETICAL RAINFALL DISTRIBUTION PATTERNS

Reproductions of specific-fequency flood peaks were based upon the use of like-frequency rainfalls, the patterns for which were determined using the procedures and plates contained in U.S. Department of Commerce Technical Paper No. 40, "Rainfall Frequency Atlas of the United States." Standard Project rainfall was determined in accordance with guidance provided in EM 1110-2-1411, Civil Engineer Bulletin NO. 52-8, dated March 1952 and revised March 1965.

The point rainfall depths for the 1, 2, 5, 10, 25, 50 and 100 year storms were obtained from the isopluvial maps contained in Technical Paper No. 40. These depths, tabulated in Table 19, are for the 1, 2, 3, 6, 12, 18 and 24-hour durations. It should be noted that the 18-hour point rainfall depths were determined graphically by plotting depth vs the 1, 2, 3, 6, 12 and 24-hour durations as it is not contained in Technical Paper No. 40. The 500-year storm depths were obtained graphically by plotting the log of the return period vs log of the depth for each of the 1, 2, 3, 6, 12, 18 and 24-hour durations and extrapolating the results.

The 24-hour point rainfall distribution pattern was developed for each storm frequency by using the duration depths noted in Table 19. These distribution patterns are given in Table 20. The order of intensities of each of the four six-hour time blocks was obtained from EM 1110-2-1411, Civil Engineering Bulletin No. 52-8. Within the most intense six-hour time block the one-hour and three-hour depths were determined from Technical Paper No. 40 and the remaining three hours were calculated based on the percentages given for these hours on Plate No. 11 of EM 1110-2-1411. The remaining one-hour values were calculated for each of the remaining three six-hour time blocks by scaling the hourly values from a smooth curve.

The Standard Project Storm rainfall depth and distribution pattern for the planning area were developed using the procedures and plates from EM 1110-2-1411, Civil Engineer Bulletin No. 52-8. The 200 square mile, 24-hour precipitation index for the basin is 10.25 inches.

FREQUENCY ANALYSIS

A frequency analysis was performed on all USGS gages in the Passaic River Basin using procedures described in "Hydrologic Frequency Analysis," EC 1110-2-249 dated 5 June 86. This document incorporates Water Resources Council Bulletin 17 B, "Guidelines for Determining Flood Flow Frequency" utilizing the Log-Pearson Type III distribution method for the statistical analysis of the gaged data. The expected probability and partial duration adjustments were made to all gages to obtain the final adopted frequency curves. For the partial duration adjustment to the curve, the Langbein method was used. To justify the use of this method, a Weibull plotting position analysis was performed on secondary annual peak flows which are above a base flow for 11 USGS gages in the Passaic River Basin. The plotted results were closely matched with the more simple Langbein method for each gage, as subsequently discussed in detail in the partial duration analysis section.

Record Homogeniety. Stream flow records at the gages pertinent to the considered main-stem plan of improvement (Section G below) are fairly homogeneous. This is a function of the spatial and temporal patterns of urbanization and to a great extent the remaining natural areas. See Section F - Urbanization and Preservation of Natural Storage. This homogeniety was demonstrated by rainfall-runoff comparisons.

Adjustments to Statistical Parameters. Table 41 shows the statistical parameters based on station data and also any indicated adjustments based on consideration of generalized skews, historical flood peaks and (where the record at a pertinent gaging station was too short to provide reliable results) correlation with another, long term, station. Source for the generalized skews was Special Projects Memo 480 of the Hydrologic Engineering Center entitled "Generalized Skew Study for State of New Jersey" and dated December 1977.

Annual Series. It should be noted that the frequency curves at the gages were statistically developed without separating the hurricane and non-hurricane events. There were many peak flows at the gages which did not occur during the hurricane season. The plotted frequency curves fit the historical data well without resulting in a high skew. Figures 42 through 48 show the frequency curves in addition to the following information: drainage area above gage, DA; mean logarithm of the annual peak flows, M; standard deviation of the logarithms, S; adopted skew coefficient of the logarithms, G; the number of annual peak flows, N; and the plotted confidence limits, which provide a measure of uncertainty in the discharge for a selected frequency. A brief summary of the 7 gages follows:

a) Passaic River at Chatham, DA = 100 sq.mi., N = 55 years, Feb. 1903 to Dec. 1911 and Oct. 1937 through 1984.

b) Rockaway River above Boonton Reservoir, DA = 116 sq.mi., N = 47 years, Oct. 1937 through 1984; with estimated Oct 1903 historical flood peak, N = 81 years.

c) Whippany River at Morristown, DA = 29.4 sq.mi., N = 64 years, Aug. 1921 through 1984; with estimated Oct. 1903 peak, N = 81 years.

d) Ramapo River at Pompton Lakes, DA = 160 sq.mi., N = 63 years, Oct. 1921 through 1984; with estimated Oct. 1903 peak, N = 81 years.

e) Pompton River at Pompton Plains, DA = 355 sq.mi, N = 44 years, May 1940 through 1984; with estimated Oct. 1903 peak, N = 81 years.

f) Passaic River at Little Falls, DA = 762 sq.mi., N = 88 years, Sept. 1897 through 1984.

g) Saddle River at Lodi, DA = 54.6 sq.mi., N = 61 years, Sept. 1923 through 1984; with estimated Oct. 1903 peak, N = 81 years.

The USGS gage on the Mahwah River at Suffern was the only gage adjusted to reflect a longer period of record (that for the USGS gage on the Ramapo River at Mahwah). Details are given in the Mahwah/Suffern Interim Report, Phase I, General Design Memorandum, dated March 1983.

The hypothetical flood hydrograph peaks developed in the hydrologic model were matched within reasonable limits against the peak flows for each flood event at all USGS gages. The hypothetical rainfall distribution patterns were developed from Technical Paper No. 40 (TP40) for the 1-year through the 100-year flood frequency events and from EM 1110-2-1411, Civil Engineering Bulletin No. 52-8. The 500-year event is extrapolated from the above frequencies.

The Standard Project Flood (SPF) rainfall was derived solely from EM 1110-2-1411, as discussed above in the "HYPOTHETICAL RAINFALL DISTRIBUTION PATTERNS" section. Whereas the historical flood calibrations used actual rainfall data in the model, the hypothetical storms were modeled with the depth-area relationship applied to the TP-40 point rainfall pattern for all frequencies. This method is explained in Addendum 2 in the HEC-1 User Manual as the Stream System (or Multiple Flood Computation) procedure. The relationship of rainfall vs area for each frequency storm analyzed is included in Table 18. Once the hydrologic models of the hypothetical storms were calibrated to the USGS gage for all frequencies analyzed, the frequency-discharge relationships, at a minimum, were obtained for all previously identified points of interest in the subbasin in addition to the gage locations. The frequencies analyzed were the 1-, 2-, 5-, 10-, 25-, 50-, 100- and 500-year events. Table 23 shows the peak discharge for each investigated frequency at ungaged locations (HEC-1 nodes) in the 8 subbasins.

The subarea unitgraph and routing parameters developed in the historical storm calibration process were used in the hydrologic model for the various specific-frequency storms. The rainfall loss rates were adjusted in each subbasin to reproduce the peak flows at the gages. The loss rates were adjusted to be within acceptable limits in order to obtain acceptable reproductions.

Partial-duration Analyses. The stream flow gages used to develop the partial duration series are the following:

Passaic River at Millington, gage No. 0137900
Passaic River at Chatham, gage No. 0137950
Rockaway River above Boonton Reservoir, gage No. 0138050
Whippany River at Morristown, gage No. 0138150
Ramapo River at Mahwah, gage No. 0138750

Ramapo River at Pompton Lakes, gage No. 0138800
Pompton River at Pompton Plains, gage No. 0138850
Passaic River at little Falls, gage No. 0138950
Ho-ho-kus Brook at Ho-ho-kus, gage No.0139100
Saddle River at Lodi, gage No. 0139150
Second River at Belleville, gage No. 0139250

The data used for the analysis is in the "WATSTORE" peak flow file that was obtained from the USGS, Reston, Virginia. The flows were the annual peak and partial peaks for each gage above the current base flow as determined by the USGS. The flows were again checked for accuracy using published data and telephone conversations with the USGS office in Trenton, New Jersey.

In the development of the partial duration curves, historical peaks were not included and all of the historical records were continuous. The flows were arranged in descending order for each gage using a computer sorting routine. This formulated the y variable that corresponds to the flow in cfs, and x variable used in the plotting of the partial duration curves. The plotting positions were determined using the Weibull formula

$$P = M/(N+1)$$

where P = plotting position (exceedence frequency/100 years), M = order number of the event and N = number of years.

For each gage we now have an x variable (Weibull plotting position) and a y variable (flow in cfs). With the use of a computer plotting routine, both variables are converted to their respective logs (base 10) and plotted. Sample partial duration curves are shown on Figures 49 and 50. Also plotted on the same graph is the annual frequency curve for the particular gage.

Table 16 shows the results of the comparison between the annual event frequency and the partial duration frequency for the same flow value. There exists some variation in values obtained from different gages and the average of all of the gages is slightly greater than the theoretical values developed by Langbein. The theoretical values are based on the assumption that a large number of independent (random) events occur each year. If the number of events is small, the average values in Table 16 are expected to be smaller than the theoretical values. If the events are not independent (large events tend to cluster in some years and small events tend to cluster in other years), the average values in Table 16 would be expected to be larger than the theoretical values.

Table 17 shows the results of each gage's partial duration frequency divided by the theoretical Langbein value for each annual event frequency. The results do not show any clear trend of the ratios with respect to hydrologic (slope, land use, upstream regulation, drainage area, main stem, etc.) or geographic (highland, flood plain, etc.) similarities.

For example, three gages that might be expected to have similar highland area characteristics are Nos. 0138050 (Rockaway River above Boonton), 0138150 (Whippany River at Morristown) and 0138750 (Ramapo River at Mahwah). However, if the ratios on Table 17 are examined, moving from left to right on the table, there exists no trend or pattern of how the Passaic partial duration frequencies compare to the Langbein partial duration frequencies. The two main stem gages, Nos. 0137950 (Passaic River at Chatham) and 0138950 (Passaic River at Little Falls), have ratios that move in opposite directions in magnitude as one scans the table from left to right. Gages close to each other geographically such as gages No. 0138800 (Ramapo River at Pom ton Lakes) and No. 0138850 (Pompton River at Pompton Plains) also do not show any similarities in their comparisons to the theoretical Langbein formula.

The total basin average of the ratios of the Passaic station partial series frequencies divided by the Langbein partial series frequencies is 1.05. This value is an average of how all of the gages tested compared with the Langbein formula values at annual event frequencies of 0.080 through 0.900. The degree of difference between the the data values and the Langbein values is shown in Table 17, where the averages are listed above the Langbein values for annual event frequencies of 0.080 through 0.900. Because the results differ from the Langbein theoretical formula by only 5 percent, the Langbein theoretical curve is drawn on Figures 49 and 50 for purposes of comparison. The validity of the Langbein partial duration analysis was evaluated by the Passaic Study economist against historical damages and was found to be acceptable. Overall, the results of the partial duration analysis indicate that the Langbein method is a sound approach for the Passaic River Basin gages.

GAGED VERSUS MODELLED FREQUENCY RELATIONS

The hydrologic models of the Passaic River and its tributaries were able to closely reproduce, at all calibration gages and most other gages in the Passaic Basin, specific-frequency flood peaks from discharge-frequency relations updated through water year 1984 (Table 22). Thus, the models can be used with confidence (1), to determine specific-frequency flood peaks at sites remote from gaging stations under existing conditions, (2), to predict future discharge-frequency relations and (3), to evaluate the impact on discharges of various plans of improvement. With respect to future-conditions relations, it is noted that rainfall losses used to develop the updated 1984 relations will also apply in the future inasmuch as such losses are taken with respect to pervious watershed components only. Thus, any increases in specific-frequency flows in the future will be the result of shortened basin response times (reflected in unitgraph parameters) or larger runoff volumes (due to increases in impervious watershed surface areas).

Four of the calibration gages are located at the downstream limits (outlets) of subbasins within the Highland Area. Downstream of these outlets, flow enters the Central Basin. These 4 USGS gages are: (1) Passaic River at Chatham; (2) Rockaway River above Boonton Reservoir; (3) Whippany River at Morristown; and (4) Pompton River at Pompton Plains. The fifth gage, Ramapo River at Pompton Lakes, is in the Highlands Area and is upstream of the gage on the Pompton River at Pompton Plains. The remaining gages are located on the Passaic River at Little Falls and the Saddle River at Lodi. The results of the frequency analysis at each of the seven gages are discussed in the following paragraphs:

Passaic River at Chatham. The modeled hypothetical storm flow values for each frequency are within + 6 percent of the frequency curve developed statistically from the gaged data. The loss rates used to reproduce all frequencies reflect the fact that this subbasin contains significant wetland areas, including the Great Swamp, which signifies that very little water would be lost (Table 21). Rather, most of the water is temporarily stored, as can be seen in the relatively high R values for each subarea unitgraph (Table 12). There is also considerable overbank storage in the routing reaches. The Oct. 1903 flood peak was measured at the Chatham gage and is actually included in the frequency analysis. The computed station skew at Chatham is 0.36 and the adopted skew is 0.30. Table 22 compares the hypothetical storm values statistically developed from the gage with the HEC-1 modeled hypothetical storm values.

Rockaway River above Boonton Reservoir. The modeled hypothetical storm peaks are very similar to the gaged flow data for all frequencies. This subbasin contains a great deal of natural storage volume other than the wetland or swamp type of storage. This storage is in the form of numerous small lakes and ponds. The subareas of this subbasin are relatively long and narrow in shape resulting in flat broad unitgraphs as shown by the relatively high Clark's R values (Table 12). The base flows in the subareas are high due to the natural storage as reflected in the QRCSN and RTIOR values. The computed inclusion of the historical Oct. 1903 flood peak in the statistical analysis has the effect of increasing the 100 year flood peak by approximately 900 cfs more than the frequency curve without inputting this flood into the statistical analysis. The skew coefficients used are: regionalized = 0.30 and final adopted =0.40. The adopted skew is based on a weighting procedure of the regionalized skew with the station computed skew. The regionalized skews are based on the "Generalized Skew Study for the State of New Jersey" done by HEC in 1977. The values are either 0.3 or 0.4 for gages in the Passaic River Basin. Table 22 compares the hypothetical flood values statistically developed from the gage data with the HEC-1 modeled hypothetical flood values. Table 21 lists the Rockaway Subbasin loss rates for hypothetical flows.

Whippany River at Morristown. The modeled storm peaks approximate the statistically derived gage data for all frequencies. The loss rates used in all of the subbasins' subareas are very similar for all frequencies but do have a downward trend for the CNSTL value for the 5-year through 500-year frequencies (Table 21). Only the 1- and 2-year frequency loss rates seem relatively low. There is a moderate amount of storage indicated by high Clark's R values for the subarea unitgraphs and low Muskingum X values of 0.02 in the routing reaches (Tables 12 and 13). The base flow is moderate with QRCSN = 0.15 and RTIOR = 1.5 in all subareas. The inclusion of the Oct. 1903 computed flood peak has no impact on the statistical frequency curve. This storm did not affect the southwest portion of the Passaic Basin as intensely as the remaining parts of the Passaic Basin. The adopted skew coefficient is 0.10, which is weighted from a regional value of 0.3 and a station skew of 0.05, resulting in a frequency event curve with a relatively small positive skew. The SPF peak flow is thus close to the 0.01 percent exceedence frequency mainly due to the low skew in the curve. A comparison of the hypothetical storm values statistically developed from the gage data with the HEC-1 modeled hypothetical storm values is shown on Table 22.

Ramapo River at Pompton Lakes. The modeled storm peaks are very close (+ 4%) to the gaged data (Table 22) for all frequencies. Loss rates used in modeling are given in Table 21. There is a moderate amount of storage due to rural land use in the subareas as indicated by moderate unitgraph Clark's R values and base flow parameters where QRCSN = 0.20 and RTIOR = 1.5 for the subareas (Table 12). The Ramapo River analysis used different floods of record than the rest of the Passaic Basin. Here, those of March 1936 and October 1955 (the two largest of record) were used because the subbasin was closer to the centers of these events. The inclusion of the Oct. 1903 computed flood peak in the frequency analysis had a moderate impact on the statistical analysis. The adopted and regionalized skews are 0.40 with the SPF being approximately equal to the 500 year flood.

Pompton River at Pompton Plains. The modeled hypothetical flood peaks are fairly close to the statistically derived gage data (Table 22). The loss rates used to match the gaged data are generally reasonable for the entire subbasin which includes the subareas above the Ramapo River at Pompton Lakes gage, previously discussed (Table 21). There is a great amount of storage in the basin due to the large number of reservoirs in the Wanaque and Pequannock River watersheds (Table 13). The high Clark's R values in the subareas' unitgraphs and relatively high base flow in which QRSCN =-0.2 and the RTIOR = 1.2 reflect the natural storage throughout the subbasin (Table 12). The Oct. 1903 computed flood peak has a small impact on the final statistical frequency curve. The adopted skew coefficient is 0.2 which is weighted from a regionalized value of 0.4. The SPF discharge of 53,311 cfs is very close to the 500-year flood discharge of 54,153.

Passaic River at Little Falls. The modeled hypothetical floods are fairly close to the gaged data for all frequencies (Table 22). The percent difference in peak flows for the modeled flows versus the gaged data vary from +1% for the 100 year flood to -11% for the 1 year flood. The loss rates used to match the gaged data peaks are reasonable for all frequencies (Table 21). There is considerable storage in the Central Basin in the form of large wetland areas upstream of the Little Falls gage (Table 13). In the Central basin, the upstream boundaries are identified by the following 4 USGS gages ; Passaic River at Chatham, Rockaway River above Boonton Reservoir, Whippany River at Morristown and Pompton River at Pompton Plains. The downstream limit of the Central Basin is the Passaic River at Little Falls USGS gage. The drainage area of this basin is 262 square miles. For the hydrologic model, the Central Basin is divided into 46 subareas and 17 routing reaches which contain measured storage-outflow relationships. The hydrologic model inputs hydrographs for each of the frequencies from the 4 upstream streamflow gages, previously mentioned, and proceeds to model the Central Basin. The baseflow in the Central Basin is moderately high with QRCSN = 0.3 and RTIOR = 1.3 for all subareas and high Clark's R values for all subarea unitgraphs (Table 12). Flow reversals are modeled by diversion and lagging functions in the Two Bridges area and the Rockaway-Whippany-Troy Brook area (Table 14). These areas of flow reversal made the Central Basin an extremely complex subbasin to model and analyze. The October 1903 and the almost equally large March 1902 floods were measured and included in the frequency analysis at the Little Falls gage. The gage has 90 years of record for deriving the adopted frequency curve, the longest record for all gages in the Passaic Basin. The adopted skew coefficient is 0.5 which is weighted from a regionalized value of 0.4. The SPF is approximately a 400-year flood.

Saddle River at Lodi. The modeled hypothetical floods are very close to the gage data for all frequencies (Table 22). Three USGS gages in the Saddle River Subbasin above Lodi were also analyzed for reproducing each frequency from the hydrologic modeling process. These gages are: Saddle River at Ridgewood, Ho-ho-kus Brook at Ho-ho-kus and Sprout Brook at Rochelle Park. The loss rates vary to reflect markedly different land use patterns in various parts of the subbasin for all frequencies and are reasonable, although the constant loss rates are relatively low at the rarer frequencies above the 50-year storm (Table 21). The subbasin is basically urbanized with a moderate natural storage area at the Sprout Brook confluence and proceeding upstream toward the Ho-ho-kus Brook confluence. The subarea base flows are moderately low with QRCSN = -0.16 and RTIOR = 2.0 (Table 12). In the statistical analysis of the gaged data, the computed October 1903 flood peak has a significant impact on the final frequency curve in which the 100 year flood is increased by 840 cfs (from 5,890 to 6,730 cfs) above the discharge generated by exclusion of this historic event. The regionalized and adopted skew coefficients are both 0.40.

Passaic Lower Valley Tributaries. The Passaic Lower Valley extends from the USGS gage at Little Falls downstream to the mouth of the Passaic River at Newark Bay. The main tributaries of the Passaic in the Lower Valley are the Peckman River, DA = 9.78 sq.mi.; Molly Ann's Brook, DA = 7.94 sq. mi,; Saddle River, DA = 59.14 sq.mi.; Third River, DA = 12.77 sq.mi.; and Second River, DA = 11.60 sq.mi. The total drainage area of the Lower Valley, including the Saddle River Basin, is 172.43 square miles. The recording USGS gages used in the Lower Valley portion of the hydrologic model are: Little Falls at the upstream boundary, Saddle River at Lodi, Weasel Brook at Clifton, Second River at Belleville and Third River at Nutley. There are no streamflow gages located on the Passaic River downstream of Little Falls with which to compare modeled results. Therefore, the HEC-1 modeled peak discharges for each frequency were determined from subarea parameters which have been calibrated from the remainder of the Passaic River Basin and from measured routing parameters. See Table 21 for the sub- area loss rates used in the development of hypothetical flows.

Typical Specific-frequency Hydrographs. A typical hypothetical hydrograph is shown for the 100-year flood at each of the hydrologic subbasin outlet gages (Figures 64 through 69 plus 81).

Other, Non-boundary Conditions Gages. The hydrologic model was able to closely reproduce specific-frequency discharges at many other, non-boundary conditions, gages. This, too, will be apparent from review of Table 22. Greatest departures will be found in connection with gages on small streams tributary to Wanaque Reservoir, but these are gages not specifically sited with a view to determining peak flows (their function was apparently to provide low-flow data for water supply purposes).

SIMULATION OF RUNOFF FROM NON-CALIBRATION HISTORIC STORMS

Runoff from the October 1903 storm, the April 1984 storm, and the transposition of Hurricane "Agnes" (June 1972) from the Susquehanna River Basin to the Passaic River Basin was simulated using the calibrated HEC-1 Passaic River Basin hydrologic model. The purpose of this work was to permit evaluation of the considered plans of improvement against large events.

Storm of October 1903. For the 8-9 October 1903 storm, the basin-wide isohyetal pattern was developed from various non-recording rain gages and is shown on Figure 8. The hourly distribution of the rainfall used is represented by the Newark hourly recording rain gage for the entire basin. The subarea loss rates were adjusted in the model to reconstitute the recorded discharges. On the Rockaway River, the HEC-1 model predicted an instantaneous flood peak of 8,050 cfs at Boonton Reservoir under present conditions vs a recorded peak daily average of 7,560 cfs at the USGS gage just downstream of the present dam. On the Pompton River at Pompton Plains, the reproduced peak of 29,048 cfs is equivalent to a recorded peak of 28,340 cfs. It was assumed that there was a significant natural detention area at the site of the future Wanaque Reservoir. This assumption is based on the relatively low annual flood peak events on the Wanaque River at the Wanaque USGS gage from 1913 to 1927, which is prior to construction of the reservoir. The October 1903 storm is generally about a 100 year flood event throughout the Passaic River Basin, but is closer to a 50 year event in some areas. From the isohyetal map, the total rainfall from each subarea in the Basin is shown in Table 26. The hourly distribution from the Newark gage is shown in Table 27. The peak discharges at various USGS gages and points of interest are shown in Table 28. For comparative purposes, the 100 year discharges calculated by the HEC-1 model at these points are also given in this table. There were some USGS gages in operation in 1903, for which recorded discharges are given in Table 9. Hydrographs with and without the recommended plan of improvement are shown on Figures 89 through 91.

Storm of April 1984. The hydrologic model discussed above was used to reproduce the flood of April 1984 with a view to evaluating the impact thereupon of the considered plans of improvement. The reproduction did not attempt to model the basins tributary to the upstream-most gages, but used the hydrographs at these gages as boundary conditions because the considered plans of improvement were all located downstream of these gages. Results of the reproduction effort and improvement evaluation are shown on Figures 52 and 86 through 88.

Transposed "Agnes". The transposition of Tropical Storm "Agnes" (June 1972) from the Susquehanna River Basin just north of Harrisburg, Pennsylvania to the Passaic River Basin was made to permit simulation of the effects of a great tropical storm on the Passaic Basin and evaluation of the impact on the flood accompanying such a storm of the considered plans of improvement. It should be noted that "Agnes" was a hurricane in the Gulf before entering the western Florida mainland. The isohyetal map for Tropical Storm "Agnes" was obtained from the National Weather Service and post-flood reports. The isohyetal pattern was placed over the Passaic in various orientations until a worst-case centering was found. The isohyetals ranged from 9" to 18". The worst-case centering was over Pompton Lakes. The total rainfall and peak rates of rainfall are much greater for the transposition of "Agnes" than for the October 1903 storm. Thus, as expected, Transposed "Agnes" caused a flood which was greater than the Standard Project Flood (SPF) for the Pompton River Basin and for the Passaic River below Two Bridges. The other tributary areas to the main stem produce peak discharges which are near the SPS. The loss rates selected for the simulation of the Transposed "Agnes" storm are the losses used in the 100 year storm events in the HEC-1 model. The isohyetal map of Transposed "Agnes" centered over the Passaic Basin is shown in Figure 16. Rainfall totals in every subarea from the isohyetals are tabulated in Table 24. The hourly rainfall distribution based on the Harrisburg recording rainfall station is shown in Table 25. Hydrographs with and without the recommended plan of improvement are shown on Figures 92 through 94.

TIDAL FLOODING AND STORM-SURGE MODELING.

The Passaic River from its mouth upstream to Dundee Dam, a distance of 17.4 miles, is subject to tidal flooding. Consequently, the stages on the Passaic River from the mouth at Newark Bay to Dundee Dam are influenced both by fluvial and tidal conditions. The tidal flood of 12 September 1960 (Hurricane "Donna") caused a water level of 8.33 feet NGVD at the East Newark tidal gage on the lower Passaic River (see Figure 53 for the location of tidal gages in New York Harbor). This 8.33 foot tide coincided with a fluvial discharge of 2,700 cfs, about 50% of the peak discharge of 5,340 cfs recorded at Little Falls during that storm. Extreme high stages recorded at the East Newark gage vs coincidental discharges at the USGS gage at Little Falls are shown in Table 31.

As part of the 1972 Passaic River Report, a study was made of the synchronization of high tides and peak floods on the Passaic River in order to determine what tide elevation should be used in Newark Bay for the design floods. The times of occurrence of the two highest flood peaks per year at S.U.M. Dam for the period 1893 through 1955 and at Beattie's Dam for the period 1955 through 1960 were compared to the times of occurrence of the corresponding high tides in Newark Bay for the month and year in which the floods occurred. A short-term record was correlated to the long-term record at Fort Hamilton to determine a correction that was applied to the Fort Hamilton records to synthesize the Newark records from 1893 to 1938. The study revealed the following:

a. The tides synchronizing with the peaks of experienced floods were about 30 percent less than the peak tide of the month and closely approached the value of the mean high tide of the month. The mean high neap tide is 2.45 feet NGVD, the mean high spring tide is 3.60 feet NGVD and the mean high tide is 3.02 feet NGVD;

b. Fifteen percent of the peaks of all floods, which ranged from 2,700 to 19,500 cfs, occurred with tide elevations between 4 and 5 feet NGVD, and over 75 percent occurred with tide elevations between 2 and 4 feet NGVD;

c. The greatest flood of record, namely that of October 1903, occurred with a tide elevation of less than 4 feet NGVD.

As per NADPL-F (21 Oct 81) 1st Ind dated 10 November 1981, Subject: NAD-NANEN-P meeting regarding Passaic River Basin hydrology, NAD indicated the following: a), in accordance with ER 1105-2-111 a Standard Project Tidal Flood is required when alternatives are to be formulated for tidal flood protection in urban areas, and b), ocean and bay storm-surge modeling would be necessary per guidance in DAEN-CWE-H multiple letter dated 22 June 1978, Subject: "Hurricane Surge Analysis".

The decision to develop a comprehensive ocean and storm surge model to obtain tidal stage-frequency relationships for the Passaic River was also included in NAD comments on the "Passaic River Status of Plan Formulation Report" inclosed in NADPL-F (30 April 82) 1st Ind dated 30 July 1982. In NADPL-F (22 Jan 82) 2nd Ind of the "Hackensack River, N.J. & N.Y. Reconnaissance Report", dated 2 August 1982, the need for coordination between tidal surge studies for the Passaic and Hackensack Basins was indicated. A joint study of the two basins was proposed in the 25 August and 3 September 1982 NANPL-P letters, Subject: Tidal Surge Study for the Passaic and Hackensack Rivers, and was subsequently approved via DAEN-CWE-HD (25 Aug 82) 2nd Ind dated 16 September 1982. The purpose of this study was to develop a stage-frequency curve for hurricanes and northeasters and their combined effects along the tidal reaches of the Passaic River up to Dundee Dam for the presently existing conditions. The study utilized Monte Carlo Joint Probability techniques for both hurricanes and northeasters.

The study used two calibrated and verified numerical hydraulic models, an offshore surge generation model which used a finite-difference grid with a five nautical-mile resolution to simulate from meteorologic driving forces the storm surge generation on the continental shelf portion of the New York Bight and within Long Island Sound, and a second, hydrodynamic, model linked to the offshore model to provide a finer spatial resolution in the study area. This near-shore surge propagation model used a link-node discretization of the embayments and waterways to simulate the surge propagation up to and along the Passaic River. A large number of synthetic storms (252 hurricanes and 43 northeasters) were simulated from meteorologic inputs to derive the final frequency-elevation curves. In this manner, accurate and hydrodynamically consistent frequency curves were developed along the entire coastline. Analyses of the measured maximum elevations at tide gages were used only for comparison and verification.

The methodologies and models used in the Passaic River surge study were expanded and adapted from the Flood Insurance Study for the City of New York performed for the New York State Department of Environmental Conservation. The flood insurance study was funded by the Flood Insurance Administration (FIA) of the Federal Emergency Management Agency (FEMA). In the flood insurance study, extended calibration and verification of both the open coast and inland models was performed. Sensitivity analyses showed that the results of the offshore simulations of the synthetic storms were directly applicable to the Passaic River Study.

However, the inland model required extension and modification to accurately simulate Newark Bay and the Passaic and Hackensack Rivers. Hydrographic considerations show that simulation of storm surges along the Passaic River is greatly affected by the adjacent Hackensack River and the Meadowlands complex. Therefore, while this study is primarily focused on the Passaic River, the network was extended to include the effects of the Hackensack River. Although the Hackensack River - Meadowlands portion of the model was only calibrated so as to accurately portray the effect of the Meadowlands on the Passaic River in the present study, complete calibration of the Hackensack portion of the network will only require minor additional geometric adjustments to the network in a future phase of the study and will not affect the results of the Passaic Study.

The Passaic portion of the investigation was completed on schedule in October 1983 and the results have been incorporated into the findings of this current study. The results of the tidal study represented 1983 conditions, which are being used as existing conditions. Figure 54 shows the final East Newark stage-frequency curve as well as curves for 1990 and 2040. These latter curves were developed using an estimated rise in sea level of 0.1 feet per decade. This estimate was coordinated with WES (Waterways Experiment Station, Vicksburg, Miss.), which concurred that it was an acceptable estimate for this area.

SECTION F - URBANIZATION AND PRESERVATION OF NATURAL STORAGE

INTRODUCTION

Many parts of the Highland and Central Basin areas of the Passaic River Basin are presently undeveloped. Future land use projections, as discussed in the ECONOMICS portion of this report, indicate increased development in the undeveloped regions. An investigation was made of the impact that such development would have on future flood flows in the potential project area. The analysis was performed in two steps as follows:

1. The impact of future urbanization on changes in unit hydrograph parameters and flood volumes (the latter a consequence of increasing imperviosity) was first determined for the entire watershed, except for development projected for the wetland areas of the Central Basin.

2. The hydrologic and hydraulic impacts of future development on changes in flood storage in the Central Basin wetlands was determined incrementally to the urbanization effects.

Historical urbanization of the Passaic River Basin prior to the 1970's has had no significant impact on stream discharge entering the major areas of interest, the Pompton Valley, the Central Passaic Basin and the Lower Valley from Beatties Dam to Dundee dam. There are two primary reasons for this. The first, and by far most important reason is the fact that development prior to 1970 significant development did not take place in the Pompton/Ramapo tributary valley that generates the bulk of the flood flows to the project area. Historical development was essentially confined to the areas from Beatties Dam to the mouth and isolated areas in the upper Passaic watershed. The Lower Valley areas were initially developed to a great degree at the turn of the century and ongoing redevelopment reflected an intensification of urban development. Essentially one type of impervious surface was traded for another. Although the Upper Passaic watershed experienced some growth prior to 1970, this area generates flood peaks that are greatly attenuated by the natural storage areas of the Central Basin, and equate to only about one third of the Pompton Valley flows. The second primary reason was that any residual development which did take place was not linked by a well-defined channel or storm water system to an established watercourse. This development tended to drain to permeable surfaces which resulted in significant absorption. A series of statistical analyses were performed at the gages entering the major areas of interest to confirm this. Both rainfall and streamgage records prior to 1978 were analyzed. It was found that the relative rate of change in rainfall was greater than the relative rate of change in streamflow indicating that urbanization changes were not significant in estimating the Basin's hydrologic response.

A great deal of the Passaic River basin is impermeable under natural conditions, or nearly so. The soil cover over bed rock in the mountains and on valley sides slopes is often thin with little water absorption capability. The water table in many areas is very close to the surface, again leaving little absorption capability, particularly in the vast Central Basin wetlands and floodplains. These areas are underlain by organic meadow mat and extensive clay deposits. In the Lower Valley, the coastal areas have been densely developed since the turn of the century. Obviously, the paving of such areas would have little negative impact even when considered cumulatively.

Future development will continue to occur in the Central Basin and Highland areas in a less haphazard manner. It will include positive drainage provisions which could result in increased stream runoff. The methodology used to assess future urbanization treats all such areas for which development is projected as being linked by these drainage provisions.

The future loss of Central Basin natural storage was evaluated as a separate step because of the need to determine the feasibility of protecting such storage as a Federal flood damage reduction measure. The combined effects of both impacts were evaluated as without-project conditions for the watershed. Each of these studies are discussed in this section.

URBANIZATION

An investigation was made of the impact that future development would have on runoff throughout the Passaic River Basin for the years 1990 and 2040 without local mitigation of hydrologic impacts via stormwater management or other local land use controls. Development beyond 2040, which is not expected to be significant, has been assumed to be subject to such controls, precluding further changes in discharges. Table 32 presents a summary of the development acres expected through the year 2040. Further information regarding the land use projections for the Passaic River Basin is contained in Part V of the Supporting Documentation - "ECONOMICS."

Methodology. The estimates given herein are based on a procedure which accounts for changes in hydrograph parameters and runoff volumes that are associated with future urbanization. This procedure lends itself to application to the Passaic River Phase I Study grid cell data bank and the HEC "HYDPAR" utility file program. The grid cell data bank variables contain information on subarea physiography, existing land use, and projected land uses for 1990 and 2040. The "HYDPAR" program accesses this grid cell data and computes, for subsequent use, hydrologic parameters that permit determination of precipitation losses and surface runoff response. The parameters that can be generated are those required for the U.S. Soil Conservation Service (SCS) curve number technique and for watershed modeling using subarea imperviousness and the Snyder unit hydrograph procedure.

Impact on Unitgraph Parameters. The urbanization effects on the hydrograph parameters TC and R were derived using the "HYDPAR" program in conjunction with the grid cell data bank. Through "HYDPAR," the SCS basin lag times were obtained for each subarea for each of the land use scenarios (existing conditions, 1990 and 2040). The relative changes in SCS basin lag times were then related to proportional changes in basin lag times used for the Snyder unitgraphs (with the Snyder peaking coefficient CP being held constant in all cases). Both the SCS and Snyder methods physically define basin lag from the center of excess rainfall to the peak of the synthetic unitgraph (although the computed lags are unequal due to computational differences between the methods). The HEC-1 program was then accessed to convert the existing HEC-1 Clark model unitgraph parameters to equivalent Snyder unitgraph parameters. Thus, based on the percent change of the SCS basin lag times between the existing and each of the two future conditions, proportional adjustments were made to the Clark model equivalent Snyder basin lag times. Table 33 gives subarea unitgraph parameters for base-year, 1990 and 2040 conditions.

Impact on Runoff Volumes. The urbanization effects on runoff volume, a function of a subbasin's imperviousness, were also derived using HYDPAR in conjunction with the grid cell data bank. The existing HEC-1 Clark model was calibrated without using the RTIMP option (percent impervious is equal to 0%). Therefore, to account for urbanization effects on runoff volumes, the differences between the percent imperviousness for existing and projected future conditions in each of the subareas were computed. These computed increases in percent impervious (Table 33) were then used to modify the RTIMP variable of the corresponding future conditions hydrologic model. It is noted that volume changes can also impact on peak discharges.

Conclusions. As can be seen from Table 32 the number of acres developed in the Basin is expected to increase in the future, with accompanying increase in stream discharge. Compared to historical growth in the Passaic River Basin, the future acreage projected to develop is relatively small. Although comparatively more acres were developed in the past than projected for the 1990 to 2040 period, the incremental effect on frequent flooding would be more significant, as reflected by the 6.6% increase expected for the 1 year flood at Little Falls for 2040 conditions. The less frequent events to be used as design storms in this study would not signifi- cantly increase along the mainstream, as seen by the 2.3% increase in the 100-year flood at Little Falls resulting from development changes through the year 2040. Also, as shown in Table 32, residentially-developed acres are expected to have the largest incremental increase from 1983 to 2040, with most of this change in the Highland Area. The results shown in Table 34 and on Figures 55 through 61 indicate that urbanization would tend to have a greater impact on the more frequent flooding, especially the 1-,2- and 10-year events. For example, a comparison can be made at the USGS gages in the various subbasins for the 1-year and 100-year floods from the following:

INCREMENTAL RUNOFF PERCENTAGES
PRESENT VS FUTURE

Locality (USGS Gage)	1990 Conditions One-Year	1990 Conditions 100-Year	2040 Conditions One-Year	2040 Conditions 100-Year
Passaic River at Chatham	2.63	1.40	6.70	3.21
Whippany River at Morristown	4.92	3.04	21.10	13.71
Rockaway River above Boonton Reservoir	5.31	3.16	19.87	10.80
Pompton River at Pompton Plains	6.71	-1.18	17.03	1.21
Ramapo River at Pompton Lakes	6.69	2.06	17.78	4.74
Passaic River at Little Falls	5.23	-0.02	12.16	2.26
Saddle River at Lodi	4.70	0.94	9.20	1.64

These results indicate that the Highland areas are most vulnerable to increased development, whereas the Central Basin and Saddle River Basin are already suburbanized and semi-developed. The exception to this observation is the Passaic River Basin above Chatham. This portion of the Central Basin contains large tracts of undeveloped land but there is a significant amount of floodplain (including the 8,500 acre Great Swamp) which currently provides attenuation of flood waves and which would minimize the impact of potential urbanization.

STORM WATER MANAGEMENT

The State of New Jersey passed a Storm Water Management Act in 1981 (PL 1981C.32). In response to this legislation the N.J. Department of Environmental Protection issued storm water management regulations which became effective in February 1983. These regulations require all municipalities to develop and enforce storm water management plans and ordinances, under certain conditions. One of these conditions is the appropriation by the State of 90% of the cost of developing these plans. Between 1983 and 1985, virtually no progress was made in implementing storm water management plans, with the exception of Bergen County, since no monies had been appropriated by the State to fund the development of the plans. In 1985, however, $2,000,000 was appropriated, $1,000,000 for counties and $1,000,000 for municipalities. State-wide to date, NJDEP has approved grants to 6 counties and has received applications for grants from an additional 2 counties and 93 municipalities.

The effects of such storm water management plans were considered in the formulation of Corps flood control plans. The only such management plan implemented to date is in Bergen County. Under Bergen County's program, all "applications for development that propose one acre or more of additional impervious surfaces are required to detail, on the plans submitted, stormwater management facilities to retain/detain the additional stormwater runoff being generated by the developed properties if downstream drainage has been determined to be inadequate to meet design standards." The design storm for all retention or detention facilities is the 25 year storm. Also, according to Bergen County, such stormwater management facilities should not allow any incremental increases in runoff for the more frequent events (i.e. the 1-, 5-, and 10-year events).

With these stormwater management requirements and information from the county regarding the effectiveness of the program to date, the Corps' hydrologic model for the Saddle River Basin was modified to simulate the effect of the county program. Review of information received from the county indicated that only 40% of the total acreages developed since the adoption of these rules required the incorporation of stormwater management measures into their plans. Based on this, projected 1990 and 2040 stream discharges were modified to reflect the estimated 40% effectiveness of the program on storms up to the 25 year event.

As shown in Table 35, the results indicated that for the Saddle River, stream discharges between now and 2040 exhibited increases only slightly less with the stormwater management program in place as opposed to having no program. For instance, the one year discharge under the program would be only 2.4% less than it would be without the program, while the 25 year discharge would be only 1% less. Applying these results basin wide, it was determined that storm Water Management Programs would not change the design level of the overall plan and would have no significant effect on Expected Annual Damages.

LOSS OF CENTRAL BASIN NATURAL FLOOD STORAGE

Currently, the wetland areas in the Central Basin are primarily undeveloped and function as natural detention areas storing a significant volume of flood water. The loss of these areas to development would reduce the volume available for flood storage and would worsen the existing flood problems downstream. Preservation of wetlands is generally applicable throughout the watershed, but is of special significance within the Central Basin because 11 remaining major wetlands and other, intermittent pockets of open-space floodplain are located in this portion of the Passaic River Basin. The 11 wetlands of significant size are presented on the Passaic River basin map shown on Figure 62. Table 36 presents the acreage totals for the major wetlands.

Methodology. The hydrologic and hydraulic analyses of preserving natural storage areas involved predicting the increase in flows and stages if the natural storage areas were lost to development in accordance with the most probable future conditions. Development of the floodplains would eliminate the natural storage which attenuates flood flows, thereby increasing both discharges and water surface elevations in downstream areas. As the natural storage is eliminated along the entire river, the adverse impacts are compounded.

For this analysis, the loss of storage areas was considered in the following areas: Passaic River from Pompton River confluence at Two Bridges upstream to the Dead River confluence; Pompton River from the mouth upstream to the Ramapo River confluence; Rockaway River from the mouth upstream to the Vail Road Bridge in Lake Hiawatha; and Whippany River from the mouth up to the Morristown border. Figures 63 and 64 relate the impacted reaches to hydrologic model schematics.

The loss of floodplain lands to development would result in two types of impact that must be modeled differently. These impacts are: (1), the changes in unitgraph parameters of and runoff volumes from the lost floodplains would result in increases in streamflow derived from the hydrologic (HEC-1) model; and (2), the loss of floodplain storage would change the storage vs discharge relationships used in the HEC-1 flood routing and reflected in the hydraulic model (HEC-2) encroachments.

It was suspected that the effect of (1) above was not significant as compared to the increase that would result from (2) above, since the relative area affected (floodplains to be developed) was small compared to the total areas considered. Therefore, impact (1) was tested through a sensitivity analysis to confirm the magnitude of its maximum effect.

In this test it was assumed that all of the wetlands in the Central Basin (including one outside the Central Basin area of interest) became commercial development sites in the computation of the revised unitgraph lag times and runoff volumes when determining the increased area runoff. Thus, if such a test for the entire basin does not produce significant increases, the impact from the Central Basin would clearly not be significant. This test is similar to the method used in predicting future land use runoff as described in the "URBANIZATION" section of this report. Basically, the land use in all areas in the Passaic Central Basin which contain wetlands was converted to commercial development in the grid cell data bank. The HEC program, "HYDPAR", accesses the data bank and yields the increased ratio of imperviousness and decreased lag time for each change or adjustment in a given subarea. The results show that for the 100 year flood, there is only a very small increase in discharge by the time the peak flow is in the Central Basin. With only a small increase at Little Falls, it is demonstrated that the impacts due to runoff changes in the wetlands are not significant compared to the increases due to changes in flood storage when routing with the Modified Puls method. Thus, the remaining analysis focused on the storage changes due to floodplain development.

With respect to the second impact, the method of analysis involved identifying the total available natural storage in the floodplains, determining the protective status of these areas, and then testing the potential impact of losing specific areas. The natural storage areas in the inventory include both frequently inundated open areas of the floodplain and wetlands. Natural storage areas which are considered to be protected generally fall into one of the following categories: (a), Federal, State or local parks and refuges; (b), land within officially designated floodway areas; (c), land in the Flood Hazard Area (but outside of the floodway) which is partially protected by the N.J. Flood Hazard Regulation, and (d), land locally zoned or designated for conservation purposes. Table 36 presents a summary of the major floodplain wetland acreages and their protection status.

Current N.J. Flood Hazard Regulations were adopted on 21 May 1984 and provide that the volume of net fill and structures to be placed on an applicant's site in the flood hazard area is limited to 20% of the total volume between the natural ground surface and the level of the flood hazard design elevation. The degree to which storage was eliminated was based on projections of developable storage areas and was analyzed by simulating development encroachments from the point where the Flood Hazard Area runs out at high ground to a point 45 percent of the way toward the most probable floodway delineation boundary. The 45 percent figure defines the horizontal extent of a volume of triangular cross-section that approximates the 20 percent fill volume that could be placed in the fringe area as part of New Jersey Flood Hazard Area Regulations (FHAR). For example, along the Passaic River, every stream cross-section used in the hydraulic model which has floodplain storage in the section was revised to simulate the encroachment of development placed on one or both river banks (the storage on each bank, where two were involved, was reduced to 80 percent of bank total). Thus, if there was 1000 feet of floodplain on the left overbank between the high ground and floodway of a particular section, an encroachment station was inserted 450 feet from the outer floodplain limit to simulate the 20% fill volume that could be placed on the left bank of that cross-section. A preliminary hydraulic (HEC-2) run was then made to obtain revised storage vs discharge relationships for the hydrologic (HEC-1) analysis. Table 37 provides a summary of the routing reaches for which the storage-discharge relations were recomputed to reflect the loss of natural storage for 1990 and 2040. Figure 79 presents storage-discharge relations for the Great Piece Meadows reach under existing conditions and also under future conditions (with loss of storage) as an example of encroachment impact. The discharges obtained from the resulting HEC-1 analysis, using the revised storage-discharge curves were then input into the hydraulic model to obtain final HEC-2 water surface profiles, reflecting the projected development in the floodplain.

In accordance with the most probable future conditions, encroachments are expected to occur over a number of years and development would begin at the outer fringes of the floodplains and proceed inward towards the river, depending on the ease of obtaining building permits and the cost of extending roads and utilities in each municipality. Based on the most probable future analysis by the years 1990 and 2040 approximately 430 and 3870 acres, respectively, of Central Basin flood plain storage areas would be filled over and above 1984 conditions.

Results. The results of this analysis show that projected development of the Central Basin natural storage areas will have a significant impact on increasing stream discharges along the Passaic River downstream of Pine Brook. The development of the 8620 acres (resulting in the filling of 3870 acres as shown in Table 36) of unprotected Central Basin floodplain, as identified in the most probable future conditions discussion would cause the 100-year flow at Little Falls to increase from 27,533 cfs to 33,053 cfs, as shown in Table 34. This 20% increase from existing conditions would result in about a 1.5 foot increase in water surface elevation for the 100-year flow at Little Falls. Figures 65 through 76 show the impact of urbanization and storage loss on hydrograph peaks, volumes and timing.

PRESERVATION OF NATURAL STORAGE

An analysis was undertaken to determine the areas to be protected to offset the increases in flood discharges and stages due to the loss of Central Basin natural storage. The hydrologic model was utilized to test the sensitivity of preventing the development and filling of various floodplain areas. For this analysis, the storage-discharge relationships of the Central Basin routing reaches were held at 1990 levels and the results were compared to the flows representing full loss of storage under 2040 conditions. Evaluation of these findings indicates that 5350 acres of developable natural storage on the Great Piece, Bog and Vly, Lower Pompton, Troy and Black Meadows, Hatfield Swamp South, and Canoe Brook floodplains provide the significant portion of flood storage due to their location and topography. Table 37 provides a listing of the routing reaches for which natural storage was at 1990 levels and corresponding storage-discharge relations were utilized. The flows resulting from protecting these floodplains at 1990 extents of development are presented in Table 38 along with the flows resulting under the without-project conditions (with a loss of storage in these areas). The results demonstrate that maintaining the natural storage in these key floodplains would limit the 2040 flows for the 100 year design event at Little Falls to 28,398 cfs or 86% of flows at 2040 projected development. As shown in Table 38, there is a similar result for other flow frequencies as well. The preservation of the floodplain storage in these key areas was found economically feasible and was recommended as a project element in this report. Therefore, the design discharges for the Dual Inlet Plan were based on future (2040) land use conditions with these floodplain areas preserved as natural storage.

SECTION G - PROPOSED PLAN OF IMPROVEMENT

GENERAL

The proposed plan of improvement has been formulated and developed through the combination and integration of the most effective features of several flood control measures presented in the Stage 2 Report on the Passaic River Basin. This section therefore reports on the hydrologic modeling of the Dual Inlet Tunnel Diversion Plan. This plan is the most cost-effective one 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 plan is also complex and, when implemented, will greatly alter stream flows in the Passaic and Pompton Rivers. The formulation and evaluation of the proposed plan is presented in the Main Report and in Appendix C, "PLAN FORMULATION." Hydrologic results which aided in the under standing 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. Hydrology was also critical during Stage 2 planning in determining the effectiveness of several measures which are no longer under consideration. This effort is summarized below in Section H.

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 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 1.3 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, as shown on Figures 77 and 78 (hydrologic model schematics). The underground tunnel would be about 125 feet below the Two Bridges inlet, and about 155 feet below the outlet. 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. Tunnel profiles are presented in Supporting Documentation Part II- "HYDRAULICS".

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 direct flood flows to the inlet and to protect upstream areas. The Pompton and Passaic River channels would be deepened for 0.3 and 0.8 miles from upstream of the Two Bridges spur tunnel inlet to divert flood flows to the inlet. Upstream of Two Bridges along the central Passaic River and tributaries, 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 miles of levee and 0.5 miles of floodwall. In the Central Basin, the levees would have an average height of 8.4 feet and the floodwalls would have an average height of 9 feet.

From the Saddle River down to Newark Bay, the plan calls for 14 levee/floodwall systems including 11.2 miles of levee and 12.8 miles of floodwall. 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.

However, downstream of the Saddle River, 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 and floodwallas 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.

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. Protection against 100-year to 500-year events would be provided above Two Bridges along the central Passaic River and tributaries.

Tunnel Elements. The function of the tunnel with its spur and two diversion inlets is to divert flood flows from the upper Pompton River and from the Passaic River at Two Bridges and reintroduce them into the estuarine portion of the Passaic River at its confluence with the Third River at Clifton and Nutley. The main tunnel would be 13.5 miles long and have a 39-foot diameter.

This plan was developed to make more efficient use of the Pompton Tunnel with the expectation that flows could be further reduced by a second inlet at Two Bridges, while operating the tunnel with a priority diversion at the Pompton River inlet. This mode effectively captures the Pompton River flows which are the major cause of flood damages in the Pompton Valley, the Great Piece Meadows area and the upper portions of the Lower Valley of the Passaic River. The spur tunnel inlet at Two Bridges takes advantage of the difference in timing, as much as 2 days, of the flood peaks to make more effective use of the tunnel. The objective is to direct as much flow as possible into the Pompton River inlet and then, if the tunnel is operating at less than capacity, allow additional flow to enter the tunnel at Two Bridges by manipulating gates in the Two Bridges inlet gate diversion spillway. This further reduces flows into the Lower Valley and flood stages in the vicinity of Two Bridges by diverting central Passaic River flow into the tunnel.

These flows are then discharged into the Lower Valley at the mouth of the Third River in the Passaic estuary, almost doubling peak flows in those reaches downstream and increasing flood stages in these reaches and also upstream, the latter effect due to backwater. The net effect is to reduce flows in the Pompton Valley, Central Basin, and Lower Valley above Dundee Dam, but increase peak flows and advance the peak to an earlier time downstream of the tunnel outlet. This is discussed in detail later in this section.

Channels. There are channels at two plan locations, those of the Pompton and Two Bridges inlets. The channels serve to provide a hydraulic transition from the natural channels to the inlets so that flows are directed effectively to the inlets. These channels are extensive upstream of the Pompton inlet along the Pequannock, Wanaque and Ramapo Rivers with a total length of 4.9 miles, and alter hydrologic characteristics in these reaches. Transition channels at Two Bridges along the Passaic and Pompton Rivers total only 1.1 miles, and their effects are considerably less due to the overwhelming effect of the tunnel inlet on stages and extremely flat stream slopes in the area, which minimize any hydrologic effect of the channels.

Levees and Floodwalls. Systems of levees and floodwalls are proposed in four locations: the mouth of the Passaic River; the reach between the Second and Saddle Rivers; the Central Basin; and upstream of the Pompton inlet. Hydrologic effects on stream flow are discussed below for each system. Interior flood control hydrology is discussed in Part II - "HYDRAULICS."

At the mouth of Passaic River, the purpose of those systems is to protect from tidal surges caused by extreme wind conditions. The large navigation channel in this reach is capable of carrying the peak tunnel discharges with no increase in flood stages. The design of these improvements is therefore based upon the results of the tidal surge model reported on in Section E above and are not considered in the HEC-1 model.

The next reach extending upstream from the Second River to the Saddle River contains levees and flood walls to protect against increased river stages caused by tunnel discharges and, flood stages caused by tidal surges. Because of the narrow valley in this reach, these levees and floodwall systems have only minimal hydrologic effect in terms of flood plain storage loss. Therefore, no hydrologic parameters are modified in this reach to reflect the presence of these structures.

The Central Basin levee systems are extensive and do have hydrologic effects on Central Basin flows. While there are several levee systems contributing to a loss in floodplain storage, the Passaic River System 2A removes a portion of the Township of Fairfield from the floodplain. The remaining systems protect small pockets of development on the edge of the floodplain and are not measurable in comparison to the large floodplain storage volumes in those reaches. The impacts of these smaller losses, however, are more than offset by lowered flood stages throughout the Central Basin resulting from tunnel diversions.

The levee systems upstream of the Pompton inlet are extensive and warrant inclusion in the plan to work with the channel modifications to safely convey flood flows to the Pompton Tunnel Inlet.

Preservation of Natural Storage. The importance of this has been discussed in the previous section. However, the effects of preservation are important in the Central Basin both with and without the plan. In the Central Basin, the impact of Passaic River System 2A levees offsets a small portion of the beneficial effects of preservation in the Great Piece Meadows area. The storage increment affected by this levee is not a "natural flood storage" area, but rather consists of developed areas of the Township of Fairfield floodplain. Results are discussed later in this section. Figure 79 shows the variation of storage with differing scenarios for a given discharge from the Great Piece Meadows, the most critical storage element.

Great Piece Weir. The function of this component is to preserve the environmental resources of the Great Piece Meadows area and to train Passaic River flows to the Two Bridges Inlet transition channel. The design and operation of this structure would not affect flows during the critical periods of a flood event. The purpose of the structure is to sustain a one-year flood stage in the lower half of the Great Piece Meadows only after flood stages have receded to that level and for a duration to be determined by those managing the environmental resources of the Great Piece Meadows. Because the weir functions only after the critical period of a flood event, it would not affect flood peaks and is therefore not reflected in output of the hydrologic model presenting peak discharges.

Pequannock Weir. The Pequannock Weir is located on the transition channel at the Morris Canal Feeder Dam on the Pequannock River. It would consist of two 85 feet wide, 15 feet high bascule gate sections which would be raised under normal conditions and lowered during a flood event. This design would preserve the existing flow 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 assume the inundation of the one year flood. Due to the negligible effect which the Pequannock Weir has on the hydrologic model, it was not included in the HEC-1 analysis.

OPERATION OF THE PLAN

Overall Rules. The fundamental components of the plan are the tunnels and their inlets and joint outlet sited in the most cost effective locations. The operation of the overall plan is therefore based on the operation of the tunnels. The purpose of the two tunnel diversion inlets is to divert flood flows away from the major Pompton Valley and 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, thereby making the most effective use of the tunnel. In previous discussions, it was noted that the larger flows attributed to the Pompton River are primary in responsibility for the flow reversal in the Central Basin and the higher peaks in both flow and flood stages throughout the Pompton Valley, Great Piece Meadows, and Lower Valley. The result is that 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 descending 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 an uncontrolled 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. Changes in this rule, for example, during the hypothetical 100-year event, giving priority to the Two Bridges Inlet would result in larger bypassed Pompton flows which would increase Two Bridges flows and also result in closer synchronization of peak flows. In terms of project component, this would require a larger tunnel below Two Bridges and possibly levees and floodwalls or channel improvements in the Pompton River Valley. For this reason, the Pompton Inlet priority is key to tunnel operation because it makes most effective use of tunnel capacity.

In addition to the preceding, 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 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. Other rules include a bypass flow rule that requires a minimum release of 500 cfs downstream of the Pompton inlet and 100 cfs downstream of the Two Bridges inlet during a flood event until peak flows have receeded below damaging stages. Only the increment of flow above this minimum would be diverted to reduce flood flows downstream. Both of these flows are insignificant during flooding events and to eliminate them would not reduce flood stages. It is also noted that another part of the rule will require that the one-year flow be bypassed once flood stages have fallen below the one-year level and only on the descending limbs of the input hydrographs upstream of the tunnel inlets. These releases are also made so that they will not affect flooding stages downstream. It is noted that when design flows exceed tunnel capacity, excess flows are bypassed. Flooding occurs, but flood stages downstream are reduced by the flows carried in the tunnel.

Operational Facilities. An operations center will be located near the Two Bridges inlet with supporting facilities located 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, 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 that is authorized and will be put into operation in the coming year by the Corps and NOAA. The balance of the data will come from the USGS and local sources. Not only will the center assure the proper operation of tunnel components, but it will issue warnings and orders to make certain that the closure structures and interior drainage facilities are tended to and functioning properly. After the peak of the flood event has passed, the center will also make decisions as to when the Great Piece 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.

Rules to be Simulated. The structure of the HEC-1 model and utility programs in the plan simulation include only those rules that affect flood discharge peaks because these are the primary determinants of flood stages. The remaining rules are generally related to protecting environmental resources and would only be put into effect when weather conditions were appropriate and flood stages were at or below the annual event. Care was taken to ensure that the operation rules would not result in increases to residual flood damages.

The plan simulation will begin diverting flows into the Pompton and Two Bridges inlets only when their respective minimum bypass flows of 500 and 100 cfs have been exceeded and the diversion will only be the increment of flow exceeding the bypass flow. The priority of diversion will be to utilize tunnel capacity to the maximum for Pompton River flows at the Pompton inlet. Any additional capacity will be utilized for diversion of Passaic River flows at Two Bridges.

There are no other rules in the simulation. The remaining rules do not affect downstream peak flood stages and damages during the modeled hypothetical events and would not affect real-time events.

PLAN EFFECTS AND DESIGN

Overall Plan Effects. The plan effects are summarized in Table 38 which lists peak flows for all major nodes, for each frequency, and compares them with existing conditions. A simplification of plan results is shown in Table 39, which compares the improved condition flows with existing conditions for the design level of protection in the 100-year frequency. This table also gives the time of peak flows.

At the first location, the Pompton River upstream of the inlet, we notice that flows are increased due to the loss of flood plain storage from the channel and levee systems. The inlet is also at this location and there is a total diversion scenario shown which considers that it is possible to divert all flow into the tunnel. This scenario gives a measure of what is possible in terms of maximum flow reduction downstream. A total diversion is shown at Two Bridges as well. In general, flows are reduced by more than 80 percent in the Pompton Valley. Note that the peaks of the plan in this reach occur later than the smaller peaks of the total diversion scenario which are caused by the residual flows that can not be diverted because the tunnel is operating at capacity during this time period. This tunnel is thus operating near maximum effectiveness in the Pompton Valley.

At Two Bridges, flows are reduced by 60 percent. Because the tunnel at this location controls the flow over Beatties' Dam, whether diverting or not diverting, the second inlet at Two Bridges is located at node 41 at Little Falls in the HEC-1 model. This is also the natural division between the Central Basin and Lower Valley models. Table 38 therefore places the Two Bridges tunnel diversion downstream of Little Falls. Maximum flows and tunnel diversions occur at Two Bridges in the later hours of the flood event while the maximum bypass flow for the plan occurs earlier, in the 38th hour. This results from the tunnel operating at capacity at the Pompton Inlet and thus all flows are bypassed at Two Bridges between the 26th and 44th hours as shown in the hydrographs for the Pompton and Two Bridges inlets, Figures 80 and 81. It is not until the 107th hour that the maximum flow would enter the tunnel at Two Bridges as the capacity of the spur tunnel increases with the decreasing flows into the Pompton Inlet.

In the Lower Valley, there is a considerable reduction of flood flows (Table 38) ranging from 70 to 30 percent down stream to the Saddle River confluence in Wallington with the dominance shifting from the second peak in the Lower Valley to the first peak which is caused by tributary flow that is not controlled by the tunnel. The 2040 "without condition" columns illustrate the influence of the Central Basin in creating the second peak which is both larger than the first peak and occurs much later as described earlier in this section of the report. The function of the tunnel is therefore to minimize the inflows to the Lower Valley from the Central Basin and contain the second flood flow peak.

Downstream of the Third River, we observe a considerable increase in flow due to the return of tunnel discharge to the Passaic River. Not only is the flow increased by nearly 50 percent but it is also advanced in time to an earlier hour in the flood event. The hydrographs shown on Figure 82 near the mouth of the Passaic River dramatically illustrate this occurrence. Navigation channels in this reach have enlarged the natural capacity of the river channel in this reach and therefore reduce these impacts to a great degree.

Figures 83 to 85 show the functioning of the plan under the Standard Project Flood.

Tunnel Size. The size of the tunnel was determined by applying formulation principles to select the most cost effective plan. Various sized tunnels ranging from 33 to 40 feet in diameter were simulated in the HEC-1 models and the tunnel utility program. With a reduction in size the tunnel becomes less effective in the Pompton and Lower Valleys and at the smallest size, the use of a second inlet at Two Bridges becomes a marginal consideration because its capacity to balance the level of protection between Pompton and Lower Valleys was minimal. By controlling the Pompton River, the flow at Two Bridges is considerably reduced and the timing of the peak Passaic and Pompton flows become less closely aligned in time so that the spur can function to contribute significantly to the level of protection in the Lower Valley.

Spur Tunnel Size. Based on the hypothetical storms, it was confirmed that by controlling the Pompton River, flood flows are considerably reduced throughout the downstream areas. For example, the hydraulic optimum size for the spur tunnel with the 39 foot main tunnel would be about 13 feet in diameter. This size spur tunnel will not allow peak flows larger than 9300 cfs to be bypassed into the Lower Valley in the 100-year event, but neither will a 22 foot or a 39 foot diameter spur tunnel. This amount will be bypassed in the 39th hour of this flood event because the main tunnel is filled with Pompton flows and will accept no flow from a Two Bridges spur tunnel under our operating rule. The notable difference is that the 13 foot spur tunnel will bypass flows ranging from 7000 to 9300 cfs over a period of 90 hours due to its size limitation and, therefore, may prolong damaging flood peaks in the Lower Valley which does not have a full 100 year level of protection. The 22 foot and larger spur tunnels, however, would only bypass flows of that magnitude for no more than 11 hours during which the main tunnel is filled to capacity by Pompton flows. Beyond that time there is capacity in the main tunnel and the bypass flow quickly falls to under 1000 cfs.

In addition, the 22 foot spur tunnel provides significant additional capacity, over and above that provided by a 13 foot capacity, necessary to handle infrequent events centered over the upper Passaic River. Such an occurrence is discussed on page I-71 regarding the simulation of the 1903 flood event. Another factor in the selection of the 22 foot diameter spur tunnel is its performance without the Pompton Inlet as a functioning entity. This would occur with phased construction of the tunnel whereby effort would focus on completion of the main tunnel up to the Two Bridges spur while the balance of construction upstream to the Pompton inlet continued. Economically, this would provide a benefit return to offset interest during construction until the entire project was completed. Because there are no Pompton flows in the main tunnel, the spur is utilized to its hydraulic capacity and the 22 foot spur diverts almost 15,500 cfs of 28200 cfs while the 13 foot spur is limited to 4500 cfs. Thus the considerable benefit of using a spur tunnel of 22 feet during this brief period justifies the additional cost of the larger capacity.

Bypass Flows. Minimum bypass flows were determined to be necessary to meet minimum stream flow requirements during a flood event. While the primary function of the plan is to reduce flows downstream as much as possible to maximize project benefit return, it was found that, for example, a 500 cfs bypass flow at all times would not increase flood flows to damaging stages in the Pompton Valley up to the design flood level. This results from the larger flows which occur when the tunnel capacity is surpassed and all residual flows are bypassed far exceeding the 500 cfs minimum. This is shown in Table 39 where Pompton River flows of the Total Diversion scenario are the absolute minimum flow that can occur with a tunnel plan. Note the Dual Inlet plan at the same locations in the Pompton Valley where the maximum peaks occur in the 42nd and 47th hours during the periods of the largest bypass flows. The first peak moving downstream between 20 and 26 hours does not exceed those later peaks despite the 500 cfs bypass flow. It is noted that further studies in the design stage, both hydrologic and environmental, could further define these constraints and requirements.

At Two Bridges, the peak flows downstream would be affected by all bypass flows because the first flood peak around 20-24 hours into the flood event in the Lower Valley is the larger peak with the tunnel in place as shown in Table 39. Therefore, a nominal 100 cfs was selected as a bypass flow to maintain flow in the upper reach of the Lower Valley during a flood event.

Levees and Floodwalls. In the Central Basin of the Passaic River, the flow reversal caused by large Pompton River flows no longer occurs except for larger-than-design events. Therefore, flood stages have been lowered in this area because of the greater flood plain storage available for Passaic River flows. Design of levees and floodwalls results in less extensive works and reduced interior drainage in the systems in Fairfield along both the Passaic River and Deepavaal Brook. The opposite is true in the Lower Valley downstream of Dundee Dam. Downstream of the tunnel outlet, flood flows are increased by about 50 percent as shown in Table 39. While levees and floodwalls are needed for protection against tidal flooding in this reach, the requirement is made mandatory due to the increased fluvial flows which increase flood stages for the 100 year design events up to 5 feet at the outlet near the Third River. Levee and floodwall systems downstream of the Second River are unaffected because the larger navigation channel in this reach contains these flows adequately.

Preservation of Natural Storage. The recommended plan was modeled both with and without the future preservation of the wetlands in the Passaic River Central Basin. The difference between the performances of the project in these two future conditions is due to the loss of flood storage under the without preservation conditions. Flows under the without preservation conditions increase, with a resulting decrease in project performance. Additional flows resulted at Two Bridges and at downstream reaches in the Lower Valley. The peak flow is prolonged and its timing is advanced, with the resulting discharge increase at the mouth of the tunnel by as much as 2000 cfs. Thus, the inclusion of the preservation of natural storage in the project allows an additional increment of protection at Two Bridges and downstream in the Passaic River Lower Valley.

Pompton Inlet Flow Restrictor. The flow restrictor is designed to function as a constraint on downstream flows only up to the 100-year design flow. Beyond that point, with the increasing flows, the two gates on each side of the center section are opened to prevent overtopping the flow restrictor at the 57,948 cfs SPS. Without downstream backwater effects, the SPS would pass through the flow restrictor without surpassing its crest. However, the backwater downstream is also controlling flow through the restrictor and the water surface elevation difference between the upstream and downstream faces decreases as bypass flows increase to a point where the restrictor is submerged by the backwater and the elevations have equalized. At the SPS, the restrictor is submerged with a downstream stage of about 188 feet NGVD or 5 feet depth. The bypassed flow for the SPS is 29,750 cfs which is less than the 100-year existing conditions flow of 32907 cfs. While the embankment is stabilized against the lesser flows, the failure of the embankment could not release a flood wave at greater flows because there is no storage of flood flows to be released.

Two Bridges Inlet. This inlet is designed to function at capacity with downstream control based on the existence of a rock-ledge channel bottom at approximate elevation 153.0 about 1000 feet upstream of Beattie's Dam in Little Falls. Thus, should Beattie's Dam fail or be removed for any reason, the tunnel would function at design capacity without increasing flows downstream or stages upstream of the inlet. It is noted that the existence of a tunnel inlet will reduce the probability of Beatties Dam failure because flows will never approach pre-project conditions in a flooding event and if failure should occur, flows would be considerably less and downstream impacts would be minimal. It is also noted that Beattie's Dam was inspected as part of the National Dam Safety Program in 1981.

While there were some structural repairs recommended, the report concluded that failure of the dam would cause a threat of loss of life to few, if any, people. However, the hazard classification is considered to be significant because failure of the dam would interrupt inflow to the Passaic Valley Water Commission's water treatment plant, which is a public utility.

EFFECTS OF PLAN ON RUNOFF FROM HISTORIC STORMS

To measure the performance of the plan under situations other than the hypothetical storm events, the plan was incorporated into the models of three storm runoff reproductions described earlier in the report. The models included the same operating rules as well as all necessary adjustments to storage-discharge relationships to simulate the plan in the year 2000. The three storms are different in character and each illustrates a different plan effect and also highlights plan limitations. The 1984 storm was a moderate event that was smaller than the 100-year storm and the tunnel was able to divert all flows. The 1903 flood was larger than the 100-year storm on the Passaic River and illustrates how the plan can still function when a storm beyond design levels is encountered. Finally, the 1972 transposed "Agnes" event, which would be larger than the SPS over much of the basin, shows the plan under an extreme occurrence which it reduces in magnitude to about the SPS, under which reference flood levels of protection are exceeded throughout the basin.

1984 Storm Event. This event is a recent occurrence that was the largest flood in many decades (Table 9A). This storm event was centered over the Pompton River and its tributaries, resulting in large flows on the Pompton at a frequency under 50 years while the Passaic River at Chatham experienced flows at about the 10- year frequency. The hydrographs show that the plan would have very capably transported all flows in excess of the bypass requirements to the mouth of the Passaic River, as shown on Figures 86 through 88.

1903 Storm Event. The 1903 storm event differed from the hypothetical 100-year event in that Passaic River peak flows upstream of Two Bridges were exceeded and the volume of flow coming down the Passaic was considerably larger. In contrast, the Pompton River was a less than 100-year event. To demonstrate the effectiveness of the tunnel plan, hydrographs for the Pompton and Two Bridges inlets and the mouth of the Passaic River are shown both with and without the plan on Figures 89 to 91. The result was that the tunnel capably transported all Pompton flows with the peak bypass flow held to the 500 cfs requirement while large volumes of floodwater around the time of peak flow had to be bypassed at Two Bridges because there was little excess capacity in the tunnel to allow diversion of flows at Two Bridges. Nonetheless, peak flows below Two Bridges and Little Falls were reduced to just more than a 10-year frequency equivalent flow. Thus the Pompton Valley was provided full protection while the upper part of the Lower Valley experienced significantly reduced flows. At the mouth, the flows are increased by approximately 50% but are still contained within the freeboard of the mitigation and tidal levees. No significant tidal storm surges have been recorded with major fluvial events assuring that these flows would be contained within the levees.

It should be noted that the 22 foot spur tunnel had adequate capacity (15,500 cfs) throughout the 1903 event to divert flows up to the available capacity in the tunnel at all times and minimized the bypass flow to the Lower Valley at all times, see Figure 90. However, a 13 foot diameter spur tunnel would have limited capacity (4500 cfs) for diversion into the main tunnel and the bypass flow into the Lower Valley would be above damaging stages (caused by flows greater than 9500 cfs) for four days or longer as compared to one half day for the larger selected spur size.

<u>1972 Transposed "Agnes" Event</u>. The magnitude of this historic event relocated over the Passaic River Basin equals the SPS on the Passaic River upstream of Two Bridges and exceeds that level significantly on the Pompton River and in the Lower Valley. Runoff from this storm overwhelms the project in all areas including overtopping of most levees. While the tunnel reduces flows in the Pompton and Lower Valleys by almost one third (Figures 92 and 93) the resultant flows are about the SPS magnitude. Flows, however, are increased at the mouth of the Passaic River due to the tunnel discharge (Figure 94).

EFFECTS OF OTHER FLOOD CONTROL PROPOSALS

There are local flood control projects proposed by the Corps of Engineers in the Passaic River Basin which are described in detail in their respective reports. As of this date, there are four areas where flood control projects are proposed. They are:

1. Ramapo and Mahwah Rivers at Mahwah, New Jersey and Suffern, New York;

2. Ramapo River at Oakland, Pompton Lakes, and Wayne, New Jersey;

3. Molly Ann's Brook at Haledon, New Jersey;

4. Lower Saddle River in Bergen County, New Jersey.

In all four of these reports, the downstream project effects were analyzed. The results in each case indicated that flow increases were not significant downstream of the local projects and, therefore, no downstream improvements to protect against such increases were required. Consequently, these projects will not affect the hydrology of main stem projects.

SECTION H - ALTERNATIVE PLANS OF IMPROVEMENT

In previous planning of this study, several alternative measures were investigated including channels, levees and floodwalls, reservoirs and reservoir re-regulation, and several tunnel route alternatives. The effectiveness of these plans was measured hydrologically while some plans were investigated in further detail with multiple frequency HEC-1 simulations while many others were tested at a selected design frequency. Plans were not optimized in these studies. However, the results of some of these investigations were updated and included as part of the formulation process which led to selection of the recommended plan. The following presents a summary of the plan concepts developed and their hydrologic effect on basin stream flows.

CHANNEL MODIFICATION PLANS

Channel modification plans were investigated both in the Lower Valley and in the Central Basin along the Pompton River. It was determined early in the study that a channel plan on the Passaic River upstream of Two Bridges would be costly in proportion to benefits received so no further study was made of this element. Channel improvements in the Pompton Valley were effective but, because of the extremely flat stream slopes, were supplemented by levees and floodwalls to provide a 100-year level of protection. This plan reduced floodplain storage considerably and resulted in flows at Little Falls increasing from 27,000 cfs to over 36,000 cfs. This condition eliminated the flow reversal along the Passaic River upstream of Two Bridges as well, which required that channels be included in the Lower Valley as well to mitigate for larger flows from the Central Basin as well as to reduce flood stages for the existing flows. Because the plan would also move the peak flow up in time, it would more closely coincide with Lower Valley flood peaks which would result in flows of over 43,000 cfs near the mouth of the Passaic River. This compares with 48,000 cfs for the recommended plan discussed earlier.

TUNNEL PLANS

Tunnel plans were evaluated in several configurations and sizes combined with channels and levees and floodwalls. A full discussion of the evaluation process is included in the Plan Formulation (Appendix C) portion of the Main Report. The tunnel plan concepts evolved into three single inlet plans with the inlet located at Beattie's Dam, at Two Bridges, or at the confluence of the upper tributaries where they form the Pompton River. The fourth planwas a dual inlet plan which included inlets at Beattie's Dam and on the upper Pompton River. This plan has now evolved into the recommended plan with the lower inlet moved from Beattie's Dam to Two Bridges.

A single inlet tunnel with the inlet at Beatties Dam or Two Bridges, while very effective in the upper Lower Valley does little to reduce flood stages in the major damage centers of the Pompton Valley. These inlets were therefore developed with a channel and levees upstream of the inlet to the Pompton tributaries. This had the same effect in those damage areas as the channel/levee/floodwall plan described in the preceding paragraphs. The large flows would be diverted into the tunnel and transported into the Lower Valley to the outlet into the Passaic River at the Third River confluence. The single inlet plans were comparable in hydrologic effect because the Two Bridges inlet tunnel substituted additional tunnel length for the 3.6 miles of channel between Two Bridges and Beattie's Dam. The Pompton inlet carried the channel trade-off concept further by replacing the Passaic and Pompton channels and levee/floodwall systems with additional tunnel length. The commonality of these plans is in controlling the Pompton River which is most important in causing flooding in the Passaic River Basin. The single Pompton inlet plan is not as effective in the Lower Valley because the smaller but later-arriving Passaic River peak at Two Bridges is not controlled.

The second inlet solved this problem making this plan as effective in the Lower Valley as the other plans. All plans eliminate the reversal of flows upstream along the Passaic River at Two Bridges and lower flow stages in the Passaic River in the Great Piece Meadows with minor reductions further upstream. Because there are no levee/floodwall systems along the Pompton River with the Pompton inlet plans, there is no concern of overtopping from floods exceeding design flows. The hydrologic effects in the Lower Valley include the considerably reduced flows in the upper reaches of the Lower Valley. In the lower reaches around Dundee Dam the 100-year flood event is only effectively reduced to a 50-year event because of the inflow from the intervening tributaries in the Lower Valley which cannot be controlled by the tunnel. The largest impact is downstream of the tunnel outlet where flows are increased by about 50 percent. This effect, although minimized by the existence of a navigation channel in this reach, still requires levee/floodwall systems to mitigate for these flow increases. Many of these effects are similar to those of the recommended plan but the formulation process has determined that these plans are less cost-effective and they are not presented in detail.

RESERVOIRS

The effectiveness of two types of reservoir plans were analyzed. The considerations were to propose new reservoirs or to perform a water supply vs flood control trade-off analysis between two reservoirs. Originally, there were five proposed sites under consideration. They are: a) the Myers Road site, which is located on the upper Passaic River near the Dead River confluence; b) the Monksville site located on the Wanaque River between Greenwood Lake and the Wanaque Reservoir; c) the Darlington site located on the Ramapo River between Mahwah and Oakland; d) the Washington Valley site located on the westerly branch of the headwaters of the Whippany River; and e) the Longwood Valley site in the headwaters of the Rockaway River. The Myers Road site is no longer under consideration because of the potential environmental destruction of a large tract of wetlands on the Dead River and in the Great Swamp National Wildlife Refuge. The Darlington site is no longer available because of the extensive development occurring within the flood pool that makes the plan no longer feasible. The Longwood Valley site appears to be feasible and is hydrologically independent from the Main Stem Study and is now being considered in a separate study underway in this office for the Upper Rockaway River. The Washington Valley site is now being designed as a water supply reservoir and, as such, is preempted from use. Hydrologic simulation showed that this reservoir would have little impact downstream on the Whippany River. The remaining site, the Monksville site, was completed recently as a water supply reservoir for the North Jersey District Water Supply Commission. This site is dedicated for water supply and a significant reallocation of its storage for flood control is not institutionally practical. Because of public interest in the effects of this site for flood control, the results of this study are discussed here.

The analysis of the management of Monksville and Wanaque Reservoirs for flood control purposes was undertaken in the context of hypothetically testing their response to basin-wide Passaic River flooding. They were not evaluated as solutions to more localized types of flood problems. The focus of the analyses were, therefore, the larger, less-frequent floods such as the 50- and 100-year flood events.

There are two basic approaches to controlling the flooding problems along the Wanaque River. Both of these utilize either the Monksville or the Wanaque Reservoirs to create flood storage by balancing water supply needs with flood control. Flood reduction effects obtained by using these sites would be intended to have regional benefits along the Pompton River.

Pompton River flooding is caused by the influence of waters from the Wanaque, Pequannock and Ramapo Rivers. Because of the complex hydrologic conditions in this subbasin, it is very difficult to exactly describe the effect of each river on the Pompton River flood flows. In very general terms, the Pequannock River contributes roughly 20%, the Ramapo River contributes a little more than 55%, and the Wanaque contributes about 25% of the Pompton River's flood flows.

The results of the analyses of the Wanaque River Subbasin indicate that the Monksville site would have minimal effect on the Wanaque River and negligible effects on the Pompton River flood stages for large events. A flood reduction/water supply trade-off using Wanaque Reservoir is very effective along the Wanaque River, but has minimal benefit on the Pompton River. Since neither of these sites would achieve the Federal objective of providing a high basin-wide level of protection, utilizing Monksville and Wanaque Reservoirs for flood damage reduction was screened from further consideration as part of this flood control study.

TABLE 1

PERTINENT WATERSHED DATA PASSAIC RIVER BASIN, N. J.

Stream	Locality	Distance Above Mouth Passaic River (Miles)	Tributary Length (Miles)	Elevation in Feet m.s.l. (b) Mouth	Source	Vertical Fall (Feet)	Streambed Slope(c) (Ft./Mi.)	Drainage Area (Sq. Mi.)
Passaic River	Mouth, Newark	0	87.6	-40			7.9	935.0
	Above Saddle River	15.5	72.1	0			9.0	815.5
	Dundee Dam, Clifton	17.4	70.2	25.4		17.0	8.9	809.9
	S.U.M. Dam, Paterson	25.2	62.4	114.5		63.0	8.6	785.0
	Beatties Dam, Little Falls	29.7	57.9	157.6		33.0	8.5	762.2
	Two Bridges	33.0	54.6	157.6			9.0	740.8
	Chatham	64.5	23.1	200			19.5	100.0
	Millington	75.8	11.8	210			37.3	55.4
	Source	87.6	-	-	650		0	0
Saddle River	Mouth	15.5	23	0	505		22.0	60.6
	At Lodi (U.S.G.S. Gage)	18.3	-	17	505		24.2	54.6
	Above Hohokus Creek	25.8	-	48	505		36.0	23.3
Hohokus Creek	Mouth	25.8	11.5	48	570		45.4	19.5
Weasel Brook	Mouth	14.2	5.0	-5	590		119.0	7.1
	At Clifton (U.S.G.S. Gage)	16.0	-	65	590		194.0	4.5
Diamond Brook	Mouth	22.2	4.0	24	330		76.5	3.1
Goffle Brook	Mouth	23.3	7.2	24	560		74.4	8.9
Molly Ann's Brook	Mouth	25.8	6.7	108	560		67.5	8.6
Slippery Rock Brook	Mouth	26.1	2.5	115	550		174.0	0.9
Peckman River	Mouth	28.2	7.7	115	660		70.8	9.8
Singac Brook	Mouth	31.8	8.5	150	810		77.6	11.5
Pompton River	Mouth (Two Bridges	33.0	44.8(a)	157.6	1100.0		21.0	378.1
	At Mountain View	34.4	43.4	157.6	1100.0		21.6	377.3
	At Pompton Feeder Dam	40.0	37.7	175.5	1100.0	8.0	24.5	353.8
Pequannock River	Mouth	39.7	30.8	165.0	1250.0		35.2	192.6
	Macopin Intake	50.3	20.0	583.7	1250.0		33.3	63.7
Wanaque River	Mouth	41.8	25.0	175.0	1000.0		33.0	108.1
	Above Wanaque Dam	46.6	20.2	300.3	1000.0	90.0	34.6	90.4
Ramapo River	Pompton Lakes Dam	41.9	35.8	200.9	1100.0	25.0	25.1	160.0
	Mahwah (U.S.G.S. Gage)	53.9	24.3	255.0	1100.0		34.8	118.0
Rockaway River	Mouth	47.0	43.0	160.0	1314.0		26.8	205.7
	Above Boonton	55.2	34.8	305.4	1314.0		29.0	116.0
Whippany River	Mouth	48.2	21.0	160.0	1090.0		44.3	72.0
	Near Morristown (USGS Gage)	60.2	9.0	280.0	1090.0		90.0	29.4
Green Pond Brook	At Picantinny Lake Dam	76.0	6.3	710.0	1260.0		87.2	8.7
Meadow Brook	At Lake Denmark Dam	78.0	3.4	818.0	1222.0		118.9	4.2

a. Source of Pompton assured to be the Ramapo.

b. At location indicated.

c. Slope from location indicated to source.

TABLE 2

TEMPERATURE, SUNSHINE AND FROST DATA, PASSAIC RIVER BASIN, N. J.

A - MONTHLY AVERAGE, ANNUAL AVERAGE AND EXTREME TEMPERATURES

Reference No. (a)	Station	Elevation (ft.,msl)	Years of Record	Temperature Degrees F.	Winter			Spring			Summer			Fall			Annual
					Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
26	Boonton, N.J.	280	1914-1925	Max.	71	73	83	93	96	99	102	103	104	88	80	69	104
			1936-1977	Min.	-15	-20	- 3	8	26	32	42	36	24	16	8	-21	-21
				Aver.	28	29	37	49	59	68	73	70	64	53	43	31	50
38	Canoe Brook, N.J.	180	1931-1977	Max.	73	76	86	94	95	102	103	104	96	93	84	74	104
				Min.	-25	-26	- 6	12	26	31	41	35	26	13	8	-16	-26
				Aver.	28	29	38	49	59	68	73	71	65	54	43	31	51
19	Charlotteburg, N.J.	760	1914-1977	Max.	71	73	85	92	96	99	105	100	100	90	81	70	105
				Min.	-19	-25	-10	6	23	29	36	32	25	10	- 1	-19	-25
				Aver.	27	28	36	48	57	66	70	69	62	52	42	30	49
2	Jersey City, N.J.	135	1914-1977	Max.	70	74	85	94	97	101	105	106	99	93	81	68	106
				Min.	- 4	-14	8	12	33	42	42	47	36	27	11	-12	-14
				Aver.	31	32	40	51	60	70	75	73	67	57	46	34	53
8	Little Falls, N.J.	157	1914-1977	Max.	73	76	87	95	101	101	105	103	105	92	84	72	105
				Min.	-13	-18	3	11	29	36	44	40	31	18	10	- 9	-18
				Aver.	30	32	40	51	61	70	75	73	66	56	45	33	53
1	Newark, N.J.	11	1914-1925	Max.	74	74	89	94	98	102	105	105	105	93	85	72	105
			1936-1977	Min.	- 5	- 7	4	13	33	41	52	48	35	25	16	-13	-13
				Aver.	31	33	41	52	62	71	76	75	68	58	46	35	54
7	Paterson, N.J.	100	1914-1974	Max.	72	75	90	95	97	103	105	104	106	92	79	71	106
			CLOSED 10-74	Min.	-12	-16	3	13	31	42	48	43	32	24	12	-13	-16
				Aver.	32	32	40	51	62	71	76	74	66	56	45	34	53
50	Somerville, N.J.	75	1914-1977	Max.	73	76	86	94	99	101	104	108	105	92	84	72	108
				Min.	-15	-16	- 1	11	26	34	44	38	29	20	8	-18	-18
				Aver.	30	32	40	51	61	70	75	73	66	55	44	33	52
58	West Point, N.Y.	360	1914-1977	Max.	71	70	86	96	97	102	104	105	105	85	81	67	105
				Min.	-11	-17	- 2	12	27	41	44	42	31	22	17	-16	-17
				Aver.	27	29.1	37.8	50	60.5	69.9	74.7	72.8	65.7	55.3	43.3	30.6	51.4
--	Entire Passaic Basin	--	---	Max.	74	76	90	96	101	103	105	108	106	93	85	74	108
				Min.	-25	-26	-10	6	23	29	36	32	24	10	-1	-21	-26
				Aver.	29	31	39	50	60	69	74	72	65	55	44	32	52
--	State of New Jersey	--	---	Max.	84	80	92	98	102	106	110	108	109	97	88	77	110
				Min.	-32	-26	-15	6	18	29	33	32	19	9	- 7	-21	-32
				Aver.	32	33	40	51	61	70	75	73	67	57	46	34	53

SUNSHINE - PERCENT POSSIBLE

Station	Years of Record		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Passaic Watershed[b]	1895-1977	Percent Possible	54	58	60	61	63	65	67	66	65	64	57	52	61

DATES OF EARLY AND LATE FROST

Location	Spring Normal	Spring Latest	Fall Normal	Fall Earliest	Days In Growing Season
Highland Area[c]	May 3	June 10	Oct. 6	Sept. 10	156
Central Basin[d]	April 27	May 25	Oct. 16	Sept. 21	173
Lower Valley[e]	April 15	May 10	Oct. 25	Sept. 27	194
Entire Passaic Area	April 25	June 10	Oct. 16	Sept. 10	174

a. These reference numbers refer to Figure 6.
b. Based on records at New York, N. Y., Atlantic City, N. J., and Trenton N. J.
c. Based on records at Dover, Charlotteburg, Sussex and Boonton, N. J. (1893-1977).
d. Based on records at Somerville, Plainfield and Little Falls, N. J. (1893-1977).
e. Based on records at Paterson, Newark and Jersey City, N. J. (1893-1977)

TABLE 3

WIND, HUMIDITY - RAINY DAYS AND EVAPORATION DATA FOR PASSAIC RIVER BASIN, N. J.

A - WIND VELOCITY AND RELATIVE HUMIDITY DATA

Locality	Elevation Feet (m.s.l.)	Period of Record	Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
				Month												
Trentun, N. J.	190	1967-1977	Wind Velocity (m.p.h.)													
			Average	10.7	11.0	11.7	11.2	9.6	8.9	8.2	8.0	8.3	9.1	10.0	10.4	10.1
			Maximum	70	70	64	55	60	62	72	51	58	56	54	64	72
			Relative Humidity[j]	71	70	68	66	68	72	73	74	74	73	73	71	71
			Prevailing Wind	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW	NW
Sandy Hook, N. J.	22	1915-1945	Wind Velocity (m.p.h.)													
			Average	15.5	15.1	15.6	14.4	12.1	11.9	11.4	12.0	12.4	13.6	15.0	15.3	13.7
			Maximum	56	61	56	55	49	50	54	55	72	53	62	59	72
			Relative Humidity	73	74	73	71	71	73	74	75	74	71	72	73	73
			Prevailing Wind	NW	NW	NW	NW	S	S	S	SW	S	NW	SW	W	NW
New York, City, N. Y.	138	1967-1977	Wind Velocity (m.p.h.)													
			Average	16.4	16.7	17.0	15.3	13.4	12.7	11.9	11.6	12.4	14.0	15.5	16.4	14.4
			Maximum	69	72	70	68	68	94	73	59	81	113	68	58	113
			Relative Humidity[j]	67	66	63	61	63	66	67	69	70	66	67	66	67
			Prevailing Wind	NW	NW	NW	NW	NW	NW	SW	SW	NW	NW	NW	NW	NW

B - DATA ON PREVAILING WIND DIRECTION AND RAINY DAYS[a]

Locality	Elevation Feet (m.s.l.)	Period of Record	Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Highland Area[b]	900	1913-1948	Wind	NW	NW	NW	NW	W	W	W	W	W	W	NW	NW	NW
		1914-1953	Rainy Days	10	9	10	11	12	12	11	10	8	8	9	10	120
Central Basin[c]	300	1914-1948	Wind	NW	NW	NW	NW	SW	SW	SW	W	NW	NW	NW	NW	NW
		1914-1953	Rainy Days	11	10	10	11	12	11	11	11	9	8	9	10	123
Lower Valley[d]	250	1914-1948	Wind	NW	BW	NW	NW	SW	SW	SW	SW	SW	NW	NW	NW	NW
		1914-1977	Rainy Days	11	10	11	10	12	12	10	10	8	7	11	13	125
			Wind	NW	NW	NW	NW	NW	SW	SW	SW	W	NW	NW	NW	NW
			Rainy Days	11	10	10	11	12	11	11	10	8	8	9	10	121

C - AVERAGE MONTHLY EVAPORATION

Locality	Elevation Feet (m.s.l.)	Period of Record	Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Runyon, N. J.	18	1924-1958	Mean Temperature - °F				49.3	59.6	69.0	74.0	72.1	65.0	53.9	43.1		
			Total Wind Movement - Miles				1983	1356	759	626	639	635	809	1258		
			Total Evaporation - Inches[e]				4.00	5.15	5.29	5.81	4.99	3.78	2.51	1.80		33.38
			Average Precipitation - Inches				3.79	3.59	3.79	3.91	4.70	3.78	3.56	3.57		30.69
Pleasantville, N. J.	11	1924-1958	Mean Temperature - °F				49.7	59.6	69.0	73.9	72.5	66.4	55.9	45.3		
			Total Wind Movement - Miles				2630	1849	1361	1209	1177	1188	1347	1842		
			Total Evaporation - Inches[e]				4.19	5.86	6.23	6.46	5.53	4.02	2.73	1.82		36.84
			Average Precipitation - Inches				3.65	3.37	3.12	3.80	5.37	3.37	3.45	3.97		30.10
Canoe Brook, N. J.	172	1931-1977	Mean Temperature - °F				48.1	58.8	68.3	73.2	71.3	64.6	54.0	42.9		
			Total Wind Movement - Miles				1334	749	488	415	360	379	513	607		
			Total Evaporation - Inches[e]				3.46	4.59	4.54	5.06	4.27	3.01	1.94	1.29		28.31
			Average Precipitation - Inches.				3.79	4.17	3.53	4.84	4.81	3.84	3.10	4.29		33.13
Entire Passaic Area			Mean Temperature - °F	30	31	39	50	60	69	74	72	65	55	44	33	52
			Average Rainfall - Inches	3.55	3.45	3.92	3.82	4.98	3.91	4.89	4.88	4.04	3.73	3.58	3.66	48.41
			Total Basin Evaporation[f]	.63	.65	.87	1.25	2.87	3.48	4.47	3.84	2.44	1.33	1.02	.79	23.3
			Water Surface Evaporation[eg]				2.91	3.90	4.01	4.36	3.66	2.70	1.79	1.23		

D - ESTIMATED FREE WATER SURFACE EVAPORATION DURING CRITICAL DRY PERIOD OF RECORD

Locality	Elevation (Feet m.s.l.)	Item	1964 Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Apr.-Nov.
Meyers Road Reservoir	225.0	Average Temperature of									
		Total Evaporation - Inches	47.5	61.0	66.2	73.0	68.3	65.6	5.08	44.9	
		Total Rainfall - Inches	1.46	5.17	3.94	4.52	3.92	3.64	1.82	0.93	25.40
		Rainfall Deficiency	5.94	1.20	3.62	7.11	0.19	1.32	1.08	2.67	23.13
		Rainfall Excess		3.97	0.32		3.73	2.32	0.74		11.08
		Period Deficiency	4.48			2.59				1.74	8.81
Two Bridges Reservoir	174.0 (Plan I)[i]	Average Temperature of									
	183.0 (Plan III)[i]	Total Evaporation - Inches	48.9	63.8	68.9	75.0	71.2	67.5	53.0	47.6	
	180.0 (Plan IV)[i]	Total Rainfall - Inches	1.49	5.17	3.94	4.52	3.92	3.64	1.82	0.94	25.44
		Rainfall Deficiency	6.22	1.14	2.73	5.01	0.60	1.31	1.29	2.83	21.13
		Rainfall Excess		4.03	1.21		3.32	2.33	0.53		11.42
		Period Deficiency	4.73			0.49				1.89	7.11

Locality	Item	1965 Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Apr.-Nov.
Meyers Road Reservoir	Total Evaporation - Inches	46.3	63.8	67.9	71.5	71.2	65.6	51.1	42.1	
	Total Rainfall - Inches	3.06	4.55	4.28	4.67	3.98	2.53	1.78	0.87	25.72
	Rainfall Deficiency	2.84	1.62	1.41	2.51	4.61	2.55	4.20	2.05	21.79
	Rainfall Excess	0.22	2.93	2.87	2.16					8.18
	Period Deficiency					0.63	0.02	2.42	1.18	4.25
Two Bridges Reservoir	Total Evaporation - Inches	48.2	65.8	70.0	73.9	73.3	67.9	53.3	44.1	
	Total Rainfall - Inches	3.06	4.55	4.28	4.67	3.98	2.53	1.78	0.82	25.67
	Rainfall Deficiency	2.24	1.40	1.44	1.17	3.74	2.86	4.56	1.62	19.03
	Rainfall Excess	0.82	3.15	2.84	3.50	0.24				
	Period Deficiency						0.33	2.78	0.80	3.91

Locality	Item	1966 Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Apr.-Nov.	Total For Period
Meyers Road Reservoir	Total Evaporation - Inches	45.3	55.7	69.6	75.3	72.8	62.9	51.6	44.9		78.73
	Total Rainfall - Inches	1.09	3.47	4.20	6.12	4.06	2.78	1.88	1.01	24.61	74.43
	Rainfall Deficiency	2.21	5.41	0.84	1.00	2.70	9.41	4.43	3.51	29.51	29.10
	Rainfall Excess			3.36	5.12	1.36				9.84	27.30
	Period Deficiency	1.12	1.94				6.63	2.55	2.50	14.74	1.30
Two Bridges Reservoir	Total Evaporation - Inches	47.6	58.2	72.2	77.8	74.7	64.7	53.9	47.3		75.79
	Total Rainfall - Inches	1.08	3.47	4.20	6.12	4.06	2.78	1.88	1.09	24.68	70.57
	Rainfall Deficiency	2.07	4.71	0.71	1.39	1.87	10.79	4.55	4.32	30.41	32.38
	Rainfall Excess			3.49	4.73	2.19				10.41	23.16
	Period Deficiency	0.99	1.24				8.01	2.67	3.23	16.14	5.22

a. Day with rain of 0.01 inches or greater.
b. Based on records at Charlotteburg, Sussex and Boonton, N. J.
c. Based on records at Little Falls, Plainfield and Somerville, N. J.
d. Based on records at Newark and Paterson, N. J.
e. Evaporation from U. S. Weather Bureau Standard Land Pan. In northeastern states, the evaporation from a large body of water averages about 0.75 of value given by land pan in Passaic basin. Refer to Technical Paper No. 37, Evaporation Maps of the U. S. Weather Bureau, U. S. Dept. of Commerce, Plate No. 3.
f. Estimated from evaporation formulae developed for Passaic River, N. J., in Geological Survey Report of New Jersey on Water Supply, Volume 3, in 1894.
g. Estimated from U. S. Weather Bureau records for the three stations noted in Table (C) averaged and multiplied by 0.75.
h. The critical period.
i. Normal water surface - elevation in feet m.s.l.
j. Records to 1945.

TABLE 4

RAINFALL DATA, PASSAIC RIVER BASIN, NEW JERSEY

A - MONTHLY AVERAGE, ANNUAL AVERAGE AND EXTREME RAINFALL (INCHES) BY STATIONS

Reference No. (a)	Station	Elevation (ft.,msl)	Period of Record	Item	Rainfall in Inches (Monthly): Winter			Spring			Summer			Fall			Annual	Date of Max. and Min. Rainfall: Monthly Value	Annual Value
					Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.			
1	Newark, N. J.	11	1843-1924	Max.	8.10	6.82	10.00	11.36	9.01	11.51	19.09	22.48	17.66	13.84	8.87	7.58	69.10	Aug 1843	1903
			1935-1966	Min.	0.64	0.69	0.72	0.39	0.42	0.07	0.89	0.27	0.14	0.21	0.35	0.92	26.09	June 1949	1965
				Aver.	3.66	3.43	3.87	3.70	3.83	3.69	4.54	4.70	3.68	3.58	3.44	3.70	45.82		
2	Jersey City, N.J	135	1871-1878	Max.	7.10	6.31	9.01	7.47	9.09	8.09	10.10	12.15	10.32	12.54	6.91	7.34	52.47	Oct 1913	1919
			1905-1966	Min.	0.64	1.65	0.96	0.84	0.47	0.02	0.36	0.02	0.14	0.18	0.67	0.10	28.49	June 1949	1965
				Aver.	3.38	3.35	3.84	3.74	3.35	3.46	4.16	4.43	3.61	3.67	3.37	3.47	43.84		
3	Ridgefield, N.J.	80	1916-1923	Max.	7.26	5.57	9.89	7.02	9.20	9.05	8.81	11.82	10.33	9.43	8.25	7.81	58.03	Aug 1955	1927
			1925-1960	Min.	0.79	1.95	1.51	1.34	0.87	0.04	0.77	0.99	0.68	0.97	0.66	0.32	34.57	June 1949	1935
				Aver.	3.48	3.25	4.17	3.58	3.99	3.90	4.61	4.49	3.92	3.37	3.73	3.59	45.98		
4	New Milford, N.J.	12	1919-1966	Max.	6.64	5.48	8.96	6.71	10.07	8.73	9.63	12.30	11.17	8.71	8.86	6.18	53.64	Aug 1955	1947
				Min.	0.60	1.60	1.32	1.22	1.06	0.14	0.67	0.72	0.30	0.20	0.66	0.25	16.01	June 1949	1965
				Aver.	3.25	2.89	3.51	3.67	3.55	3.57	4.39	4.34	3.69	3.03	3.55	3.24	42.68		
5	Woodcliff Lake, N.J.	103	1919-1966	Max.	6.12	5.44	9.66	7.49	8.63	7.81	14.06	10.36	10.23	9.22	9.48	6.57	61.01	July 1945	1945
				Min.	0.64	1.66	0.80	1.20	0.83	0.24	0.61	0.77	0.33	0.16	0.67	0.20	31.37	Oct 1924	1965
				Aver.	3.45	3.46	3.83	3.83	3.78	3.48	4.47	4.57	3.91	3.19	3.65	3.27	43.67		
7	Paterson, N.J.	100	1864-1966	Max.	8.02	8.15	16.11	7.78	13.46	11.74	12.64	14.69	25.98	16.19	9.59	8.33	85.99	Sept 1882	1882
				Min.	0.84	0.63	0.67	0.86	0.71	0.24	0.51	0.37	0.33	0.25	0.52	0.38	30.14	June 1949	1935
				Aver.	3.70	3.84	4.18	3.71	4.25	4.02	4.80	4.74	4.11	3.78	3.53	3.85	48.51		
8	Little Falls, N.J.	157	1903-1966	Max.	7.59	6.86	9.09	7.60	11.10	8.20	16.52	14.55	13.42	14.12	12.66	9.15	68.17	July 1945	1945
				Min.	0.67	1.67	0.97	1.17	0.89	0.16	1.07	0.60	0.21	0.27	0.58	0.27	29.64	June 1949	1965
				Aver.	3.60	3.32	3.82	4.18	3.95	3.90	4.54	4.72	4.14	3.93	3.77	3.72	47.59		
11	Pompton Plains, N.J.	195	1903-1920	Max.	6.19	6.97	8.30	6.90	10.31	9.18	12.78	8.03	12..37	14.22	5.90	6.44	58.63	Oct 1903	1919
				Min.	1.26	2.03	1.05	1.87	0.66	1.92	1.02	0.57	0.52	0.89	0.59	2.07	39.20	Sept 1914	1918
				Aver.	3.72	3.76	3.96	4.11	3.60	4.21	4.78	4.40	4.29	4.43	2.98	4.02	48.26		
12	Mahwah, N.J.	253	1903-1914	Max.	5.47	7.29	7.58	8.08	10.19	10.58	9.72	7.34	10.55	10.03	6.46	9.30	55.27	June 1903	1913
			1956-1966	Min.	1.94	1.95	1.73	1.37	0.43	1.43	0.84	1.25	1.41	0.62	0.62	1.14	32.14	May 1964	1964
				Aver.	3.42	3.45	3.89	4.31	3.17	3.72	3.85	4.44	4.41	4.18	3.59	3.49	45.92		
19	Charlotteburg, N.J.	760	1893-1966	Max.	7.13	10.06	9.50	10.22	8.81	9.56	13.34	16.94	12.58	14.06	10.41	10.02	73.26	Aug 1955	1952
				Min.	0.58	0.79	0.76	0.69	0.24	0.62	1.03	0.84	0.33	0.12	0.55	0.45	34.00	Oct 1924	1965
				Aver.	3.62	3.58	4.08	4.17	3.98	4.13	4.64	4.62	4.32	4.02	4.07	3.92	49.15		
20	Newfoundland, N.J.	780	1897-1909	Max.	8.31	7.75	7.71	9.20	8.46	11.22	14.35	12.50	12.89	14.10	6.64	9.48	66.69	July 1897	1903
				Min.	2.42	0.94	2.84	1.83	0.26	2.04	1.39	1.98	1.45	1.45	0.85	2.46	42.78	May 1903	1900
				Aver.	4.15	4.58	4.65	4.56	4.25	4.53	5.39	5.22	4.88	4.74	3.03	4.69	54.67		
21	Ocean Park, N.J.	1060	1911-1923	Max.	6.01	5.38	7.30	5.65	5.32	6.85	9.49	8.77	8.32	7.77	4.85	5.66	57.16	July 1919	1920
				Min.	1.32	0.92	0.40	1.50	2.09	1.17	2.20	1.01	0.33	0.85	0.78	1.74	34.34	Sept 1914	1918
				Aver.	3.07	2.45	3.61	3.34	3.63	3.81	4.99	4.43	3.07	3.41	3.40	3.58	42.79		
22	Oak Ridge, N.J.	870	1893-1966	Max.	7.06	7.04	9.29	7.94	9.23	11.29	14.78	16.08	13.42	12.90	10.87	7.92	71.72	Aug 1955	1952
				Min.	0.97	0.14	0.90	0.81	0.40	0.59	0.80	1.01	0.37	0.16	0.87	0.56	32.43	Feb 1895	1965
				Aver.	3.61	3.50	3.87	4.02	3.81	4.17	4.95	4.92	4.25	3.93	4.08	3.93	49.04		
23	Canistear, N.J.	1040	1926-1966	Max.	5.85	4.77	9.15	8.70	9.05	11.79	10.95	21.74	11.55	13.52	9.56	9.56	64.48	Aug 1955	1952
				Min.	0.81	1.51	1.67	1.13	0.93	0.61	1.02	1.26	0.92	0.12	0.88	0.64	29.11	Oct 1963	1965
				Aver.	3.49	3.16	3.95	4.14	3.64	4.54	4.78	5.16	4.11	3.87	4.42	3.59	48.85		
26	Boonton, N.J.	280	1892-1900	Max.	6.55	8.15	8.43	7.30	8.89	7.66	14.14	11.36	12.95	9.35	10.01	8.70	60.47	July 1919	1952
				Min.	0.62	0.57	0.80	1.08	0.74	0.46	0.87	0.47	0.26	0.26	0.30	0.21	32.51	Dec 1955	1965
				Aver.	3.26	3.22	3.63	3.82	3.94	3.58	4.32	4.54	4.09	3.45	3.78	3.39	45.02		
30	Dover, N.J.	600	1885-1944	Max.	7.75	8.39	8.01	7.53	8.85	15.02	13.27	12.87	12.16	10.77	9.73	7.79	69.25	June 1903	1903
				Min.	1.78	0.77	1.03	0.64	0.37	1.00	0.61	1.32	0.36	0.11	0.56	1.08	35.33	Oct 1904	1895
				Aver.	4.10	3.74	4.02	3.76	3.79	4.32	5.15	4.67	4.28	3.88	3.82	3.99	49.52		
32	Hanover, N.J.	213	1888-1903	Max.	8.26	8.44	8.43	7.91	7.18	8.94	11.83	13.07	9.77	10.44	10.72	7.95	71.56	Aug 1903	1902
				Min.	1.41	0.80	1.61	1.02	0.56	1.37	1.35	2.25	1.17	0.67	0.73	1.35	36.75	May 1903	1895
				Aver.	3.95	4.12	4.01	3.75	4.11	3.67	5.24	5.69	4.49	3.92	3.67	3.96	50.58		

TABLE 4 (Cont.)

33	Morristown, N.J.	332	1926-1938	Max.	4.27	3.43	4.62	5.16	4.98	8.48	8.18	11.41	9.89	8.79	5.93	4.14	39.11	Aug 1928	1934
				Min.	0.64	0.49	0.83	0.60	0.47	1.76	0.44	1.62	1.34	0.87	0.26	0.11	25.26	Dec 1930	1930
				Aver.	1.82	1.41	1.97	2.19	2.64	3.98	4.20	5.14	3.99	3.40	2.42	1.50	34.66		
35	Roseland, N.J.	369	1897-1902	Max.	5.15	6.90	7.27	8.26	8.02	5.86	11.51	10.37	6.93	6.72	6.99	7.71	59.50	July 1897	1902
				Min.	1.86	0.77	3.65	2.18	1.65	1.55	4.44	2.82	1.30	1.72	1.08	2.18	45.94	Feb 1901	1895
				Aver.	3.99	4.82	4.93	4.09	5.18	3.03	7.03	5.95	3.67	3.69	3.65	5.06	55.14		
36	Verona, N.J.	490	1926-1932	Max.	5.08	6.00	5.38	8.04	6.11	4.91	9.34	11.75	4.87	8.17	5.13	4.09	61.46	Aug 1927	1927
				Min.	2.01	2.22	1.64	2.17	1.80	2.04	0.74	2.56	1.62	0.84	1.02	0.90	36.99	July 1929	1930
				Aver.	3.10	4.10	3.50	4.11	3.58	3.89	5.98	6.06	3.61	3.81	3.19	3.03	47.96		
38	Canoe Brock, N.J.	180	1931-1966	Max.	7.62	5.26	8.19	6.38	10.12	7.94	13.71	14.65	9.97	7.86	11.36	7.44	66.99	Aug 1942	1945
				Min..	0.86	1.72	1.90	0.72	1.14	0.05	0.44	0.19	0.27	0.61	0.53	0.14	32.92	June 1949	1965
				Aver.	3.59	3.04	4.18	3.99	3.89	3.74	4.40	4.89	4.26	3.29	4.07	3.60	46.94		
39	Chatham, N.J.	185	1903-1962	Max.	7.30	6.26	9.05	9.23	9.66	8.80	12.18	15.80	10.80	11.00	12.20	8.52	66.10	Aug 1955	1945
				Min.	0.77	1.80	0.96	1.33	0.82	0.07	0.58	0.71	0.38	0.22	0.45	0.14	37.64	June 1949	1917
				Aver.	3.63	3.44	4.09	4.18	3.98	4.05	4.76	4.98	4.34	3.[illegible]4	3.76	4.02	51.22		
40	Gillette, N.J.	400	1867-1896	Max.	6.46	6.21	6.77	5.41	7.43	5.94	12.31	8.07	10.34	5.16	10.19	6.09	62.41	July 1889	1889
				Min.	1.29	1.71	2.19	0.97	2.72	1.40	1.25	1.15	0.95	0.65	0.67	1.43	38.63	Oct 1892	1895
				Aver.	3.91	3.66	3.88	3.23	4.52	3.35	5.62	4.49	4.18	3.29	4.09	3.66	47.88		
48	Sussex, N.J.	440	1891-1916	Max.	8.50	6.06	7.27	8.66	7.80	14.87	12.77	17.30	12.03	9.24	7.99	8.11	63.25	Aug 1955	1942
			1919-1966	Min.	0.71	0.85	0.60	0.80	0.70	0.21	0.62	1.00	0.29	0.01	0.24	0.70	29.56	Oct 1924	1964
				Aver.	3.30	2.99	3.30	3.62	3.63	3.99	4.62	4.57	3.79	3.21	3.55	3.30	43.87		
50	Somerville, N.J.	75	1880-1889	Max.	7.70	6.74	8.17	7.60	8.66	11.66	12.33	14.51	11.05	9.97	8.31	7.75	59.47	Aug 1955	1902
			1891-1966	Min.	0.92	0.90	0.73	0.48	0.42	0.08	0.64	0.43	0.18	0.26	0.27	0.31	29.87	June 1949	1965
				Aver.	3.45	3.32	3.77	3.57	3.67	3.60	4.94	4.71	3.66	3.29	3.24	3.50	44.72		
52	Plainfield, N.J.	120	1867-1966	Max.	8.37	7.65	8.28	8.22	9.17	10.14	15.52	15.64	13.13	9.47	11.13	7.67	82.37	Aug 1955	1888
				Min.	0.89	0.79	0.88	0.87	0.84	0.02	0.33	0.50	0.14	0.23	0.40	0.21	32.56	June 1949	1965
				Aver.	3.72	3.77	4.11	3.84	3.87	3.89	5.31	4.97	4.35	3.70	3.52	3.72	48.77		
55	Elizabeth, N.J.	33	1880-1966	Max.	8.58	7.83	8.77	8.27	9.12	8.76	20.80	16.29	18.58	11.22	9.43	8.20	63.35	July 1897	1945
				Min.	1.34	0.91	1.08	0.15	0.30	0.16	0.59	0.50	0.07	0.40	0.56	0.12	29.47	Sept 1941	1965
				Aver.	3.98	3.88	4.22	3.86	3.88	3.66	5.02	4.53	4.08	3.70	3.50	3.79	48.10		
57	New York, N.Y., WB	132	1826-1966	Max.	7.45	7.81	7.91	11.19	9.10	12.53	9.99	14.22	14.51	11.55	9.82	7.15	56.68	Sept 1882	1859
				Min.	0.10	0.55	0.37	0.30	0.19	0.16	0.23	0.24	0.06	0.06	0.61	0.45	26.09	Oct 1853	1965
				Aver.	3.27	3.26	3.52	3.36	3.42	3.38	4.01	4.29	3.42	3.36	3.40	3.27	41.96		
58	West Point, N.Y.	360	1840-1859	Max.	9.95	7.29	12.02	10.53	11.66	7.37	10.48	11.75	13.50	12.75	10.02	9.51	65.01	Sept 1882	1952
			1864-1966	Min.	0.74	0.63	0.52	0.50	0.57	0.69	1.04	0.05	0.17	0.00	0.25	0.76	29.99	Oct 1924	1931
				Aver.	3.43	3.25	3.75	3.84	4.00	3.54	4.30	4.24	3.81	3.57	3.88	3.55	45.16		
	Average				3.53	3.45	3.87	3.80	3.81	3.82	4.81	4.79	4.01	3.66	3.59	3.63	46.77		

B - SEASONAL AVERAGE RAINFALL (INCHES) BY REGIONS

Location	Annual	Winter Jan. - March	Spring April - June	Summer July - Sept.	Fall Oct. - Dec.
Highland Area [b]	47.67	10.91	11.81	13.54	11.41
Central Basin [c]	47.18	10.77	11.37	14.20	10.84
Lower Valley [d]	45.85	10.85	11.20	13.27	10.53
Entire Passaic Area	46.77	10.85	11.43	13.61	10.88
Percentage	100.00	23.2	24.4	29.1	23.3

a. These reference numbers refer to Figure A6.

b. Based on records at Mahwah, Charlotteburg, Newfoundland, Ocean Park, Oak Ridge, Canistear, Dover, Sussex, New Jersey; and West Point, New York.

c. Based on records at Pompton Plains, Boont[illegible] [illegible]over, Morristown, Roseland, Canoe Brook, Chatham, Gillette.

d. Based on records at Newark, Jersey City, Ridgefield, New Milford, Woodcliff Lake, Paterson, Little Falls, Verona, Somerville, Plainfield, Elizabeth, [illegible]

TABLE 5

SNOWFALL DATA, PASSAIC RIVER BASIN, N. J.

Locality	Elevation (Ft., m.s.l.)	Years of Record	Jan.	Feb.	Mar.	Apr.	Oct.	Nov.	Dec.	Annual
AVERAGE MONTHLY AND ANNUAL SNOWFALL (INCHES) BY STATIONS										
Dover (discont. in 1945)	600	48	10.3	10.5	6.9	1.7	0.1	2.3	7.3	39.1
Charlotteburg	760	79	10.2	11.2	6.5	1.6	0.1	1.9	7.6	39.1
Newton	565	81	11.1	11.9	6.9	1.4	T	2.4	7.9	41.9
Sussex	440	73	10.8	11.5	6.3	1.2	0.1	2.1	7.6	40.1
Warwick, N.Y. (discont.'74)	680	54	12.5	13.9	8.4	1.8	0.1	2.3	10.7	50.2
Boonton	280	32	6.7	10.0	6.5	1.4	T	1.3	5.9	32.0
Chatham (discont. in 1966)	185	19	7.6	9.2	7.5	1.7	0.1	1.3	6.9	34.2
Elizabeth (discont. in 1970)	33	73	7.5	9.6	5.2	1.0	0.1	1.1	6.0	30.3
Plainfield	120	85	8.0	9.8	5.5	0.9	0.1	1.2	6.6	32.2
Somerville	75	80	7.5	8.3	5.2	0.8	T	.9	5.0	27.9
Little Falls	157	68	7.8	8.5	5.7	1.0	0.1	1.0	6.3	30.6
Paterson	100	78	8.4	10.0	6.0	1.1	T	1.2	6.7	33.5
Newark	11	74	7.7	9.4	5.6	1.2	0.1	1.2	6.6	31.7
Jersey City (No Change)	135	58	6.5	7.8	4.7	1.1	T	0.7	5.3	24.7
Ridgefield (discont. in 1962)	80	43	7.9	9.4	6.5	1.1	0.1	1.1	7.2	33.1
New York, N. Y.	132	93	7.1	8.5	5.7	0.8	T	0.7	5.6	28.0
AVERAGE MONTHLY AND ANNUAL SNOWFALL (INCHES) BY REGIONS										
Highland Area[a]			10.3	11.5	6.9	1.5	0.1	2.1	7.8	40.4
Central Basin[b]			7.7	9.1	5.8	1.1	0.1	1.1	6.2	31.0
Lower Valley[c]			7.5	9.0	5.7	1.1	T	1.0	6.3	30.2
Entire Passaic Area			8.6	10.0	6.2	1.2	0.1	1.4	6.8	34.3

a. Based on records at Dover, Charlotteburg, Newton, Sussex, Boonton, N.J., and Warwick, N.Y.
b. Based on records at Chatham, Elizabeth, Plainfield, Somerville and Little Falls, N.J.
c. Based on records at Paterson, Newark, Jersey City, Ridgefield, N.J., and New York, N.Y.

TABLE 6

GREAT STORMS OVER THE NORTHEASTERN STATES

Storm No.	Date	Location of Storm Center	Distance (Miles) and Direction of Storm Center Thru Paterson	Type of Storm	Maximum Storm Rainfall at Center (inches)	Average Rainfall Over Passaic Area (inches)	Percent of Total Rain Falling in Period Indicated* Maximum 1-day	Maximum 2-day	Area of 9-inch Isohyetal (sq. mi.)
1	July 17-18, 1942	Port Allegheny, Pa.	219 N.W.	Extra-tropical	35.0	1.3	100	100	1,250
2	Aug. 31-Sept. 1, 1940	Ewan, N.J.	100 S.W.	Extra-tropical	24.0	1.5	100	100	1,450
3	August 19, 1939	Manahawkin, N.J.	85 S.	Extra-tropical	18.0	1.9	100	100	2,800
4	Sept. 20-24, 1882	Paterson, N.J.	0	Extra-tropical	17.90	9.2	-	82	2,756
5	Sept. 2-6, 1935	Easton, Md.	180 S.W.	Hurricane	16.68	2.5	50-63	89-95	8,663
6	Aug. 20-26, 1933	Peekamoose, N.Y.	71 N.W.	Hurricane	15.98	5.8	49-69	66-83	5,959
7	July 26-29, 1897	Jewel, Md.	192 S.W.	Hurricane	15.80	4.5	-	-	256
8	Sept. 16-23, 1938	Hubbardston, Mass.	151 N.E.	Hurricane	15.60	7.0	43-65	65-79	14,226
9	Oct. 7-12, 1903	Paterson, N.J.	0	Extra-tropical	15.51	11.4	50-81	90-98	3,565
10	July 15-23, 1945	Midland Park, N.J.	6 N.N.E.	Extra-tropical	14.73	8.5	28-59	35-70	440
11	July 6-13,1935	Hector, N.Y.	179 N.W.	Extra-tropical	14.23	2.5	44-73	78-90	1,946
12	Sept. 16-23, 1938	Storrs, Conn.	115 N.E.	Hurricane	14.16	7.0	31-51	56-71	14,226
13	Aug. 20-26, 1933	York, Pa.	149 S.W.	Hurricane	14.01	5.8	43.70	79-83	5,959
14	Aug. 9-13, 1928	Cheltenham, Md.	206 S.W.	Hurricane	13.29	0.8	52-83	88-100	2,050
15	Sept. 14-17, 1933	Provincetown, Mass.	221 N.E.	Hurricane	13.27	3.3	43-75	67-95	1,585
16	July 19-23, 1919	Boonton, N.J.	13 S.W.	Hurricane	12.97	7.8	25-65	50-78	1,223
17	Oct. 3-4, 1869	Canton, Conn.	91 N.E.	Extra-tropical	12.35	4.0	-	100	900
18	May 17-25, 1894	Bridgeton, N.J.	117 S.W.	Extra-tropical	12.07	2.6	-	-	--
19	Mar. 9-22, 1936	Plymouth, N.H.	226 N.E.	Transcontinental	11.18	6.0	28	30	--
20	May 17-25, 1894	Moorestown, N.J.	81 S.W.	Extra-tropical	10.41	2.6	-	-	230
21	Sept. 26-28, 1942	Elka Park, N.Y.	86 N.	Extra-tropical	10.40	3.0	58	100	20
22	July 11-15, 1897	Southington, Conn.	81 N.E.	Hurricane	10.30	4.3	80-90	100	--
23	Mar. 9-22, 1936	Fitchburg, Mass.	166 N.E.	Transcontinental	9.70	6.0	33	37	154
24	Nov. 2-6, 1927	Somerset, Vt.	151 N.E.	Hurricane	9.68	3.0	72-100	95-100	400
25	Mar. 9-22, 1936	Southbridge, Mass.	135 N.E.	Transcontinental	9.29	6.0	36	48	141
26	Aug. 17-20, 1955	Westfield, Mass.	138 N.E.	Hurricane	19.75	5.0	62-92	95-98	--
27	Oct. 14-18, 1955	West Schokan, N.Y.	115 N.	Extra-tropical	17.80	5.5	25-87	26-87	--
28	Sept. 12, 1960	Cold Brook, N.Y.	80 N.	Hurricane	8.39	4.5	47-70	81-99	--
29	May 29, 30, 1968	Newark, N.J.	5 S.E.	Extra-tropical	7.3	4.5	60	100	--
30	Aug. 27, 28, 1971	Bound Brook, N.J.	20 S.W.	Hurricane	9.2	8.0	55-85	100	--
31	June 17-24, 1972	Harrisburg, Pa.	125 W.	Hurricane	18.3	3.5	10-30	50-75	--
32	Aug. 23, 1973	Watchung, N.J.	10 S.W.	Local	8.0	2.2	95	100	--
33	Sept. 23-27, 1975	Westminster, Md.	200 S.W.	Extra-tropical	14.3	7.7	25-35	45-65	--
34	Nov. 7, 8, 1977	Sandy Hook, N.J.	155 S.E.	Extra-tropical	8.2	5.5	80	100	--

TABLE 7

ANNUAL PEAK DISCHARGES
SELECTED GAGES
PASSAIC RIVER BASIN, N.J.

MAIN STREAM (PASSAIC RIVER) GAGES

WATER YEAR	MILLINGTON, N.J. (55.4 SQ.MI.) MONTH AND DAY	MILLINGTON, N.J. (55.4 SQ.MI.) PEAK FLOW (CFS)	CHATHAM, N.J. (100 SQ.MI.) MONTH AND DAY	CHATHAM, N.J. (100 SQ.MI.) PEAK FLOW (CFS)	LITTLE FALLS, N.J. PATERSON, N.J. JOINT RECORD (762/785 SQ.MI.) MONTH AND DAY	LITTLE FALLS, N.J. PATERSON, N.J. JOINT RECORD (762/785 SQ.MI.) PEAK FLOW (CFS)
1811					NOV 24	27,000
1865					JUL 17	22,500
1882					SEP 24	19,000
1896					FEB 07	16,700
1898					FEB 22	9,500 1/
1899					MAR 06	7,830 1/
1900					FEB 14	9,430 1/
1901					APR 23	9,270 1/
1902					MAR 02	23,400
1903					DEC 23	11,000
1904	OCT 10	2,077	OCT 09	2,310	OCT 10	31,700
1905	JAN 09	2,000	JAN 09	3,000	MAR 22	8,760 1/
1906	MAR 04	1,320	APR 16	1,190	MAR 05	6,110 1/
1907	MAR 18	2,000	MAR 18	2,860	MAR 19	8,100 1/
1908			FEB 28	1,600	NOV 08	9,190 1/
1909			FEB 25	1,360	FEB 25	6,490 1/
1910			MAR 04	2,260	APR 27	8,980 1/
1911			NOV 05	525	APR 06	3,370 1/
1912					MAR 16	10,400 1/
1913					MAR 29	7,450 1/
1914					MAR 29	7,980 1/
1915					JAN 14	7,800 1/
1916					APR 01	6,130 1/
1917					MAR 28	4,530 1/
1918					FEB 28	6,490 1/
1919	JUL 24	2,000			JUL 24	8,630 1/
1920					MAR 18	11,600 1/
1921					MAR 04	6,244 1/
1922	MAR 07	548			MAR 09	6,563 1/
1923	MAR 17	700			MAR 18	7,675 1/
1924	APR 07	1,100			APR 08	10,787 1/
1925	FEB 25	718			FEB 16	6,036 1/

C O N T N I U E D

TABLE 7 (CONT'D)

MAIN STREAM (PASSAIC RIVER) GAGES

WATER YEAR	MILLINGTON, N.J. (55.4 SQ.MI.) MONTH AND DAY	MILLINGTON, N.J. (55.4 SQ.MI.) PEAK FLOW (CFS)	CHATHAM, N.J. (100 SQ.MI.) MONTH AND DAY	CHATHAM, N.J. (100 SQ.MI.) PEAK FLOW (CFS)	LITTLE FALLS, N.J. PATERSON, N.J. JOINT RECORD (762/785 SQ.MI.) MONTH AND DAY	LITTLE FALLS, N.J. PATERSON, N.J. JOINT RECORD (762/785 SQ.MI.) PEAK FLOW (CFS)
1926	FEB 26	668			FEB 26	5,519 1/
1927	FEB 26	490			SEP 03	8,707 1/
1928	FEB 24	700			OCT 21	5,965 1/
1929	FEB 28	735			MAR 07	5,116 1/
1930	MAR 08	565			MAR 09	3,614 1/
1931	MAR 30	460			JUN 18	3,953 1/
1932	MAR 28	665			APR 02	4,650 1/
1933	SEP 16	934			NOV 21	8,480
1934	MAR 05	972			APR 02	5,660
1935	FEB 17	504			DEC 02	3,950
1936	MAR 12	1,480			MAR 13	19,200
1937	DEC 20	602			FEB 23	5,400
1938	SEP 22	1,040	SEP 21	1,910	SEP 23	9,350
1939	FEB 04	585	FEB 05	972	DEC 07	5,670
1940	MAR 15	938	MAR 15	1,090	APR 10	5,620
1941	FEB 08	493	FEB 09	756	FEB 08	5,070
1942	AUG 14	1,360	AUG 16	2,020	AUG 18	7,050
1943	DEC 31	916	DEC 31	1,420	JAN 01	7,490
1944	APR 25	574	APR 26	964	APR 25	5,080
1945	FEB 27	748	FEB 27	1,040	JUL 23	19,500
1946	JUN 03	800	JUN 04	1,040	DEC 27	7,090
1947	APR 06	549	APR 05	869	APR 06	5,490
1948	NOV 09	762	NOV 12	1,410	NOV 08	5,220
1949	DEC 31	1,300	JAN 01	1,710	JAN 01	8,960
1950	MAR 24	395	MAY 23	670	MAR 24	4,320
1951	MAR 31	740	APR 03	1,010	APR 01	12,400
1952	JUN 02	813	JUN 01	1,290	JUN 03	12,000
1953	MAR 16	728	MAR 16	1,150	JAN 26	7,430
1954	DEC 15	335	DEC 14	651	MAY 11	2,970
1955	AUG 19	977	AUG 19	1,390	AUG 20	9,850
1956	OCT 16	704	OCT 16	1,150	OCT 18	11,600
1957	APR 07	704	APR 07	1,100	APR 09	5,270
1958	MAR 01	725	MAR 02	1,140	APR 08	6,330
1959	OCT 27	439	OCT 26	770	MAR 07	3,600
1960	APR 05	682	SEP 12	1,110	APR 07	7,140

C O N T I N U E D

B

TABLE 7 (CONT'D)

MAIN STREAM (PASSAIC RIVER) GAGES

	MILLINGTON, N.J. (55.4 SQ.MI.)		CHATHAM, N.J. (100 SQ.MI.)		LITTLE FALLS, N.J. PATERSON, N.J. JOINT RECORD (762/785 SQ.MI.)	
WATER YEAR	MONTH AND DAY	PEAK FLOW (CFS)	MONTH AND DAY	PEAK FLOW (CFS)	MONTH AND DAY	PEAK FLOW (CFS)
1961	FEB 26	990	FEB 27	1,290	FEB 27	7,610
1962	MAR 13	972	MAR 12	1,450	MAR 15	4,960
1963	MAR 07	768	MAR 09	980	MAR 10	3,250
1964	JAN 10	496	JAN 09	872	JAN 26	3,420
1965	FEB 09	636	FEB 10	980	FEB 08	4,630
1966	FEB 15	650	FEB 13	1,010	FEB 14	3,630
1967	MAR 08	801	MAR 07	1,320	MAR 14	5,720
1968	MAY 29	1,070	MAY 29	2,560	MAY 31	13,500
1969	MAR 26	714	JUL 28	1,640	MAR 26	5,210
1970	APR 03	980	APR 02	1,420	APR 05	9,110
1971	AUG 29	1,670	AUG 28	2,540	AUG 29	8,010
1972	JUN 23	1,070	JUN 22	1,520	JUN 25	10,300
1973	NOV 09	1,090	AUG 02	3,200	FEB 05	10,600
1974	DEC 21	990	DEC 21	1,400	DEC 23	8,910
1975	SEP 27	1,340	SEP 27	2,520	SEP 27	9,640
1976	JAN 28	858	OCT 19	1,240	JAN 30	6,390
1977	MAR 23	850	MAR 22	1,390	MAR 25	8,440
1978	MAR 27	1,010	AUG 12	1,540	MAR 19	10,100
1979	JAN 25	1,300	JAN 26	1,710	JAN 27	10,200
1980	MAR 25	740	MAR 25	1,370	APR 11	9,870
1981	MAY 12	621	MAY 13	899	FEB 21	4,370
1982	JAN 04	882	JAN 04	1,240	JAN 06	4,230
1983	APR 17	1,030	MAR 21	1,380	MAR 22	9,740
1984	APR 05	1,370	APR 06	1,930	APR 07	18,400

1/ MEAN DAILY FLOW.

C

TABLE 7 (CONT'D)

RAMAPO RIVER GAGES

	MAHWAH, N.J. (118 SQ.MI.)		POMPTON LAKES, N.J. (160 SQ.MI.)	
WATER YEAR	MONTH AND DAY	PEAK FLOW (CFS)	MONTH AND DAY	PEAK FLOW (CFS)
1882	SEP 15	7,200	SEP 25	10,500
1886	FEB 14	8,100	FEB 14	12,000
1896	FEB 08	6,100	FEB 08	8,730
1902	MAR 02	4,300	MAR 02	7,050
1904	OCT 09	12,400	OCT 09	17,092
1905	OCT 22	2,300		
1906	MAR 04	2,200		
1907	MAR 18	2,810		
1908	OCT 30	3,250		
1909	FEB 20	3,450		
1910	JAN 22	5,200		
1911	AUG 29	3,650		
1912	MAR 13	3,450		
1913	MAR 27	2,810		
1914	OCT 25	3,250		
1922			MAR 07	5,900
1923	MAR 17	1,520	MAR 18	2,270
1924	APR 07	4,150	APR 07	6,800
1925	FEB 12	2,410	FEB 12	3,200
1926	FEB 26	1,490	FEB 27	2,020
1927	SEP 02	5,140	SEP 02	7,220
1928	NOV 04	3,100	NOV 04	3,930
1929	MAR 06	1,560	MAR 06	2,040
1930	MAR 09	1,390	MAR 09	1,720
1931	MAR 09	1,040	MAY 09	1,420
1932	MAR 28	1,420	MAR 29	1,870
1933	AUG 24	5,650	AUG 24	5,680
1934	MAR 05	1,930	MAR 06	2,650
1935	DEC 01	1,400	DEC 01	1,840
1936	MAR 12	7,780	MAR 12	12,300
1937	DEC 20	3,450	FEB 22	3,510
1938	SEP 22	6,720	SEP 22	6,620
1939	DEC 06	2,480	DEC 06	3,260
1940	MAR 31	2,030	APR 09	2,940
1941	FEB 08	1,560	FEB 08	1,860
1942	AUG 18	1,590	AUG 18	1,960
1943	DEC 31	2,090	DEC 31	2,740
1944	NOV 09	1,880	NOV 10	2,200

C O N T I N U E D

D

TABLE 7 (CONT'D)

RAMAPO RIVER GAGES

WATER YEAR	MAHWAH, N.J. (118 SQ.MI.) MONTH AND DAY	MAHWAH, N.J. (118 SQ.MI.) PEAK FLOW (CFS)	POMPTON LAKES, N.J. (160 SQ.MI.) MONTH AND DAY	POMPTON LAKES, N.J. (160 SQ.MI.) PEAK FLOW (CFS)
1945	JUL 23	4,330	JUL 23	8,560
1946	MAY 28	1,920	MAY 28	2,520
1947	MAR 15	2,050	MAR 15	2,540
1948	MAR 17	1,830	MAR 18	2,360
1949	DEC 31	4,200	DEC 31	5,520
1950	MAR 23	1,290	MAR 24	1,780
1951	MAR 31	6,940	MAR 31	8,520
1952	MAR 12	4,150	JUN 02	4,780
1953	JAN 25	2,520	JAN 25	3,190
1954	DEC 15	1,260	DEC 15	1,360
1955	AUG 19	8,580	AUG 19	8,570
1956	OCT 16	10,900	OCT 16	12,000
1957	APR 06	1,950	APR 06	2,540
1958	DEC 21	3,800	DEC 21	4,750
1959	MAR 06	1,620	MAR 07	1,640
1960	AUG 20	3,450	AUG 20	3,550
1961	FEB 26	3,120	FEB 26	3,950
1962	MAR 13	2,360	MAR 13	2,520
1963	NOV 11	1,370	NOV 11	1,310
1964	JAN 26	1,380	JAN 26	1,360
1965	FEB 08	1,980	FEB 09	2,160
1966	FEB 14	1,360	FEB 14	1,460
1967	MAR 12	1,180	MAR 12	1,380
1968	MAY 29	8,770	MAY 29	8,530
1969	MAR 25	3,000	MAR 26	3,160
1970	APR 02	3,380	APR 03	4,540
1971	AUG 28	6,700	AUG 28	6,420
1972	JUN 23	2,630	JUN 23	3,190
1973	FEB 03	4,340	FEB 03	5,580
1974	DEC 21	6,050	DEC 21	7,040
1975	SEP 27	2,940	SEP 27	3,380
1976	JAN 28	2,740	JAN 28	3,090
1977	MAR 23	4,100	MAR 23	5,290
1978	NOV 08	11,800	NOV 08	10,300
1979	JAN 25	4,750	JAN 25	5,130
1980	MAR 22	6,520	MAR 22	6,700
1981	FEB 20	3,270	FEB 21	3,630
1982	JAN 05	2,520	JAN 05	2,590
1983	MAR 19	4,480	MAR 19	5,160
1984	APR 05	15,500	MAY 05	15,400

TABLE 7(CONT'D)

OTHER GAGES

WATER YEAR	ROCKAWAY RIVER BELOW RESERVOIR BOONTON, N.J. (119 SQ.MI.) MONTH AND DAY	ROCKAWAY PEAK FLOW (CFS)	WHIPPANY RIVER MORRISTOWN, N.J. (29.4 SQ.MI.) MONTH AND DAY	WHIPPANY PEAK FLOW (CFS)	SADDLE RIVER LODI, N.J. (54.6 SQ.MI.) MONTH AND DAY	SADDLE PEAK FLOW (CFS)
1882	SEP 25	4,850				
1896	FEB 08	5,500	FEB 08	2,600		
1902	MAR 02	4,590	MAR 02	2,100	MAR 02	4,500
1904	OCT 10	7,560 1/	OCT 10	2,444	OCT 09	6,500
1913	JAN 04	1,560 1/				
1914	MAR 29	1,200 1/				
1915	JAN 14	1,480 1/				
1916	FEB 26	1,060 1/				
1917	MAR 29	698 1/				
1918	FEB 21	1,060 1/				
1919	JUL 24	2,670 1/				
1920	MAR 14	2,120 1/				
1921	JAN 16	993 1/				
1922	MAR 09	1,870 1/	JUL 01	1,020		
1923	MAR 18	994 1/	MAR 16	815		
1924	APR 08	1,950 1/	APR 07	1,530	APR 07	1,280
1925	FEB 15	684 1/	AUG 01	975	FEB 12	980
1926	FEB 26	688	FEB 25	783	FEB 26	741
1927	AUG 29	759	NOV 16	450	SEP 02	1,630
1928	AUG 27	1,110	AUG 26	2,000	JUL 07	829
1929	APR 26	759	FEB 07	1,290	FEB 08	903
1930	MAR 09	659	MAR 08	570	APR 08	418
1931	JUL 11	1,000	JUL 11	552	APR 24	549
1932	MAR 29	900	MAR 28	604	MAR 29	686
1933	NOV 20	2,150	NOV 19	1,820	NOV 20	1,320
1934	SEP 30	1,460	MAR 05	847	MAR 06	850
1935	JUL 11	1,790	OCT 06	467	OCT 11	614
1936	MAR 12	3,750	MAR 12	1,500	MAR 12	1,720
1937	MAY 16	914	DEC 20	491	MAY 15	1,060
1938	SEP 22	1,860	SEP 22	1,170	SEP 22	1,680
1939	DEC 07	993	APR 19	529	DEC 06	760
1940	APR 09	1,010	MAR 15	1,500	MAR 15	1,380
1941	FEB 08	652	FEB 08	679	FEB 08	1,030
1942	AUG 10	1,000	AUG 14	1,220	AUG 10	820
1943	DEC 31	1,270	DEC 30	540	DEC 31	1,020
1944	APR 25	1,130	MAR 07	640	APR 25	998
1945	JUL 21	1,270	JAN 01	460	JUL 23	3,500
1946	JUL 24	1,110	MAY 13	1,020	MAY 28	1,100

C O N T I N U E D

TABLE 7 (CONT'D)

OTHER GAGES

WATER YEAR	ROCKAWAY RIVER BELOW RESERVOIR BOONTON, N.J. (119 SQ.MI.) MONTH AND DAY	ROCKAWAY RIVER PEAK FLOW (CFS)	WHIPPANY RIVER MORRISTOWN, N.J. (29.4 SQ.MI.) MONTH AND DAY	WHIPPANY RIVER PEAK FLOW (CFS)	SADDLE RIVER LODI, N.J. (54.6 SQ.MI.) MONTH AND DAY	SADDLE RIVER PEAK FLOW (CFS)
1947	MAR 15	1,140	MAY 26	591	APR 06	1,010
1948	MAR 17	1,080	NOV 08	829	NOV 09	830
1949	DEC 31	2,360	DEC 31	1,350	DEC 31	1,030
1950	MAR 24	756	MAR 23	375	MAR 24	452
1951	MAR 31	1,910	MAR 31	938	MAR 31	2,530
1952	JUN 21	2,670	JUN 01	1,360	JUN 02	1,740
1953	JAN 25	1,590	JAN 24	804	MAR 14	1,860
1954	MAY 09	418	SEP 11	282	SEP 12	1,270
1955	AUG 21	1,870	AUG 19	1,160	AUG 19	2,200
1956	OCT 16	1,810	OCT 15	900	OCT 16	1,530
1957	APR 06	1,060	MAY 14	613	NOV 02	795
1958	APR 07	1,230	FEB 28	925	FEB 28	1,760
1959	MAR 07	924	AUG 09	509	MAR 07	806
1960	SEP 13	1,730	SEP 12	684	SEP 13	1,190
1961	FEB 26	1,500	FEB 26	475	FEB 26	952
1962	MAR 13	1,530	MAR 12	1,160	MAR 13	1,670
1963	APR 04	294	MAR 06	367	MAR 07	824
1964	JAN 26	835	NOV 07	401	JAN 10	702
1965	APR 12	150	FEB 08	716	FEB 08	1,490
1966	MAR 06	735	SEP 21	640	SEP 22	1,600
1967	AUG 05	1,230	MAR 07	500	MAR 07	800
1968	MAY 29	3,450	MAY 29	956	MAY 29	3,330
1969	MAR 25	1,450	JUN 15	624	MAR 25	1,540
1970	APR 03	2,640	APR 02	1,310	APR 03	2,130
1971	AUG 28	2,380	AUG 28	2,280	SEP 12	3,770
1972	JUN 01	2,780	JUN 19	946	JUN 19	2,240
1973	FEB 03	2,680	FEB 03	1,360	FEB 03	3,210
1974	DEC 22	2,710	DEC 21	1,450	DEC 21	2,940
1975	SEP 25	1,620	SEP 25	1,020	JUL 14	2,270
1976	JUL 01	1,990	JAN 27	752	JUL 01	2,440
1977	MAR 23	2,620	MAR 22	1,480	FEB 25	3,130
1978	MAR 27	2,020	NOV 08	1,140	NOV 09	4,500
1979	JAN 25	4,380	JAN 25	2,080	JAN 21	2,890
1980	MAR 22	2,350	FEB 22	1,100	APR 10	2,470
1981	MAY 12	2,090	JUL 27	1,240	MAY 12	1,900
1982	FEB 04	1,320	JAN 04	871	JAN 04	1,980
1983	APR 17	2,940	APR 16	1,250	APR 16	2,550
1984	APR 06	4,260	APR 05	1,680	APR 05	3,350

1/ MEAN DAILY FLOW.

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TABLE 8

COMPARATIVE RUNOFF DATA - PASSAIC RIVER BASIN, N. J.

Stream	Gaging Station	Drainage Area (sq. mi.)	Operating Agency	Years of Record	Peak Discharge C.F.S.	Date	Average Discharge (C.F.S. per Sq. Mi.) Daily Max.	Daily Min.	Monthly Max.	Monthly Min.	Annual Average Max.	Annual Average Min.	Average for Period[b]
Passaic	Millington	55.4	U.S.G.S.	Nov.1903-July 1906	2,000	Oct. 10, 1903	31.6	0.144	8.12	0.277	1.94	1.62	1.81
Passaic	Millington	55.4	U.S.G.S.	Nov.1921-Sept.1977	2,000	Oct. 10, 1903	30.0	0.007	7.76	0.013	2.82	0.531	1.59
Passaic	Chatham	100.0	U.S.G.S.	Feb.1903-Dec.1911	5,150	Oct. 9, 1903	29.6	0.020	7.00	0.047	2.68	0.696	1.73
Passaic	Chatham	100.0	U.S.G.S.	Jan.1938-Sept.1977	5,150	Oct. 9, 1903	21.2	0.022	7.13	0.052	2.87	0.644	1.68
Passaic	Paterson (S.U.M. OAM)	785.0	U.S.G.S.	1877-1893	31,700	Oct. 10, 1903	--	--	6.37	0.269	2.64	1.11	1.91
Passaic	Little Falls[f]	762.0	U.S.G.S.	Sept.1897-Sept.1977	31,700	Oct. 10, 1903	35.7	0.00	8.61	0.038	3.53	0.356	1.52
Passaic	Paterson (S.U.M. OAM)	785.0	U.S.G.S.	Sept.1897-Sept.1953[a]	31,700	Oct. 10, 1903	35.7	0.00	9.30	0.113	3.71	0.966	1.90
Whippany	Morristown	29.4	U.S.G.S.	Sept.1921-Sept.1977	3,200	Oct. 10, 1903	51.4	0.143	7.31	0.251	2.99	0.830	1.74
Rockaway	Boonton) Below Reservoir	119.0	J.C.W.D.-U.S.G.S.	Jan.1906-Sept.1977	7,560	Oct. 10, 1903	29.4	0.00	8.48	0.000	2.33	0.062	1.13
Rockaway	Boonton)	119.0	J.C.W.D.-U.S.G.S.	Jan.1906-Sept.1953[a]	7,560[e]	Oct. 10, 1903	29.4	0.00	9.17	0.117	3.35	1.01	1.89
Pequannock	Macopin Dam	63.7	N.W.D.-U.S.G.S.	Jan.1892-Sept.1922	6,100	Oct. 10, 1903	--	--	8.47	0.036	3.07	1.26	2.03
Pequannock	Macopin Dam	63.7	N.W.D.-U.S.G.S.	Oct.1922-Sept.1977	6,100	Oct. 10, 1903	33.4	0.00	9.24	0.00	1.79	.003	0.81
Pequannock	Macopin Dam	63.7	N.W.D.-U.S.G.S.	Oct.1922-Sept.1953[a]	6,100	Oct. 10, 1903	33.4	0.00	10.38	0.005	3.19	0.904	1.93
Wanaque	Awosting (Greenwood Lake)	27.1	N.J.D.W.S.C.-U.S.G.S.	May 1919-Sept.1977	1,300	Oct. 16, 1955	46.1	0.00	9.45	0.000	3.30	0.775	1.93
Wanaque	Awosting	27.1	N.J.D.W.S.C.-U.S.G.S.	Oct.1934-Sept.1953[a]	1,190	Mar. 31, 1951	41.0	0.00	9.36	0.000	3.30	0926	1.98
Wanaque	Wanaque	90.4	N.J.D.W.S.C.-U.S.G.S.	May 1912-May 1915	11,100	Oct. 9, 1903	17.5	0.144	5.21	0.313	2.44	2.09	2.23
Wanaque	Wanaque	90.4	N.J.D.W.S.C.-U.S.G.S.	Sept.1929-Sept.1977	11,100	Oct. 9, 1903	58.2	0.006	8.38	0.008	2.57	0.026	.87
Wanaque	Wanaque	90.4	N.J.D.W.S.C.-U.S.G.S.	May 1919-Sept.1953[a]	11,100	Oct. 9, 1903	58.2	0.006	9.86	0.000	3.08	0.887	1.86
Wanaque	Monks	40.4	U.S.G.S.	Jan.1935-Sept.1977	3,640	Aug. 19, 1955	71.8	0.000	10.17	0.086	3.19	0.804	2.00
Wanaque	Monks	40.4	U.S.G.S.	Jan.1935-Sept.1953[a]	2,660	Mar. 31, 1951	49.5	0.000	10.30	0.000	3.20	1.32	2.07
Ramapo	Mahwah	118.0	U.S.G.S.	Feb.1903-Dec.1906[c]	12,400	Oct. 9, 1903	45.6	0.093	8.08	0.350	3.91	1.84	2.59
Ramapo	Mahwah	118.0	U.S.G.S.	Sept.1922-Sept.1977	12,400	Oct. 9, 1903	65.6	0.068	9.75	0.094	2.91	1.03	1.93
Ramapo	Pompton Lakes	160.0	U.S.G.S.	Sept.1921-Sept.1977	15,800	Oct. 9, 1903	65.9	0.00	10.40	0.108	2.98	0.523	1.87
Ramapo	Pompton Lakes	160.0	U.S.G.S.	Dec.1953-Sept.1966[a]	15,800	Oct. 9, 1903	60.9	0.5	7.22	0.068	2.49	1.01	1.92
Saddle	Lodi	54.6	U.S.G.S.	Sept.1923-Sept.1977	7,000	Oct. 9, 1903	49.1	0.110	6.15	0.206	2.86	0.947	1.81
Pompton	Pompton Feeder Dam	355.0	U.S.G.S.	June 1940-Sept.1977[d]	28,340	Oct. 9, 1903	79.8	0.056	6.28	0.096	2.45	0.341	1.34
Pompton	Pompton Feeder Dam	355.0	U.S.G.S.	June 1940-Sept.1953[a,d]	28,340	Oct. 9, 1903	79.8	0.132	5.60	0.009	3.09	1.38	2.02
Ringwood Cr.	Wanaque	19.1	U.S.G.S.	Jan.1935-Sept.1977	1,150	Mar. 30, 1951	40.1	0.00	6.84	0.015	2.78	0.754	1.73
Cupsaw Br.	Wanaque	4.4	U.S.G.S.	Jan.1935-Sept.1958	536	Mar. 11, 1936	55.0	0.00	9.34	0.00	2.79	1.05	1.83
Blue Mine Br.	Wanaque	1.7	U.S.G.S.	Jan.1935-Sept.1958	458	Mar. 30, 1951	70.8	0.00	7.25	0.00	2.21	0.882	1.36
Weasel Br.	Clifton	4.4	U.S.G.S.	Mar.1937-Sept.1962	556	Mar. 12, 1962	37.5	0.00	4.67	0.044	2.16	0.796	1.34
West Br.	Wanaque	11.8	U.S.G.S.	Jan.1935-Sept.1977	1,900	Mar. 30, 1951	56.1	0.017	10.10	0.051	3.28	0.992	2.03
Second River	Belleville	11.6	U.S.G.S.	May 1937-Sept.1964	3,300	Jul. 23, 1938	47.0	0.198	3.87	0.406	2.07	1.24	2.03

a. Corrected for water supply diversions and storage.
b. Averages were based on the water year extending from October through September, with the exception of Ramapo River at Pompton Lakes which is based on the calendar year.
c. Records from 1907-1914 consist of gage heights only, published by U.S. Weather Bureau.
d. Records available from March 1903 to December 1904.
e. Average daily value.
f. Record at Paterson (drainage area 785.0 square miles) prior to October 1955.

Operating Agencies:

U.S.G.S. - U. S. Geological Survey
J.C.W.D. - Jersey City Water Department
N.W.D. - Newark Water Department
N.J.D.W.S.C. - North Jersey District Water Supply Commission

TABLE 9

COMPARATIVE FLOOD DATA - MAXIMUM FLOODS OF RECORD, PASSAIC RIVER BASIN, N. J.

COMPARISON OF REPRODUCED AND OBSERVED DATA, FLOOD OF OCTOBER 1903

Stream and Locality	Gross Drainage Area (Sq.Mi.)	Floods Reproduced by Corps: Peak Discharge (c.f.s.)	Floods Reproduced by Corps: Day and Hour of Peak	Observed or Estimated by Other Agencies: Peak Discharge (c.f.s.)	Observed or Estimated by Other Agencies: Day and Hour of Peak	Authority
Passaic R. at Millington	55.4	2,077		-	-	-
Passaic R. at Chatham	100.0	3,232	9TH 2 pm	2,400[a]	10th, 12 am	D
Passaic R. at Chatham	-			-	9th, 12 pm	A
Passaic R. at Chatham	-			-	11th, 7 am	B
Rockaway R. at Boonton	119.3	9,014	9TH 7 pm	7,560[b]	10th, 4 am	D, E
Rockaway R. at Boonton	-			5,764[a]	10th, 4 am	A, B
Whippany R. at Morristown	29.4	2,244		-	-	-
Whippany R. at Whippany	38.0			2,500	9th, 12 pm[a]	D
Whippany R. at Whippany	-			-	9th, 5 pm	A
Ramapo R. at Mahwah	118.0	12,232	9TH 5 pm	12,400	9th	E, F
Ramapo R. at Pompton Lakes	160.0	17,002	9TH 2 pm	9,000[a]	9th, 1 pm	A, B
Wanaque R. at Wanaque	90.4	8,425		-	-	-
Wanaque R. at Pompton	108.1	12,042		8,440[a]	9th, 12 am	A, D, F
Pequannock R. at Macopin Dam	63.7	6,642		5,800[a]	10th, 4 am	D
Pequannock R. at Macopin Dam	-			6,100[c]	10th	E, F
Pequannock R. at Pompton	85.0	5,131		-	-	-
Pompton R. at Pompton	353.8	29,049	9TH 1 pm	28,300[a]	10th, 6 am[a]	D, F
Pompton R. at Mountain View	377.3	28,090		23,400[a]	9th, 4:30 pm to 10th, 12 am	A, F
Passaic R. at Little Falls	762.2	31,570	10TH 2 pm	31,700	10th, 4 pm	A, C, F
Passaic R. at Little Falls	-			32,700	10th, 6 pm	G
Passaic R. at Paterson	785.0	31,913		28,000[b]	10th	F
Passaic R. at Dundee	809.9	32,050		35,800	10th, 9 pm	A, E, F

A = New Jersey State Geologist, Report of 1903.
B = Northern New Jersey Flood Commission, Report of 1904.
C = U. S. Geological Survey, Water Supply Paper No. 92 (1904).
D = New Jersey State Water Policy Commission, Report of 1931.
E = U. S. Geological Survey, Water Supply Paper No. 799 (1936).
F = U. S. Geological Survey, Water Supply Paper No. 847.
G = New Jersey Dept. of Conservation and Development (C C Vermoule) 1928.

a. Estimated value
b. Maximum daily discharge.
c. Maximum daily discharge, 5,360 c.f.s.

COMPARATIVE DISCHARGES OF MARCH 1902 AND OCTOBER 1903 FLOODS

Source of Data	Little Falls - Beatties Dam D.A. = 762.2 sq. mi.					Clifton - Dundee Dam D.A. = 809.9 sq. mi.				
	Discharge		Volume			Discharge		Volume		
	Peak (c.f.s.)	Peak Time	Inches	Time Limits From	Time Limits To	Peak (c.f.s.)	Peak Time	Inches	Time Limits From	Time Limits To
October 10, 1903										
U.S.G.S. 1904	31,675	2 pm - 8 pm[a] 6 pm[a]	6.61	10/8 6 pm	10/17 6 am	35,000	9 pm	7.83[b]	10/8 6 am	10/17 9 am
U.S.G.S. 1937	31,700	-	-	-	-	35,800	-	-	-	-
Vermoule 1903	-	2 pm	-	-	-	31,410	8 pm	7.12[e]	-	-
Vermoule 1928	32,628	6 pm	6.22[e]	-	-	31,410	-	6.24[d]	-	-
N.J.F.C. 1904[f]	-	-	-	-	-	37,300	9 pm	7.10	10/9 4 am	10/17 10 pm
Adopted	31,700	2 pm	6.22	10/8 6 pm	10/17 6 am	35,800	9 pm	6.50	10/8 6 am	10/17 9 am
March 2, 1902										
U.S.G.S. 1902	23,600	12 N	6.35	2/25 12 N	3/6 6 pm	25,000	6 pm	6.93[c]	2/25 12 N	3/8 6 pm
U.S.G.S. 1937	21,200	-	-	-	-	25,000	-	-	-	-
Vermoule 1902	21,207	9 am	-	-	-	22,677	7 pm	5.35[e]	-	-
Vermoule 1928	21,207	12 N	-	-	-	22,677	-	-	-	-
N.J.F.C. 1904	-	-	-	-	-	26,000	6 pm	6.25	2/25 12 N	3/8 6 pm
Adopted	21,200	12 N	5.94	2/25 12 N	3/8 6 pm	24,000	6 pm	5.82	2/25 12 N	3/8 6 pm

a. U.S.G.S - United States Geological Survey - W. S. & I Paper 92 (1904 Report) (Pages 9, 16 and 17).
b. Reported as 7.83 Inches of Runoff on Page 19 Reference (a).
c. Reported as 7.10 Inches of Runoff on Page 19 Reference (a).
d. New Jersey Department of Conservation & Development (1928 Report) by C.C. Vermoule (Page 15).
e. Geological Survey of New Jersey (1903 Report) by C.C. Vermoule (Page 24).
f. N.J.F.C. - Northern New Jersey Flood Commission.

TABLE 9A
RANKINGS OF APRIL 1984 FLOOD (A)
AT
LONG-TERM GAGING STATIONS
PASSAIC RIVER AND TRIBUTARIES, N.J. AND N.Y.

BASIN OR SUB-BASIN	STREAM	GAGING STATION	STATION YEARS OF RECORD (B)	RANKING OF FLOOD
Rockaway	Rockaway	Above Reservoir	47	Highest
Pompton	Pequannock	Macopin	49	Second (C)
"	Wanaque	Awosting	66	Highest
"	"	Monks	50	Highest
"	"	Wanaque	66	Highest
"	Ramapo	Mahwah	62	Highest
"	"	Pompton Lakes	63	Highest
"	Pompton	Pompton Plains	44	Second (C)
Passaic	Passaic	Little Falls	52	Fifth (C)

(A) Reference floods unadjusted for urbanization effects, if any.
(B) Period of continuous record through water year 1984.
(C) Highest flood occurred prior to start of continuous record.

TABLE. 10 SUMMARY OF SUBAREA DATA, PASSAIC RIVER BASIN, N.Y. & N.J.

Subarea Number	Point of Interest	Drainage Area (sq.mi.)	Watercourse Length (mi.)	Stream Slope (ft/mi.)	Length to Center of Gravity (mi.)	Subarea Slope (%)	Average Imperviousnes (%)
10		3.27	2.23	24.2	1.41	6.66	11.23
15		5.56	3.01	69.8	1.73	9.93	10.00
20		3.97	1.62	35.8	0.61	2.85	24.39
30		25.8	9.56	9.56	6.00	4.53	18.43
40		12.6	6.95	6.10	3.61	3.38	21.40
50		1.33	1.69	15.7	0.63	2.29	22.57
60	1	2.87	0.58	86.7	0.31	3.69	21.18
70	2	2.50	0.79	31.7	0.40	3.24	16.20
80	3	20.5	7.61	10.4	3.21	3.85	13.96
90	4	11.8	1.09	24.2	0.39	4.23	21.38
100		3.40	1.13	18.2	0.40	5.00	29.1
110	5	4.60	3.60	56.8	1.03	5.78	28.85
120	6	1.80	0.90	88.9	0.13	5.85	16.60
130		3.76	1.48	108.0	0.62	2.97	34.32
140	7	2.80	3.32	63.7	2.02	4.80	13.75
150	8	1.50	2.88	59.4	2.32	3.23	20.70
160	9	2.38	2.64	125.0	1.54	7.61	13.95
170	10	3.37	2.48	125.0	1.37	4.61	17.41
180		1.78	0.49	240.0	0.32	2.83	31.63
190	11	2.72	2.35	12.5	1.71	2.93	25.69
200	12	10.2	1.10	18.2	0.63	2.24	28.17
210	13	3.85	3.42	105.0	1.48	3.97	22.17
220	14	0.41	0.81	33.3	0.59	3.00	15.33
230	15	6.42	0.79	16.7	0.41	3.16	23.82
240		23.1	14.2	35.9	9.71	12.84	10.23
245		7.70	1.11	106.0	0.53	9.22	16.97
250		14.9	10.8	51.2	5.68	10.65	30.36
260	16	0.91	0.34	156.0	0.21	3.93	35.95
270		4.59	3.00	120.0	1.32	7.78	16.64
280	17	1.30	1.41	93.1	1.42	5.96	22.10
290		2.90	0.84	120.0	0.53	8.87	35.83
300		4.90	5.09	74.6	2.86	8.78	16.69
310	18	3.55	1.37	122.0	0.22	6.65	24.51
315		5.00	2.35	56.7	2.01	9.92	20.24
320		3.38	3.22	135.0	1.89	11.20	7.44
322		1.02	1.14	134.5	0.29	10.63	6.66
325		8.10	5.09	75.6	2.24	11.23	9.83
330		5.35	3.88	96.2	1.56	7.99	28.77

TABLE 10 SUMMARY OF SUBAREA DATA, PASSAIC RIVER BASIN, N.Y. & N.J.
(Continued)

Subarea Number	Point of Interest	Drainage Area (sq.mi.)	Watercourse Length (mi.)	Stream Slope (ft/mi.)	Length to Center of Gravity (mi.)	Subarea Slope (%)	Average Imperviousnes (%)
340	105	7.36	6.57	40.6	3.28	8.97	18.15
342		1.18	1.87	14.0	0.89	5.92	27.55
345		1.20	0.38	193.0	0.08	4.45	27.92
350	19	3.07	2.39	41.3	0.98	6.93	22.57
360		1.04	0.34	57.8	0.18	9.56	13.87
370		4.88	4.72	28.4	2.39	10.75	14.23
373		0.58	0.74	41.4	0.28	10.00	9.59
375		2.95	2.89	73.8	1.79	11.68	6.95
377		3.67	3.57	79.6	1.75	9.06	11.93
380		0.68	0.79	28.3	0.51	8.48	13.93
385		2.69	1.29	159.0	0.79	10.33	15.92
390	21	3.00	2.19	80.0	0.87	3.85	54.74
400		1.76	0.49	187.0	0.29	5.03	23.74
410	22	7.71	6.23	43.9	3.03	9.44	16.05
420		3.36	1.18	94.4	0.69	1.91	33.31
430	23	1.59	2.10	17.1	1.08	4.04	17.82
440	24	0.85	0.32	178.0	0.21	2.06	34.94
450		14.0	6.11	77.4	3.59	9.75	11.33
455		2.31	0.78	38.3	0.38	9.14	15.88
460	25	3.55	4.18	85.1	3.21	9.90	13.56
470	26	0.63	1.50	52.4	0.91	5.14	26.41
480	27	1.94	2.74	219.0	1.29	10.36	14.71
485		1.53	1.90	180.4	0.84	9.27	19.98
490	29	3.31	2.14	54.0	0.88	8.59	25.76
500	30	2.13	0.60	66.7	0.37	3.38	43.63
510		9.02	5.51	31.8	3.10	2.72	29.95
520		10.4	2.68	4.41	1.37	2.43	27.79
530		1.38	0.69	3.91	0.73	1.68	34.5
540	31	11.6	6.51	69.9	3.58	3.07	30.70
550	32	1.31	2.71	37.5	1.31	2.12	18.31
560		1.89	0.82	3.31	0.42	1.00	32.56
570	34	4.04	2.50	10.7	1.00	1.79	24.17
580	36	0.58	1.21	6.66	0.92	1.00	30.19
590	38	3.09	3.10	120.0	2.21	5.59	24.30
600	39	0.62	0.59	62.2	0.41	4.22	35.19
610		2.27	1.50	4.41	0.82	1.34	26.79
620	40	11.3	1.61	5.82	0.69	3.15	28.06
630		6.47	5.91	49.7	4.10	10.01	5.98
640		5.51	4.18	57.1	2.10	9.22	14.63
650		1.37	0.62	24.4	0.12	11.83	9.71
660		5.40	2.31	59.7	0.31	10.71	9.53

TABLE 10 SUMMARY OF SUBAREA DATA, PASSAIC BASIN, N.Y. & N.J.
(Continued)

Subarea Number	Point of Interest	Drainage Area (sq.mi.)	Watercourse Length (mi.)	Stream Slope (Ft./mi.)	Length to Center of Gravity (mi.)	Subarea Slope (%)	Average Imperviousnes (%)
670		2.81	2.81	74.8	1.20	12.89	5.84
680		1.33	2.27	159.0	1.09	10.53	3.64
690		3.59	0.79	281.0	0.18	10.74	25.21
700		5.42	1.52	127.0	0.61	7.37	14.69
710		10.3	6.10	35.0	3.08	10.56	14.93
720		2.35	1.44	55.2	0.31	8.94	8.97
730		6.66	4.91	20.1	0.83	11.72	8.38
740		5.11	1.71	115.0	0.91	11.49	17.58
750		4.54	2.37	44.4	1.21	8.59	19.20
760		0.90	0.27	403.0	0.10	17.06	3.74
770		1.91	1.41	185.0	0.73	15.8	11.41
780		10.7	1.49	187.0	0.80	13.01	18.00
790		7.08	6.43	87.5	3.51	10.16	20.22
800	41	3.60	2.00	199.0	0.41	11.38	18.91
810		27.1	8.51	42.4	0.19	13.29	19.06
820		13.3	2.73	103.0	1.01	16.01	6.19
830		19.1	10.4	59.9	4.59	16.03	10.51
840		4.38	3.31	97.0	1.41	13.65	12.43
850		11.8	4.89	179.0	2.21	12.81	9.29
860		1.71	1.92	275.0	1.61	15.16	5.00
870		13.02	1.04	261.0	0.42	12.82	30.91
880		5.84	6.13	98.4	2.71	14.58	12.61
890		1.80	0.82	193.0	0.14	11.62	22.23
900		8.09	7.77	118.0	4.10	11.33	15.93
910	42	0.65	1.31	3.08	0.81	2.18	30.78
920	44	2.05	1.18	44.4	0.53	4.57	27.64
930	45	8.58	4.71	56.7	1.52	7.74	17.56
935		50.9	17.95	15.60	7.16	15.45	12.89
940		18.1	9.27	71.7	4.88	13.92	9.18
950	46	3.55	3.02	153.0	1.82	15.93	15.34
960	47	1.84	3.00	66.7	2.49	13.56	6.47
970	49	1.05	0.69	514.0	0.51	15.45	14.79
980	50	8.66	1.48	245.0	1.37	18.28	11.10
985		12.3	5.78	26.4	2.51	12.43	12.09
990	51	7.38	2.01	98.0	0.69	7.71	18.71
1000		0.63	0.40	300.0	0.22	4.39	43.66
1010		3.59	4.20	65.5	1.51	4.52	31.22
1015		0.76	0.95	33.5	0.40	6.53	23.51
1020	55	0.65	0.49	160.0	0.21	9.95	43.48
1030	56	20.1	2.17	296.0	0.83	12.63	10.52
1040	54	7.82	5.48	35.2	2.71	6.99	22.39

TABLE 10 SUMMARY OF SUBAREA DATA, PASSAIC RIVER BASIN, N.Y. & N.J.
(Continued)

Subarea Number	Point of Interest	Drainage Area (sq.mi.)	Watercourse Length (mi.)	Stream Slope (ft/mi.)	Length to Center of Gravity (mi.)	Subarea Slope (%)	Average Imperviousnes (%)
1050		2.13	0.79	642.0	0.29	13.16	9.50
1060		0.71	0.61	622.0	0.21	13.98	9.28
1070	58	4.59	1.11	194.0	0.20	10.62	18.93
1080	59	6.66	1.20	101.0	0.57	7.67	34.25
1090	60	1.11	0.61	160.0	0.21	6.18	31.65
1100	61-A	2.60	0.81	25.0	0.37	2.38	32.36
1110	62	1.58	1.02	42.7	0.58	2.28	24.04
1120		3.54	3.11	23.7	5.87	6.92	10.91
1130	63	2.25	3.09	62.4	2.21	9.41	10.35
1140	64	4.37	4.11	40.7	2.43	7.19	18.80
1150	65	2.30	1.61	16.7	0.62	6.04	20.76
1155		0.34	0.41	33.3	0.21	1.00	23.25
1160		2.38	0.79	8.30	0.59	3.67	29.36
1170	66	1.96	1.80	14.8	0.80	6.11	30.10
1180	67	1.90	0.83	41.7	0.41	4.99	33.46
1190	68	0.89	0.90	25.2	0.61	2.30	34.89
1200	70	1.89	2.21	144.0	2.02	5.07	17.86
1210	71	2.16	1.49	107.0	1.12	5.00	27.74
1220	72	1.52	1.44	3.81	0.41	1.29	42.87
1230	73	1.71	0.79	5.00	0.51	2.45	49.96
1240	74	6.90	4.69	36.0	2.62	6.72	24.27
1250	75	4.35	2.81	78.6	0.41	4.17	33.06
1260	76	4.03	1.11	42.4	0.21	4.41	42.95
1270		0.72	0.61	100.0	0.32	2.89	66.22
1280	77	2.02	1.52	28.4	0.79	6.10	18.25
1290	78	4.36	1.81	66.7	0.50	6.40	34.18
1300	79	3.40	0.79	217.0	0.21	5.94	31.70
1310		1.45	1.39	76.2	0.61	6.42	21.27
1315		3.66	1.73	70.6	0.88	9.03	21.09
1317		0.54	1.21	297.0	0.64	9.39	42.03
1320		2.29	0.79	183.0	0.22	7.22	38.58
1330	82	4.31	2.00	147.0	0.73	7.07	33.93
1340	83	8.71	6.89	51.0	4.21	5.14	27.83
1350		3.73	0.83	50.0	0.27	5.33	57.26
1360	84	2.97	2.47	16.0	2.11	3.52	35.88
1370	85	1.31	1.09	30.3	1.09	2.10	52.05
1380		6.64	1.43	28.6	0.22	2.54	51.46
1385		1.37	1.40	19.0	0.95	1.43	50.91
1390		3.57	3.21	8.19	1.31	2.73	52.24
1400		21.6	10.2	39.0	6.13	5.59	21.17
1410	86	1.40	0.41	73.3	0.22	1.73	28.44
1413		2.63	4.77	50.3	2.42	4.21	21.98
1415		9.11	4.35	24.5	2.12	3.84	24.57

TABLE 10 SUMMARY OF SUBAREA DATA, PASSAIC RIVER BASIN, N.Y. & N.J.
(Continued)

Subarea Number	Point of Interest	Drainage Area (sq.mi.)	Watercourse Length (mi.)	Stream Slope (ft/mi.)	Length to Center of Gravity (mi.)	Subarea Slope (%)	Average Imperviousnes (%)
1417		3.10	2.58	1.51	1.32	3.26	27.32
1420	87	2.02	1.06	56.00	0.64	5.41	29.81
1430	88	3.12	0.61	200.0	0.42	3.02	32.54
1440	90	2.02	1.29	8.21	0.62	1.50	37.18
1445		1.28	0.76	10.0	0.49	1.95	31.35
1450	91	1.12	1.01	8.04	0.79	1.03	44.64
1460	92	4.97	5.32	8.79	2.31	2.23	40.35
1470	93	0.59	0.41	57.6	0.18	1.71	68.29
1475		0.30	0.45	40.6	0.22	1.32	39.61
1480	94	0.46	0.68	7.61	0.63	1.50	65.36
1490	95	0.88	1.08	24.2	0.31	1.65	43.28
1500	96	4.54	0.81	25.0	0.29	3.18	48.91
1505		4.45	2.05	68.3	1.29	5.58	47.96
1510	97	2.04	0.67	33.0	0.35	1.89	50.51
1520	98	2.28	1.23	25.6	1.21	2.47	43.18
1525		0.41	0.81	86.7	0.49	2.11	40.15
1530	99	6.55	6.09	30.6	3.31	4.09	35.65
1540	100	2.74	0.48	235.0	0.23	2.98	35.37
1550	101	2.51	1.57	55.8	0.49	3.51	43.46
1560		0.97	0.79	133.0	0.08	1.92	62.08
1570		3.57	0.53	26.7	0.32	2.95	50.44
1580		4.24	0.59	107.0	0.32	3.43	49.65
1590	102	10.81	4.21	61.0	2.33	4.50	41.25
1600	103	0.79	0.42	167.0	0.22	2.02	48.25
1610		7.88	2.79	5.51	1.92	1.85	45.09
1620	104	13.0	1.10	82.6	0.39	1.91	59.01

TABLE 11 - CALIBRATION STORM RAINFALL IN INCHES
(GAGING STATION RECORDS)
PASSAIC RIVER BASIN, N.J. AND N.Y.

GAGING STATION			STORM OF						
NO. 1/	LOCATION	TYPE 2/	8/55	10/55	5/68	4/70	8/71	12/73	11/77
1	NEWARK	R	2.27	2.99	4.22	1.95	7.97	2.15	7.46
2	JERSEY CITY	NR	0.90	4.54			1.57	2.62	4.00
3	RIDGEFIELD	NR	2.20	4.24					
4	NEW MILFORD	R	3.13	4.02	4.56	1.84	6.13	2.83	8.07
5	WOODCLIFF LAKE	R	3.24	4.73	4.14	2.13	7.21	2.92	8.07
7	PATERSON	NR	4.93	4.13	5.15		6.66	3.50	
8	LITTLE FALLS	R	4.31	4.92	6.41	2.20	9.65	3.34	7.76
9	CEDAR GROVE	NR	2.87	5.86					
12	MAHWAH	NR			6.46		8.25	3.23	5.06
15	WANAQUE	R	5.22	5.54	5.98	3.12	7.40	3.19	6.04
16	RINGWOOD	NR	4.68	7.23	6.12		8.15	2.62	5.79
17	GREENWOOD LAKE	NR	5.05	7.09	6.16		7.66	3.52	5.74
18	MACOPIN DAM	NR	6.42	7.58					
19	CHARLOTTEBURG	NR 3/	6.73	7.27	6.96		7.67	3.40	5.50
22	OAK RIDGE RES	NR	6.61	7.61	4.32		6.12	2.36	3.20
23	CANISTEAR RES	NR	7.70	7.70	4.42		6.71	2.65	3.25
24	MILTON	NR	4.31	4.69	4.16		6.10		
25	MORRIS PLAINS	NR	4.92	5.00	5.63		9.72	2.89	4.33
26	BOONTON	NR	3.07	5.35	6.24		3.74	2.96	4.08
29	SPLIT ROCK POND	NR	3.94	6.52	5.28		7.65	3.18	4.15
7	ORANGE	R	2.45	4.19					
38	CANOE BROOK	NR	3.48	4.07	7.96		9.20	2.78	5.17
39	CHATHAM	NR	3.56						
42	SUFFERN	NR	6.03		6.30		8.64	3.11	7.86
43	MIDLAND PARK	NR	6.40	5.40	6.79		8.53	3.43	6.78
44	ALLENDALE	R	6.25		5.73	2.35	7.91	3.21	
45	BENARDSVILLE	NR			5.68		9.53	2.52	4.10
46	ESSEX FELLS	R	3.31	4.73	6.48	2.07	7.48	3.00	7.11
47	WHARTON	NR			4.58		7.69	3.03	2.63
48	SUSSEX	NR	8.10	6.05	2.64		6.58	2.40	2.54
49	NEWTON	R	7.64	4.89	2.57	3.17	5.84	2.75	2.08
50	SOMERVILLE	NR	3.80	5.84	3.97		9.37	2.31	3.36
51	WATCHUNG	R	3.65	3.46	5.62	2.00	8.75	2.62	5.45
52	PLAINFIELD	NR	3.32	4.37	6.13		8.87	2.50	4.75
53	WESTFIELD	R	2.81	4.34					
54	SPRINGFIELD	R	3.22	3.08	6.30	1.95	9.45	2.70	5.14
55	ELIZABETH	NR	2.25	5.24	4.66				
56	ELIZABETHPORT	R	1.95	3.48					
57	CENTRAL PARK	R	1.86	2.69	4.92		5.96	2.65	9.56
58	WEST POINT	NR	4.86	7.30	3.30		6.68	1.18	5.05
59	WARWICK	NR	3.87	6.17	4.25			2.93	

1/ SEE FIGURE 6.
2/ R = RECORDING; NR = NON-RECORDING.
3/ RECORDING FOR 12/73 AND 11/77 EVENTS.

TABLE 12 HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
RAMAPO RIVER SUBBASIN, Page 1

Subarea	DA	TC	R	R / (TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					5/68	4/70	11/77		5/68	4/70	11/77		5/68	4/70	11/77		5/68	4/70	11/77	
930	8.58	5.6	7.6	.58	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	1.3		.23	.11	.05	
935	50.9	11.5	15.5	.57	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	1.3		.23	.11	.05	
940	18.1	7.4	10.0	.57	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	1.3		.23	.11	.05	
950	3.55	4.1	5.5	.57	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	1.3		.23	.11	.05	
960	1.84	3.3	4.5	.58	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	1.3		.23	.11	.05	
970	1.05	3.0	4.5	.60	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	1.3		.23	.11	.05	
980	8.66	5.6	7.6	.58	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	1.3		.23	.11	.05	
985	12.3	3.0	8.2	.73	-.30	-.20	-.20		1.5	1.2	1.5		1.3	.10	1.2		.17	.05	.08	
990	7.38	5.3	7.2	.58	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	1.3		.23	.11	.05	
1000	0.63	2.5	4.5	.64	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	1.3		.23	.11	.05	
1010	3.59	4.1	5.5	.57	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	.50		.23	.11	.03	
1015	0.76	2.7	4.7	.64	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	.50		.23	.11	.03	
1020	0.65	2.6	4.5	.63	-.20	-.20	-.20		1.5	1.2	1.5		.80	.15	1.3		.23	.11	.05	
1030	20.1	5.6	10.5	.65	-.20	-.20	-.20		1.5	1.5	1.5		.50	.15	1.25		.38	.06	.50	
1040	7.82	3.8	5.1	.57	-.20	-.20	-.20		1.5	1.5	1.5		.50	.15	1.25		.38	.06	.50	

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. – N.Y.
RAMAPO RIVER SUBBASIN, Page 2

Subarea	DA	TC	R	R/(TC+R)	QRCSN			RTIOR			STRTL			CNSTL		
					5/68	4/70	11/77	5/68	4/70	11/77	5/68	4/70	11/77	5/68	4/70	11/77
1050	2.13	2.0	3.4	.62	-.20	-.20	-.20	1.5	1.5	1.5	.50	.15	1.25	.38	.06	.50
1060	0.71	1.0	3.4	.77	-.20	-.20	-.20	1.5	1.5	1.5	.50	.15	1.25	.38	.06	.50
1070	4.59	3.1	4.25	.58	-.20	-.20	-.20	1.5	1.5	1.5	.50	.15	1.25	.38	.06	.50
1080	6.66	3.8	5.1	.57	-.20	-.20	-.20	1.5	1.5	1.5	.50	.15	1.25	.38	.06	.50

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
POMPTON RIVER SUBBASIN, Page 1

Subarea	DA	TC	R	R / (TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70
630	6.47	2.0	13.0	.87	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.38	.11	.35	.08
640	5.51	2.0	12.0	.86	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.38	.11	.35	.08
650	1.37	1.6	7.4	.82	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.39	.11	.35	.08
660	5.40	2.2	11.8	.84	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.39	.11	.35	.08
670	2.81	1.5	9.5	.86	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.38	.11	.35	.08
680	1.33	1.6	7.4	.82	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.38	.11	.35	.08
690	3.59	3.0	10.0	.77	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.39	.11	.35	.08
700	5.42	2.0	12.0	.86	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.38	.11	.35	.08
710	10.3	3.0	14.7	.83	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.39	.11	.35	.08
720	2.35	1.6	8.9	.85	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.38	.11	.35	.08
730	6.66	2.5	12.5	.83	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.37	.11	.35	.08
740	5.11	2.0	11.5	.85	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.37	.11	.35	.08
750	4.54	2.5	11.0	.81	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.37	.11	.35	.08
760	0.90	1.5	7.0	.82	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.37	.11	.35	.08
770	1.91	3.0	7.0	.70	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	.86	1.25	.7	.37	.11	.35	.08

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
POMPTON RIVER SUBBASIN, Page 2

Subarea	DA	TC	R	R / (TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70
780	10.7	4.0	15.0	.79	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.9	.55	1.3	.15	.20	.07	.56	.02
790	7.08	3.0	13.0	.81	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.9	.55	1.3	.15	.20	.07	.56	.02
800	3.6	3.5	10.5	.75	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.9	.55	1.3	.15	.20	.07	.56	.02
810	27.1	5.0	35.0	.88	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.4	1.0	.6	.5	.02	.01	.15	.02
820	13.3	3.5	4.0	.53	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.5	.4	.6	.5	.08	.09	.22	.02
830	19.1	1.8	27.8	.94	-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.45	.55	.5	.6	.17	.03	.23	.02
840	4.38	1.03	9.27		-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.8	3.3	.5	.6	.26	.02	.10	.09
850	11.8	1.03	16.0		-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.32	.35	.43	.45	.1	.04	.43	.09
860	1.71	1.03	8.33		-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.65	1.45	.5	.8	.28	.09	.1	.1
870	13.02	3.0	4.0		-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.9	2.0	.5	1.5	.18	.35	.05	.3
880	5.84	2.3	7.5		-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.5	.45	1.3	.1	.09	.04	.6	.02
890	1.80	1.7	5.0		-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.5	.45	1.3	.1	.09	.04	.6	.02
900	8.09	3.0	15.0		-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.5	.45	1.3	.1	.09	.04	.6	.02
910	0.65	2.5	4.5		-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.5	.45	1.3	.1	.09	.04	.6	.02
920	2.05	1.5	4.5		-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.5	.45	1.3	.1	.09	.04	.6	.02

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
POMPTON RIVER SUBBASIN, Page 3

Subarea	DA	TC	R	R/(TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70
1090	1.11	2.0	4.5		-.2	-.2	-.2	-.2	1.2	1.2	1.2	1.2	.5	.45	1.3	.1	.09	.04	.6	.02

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
ROCKAWAY RIVER SUBBASIN, Page 1

Subarea	DA	TC	R	R/(TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					5/68	4/70	8/71	12/73	5/68	4/70	8/71	12/73	5/68	4/70	8/71	12/73	5/68	4/70	8/71	12/73
240	23.1	4.0	22.5	.85	-.20	-.2	-.2	-.3	1.4	1.2	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
245	7.7	3.0	15.0	.83	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
250	14.9	3.0	22.1	.88	-.5	-.5	-.5	-.5	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
260	0.91	1.0	7.00	.88	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
270	4.59	2.0	13.1	.87	-.2	-.2	-.2	-.2	1.4	1.36	1.3	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
280	1.30	1.5	8.5	.85	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
290	2.90	2.5	10.1	.80	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
300	4.90	2.5	13.6	.84	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
310	3.55	2.0	12.1	.86	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
315	5.00	2.0	15.0	.88	-.5	-.5	-.5	-.5	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
320	3.38	2.0	12.0	.86	-.3	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
322	1.02	1.5	8.5	.85	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
325	8.10	2.6	17.6	.87	-.5	-.5	-.5	-.5	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
330	5.35	2.2	15.3	.87	-.5	-.5	-.5	-.5	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
340	7.36	2.7	16.9	.86	-.5	-.5	-.5	-.5	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
ROCKAWAY RIVER SUBBASIN, Page 2

Subarea	DA	TC	R	R/(TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					5/68	4/70	8/71	12/73	5/68	4/70	8/71	12/73	5/68	4/70	8/71	12/73	5/68	4/70	8/71	12/73
342	1.18	1.5	8.6	.85	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
345	1.20	1.5	8.7	.85	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
350	3.07	2.0	12.5	.86	-.5	-.5	-.5	-.5	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
360	1.04	1.0	9.2	.90	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	1.75	.22	.29	.06	1.0	.06
370	4.85	2.0	15.0	.88	-.4	-.4	-.4	-.4	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
373	0.58	1.0	8.4	.89	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
375	2.95	2.0	11.5	.85	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
377	3.67	2.4	13.1	.85	-.4	-.4	-.4	-.4	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
380	0.68	1.0	8.1	.89	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06
385	2.69	2.0	11.5	.85	-.2	-.2	-.2	-.2	1.4	1.36	1.2	1.2	1.75	.19	2.1	.22	.29	.06	1.0	.06

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
WHIPPANY RIVER SUBBASIN, Page 1

Subarea	DA	TC	R	R / (TC+R)	QRCSN 8/55	QRCSN 10/55	QRCSN 4/70		RTIOR 8/55	RTIOR 10/55	RTIOR 4/70		STRTL 8/55	STRTL 10/55	STRTL 4/70		CNSTL 8/55	CNSTL 10/55	CNSTL 4/70	
450	14.0	5.0	25	0.83	-.15	-.15	-.15		1.5	1.5	1.5		.5	1.0	.25		.25	.47	.01	
455	2.31	2.0	8.9	0.82	-.15	-.15	-.15		1.5	1.5	1.5		.5	1.0	.25		.25	.47	.01	
460	3.55	2.7	10.2	0.79	-.15	-.15	-.15		1.5	1.5	1.5		.5	1.0	.25		.25	.47	.01	
470	0.63	1.5	5.4	0.78	-.15	-.15	-.15		1.5	1.5	1.5		.5	1.0	.25		.25	.47	.01	
480	1.94	2.1	8.4	0.80	-.15	-.15	-.15		1.5	1.5	1.5		.5	1.0	.25		.25	.47	.01	
485	1.53	1.7	7.8	0.82	-.15	-.15	-.15		1.5	1.5	1.5		.5	1.0	.25		.25	.47	.01	
490	3.31	2.3	10.0	0.81	-.15	-.15	-.15		1.5	1.5	1.5		.5	1.0	.25		.25	.47	.01	
500	2.13	2.1	7.0	0.77	-.15	-.15	-.15		1.5	1.5	1.5		.5	1.0	.25		.25	.47	.01	

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
PASSAIC RIVER HIGHLAND AREA, Page 1

Subarea	DA	TC	R	R / (TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					5/68	8/71	12/73	4/70	5/68	8/71	12/73	4/70	5/68	8/71	12/73	4/70	5/68	8/71	12/73	4/70
10	3.27	1.50	2.97	0.66	-0.2	-0.2	-0.2	-0.2	2.0	2.0	2.0	2.0	.90	4.0	.53	.01	.51	.08	.13	.01
15	5.56	1.50	2.97	0.66	-0.2	-0.2	-0.2	-0.2	2.0	2.0	2.0	2.0	.90	4.0	.53	.01	.51	.08	.13	.01
20	3.97	1.50	6.00	0.8	-0.2	-0.2	-0.2	-0.2	1.7	1.7	1.7	1.7	.90	2.9	.05	.01	.26	.27	.01	.01
30	25.8	6.00	20.0	0.77	-0.2	-0.2	-0.2	-0.2	1.2	1.2	1.2	1.2	.90	2.9	.05	.01	.26	.27	.01	.01
40	12.6	6.00	16.0	0.73	-0.2	-0.2	-0.2	-0.2	1.2	1.2	1.2	1.2	.90	2.9	.05	.01	.26	.27	.01	.01
50	1.33	1.34	10.0	0.88	-0.2	-0.2	-0.2	-0.2	1.7	1.7	1.7	1.7	.90	2.9	.05	.01	.26	.27	.01	.01
60	2.87	1.50	15.0	0.91	-0.2	-0.2	-0.2	-0.2	1.7	1.7	1.7	1.7	.90	3.0	.05	.01	.26	.27	.01	.01
70	2.50	1.40	9.10	0.87	-0.2	-0.2	-0.2	-0.2	1.6	1.6	1.6	1.6	.15	1.2	.10	.01	.05	.40	.04	.01
80	20.5	5.00	18.5	0.79	-0.2	-0.2	-0.2	-0.2	1.7	1.7	1.7	1.7	.15	1.25	.10	.01	.05	.40	.04	.01
90	11.8	3.20	15.3	0.82	-0.2	-0.2	-0.2	-0.2	1.7	1.7	1.7	1.7	.20	1.25.	.10	.01	.09	.40	.04	.01
100	3.40	1.50	5.50	0.79	-0.2	-0.2	-0.2	-0.2	1.7	1.7	1.7	1.7	.25	1.25	.10	.01	.25	.40	.04	.01
110	4.60	2.00	5.60	0.74	-0.2	-0.2	-0.2	-0.2	1.7	1.7	1.7	1.7	.25	1.25	.10	.01	.25	.40	.04	.01
120	1.80	1.40	4.10	0.75	-0.2	-0.2	-0.2	-0.2	1.7	1.7	1.7	1.7	.25	1.25	.10	.01	.25	.40	.04	.01

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
PASSAIC RIVER CENTRAL BASIN, Page 1

Subarea	DA	TC	R	R/(TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70
130	3.76	1.1	5.6	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
140	2.8	1.0	5.0	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
150	1.5	1.0	4.2	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
160	2.38	1.1	4.7	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
170	3.37	1.1	5.5	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
180	1.78	1.5	5.0	0.77	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
190	2.72	1.0	5.0	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
200	10.2	2.5	12.0	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
210	3.85	1.2	5.6	0.82	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
220	0.41	1.0	4.0	0.80	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
230	6.42	2.5	11.0	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
400	1.76	1.0	4.3	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
410	7.71	1.5	7.3	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
PASSAIC RIVER CENTRAL BASIN, Page 2

Subarea	DA	TC	R	R / (TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70
420	3.36	2.0	7.2	0.78	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
430	1.59	1.0	4.2	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
440	0.85	1.0	5.0	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
510	9.02	2.0	9.7	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
520	10.4	2.5	11.0	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
530	1.38	2.0	5.0	0.71	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
540	11.6	2.0	8.0	0.80	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
550	1.31	1.0	4.0	0.80	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
560	1.89	1.5	9.0	0.86	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
570	4.04	2.3	8.7	0.79	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
580	0.58	1.1	6.0	0.85	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
590	3.09	1.0	5.4	0.84	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
600	0.62	1.0	4.0	0.80	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
610	2.27	2.0	8.7	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
620	11.3	3.0	16.0	0.84	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
PASSAIC RIVER CENTRAL BASIN, Page 3

Subarea	DA	TC	R	R/(TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70
1100	2.6	1.0	5.0	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1110	1.58	1.0	4.0	0.80	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1120	3.54	1.2	5.5	0.82	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1130	2.25	1.1	4.5	0.82	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1140	4.37	1.2	5.8	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1150	2.3	1.0	4.6	0.82	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1155	0.34	1.0	3.5	0.78	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1160	2.38	1.1	4.7	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1170	1.96	1.0	4.4	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1180	1.9	1.0	4.4	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1190	0.89	1.0	4.0	0.80	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1200	1.89	1.0	4.4	0.81	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1210	2.16	1.0	4.5	0.82	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1220	1.52	2.0	6.0	0.75	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1230	1.71	1.0	4.0	0.80	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
PASSAIC RIVER CENTRAL BASIN, Page 4

Subarea	DA	TC	R	R/(TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70	8/55	10/55	5/68	4/70
1240	6.9	1.4	7.0	0.83	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1250	4.35	1.0	6.0	0.86	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
1260	4.03	1.0	6.0	0.86	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1
390	3.0	1.0	5.3	0.84	-.3	-.3	-.3	-.3	1.3	1.3	1.3	1.3	1.5	2.0	1.0	0.2	0.5	0.5	0.3	0.1

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
PASSAIC RIVER LOWER VALLEY SUBBASIN, Page 1

Subarea	DA	TC	R	R/(TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					5/68				5/68				5/68				5/68			
1270	0.72	1.0	2.0	.67	-.2				1.5				1.0				0.3			
1280	2.02	1.1	2.35	.70	-.1				2.0				1.0				0.3			
1290	4.36	1.35	2.95	.69	-.1				2.0				1.0				0.3			
1300	3.40	1.25	2.70	.68	-.1				2.0				1.0				0.3			
1330	4.31	1.5	2.80	.65	-.1				1.5				1.0				0.3			
1310	1.45	1.0	2.10	.68	-.1				2.0				1.0				0.3			
1315	3.66	1.28	2.8	.69	-.1				2.0				1.0				0.3			
1317	0.54	1.0	2.0	.67	-.1				2.0				1.0				0.3			
1320	2.29	1.2	2.6	.68	-.1				2.0				1.0				0.3			
1350	3.73	1.5	2.7	.64	-.2				1.5				1.0				0.3			
1340	8.71	1.85	3.7	.67	-.16				2.0				1.0				0.37			
1360	2.97	1.2	2.6	.68	-.16				2.0				1.0				0.37			
1380	6.64	1.5	3.4	.69	-.20				1.5				1.0				0.3			
1370	1.31	1.0	2.0	.67	-.16				2.0				1.0				0.37			
1385	1.37	1.0	2.0	.67	-.20				1.5				1.0				0.3			

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
PASSAIC RIVER LOWER VALLEY SUBBASIN, Page 2

Subarea	DA	TC	R	R/(TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					5/68				5/68				5/68				5/68			
1390	3.57	1.5	2.6	.63	-.2				1.5				1.0				0.3			
1500	4.54	1.35	3.0	.69	-.16				2.0				.5				0.05			
1505	4.45	2.5	5.5	.69	-.16				2.0				1.0				0.4			
1510	2.04	2.8	4.4	.61	-.16				2.0				1.0				0.4			
1570	3.57	1.5	2.6	.63	-.2				1.5				1.0				0.3			
1520	2.28	1.1	2.4	.69	-.16				2.0				1.0				0.3			

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
PASSAIC RIVER LOWER VALLEY SUBBASIN, Page 3

Subarea	DA	TC	R	R / (TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					5/68				5/68				5/68				5/68			
1525	0.41	1.0	2.0	.67	-.16				2.0				1.0				0.3			
1530	6.55	1.65	3.5	.68	-.16				2.0				1.0				0.37			
1540	2.74	1.2	2.65	.69	-.16				2.0				1.0				0.37			
1550	2.51	1.17	2.6	.69	-.16				2.0				1.0				0.37			
1560	0.97	1.0	2.0	.67	-.16				2.0				1.0				0.37			
1580	4.24	1.4	2.8	.67	-.2				1.5				1.0				0.3			
1590	10.81	1.5	2.8	.65	-.16				2.0				1.0				0.49			
1600	0.79	1.0	1.5	.6	-.16				2.0				1.0				0.49			
1610	7.88	2.0	3.5	.64	-.2				1.5				1.0				0.3			
1620	13.0	2.5	4.5	.64	-.2				1.5				1.0				0.3			

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
SADDLE RIVER SUBBASIN, Page 1

Subarea	DA	TC	R	R/(TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					8/71	9/71	12/73	11/77	8/71	9/71	12/73	11/77	8/71	9/71	12/73	11/77	8/71	9/71	12/73	11/77
1400	21.6	4.4	4.0	.48	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	3.0	2.4	.5	1.0	.6	.34	.11	.25
1410	1.4	1.0	2.1	.68	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	1.5	1.0	.15	.5	.1	.1	.04	.40
1413	2.63	1.5	2.2	.59	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	2.2	2.2	.14	.5	.3	.09	.05	.06
1415	9.11	1.9	3.7	.66	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	3.2	2.0	.36	.5	.73	.37	.17	.21
1417	3.10	1.2	2.7	.69	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	2.2	2.2	.14	.15	.3	.08	.05	.11
1420	2.02	1.05	2.45	.7	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	2.2	2.2	.25	.15	.3	.08	.1	.11
1430	3.12	1.2	2.7	.69	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	1.5	1.0	.15	.5	.1	.1	.04	.4
1440	2.02	1.1	2.3	.68	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	1.5	1.0	.15	.5	.1	.1	.04	.4
1445	1.28	1.0	2.1	.68	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	2.0	1.0	.15	.5	.25	.1	.04	.4
1450	1.12	1.0	2.0	.67	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	2.0	1.0	.15	.5	.25	.1	.04	.4
1460	4.97	1.4	3.1	.69	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	2.5	.5	.25	.5	.7	.17	.17	.4
1470	0.59	1.0	2.0	.67	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	2.5	.5	.25	.5	.7	.17	.17	.4
1475	0.30	1.0	2.0	.67	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	1.5	1.0	.15	.5	.25	.1	.04	.4
1480	0.46	1.0	2.0	.67	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	1.5	1.0	.15	.5	.25	.1	.04	.4
1490	0.88	1.0	2.0	.67	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	1.5	1.0	.15	.5	.25	.1	.04	.4

TABLE 12 (CONT'D) HYDROLOGIC MODEL SUBAREA PARAMETERS

PASSAIC RIVER BASIN, N.J. - N.Y.
SADDLE RIVER SUBBASIN, Page 2

Subarea	DA	TC	R	R / (TC+R)	QRCSN				RTIOR				STRTL				CNSTL			
					8/71	9/71	12/73	11/77	8/71	9/71	12/73	11/77	8/71	9/71	12/73	11/77	8/71	9/71	12/73	11/77
1500	4.54	1.35	3.0	.69	-.16	-.16	-.16	-.16	2.0	2.0	2.0	2.0	1.5	1.0	.15	.5	.25	.1	.04	.4

TABLE 13 (PAGE 1 OF 8) ROUTING PARAMETERS

- RAMAPO RIVER SUBBASIN -

MODIFIED PULS ROUTING

NODES								
7-8	STORAGE (A-F)	0	51	142	179	310	418	794
	DISCHARGE (CFS)	0	542	2080	2660	4500	6160	12800
1010-9	STORAGE (A-F)	0	7	60	111	162	181	247
	DISCHARGE (CFS)	0	161	620	792	1340	1840	3810
11-12	STORAGE (A-F)	0	167	304	441	480	582	1002
	DISCHARGE (CFS)	0	2160	6760	11800	12900	16600	29000
12-13	STORAGE (A-F)	0	2156	4039	5579	6436	7722	12089
	DISCHARGE (CFS)	0	2580	7450	11100	14100	18100	31000
13-14	STORAGE (A-F)	0	93	273	411	634	787	1255
	DISCHARGE (CFS)	0	2720	7840	11100	14960	19100	32700
14-15	STORAGE (A-F)	0	66	150	224	398	519	1049
	DISCHARGE (CFS)	0	2770	8000	10900	15200	19400	33300
15-16	STORAGE (A-F)	0	199	579	761	1036	1351	2308
	DISCHARGE (CFS)	0	2770	8000	10900	15200	19400	33300
16-17	STORAGE (A-F)	1100	1320	1713	1854	2179	2524	3337
	DISCHARGE (CFS)	0	2850	8250	10900	15600	20000	34300

MUSKINGUM ROUTING

NODES	STEP	AMSKK			X		
		5/68	4/70	11/77	5/68	4/70	11/77
930*-2	1	9.53	9.53	9.53	.2	.18	.2
2-4	1	.67	.67	.67	.2	.18	.2
4-5	1	3.	3.	3.	.2	.18	.2
6-7	1	2.1	2.1	2.1	.2	.18	.2

*SUBAREA

TABLE 13 (PAGE 2 OF 8) ROUTING PARAMETERS

- POMPTON RIVER SUBBASIN -

MODIFIED PULS ROUTING

CANISTEAR RESERVOIR	STORAGE (A-F)	4170	7390	7690	8000	8322	8644	8971	9315
	DISCHARGE (CFS)	0	0	840	2375	4365	6720	9391	12345
OAK RIDGE RESERVOIR	STORAGE (A-F)	5670	11700	12200	12600	13100	13600	14100	15000
	DISCHARGE (CFS)	0	0	1241	3723	7132	11430	16435	27225
CLINTON RESERVOIR	STORAGE (A-F)	8000	10800	11490	11560				
	DISCHARGE (CFS)	0	0	1026	3021				
CHARLOTTEBURG RESERVOIR	STORAGE (A-F)	7390	9100	9440	9850	12200			
	DISCHARGE (CFS)	0	0	5875	11000	32000			
ECHO LAKE RESERVOIR	STORAGE (A-F)	2800	4870	5144	5426	5716	6014	6320	6634
	DISCHARGE (CFS)	0	0	163	482	918	1440	2039	2681
(CON'T)	STORAGE (A-F)	6956	7286						
	DISCHARGE (CFS)	3423	4192						
WANAQUE RESERVOIR	STORAGE (A-F)	45420	63326	84701	90931	92343	94736	97130	99615
	DISCHARGE (CFS)	16	16	16	16	820	3560	7340	11910
(CON'T)	STORAGE (A-F)	102130	104675						
	DISCHARGE (CFS)	17210	23110						

MUSKINGUM ROUTING

NODES	STEP	AMSKK[1]	X[1]
2-4	1	3.5	0.05
5-7	1	4.0	0.08
6-7	1	4.5	0.05
8-9	1	4.0[2]	0.07[2]
9-11	1	3.5	0.10
10-11	1	4.0	0.10
11-12	1	4.0	0.08
12-13	1	4.0	0.10
GREENWOOD LAKE	1	5.8	0.03
14-15	1	2.5	0.20
18-19	1	3.0	0.10
19-20	1	4.0	0.10
21-22	1	5.0	0.10

[1]CONSTANT FOR ALL CALIBRATION STORMS
[2]8/55 AND 10/55 STORMS ONLY

TABLE 13 (PAGE 3 OF 8) ROUTING PARAMETERS

- ROCKAWAY RIVER SUBBASIN -

MODIFIED PULS ROUTING

NODES									
2-3	STORAGE (A-F)	0	28	55	58	69	83	99	157
	DISCHARGE (CFS)	0	688	1490	1597	1934	2310	2730	3930
3-4	STORAGE (A-F)	0	66	153	168	214	266	366	604
	DISCHARGE (CFS)	0	688	1490	1597	1934	2310	2730	3930
4-5	STORAGE (A-F)	0	93	214	232	292	369	459	770
	DISCHARGE (CFS)	0	1030	2240	2399	2904	3470	4100	5910
10-12	STORAGE (A-F)	0	206	555	619	796	965	1155	1702
	DISCHARGE (CFS)	0	1370	2960	3168	3838	4580	5410	7800
12-13	STORAGE (A-F)	0	318	797	877	1079	1283	1488	1986
	DISCHARGE (CFS)	0	1370	2960	3168	3838	4580	5410	7800
13-17	STORAGE (A-F)	0	245	487	515	606	699	809	1091
	DISCHARGE (CFS)	0	1370	2960	3168	3838	4580	5410	7800
17-18	STORAGE (A-F)	0	143	289	306	354	404	457	613
	DISCHARGE (CFS)	0	1370	2960	3168	3838	4580	5410	7800
18-19	STORAGE (A-F)	0	176	258	268	304	338	375	482
	DISCHARGE (CFS)	0	1530	3320	3550	4300	5130	6060	8740

MUSKINGUM ROUTING

NODES	STEP[1]	AMSKK 5/68	AMSKK 4/70	AMSKK 8/71	AMSKK 12/73	X[2]
1-2	1	2.0	4.0	4.0	4.0	.2
6-7	1	1.88	1.88	1.88	1.88	.2
7-8	1	1.88	1.88	1.88	1.88	.2
8-9	1	1.88	1.88	1.88	1.88	.2
11-12	1	1.88	1.88	1.88	1.88	.2
14-15	1	1.88	1.88	1.88	1.88	.2
15-16	1	1.88	1.88	1.88	1.88	.2

[1]STEP REMAINS CONSTANT FOR ALL CALIBRATION STORMS
[2]X REMAINS CONSTANT FOR ALL CALIBRATION STORMS

 ROUTING PARAMETERS

- WHIPPANY RIVER SUBBASIN -

MUSKINGUM ROUTING									
NODES	STEP			AMSKK			X		
	8/55	10/55	4/70	8/55	10/55	4/70	8/55	10/55	4/70
450*-450*	1	1	2	2	2	2	.02	.02	.5
101-102	1	1	1	1	1	1	.02	.02	.5
103-104	1	1	2	2	2	2	.02	.02	.5
104-105	1	1	1	1	1	1	.02	.02	.5
106-107	1	1	3	3	3	3	.02	.02	.5
107-108	1	1	1	1	1	1	.02	.02	.5

*SUBAREA

TABLE 13 (PAGE 5 OF 8) ROUTING PARAMETERS

- PASSAIC RIVER HIGHLAND AREA -

MODIFIED PULS ROUTING									
NODES									
104-105	STORAGE (A-F)	0	91	207	1650	2650	5350	8200	13996
	DISCHARGE (CFS)	0	185	270	650	850	1400	2000	3200
107-108	STORAGE (A-F)	0	1204	3576	5978	7243	10806		
	DISCHARGE (CFS)	0	1119	2327	3495	4089	5732		
108-109	STORAGE (A-F)	0	305	710	1145	1360	1950		
	DISCHARGE (CFS)	0	1028	2139	3212	3758	5269		
109-110	STORAGE (A-F)	0	176	362	550	664	994		
	DISCHARGE (CFS)	0	1130	2350	3530	4130	5790		

MUSKINGUM ROUTING						
			X			
NODES	STEP	AMSKK	5/68	8/71	12/73	4/70
101-102	1	1	.40	.40	.40	.40
102-103	1	3	.10	.10	.10	.10
105-106	1	13	0	0	0	0
80*-107	1	8.7	0	0	0	0

*SUBAREA

MODIFIED PULS ROUTING

NODES (SUBAREA)					
13795-1 (130)	STORAGE (A-F)	0	706	861	2467
	DISCHARGE (CFS)	0	5300	6800	10500
7-8 (200)	STORAGE (A-F)	0	3082	4174	10210
	DISCHARGE (CFS)	0	2800	3000	6700
8-9 (230)	STORAGE (A-F)	0	2523	4798	9833
	DISCHARGE (CFS)	0	2100	3300	5400
9922-23 (610)	STORAGE (A-F)	0	1883	3767	7152
	DISCHARGE (CFS)	0	5400	8300	15600
23-24 (620)	STORAGE (A-F)	0	16057	36801	73862
	DISCHARGE (CFS)	0	5500	9500	16500
40-41 (1260)	STORAGE (A-F)	0	1869	3694	7319
	DISCHARGE (CFS)	0	13100	22700	37500
11-12 (420)	STORAGE (A-F)	0	1345	2563	7175
	DISCHARGE (CFS)	0	4300	6800	13900
12-13 (440)	STORAGE (A-F)	0	686	1358	3421
	DISCHARGE (CFS)	0	5400	8900	16400
19-20 (580)	STORAGE (A-F)	0	1112	2176	3538
	DISCHARGE (CFS)	0	5400	8900	16400
13815-14 (510)	STORAGE (A-F)	0	1533	2226	6349
	DISCHARGE (CFS)	0	2450	3970	6300
14-15 (530)	STORAGE (A-F)	0	692	1208	2210
	DISCHARGE (CFS)	0	2280	3670	6290
15-18 (570)	STORAGE (A-F)	0	5145	10410	19131
	DISCHARGE (CFS)	0	2150	4360	6860
16-17 (560)	STORAGE (A-F)	0	3859	7808	14348
	DISCHARGE (CFS)	0	2150	4360	6860
13885-25 (1100)	STORAGE (A-F)	0	1557	4553	8385
	DISCHARGE (CFS)	0	12900	29500	46500
25-26 (1110)	STORAGE (A-F)	0	2220	6846	14386
	DISCHARGE (CFS)	0	12100	26800	44000
30-31 (1160)	STORAGE (A-F)	0	5640	14614	24809
	DISCHARGE (CFS)	0	12700	26800	43900
33-34 (1190)	STORAGE (A-F)	0	1654	3216	5271
	DISCHARGE (CFS)	0	12400	26500	43400

MUSKINGUM ROUTING

NODES	STEP	AMSKK	X
140*-2	1	1.4	0.2
3-4	1	1.1	0.2
4-5	1	1.3	0.2
10-11	1	1.4	0.2
590*-22	1	1.0	0.2
600*-22	1	1.0	0.2
27-28	1	1.0	0.2
28-29	1	1.6	0.2
1170*-32	1	1.1	0.2
37-38	1	2.0	0.2
1240*-39	1	4.0	0.2

*SUBAREA

TABLE 13 (PAGE 7 OF 8) ROUTING PARAMETERS

- PASSAIC LOWER VALLEY SUBBASIN -

MODIFIED PULS ROUTING

NODES										
1-2[2]	STORAGE (A-F)	0	15	30	37	43	50	71	102
	DISCHARGE (CFS)	0	650	1760	2343	2797	3426	4700	6410
2-3[2]	STORAGE (A-F)	0	79	407	592	801	1035	1538	2120
	DISCHARGE (CFS)	0	827	2313	2935	3458	4155	5389	7384
3-4[1]	STORAGE (A-F)	0	48	135	182	311	426	674	
	DISCHARGE (CFS)	0	748	1887	2257	2876	3404	4424	
176-177	STORAGE (A-F)	0	130	374	426	807	985	1495	3632
	DISCHARGE (CFS)	0	1140	3280	3580	4840	6150	7860	13600

[1]MOLLY ANNS BROOK
[2]PECKMAN RIVER
*SUBAREA

MUSKINGUM ROUTING

NODES	STEP	AMSKK	X
LITTLE FALLS-100	1	0.65	0.20
100-200	1	1.40	0.20
1-2[1]	1	1.0	0.20
200-300	1	1.0	0.20
300-400	1	2.4	0.20
400-500	1	0.9	0.20
1385*-450	1	0.9	0.20
1505*-101	1	1.5	0.20
500-600	1	2.2	0.20
1520*-201	1	1.0	0.20
1530*-301	1	1.5	0.20
301-302	1	1.0	0.20
302-303	1	1.0	0.20
600-700	1	1.6	0.20
1590*-401	1	1.0	0.20
700-800	1	2.0	0.20

TABLE 13 (PAGE 8 OF 8) ROUTING PARAMETERS

- SADDLE RIVER SUBBASIN -

MODIFIED PULS ROUTING

NODES										
1701-171	STORAGE (A-F)	0	86	200	322	675	1347	2175	4265	4397
	DISCHARGE (CFS)	0	970	2108	2903	4204	5323	6796	13464	14119
1460-1729	STORAGE (A-F)	0	13	34	63	115	208	324	697	738
	DISCHARGE (CFS)	0	245	563	771	1053	1508	2122	3449	3775
1729-173	STORAGE (A-F)	0	13	25	42	85	152	270	781	995
	DISCHARGE (CFS)	0	263	574	788	986	1447	2061	3339	3663
175-176	STORAGE (A-F)	0	59	122	179	350	578	830	2086	2161
	DISCHARGE (CFS)	0	1000	2183	3013	4296	5400	7007	13377	13929
176-177	STORAGE (A-F)	0	112	211	319	522	786	1135	3008	3180
	DISCHARGE (CFS)	0	1008	2212	3044	4236	5392	6864	12492	12907

MUSKINGUM ROUTING

NODES	STEP	AMSKK	X
166-1661	1	4.5	0.2
1669-167	1	2.0	0.35
167-1671	1	1.0	0.2
1671-168	1	2.5	0.2
169-170	1	1.92	0.2
170-1701	1	3.5	0.15

TABLE 14 HEC1 DIVERSION FUNCTIONS FOR THE PASSAIC CENTRAL BASIN MODEL HISTORIC CALIBRATIONS

DIVERSION #												
1* NODE 13-15	DIVERSION:	TO NODE 9913 - THRESHOLD FLOW = 0 cfs										
		DIS Q (cfs)	0	2000	4000	6000	8000	10000	15000	20000		
		FRAC DIV.	0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.1		
2* NODE 20-8	DIVERSION:	TO NODE 9920 - THRESHOLD FLOW = 0 cfs										
		DIS Q (cfs)	0	2000	4000	6000	8000	10000	15000	20000		
		FRAC DIV.	0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.1		
3* NODE 34-23	DIVERSION:	TO NODE 9923 - THRESHOLD FLOW = 5,000 cfs										
		DIS Q (cfs)	0	1500	2500	3300	4400	7500	13000	20000	40000	90000
		FRAC DIV.	0.9	0.9	0.8	0.8	0.7	0.65	0.6	0.4	0.27	0.2

ROUTING PARAMETERS DIVERSION 3

Modified PULS

R1*	STORAGE (A-F)	0	2608	5217	8602
	DISCHARGE (cfs)	0	5400	8300	15600
R5*	STORAGE (A-F)	0	21857	48401	85282
	DISCHARGE (cfs)	0	5500	9500	16500

Muskingum

	AMSKK	X
R2*	8.0 hr.	0.5
R4*	Function of Flood Magnitude 2.0 to 6.0 hr	0.5

*REFER TO FIGURES 29 and 30 FOR SCHEMATIC REPRESENTATION OF DIVERSION LOCATIONS

TABLE 15 -HISTORIC FLOOD CALIBRATIONS
COMPUTED VERSUS OBSERVED PARAMETERS AT GAGES
PASSAIC RIVER BASIN, N.J. AND N.Y.

GAGING STATION			PEAK			VOLUME			PEAK TIME LAG (HOURS)
NUMBER	STREAM	EVENT	COMP	OBS	% DIFF	COMP	OBS	% DIFF	
0138800	RAMAPO RIVER AT POMPTON LAKES	5/68	10413	9530	+9	297000	340000	-12	-1
		4/70	3481	4540	-23	177000	253000	-30	-6
		11/77	10398	10300	+1	326000	328000	-1	3
0139150	SADDLE RIVER AT LODI	8/71	3350	3535	-5	102000	97200	+5	0
		9/71	3812	3770	+1	94500	98000	-4	0
		12/73	2728	2940	-7	65600	65500	0	-2
		11/77	4822	4500	+7	110000	113000	-3	+4
0138950	PASSAIC RIVER AT LITTLE FALLS	8/55	10216	9440	8.2	736111	760702	-3.2	-5
		10/55	11639	11600	0.3	1287697	1329838	-3.2	-15
		5/68	13753	13500	1.9	1100463	1125895	-2.3	-6
		4/70	9212	9108	1.1	1134105	1167017	-2.8	-3
0137950	PASSAIC RIVER AT CHATHAM	5/68	2686	2560	+5	222667	237174	-6	+5
		8/71	2498	2540	-2	289989	303079	-4	+1
		12/73	1386	1400	-1	142734	151261	-6	+1
		4/70	1441	1470	-2	157161	186230	-16	+3
0138150	WHIPPANY RIVER AT MORRISTOWN	8/55	1162	1160	+0.1	32114	29052	+10	-1
		10/55	886	900	-2.0	23314	23165	+1	-2
		4/70	1306	1310	-0.3	38013	34013	+12	-2
0138050	ROCKAWAY RIVER ABOVE RESERVOIR	5/68	3187	3020	+6	115861	127358	-9	1
		4/70	3170	2850	+11	133606	151312	-12	0
		8/71	3439	3550	-3	142309	144163	-1	3
		12/73	4142	4280	-3	181904	191252	-5	0
0138850	POMPTON RIVER AT POMPTON PLAINS	8/55	12507	12900	-3	552000	641000*	-14	-5
		10/55	15501	15800	-2	890000	1040000*	-14	-6
		5/68	14631	13100	+12	657000	579000	+13	+3
		4/70	8728	8630	+1	509000	535000	-5	+1

* VOLUME ESTIMATED FROM AVERAGE DAILY FLOW DATA

TABLE 16 SUMMARY OF PARTIAL DURATION RATIOS

GAGE STATION	PARTIAL DURATION FREQUENCIES FOR ANNUAL EVENT FREQUENCIES OF .08	.10	.20	.30	.40	.50	.60	.70	.80	.90
0137900	.080	.100	.219	.354	.476	.634	.912	1.32	1.76	2.43
0137950	.080	.100	.229	.347	.479	.661	.977	1.51	2.00	3.55
0138050	.080	.100	.251	.412	.562	.813	1.20	1.68	2.37	3.72
0138150	.085	.112	.294	.483	.646	.871	1.12	1.48	1.70	2.23
0138750	.083	.107	.226	.380	.536	.756	1.05	1.07	1.51	2.04
0138800	.085	.110	.251	.372	.511	.693	.912	1.23	1.70	2.28
0138850	.049	.082	.259	.442	.646	.933	1.27	1.80	2.48	3.80
0138950	.080	.100	.224	.339	.447	.575	.759	1.00	1.29	1.91
0139100	.085	.107	.214	.324	.436	.562	.759	.953	1.09	1.91
0139150	.091	.123	.323	.507	.692	.902	1.12	1.32	1.57	1.87
0139250	.080	.100	.200	.316	.427	.537	.716	1.00	.912	1.12
AVERAGE	.080	.104	.245	.389	.533	.722	.981	1.31	1.67	2.44
LANGBEIN	.083	.105	.223	.356	.510	.693	.917	1.20	1.61	2.30

TABLE 17 RATIO OF PARTIAL DURATION FREQUENCIES AND LANGBEIN PARTIAL DURATION FREQUENCIES

GAGE STATION	RATIO OF PARTIAL DURATION FREQUENCIES FOR ANNUAL EVENT FREQUENCIES OF									
	.080	.100	.200	.300	.400	.500	.600	.700	.800	.900
0137900	.964	.952	.982	.994	.933	.915	.995	1.10	1.09	1.06
0137950	.964	.952	1.03	.975	.939	.954	1.07	1.26	1.24	1.54
0138050	.964	.952	1.13	1.16	1.10	1.17	1.31	1.40	1.47	1.62
0138150	1.02	1.07	1.32	1.36	1.27	1.26	1.22	1.23	1.06	.970
0138750	1.00	.791	1.01	1.07	1.05	1.09	1.15	.892	.938	.887
0138800	1.02	1.05	1.13	1.04	1.00	1.00	.995	1.03	1.06	.991
0138850	.590	.781	1.16	1.24	1.27	1.35	1.39	1.50	1.54	1.65
0138950	.964	.952	1.00	.952	.877	.830	.828	.833	.801	.830
0139100	1.02	1.02	.960	.910	.855	.811	.828	.794	.677	.830
0139150	1.10	1.17	1.45	1.42	1.36	1.30	1.22	1.10	.975	.813
0139250	.964	.952	.900	.888	.837	.775	.781	.833	.567	.487
AVERAGE	.964	.991	1.10	1.09	1.05	1.04	1.07	1.09	1.04	1.06

TOTAL PASSAIC RIVER BASIN AVG.
FOR ALL FREQUENCIES TESTED = 1.05

TABLE 18 - PRECIPITATION DEPTH AREA RELATIONSHIPS
24 HOUR DURATION

AREA (Miles^2)	0.20	20	50	100	1000*
% RAINFALL	99.9	97.2	95	93.3	83
1-YR (2.65")	2.65	2.58	2.52	2.47	2.20
5-YR (4.25")	4.25	4.13	4.04	3.97	3.53
10-YR (5.10")	5.09	4.96	4.85	4.76	4.23
25-YR (5.70")	5.69	5.54	5.42	5.32	4.73
50-YR (6.45")	6.44	6.27	6.13	6.02	5.35
100-YR (7.20")	7.19	7.00	6.84	6.72	5.98
500-YR (9.00")	8.99	8.75	8.55	8.40	7.47
SPS [%]	[117.9]	[114.5]	[110.5]	[106]	[84]
(10.25") RAIN	12.08	11.74	11.33	10.87	8.61

*-DEPTHS FOR 1000 SQ. MILE AREA CORRESPOND TO COMPOSITE CURVE ON FIGURE 51

TABLE 19

POINT RAINFALL FOR HYPOTHETICAL STORM EVENTS

Duration (hours)	1yr	5yr	10yr	25yr (inches)	50yr	100yr	500yr**
1	1.20	1.75	2.10	2.40	2.70	3.00	3.65
2	1.45	2.20	2.70	3.15	3.35	3.70	4.65
3	1.65	2.60	2.95	3.45	3.75	4.25	5.15
6	1.90	3.15	3.60	4.15	4.55	5.20	6.30
12	2.30	3.65	4.30	5.10	5.45	6.25	7.70
18*	2.50	4.00	4.75	5.50	6.00	6.80	8.40
24	2.65	4.25	5.10	5.70	6.45	7.20	9.00

*18-hours storms done by graphical interpolation for each return period

**500-yr storms done by extrapolation according to procedures contained in Technical Paper No.40 for return periods longer than 100 years.

TABLE 20 24-HOUR POINT RAINFALL DISTRIBUTIONS
FOR HYPOTHETICAL STORM EVENTS

	Frequency Storm							
Hour	1	5	10	25	50	100	500	SPS
1	.02	.03	.04	.01	.06	.03	.06	.03
2	.02	.03	.05	.02	.06	.05	.08	.04
3	.02	.04	.06	.02	.07	.07	.09	.05
4	.03	.04	.06	.03	.07	.07	.11	.07
5	.03	.05	.07	.05	.09	.08	.12	.08
6	.03	.06	.07	.07	.10	.10	.14	.09
7	.06	.06	.07	.13	.11	.12	.17	.12
8	.06	.07	.09	.14	.12	.14	.20	.14
9	.07	.07	.11	.15	.14	.16	.21	.16
10	.07	.08	.12	.16	.15	.18	.24	.18
11	.07	.10	.14	.18	.18	.21	.27	.22
12	.07	.12	.17	.19	.20	.24	.31	.34
13	.08	.17	.20	.21	.24	.29	.35	.80
14	.09	.20	.23	.26	.29	.34	.42	.96
15	.25	.46	.60	.75	.65	.70	1.00	1.21
16	1.20	1.75	2.10	2.40	2.70	3.00	3.65	3.05
17	.20	.40	.25	.30	.40	.55	.50	1.13
18	.08	.18	.22	.23	.27	.32	.38	.88
19	.05	.10	.13	.15	.15	.15	.21	.17
20	.04	.08	.09	.10	.10	.10	.16	.14
21	.03	.06	.07	.06	.08	.08	.12	.12
22	.03	.05	.06	.04	.08	.08	.09	.10
23	.03	.03	.06	.03	.07	.07	.07	.09
24	.02	.03	.04	.02	.07	.07	.05	.08

Rainfall in Inches

TABLE 21
SUBAREA LOSS RATES FOR HYPOTHETICAL FLOWS
PASSAIC RIVER BASIN, N.J. AND N.Y.

Subarea	Return Period (Yrs)																Std. Proj. Flood	
	1		2		5		10		25		50		100		500			
	ST*	CN*	ST	CN	ST	CN	ST	CN	ST	CN	ST	CN	ST	CN	ST	CN	ST	CN
PASSAIC RIVER ABOVE CHATHAM																		
10-60	1.00	0.04	1.00	0.05	1.00	0.08	1.00	0.08	1.00	0.06	1.00	0.05	1.00	0.01	1.00	0.01	1.00	0.01
70-120	1.00	0.01	1.00	0.01	1.00	0.08	1.00	0.08	1.00	0.06	1.00	0.02	1.00	0.01	0.10	0.01	0.10	0.01
WHIPPANY RIVER ABOVE MORRISTOWN																		
450-500	1.00	0.16	1.00	0.17	1.00	0.24	1.00	0.21	1.00	0.19	1.00	0.17	1.00	0.18	1.00	0.16	1.00	0.16
ROCKAWAY RIVER ABOVE BOONTON																		
240-385	1.00	0.39	1.00	0.39	1.00	0.38	1.00	0.38	1.00	0.29	1.00	0.23	1.00	0.23	1.00	0.16	1.00	0.16
RAMAPO RIVER ABOVE POMPTON LAKES																		
930-980	1.00	0.27	1.00	0.25	1.00	0.23	1.00	0.17	1.00	0.10	1.00	0.03	1.00	0.01	1.00	0.01	1.00	0.01
985	1.00	0.60	1.00	0.58	1.00	0.55	1.00	0.52	1.00	0.40	1.00	0.28	1.00	0.25	1.00	0.24	1.00	0.24
990-1080	1.00	0.27	1.00	0.25	1.00	0.23	1.00	0.17	1.00	0.10	1.00	0.03	1.00	0.01	1.00	0.01	1.00	0.01
POMPTON RIVER ABOVE POMPTON PLAINS																		
630-770	1.00	0.70	1.00	0.32	1.00	0.29	1.00	0.19	1.00	0.11	1.00	0.08	1.00	0.07	1.00	0.06	1.00	0.06
780-800	1.00	0.19	1.00	0.18	1.00	0.16	1.00	0.10	1.00	0.07	1.00	0.02	1.00	0.02	1.00	0.02	1.00	0.02
810	1.00	0.65	1.00	0.60	1.00	0.40	1.00	0.38	1.00	0.17	1.00	0.10	1.00	0.02	1.00	0.01	1.00	0.01
820	1.00	0.50	1.00	0.44	1.00	0.33	1.00	0.28	1.00	0.17	1.00	0.10	1.00	0.02	1.00	0.01	1.00	0.01
830-920	1.00	0.19	1.00	0.18	1.00	0.16	1.00	0.10	1.00	0.07	1.00	0.02	1.00	0.02	1.00	0.02	1.00	0.02
1090	1.00	0.19	1.00	0.18	1.00	0.16	1.00	0.10	1.00	0.07	1.00	0.02	1.00	0.02	1.00	0.02	1.00	0.02
PASSAIC RIVER CENTRAL BASIN																		
130-230	0.50	0.14	0.50	0.14	0.50	0.13	0.50	0.12	0.50	0.10	0.50	0.10	0.50	0.10	0.50	0.10	0.50	0.10
390-440	0.50	0.14	0.50	0.14	0.50	0.13	0.50	0.12	0.50	0.10	0.50	0.10	0.50	0.10	0.50	0.10	0.50	0.10
510-620	0.50	0.14	0.50	0.14	0.50	0.13	0.50	0.12	0.50	0.10	0.50	0.10	0.50	0.10	0.50	0.10	0.50	0.10
1100-1260	0.50	0.14	0.50	0.14	0.50	0.13	0.50	0.12	0.50	0.10	0.50	0.10	0.50	0.10	0.50	0.10	0.50	0.10

TABLE 21 (CONT'D)

SUBAREA LOSS RATES FOR HYPOTHETICAL FLOWS

PASSAIC RIVER BASIN, N.J. AND N.Y. (CONT)

Subarea	Return Period (Yrs) 1		2		5		10		25		50		100		500		Std. Proj. Flood	
	ST*	CN*	ST	CN	ST	CN	ST	CN	ST	CN	ST	CN	ST	CN	ST	CN	ST	CN
SADDLE RIVER ABOVE LODI																		
1400	1.00	0.75	1.00	0.76	1.00	0.85	1.00	0.75	1.00	0.57	1.00	0.35	1.00	0.25	1.00	0.23	1.00	0.22
1410	1.00	0.35	1.00	0.30	1.00	0.30	1.00	0.26	1.00	0.11	1.00	0.02	1.00	0.02	1.00	0.15	1.00	0.10
1413-1415	1.00	0.70	1.00	0.68	1.00	0.68	1.00	0.60	1.00	0.44	1.00	0.25	1.00	0.18	1.00	0.10	1.00	0.12
1417-1420	1.00	0.43	1.00	0.41	1.00	0.41	1.00	0.36	1.00	0.27	1.00	0.15	1.00	0.11	1.00	0.05	1.00	0.07
1430-1450	1.00	0.35	1.00	0.30	1.00	0.30	1.00	0.26	1.00	0.11	1.00	0.02	1.00	0.02	1.00	0.15	1.00	0.10
1460-1470	1.00	0.77	1.00	0.80	1.00	0.90	1.00	0.80	1.00	0.57	1.00	0.23	1.00	0.10	1.00	0.10	1.00	0.15
1475-1490	1.00	0.35	1.00	0.30	1.00	0.30	1.00	0.26	1.00	0.11	1.00	0.02	1.00	0.02	1.00	0.15	1.00	0.10
PASSAIC RIVER LOWER VALLEY																		
1270	1.00	0.34	1.00	0.30	1.00	0.30	1.00	0.24	1.00	0.21	1.00	0.15	1.00	0.10	1.00	0.10	1.00	0.10
1280-1320	1.00	0.40	1.00	0.37	1.00	0.35	1.00	0.30	1.00	0.20	1.00	0.15	1.00	0.10	0.10	0.10	0.10	0.10
1330-1390	1.00	0.34	1.00	0.30	1.00	0.30	1.00	0.24	1.00	0.21	1.00	0.15	1.00	0.10	1.00	0.10	1.00	0.10
1500	1.00	0.35	1.00	0.30	1.00	0.30	1.00	0.26	1.00	0.11	1.00	0.02	1.00	0.02	1.00	0.10	1.00	0.10
1505-1580	1.00	0.34	1.00	0.30	1.00	0.30	1.00	0.24	1.00	0.21	1.00	0.15	1.00	0.10	1.00	0.10	1.00	0.10
1590-1600	1.00	0.08	1.00	0.08	1.00	0.17	1.00	0.13	1.00	0.10	1.00	0.06	1.00	0.03	1.00	0.03	1.00	0.03
1610-1620	1.00	0.34	1.00	0.30	1.00	0.30	1.00	0.24	1.00	0.21	1.00	0.15	1.00	0.10	1.00	0.10	1.00	0.10

* ST = starting loss (inches); CN = constant loss (in/hr)

TABLE 22
HYPOTHETICAL FLOOD PEAKS *
INCLUDING
MODELED VS GAGED WHERE APPROPRIATE
PASSAIC RIVER BASIN, N.J. AND N.Y.

GAGE	LOCATION		RETURN PERIOD (YRS) 1	2	5	10	25	50	100	500	STD. PROJ. FLOOD
PASSAIC RIVER ABOVE CHATHAM											
01379000	PASSAIC RIVER NEAR MILLINGTON	MODEL	710	927	1150	1387	1690	1952	2276	3075	4135
		GAGE	690	925	1120	1360	1700	1970	2270	3080	---
		%DIFF	2.9	0.2	2.6	1.9	-0.6	-1.0	0.2	-0.2	---
01379500	PASSAIC RIVER NEAR CHATHAM	MODEL	1104	1615	1891	2342	2955	3516	4076	5493	7130
		GAGE	1130	1600	1900	2350	3000	3530	4130	5790	---
		%DIFF	-2.3	0.9	-0.5	-0.3	-1.5	-0.4	-1.3	-5.1	---
WHIPPANY RIVER ABOVE MORRISTOWN											
01381500	WHIPPANY RIVER AT MORRISTOWN	MODEL	711	1008	1290	1608	2057	2430	2859	3891	5973
		GAGE	703	1010	1280	1590	2040	2410	2810	3890	---
		%DIFF	1.1	-.02	0.7	1.1	0.8	0.7	1.7	0.0	---
ROCKAWAY RIVER ABOVE BOONTON											
01380500	ROCKAWAY RIVER ABOVE BOONTON RESERVOIR	MODEL	1656	2262	3072	4094	5471	6661	8050	12002	17629
		GAGE	1670	2250	3205	4090	5450	6700	8050	12100	---
		%DIFF	-0.8	0.5	-4.1	0.1	0.4	-0.6	0.0	-0.8	---
RAMAPO RIVER ABOVE POMPTON LAKES											
01387450	MAHWAH RIVER AT SUFFERN	MODEL	423	619	889	1217	1712	2134	2643	4883	5336
		GAGE	405	590	880	1160	1650	2110	2710	4550	---
		%DIFF	4.4	4.9	1.0	4.9	3.8	0.7	-2.5	7.3	---
01387500	RAMAPO RIVER NEAR MAHWAH	MODEL	2469	3546	5500	7403	10566	14197	17127	29537	29798
		GAGE	2350	3400	5450	7180	10500	13900	17900	31400	---
		%DIFF	5.1	4.3	0.9	3.1	0.6	2.1	-4.3	-5.9	---
0138800	RAMAPO RIVER AT POMPTON LAKES	MODEL	2857	4193	6490	8803	12684	17042	20742	36783	36411
		GAGE	2800	4150	6380	9000	12900	16600	21500	33000	---
		%DIFF	2.0	0.8	1.7	-2.2	-1.7	2.7	-3.5	11.5	---

TABLE 22 (CONT'D)
HYPOTHETICAL FLOOD PEAKS *
INCLUDING
MODELED VS GAGED WHERE APPROPRIATE
PASSAIC RIVER BASIN, N.J. AND N.Y.

GAGE	LOCATION		RETURN PERIOD (YRS) 1	2	5	10	25	50	100	500	STD. PROJ. FLOOD
POMPTON RIVER ABOVE POMPTON PLAINS											
01382500	PEQUANNOCK RIVER AT MACOPIN INTAKE DAM	MODEL	554	1346	2070	3004	4530	5551	6716	9231	13281
		GAGE	506	1280	1930	2910	4280	5360	6460	9000	---
		%DIFF	9.5	5.2	7.3	3.2	5.8	3.6	4.0	2.6	---
01383500	WANAQUE RIVER AT AWOSTING	MODEL	377	590	1001	1390	2235	2942	4077	7143	7457
		GAGE	375	585	985	1360	2180	3020	4050	7710	---
		%DIFF	0.5	0.9	1.6	2.2	2.5	-2.6	0.7	-7.4	---
01384000	WANAQUE RIVER AT MONKS	MODEL	894	1337	2143	2881	4134	5269	6876	11839	12044
		GAGE	895	1350	2150	2860	4180	5450	6920	11800	---
		%DIFF	-0.1	-1.0	-0.3	0.7	-1.1	-3.3	-0.6	0.3	---
01384500	RINGWOOD CREEK NEAR WANAQUE **	MODEL	406	583	857	1173	1483	1831	2114	3618	3833
		GAGE	413	630	808	1050	1400	1700	2040	2980	---
		%DIFF	-1.7	-7.5	6.1	11.7	5.9	7.7	3.6	21.4	---
01385000	CUPSAW BROOK NEAR WANAQUE **	MODEL	264	370	536	730	906	1079	1229	2087	2153
		GAGE	148	257	360	528	829	1140	1560	3170	---
		%DIFF	78.4	44.0	48.9	36.3	9.3	-5.4	-21.2	-34.2	---
01386000	WEST BROOK NEAR WANAQUE	MODEL	428	602	881	1202	1489	1833	2117	3583	3793
		GAGE	470	660	895	1160	1550	1890	2270	3380	---
		%DIFF	-8.9	-8.8	-1.6	3.7	-3.3	-3.0	-6.7	6.0	---
01386500	BLUE MINE BROOK NEAR WANAQUE **	MODEL	115	160	232	314	390	463	527	891	913
		GAGE	95	170	212	300	449	599	792	1500	---
		%DIFF	21.1	-5.9	9.4	4.7	-13.1	-22.7	-33.5	-40.6	---
01387000	WANAQUE RIVER AT WANAQUE	MODEL	989	1661	2713	3928	5674	7687	9864	18786	18927
		GAGE	939	1900	2360	3600	5580	7390	9510	15900	---
		%DIFF	5.3	-12.6	15.0	9.1	1.7	4.0	3.7	18.2	---
01388500	POMPTON RIVER AT POMPTON PLAINS	MODEL	3992	6462	10049	13979	19870	26788	32515	55332	54666
		GAGE	4320	6600	10600	14100	20300	25600	32400	53100	---
		%DIFF	-7.6	-2.1	-5.2	-0.9	-2.1	3.8	0.4	4.2	---

TABLE 22 (CONT'D)
HYPOTHETICAL FLOOD PEAKS *
INCLUDING
MODELED VS GAGED WHERE APPROPRIATE
PASSAIC RIVER BASIN, N.J. AND N.Y.

GAGE	LOCATION		RETURN PERIOD (YRS) 1	2	5	10	25	50	100	500	STD. PROJ. FLOOD
PASSAIC RIVER CENTRAL BASIN											
01389500	PASSAIC RIVER AT LITTLE FALLS	MODEL	5486	7787	10332	13354	18190	22961	27533	44471	44406
		GAGE	6140	8100	11250	13900	18700	22700	27200	40600	---
		%DIFF	-10.7	-3.9	-8.2	-3.9	-2.7	1.1	1.2	9.5	---
SADDLE RIVER ABOVE LODI											
01390500	SADDLE RIVER AT RIDGEWOOD	MODEL	816	1268	1735	2647	3923	5276	6981	11710	13836
		GAGE	769	1330	1730	2460	3710	4970	6600	12600	---
		%DIFF	6.1	-4.7	0.3	7.6	5.7	6.2	5.8	-7.1	---
01391000	HOHOKUS BROOK AT HOHOKUS	MODEL	776	1162	1650	2330	3381	4573	5935	10170	11642
		GAGE	772	1290	1670	2320	3420	4510	5900	10900	---
		%DIFF	0.5	-9.9	-1.1	0.5	-1.1	1.4	0.6	-6.7	---
01391485	SPROUT BROOK AT ROCHELLE PARK	MODEL	275	403	551	721	1072	1510	2118	3042	3412
		GAGE	271	410	526	723	1100	1530	2180	3250	---
		%DIFF	1.5	-1.7	4.8	6.6	-2.5	-1.3	-2.8	-6.4	---
01391500	SADDLE RIVER AT LODI	MODEL	1007	1544	2176	3042	4228	5226	6565	11526	12964
		GAGE	1060	1700	2210	3050	4410	5360	6700	11100	---
		%DIFF	-5.0	-9.2	-1.5	-0.3	-4.2	-2.5	-2.0	3.8	---
PASSAIC RIVER LOWER VALLEY											
01392000	WEASEL BROOK AT CLIFTON	MODEL	311	422	624	827	1051	1286	1601	2499	3823
		GAGE	317	490	600	779	1050	1290	1570	2400	---
		%DIFF	-1.9	-13.9	4.0	6.2	0.0	-0.3	2.0	4.1	---
01392500	SECOND RIVER AT BELLEVILLE	MODEL	1650	2350	2856	3712	4624	5385	6363	9522	10500
		GAGE	1690	2450	2880	3570	4560	5430	6380	9090	---
		%DIFF	-2.4	-4.1	-0.8	4.0	1.0	-0.8	-0.3	5.1	---

* IN CUBIC FEET PER SECOND.
** GAGE NOT SPECIFICALLY CITED FOR MEASURING PEAK FLOWS.
SEE 'OTHER NON-BOUNDARY CONDITIONS GAGES' IN TEXT.

TABLE 23
FREQUENCY VS DISCHARGE FOR UNGAGED LOCATIONS
PASSAIC RIVER BASIN, N.J. AND N.Y.
EXISTING CONDITIONS

POI	HEC-1 NODE	RETURN PERIOD (YRS) 1	2	5	10	25	50	100	500	STD. PROJ. FLOOD
PASSAIC RIVER ABOVE CHATHAM										
1	105	710	927	1150	1387	1690	1952	2276	3075	4135
2	106	650	858	1065	1287	1568	1814	2117	2860	3838
3	107	1020	1417	1647	2014	2511	3030	3536	4643	6420
4	108	963	1325	1467	1743	2129	2536	2924	3953	5125
5	110*	534	755	933	1134	1402	1631	1889	2415	3231
6	110**	1104	1615	1891	2342	2955	3516	4076	5493	7130
WHIPPANY RIVER ABOVE MORRISTOWN										
25	460	188	263	333	413	524	615	720	955	1424
26	104	186	261	332	415	529	621	729	981	1498
27	106	352	495	632	789	1006	1183	1388	1869	2848
28	107	650	918	1174	1465	1872	2207	2595	3520	5394
29	108	668	946	1210	1507	1927	2276	2678	3639	5590
30	109	711	1008	1290	1608	2057	2430	2859	3891	5973
ROCKAWAY RIVER ABOVE BOONTON										
16	2	729	987	1361	1836	2442	2971	3579	5352	8166
17	280	63	83	116	153	202	246	293	416	606
18	5	1075	1465	2013	2678	3456	4149	4938	7306	10983
105	340	191	252	353	468	619	753	902	1313	1981
19	13	1531	2066	2809	3722	4965	6045	7285	10828	15997
20	19	1656	2262	3072	4094	5471	6661	8050	12002	17626
RAMAPO RIVER ABOVE POMPTON LAKES										
50	5	2049	2912	4527	6065	8604	11574	13896	23794	24131
51	7	735	1045	1550	2089	2927	3681	4483	7924	8652
52	8	729	1044	1558	2113	2938	3690	4492	7997	8756
53	9	269	362	543	725	902	1213	1478	2715	2866
54	10	968	1383	2075	2797	3811	4822	5843	10386	11198
55	12	2469	3546	5500	7403	10566	14197	17127	29557	29798
56	13	2660	3864	5999	8147	11771	15858	19237	33775	33769
57	15	2770	4044	6272	8494	12232	16522	20050	35385	35183
58	16	2805	4101	6357	8612	12425	16715	20308	35800	35552
59	17	2857	4183	6490	8802	12684	17042	20742	36782	36411

TABLE 23 (CONT'D)
FREQUENCY VS DISCHARGE FOR UNGAGED LOCATIONS
PASSAIC RIVER BASIN, N.J. AND N.Y.
EXISTING CONDITIONS

POI	HEC-1 NODE	RETURN PERIOD (YRS)								STD. PROJ. FLOOD
		1	2	5	10	25	50	100	500	
POMPTON RIVER ABOVE POMPTON PLAINS										
41	13	793	1617	2463	3523	5113	6418	7647	10329	14546
42	20	1121	1882	3056	4394	6241	8416	10581	19633	19610
43	21	1724	3323	5239	7545	10839	14194	17467	28672	31531
44	22	1702	3245	5105	7313	10443	13619	16722	27288	30017
45	930	438	603	921	1224	1693	2154	2550	4234	4469
46	960	154	212	320	419	566	702	825	1338	1400
47	950	248	339	514	688	934	1154	1355	2240	2331
48	3	399	547	829	1101	1493	1847	2170	3563	3696
49	4	2012	2854	4436	5952	8438	11235	13467	23038	23482
60	24	2872	4208	6526	8850	12743	17114	20825	36922	36522
61	25	3992	6462	10049	13979	19870	26788	32515	55337	54868
PASSAIC RIVER CENTRAL BASIN										
-	25	4021	6493	10089	13952	19681	26543	32106	54228	53813
62	26	3997	6449	10014	13696	19003	25437	30575	50709	50454
-	30	4288	6806	10521	14308	19729	26216	31455	51801	51688
-	31	4050	6429	9912	13461	18283	23941	28969	47605	47710
-	33	4132	6529	10051	13628	18472	24147	29200	47893	48019
68	34	4128	6521	10034	13630	18477	24123	29144	47796	47935
37	23	2933	3876	5150	6525	8622	10186	12283	18420	24243
40	24	2511	3447	5249	6858	8857	10336	12040	16471	19832
69	35	5201	7535	9965	12850	17567	22288	26843	43630	43435
76	41	5486	7787	10332	13354	18190	22961	27533	44471	44406
SADDLE RIVER ABOVE LODI										
86	1661	552	854	1170	1770	2617	3523	4751	8064	10130
87	1671	776	1162	1652	2332	3381	4573	5935	10170	11643
88	168	728	1061	1512	2115	3102	4284	5528	9342	10957
89	169	1196	1850	2595	3776	5572	7624	10001	17011	20286
90	170	1092	1680	2362	3415	5038	6845	8970	15312	16366
91	171	977	1486	2094	2942	4128	5101	6363	11526	14067
92	1460	275	414	568	880	1344	2013	2693	4147	4342
93	1725	275	403	551	771	1072	1510	2118	3040	3412
94	175	1007	1539	2168	3050	4279	5319	6651	11971	14576
95	176	1007	1544	2176	3040	4228	5226	6565	11526	13984
96	177	1022	1578	2227	3073	4236	5247	6510	10842	12867

TABLE 23 (CONT'D)
FREQUENCY VS DISCHARGE FOR UNGAGED LOCATIONS
PASSAIC RIVER BASIN, N.J. AND N.Y.
EXISTING CONDITIONS

POI	HEC-1 NODE	RETURN PERIOD (YRS) 1	2	5	10	25	50	100	500	STD. PROJ. FLOOD
PASSAIC RIVER LOWER VALLEY										
76	41	5486	7787	10332	13354	18190	22961	27533	44471	44406
-	100	5492	7795	10338	13364	18214	22994	27566	44549	44439
82	200	5505	7806	10354	13397	18255	23044	27626	44685	44490
-	300	5517	7817	10371	13429	18294	23096	27692	44801	44533
DUNDEE	400	5514	7821	10366	13443	18298	23098	27693	44817	44509
-	500	5576	7893	10452	13606	18565	23506	28207	45837	45137
-	600	5576	7902	10467	13624	18569	23513	28222	45913	45106
104	700	5603	7940	10512	13692	18653	23622	28362	46191	45236
MOUTH	800	5596	7951	10537	13710	18647	23613	28365	46272	45243

* SUBBASIN
** NODE

TABLE 24 - STORM: TRANSPOSED AGNES
(Page 1 of 2)

	Subbasin	Rain
PASSAIC ABOVE CHATHAM	10	14.7
	15	14.8
	20	15.0
	30	15.3
	40	15.2
	50	15.1
	60	15.1
	70	15.1
	80	14.8
	90	15.1
	100	15.0
	110	14.8
	120	15.0
CENTRAL BASIN	130	15.0
	140	15.0
	150	15.0
	160	14.9
	170	14.8
	180	14.9
	190	15.2
	200	15.2
	210	15.3
	220	15.4
	230	15.5
ROCKAWAY ABOVE BOONTON	240	13.6
	245	13.7
	250	14.0
	260	14.1
	270	14.1
	280	14.3
	290	14.4
	300	14.4
	310	14.6
	315	14.8
	320	14.9
ROCKAWAY ABOVE BOONTON	322	14.9
	325	14.5
	330	14.5
	340	14.7
	342	15.1
	345	14.9
	350	15.2
	360	15.4
	370	16.6
	373	16.1
	375	16.1
	377	15.5
	380	15.7
	385	16.0
CENTRAL BASIN	390	16.0
	400	16.3
	410	16.6
	420	16.2
	430	16.3
	440	16.2
WHIPPANY	450	14.8
	455	15.0
	460	15.2
	470	15.2
	480	15.1
	485	15.0
	490	15.3
	500	15.4
CENTRAL BASIN	510	15.4
	520	15.5
	530	15.6
	540	15.6
	550	15.6
	560	15.8
CENTRAL BASIN	570	15.8
	580	15.9
	590	15.4
	600	15.5
	610	15.7
	620	16.5
POMPTON	630	12.7
	640	12.8
	650	12.9
	660	13.2
	670	13.0
	680	13.4
	690	13.5
	700	13.7
	710	13.0
	720	13.7
	730	14.0
	740	14.5
	750	14.1
	760	14.6
	770	14.7
	780	16.0
	790	16.2
	800	17.7
	810	12.7
	820	12.8
	825	-
	830	13.0
	840	14.4
	850	14.1
	860	15.0
	870	14.5
	880	16.0
	890	18.0

TABLE 24 - STORM: TRANSPOSED AGNES
(Page 2 of 2)

	Subbasin	Rain
POMPTON	900	16.0
RIVER	910	18.0
	920	18.0
RAMAPO	930	12.8
RIVER	935	13.5
	940	13.8
	950	14.6
	960	13.9
	960	13.9
	970	14.3
	980	14.9
	990	13.7
	1000	15.0
	1000	15.4
	1015	15.6
	1020	15.5
	1030	15.5
	1040	16.1
	1050	18.0
	1060	17.5
	1070	18.0
	1080	18.0
POMPTON	1090	18.0
CENTRAL	1100	17.9
BASIN	1110	17.7
	1120	17.0
	1130	17.4
	1140	17.5
	1150	17.3
	1155	17.2
	1160	17.2
	1170	17.4
	1180	17.2
	1190	16.8
	1200	15.9
	1210	15.7
	1220	15.7
	1230	16.2
CENTRAL	1240	17.2
BASIN	1250	16.6
	1260	16.2
	1270	16.2
	1280	14.9
	1290	15.2
	1300	15.5
	1310	17.8
	1315	17.2
	1317	17.0
LOWER	1320	16.7
VALLEY	1330	16.1
	1340	17.2
	1350	16.2
	1360	16.6
	1370	14.8
	1380	15.5
	1385	14.8
	1390	14.3
SADDLE	1400	15.5
RIVER	1410	16.1
	1413	16.5
	1415	17.5
	1417	17.3
	1420	17.0
	1430	16.4
	1440	15.7
	1445	14.9
	1450	14.5
	1460	14.8
	1470	14.1
	1475	14.0
	1480	14.2
	1490	13.8
LOWER	1500	13.6
VALLEY	1505	15.0
	1510	14.4
	1520	14.3
	1525	14.1
	1530	14.8
	1540	14.3
	1550	14.3
	1560	14.1
	1570	13.8
	1580	13.8
	1590	14.6
	1600	14.2
	1610	14.2
	1620	13.2

TABLE 25
HARRISBURG HOURLY BREAKDOWN JUNE 1972 SUSQUEHANNA BASIN

Period (hr)	Rainfall (inches)	Period (hr)	Rainfall (inches)
1	.17	26	.74
2	.17	27	.60
3	.18	28	.41
4	.18	29	.36
5	.20	30	.36
6	.45	31	.35
7	.35	32	.35
8	.10	33	.25
9	.10	34	.20
10	0	35	.15
11	.05	36	.10
12	.05	37	.09
13	.20	38	.09
14	.65	39	.09
15	1.15	40	.09
16	1.76	41	.03
17	1.64	42	0
18	.90	43	0
19	.40	44	.02
20	.31	45	.02
21	.35	46	.05
22	.35	47	.02
23	.35	48	.01
24	.35	49	.01
25	.35	50	.01

Total: 15.16"

TABLE 26 - SUBBASIN RAINFALL
(Page 1 of 2)

	Subbasin	Rain
PASSAIC	10	8.7
ABOVE	15	8.3
CHATHAM	20	8.0
	30	8.7
	40	8.3
	50	7.8
	60	7.6
	70	7.3
	80	7.2
	90	7.4
	100	8.1
	110	8.5
	120	8.7
	130	9.1
	140	11.0
	150	10.1
	160	10.4
	170	9.7
	180	9.3
CENTRAL	190	9.2
BASIN	200	9.6
	210	11.0
	220	11.3
	230	10.4
	240	11.5
	245	10.3
	250	11.0
	260	10.4
ROCKAWAY	270	10.2
ABOVE	280	10.5
BOONTON	290	10.4
	300	10.0
	310	10.6
	315	12.3
	320	11.9

	Subbasin	Rain
ROCKAWAY	322	11.5
ABOVE	325	11.5
BOONTON	330	10.8
	340	10.1
	342	10.7
	345	10.9
	350	11.1
	360	11.5
	370	12.7
	373	12.2
	375	12.3
	377	12.2
	380	11.7
	385	11.7
	390	11.5
	400	11.8
CENTRAL	410	12.4
BASIN	420	11.5
	430	11.9
	440	11.4
	450	9.5
	455	9.6
	460	10.3
	470	9.7
WHIPPANY	480	10.0
	485	9.7
	490	9.3
	500	9.3
	510	9.7
	520	9.5
CENTRAL	530	10.0
BASIN	540	10.5
	550	10.2
	560	11.0

	Subbasin	Rain
CENTRAL	570	10.5
BASIN	580	11.0
	590	12.5
	600	11.7
	610	11.6
	620	11.6
	630	11.0
	640	11.0
	650	11.2
	660	11.4
	670	11.4
	680	11.7
	690	11.8
	700	12.2
	710	11.5
	720	12.2
	730	12.3
	740	12.4
POMPTON	750	12.2
RIVER	760	12.4
	770	12.5
	780	12.7
	790	12.8
	800	13.4
	810	11.3
	820	11.3
	825	-
	830	11.4
	840	11.0
	850	11.9
	860	12.2
	870	12.0
	880	12.2
	890	13.0

TABLE 26 - SUBBASIN RAINFALL
(Page 2 of 2)

	Subbasin	Rain
	900	12.8
POMPTON	910	13.6
RIVER	920	13.7
	930	13.7
	935	12.0
	940	10.4
	950	11.0
	960	11.0
	970	10.8
	980	10.5
	990	9.8
	1000	10.6
	1010	11.0
	1015	10.9
RAMAPO	1020	10.9
RIVER	1030	11.9
	1040	13.5
	1050	12.5
	1060	12.8
	1070	13.0
	1080	14.0
POMPTON	1090	14.0
	1100	14.0
	1110	14.0
	1120	13.0
	1130	13.4
CENTRAL	1140	13.5
BASIN	1150	13.4
	1155	13.6
	1160	14.0
	1170	14.3
	1180	14.0
	1190	13.8

	Subbasin	Rain
	1200	13.4
	1210	13.0
	1220	12.4
	1230	13.1
CENTRAL	1240	14.6
BASIN	1250	14.2
	1260	14.2
	1270	14.3
	1280	12.0
	1290	13.0
	1300	14.0
	1310	13.9
	1315	14.4
	1317	14.7
LOWER	1320	15.0
VALLEY	1330	14.7
	1340	13.9
	1350	15.0
	1360	14.0
	1370	14.8
	1380	15.0
	1385	15.0
	1390	14.7
	1400	12.0
	1410	13.7
	1413	12.0
	1415	12.5
SADDLE	1417	13.0
RIVER	1420	13.2
	1430	13.7
	1440	14.4
	1445	14.6
	1450	14.5
	1460	14.0

	Subbasin	Rain
SADDLE	1470	14.2
RIVER	1475	14.2
	1480	14.6
	1490	14.0
	1500	14.0
	1505	14.6
	1510	14.5
	1520	14.2
	1525	14.0
	1530	13.8
	1540	13.1
LOWER	1550	13.5
VALLEY	1560	13.8
	1570	14.0
	1580	13.3
	1590	12.5
	1600	12.8
	1610	12.0
	1620	12.2

TABLE 27 - RAINFALL DISTRIBUTION

OCT 1903
NEWARK STATION

8 OCT 1903	RAINFALL (Inches)
8-9 AM	.05
10	.09
11	0
NOON	0
1 PM	.14
2	.72
3	.43
4	.11
5	1.05
6	.45
7	1.20
8	.60
9	.24
10	.24
11	.15
MIDNIGHT	.17
1 AM	.29
2	.33
3	.62
4	.29
5	.35
6	.26
7	.13
8	.29
9	.69
10	.69
11	.39
NOON	.20
1 PM	.39
2	.28
3	.34
4	.13

Total: 11.30"

TABLE 28

PASSAIC RIVER BASIN OCT. 1903 STORM
LOSSES AND FLOW COMPARISONS

MODEL	LOCATION	HEC-1 NODE	POI	USGS GAGE NO.	SUBBASIN LOSSES STRTL	SUBBASIN LOSSES CNSTL	MODEL PEAK FLOW cfs	RECORDED DISCHARGE cfs	100 YEAR DISCHARGE cfs
RAMAPO RIVER	MAHWAH	12 (A)	55	13875	1.0"	0.12"/hr	16236	12400	17900
	POMPTON LAKES	17 (A)	59	13880	1.0	0.50	17092	–	21500
POMPTON RIVER	POMPTON PLAINS	25 (A)	61	13885	1.0	0.29	29048	28340	32400
ROCKAWAY RIVER	ABOVE BOONTON	19 (A)	20	13805	1.0	0.25	8014	7560	8050
WHIPPANY RIVER	MORRIS-TOWN	109 (A)	30	13815	1.0	0.16	2444	–	2810
PASSAIC RIVER	MILLING-TON	105 (A)	1	13780	1.0	0.09	2077	–	2270
	CHATHAM	110 (A)	6	13795	1.0	0.06	3236	–	4130
	LITTLE FALLS	41 (A)	76	13895	0.5	0.05	31334	31700	27200
SADDLE RIVER	LODI	176 (A)	95	13915	1.0	0.26	6498	–	6700
MOLLY ANN's BROOK	MOUTH	4	81	–	1.0	0.10	3359	–	3707 (B)

(A) GAGING STATION
(B) FROM HYDROLOGIC MODEL

TABLE 29

OBSERVED VS COMPUTED HYOROGRAPHS
APRIL 1984 FLOOD
PASSAIC RIVER BASIN, N.J. AND N.Y.

STREAM AND LOCATION	PEAK FLOW (A) (B)	TIME OF PEAK (B) (C)	CHARACTER OF REPRODUCTION AROUND PEAK	ILLUSTRATED ON FIGURE
RAMAPO RIVER NEAR MAHWAH, N.J.	15345 (15067)	052000 (051900)	EXCELLENT	-
RAMAPO RIVER AT POMPTON LAKES, N.J.	15429 (16131)	052300 (052300)	VERY GOOD	52
POMPTON RIVER AT POMPTON LAKES, N.J.	25352 (24177)	060330 (060200)	GOOD	86
PASSAIC RIVER AT LITTLE FALLS, N.J.	18400 (21259)	071000 (070500)	FAIR	87

(A) HIGHEST ORDINATE (C.F.S) AT WHOLE CLOCK HOUR (MAY HAVE BEEN SLIGHTLY HIGHER BETWEEN CLOCK HOURS).
(B) REPRODUCED VALUES SHOWN IN PARENTHESES.
(C) FIRST TWO DIGITS ARE DATE, LAST FOUR, TIME (24-HOUR CLOCK).
(D) CORRESPONDING FLOW OCCURRED AT BOTH 0300 HOURS AND 0400 HOURS.

TABLE 30 (Page 1 of 7)

RECURRENCE OF HISTORICAL EVENTS
FOR PRESENT LAND USE

RAMAPO RIVER BASIN

	POI	NODE OR SUBBASIN	FLOW (cfs) WITH EXC. FREQ. OCT. 1903	freq.	TRANSPOSED AGNES	freq.	SPF	freq.
	45	930	1934		2615			
	46	960	446		854			
	47	950	753		1551			
	48	3	1199		2404			
	49	4	12168		18725			
	50	5	12944		20798			
	51	7	2769		6440			
	52	8	2813		6582			
	53	9	805		2017			
	54	10	3576		8367			
	-	11	16170		27562			
MAHWAH	55	12	16236	100 YR.	27717	450 YR.	29450	530 YR.
	56	13	16591		32884			
	57	15	16864		35775			
	58	16	16934		36922			
POMPTON LAKES	59	17	17092	66 YR.	38811	715 YR.	35207	530 YR.

POMPTON RIVER BASIN

	POI	NODE OR SUBBASIN	OCT. 1903	freq.	TRANSPOSED AGNES	freq.	SPF	freq.
POMPTON PLAINS	41	13	5931		14557			
	42	20	6721		18111			
	43	21	12640		32624			
	44	22	12206		31355			
	60	24	17151		39108			
	61	25	29048	83 YR.	66056	1000 YR.	53311	530 YR.

TABLE 30 (Page 2 of 7)

RECURRENCE OF HISTORICAL EVENTS
FOR PRESENT LAND USE

ROCKAWAY RIVER BASIN

	POI	NODE OR SUBBASIN	FLOW (cfs) WITH EXC. FREQ.					
			OCT. 1903	freq.	TRANSPOSED AGNES	freq.	SPF	freq.
	16	2	3191		4833			
	17	280	160		6327			
	18	5	4212		7022			
	105	340	486		1114			
ABOVE	19	13	6685		11231			
BOONTON	20	19	8014	133 YR.	13353	900 YR.	17148	

WHIPPANY RIVER BASIN

	POI	NODE OR SUBBASIN	OCT. 1903	freq.	TRANSPOSED AGNES	freq.	SPF	freq.
	25	460	440		934			
	26	104	508		1103			
	27	106	906		2026			
	28	107	2038		4022			
	29	108	2294		4610			
MORRIS-TOWN	30	109	2444	55 YR.	5095	2000 YR.	5962	

PASSAIC RIVER BASIN CHATHAM

	POI	NODE OR SUBBASIN	OCT. 1903	freq.	TRANSPOSED AGNES	freq.	SPF	freq.
	1	105	2077		4803			
	2	106	1930		4486			
	3	107	3035		7645			
	4	108	2595		6261			
	5	110[1]	819		2159			
CHATHAM	6	110[2]	3236	35 YR.	7099	1333 YR.	7186	

[1] SUBBASIN
[2] NODE

TABLE 30 (Page 3 of 7)

RECURRENCE OF HISTORICAL EVENTS
FOR PRESENT LAND USE

PASSAIC RIVER CENTRAL BASIN

POI	NODE OR SUBBASIN	FLOW (cfs) WITH EXC. FREQ.					
		OCT. 1903	freq.	TRANSPOSED AGNES	freq.	SPF	freq.
7	140	829		1329			
8	2	1163		1927			
9	3	1818		3029			
10	4	2475		4207			
11	190	657		1310			
12	8*	5513		9137			
12	8**	7341		10803			
13	210	1046		1718			
14	220	141		228			
15	9	5863		9542			
21	10	8401		13894			
22	410	2054		3189			
23	430	566		915			
24	13*	8435		13147			
24	13**	6932		11833			
31	540	2409		4220			
32	550	403		738			
33	16	2785		4902			
34	18	5825		7785			
35	19	12752		19618			
36	20*	12692		19547			
36	20**	11422		17592			

* BEFORE DIVERSION
**AFTER DIVERSION

TABLE 30 (Page 4 of 7)

RECURRENCE OF HISTORICAL EVENTS
FOR PRESENT LAND USE

PASSAIC RIVER CENTRAL BASIN

	POI	NODE OR SUBBASIN	FLOW (cfs) WITH EXC. FREQ.					
			OCT. 1903	freq.	TRANSPOSED AGNES	freq.	SPF	freq.
	37	9922	17457		26581			
	-	23*	16982		25949			
	-	23**	25329		39532			
	38	590	1008		1440			
	39	600	222		347			
	40	24	14454		22321			
	62	26	28111		62200			
	63	1130	874		1331			
	64	1140	1461		2211			
	65	28	4197		6357			
	66	1170	833		1180			
	67	32	1528		2167			
	68	34*	28072		60022			
	68	34**	20054		46708			
	69	35	30224					
	70	1200	748		1031			
	71	36	1566		2178			
	72	37	1984		2808			
	73	38	2329		3247			
	74	1240	2261		3045			
	75	39	3123		3912			
LITTLE FALLS	76	41	31334	200 YR.	61998	2900 YR.	43143	

*BEFORE DIVERSION
**AFTER DIVERSION

TABLE 30 (Page 5 of 7) RECURRENCE OF HISTORICAL EVENTS FOR PRESENT LAND USE

PASSAIC RIVER CENTRAL BASIN

	POI	NODE OR SUBBASIN	FLOW (cfs) WITH EXC. FREQ.					
			OCT. 1903	freq.	TRANSPOSED AGNES	freq.	SPF	freq.
	-	1	3190		7629			
	-	6	5934		10871			
	-	7	6370		11783			
	-	21	17059		26045			
PASSAIC	-	40	31369		62287			
	-	25	29048		66056			
	-	30	29298		63897			
	-	31	27755		59667			
POMPTON	-	33	28088		60105			
	-	11	9444		15511			
ROCKAWAY	-	12	8456		13353			
	-	14	5128		8782			
	-	15*	5034		8375			
WHIPPANY	-	15**	6834		10006			

*BEFORE DIVERSION
**AFTER DIVERSION

TABLE 30 (Page 6 of 7) RECURRENCE OF HISTORICAL EVENTS FOR PRESENT LAND USE

SADDLE RIVER BASIN

	POI	NODE OR SUBBASIN	FLOW (cfs) WITH EXC. FREQ.					
			OCT. 1903	freq.	TRANSPOSED AGNES	freq.	SPF	freq.
	86	1661	3467		6965			
	87	1671	3782		8719			
	88	168	3638		8744			
	89	169	7035		15709			
	90	170	6900		15377			
	91	171	5593		12693			
	92	1460	1750		2936			
	93	1729	1514		2468			
	94	175	6545		14126			
LODI	95	176	6498	90 YR.	13802	1000 YR.	13963	
	96	177	7268		13189			

TABLE 30 (Page 7 of 7)

RECURRENCE OF HISTORICAL EVENTS
FOR PRESENT LAND USE

PASSAIC RIVER LOWER VALLEY

	POI	NODE OR SUBBASIN	FLOW (cfs) WITH EXC. FREQ. OCT. 1903	freq.	TRANSPOSED AGNES	freq.	SPF	freq.
LITTLE FALLS	76	41	315797		61998			
	77	1280	843		1374			
	78	2	2595		4100			
PECKMAN	79	3	3277		4735			
	80	2	2357		3822			
MOLLY ANN	81	4	3359		4738			
GOFFLE	83	1340	3371		5395			
DIAMOND	84	1360	1412		2175			
WABASH	85	1370	743		934			
SADDLE	96	177	7268		13189			
WEASEL	97	1505	1456		1903			
MCDONALD	98	1520	1149		1471			
	99	1530	2552		3583			
	100	301	3280		4582			
THIRD	101	302	3959		5460			
	102	1590	4212		7021			
SECOND	103	401	4274		7089			
	-	100	31664		62098			
	82	200	31813		62275			
	-	300	31977		62458			
	Dundee	400	32050		62458			
	-	500	34047		63636			
	-	600	37259		63701			
PASSAIC	104	700	40659		63973			
MAINSTEM	Mouth	800	41135		63957			

TABLE 31

TIDE ELEVATION VERSUS DISCHARGES, PASSAIC RIVER BASIN

Date	Tide Elevation East Newark (Ft. above M.S.L.)	Passaic River at U.S.G.S. Gage Little Falls, N. J. (Discharge in C.F.S.)
21 Sept 1938	5.99	4,590
26 Oct 1943	6.04	521
14 Sept 1944	6.28	717
30 Nov 1944	6.11	2,540
16 Jan 1945	6.10	644
25 Nov 1950	7.86	1,000
8 Dec 1950	6.37	5,090
23 Oct 1953	6.05	36
7 Nov 1953	7.75	245
31 Aug 1954	6.10	815
14 Oct 1955	7.03	895
20 Mar 1958	6.03	2,170
3 Apr 1958	6.12	4,040
29 Dec 1959	6.17	2,510
19 Feb 1960	7.27	2,510
12 Sept 1960	8.33	2,700
9 Mar 1961	6.00	3,140
13 Apr 1961	7.30	2,770
22 Oct 1961	6.30	147
6 Mar 1962	7.60	1,750
10 Nov 1962	6.70	1,670
6 Dec 1962	6.10	1,320
29 Mar 1984	6.82 (NGVD)	

TABLE 32 PASSAIC RIVER BASIN FUTURE DEVELOPMENT PROJECTIONS AND HYDROLOGIC IMPACTS DUE TO URBANIZATION

FUTURE DEVELOPMENT

LAND USE CATEGORY	1990 Development (Acres)	2040 Development (Acres)	% Increase
Residential	213,042	237,126	11.3%
Commercial	28,312	31,472	11.2%
Industrial	13,867	15,042	8.5%
Other 1/	50,070	57,004	13.8%
Developed Basin Acreage 2/	305,291	340,644	12%
Total Basin Acreage	600,147	600,147	-

HYDROLOGIC IMPACT - Passaic River Main stem at Little Falls

Event (Recurrence Freq)	1990 Conditions Discharge (cfs)	2040 Conditions Discharge (cfs)	% Increase
1yr	5,773	6,153	6.6%
100yr	27,527	28,156	2.3%

1/ Other acres include agriculture, mining, construction, transportation, government and miscellaneous public and institutional usages.

2/ The developed acreage in the basin does not include woodland, wetland and other undeveloped land. Therefore, the developed acreage is less than the total drainage basin acreage.

TABLE 33
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
*240	23.10	4.00	22.50	4.57	0.18	0.00*	10.23 *
*240	23.10	3.88	22.00	4.41	0.18	2.40*	12.63 *
*240	23.10	3.72	20.53	4.15	0.18	6.96*	17.19 *
*250	14.90	3.00	22.10	3.71	0.16	0.00*	30.36 *
*250	14.90	3.01	21.80	3.71	0.16	0.61*	30.97 *
*250	14.90	2.77	20.77	3.57	0.16	3.91*	34.27 *
*245	7.70	3.00	15.00	3.56	0.21	0.00*	16.97 *
*245	7.70	2.87	14.50	3.43	0.21	2.55*	19.52 *
*245	7.70	2.65	12.60	3.05	0.21	11.70*	28.67 *
*270	4.59	2.00	13.10	2.70	0.19	0.00*	16.64 *
*270	4.59	1.72	12.85	2.61	0.19	2.41*	19.05 *
*270	4.59	1.55	11.48	2.40	0.19	7.43*	24.07 *
*260	0.91	1.00	7.00	1.68	0.23	0.00*	35.95 *
*260	0.91	1.05	7.00	1.69	0.23	0.10*	36.05 *
*260	0.91	1.05	7.00	1.69	0.23	0.78*	36.73 *
*280	1.30	1.50	8.50	2.08	0.22	0.00*	22.10 *
*280	1.30	1.49	8.11	2.03	0.22	4.88*	26.98 *
*280	1.30	1.42	7.17	1.86	0.22	10.18*	32.28 *
*290	2.90	2.50	10.10	2.85	0.24	0.00*	35.83 *
*290	2.90	2.34	10.22	2.79	0.24	1.72*	37.55 *
*290	2.90	2.18	10.16	2.72	0.24	3.42*	39.25 *
*300	4.90	2.50	13.60	2.89	0.19	0.00*	16.69 *
*300	4.90	2.43	13.47	2.86	0.19	0.64*	17.33 *
*300	4.90	2.03	13.47	2.71	0.19	4.44*	21.13 *
*310	3.55	2.00	12.10	2.68	0.21	0.00*	24.51 *
*310	3.55	1.82	11.47	2.62	0.21	0.99*	25.50 *
*310	3.55	1.62	10.39	2.43	0.21	6.57*	31.08 *
*315	5.00	2.00	15.00	2.73	0.17	0.00*	20.24 *
*315	5.00	2.09	15.42	2.76	0.17	0.16*	20.40 *
*315	5.00	2.09	15.42	2.76	0.17	0.16*	20.40 *
*320	3.38	2.00	12.00	2.68	0.21	0.00*	7.44 *
*320	3.38	2.06	11.92	2.70	0.21	0.40*	7.84 *
*320	3.38	1.66	10.87	2.50	0.21	6.83*	14.27 *
*322	1.02	1.50	8.50	2.08	0.22	0.00*	6.66 *
*322	1.02	1.51	8.41	2.09	0.22	0.00*	6.66 *
*322	1.02	1.32	7.24	1.80	0.22	8.73*	15.39 *
*325	8.10	2.60	17.60	3.19	0.17	0.00*	9.83 *
*325	8.10	2.59	16.68	3.14	0.17	1.58*	11.41 *
*325	8.10	2.53	15.93	3.02	0.17	5.18*	15.01 *

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
140	2.80	1.00	5.00	1.62	0.30	0.00	13.75
140	2.80	1.00	14.55	9.17	0.30	5.07	18.82
140	2.80	1.00	4.90	1.62	0.30	14.57	28.32
150	1.50	1.00	4.20	1.58	0.33	0.00	20.70
150	1.50	1.00	13.18	9.17	0.33	1.62	22.32
150	1.50	1.00	4.25	1.58	0.33	7.52	28.22
160	2.38	1.10	4.70	1.64	0.31	0.00	13.95
160	2.38	1.00	15.58	10.22	0.34	8.63	22.58
160	2.38	1.00	4.67	1.61	0.31	17.16	31.11
170	3.37	1.10	5.50	1.67	0.28	0.00	17.41
170	3.37	1.00	15.56	9.17	0.28	3.37	20.78
170	3.37	1.00	5.38	1.64	0.28	7.65	25.06
180	1.78	1.50	5.00	1.82	0.29	0.00	31.63
180	1.78	1.00	15.07	9.17	0.26	0.00	31.63
180	1.78	1.48	5.00	1.81	0.29	2.35	33.98
190	2.72	1.00	5.00	1.62	0.30	0.00	25.69
190	2.72	1.00	14.55	9.17	0.27	0.10	25.79
190	2.72	1.04	4.91	1.63	0.30	0.46	26.15
200	10.20	2.50	12.00	2.87	0.21	0.00	28.17
200	10.20	1.00	20.89	9.17	0.21	3.15	31.32
200	10.20	2.02	11.95	2.69	0.21	6.41	34.58
210	3.85	1.20	5.60	1.72	0.27	0.00	22.17
210	3.85	1.00	16.15	9.17	0.27	1.86	24.03
210	3.85	1.00	5.63	1.65	0.27	7.22	29.39
220	0.41	1.00	4.00	1.57	0.34	0.00	15.33
220	0.41	1.00	0.50	9.69	0.00	5.71	21.04
220	0.41	1.00	4.06	1.57	0.34	10.89	26.22
230	6.42	2.50	11.00	2.86	0.22	0.00	23.82
230	6.42	1.00	19.92	9.17	0.22	2.20	26.02
230	6.42	2.21	11.35	2.75	0.22	4.46	28.28
590	3.09	1.00	5.40	1.64	0.28	0.00	24.30
590	3.09	1.00	15.56	9.17	0.28	1.74	26.04
590	3.09	1.00	5.38	1.64	0.28	6.11	30.41
600	0.62	1.00	4.00	1.57	0.34	0.00	35.19
600	0.62	1.00	12.72	9.17	0.34	0.13	35.32
600	0.62	1.00	4.06	1.57	0.34	4.57	39.76
610	2.27	2.00	8.70	2.58	0.26	0.00	26.79
610	2.27	1.00	16.86	9.17	0.26	0.85	27.64
610	2.27	1.97	8.93	2.58	0.26	1.78	28.57

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
* 10	3.27	1.50	2.97	1.72	0.41	0.00*	11.23 *
* 10	3.27	1.47	3.00	1.71	0.41	0.67*	11.90 *
* 10	3.27	1.40	3.00	1.68	0.41	2.38*	13.61 *
* 15	5.56	1.50	2.97	1.72	0.41	0.00*	10.00 *
* 15	5.56	1.24	3.00	1.59	0.41	4.18*	14.18 *
* 15	5.56	1.11	2.98	1.51	0.41	7.34*	17.34 *
* 20	3.97	1.50	6.00	1.88	0.26	0.00*	24.39 *
* 20	3.97	1.50	5.79	1.86	0.26	0.50*	24.69 *
* 20	3.97	1.50	5.79	1.86	0.26	0.98*	25.37 *
* 30	25.80	6.00	20.00	6.10	0.26	0.00*	18.43 *
* 30	25.80	5.92	19.39	6.03	0.26	1.26*	19.69 *
* 30	25.80	5.64	19.29	5.90	0.26	3.06*	21.49 *
* 40	12.60	6.00	16.00	6.01	0.30	0.00*	21.40 *
* 40	12.60	5.97	16.34	6.01	0.30	0.25*	21.65 *
* 40	12.60	5.92	16.25	5.98	0.30	0.81*	22.21 *
* 50	1.33	1.34	10.00	1.88	0.17	0.00*	22.57 *
* 50	1.33	1.27	9.89	1.81	0.17	1.36*	23.93 *
* 50	1.33	1.21	10.00	1.79	0.17	1.82*	24.39 *
* 60	2.87	1.50	15.00	2.50	0.16	0.00*	21.18 *
* 60	2.87	1.49	14.29	2.45	0.16	1.77*	22.95 *
* 60	2.87	1.46	13.60	2.35	0.16	3.44*	24.62 *
* 70	2.50	1.40	9.10	1.95	0.19	0.00*	16.20 *
* 70	2.50	1.39	9.03	1.93	0.19	0.66*	16.86 *
* 70	2.50	1.37	8.84	1.87	0.19	1.69*	17.89 *
* 80	20.50	5.00	18.50	5.18	0.24	0.00*	13.96 *
* 80	20.50	4.90	18.13	5.08	0.24	2.09*	16.05 *
* 80	20.50	4.16	16.21	4.53	0.24	9.93*	23.89 *
* 90	11.80	3.20	15.30	3.72	0.22	0.00*	21.38 *
* 90	11.80	3.04	14.63	3.58	0.22	3.17*	24.55 *
* 90	11.80	2.88	13.59	3.37	0.22	7.42*	28.80 *
*100	3.40	1.50	5.50	1.84	0.27	0.00*	29.10 *
*100	3.40	1.46	5.51	1.82	0.27	1.18*	30.28 *
*100	3.40	1.43	5.57	1.81	0.27	2.39*	31.49 *
*110	4.60	2.00	5.60	2.34	0.34	0.00*	28.85 *
*110	4.60	2.00	5.62	2.34	0.34	0.28*	29.13 *
*110	4.60	1.99	5.58	2.33	0.34	0.71*	29.56 *
*120	1.80	1.40	4.10	1.75	0.34	0.00*	16.60 *
*120	1.80	1.45	3.98	1.77	0.34	0.57*	17.17 *
*120	1.80	1.07	4.05	1.59	0.34	5.95*	22.55 *

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
*330	5.35	2.20	15.30	2.80	0.17	0.00*	28.77 *
*330	5.35	2.26	15.49	2.82	0.17	0.31*	29.08 *
*330	5.35	2.02	15.40	2.74	0.17	2.11*	30.88 *
*340	7.36	2.70	16.90	3.32	0.18	0.00*	18.15 *
*340	7.36	2.69	16.36	3.28	0.18	1.15*	19.30 *
*340	7.36	2.51	14.48	2.93	0.18	8.84*	26.99 *
*342	1.18	1.50	8.60	2.08	0.21	0.00*	27.55 *
*342	1.18	1.46	8.46	2.00	0.21	1.33*	28.88 *
*342	1.18	1.37	7.66	1.83	0.21	9.21*	36.76 *
*345	1.20	1.50	8.70	2.09	0.21	0.00*	27.92 *
*345	1.20	1.49	8.87	2.09	0.21	0.23*	28.15 *
*345	1.20	1.46	8.46	2.00	0.21	3.86*	31.78 *
*350	3.07	2.00	12.50	2.69	0.20	0.00*	22.57 *
*350	3.07	2.06	12.63	2.71	0.20	0.26*	22.83 *
*350	3.07	1.62	11.49	2.49	0.20	5.58*	28.15 *
*370	4.88	2.00	15.00	2.73	0.17	0.00*	14.23 *
*370	4.88	2.20	7.65	2.65	0.30	2.28*	16.51 *
*370	4.88	1.90	6.95	2.42	0.30	9.36*	23.59 *
*375	2.95	2.00	11.50	2.67	0.21	0.00*	6.95 *
*375	2.95	1.80	11.47	2.61	0.21	2.74*	9.69 *
*375	2.95	1.61	10.23	2.39	0.21	9.47*	16.42 *

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
400	1.76	1.00	4.30	1.59	0.33	0.00	23.74
400	1.76	1.00	13.18	9.17	0.33	1.52	25.26
400	1.76	1.00	4.25	1.58	0.33	4.55	28.29
420	3.36	2.00	7.20	2.50	0.30	0.00	33.31
420	3.36	1.00	14.46	9.17	0.30	0.38	33.69
420	3.36	1.96	7.13	2.47	0.30	1.19	34.50
430	1.59	1.00	4.20	1.58	0.33	0.00	17.82
430	1.59	1.00	13.18	9.17	0.33	1.89	19.71
430	1.59	1.00	4.25	1.58	0.33	2.23	20.05
440	0.85	1.00	5.00	1.62	0.30	0.00	34.94
440	0.85	1.00	14.49	9.17	0.30	2.92	37.86
440	0.85	1.00	4.88	1.62	0.30	5.63	40.57
510	9.02	2.00	9.70	2.62	0.24	0.00	29.95
510	9.02	1.00	18.22	9.17	0.24	3.83	33.78
510	9.02	1.71	8.90	2.42	0.24	7.47	37.42
520	10.40	2.50	11.00	2.86	0.22	0.00	27.79
520	10.40	1.00	19.91	9.17	0.22	0.27	28.06
520	10.40	2.42	11.41	2.84	0.22	2.83	30.62
530	1.38	2.00	5.00	2.26	0.36	0.00	34.50
530	1.38	1.00	13.34	10.22	0.40	0.00	34.50
530	1.38	1.98	4.97	2.24	0.36	2.20	36.70
570	4.04	2.30	8.70	2.74	0.27	0.00	24.17
570	4.04	1.00	16.12	9.17	0.27	0.00	24.17
570	4.04	2.35	8.73	2.76	0.27	0.04	24.21
540	11.60	2.00	8.00	2.55	0.28	0.00	30.70
540	11.60	1.00	15.54	9.17	0.28	3.25	33.95
540	11.60	1.76	6.87	2.28	0.28	7.28	37.98
550	1.31	1.00	4.00	1.57	0.34	0.00	18.31
550	1.31	1.00	12.72	9.17	0.34	1.15	19.46
550	1.31	1.00	4.05	1.57	0.34	5.18	23.49
560	1.89	1.50	9.00	2.11	0.21	0.00	32.56
560	1.89	1.00	20.98	9.17	0.19	0.00	32.56
560	1.89	1.50	8.97	2.11	0.21	0.00	32.56
580	0.58	1.10	6.00	1.69	0.26	0.00	30.19
580	0.58	1.00	16.79	9.17	0.26	0.00	30.19
580	0.58	1.15	5.90	1.70	0.26	0.00	30.19
130	3.76	1.10	5.60	1.67	0.27	0.00	34.32
130	3.76	1.00	16.15	9.17	0.27	0.91	35.23
130	3.76	1.00	5.68	1.65	0.27	1.57	35.89

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
*450	14.00	5.00	25.00	5.40	0.19	0.00*	11.33 *
*450	14.00	4.90	24.50	5.27	0.19	1.74*	13.07 *
*450	14.00	4.57	23.11	4.95	0.19	6.15*	17.48 *
*455	2.31	2.00	8.90	2.59	0.26	0.00*	15.88 *
*455	2.31	1.79	8.33	2.45	0.26	2.82*	18.70 *
*455	2.31	1.75	7.93	2.38	0.26	5.77*	21.65 *
*460	3.55	2.70	10.20	2.98	0.25	0.00*	13.56 *
*460	3.55	2.20	9.65	2.72	0.25	6.79*	20.35 *
*460	3.55	1.68	7.82	2.27	0.25	19.68*	33.24 *
*470	0.63	1.50	5.40	1.83	0.27	0.00*	26.41 *
*470	0.63	1.44	5.51	1.81	0.27	0.45*	26.86 *
*470	0.63	1.32	5.54	1.77	0.27	6.97*	33.38 *
*480	1.94	2.10	8.40	2.63	0.27	0.00*	14.71 *
*480	1.94	2.03	8.54	2.59	0.27	0.80*	15.51 *
*480	1.94	1.63	6.36	2.08	0.27	13.89*	28.60 *
*485	1.53	1.70	7.80	2.30	0.26	0.00*	19.98 *
*485	1.53	1.71	7.50	2.28	0.26	0.53*	20.51 *
*485	1.53	1.59	6.53	2.04	0.26	4.98*	24.96 *
*490	3.31	2.30	10.00	2.77	0.24	0.00*	25.76 *
*490	3.31	2.09	10.15	2.68	0.24	2.19*	27.95 *
*490	3.31	1.80	9.46	2.53	0.24	4.45*	30.21 *
*500	2.13	2.10	7.00	2.56	0.31	0.00*	43.63 *
*500	2.13	2.01	6.90	2.49	0.31	0.26*	43.89 *
*500	2.13	2.01	6.90	2.49	0.31	1.09*	44.72 *

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
630	6.47	2.00	13.00	2.70	0.19	0.00	5.98
630	6.47	2.01	13.41	2.71	0.19	0.86	6.84
630	6.47	1.56	11.64	2.42	0.19	11.63	17.61
640	5.51	2.00	12.00	2.68	0.21	0.00	4.63
640	5.51	1.88	11.69	2.64	0.21	0.87	5.50
640	5.51	1.75	11.34	2.58	0.21	2.11	6.74
650	1.37	1.60	7.40	2.13	0.25	0.00	9.71
650	1.37	1.60	7.41	2.14	0.25	0.21	9.92
650	1.37	1.54	6.67	1.99	0.25	3.27	12.98
660	5.40	2.20	11.80	2.76	0.21	0.00	9.53
660	5.40	2.10	12.05	2.72	0.21	1.33	10.86
660	5.40	1.65	10.86	2.49	0.21	11.63	21.16
670	2.81	1.50	9.50	2.15	0.20	0.00	5.84
670	2.81	1.49	9.70	2.15	0.20	0.00	5.84
670	2.81	1.49	9.70	2.15	0.20	0.10	5.94
680	1.33	1.60	7.40	2.13	0.25	0.00	3.64
680	1.33	1.60	7.41	2.14	0.25	0.00	3.64
680	1.33	1.60	7.41	2.14	0.25	0.00	3.64
690	3.59	3.00	10.00	3.26	0.28	0.00	25.21
690	3.59	2.99	9.78	3.23	0.28	0.00	25.21
690	3.59	2.99	9.78	3.23	0.28	0.32	25.53
700	5.42	2.00	12.00	2.68	0.21	0.00	14.69
700	5.42	1.88	11.69	2.64	0.21	1.34	16.03
700	5.42	1.62	10.56	2.44	0.21	7.10	23.13
710	10.30	3.00	14.70	3.55	0.22	0.00	14.93
710	10.30	3.00	14.48	3.54	0.22	0.03	14.96
710	10.30	3.00	14.48	3.54	0.22	0.08	15.01
720	2.35	1.60	8.90	2.27	0.23	0.00	8.97
720	2.35	1.60	8.67	2.25	0.23	1.69	10.66
720	2.35	1.57	8.11	2.15	0.23	6.18	15.15
730	6.66	2.50	12.50	2.87	0.20	0.00	8.38
730	6.66	2.47	12.67	2.87	0.20	0.41	8.79
730	6.66	2.46	12.68	2.86	0.20	0.88	9.26
740	5.11	2.00	11.50	2.67	0.21	0.00	17.58
740	5.11	1.90	11.65	2.65	0.21	0.44	18.02
740	5.11	1.90	11.65	2.65	0.21	0.55	18.13
750	4.54	2.50	11.00	2.86	0.22	0.00	19.20
750	4.54	2.51	11.32	2.86	0.22	0.00	19.20
750	4.54	2.51	11.32	2.86	0.22	0.84	20.04

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
760	0.90	1.50	7.00	1.96	0.24	0.00	3.74
760	0.90	1.51	6.91	1.97	0.24	0.00	3.74
760	0.90	1.51	6.91	1.97	0.24	0.37	4.11
770	1.91	3.00	7.00	3.04	0.34	0.00	11.41
770	1.91	3.00	7.13	3.04	0.34	1.52	12.93
770	1.91	2.94	6.91	2.98	0.34	3.46	14.87
780	10.70	4.00	15.00	4.24	0.24	0.00	18.00
780	10.70	3.98	15.05	4.22	0.24	1.05	19.05
780	10.70	3.80	14.39	4.03	0.24	3.89	21.89
790	7.08	3.00	13.00	3.47	0.24	0.00	20.22
790	7.08	2.97	12.59	3.42	0.24	0.87	21.09
790	7.08	2.92	12.01	3.32	0.24	3.36	23.58
800	3.60	3.50	10.50	3.78	0.30	0.00	18.91
800	3.60	3.23	9.93	3.54	0.30	3.55	22.46
800	3.60	3.13	9.42	3.37	0.30	6.21	25.12
810	27.10	5.00	35.00	5.66	0.15	0.00	19.06
810	27.10	4.83	33.42	5.44	0.15	2.36	21.42
810	27.10	4.79	32.35	5.34	0.15	4.58	23.64
820	13.30	3.50	4.00	3.12	0.51	0.00	6.19
820	13.30	3.48	3.89	3.08	0.51	1.07	7.26
820	13.30	3.47	3.84	3.06	0.51	3.17	9.36
830	19.10	1.80	27.80	2.78	0.10	0.00	10.51
830	19.10	1.37	25.45	2.59	0.10	5.56	16.07
830	19.10	1.31	24.00	2.44	0.10	12.77	23.28
840	4.38	1.03	9.27	1.73	0.18	0.00	12.43
840	4.38	1.03	9.41	1.73	0.18	0.52	12.95
840	4.38	1.03	9.41	1.73	0.18	1.12	13.55
850	11.80	1.03	16.00	1.77	0.11	0.00	9.29
850	11.80	1.03	16.61	1.78	0.11	0.42	9.71
850	11.80	1.00	16.67	1.77	0.11	3.17	12.46
860	1.71	1.03	8.33	1.71	0.20	0.00	5.00
860	1.71	1.08	8.24	1.73	0.20	0.00	5.00
860	1.71	1.00	8.31	1.71	0.20	1.82	6.82
870	13.02	3.00	4.00	2.83	0.48	33.00	63.91
870	13.02	3.07	3.93	2.85	0.48	33.09	64.00
870	13.02	3.07	3.93	2.85	0.48	33.63	64.54
880	5.84	2.30	7.50	2.70	0.30	0.00	12.61
880	5.84	2.32	7.65	2.72	0.30	0.40	13.01
880	5.84	2.26	7.65	2.69	0.30	1.73	14.34

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
*1270	0.72	1.00	2.00	1.28	0.47	0.00*	66.22 *
*1270	0.72	1.00	1.93	1.26	0.47	5.47*	71.69 *
*1270	0.72	1.00	1.93	1.26	0.47	10.94*	77.16 *
*1280	2.02	1.10	2.35	1.41	0.46	0.00*	18.25 *
*1280	2.02	1.10	2.30	1.40	0.46	1.75*	20.00 *
*1280	2.02	1.00	2.11	1.31	0.46	18.21*	36.46 *
*1290	4.36	1.35	2.95	1.65	0.42	0.00*	34.18 *
*1290	4.36	1.21	2.87	1.56	0.42	4.70*	38.88 *
*1290	4.36	1.14	2.86	1.52	0.42	7.76*	41.94 *
*1300	3.40	1.25	2.70	1.56	0.44	0.00*	31.70 *
*1300	3.40	1.15	2.60	1.49	0.44	4.95*	36.65 *
*1300	3.40	1.00	2.51	1.40	0.44	11.76*	43.46 *
*1330	4.31	1.50	2.80	1.71	0.43	0.00*	33.93 *
*1330	4.31	1.41	2.77	1.67	0.43	3.31*	37.24 *
*1330	4.31	1.32	2.77	1.62	0.43	7.72*	41.65 -*
*1310	1.45	1.00	2.10	1.31	0.46	0.00*	21.27 *
*1310	1.45	1.00	2.20	1.33	0.46	0.14*	21.41 *
*1310	1.45	1.00	2.11	1.31	0.46	3.35*	24.62 *
*1315	3.66	1.28	2.80	1.59	0.43	0.00*	21.09 *
*1315	3.66	1.21	2.75	1.55	0.43	2.57*	23.66 *
*1315	3.66	1.00	2.67	1.43	0.43	9.20*	30.29 *
*1317	0.54	1.00	2.00	1.28	0.47	0.00*	42.03 *
*1317	0.54	1.00	1.99	1.28	0.47	1.12*	43.15 *
*1317	0.54	1.00	1.93	1.26	0.47	5.33*	47.36 *
*1320	2.29	1.20	2.60	1.52	0.44	0.00*	38.58 *
*1320	2.29	1.13	2.60	1.48	0.44	3.69*	42.27 *
*1320	2.29	1.05	2.55	1.42	0.44	7.81*	46.39 *
*1350	3.73	1.50	2.70	1.70	0.44	0.00*	57.26 *
*1350	3.73	1.54	2.67	1.71	0.44	0.71*	57.97 *
*1350	3.73	1.54	2.67	1.71	0.44	2.47*	59.73 *
*1340	8.71	1.85	3.70	1.98	0.39	0.00*	27.83 *
*1340	8.71	1.84	3.62	1.96	0.39	0.29*	28.12 *
*1340	8.71	1.81	3.49	1.92	0.39	2.44*	30.27 *
*1360	2.97	1.20	2.60	1.52	0.44	0.00*	35.88 *
*1360	2.97	1.22	2.63	1.53	0.44	0.00*	35.88 *
*1360	2.97	1.20	2.62	1.52	0.44	0.41*	36.29 *
*1380	6.64	1.50	3.40	1.75	0.38	0.00*	51.46 *
*1380	6.64	1.53	3.35	1.76	0.38	0.00*	51.46 *
*1380	6.64	1.53	3.35	1.76	0.38	0.27*	51.73 *

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
890	1.80	1.70	5.00	2.01	0.32	0.00	22.23
890	1.80	1.70	4.85	2.00	0.32	1.24	23.47
890	1.80	1.66	4.65	1.94	0.32	3.00	25.23
900	8.09	3.00	15.00	3.56	0.21	0.00	15.93
900	8.09	2.88	14.91	3.46	0.21	2.79	18.72
900	8.09	2.82	14.03	3.34	0.21	6.40	22.33
910	0.65	2.50	4.50	2.64	0.44	0.00	30.78
910	0.65	2.54	4.45	2.66	0.44	0.00	30.78
910	0.65	2.54	4.45	2.66	0.44	0.00	30.78
920	2.05	1.50	4.50	1.81	0.31	0.00	27.64
920	2.05	1.39	4.57	1.77	0.31	3.67	31.31
920	2.05	1.28	4.61	1.72	0.31	7.89	35.53
930	8.58	5.60	7.60	5.14	0.47	0.00	17.56
930	8.58	5.17	7.16	4.88	0.47	4.90	22.46
930	8.58	4.78	6.87	4.55	0.47	12.36	29.92
935	50.90	11.50	15.50	10.96	0.49	0.00	12.89
935	50.90	11.31	14.98	10.66	0.49	2.47	15.36
935	50.90	10.87	14.18	10.24	0.49	6.94	19.83
940	18.10	7.40	10.00	6.97	0.48	0.00	9.18
940	18.10	7.49	9.97	7.01	0.48	0.01	9.19
940	18.10	7.49	9.97	7.01	0.48	0.23	9.41
950	3.55	4.10	5.50	3.85	0.48	0.00	15.34
950	3.55	3.95	5.46	3.78	0.48	4.76	20.10
950	3.55	3.72	5.32	3.61	0.48	7.24	22.58
960	1.84	3.30	4.50	3.03	0.46	0.00	6.47
960	1.84	3.21	4.33	2.95	0.46	3.94	10.41
960	1.84	2.53	4.13	2.63	0.46	10.62	17.09
970	1.05	3.00	4.50	2.86	0.44	0.00	14.79
970	1.05	2.44	4.40	2.60	0.44	5.79	20.58
970	1.05	2.17	3.70	2.21	0.44	23.21	38.00
980	8.66	5.60	7.60	5.14	0.47	0.00	11.10
980	8.66	5.52	7.33	5.06	0.47	2.30	13.40
980	8.66	4.77	6.74	4.52	0.47	13.07	24.17
985	12.30	3.00	8.20	3.13	0.31	0.00	12.09
985	12.30	2.83	7.66	2.96	0.31	4.05	16.14
985	12.30	2.76	7.37	2.88	0.31	6.51	18.60
990	7.38	5.30	7.20	4.93	0.47	0.00	18.71
990	7.38	4.89	7.11	4.69	0.47	3.72	22.43
990	7.38	4.72	6.58	4.41	0.47	8.83	27.54

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
*1370	1.31	1.00	2.00	1.28	0.47	0.00*	52.05 *
*1370	1.31	1.00	2.05	1.29	0.47	0.00*	52.05 *
*1370	1.31	1.00	2.05	1.29	0.47	0.00*	52.05 *
*1385	1.37	1.00	2.00	1.28	0.47	0.00*	50.91 *
*1385	1.37	1.00	1.98	1.27	0.47	1.54*	52.45 *
*1385	1.37	1.00	1.94	1.26	0.47	3.61*	54.52 *
*1390	3.57	1.50	2.60	1.69	0.45	0.00*	52.24 *
*1390	3.57	1.53	2.57	1.70	0.45	0.00*	52.24 *
*1390	3.57	1.53	2.57	1.70	0.45	0.00*	52.24 *
*1400	21.60	4.40	4.00	3.86	0.58	0.00*	21.17 *
*1400	21.60	4.32	3.94	3.82	0.58	1.75*	22.92 *
*1400	21.60	4.24	3.98	3.79	0.58	3.41*	24.58 *
*1410	1.40	1.00	2.10	1.31	0.46	0.00*	28.44 *
*1410	1.40	1.00	2.16	1.32	0.46	0.64*	29.08 *
*1410	1.40	1.00	2.16	1.32	0.46	1.75*	30.19 *
*1413	2.63	1.50	2.20	1.64	0.49	0.00*	21.98 *
*1413	2.63	1.51	2.18	1.64	0.49	0.93*	22.91 *
*1413	2.63	1.47	2.17	1.62	0.49	2.98*	24.96 *
*1415	9.11	1.90	3.70	2.01	0.40	0.00*	24.57 *
*1415	9.11	1.87	3.58	1.98	0.40	0.98*	25.55 *
*1415	9.11	1.85	3.52	1.96	0.40	1.47*	26.04 *
*1417	3.10	1.20	2.70	1.53	0.43	0.00*	27.32 *
*1417	3.10	1.20	2.75	1.54	0.43	0.74*	28.06 *
*1417	3.10	1.17	2.74	1.52	0.43	0.93*	28.25 *
*1420	2.02	1.05	2.45	1.41	0.45	0.00*	29.81 *
*1420	2.02	1.08	2.43	1.42	0.45	0.33*	30.14 *
*1420	2.02	1.08	2.43	1.42	0.45	0.96*	30.77 *
*1430	3.12	1.20	2.70	1.53	0.43	0.00*	32.54 *
*1430	3.12	1.15	2.73	1.51	0.43	0.42*	32.96 *
*1430	3.12	1.15	2.73	1.51	0.43	0.42*	32.96 *
*1440	2.02	1.10	2.30	1.40	0.46	0.00*	37.18 *
*1440	2.02	1.11	2.32	1.41	0.46	0.00*	37.18 *
*1440	2.02	1.06	2.28	1.38	0.46	0.32*	37.50 *
*1445	1.28	1.00	2.10	1.31	0.46	0.00*	31.35 *
*1445	1.28	1.00	2.20	1.33	0.46	0.32*	31.67 *
*1445	1.28	1.00	2.20	1.33	0.46	1.46*	32.81 *
*1450	1.12	1.00	2.00	1.28	0.47	0.00*	44.64 *
*1450	1.12	1.00	2.05	1.29	0.47	0.80*	45.44 *
*1450	1.12	1.00	1.94	1.26	0.47	3.62*	48.26 *

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
*1100	2.60	1.00	5.00	1.62	0.30	0.00*	32.36 *
*1100	2.60	1.95	0.50	0.79	0.00	7.28*	39.64 *
*1100	2.60	1.00	4.90	1.62	0.30	8.75*	41.11 *
*1110	1.58	1.00	4.00	1.57	0.34	0.00*	24.04 *
*1110	1.58	1.00	0.50	11.79	0.00	12.82*	36.86 *
*1110	1.58	1.00	4.06	1.57	0.34	19.26*	43.30 *
*1120	3.54	1.20	5.50	1.71	0.28	0.00*	10.91 *
*1120	3.54	1.00	19.18	11.27	0.28	2.96*	13.87 *
*1120	3.54	1.00	5.39	1.64	0.28	4.36*	15.27 *
*1130	2.25	1.10	4.50	1.63	0.32	0.00*	10.35 *
*1130	2.25	1.00	16.73	11.27	0.32	1.83*	12.18 *
*1130	2.25	1.00	4.45	1.60	0.32	4.60*	14.95 *
*1140	4.37	1.20	5.80	1.72	0.26	0.00*	18.80 *
*1140	4.37	1.00	20.64	11.27	0.26	2.92*	21.72 *
*1140	4.37	1.00	5.94	1.66	0.26	5.32*	24.12 *
*1150	2.30	1.00	4.60	1.60	0.31	0.00*	20.76 *
*1150	2.30	1.00	17.28	11.27	0.31	0.60*	21.36 *
*1150	2.30	1.00	4.65	1.61	0.31	2.03*	22.79 *
*1155	0.34	1.00	3.50	1.53	0.37	0.00*	23.25 *
*1155	0.34	1.00	0.50	9.69	0.00	12.30*	35.55 *
*1155	0.34	1.00	3.52	1.53	0.37	16.40*	39.65 *
*1160	2.38	1.10	4.70	1.64	0.31	0.00*	29.36 *
*1160	2.38	1.00	15.58	10.22	0.31	1.66*	31.02 *
*1160	2.38	1.00	4.65	1.61	0.31	4.00*	33.36 *
*1170	1.96	1.00	4.40	1.59	0.32	0.00*	30.10 *
*1170	1.96	1.00	13.61	9.17	0.32	0.00*	30.10 *
*1170	1.96	1.00	4.45	1.60	0.32	3.89*	33.99 *
*1180	1.90	1.00	4.40	1.59	0.32	0.00*	33.46 *
*1180	1.90	1.00	13.61	9.17	0.32	2.62*	36.08 *
*1180	1.90	1.00	4.45	1.60	0.32	3.65*	37.11 *
*1190	0.89	1.00	4.00	1.57	0.34	0.00*	34.89 *
*1190	0.89	1.00	12.72	9.17	0.34	1.47*	36.36 *
*1190	0.89	1.00	4.06	1.57	0.34	4.63*	39.52 *
* 390	3.00	1.00	5.30	1.63	0.29	0.00*	54.74 *
* 390	3.00	1.00	15.01	9.17	0.29	1.87*	56.61 *
* 390	3.00	1.00	5.14	1.63	0.29	8.25*	62.99 *
* 410	7.71	1.50	7.30	1.98	0.23	0.00*	16.05 *
* 410	7.71	1.00	19.05	9.17	0.23	2.33*	18.38 *
* 410	7.71	1.44	6.78	1.86	0.23	5.52*	21.57 *

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
*1000	0.63	2.50	4.50	2.64	0.44	0.00*	43.66 *
*1000	0.63	2.54	4.45	2.66	0.44	1.88*	45.54 *
*1000	0.63	2.54	4.45	2.66	0.44	1.88*	45.54 *
*1010	3.59	4.10	5.50	3.85	0.48	0.00*	31.22 *
*1010	3.59	4.04	5.45	3.82	0.48	1.43*	32.65 *
*1010	3.59	3.97	5.46	3.79	0.48	1.69*	32.91 *
*1015	0.76	2.70	4.70	2.76	0.43	0.00*	23.51 *
*1015	0.76	2.76	4.65	2.78	0.43	1.57*	25.08 *
*1015	0.76	2.63	4.64	2.72	0.43	1.57*	25.08 *
*1020	0.65	2.60	4.50	2.70	0.44	0.00*	43.48 *
*1020	0.65	2.65	4.48	2.72	0.44	0.00*	43.48 *
*1020	0.65	2.42	4.38	2.57	0.44	4.87*	48.35 *
*1030	20.10	5.60	10.50	5.42	0.39	0.00*	10.52 *
*1030	20.10	5.54	10.37	5.33	0.39	1.94*	12.46 *
*1030	20.10	5.48	10.12	5.24	0.39	4.97*	15.49 *
*1050	2.13	2.00	3.40	2.03	0.43	0.00*	9.50 *
*1050	2.13	2.00	3.42	2.04	0.43	0.27*	9.77 *
*1050	2.13	2.00	3.42	2.04	0.43	0.61*	10.11 *
*1060	0.71	1.00	3.40	1.52	0.38	0.00*	9.28 *
*1060	0.71	1.06	3.40	1.54	0.38	0.79*	10.07 *
*1060	0.71	1.00	3.38	1.52	0.38	4.16*	13.44 *
*1040	7.82	3.80	5.10	3.65	0.49	0.00*	22.39 *
*1040	7.82	3.80	5.20	3.66	0.49	0.88*	23.27 *
*1040	7.82	3.63	4.89	3.45	0.49	4.13*	26.52 *
*1070	4.59	3.10	4.25	2.88	0.46	0.00*	18.93 *
*1070	4.59	2.98	4.21	2.84	0.46	3.81*	22.74 *
*1070	4.59	2.63	4.17	2.69	0.46	7.93*	26.86 *
*1080	6.66	3.80	5.10	3.65	0.49	0.00*	34.25 *
*1080	6.66	3.72	5.12	3.59	0.49	2.74*	36.99 *
*1080	6.66	3.56	4.56	3.28	0.49	8.02*	42.27 *
*1090	1.11	2.00	4.50	2.19	0.38	0.00*	31.65 *
*1090	1.11	1.76	3.51	1.89	0.38	14.81*	46.46 *
*1090	1.11	1.76	3.51	1.89	0.38	14.81*	46.46 *

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
*1460	4.97	1.40	3.10	1.69	0.40	0.00*	40.35 *
*1460	4.97	1.41	3.12	1.69	0.40	0.31*	40.66 *
*1460	4.97	1.36	3.13	1.67	0.40	2.27*	42.62 *
*1470	0.59	1.00	2.00	1.28	0.47	0.00*	68.29 *
*1470	0.59	1.00	2.05	1.29	0.47	0.00*	68.29 *
*1470	0.59	1.00	2.05	1.29	0.47	4.32*	72.61 *
*1475	0.30	1.00	2.00	1.28	0.47	0.00*	39.61 *
*1475	0.30	1.00	2.05	1.29	0.47	0.00*	39.61 *
*1475	0.30	1.00	2.05	1.29	0.47	0.00*	39.61 *
*1480	0.46	1.00	2.00	1.28	0.47	0.00*	65.36 *
*1480	0.46	1.00	2.05	1.29	0.47	0.00*	65.36 *
*1480	0.46	1.00	2.05	1.29	0.47	0.00*	65.36 *
*1490	0.88	1.00	2.00	1.28	0.47	0.00*	43.28 *
*1490	0.88	1.00	2.05	1.29	0.47	0.00*	43.28 *
*1490	0.88	1.00	2.03	1.29	0.47	2.58*	45.86 *
*1500	4.54	1.35	3.00	1.65	0.41	0.00*	48.91 *
*1500	4.54	1.36	3.01	1.66	0.41	0.00*	48.91 *
*1500	4.54	1.36	3.01	1.66	0.41	0.53*	49.44 *
*1505	4.45	2.55	5.50	2.74	0.38	0.00*	47.96 *
*1505	4.45	2.59	5.56	2.76	0.38	1.25*	49.21 *
*1505	4.45	2.59	5.56	2.76	0.38	1.25*	49.21 *
*1510	2.04	2.80	4.40	2.78	0.45	0.00*	50.51 *
*1510	2.04	2.85	4.35	2.80	0.45	0.00*	50.51 *
*1510	2.04	2.85	4.35	2.80	0.45	0.00*	50.51 *
*1570	3.57	1.50	2.60	1.69	0.45	0.00*	50.44 *
*1570	3.57	1.53	2.57	1.70	0.45	0.00*	50.44 *
*1570	3.57	1.53	2.57	1.70	0.45	0.00*	50.44 *
*1520	2.28	1.10	2.40	1.42	0.45	0.00*	43.18 *
*1520	2.28	1.09	2.44	1.43	0.45	0.00*	43.18 *
*1520	2.28	1.09	2.44	1.43	0.45	0.22*	43.40 *
*1525	0.41	1.00	2.00	1.28	0.47	0.00*	40.15 *
*1525	0.41	1.00	1.99	1.28	0.47	0.89*	41.04 *
*1525	0.41	1.00	1.96	1.27	0.47	5.11*	45.26 *
*1530	6.55	1.65	3.50	1.82	0.37	0.00*	35.65 *
*1530	6.55	1.59	3.48	1.80	0.37	1.79*	37.44 *
*1530	6.55	1.59	3.48	1.80	0.37	2.74*	38.39 *
*1540	2.74	1.20	2.65	1.53	0.44	0.00*	35.37 *
*1540	2.74	1.23	2.63	1.54	0.44	0.00*	35.37 *
*1540	2.74	1.23	2.63	1.54	0.44	0.00*	35.37 *

TABLE 33 (CONT.)
CLARK AND SNYDER UNITGRAPH PARAMETERS
IMPERVIOUS PERCENTAGES
EXISTING 1990 AND 2040

SUB-AREA	DRAINAGE AREA	TC	R	TP	CP	RELATIVE % IMPERVIOUS	ABSOLUTE % IMPERVIOUS
*1550	2.51	1.17	2.60	1.50	0.44	0.00*	43.46 *
*1550	2.51	1.19	2.62	1.51	0.44	0.00*	43.46 *
*1550	2.51	1.19	2.62	1.51	0.44	0.00*	43.46 *
*1560	0.97	1.00	2.00	1.28	0.47	0.00*	62.08 *
*1560	0.97	1.00	1.99	1.28	0.47	1.84*	63.92 *
*1560	0.97	1.00	1.99	1.28	0.47	1.84*	63.92 *
*1580	4.24	1.40	2.80	1.66	0.43	0.00*	49.65 *
*1580	4.24	1.43	2.77	1.68	0.43	0.00*	49.65 *
*1580	4.24	1.43	2.77	1.68	0.43	0.00*	49.65 *
*1590	10.81	1.50	2.80	1.71	0.43	0.00*	41.25 *
*1590	10.81	1.54	2.77	1.72	0.43	0.19*	41.44 *
*1590	10.81	1.47	2.77	1.70	0.43	1.20*	42.45 *
*1600	0.79	1.00	1.50	1.14	0.50	0.00*	48.25 *
*1600	0.79	1.04	1.51	1.15	0.50	0.00*	48.25 *
*1600	0.79	1.04	1.51	1.15	0.50	0.00*	48.25 *
*1610	7.88	2.00	3.50	2.05	0.42	0.00*	45.09 *
*1610	7.88	1.97	3.51	2.03	0.42	1.85*	46.94 *
*1610	7.88	1.96	3.48	2.02	0.42	2.64*	47.73 *
*1620	13.00	2.50	4.50	2.64	0.44	0.00*	59.01 *
*1620	13.00	2.47	4.42	2.62	0.44	3.45*	62.46 *
*1620	13.00	2.47	4.42	2.62	0.44	5.42*	64.43 *

TABLE 34

COMPARISON OF PEAK FLOWS RESULTING FROM FUTURE
URBANIZATION AND FLOOD PLAIN DEVELOPMENT
1 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	PEAK DISCHARGE IN CFS: EXIST. COND. Q1	PEAK DISCHARGE IN CFS: URBANIZATION 1990 Q2	PEAK DISCHARGE IN CFS: URBANIZATION 2040 Q3	PEAK DISCHARGE IN CFS: FLOOD PLAIN DEV. 1990 Q4	PEAK DISCHARGE IN CFS: FLOOD PLAIN DEV. 2040 Q5	PERCENT COMPARISON WITH Q1: URBANIZATION 1990 Q2	PERCENT COMPARISON WITH Q1: URBANIZATION 2040 Q3	PERCENT COMPARISON WITH Q1: FLOOD PLAIN DEV. 1990 Q4	PERCENT COMPARISON WITH Q1: FLOOD PLAIN DEV. 2040 Q5
UPPER TRIBUTARIES											
RAMAPO R. AT MAHWAH	55	12	2469	2641	2909	2641	2909	6.97	17.82	6.97	17.82
RAMAPO R. AT POMPTON LAKES	59	17	2857	3048	3365	3048	3365	6.69	17.78	6.69	17.78
ROCKAWAY RIVER ABOVE BOONTON	20	19	1656	1744	1985	1744	1985	5.31	19.87	5.31	19.87
WHIPPANY RIVER AT MORRISTOWN	30	109	711	746	861	746	861	4.92	21.10	4.92	21.10
PASSAIC RIVER AT MILLINGTON	1	105	710	719	726	719	726	1.27	2.25	1.27	2.25
PASSAIC RIVER AT CHATHAM	6	110	1104	1133	1178	1138	1203	2.63	6.70	3.08	8.97
CENTRAL BASIN											
POMPTON RIVER AT USGS GAGE	61	25	3992	4260	4672	4260	4672	6.71	17.03	6.71	17.03
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	3997	4269	4670	4255	4658	6.81	16.84	6.45	16.54
POMPTON RIVER AT EAST-WEST DITCH	--	30	4288	4569	4975	4555	4963	6.55	16.02	6.23	15.74
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	4050	4314	4692	4310	4717	6.52	15.85	6.42	16.47
POMPTON RIVER AT PACKANACK BROOK	--	33	4132	4396	4776	4392	4800	6.39	15.59	6.29	16.17
POMPTON RIVER AT MOUTH	68	34	4128	4390	4767	4390	4805	6.35	15.48	6.35	16.40
PASSAIC RIVER AT PINE BROOK	37	23	2933	3018	3208	3043	3504	2.90	9.38	3.75	19.47
PASSAIC RIVER ABOVE POMPTON	40	24	2511	2579	2743	2594	2822	2.71	9.24	3.31	12.39
PASSAIC RIVER BELOW POMPTON	69	35	5201	5476	5842	5489	5918	5.29	12.32	5.54	13.79
DEEPAVAAL BROOK	73	38	684	706	716	706	716	3.22	4.68	3.22	4.68
PASSIAC RIVER AT LITTLE FALLS	76	41	5486	5773	6153	5784	6232	5.23	12.16	5.43	13.60
LOWER VALLEY											
AT PECKMAN RIVER	--	100	5492	5780	6164	5792	6243	5.24	12.24	5.46	13.67
AT GREAT FALLS	82	200	5505	5795	6184	5805	6262	5.27	12.33	5.45	13.75
AT DIAMOND BROOK	--	300	5517	5806	6198	5816	6277	5.24	12.34	5.42	13.78
AT DUNDEE DAM	--	400	5514	5803	6196	5812	6271	5.24	12.37	5.40	13.73
AT SADDLE RIVER	--	500	5576	5869	6276	5876	6351	5.25	12.55	5.38	13.90
AT THIRD RIVER	--	600	5576	5868	6276	5874	6350	5.24	12.55	5.34	13.88
AT SECOND RIVER	104	700	5603	5895	6306	5902	6379	5.21	12.55	5.34	13.85
AT MOUTH	--	800	5596	5888	6300	5895	6370	5.22	12.58	5.34	13.83

Q1 = Existing Conditions.
Q2 = Effects of Urbanization to year 1990.
Q3 = Same as Q2 but to year 2040.
Q4 = Effects of Urbanization and Development in the Central Basin with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.

TABLE 34 (CONT'D)

COMPARISON OF PEAK FLOWS RESULTING FROM FUTURE URBANIZATION AND FLOOD PLAIN DEVELOPMENT
2 YEAR FLOOD EVENT

			PEAK DISCHARGE IN CFS					PERCENT COMPARISON WITH Q1			
				URBANIZATION		FLOOD PLAIN DEV.		URBANIZATION		FLOOD PLAIN DEV.	
LOCATION	POI	HEC-1 NODE	EXIST. COND. Q1	1990 Q2	2040 Q3	1990 Q4	2040 Q5	1990 Q2	2040 Q3	1990 Q4	2040 Q5
UPPER TRIBUTARIES											
RAMAPO R. AT MAHWAH	55	12	3546	3769	4118	3769	4118	6.29	16.13	6.29	16.13
RAMAPO R. AT POMPTON LAKES	59	17	4183	4427	4826	4427	4826	5.83	15.37	5.83	15.37
ROCKAWAY RIVER ABOVE BOONTON	20	19	2262	2376	2681	2376	2681	5.04	18.52	5.04	18.52
WHIPPANY RIVER AT MORRISTOWN	30	109	1008	1052	1198	1052	1198	4.37	18.85	4.37	18.85
PASSAIC RIVER AT MILLINGTON	1	105	927	937	946	937	946	1.08	2.05	1.08	2.05
PASSAIC RIVER AT CHATHAM	6	110	1615	1652	1709	1659	1743	2.29	5.82	2.72	7.93
CENTRAL BASIN											
POMPTON RIVER AT USGS GAGE	61	25	6462	6766	7279	6766	7279	4.70	12.64	4.70	12.64
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	6449	6755	7255	6765	7237	4.74	12.50	4.90	12.22
POMPTON RIVER AT EAST-WEST DITCH	--	30	6808	7125	7633	7136	7614	4.66	12.12	4.82	11.84
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	6429	6727	7202	6752	7254	4.64	12.02	5.02	12.83
POMPTON RIVER AT PACKANACK BROOK	--	33	6529	6828	7305	6854	7357	4.58	11.89	4.98	12.68
POMPTON RIVER AT MOUTH	68	34	6521	6820	7292	6848	7360	4.59	11.82	5.01	12.87
PASSAIC RIVER AT PINE BROOK	37	23	3876	3992	4256	4044	4649	2.99	9.80	4.33	19.94
PASSAIC RIVER ABOVE POMPTON	40	24	3447	3576	3844	3606	3944	3.74	11.52	4.61	14.42
PASSAIC RIVER BELOW POMPTON	69	35	7535	7767	8127	7773	8214	3.08	7.86	3.16	9.01
DEEPAVAAL BROOK	73	38	871	898	911	898	911	3.10	4.59	3.10	4.59
PASSIAC RIVER AT LITTLE FALLS	76	41	7787	8016	8372	8037	8496	2.94	7.51	3.21	9.10
LOWER VALLEY											
AT PECKMAN RIVER	--	100	7795	8022	8377	8039	8503	2.91	7.47	3.13	9.08
AT GREAT FALLS	82	200	7806	8033	8387	8050	8523	2.91	7.44	3.13	9.19
AT DIAMOND BROOK	--	300	7817	8042	8395	8061	8540	2.88	7.39	3.12	9.25
AT DUNDEE DAM	--	400	7821	8045	8397	8063	8554	2.86	7.36	3.09	9.37
AT SADDLE RIVER	--	500	7893	8106	8446	8128	8621	2.70	7.01	2.98	9.22
AT THIRD RIVER	--	600	7902	8112	8450	8133	8635	2.66	6.93	2.92	9.28
AT SECOND RIVER	104	700	7940	8145	8477	8167	8674	2.58	6.76	2.86	9.24
AT MOUTH	--	800	7951	8155	8485	8178	8694	2.57	6.72	2.85	9.34

Q1 = Existing Conditions.
Q2 = Effects of Urbanization to year 1990.
Q3 = Same as Q2 but to year 2040.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.

TABLE 34 (CONT'D)

COMPARISON OF PEAK FLOWS RESULTING FROM FUTURE URBANIZATION AND FLOOD PLAIN DEVELOPMENT
5 YEAR FLOOD EVENT

			PEAK DISCHARGE IN CFS					PERCENT COMPARISON WITH Q1			
				URBANIZATION		FLOOD PLAIN DEV.		URBANIZATION		FLOOD PLAIN DEV.	
LOCATION	POI	HEC-1 NODE	EXIST. COND. Q1	1990 Q2	2040 Q3	1990 Q4	2040 Q5	1990 Q2	2040 Q3	1990 Q4	2040 Q5
UPPER TRIBUTARIES											
RAMAPO R. AT MAHWAH	55	12	5500	5773	6196	5773	6196	4.96	12.65	4.96	12.65
RAMAPO R. AT POMPTON LAKES	59	17	6490	6785	7274	6785	7274	4.55	12.08	4.55	12.08
ROCKAWAY RIVER ABOVE BOONTON	20	19	3072	3219	3590	3219	3590	4.79	16.86	4.79	16.86
WHIPPANY RIVER AT MORRISTOWN	30	109	1290	1345	1529	1345	1529	4.26	18.53	4.26	18.53
PASSAIC RIVER AT MILLINGTON	1	105	1150	1162	1172	1162	1172	1.04	1.91	1.04	1.91
PASSAIC RIVER AT CHATHAM	6	110	1891	1935	1997	1947	2045	2.33	5.61	2.96	8.14
CENTRAL BASIN											
POMPTON RIVER AT USGS GAGE	61	25	10049	10359	10971	10359	10971	3.08	9.18	3.08	9.18
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	10014	10325	10917	10332	10889	3.11	9.02	3.18	8.74
POMPTON RIVER AT EAST-WEST DITCH	--	30	10521	10844	11443	10852	11415	3.07	8.76	3.15	8.50
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	9912	10221	10784	10263	10867	3.12	8.80	3.54	9.63
POMPTON RIVER AT PACKANACK BROOK	--	33	10051	10362	10928	10405	11011	3.09	8.73	3.52	9.55
POMPTON RIVER AT MOUTH	68	34	10034	10345	10905	10393	11012	3.10	8.68	3.58	9.75
PASSAIC RIVER AT PINE BROOK	37	23	5150	5285	5647	5347	6173	2.62	9.65	3.83	19.86
PASSAIC RIVER ABOVE POMPTON	40	24	5249	5428	5759	5496	6148	3.41	9.72	4.71	17.13
PASSAIC RIVER BELOW POMPTON	69	35	9965	10209	10609	10249	11068	2.45	6.46	2.85	11.07
DEEPAVAAL BROOK	73	38	1265	1294	1308	1294	1308	2.29	3.40	2.29	3.40
PASSIAC RIVER AT LITTLE FALLS	76	41	10332	10575	11012	10615	11536	2.35	6.58	2.74	11.65
LOWER VALLEY											
AT PECKMAN RIVER	--	100	10338	10580	11024	10619	11551	2.34	6.64	2.72	11.73
AT GREAT FALLS	82	200	10354	10597	11054	10637	11583	2.35	6.76	2.73	11.87
AT DIAMOND BROOK	--	300	10371	10611	11079	10652	11613	2.31	6.83	2.71	11.98
AT DUNDEE DAM	--	400	10386	10629	11090	10670	11622	2.34	6.78	2.73	11.90
AT SADDLE RIVER	--	500	10452	10709	11208	10757	11769	2.46	7.23	2.92	12.60
AT THIRD RIVER	--	600	10467	10726	11220	10774	11782	2.47	7.19	2.93	12.56
AT SECOND RIVER	104	700	10512	10781	11273	10830	11839	2.56	7.24	3.03	12.62
AT MOUTH	--	800	10537	10805	11289	10854	11851	2.54	7.14	3.01	12.47

Q1 = Existing Conditions
Q2 = Effects of Urbanization to year 1990.
Q3 = Same as Q2 but to year 2040.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.

TABLE 34 (CONT'D)

COMPARISON OF PEAK FLOWS RESULTING FROM FUTURE
URBANIZATION AND FLOOD PLAIN DEVELOPMENT
10 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	PEAK DISCHARGE IN CFS: EXIST. COND. Q1	URBANIZATION 1990 Q2	URBANIZATION 2040 Q3	FLOOD PLAIN DEV. 1990 Q4	FLOOD PLAIN DEV. 2040 Q5	PERCENT COMPARISON WITH Q1: URBANIZATION 1990 Q2	URBANIZATION 2040 Q3	FLOOD PLAIN DEV. 1990 Q4	FLOOD PLAIN DEV. 2040 Q5
UPPER TRIBUTARIES											
RAMAPO R. AT MAHWAH	55	12	7403	7719	8203	7719	8203	4.27	10.81	4.27	10.81
RAMAPO R. AT POMPTON LAKES	59	17	8802	9164	9741	9164	9741	4.11	10.67	4.11	10.67
ROCKAWAY RIVER ABOVE BOONTON	20	19	4094	4267	4726	4267	4726	4.23	15.44	4.23	15.44
WHIPPANY RIVER AT MORRISTOWN	30	109	1608	1673	1888	1673	1888	4.04	17.41	4.04	17.41
PASSAIC RIVER AT MILLINGTON	1	105	1387	1400	1411	1400	1411	0.94	1.73	0.94	1.73
PASSAIC RIVER AT CHATHAM	6	110	2342	2394	2466	2407	2522	2.22	5.29	2.78	7.69
CENTRAL BASIN											
POMPTON RIVER AT USGS GAGE	61	25	13979	14268	14960	14268	14960	2.07	7.02	2.07	7.02
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	13696	13938	14529	13996	14761	1.77	6.08	2.19	7.78
POMPTON RIVER AT EAST-WEST DITCH	--	30	14308	14562	15154	14618	15404	1.78	5.91	2.17	7.66
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	13461	13728	14272	13788	14487	1.98	6.02	2.43	7.62
POMPTON RIVER AT PACKANACK BROOK	--	33	13628	13894	14436	13954	14658	1.95	5.93	2.39	7.56
POMPTON RIVER AT MOUTH	68	34	13630	13898	14443	13959	14658	1.97	5.96	2.41	7.54
PASSAIC RIVER AT PINE BROOK	37	23	6525	6735	7206	6815	7927	3.22	10.44	4.44	21.49
PASSAIC RIVER ABOVE POMPTON	40	24	6858	7031	7346	7144	9160	2.52	7.12	4.17	33.57
PASSAIC RIVER BELOW POMPTON	69	35	12850	13084	13635	13149	14917	1.82	6.11	2.33	16.09
DEEPAVAAL BROOK	73	38	1541	1572	1587	1572	1587	2.01	2.99	2.01	2.99
PASSIAC RIVER AT LITTLE FALLS	76	41	13354	13589	14159	13653	15323	1.76	6.03	2.24	14.74
LOWER VALLEY											
AT PECKMAN RIVER	--	100	13364	13605	14177	13669	15322	1.80	6.08	2.28	14.65
AT GREAT FALLS	82	200	13397	13639	14214	13705	15338	1.81	6.10	2.30	14.49
AT DIAMOND BROOK	--	300	13429	13673	14244	13740	15345	1.82	6.07	2.32	14.27
AT DUNDEE DAM	--	400	13443	13694	14252	13762	15353	1.87	6.02	2.37	14.21
AT SADDLE RIVER	--	500	13606	13868	14458	13941	15394	1.93	6.26	2.46	13.14
AT THIRD RIVER	--	600	13624	13889	14469	13963	15394	1.95	6.20	2.49	12.99
AT SECOND RIVER	104	700	13692	13964	14541	14037	15429	1.99	6.20	2.52	12.69
AT MOUTH	--	800	13710	13986	14551	14061	15452	2.01	6.13	2.56	12.71

Q1 = Existing Conditions.
Q2 = Effects of Urbanization to year 1990.
Q3 = Same as Q2 but to year 2040.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.

TABLE 34 (CONT'D)

COMPARISON OF PEAK FLOWS RESULTING FROM FUTURE URBANIZATION AND FLOOD PLAIN DEVELOPMENT

25 YEAR FLOOD EVENT

			PEAK DISCHARGE IN CFS					PERCENT COMPARISON WITH Q1			
				URBANIZATION		FLOOD PLAIN DEV.		URBANIZATION		FLOOD PLAIN DEV.	
LOCATION	POI	HEC-1 NODE	EXIST. COND. Q1	1990 Q2	2040 Q3	1990 Q4	2040 Q5	1990 Q2	2040 Q3	1990 Q4	2040 Q5
UPPER TRIBUTARIES											
RAMAPO R. AT MAHWAH	55	12	10566	10912	11419	10912	11419	3.27	8.07	3.27	8.07
RAMAPO R. AT POMPTON LAKES	59	17	12684	13042	13597	13042	13597	2.82	7.20	2.82	7.20
ROCKAWAY RIVER ABOVE BOONTON	20	19	5471	5674	6169	5674	6169	3.71	12.76	3.71	12.76
WHIPPANY RIVER AT MORRISTOWN	30	109	2057	2129	2375	2129	2375	3.50	15.46	3.50	15.46
PASSAIC RIVER AT MILLINGTON	1	105	1690	1704	1714	1704	1714	0.83	1.42	0.83	1.42
PASSAIC RIVER AT CHATHAM	6	110	2955	3008	3079	3024	3150	1.79	4.20	2.34	6.60
CENTRAL BASIN											
POMPTON RIVER AT USGS GAGE	61	25	19870	19985	20712	19985	20712	0.58	4.24	0.58	4.24
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	19003	19133	19807	19308	20351	0.68	4.23	1.61	7.09
POMPTON RIVER AT EAST-WEST DITCH	--	30	19729	19879	20559	20054	21144	0.76	4.21	1.65	7.17
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	18283	18432	19011	18550	19571	0.81	3.98	1.46	7.04
POMPTON RIVER AT PACKANACK BROOK	--	33	18472	18621	19206	18744	19776	0.81	3.97	1.47	7.06
POMPTON RIVER AT MOUTH	68	34	18477	18628	19207	18742	19773	0.82	3.95	1.43	7.01
PASSAIC RIVER AT PINE BROOK	37	23	8622	8864	9424	9022	10419	2.81	9.30	4.64	20.84
PASSAIC RIVER ABOVE POMPTON	40	24	8857	9029	9350	9121	11771	1.94	5.57	2.98	32.90
PASSAIC RIVER BELOW POMPTON	69	35	17567	17744	18276	17919	21236	1.01	4.04	2.00	20.89
DEEPAVAAL BROOK	73	38	1934	1965	1980	1965	1980	1.60	2.38	1.60	2.38
PASSIAC RIVER AT LITTLE FALLS	76	41	18190	18381	18927	18555	21777	1.05	4.05	2.01	19.72
LOWER VALLEY											
AT PECKMAN RIVER	--	100	18214	18405	18953	18579	21782	1.05	4.06	2.00	19.59
AT GREAT FALLS	82	200	18255	18448	19000	18623	21805	1.06	4.08	2.02	19.45
AT DIAMOND BROOK	--	300	18294	18490	19040	18659	21818	1.07	4.08	2.00	19.26
AT DUNDEE DAM	--	400	18298	18496	19048	18665	21807	1.08	4.10	2.01	19.18
AT SADDLE RIVER	--	500	18565	18765	19325	18940	21946	1.08	4.09	2.02	18.21
AT THIRD RIVER	--	600	18569	18772	19333	18946	21932	1.09	4.11	2.03	18.11
AT SECOND RIVER	104	700	18653	18858	19416	19028	21979	1.10	4.09	2.01	17.83
AT MOUTH	--	800	18647	18857	19416	19025	21968	1.13	4.12	2.03	17.81

Q1 = Existing Conditions.
Q2 = Effects of Urbanization to year 1990.
Q3 = Same as Q2 but to year 2040.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to 1990.
Q5 = Same as Q4 but to year 2040.

TABLE 34 (CONT'D)

COMPARISON OF PEAK FLOWS RESULTING FROM FUTURE
URBANIZATION AND FLOOD PLAIN DEVELOPMENT
50 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	PEAK DISCHARGE IN CFS: EXIST. COND. Q1	URBANIZATION 1990 Q2	URBANIZATION 2040 Q3	FLOOD PLAIN DEV. 1990 Q4	FLOOD PLAIN DEV. 2040 Q5	PERCENT COMPARISON WITH Q1: URBANIZATION 1990 Q2	URBANIZATION 2040 Q3	FLOOD PLAIN DEV. 1990 Q4	FLOOD PLAIN DEV. 2040 Q5
UPPER TRIBUTARIES											
RAMAPO R. AT MAHWAH	55	12	14197	14560	15083	14560	15083	2.56	6.24	2.56	6.24
RAMAPO R. AT POMPTON LAKES	59	17	17042	17435	17983	17435	17983	2.31	5.52	2.31	5.52
ROCKAWAY RIVER ABOVE BOONTON	20	19	6661	6898	7464	6898	7464	3.56	12.06	3.56	12.06
WHIPPANY RIVER AT MORRISTOWN	30	109	2430	2508	2778	2508	2778	3.21	14.32	3.21	14.32
PASSAIC RIVER AT MILLINGTON	1	105	1952	1967	1977	1967	1977	0.77	1.28	0.77	1.28
PASSAIC RIVER AT CHATHAM	6	110	3516	3574	3653	3593	3738	1.65	3.90	2.19	6.31
CENTRAL BASIN											
POMPTON RIVER AT USGS GAGE	61	25	26788	26657	27398	26657	27398	-0.49	2.28	-0.49	2.28
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	25437	25388	26009	25720	27036	-0.19	2.25	1.11	6.29
POMPTON RIVER AT EAST-WEST DITCH	--	30	26216	26182	26811	26533	27903	-0.13	2.27	1.21	6.44
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	23941	23955	24541	24152	25459	0.06	2.51	0.88	6.34
POMPTON RIVER AT PACKANACK BROOK	--	33	24147	24161	24748	24363	25683	0.06	2.49	0.89	6.36
POMPTON RIVER AT MOUTH	68	34	24123	24141	24724	24336	25694	0.07	2.49	0.88	6.51
PASSAIC RIVER AT PINE BROOK	37	23	10186	10472	11077	10682	12256	2.81	8.75	4.87	20.32
PASSAIC RIVER ABOVE POMPTON	40	24	10336	10515	10862	10629	12941	1.73	5.09	2.83	25.20
PASSAIC RIVER BELOW POMPTON	69	35	22288	22361	22909	22589	26841	0.33	2.79	1.35	20.43
DEEPAVAAL BROOK	73	38	2143	2175	2191	2175	2191	1.49	2.24	1.49	2.24
PASSIAC RIVER AT LITTLE FALLS	76	41	22961	23050	23583	23278	27416	0.39	2.71	1.38	19.40
LOWER VALLEY											
AT PECKMAN RIVER	--	100	22994	23082	23613	23308	27435	0.38	2.69	1.37	19.31
AT GREAT FALLS	82	200	23044	23135	23673	23370	27469	0.39	2.73	1.41	19.20
AT DIAMOND BROOK	--	300	23096	23191	23731	23424	27498	0.41	2.75	1.42	19.06
AT DUNDEE DAM	--	400	23098	23195	23740	23425	27485	0.42	2.78	1.42	18.99
AT SADDLE RIVER	--	500	23506	23606	24155	23856	27769	0.43	2.76	1.49	18.14
AT THIRD RIVER	--	600	23513	23616	24169	23869	27755	0.44	2.79	1.51	18.04
AT SECOND RIVER	104	700	23622	23728	24281	23980	27830	0.45	2.79	1.52	17.81
AT MOUTH	--	800	23613	23726	24283	23972	27804	0.48	2.84	1.52	17.75

Q1 = Existing Conditions.
Q2 = Effects of Urbanization to year 1990.
Q3 = Same as Q2 but to year 2040.
Q4 = Effects of Urbanization and Development in the Central Basin with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.

TABLE 34 (CONT'D)

COMPARISON OF PEAK FLOWS RESULTING FROM FUTURE
URBANIZATION AND FLOOD PLAIN DEVELOPMENT
100 YEAR FLOOD EVENT

			PEAK DISCHARGE IN CFS					PERCENT COMPARISON WITH Q1			
				URBANIZATION		FLOOD PLAIN DEV.		URBANIZATION		FLOOD PLAIN DEV.	
LOCATION	POI	HEC-1 NODE	EXIST. COND. Q1	1990 Q2	2040 Q3	1990 Q4	2040 Q5	1990 Q2	2040 Q3	1990 Q4	2040 Q5
UPPER TRIBUTARIES											
RAMAPO R. AT MAHWAH	55	12	17127	17506	18022	17506	18022	2.21	5.23	2.21	5.23
RAMAPO R. AT POMPTON LAKES	59	17	20742	21170	21725	21170	21725	2.06	4.74	2.06	4.74
ROCKAWAY RIVER ABOVE BOONTON	20	19	8050	8304	8919	8304	8919	3.16	10.80	3.16	10.80
WHIPPANY RIVER AT MORRISTOWN	30	109	2859	2946	3251	2946	3251	3.04	13.71	3.04	13.71
PASSAIC RIVER AT MILLINGTON	1	105	2276	2292	2301	2292	2301	0.70	1.10	0.70	1.10
PASSAIC RIVER AT CHATHAM	6	110	4076	4133	4207	4147	4317	1.40	3.21	1.74	5.91
CENTRAL BASIN											
POMPTON RIVER AT USGS GAGE	61	25	32515	32130	32907	32130	32907	-1.18	1.21	-1.18	1.21
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	30575	30340	30968	30808	32405	-0.77	1.29	0.76	5.99
POMPTON RIVER AT EAST-WEST DITCH	--	30	31455	31236	31871	31729	33382	-0.70	1.32	0.87	6.13
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	28969	28840	29449	29180	30561	-0.45	1.66	0.73	5.50
POMPTON RIVER AT PACKANACK BROOK	--	33	29200	29071	29681	29418	30821	-0.44	1.65	0.75	5.55
POMPTON RIVER AT MOUTH	68	34	29144	29020	29634	29394	30802	-0.43	1.68	0.86	5.69
PASSAIC RIVER AT PINE BROOK	37	23	12283	12621	13381	12886	14921	2.75	8.94	4.91	21.48
PASSAIC RIVER ABOVE POMPTON	40	24	12040	12235	12609	12383	14451	1.62	4.73	2.85	20.02
PASSAIC RIVER BELOW POMPTON	69	35	26843	26815	27450	27050	32547	-0.10	2.26	0.77	21.25
DEEPAVAAL BROOK	73	38	2502	2536	2553	2536	2553	1.36	2.04	1.36	2.04
PASSIAC RIVER AT LITTLE FALLS	76	41	27533	27527	28156	27760	33053	-0.02	2.26	0.82	20.05
LOWER VALLEY											
AT PECKMAN RIVER	--	100	27566	27555	28190	27805	33085	-0.04	2.26	0.87	20.02
AT GREAT FALLS	82	200	27626	27626	28259	27874	33123	0.00	2.29	0.90	19.90
AT DIAMOND BROOK	--	300	27692	27689	28324	27948	33157	-0.01	2.28	0.92	19.73
AT DUNDEE DAM	--	400	27693	27695	28324	27955	33098	0.01	2.28	0.95	19.52
AT SADDLE RIVER	--	500	28207	28206	28843	28524	33621	0.00	2.25	1.12	19.19
AT THIRD RIVER	--	600	28222	28225	28858	28543	33592	0.01	2.25	1.14	19.03
AT SECOND RIVER	104	700	28362	28369	28999	28690	33706	0.02	2.25	1.16	18.84
AT MOUTH	--	800	28365	28380	29006	28698	33645	0.05	2.26	1.17	18.61

Q1 = Existing Conditions.
Q2 = Effects of Urbanizations to year 1990.
Q3 = Same as Q2 but to year 2040.
Q4 = Effects of Urbanization and Development in the Central Basin with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.

TABLE 34 (CONT'D)

COMPARISON OF PEAK FLOWS RESULTING FROM FUTURE URBANIZATION AND FLOOD PLAIN DEVELOPMENT

500 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	PEAK DISCHARGE IN CFS: EXIST. COND. Q1	PEAK DISCHARGE IN CFS: URBANIZATION 1990 Q2	PEAK DISCHARGE IN CFS: URBANIZATION 2040 Q3	PEAK DISCHARGE IN CFS: FLOOD PLAIN DEV. 1990 Q4	PEAK DISCHARGE IN CFS: FLOOD PLAIN DEV. 2040 Q5	PERCENT COMPARISON WITH Q1: URBANIZATION 1990 Q2	PERCENT COMPARISON WITH Q1: URBANIZATION 2040 Q3	PERCENT COMPARISON WITH Q1: FLOOD PLAIN DEV. 1990 Q4	PERCENT COMPARISON WITH Q1: FLOOD PLAIN DEV. 2040 Q5
UPPER TRIBUTARIES											
RAMAPO R. AT MAHWAH	55	12	29557	30140	30948	30140	30948	1.97	4.71	1.97	4.71
RAMAPO R. AT POMPTON LAKES	59	17	36782	37446	38213	37446	38213	1.81	3.89	1.81	3.89
ROCKAWAY RIVER ABOVE BOONTON	20	19	12002	12314	13027	12314	13027	2.60	8.54	2.60	8.54
WHIPPANY RIVER AT MORRISTOWN	30	109	3891	3994	4366	3994	4366	2.65	12.21	2.65	12.21
PASSAIC RIVER AT MILLINGTON	1	105	3075	3091	3099	3091	3099	0.52	0.78	0.52	0.78
PASSAIC RIVER AT CHATHAM	6	110	5493	5561	5657	5605	5924	1.24	2.99	2.04	7.85
CENTRAL BASIN											
POMPTON RIVER AT USGS GAGE	61	25	55337	54567	55673	54567	55673	-1.39	0.61	-1.39	0.61
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	50709	50205	51097	51231	54448	-0.99	0.77	1.03	7.37
POMPTON RIVER AT EAST-WEST DITCH	--	30	51801	51316	52238	52371	55693	-0.94	0.84	1.10	7.51
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	47605	47302	48120	48055	50159	-0.64	1.08	0.95	5.36
POMPTON RIVER AT PACKANACK BROOK	--	33	47893	47589	48407	48349	50480	-0.63	1.07	0.95	5.40
POMPTON RIVER AT MOUTH	68	34	47796	47505	48309	48245	50438	-0.61	1.07	0.94	5.53
PASSAIC RIVER AT PINE BROOK	37	23	18420	18819	19611	19132	21300	2.17	6.47	3.87	15.64
PASSAIC RIVER ABOVE POMPTON	40	24	16471	16695	17116	16875	18443	1.36	3.92	2.45	11.97
PASSAIC RIVER BELOW POMPTON	69	35	43630	43507	44319	43980	50860	-0.28	1.58	0.80	16.57
DEEPAVAAL BROOK	73	38	3148	3185	3204	3185	3204	1.18	1.78	1.18	1.78
PASSIAC RIVER AT LITTLE FALLS	76	41	44471	44374	45201	44868	51565	-0.22	1.64	0.89	15.95
LOWER VALLEY											
AT PECKMAN RIVER	--	100	44549	44462	45284	44953	51682	-0.20	1.65	0.91	16.01
AT GREAT FALLS	82	200	44685	44594	45425	45108	51846	-0.20	1.66	0.95	16.03
AT DIAMOND BROOK	--	300	44801	44714	45541	45244	51996	-0.19	1.65	0.99	16.06
AT DUNDEE DAM	--	400	44817	44739	45564	45262	51949	-0.17	1.67	0.99	15.91
AT SADDLE RIVER	--	500	45837	45748	46590	46403	53903	-0.19	1.64	1.23	17.60
AT THIRD RIVER	--	600	45913	45827	46670	46532	53941	-0.19	1.65	1.35	17.49
AT SECOND RIVER	104	700	46191	46101	46952	46852	54265	-0.19	1.65	1.43	17.48
AT MOUTH	--	800	46272	46187	47050	46994	54269	-0.18	1.68	1.56	17.28

Q1 = Existing Conditions.
Q2 = Effects of Urbanization to year 1990.
Q3 = Same as Q2 but to year 2040.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.

TABLE 34 (CONT'D)

COMPARISON OF PEAK FLOWS RESULTING FROM FUTURE URBANIZATION AND FLOOD PLAIN DEVELOPMENT
SPS FLOOD EVENT

			PEAK DISCHARGE IN CFS					PERCENT COMPARISON WITH Q1			
				URBANIZATION		FLOOD PLAIN DEV.		URBANIZATION		FLOOD PLAIN DEV.	
LOCATION	POI	HEC-1 NODE	EXIST. COND. Q1	1990 Q2	2040 Q3	1990 Q4	2040 Q5	1990 Q2	2040 Q3	1990 Q4	2040 Q5
UPPER TRIBUTARIES											
RAMAPO R. AT MAHWAH	55	12	29798	30397	31250	30397	31250	2.01	4.87	2.01	4.87
RAMAPO R. AT POMPTON LAKES	59	17	36411	37089	37888	37089	37888	1.86	4.06	1.86	4.06
ROCKAWAY RIVER ABOVE BOONTON	20	19	17626	18008	18903	18008	18903	2.17	7.24	2.17	7.24
WHIPPANY RIVER AT MORRISTOWN	30	109	5973	6106	6608	6106	6608	2.23	10.63	2.23	10.63
PASSAIC RIVER AT MILLINGTON	1	105	4135	4153	4159	4153	4159	0.44	0.58	0.44	0.58
PASSAIC RIVER AT CHATHAM	6	110	7130	7219	7353	7273	7583	1.25	3.13	2.01	6.35
CENTRAL BASIN											
POMPTON RIVER AT USGS GAGE	61	25	54868	54134	55173	54134	55173	-1.34	0.56	-1.34	0.56
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	50454	49968	50856	50944	54047	-0.96	0.80	0.97	7.12
POMPTON RIVER AT EAST-WEST DITCH	--	30	51688	51209	52119	52239	55457	-0.93	0.83	1.07	7.29
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	47710	47413	48205	48146	50201	-0.62	1.04	0.91	5.22
POMPTON RIVER AT PACKANACK BROOK	--	33	48019	47721	48514	48463	50547	-0.62	1.03	0.92	5.26
POMPTON RIVER AT MOUTH	68	34	47935	47638	48444	48389	50525	-0.62	1.06	0.95	5.40
PASSAIC RIVER AT PINE BROOK	37	23	24243	24641	25430	24886	27188	1.64	4.90	2.65	12.15
PASSAIC RIVER ABOVE POMPTON	40	24	19832	20079	20536	20323	21934	1.25	3.55	2.48	10.60
PASSAIC RIVER BELOW POMPTON	69	35	43435	43357	44137	43746	50265	-0.18	1.62	0.72	15.72
DEEPAVAAL BROOK	73	38	4548	4592	4616	4592	4616	0.97	1.50	0.97	1.50
PASSIAC RIVER AT LITTLE FALLS	76	41	44406	44351	45132	44766	51306	-0.12	1.63	0.81	15.54
LOWER VALLEY											
AT PECKMAN RIVER	--	100	44439	44371	45162	44806	51362	-0.15	1.63	0.83	15.58
AT GREAT FALLS	82	200	44490	44431	45217	44870	51455	-0.13	1.63	0.85	15.66
AT DIAMOND BROOK	--	300	44533	44475	45264	44923	51535	-0.13	1.64	0.88	15.72
AT DUNDEE DAM	--	400	44509	44449	45243	44909	51477	-0.13	1.65	0.90	15.66
AT SADDLE RIVER	--	500	45137	45066	45872	45610	52834	-0.16	1.63	1.05	17.05
AT THIRD RIVER	--	600	45106	45039	45845	45612	52797	-0.15	1.64	1.12	17.05
AT SECOND RIVER	104	700	45236	45177	45976	45777	53030	-0.13	1.64	1.20	17.23
AT MOUTH	--	800	45243	45184	45993	45817	53040	-0.13	1.66	1.27	17.23

Q1 = Existing Conditions
Q2 = Effects of Urbanization to year 1990.
Q3 = Same as Q2 but to year 2040.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.

TABLE 35

SADDLE RIVER BASIN
EFFECTS OF STORMWATER MANAGEMENT
2040 LAND USE

NO STORMWATER MANAGEMENT (SWMM)

HEC-1 NODE	CONDITION	1 Yr.	5 Yr.	10 Yr.	25 Yr.	50 Yr.	100 Yr.	500 Yr.	SPS
170	W/O SWMM	1195	2523	3595	5233	7040	9175	15571	18651
	WITH SWMM	1169	2483	3552	5186				
1701	W/O SWMM	1071	2253	3195	4661	6259	8122	13779	16513
	WITH SWMM	1047	2215	3154	4615				
171	W/O SWMM	1063	2210	3044	4260	5204	6477	11696	14293
	WITH SWMM	1039	2177	3014	4222				
175	W/O SWMM	1096	2291	3159	4420	5424	6768	12170	14841
	WITH SWMM	1069	2252	3120	4368				
176	W/O SWMM	1097	2298	3143	4355	5325	6677	11696	14218
	WITH SWMM	1069	2258	3106	4312				
177	W/O SWMM	1116	2344	3177	4363	5340	6617	10995	13003
	WITH SWMM	1085	2303	3138	4304				
1729	NO SWMM	295	583	796	1093	1524	2123	3046	3419
173	NO SWMM	298	609	795	1004	1416	1870	2415	2615

TABLE 36
ACRES OF NATURAL FLOOD STORAGE THAT ARE PROTECTED AND UNPROTECTED 1/
(1984 Conditions)

STORAGE AREA NAME	ACRES	ACRES 2/ PROTECTED BY FLOODWAY DELINEATIONS	ACRES 3/ PROTECTED AS PARKLAND OR OPEN SPACE	TOTAL ACRES PROTECTED	PERCENT PROTECTED	REMAINING DEVLOPABLE ACRES	DEVELOPABLE 5/ ACRES PROTECTED WITH FHAR	ACRES LEGALLY 6/ SUSCEPTABLE TO FILL
Great Piece Meadows	4125	2185	220	2405	58%	1720	945	775
Troy Meadows	2390	805	315	1120	47%	1270	700	570
Canoe Brook	1245	745	140	885	71%	360	200	160
Upper Passaic River	2200	675	930	1605	73%	595	330	265
Hatfield Swamp	1775	1045	205	1250	70%	525	290	235
Black Meadows	1330	40	0	40	3%	1260	695	565
Great Swamp	8500	0	7500	7500 4/	88%	1000	550	450
Dead River	850	180	0	180	21%	670	370	300
Bog & Vly Meadows	650	250	0	205	32%	445	245	200
Hatfield Swamp (South)	605	220	175	395	65%	210	115	95
Lower Pompton	845	280	0	280	33%	565	310	255
TOTAL	24,485	6,380	9,485	15,865	65%	8,620	4,750	3,870

1/ Storage areas are not always analogus to wetland designations.
2/ Approximate acreage protected by floodway delineations.
3/ Approximate acreage protected consists of those areas in public ownership expected to remain as parkland or open space.
4/ The Great Swamp National Wildlife Refuge/Lord Sterling Park protects 7500 acres.
5/ Developable acres estimated to remain as open space due to the Flood Hazard Area Regulations limitation on fill placement in flood fringe.
6/ Developable acres estimated to be filled under the Flood Hazard Area Regulations.

TABLE 37

IMPACT ON STORAGE - DISCHARGE RELATIONS
OF
VARIOUS DEVELOPMENT SCENARIOS

Routing Reach	Area	$Q_1/Q_4/Q_5$ w/o Project (Exist, 1990 & 2040)	Q_6 Preservation	Q_{22} Tunnel Only	Q_{23} Tunnel & Levees	Q_{25} Tunnel, Levees & Pres.
40-41	Two Br. - Beatties	S	S	ST	ST	ST
Tribs. u/s of Inlet	RAMAPO PEQUANNOCK WANAQUE	S	S	STL	STL	STL
3885-25	POMPTON					
25-26		S	SP	ST	ST	STP***
30-31		S	SP	ST	ST	STP***
33-34		S	SP	ST**	ST**	STP***
23-24	GREAT PIECE	S	SP	ST	STL	STLP
14-15	TROY	S	SP	S	S*	SP
15-18		S	SP	S	S*	SP
16-17		S	SP	S	S*	SP
8- 9	HATFIELD	S	SP	S	S*	SP
19-20		S	SP	S	S*	SP
3815-14	BLACK	S	SP	S	S*	SP
7- 8	CANOE	S	SP	S	S	SP
11-12	ROCKAWAY	S	S	S	S	S
12-13		S	S	S	S	S
107-108	UPPER PASSAIC	S	S	S	S	S
108-109		S	S	S	S	S
109-110		S	S	S	S	S
3795- 1		S	S	S	S	S

*PRESUMING NO LEVEE EFFECTS
**PRELIMINARY DATA INDICATE TUNNEL EFFECTS ARE SMALL
***PRESERVATION EFFECTS ARE EXPECTED TO BE SMALL

S = BASELINE, 1990 OR 2040 STORAGE
P = PRESERVATION STORAGE
T = TUNNEL STORAGE
L = LEVEE STORAGE

TABLE 38
COMPARISON OF PEAK FLOWS FOR THE RECOMMENDED PLAN
1 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	EXIST. COND. Q1	FLOOD PLAIN DEVELOPMENT 1990 Q4	FLOOD PLAIN DEVELOPMENT 2040 Q5	PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25	PERCENT COMPARISON WITH Q5: PRESERV. NAT. STOR. 2040 Q6	PERCENT COMPARISON WITH Q5: PLAN 2040 Q25
UPPER TRIBUTARIES									
RAMAPO R. AT MAHWAH	55	12	2469	2641	2909	2909	2909	0.00	0.00
RAMAPO R. AT POMPTON LAKES	59	17	2857	3048	3365	3365	3365	0.00	0.00
ROCKAWAY RIVER ABOVE BOONTON	20	19	1656	1744	1985	1985	1985	0.00	0.00
WHIPPANY RIVER AT MORRISTOWN	30	109	711	746	861	861	861	0.00	0.00
PASSAIC RIVER AT MILLINGTON	1	105	710	719	726	726	726	0.00	0.00
PASSAIC RIVER AT CHATHAM	6	110	1104	1138	1203	1203	1203	0.00	0.00
CENTRAL BASIN									
POMPTON RIVER AT USGS GAGE	61	25	3992	4260	4672	4672	4672	0.00	0.00
POMPTON INLET TUNNEL DIVERSION	--	99600	N/A	N/A	N/A	N/A	N/A	N/A	N/A
POMPTON RIVER BELOW TUNNEL DIVERSION	--	25D	3992	4260	4672	4672	4672	0.00	0.00
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	3997	4255	4658	4659	4659	0.02	0.02
POMPTON RIVER AT EAST-WEST DITCH	--	30	4288	4555	4963	4964	4964	0.02	0.02
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	4050	4310	4717	4700	4700	-0.36	-0.36
POMPTON RIVER AT PACKANACK BROOK	--	33	4132	4392	4800	4783	4783	-0.35	-0.35
POMPTON RIVER AT MOUTH	68	34	4128	4390	4805	4778	4778	-0.56	-0.56
PASSAIC RIVER AT PINE BROOK	37	23	2933	3043	3504	3262	3262	-6.91	-6.91
PASSAIC RIVER ABOVE POMPTON	40	24	2511	2594	2822	2773	2773	-1.74	-1.74
PASSAIC RIVER BELOW POMPTON	69	35	5201	5489	5918	5871	5871	-0.79	-0.79
DEEPAVAAL BROOK	73	38	684	706	716	716	716	0.00	0.00
PASSIAC RIVER AT LITTLE FALLS	76	41	5486	5784	6232	6182	6182	-0.80	-0.80
TWO BRIDGES TUNNEL DIVERSION			N/A	N/A	N/A	N/A	N/A	-	-
BYPASS FLOW D/S OF LITTLE FALLS			5486	5784	6232	6182	6182	-0.80	-0.80
LOWER VALLEY									
AT PECKMAN RIVER	--	100	5492	5792	6243	6194	6194	-0.78	-0.78
AT GREAT FALLS	82	200	5505	5805	6262	6213	6213	-0.78	-0.78
AT DIAMOND BROOK	--	300	5517	5816	6277	6228	6228	-0.78	-0.78
AT DUNDEE DAM	--	400	5514	5812	6271	6225	6225	-0.73	-0.73
AT SADDLE RIVER	--	500	5576	5876	6351	6305	6305	-0.72	-0.72
AT THIRD RIVER	--	600	5576	5874	6350	6305	6305	-0.71	-0.71
TUNNEL DISCHARGE	--	600D	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AT SECOND RIVER	104	700	5603	5902	6379	6335	6335	-0.69	-0.69
AT MOUTH	--	800	5596	5895	6370	6329	6329	-0.64	-0.64

N/A = Not Applicable
Q1 = Existing Conditions.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.
Q6 = Q5 Modified to Preserve Specified Floodplain Areas in the Central Basin beginning 1990.
Q25 = Dual Inlet Tunnel Plan.

TABLE 38 (CONT)
COMPARISON OF PEAK FLOWS FOR THE RECOMMENDED PLAN
2 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	EXIST. COND. Q1	FLOOD PLAIN DEVELOPMENT 1990 Q4	FLOOD PLAIN DEVELOPMENT 2040 Q5	PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25	PERCENT COMPARISON WITH Q25: PRESERV. NAT. STOR. 2040 Q6	PERCENT COMPARISON WITH Q25: PLAN 2040 Q25
UPPER TRIBUTARIES									
RAMAPO R. AT MAHWAH	55	12	3546	3769	4118	4118	4118	0.00	0.00
RAMAPO R. AT POMPTON LAKES	59	17	4183	4427	4826	4826	4826	0.00	0.00
ROCKAWAY RIVER ABOVE BOONTON	20	19	2262	2376	2681	2681	2681	0.00	0.00
WHIPPANY RIVER AT MORRISTOWN	30	109	1008	1052	1198	1198	1198	0.00	0.00
PASSAIC RIVER AT MILLINGTON	1	105	927	937	946	946	946	0.00	0.00
PASSAIC RIVER AT CHATHAM	6	110	1615	1659	1743	1743	1743	0.00	0.00
CENTRAL BASIN									
POMPTON RIVER AT USGS GAGE	61	25	6462	6766	7279	7279	7216	0.00	-0.87
POMPTON INLET TUNNEL DIVERSION	--	99600	6472	6766	7279	7279	6716	-	-
POMPTON RIVER BELOW TUNNEL DIVERSION	--	25D	6462	6766	7279	7279	500	0.00	-93.13
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	6449	6765	7237	7238	753	0.01	-89.60
POMPTON RIVER AT EAST-WEST DITCH	--	30	6808	7136	7614	7614	2061	0.00	-72.93
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	6429	6752	7254	7213	1610	-0.57	-77.81
POMPTON RIVER AT PACKANACK BROOK	--	33	6529	6854	7357	7316	1799	-0.56	-75.55
POMPTON RIVER AT MOUTH	68	34	6521	6848	7360	7309	1820	-0.69	-75.27
PASSAIC RIVER AT PINE BROOK	37	23	3876	4044	4649	4321	4321	-7.06	-7.06
PASSAIC RIVER ABOVE POMPTON	40	24	3447	3606	3944	3893	4132	-1.29	4.77
PASSAIC RIVER BELOW POMPTON	69	35	7535	7773	8214	8188	4705	-0.32	-42.72
DEEPAVAAL BROOK	73	38	871	898	911	911	911	0.00	0.00
PASSIAC RIVER AT LITTLE FALLS	76	41	7787	8037	8496	8431	4875	-0.77	-42.62
TWO BRIDGES TUNNEL DIVERSION			N/A	N/A	N/A	N/A	4775	-	-
BYPASS FLOW D/S OF LITTLE FALLS			7787	8037	8496	8431	100	-0.77	-98.82
LOWER VALLEY									
AT PECKMAN RIVER	--	100	7795	8039	8503	8437	1347	-0.78	-84.16
AT GREAT FALLS	82	200	7806	8050	8523	8446	2559	-0.90	-69.98
AT DIAMOND BROOK	--	300	7817	8061	8540	8453	3467	-1.02	-59.40
AT DUNDEE DAM	--	400	7821	8063	8554	8454	3277	-1.17	-61.69
AT SADDLE RIVER	--	500	7893	8128	8621	8503	4645	-1.37	-46.12
AT THIRD RIVER	--	600	7902	8133	8635	8506	5200	-1.49	-39.78
TUNNEL DISCHARGE	--	600D	N/A	N/A	N/A	N/A	10368	N/A	N/A
AT SECOND RIVER	104	700	7940	8167	8674	8533	13257	-1.63	52.84
AT MOUTH	--	800	7951	8178	8694	8540	13312	-1.77	53.12

N/A = Not Applicable
Q1 = Existing Conditions.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.
Q6 = Q5 Modified to preserve specified floodplain areas in the Central Basin beginning 1990.
Q25 = Dual Inlet Tunnel Plan. Peak flows do not contain mitigation bypass flow downstream of inlets

TABLE 38 (CONT)
COMPARISON OF PEAK FLOWS FOR THE RECOMMENDED PLAN
5 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	EXIST. COND. Q1	FLOOD PLAIN DEVELOPMENT 1990 Q4	FLOOD PLAIN DEVELOPMENT 2040 Q5	PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25	PERCENT COMPARISON WITH Q25: PRESERV. NAT. STOR. 2040 Q6	PERCENT COMPARISON WITH Q25: PLAN 2040 Q25
UPPER TRIBUTARIES									
RAMAPO R. AT MAHWAH	55	12	5500	5773	6196	6196	6196	0.00	0.00
RAMAPO R. AT POMPTON LAKES	59	17	6490	6785	7274	7274	7274	0.00	0.00
ROCKAWAY RIVER ABOVE BOONTON	20	19	3072	3219	3590	3590	3590	0.00	0.00
WHIPPANY RIVER AT MORRISTOWN	30	109	1290	1345	1529	1529	1529	0.00	0.00
PASSAIC RIVER AT MILLINGTON	1	105	1150	1162	1172	1172	1172	0.00	0.00
PASSAIC RIVER AT CHATHAM	6	110	1891	1947	2045	2045	2045	0.00	0.00
CENTRAL BASIN									
POMPTON RIVER AT USGS GAGE	61	25	10049	10359	10971	10971	11144	0.00	1.58
POMPTON INLET TUNNEL DIVERSION	--	99600	N/A	N/A	N/A	N/A	10644	-	-
POMPTON RIVER BELOW TUNNEL DIVERSION	--	25D	10049	10359	10971	10971	500	0.00	-95.44
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	10014	10332	10889	10890	923	0.01	-91.52
POMPTON RIVER AT EAST-WEST DITCH	--	30	10521	10852	11415	11416	2792	0.01	-75.54
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	9912	10263	10867	10799	2149	-0.63	-80.22
POMPTON RIVER AT PACKANACK BROOK	--	33	10051	10405	11011	10943	2444	-0.62	-77.80
POMPTON RIVER AT MOUTH	68	34	10034	10393	11012	10929	2462	-0.75	-77.64
PASSAIC RIVER AT PINE BROOK	37	23	5150	5347	6173	5716	5716	-7.40	-7.40
PASSAIC RIVER ABOVE POMPTON	40	24	5249	5496	6148	5869	5449	-4.54	-11.37
PASSAIC RIVER BELOW POMPTON	69	35	9965	10249	11068	10688	6064	-3.43	-45.21
DEEPAVAAL BROOK	73	38	1265	1294	1308	1308	1308	0.00	0.00
PASSIAC RIVER AT LITTLE FALLS	76	41	10332	10615	11536	11087	6315	-3.89	-45.26
TWO BRIDGES TUNNEL DIVERSION			N/A	N/A	N/A	N/A	6215	-	-
BYPASS FLOW D/S OF LITTLE FALLS			10332	10615	11536	11087	100	-3.89	-99.13
LOWER VALLEY									
AT PECKMAN RIVER	--	100	10338	10619	11551	11099	1809	-3.91	-84.34
AT GREAT FALLS	82	200	10354	10637	11583	11129	3453	-3.92	-70.19
AT DIAMOND BROOK	--	300	10371	10652	11613	11153	4779	-3.96	-58.85
AT DUNDEE DAM	--	400	10386	10670	11622	11163	4499	-3.95	-61.29
AT SADDLE RIVER	--	500	10452	10757	11769	11281	6433	-4.15	-45.34
AT THIRD RIVER	--	600	10467	10774	11782	11292	7228	-4.16	-38.65
TUNNEL DISCHARGE	--	600D	N/A	N/A	N/A	N/A	15517	N/A	N/A
AT SECOND RIVER	104	700	10512	10830	11839	11345	19629	-4.17	65.80
AT MOUTH	--	800	10537	10854	11851	11360	19632	-4.14	65.66

N/A = Not Applicable
Q1 = Existing Conditions.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.
Q6 = Q5 Modified to preserve specified floodplain area in the Central Basin beginning 1990.
Q25 = Dual Inlet Tunnel Plan. Peak flows do not contain mitigation bypass flow downstream of inlets.

TABLE 38 (CONT)
COMPARISON OF PEAK FLOWS FOR THE RECOMMENDED PLAN
10 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	PEAK DISCHARGE IN CFS: EXIST. COND. Q1	FLOOD PLAIN DEVELOPMENT 1990 Q4	FLOOD PLAIN DEVELOPMENT 2040 Q5	PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25	PERCENT COMPARISON WITH Q25: PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25
UPPER TRIBUTARIES									
RAMAPO R. AT MAHWAH	55	12	7403	7719	8203	8203	8203	0.00	0.00
RAMAPO R. AT POMPTON LAKES	59	17	8802	9164	9741	9741	9741	0.00	0.00
ROCKAWAY RIVER ABOVE BOONTON	20	19	4094	4267	4726	4726	4726	0.00	0.00
WHIPPANY RIVER AT MORRISTOWN	30	109	1608	1673	1888	1888	1888	0.00	0.00
PASSAIC RIVER AT MILLINGTON	1	105	1387	1400	1411	1411	1411	0.00	0.00
PASSAIC RIVER AT CHATHAM	6	110	2342	2407	2522	2522	2522	0.00	0.00
CENTRAL BASIN									
POMPTON RIVER AT USGS GAGE	61	25	13979	14268	14960	14960	15383	0.00	2.83
POMPTON INLET TUNNEL DIVERSION	--	99600	N/A	N/A	N/A	N/A	14883	-	-
POMPTON RIVER BELOW TUNNEL DIVERSION	--	250	13979	14268	14960	14960	500	0.00	-96.66
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	13696	13996	14761	14594	1063	-1.13	-92.80
POMPTON RIVER AT EAST-WEST DITCH	--	30	14308	14618	15404	15221	3323	-1.19	-78.43
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	13461	13788	14487	14313	2556	-1.20	-82.36
POMPTON RIVER AT PACKANACK BROOK	--	33	13628	13954	14658	14481	2933	-1.21	-79.99
POMPTON RIVER AT MOUTH	68	34	13630	13959	14658	14479	2948	-1.22	-79.89
PASSAIC RIVER AT PINE BROOK	37	23	6525	6815	7927	7307	7307	-7.82	-7.82
PASSAIC RIVER ABOVE POMPTON	40	24	6858	7144	9160	7471	6861	-18.44	-25.10
PASSAIC RIVER BELOW POMPTON	69	35	12850	13149	14917	13729	7475	-7.96	-49.89
DEEPAVAAL BROOK	73	38	1541	1572	1587	1587	1587	0.00	0.00
PASSIAC RIVER AT LITTLE FALLS	76	41	13354	13653	15323	14247	7770	-7.02	-49.29
TWO BRIDGES TUNNEL DIVERSION			N/A	N/A	N/A	N/A	7670	-	-
BYPASS FLOW D/S OF LITTLE FALLS			13354	13653	15323	14247	100	-7.02	-99.35
LOWER VALLEY									
AT PECKMAN RIVER	--	100	13364	13669	15322	14264	2359	-6.91	-84.60
AT GREAT FALLS	82	200	13397	13705	15338	14301	4621	-6.76	-69.87
AT DIAMOND BROOK	--	300	13429	13740	15345	14330	6551	-6.61	-57.31
AT DUNDEE DAM	--	400	13443	13762	15353	14339	6132	-6.60	-60.06
AT SADDLE RIVER	--	500	13606	13941	15394	14543	8947	-5.53	-41.88
AT THIRD RIVER	--	600	13624	13963	15394	14554	10025	-5.46	-34.88
TUNNEL DISCHARGE	--	6000	N/A	N/A	N/A	N/A	20691	N/A	N/A
AT SECOND RIVER	104	700	13692	14037	15429	14627	26581	-5.20	72.28
AT MOUTH	--	800	13710	14061	15452	14638	26625	-5.27	72.31

N/A = NOT APPLICABLE
Q1 = Existing Conditions.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.
Q6 = Q5 Modified to preserve specified floodplain areas in the Central Basin beginning 1990.
Q25 = Dual Inlet Tunnel Plan. Peak flows do not contain mitigation bypass flow downstream of inlets.

TABLE 38 (CONT)
COMPARISON OF PEAK FLOWS FOR THE RECOMMENDED PLAN
25 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	PEAK DISCHARGE IN CFS: EXIST. COND. Q1	PEAK DISCHARGE IN CFS: FLOOD PLAIN DEVELOPMENT 1990 Q4	PEAK DISCHARGE IN CFS: FLOOD PLAIN DEVELOPMENT 2040 Q5	PEAK DISCHARGE IN CFS: PRESERV. NAT. STOR. 2040 Q6	PEAK DISCHARGE IN CFS: PLAN 2040 Q25	PERCENT COMPARISON WITH Q25: PRESERV. NAT. STOR. 2040 Q6	PERCENT COMPARISON WITH Q25: PLAN 2040 Q25
UPPER TRIBUTARIES									
RAMAPO R. AT MAHWAH	55	12	10566	10912	11419	11419	11419	0.00	0.00
RAMAPO R. AT POMPTON LAKES	59	17	12684	13042	13597	13597	13597	0.00	0.00
ROCKAWAY RIVER ABOVE BOONTON	20	19	5471	5674	6169	6169	6169	0.00	0.00
WHIPPANY RIVER AT MORRISTOWN	30	109	2057	2129	2375	2375	2375	0.00	0.00
PASSAIC RIVER AT MILLINGTON	1	105	1690	1704	1714	1714	1714	0.00	0.00
PASSAIC RIVER AT CHATHAM	6	110	2955	3024	3150	3150	3150	0.00	0.00
CENTRAL BASIN									
POMPTON RIVER AT USGS GAGE	61	25	19870	19985	20712	20712	21150	0.00	2.11
POMPTON INLET TUNNEL DIVERSION	--	99600	N/A	N/A	N/A	N/A	20650	-	-
POMPTON RIVER BELOW TUNNEL DIVERSION	--	250	19870	19985	20712	20712	500	0.00	-97.59
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	19003	19308	20351	19981	1232	-1.82	-93.95
POMPTON RIVER AT EAST-WEST DITCH	--	30	19729	20054	21144	20751	4074	-1.86	-80.73
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	18283	18550	19571	19121	2983	-2.30	-84.76
POMPTON RIVER AT PACKANACK BROOK	--	33	18472	18744	19776	19316	3566	-2.33	-81.97
POMPTON RIVER AT MOUTH	68	34	18477	18742	19773	19315	3551	-2.32	-82.04
PASSAIC RIVER AT PINE BROOK	37	23	8622	9022	10419	9604	9604	-7.82	-7.82
PASSAIC RIVER ABOVE POMPTON	40	24	8857	9121	11771	9464	8829	-19.60	-24.99
PASSAIC RIVER BELOW POMPTON	69	35	17567	17919	21236	18459	9496	-13.08	-55.28
DEEPAVAAL BROOK	73	38	1934	1965	1980	1980	1980	0.00	0.00
PASSIAC RIVER AT LITTLE FALLS	76	41	18190	18555	21777	19103	9867	-12.28	-54.69
TWO BRIDGES TUNNEL DIVERSION			N/A	N/A	N/A	N/A	9767	-	-
BYPASS FLOW D/S OF LITTLE FALLS			18190	18555	21777	19103	100	-12.28	-99.54
LOWER VALLEY									
AT PECKMAN RIVER	--	100	18214	18579	21782	19125	2948	-12.20	-86.47
AT GREAT FALLS	82	200	18255	18623	21805	19174	5964	-12.07	-72.65
AT DIAMOND BROOK	--	300	18294	18659	21818	19212	8396	-11.94	-61.52
AT DUNDEE DAM	--	400	18298	18665	21807	19214	7855	-11.89	-63.98
AT SADDLE RIVER	--	500	18565	18940	21946	19499	11904	-11.15	-45.76
AT THIRD RIVER	--	600	18569	18946	21932	19506	13241	-11.06	-39.63
TUNNEL DISCHARGE	--	6000	N/A	N/A	N/A	N/A	27697	N/A	N/A
AT SECOND RIVER	104	700	18653	19028	21979	19587	35575	-10.88	61.86
AT MOUTH	--	800	18647	19025	21968	19583	35626	-10.86	62.17

N/A = Not Applicable
Q1 = Existing Conditions.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.
Q6 = Q5 Modified to preserve specified floodplain areas in the Central Basin beginning 1990.
Q25 = Dual Inlet Tunnel Plan. Peak flows do not contain mitigation bypass flow downstream of inlets.

TABLE 38 (CONT)
COMPARISON OF PEAK FLOWS FOR THE RECOMMENDED PLAN
50 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	PEAK DISCHARGE IN CFS: EXIST. COND. Q1	FLOOD PLAIN DEVELOPMENT 1990 Q4	FLOOD PLAIN DEVELOPMENT 2040 Q5	PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25	PERCENT COMPARISON WITH Q25: PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25
UPPER TRIBUTARIES									
RAMAPO R. AT MAHWAH	55	12	14197	14560	15083	15083	15083	0.00	0.00
RAMAPO R. AT POMPTON LAKES	59	17	17042	17435	17983	17983	17983	0.00	0.00
ROCKAWAY RIVER ABOVE BOONTON	20	19	6661	6898	7464	7464	7464	0.00	0.00
WHIPPANY RIVER AT MORRISTOWN	30	109	2430	2508	2778	2778	2778	0.00	0.00
PASSAIC RIVER AT MILLINGTON	1	105	1952	1967	1977	1977	1977	0.00	0.00
PASSAIC RIVER AT CHATHAM	6	110	3516	3593	3738	3738	3738	0.00	0.00
CENTRAL BASIN									
POMPTON RIVER AT USGS GAGE	61	25	26788	26657	27398	27398	27787	0.00	1.42
POMPTON INLET TUNNEL DIVERSION	--	99600	N/A	N/A	N/A	N/A	26642	-	-
POMPTON RIVER BELOW TUNNEL DIVERSION	--	250	26788	26657	27398	27398	1145	0.00	-95.82
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	25437	25720	27036	26373	1354	-2.45	-94.99
POMPTON RIVER AT EAST-WEST DITCH	--	30	26216	26533	27903	27194	4490	-2.54	-83.91
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	23941	24152	25459	24750	3149	-2.78	-87.63
POMPTON RIVER AT PACKANACK BROOK	--	33	24147	24363	25683	24963	3860	-2.80	-84.97
POMPTON RIVER AT MOUTH	68	34	24123	24336	25694	24937	3849	-2.95	-85.02
PASSAIC RIVER AT PINE BROOK	37	23	10186	10682	12256	11312	11312	-7.70	-7.70
PASSAIC RIVER ABOVE POMPTON	40	24	10336	10629	12941	11003	10178	-14.98	-21.35
PASSAIC RIVER BELOW POMPTON	69	35	22288	22589	26841	23125	10880	-13.84	-59.46
DEEPAVAAL BROOK	73	38	2143	2175	2191	2191	2191	0.00	0.00
PASSIAC RIVER AT LITTLE FALLS	76	41	22961	23278	27416	23799	11299	-13.19	-58.79
TWO BRIDGES TUNNEL DIVERSION			N/A	N/A	N/A	N/A	11199	-	-
BYPASS FLOW D/S OF LITTLE FALLS			22961	23278	27416	23799	4981	-13.19	-81.83
LOWER VALLEY									
AT PECKMAN RIVER	--	100	22994	23308	27435	23828	5235	-13.15	-80.92
AT GREAT FALLS	82	200	23044	23370	27469	23895	7082	-13.01	-74.22
AT DIAMOND BROOK	--	300	23096	23424	27498	23951	10200	-12.90	-62.91
AT DUNDEE DAM	--	400	23098	23425	27495	23958	9715	-12.83	-64.65
AT SADDLE RIVER	--	500	23506	23856	27769	24392	15074	-12.16	-45.72
AT THIRD RIVER	--	600	23513	23869	27755	24408	16824	-12.06	-39.38
TUNNEL DISCHARGE	--	6000	N/A	N/A	N/A	N/A	30730	N/A	N/A
AT SECOND RIVER	104	700	23622	23980	27830	24523	43601	-11.88	56.67
AT MOUTH	--	800	23613	23972	27804	24521	42966	-11.81	54.17

N/A = Not Applicable
Q1 = Existing Conditions.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.
Q6 = Q5 Modified to preserve specified floodplain areas in the Central Basin beginning 1990.
Q25 = Dual Inlet Tunnel Plan. Peak flows do not contain mitigation bypass flow downstream of inlets.

TABLE 38 (CONT)
COMPARISON OF PEAK FLOWS FOR THE RECOMMENDED PLAN
100 YEAR FLOOD EVENT

			PEAK DISCHARGE IN CFS					PERCENT COMPARISON WITH Q25	
			EXIST. COND.	FLOOD PLAIN DEVELOPMENT		PRESERV. NAT. STOR.	PLAN	PRESERV. NAT. STOR.	PLAN
LOCATION	POI	HEC-1 NODE	Q1	1990 Q4	2040 Q5	2040 Q6	2040 Q25	2040 Q6	2040 Q25
UPPER TRIBUTARIES									
RAMAPO R. AT MAHWAH	55	12	17127	17506	18022	18022	18022	0.00	0.00
RAMAPO R. AT POMPTON LAKES	59	17	20742	21170	21725	21725	21725	0.00	0.00
ROCKAWAY RIVER ABOVE BOONTON	20	19	8050	8304	8919	8919	8919	0.00	0.00
WHIPPANY RIVER AT MORRISTOWN	30	109	2859	2946	3251	3251	3251	0.00	0.00
PASSAIC RIVER AT MILLINGTON	1	105	2276	2292	2301	2301	2301	0.00	0.00
PASSAIC RIVER AT CHATHAM	6	110	4076	4147	4317	4317	4317	0.00	0.00
CENTRAL BASIN									
POMPTON RIVER AT USGS GAGE	61	25	32515	32130	32907	32907	33880	0.00	2.96
POMPTON INLET TUNNEL DIVERSION	--	99600	N/A	N/A	N/A	N/A	28709	-	-
POMPTON RIVER BELOW TUNNEL DIVERSION	--	25D	32515	32130	32907	32907	5171	0.00	-84.29
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	30575	30808	32405	31507	4536	-2.77	-86.00
POMPTON RIVER AT EAST-WEST DITCH	--	30	31455	31729	33382	32443	5504	-2.81	-83.51
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	28969	29180	30561	29791	4914	-2.52	-83.92
POMPTON RIVER AT PACKANACK BROOK	--	33	29200	29418	30821	30031	5191	-2.56	-83.16
POMPTON RIVER AT MOUTH	68	34	29144	29394	30802	30005	5180	-2.59	-83.18
PASSAIC RIVER AT PINE BROOK	37	23	12283	12886	14921	13768	13768	-7.73	-7.73
PASSAIC RIVER ABOVE POMPTON	40	24	12040	12383	14451	12773	11482	-11.61	-20.55
PASSAIC RIVER BELOW POMPTON	69	35	26843	27050	32547	27678	12544	-14.96	-61.46
DEEPAVAAL BROOK	73	38	2502	2536	2553	2553	2553	0.00	0.00
PASSIAC RIVER AT LITTLE FALLS	76	41	27533	27760	33053	28398	13098	-14.08	-60.37
TWO BRIDGES TUNNEL DIVERSION			N/A	N/A	N/A	N/A	12998	-	-
BYPASS FLOW D/S OF LITTLE FALLS			27533	27760	33053	28398	9232	-14.08	-72.07
LOWER VALLEY									
AT PECKMAN RIVER	--	100	27566	27805	33085	28439	9496	-14.04	-71.30
AT GREAT FALLS	82	200	27626	27874	33123	28515	9768	-13.91	-70.51
AT DIAMOND BROOK	--	300	27692	27948	33157	28580	12774	-13.80	-61.47
AT DUNDEE DAM	--	400	27693	27955	33098	28588	12402	-13.63	-62.53
AT SADDLE RIVER	--	500	28207	28524	33621	29169	18892	-13.24	-43.81
AT THIRD RIVER	--	600	28222	28543	33592	29187	21279	-13.11	-36.65
TUNNEL DISCHARGE	--	600D	N/A	N/A	N/A	N/A	31656	N/A	N/A
AT SECOND RIVER	104	700	28362	28690	33706	29328	50543	-12.99	49.95
AT MOUTH	--	800	28365	28698	33645	29332	48544	-12.82	44.28

N/A = NOT APPLICABLE
Q1 = Existing Conditions.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.
Q6 = Q5 Modified to preserve specified floodplain areas in the Central Basin beginning 1990.
Q25 = Dual Inlet Tunnel Plan. Peak flows do not contain mitgation bypass flow downstream of inlets.

TABLE 38 (CONT)
COMPARISON OF PEAK FLOWS FOR THE RECOMMENDED PLAN
500 YEAR FLOOD EVENT

LOCATION	POI	HEC-1 NODE	PEAK DISCHARGE IN CFS: EXIST. COND. Q1	FLOOD PLAIN DEVELOPMENT 1990 Q4	FLOOD PLAIN DEVELOPMENT 2040 Q5	PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25	PERCENT COMPARISON WITH Q25: PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25
UPPER TRIBUTARIES									
RAMAPO R. AT MAHWAH	55	12	29557	30140	30948	30948	30948	0.00	0.00
RAMAPO R. AT POMPTON LAKES	59	17	36782	37446	38213	38213	38213	0.00	0.00
ROCKAWAY RIVER ABOVE BOONTON	20	19	12002	12314	13027	13027	13027	0.00	0.00
WHIPPANY RIVER AT MORRISTOWN	30	109	3891	3994	4366	4366	4366	0.00	0.00
PASSAIC RIVER AT MILLINGTON	1	105	3075	3091	3099	3099	3099	0.00	0.00
PASSAIC RIVER AT CHATHAM	6	110	5493	5605	5924	5924	5924	0.00	0.00
CENTRAL BASIN									
POMPTON RIVER AT USGS GAGE	61	25	55337	54567	55673	55673	57536	0.00	3.35
POMPTON INLET TUNNEL DIVERSION	--	99600	N/A	N/A	N/A	N/A	28709	-	-
POMPTON RIVER BELOW TUNNEL DIVERSION	--	25D	55337	54567	55673	55673	28827	0.00	-48.22
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	50709	51231	54448	52462	26251	-3.65	-51.79
POMPTON RIVER AT EAST-WEST DITCH	--	30	51801	52371	55693	53642	27461	-3.68	-50.69
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	47605	48055	50159	48996	25184	-2.32	-49.79
POMPTON RIVER AT PACKANACK BROOK	--	33	47893	48349	50480	49300	25522	-2.34	-49.44
POMPTON RIVER AT MOUTH	68	34	47796	48245	50438	49203	25387	-2.45	-49.67
PASSAIC RIVER AT PINE BROOK	37	23	18420	19132	21300	20234	20234	-5.00	-5.00
PASSAIC RIVER ABOVE POMPTON	40	24	16471	16875	18443	17265	14942	-6.39	-18.98
PASSAIC RIVER BELOW POMPTON	69	35	43630	43980	50860	44840	27013	-11.84	-46.89
DEEPAVAAL BROOK	73	38	3148	3185	3204	3204	3204	0.00	0.00
PASSIAC RIVER AT LITTLE FALLS	76	41	44471	44868	51565	45753	27906	-11.27	-45.88
TWO BRIDGES TUNNEL DIVERSION			N/A	N/A	N/A	N/A	14780	-	-
BYPASS FLOW D/S OF LITTLE FALLS			44471	44868	51565	45753	27906	-11.27	-45.88
LOWER VALLEY									
AT PECKMAN RIVER	--	100	44549	44953	51682	45859	28087	-11.27	-45.65
AT GREAT FALLS	82	200	44685	45108	51846	46012	28339	-11.25	-45.34
AT DIAMOND BROOK	--	300	44801	45244	51996	46152	28581	-11.24	-45.03
AT DUNDEE DAM	--	400	44817	45262	51949	46178	28572	-11.11	-45.00
AT SADDLE RIVER	--	500	45837	46403	53903	47381	32609	-12.10	-39.50
AT THIRD RIVER	--	600	45913	46532	53941	47552	33303	-11.84	-38.26
TUNNEL DISCHARGE	--	6000	N/A	N/A	N/A	N/A	31531	N/A	N/A
AT SECOND RIVER	104	700	46191	46852	54265	47911	64672	-11.71	19.18
AT MOUTH	--	800	46272	46994	54269	48077	62803	-11.41	15.73

N/A = Not Applicable
Q1 = Existing Conditions
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
Q5 = Same as Q4 but to year 2040.
Q6 = Q5 Modified to preserve specified floodplain areas in the Central Basin beginning 1990.
Q25 = Dual Inlet Tunnel Plan. Peak flows do not contain mitigation bypass flow downstream of inlets.

TABLE 38 (CONT)
COMPARISON OF PEAK FLOWS FOR THE RECOMMENDED PLAN
SPS FLOOD EVENT

LOCATION	POI	HEC-1 NODE	PEAK DISCHARGE IN CFS: EXIST. COND. Q1	FUTURE URBANIZATION 1990 Q4	FUTURE URBANIZATION 2040 Q5	PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25	PERCENT COMPARISON WITH Q25: PRESERV. NAT. STOR. 2040 Q6	PLAN 2040 Q25
UPPER TRIBUTARIES									
RAMAPO R. AT MAHWAH	55	12	29798	30397	31250	31250	31250	0.00	0.00
RAMAPO R. AT POMPTON LAKES	59	17	36411	37089	37888	37888	37888	0.00	0.00
ROCKAWAY RIVER ABOVE BOONTON	20	19	17626	18008	18903	18903	18903	0.00	0.00
WHIPPANY RIVER AT MORRISTOWN	30	109	5973	6106	6608	6608	6608	0.00	0.00
PASSAIC RIVER AT MILLINGTON	1	105	4135	4153	4159	4159	4159	0.00	0.00
PASSAIC RIVER AT CHATHAM	6	110	7130	7273	7583	7583	7583	0.00	0.00
CENTRAL BASIN									
POMPTON RIVER AT USGS GAGE	61	25	54868	54134	55173	55173	57369	0.00	3.98
POMPTON INLET TUNNEL DIVERSION	--	99600	N/A	N/A	N/A	N/A	28709	-	-
POMPTON RIVER BELOW TUNNEL DIVERSION	--	25D	54868	54134	55173	55173	28660	0.00	-48.05
POMPTON RIVER AT LINCOLN PARK - PEQUANNOCK TOWN LINE	62	26	50454	50944	54047	52124	26315	-3.56	-51.31
POMPTON RIVER AT EAST-WEST DITCH	--	30	51688	52239	55457	53438	27677	-3.64	-50.09
POMPTON RIVER ABOVE PACKANACK BROOK	--	31	47710	48146	50201	49079	25492	-2.24	-49.22
POMPTON RIVER AT PACKANACK BROOK	--	33	48019	48463	50547	49406	25855	-2.26	-48.85
POMPTON RIVER AT MOUTH	68	34	47935	48389	50525	49307	25740	-2.41	-49.05
PASSAIC RIVER AT PINE BROOK	37	23	24243	24886	27188	25950	25950	-4.55	-4.55
PASSAIC RIVER ABOVE POMPTON	40	24	19832	20323	21934	20777	16961	-5.27	-22.67
PASSAIC RIVER BELOW POMPTON	69	35	43435	43746	50265	44587	26299	-11.30	-47.68
DEEPAVAAL BROOK	73	38	4548	4592	4616	4616	4616	0.00	0.00
PASSIAC RIVER AT LITTLE FALLS	76	41	44406	44766	51306	45628	27565	-11.07	-46.27
TWO BRIDGES TUNNEL DIVERSION			N/A	N/A	N/A	N/A	14810	-	-
BYPASS FLOW D/S OF LITTLE FALLS			44406	44766	51306	45628	27565	-11.07	-46.27
LOWER VALLEY									
AT PECKMAN RIVER	--	100	44439	44806	51362	45659	27744	-11.10	-45.98
AT GREAT FALLS	82	200	44490	44870	51455	45737	27970	-11.11	-45.64
AT DIAMOND BROOK	--	300	44533	44923	51535	45796	28188	-11.14	-45.30
AT DUNDEE DAM	--	400	44509	44909	51477	45768	28185	-11.09	-45.25
AT SADDLE RIVER	--	500	45137	45610	52834	46532	32209	-11.93	-39.04
AT THIRD RIVER	--	600	45106	45612	52797	46546	33808	-11.84	-35.97
TUNNEL DISCHARGE	--	6000	N/A	N/A	N/A	N/A	31743	N/A	N/A
AT SECOND RIVER	104	700	45236	45777	53030	46726	64810	-11.89	22.21
AT MOUTH	--	800	45243	45817	53040	46789	62406	-11.79	17.66

N/A = Not Applicable
Q1 = Existing Conditions.
Q4 = Effects of Urbanization and Development in the Central Basin floodplain with NJDEP 20% fill rule to year 1990.
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Q6 = Q5 Modified to preserve specified floodplain areas in the Central Basin beginning 1990.
Q25 = Dual Inlet Tunnel Plan. Peak flows do not contain mitigation bypass flow downstream of inlets.

TABLE 39 DUAL INLEIT TUNNEL PLAN COMPARISON - 100 YEAR EVENT

	2040 w/o Project Conditions		Total Diversion [1]			Dual Inlet Plan		
	Flow	Hour	Flow	Hour	Red	Flow	Hour	Red
CENTRAL BASIN								
Pompton River	32907	33	33880	33	(-3) [3]	33880	33 [3]	(-3)
Tunnel diversion	-	-	33880	33	-	28709	29	-
Flow Downstream of Tunnel	32907	33	0	-	100	5171	33	84
Below Packanack Brook	30821	44	4095	20	87	5191	41	83
Mouth of Pompton R.	30802	49	4073	26	87	5180	47	93
Passaic River Down stream of Two Bridges	32547	55	11946	75	63	12544	73	61
Flow at Two Bridges Inlet	33053	57	12532	76	62	13098	76	60
Tunnel Diversion	-	-	12532	76	-	12998 [2]	76	-
LOWER VALLEY								
Flow Downstream of Tunnel - Little Falls	33053	57	0	-	100	9232	39	72

TABLE 39 DUAL INLET TUNNEL PLAN COMPARISON - 100 YEAR EVENT (CONT)

	2040 w/o Project Conditions		Total Diversion 1/			Dual Inlet Plan		
	Flow	Hour	Flow	Hour	Red	Flow	Hour	Red
Below Peckman R.	8663	19	3939	17	88	4039	17	-
- West Paterson	33085	58		-	-	9496	40	71
Below great Falls	12024	19	8501	18	74	8601	18	-
- Paterson	33123	59	-	-	-	9768	40	71
Below Dundee Dam	14917	21	12302	20	63	12402	20	63
- Garfield	33098	63	-	-	-	10387	42	-
Below Saddle R.	20956	21	18792	21	44	18892	21	44
Wallington	33621	64	-	-	-	16371	38	-
Below Third R.	23040	23	50000+ 4/	-	-	49998 4/	24	(-49)
Nutley,	33592	66				46626	46	-
- Clifton								
Below Second R.	25070	23	50000+ 4/	-	-	50543 4/	25	(-50)
- Newark	33706	66	-	-	-	46946	46	-

NOTES: (1) Total diversion is shown at both the Pompton River and Little Falls inlets.

(2) At the time of peak bypass flow downstream of Little Falls, no diversion is possible due to the complete utilization of the tunnel at the Pompton Inlet. Diversion at other times is limited ony by the difference between the flow diverted at the Pompton River and the design capacity of the tunnel, which is over 30,000 cfs with no Pompton flow diversion. This capacity at Little Falls is thus often more than adequate to prevent damaging flood flows.

(3) Minus sign (-) means net increase in flows.

(4) Flow includes tunnel discharge and exceeds 2040 without plan condition.

TABLE 40

IMPACT OF PLAN OF IMPROVEMENT
ON HISTORIC STORMS

NODE	SITE	1903 FLOOD WITHOUT PLAN (HRS)	1903 FLOOD WITHOUT PLAN (CFS)	1903 FLOOD WITH PLAN (HRS)	1903 FLOOD WITH PLAN (CFS)	TRANSPOSED "AGNES" FLOOD WITHOUT PLAN (HRS)	TRANSPOSED "AGNES" FLOOD WITHOUT PLAN (CFS)	TRANSPOSED "AGNES" FLOOD WITH PLAN (HRS)	TRANSPOSED "AGNES" FLOOD WITH PLAN (CFS)	1984 FLOOD WITHOUT PLAN (HRS)	1984 FLOOD WITHOUT PLAN (CFS)	1984 FLOOD WITH PLAN (HRS)	1984 FLOOD WITH PLAN (CFS)
25	POMPTON PLAINS	38	28879	38	28972	38	68997	38	72510	40	24177	40	24611
	TUNNEL DIVERSION			38	28472			38	28709			40	24611
	BYPASS			9-24	500			38	43801			1	500
25	BELOW POMPTON GAGE	40	28818	24	1499	41	68265	41	41999	42	23839	20	630
33	POMPTON BELOW PCNCK	50	27975	31	6320	53	62983	48	40908	55	21317	33	1381
24	GREAT PIECE OUTFLOW	92	14540	86	13025	104	23234	100	18618	98	8722	91	6350
35	TWO BRIDGES OUTFLOW	59	29844	57	14919	62	63872	54	45125	64	21101	90	6952
41	LITTLE FALLS		31005	57	16403	65	65047	57	46564	67	21259	90	7076
	TUNNEL DIVERSION			92	14850			120	14491			90	6976
41	BYPASS			38	14561			57	46209				100
100	BELOW PECKMAN R.	62	31095	39	14983	65	65033	57	46391	67	21285	20	1991
200	S.U.M. DAM	63	31259	40	15516	67	65327	59	46635	69	21308	20	3646
300		64	31444	41	16234	68	65531	60	46946	70	21336	20	5419
400	DUNDEE DAM	66	31524	43	16544	70	65519	62	46890	72	21318	22	5697
500	BELOW SADDLE R.	32	33828	33	24364	70	66849	61	51288	73	21698	22	9018
600	BELOW THIRD R.	32	36843	33	27119	72	66938	63	51383	75	21686	24	9730
600D	RECALL OF DIVERSION			47	31730			68	31662			40	29064
600C	BELOW TUNNEL MOUTH			32	57865			63	80447			38	35084
700	BELOW SECOND RIVER	32	40175	32	61500	74	67248	64	80924	77	21731	39	35443
800	PASSAIC AT MOUTH	35	40644	35	61874	78	67257	70	80924	81	21689	44	35226

TABLE 41

STATISTICAL PARAMETERS
DISCHARGE-FREQUENCY RELATIONS
PRINCIPAL GAGES
PASSAIC RIVER BASIN, N.J.

GAGING STATION	STATION #	SOURCE	MEAN	STD. DEV.	CMPTD. SKEW	GNLZD. SKEW	ADPTD. SKEW
PASSAIC RIVER AT CHATHAM	3795	(A)	3.1265	0.1765	0.3323	0.3000	0.3000
		(B)					
		(C)					
ROCKAWAY RIVER ABOVE BOONTON RESERVOIR	3805	(A)	3.2957	0.2162	0.1788	0.3000	0.2000
		(B)	3.3032	0.2244	0.3081	0.3000	0.3000
		(C)					
ROCKAWAY RIVER BELOW BOONTON RESERVOIR	3810	(A)	3.1442	0.2699	-0.5857	0.3000	-0.3000
		(B)	3.1639	0.2564	0.1834	0.3000	0.2000
		(C)					
WHIPPANY RIVER AT MORRISTOWN	3815	(A)	2.9326	0.2049	-0.1121	0.3000	0.0000
		(B)	2.9383	0.2097	-0.0490	0.3000	0.0000
		(C)					
MAHWAH RIVER NEAR SUFFERN	38475	(A)	2.7580	0.2785	0.2223	0.4000	0.3000
		(B)	2.7672	0.2854	0.3177	0.4000	0.3000
		(C)	2.712	0.262	0.500		
RAMAPO RIVER AT MAHWAH	3875	(A)	3.4830	0.2767	0.5999	0.4000	0.5000
		(B)					
		(C)					
RAMAPO RIVER AT POMPTON LAKES	3880	(A)	3.5515	0.2745	0.3534	0.4000	0.4000
		(B)	3.5597	0.2821	0.3963	0.4000	0.4000
		(C)					
POMPTON RIVER AT POMPTON PLAINS	3885	(A)	3.7358	0.2956	-0.0827	0.4000	0.1000
		(B)	3.7448	0.3033	0.0145	0.4000	0.1000
		(C)					
PASSAIC RIVER AT LITTLE FALLS	3895	(A)	3.8707	0.2027	0.5150	0.4000	0.5000
		(B)					
		(C)					
SADDLE RIVER AT LODI	3915	(A)	3.1476	0.2321	0.0224	0.4000	0.1000
		(B)	3.1825	0.2409	0.1574	0.4000	0.2000
		(C)					

(A) SYSTEMATIC RECORD.
(B) ADJUSTED FOR HISTORICAL EVENT.
(C) TWO-STATION CORRELATION.

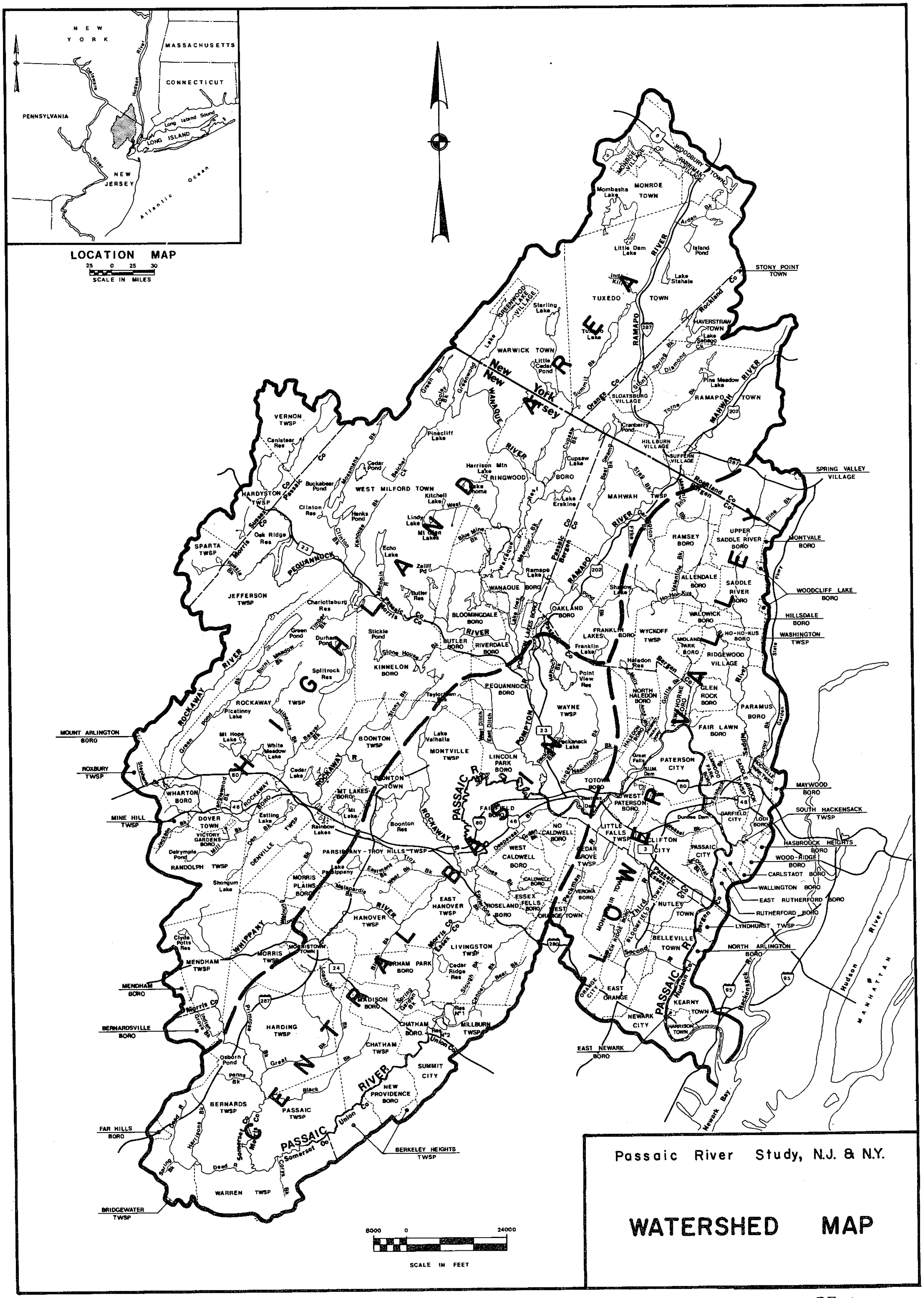
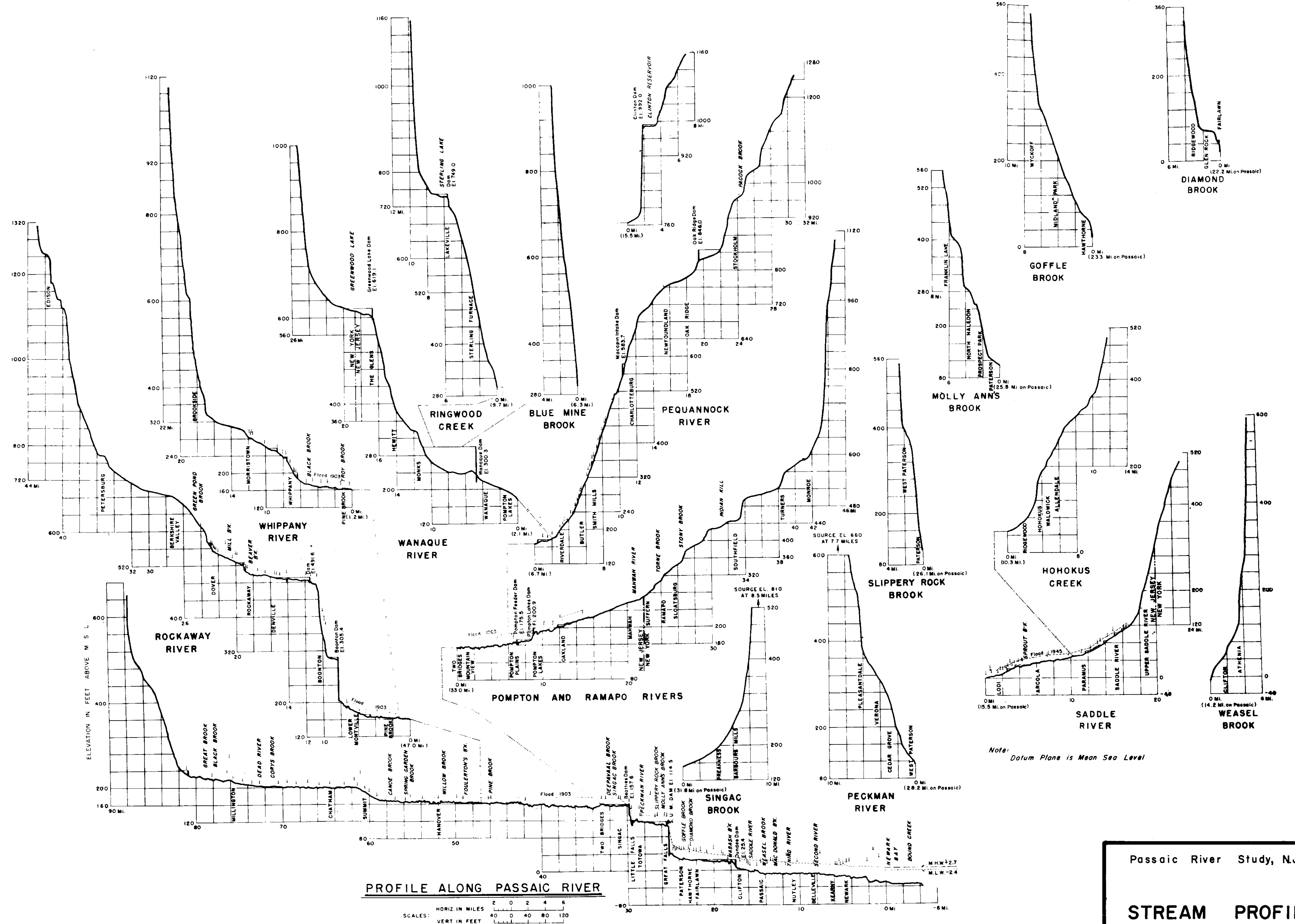

Passaic River Study, N.J. & N.Y.
WATERSHED MAP
LOCATION MAP
SCALE IN MILES
SCALE IN FEET
NEW YORK
MASSACHUSETTS
CONNECTICUT
PENNSYLVANIA
NEW JERSEY
LONG ISLAND
Long Island Sound
Atlantic Ocean
HIGHLANDS AREA
CENTRAL BASIN
LOWER VALLEY
New York
New Jersey
PASSAIC RIVER
POMPTON RIVER
RAMAPO RIVER
WANAQUE RIVER
PEQUANNOCK RIVER
ROCKAWAY RIVER
WHIPPANY RIVER
SADDLE RIVER
HACKENSACK RIVER
Hudson River
MANHATTAN
Newark Bay
MONROE TOWN
TUXEDO TOWN
WARWICK TOWN
RAMAPO TOWN
STONY POINT TOWN
HAVERSTRAW TOWN
SPRING VALLEY VILLAGE
VERNON TWSP
HARDYSTON TWSP
SPARTA TWSP
JEFFERSON TWSP
WEST MILFORD TOWN
RINGWOOD BORO
MAHWAH TWSP
RAMSEY BORO
UPPER SADDLE RIVER BORO
MONTVALE BORO
WOODCLIFF LAKE BORO
HILLSDALE BORO
WASHINGTON TWSP
WANAQUE BORO
OAKLAND BORO
FRANKLIN LAKES BORO
WYCKOFF TWSP
RIDGEWOOD VILLAGE
PARAMUS BORO
FAIR LAWN BORO
KINNELON BORO
ROCKAWAY TWSP
BOONTON TWSP
MONTVILLE TWSP
WAYNE TWSP
PATERSON CITY
MOUNT ARLINGTON BORO
ROXBURY TWSP
WHARTON BORO
MINE HILL TWSP
DOVER TOWN
RANDOLPH TWSP
DENVILLE TWSP
PARSIPPANY - TROY HILLS TWSP
HANOVER TWSP
EAST HANOVER TWSP
LIVINGSTON TWSP
MORRISTOWN TOWN
MENDHAM TWSP
MENDHAM BORO
BERNARDSVILLE BORO
HARDING TWSP
CHATHAM TWSP
SUMMIT CITY
NEW PROVIDENCE BORO
BERNARDS TWSP
PASSAIC TWSP
FAR HILLS BORO
WARREN TWSP
BRIDGEWATER TWSP
BERKELEY HEIGHTS TWSP
CLIFTON CITY
PASSAIC CITY
NUTLEY TOWN
BELLEVILLE TOWN
EAST ORANGE
NEWARK CITY
KEARNY TOWN
HARRISON TOWN
EAST NEWARK BORO
MAYWOOD BORO
SOUTH HACKENSACK TWSP
HASBROUCK HEIGHTS BORO
WOOD-RIDGE BORO
CARLSTADT BORO
WALLINGTON BORO
EAST RUTHERFORD BORO
RUTHERFORD BORO
LYNDHURST TWSP
NORTH ARLINGTON BORO

FIGURE 1



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

STREAM PROFILES

FIGURE 2

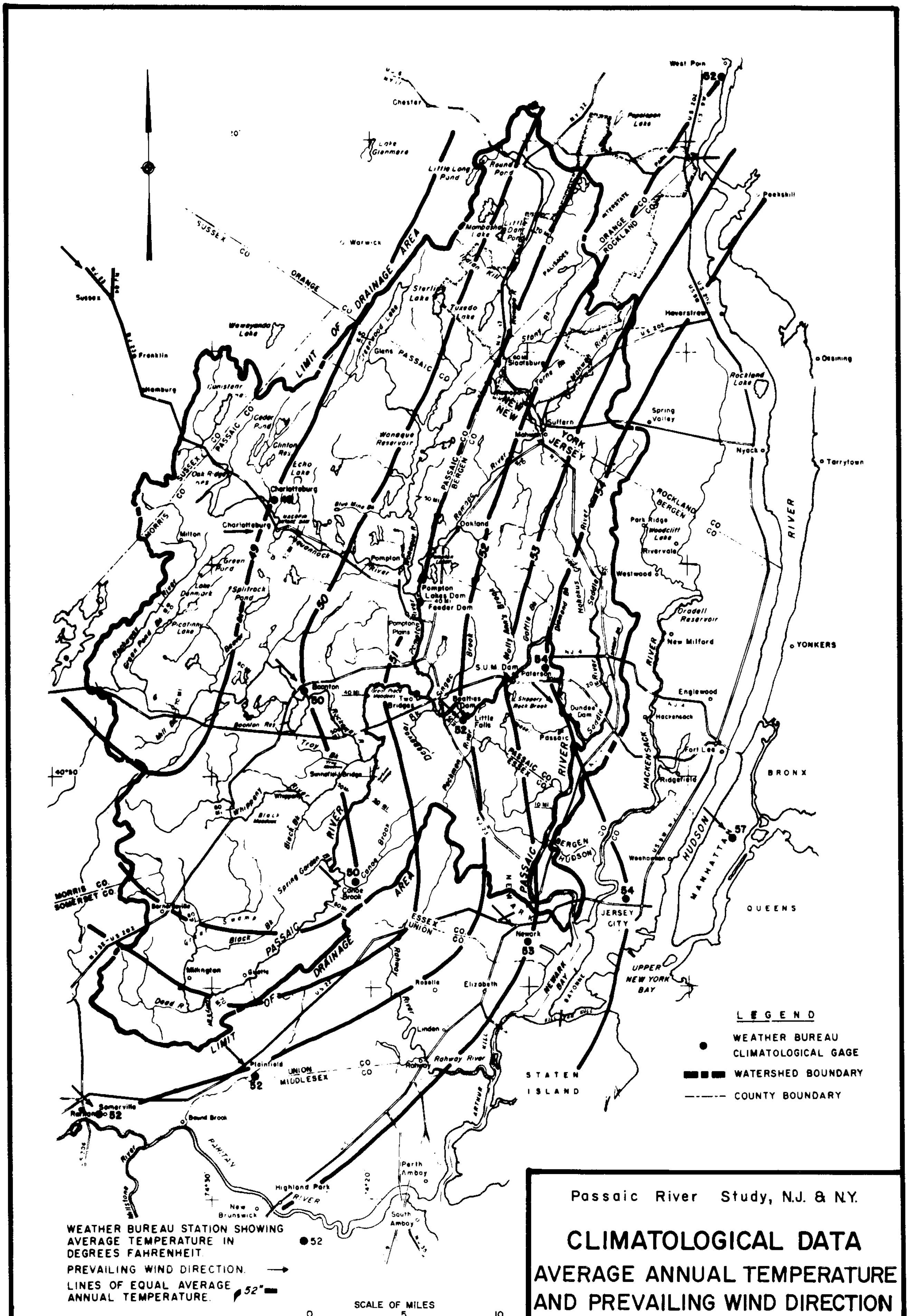
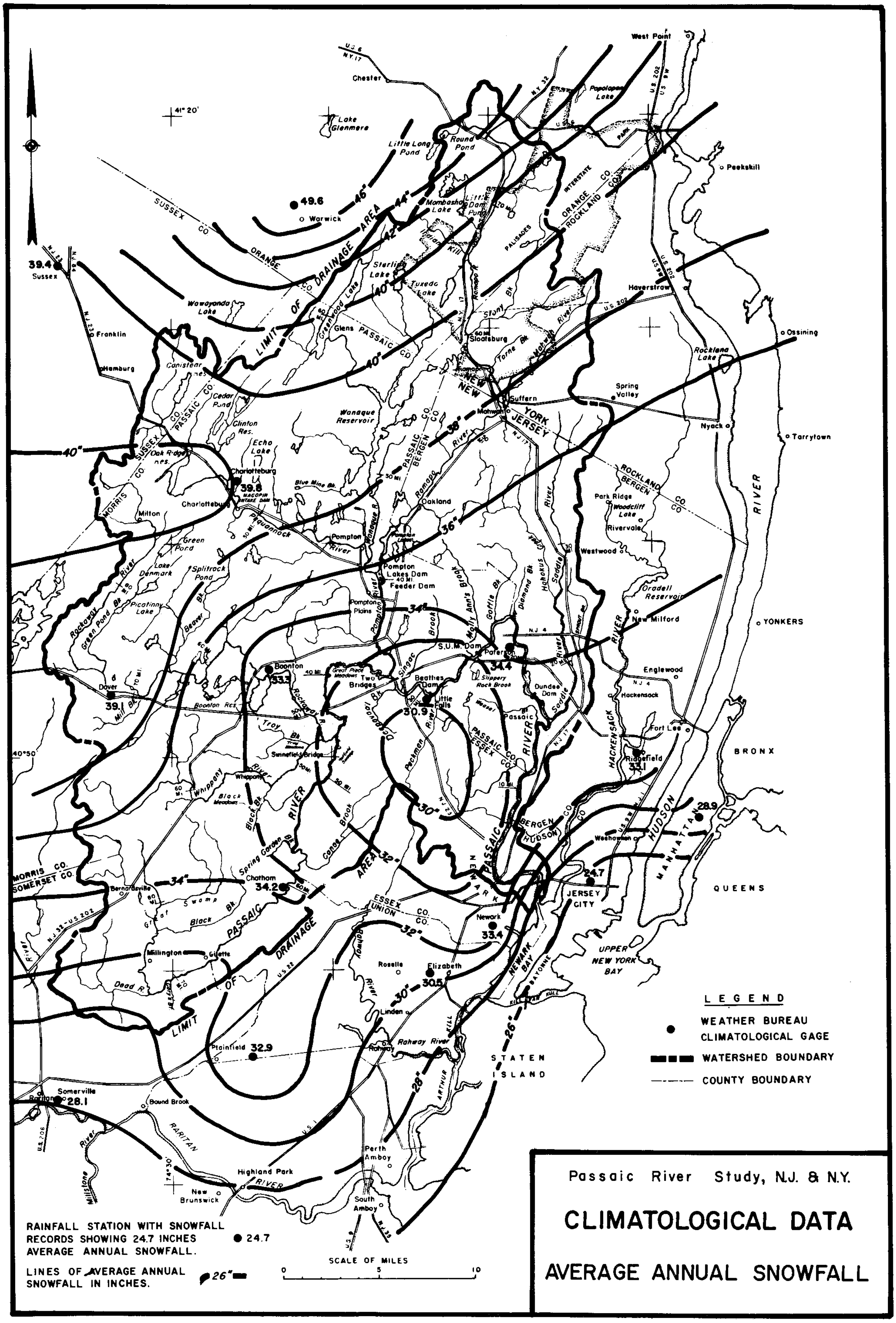

Passaic River Study, N.J. & N.Y.
CLIMATOLOGICAL DATA
AVERAGE ANNUAL TEMPERATURE
AND PREVAILING WIND DIRECTION
LEGEND
WEATHER BUREAU CLIMATOLOGICAL GAGE
WATERSHED BOUNDARY
COUNTY BOUNDARY
WEATHER BUREAU STATION SHOWING AVERAGE TEMPERATURE IN DEGREES FAHRENHEIT
52
PREVAILING WIND DIRECTION
LINES OF EQUAL AVERAGE ANNUAL TEMPERATURE
52°
SCALE OF MILES
0
5
10
LIMIT OF DRAINAGE AREA
PASSAIC RIVER
HUDSON RIVER
HACKENSACK RIVER
NEW YORK
NEW JERSEY
STATEN ISLAND
UPPER NEW YORK BAY
MANHATTAN
BRONX
QUEENS
YONKERS
Newark
JERSEY CITY
Paterson
Plainfield
Somerville
Boonton
Suffern
West Point
Peekskill
Haverstraw
Nyack
Tarrytown
Ossining
Charlottesburg
Elizabeth
Perth Amboy
New Brunswick

FIGURE 3



Passaic River Study, N.J. & N.Y.
CLIMATOLOGICAL DATA
AVERAGE ANNUAL SNOWFALL
LEGEND
WEATHER BUREAU CLIMATOLOGICAL GAGE
WATERSHED BOUNDARY
COUNTY BOUNDARY
RAINFALL STATION WITH SNOWFALL RECORDS SHOWING 24.7 INCHES AVERAGE ANNUAL SNOWFALL.
24.7
LINES OF AVERAGE ANNUAL SNOWFALL IN INCHES.
26"
SCALE OF MILES
0
5
10
LIMIT OF DRAINAGE AREA
49.6
Warwick
39.4
Sussex
39.8
Charlotteburg
39.1
Dover
33.3
Boonton
34.4
Paterson
30.9
Little Falls
33.1
Ridgefield
28.9
24.7
JERSEY CITY
34.2
Chatham
33.4
Newark
30.5
Elizabeth
32.9
Plainfield
28.1
Somerville

FIGURE 4

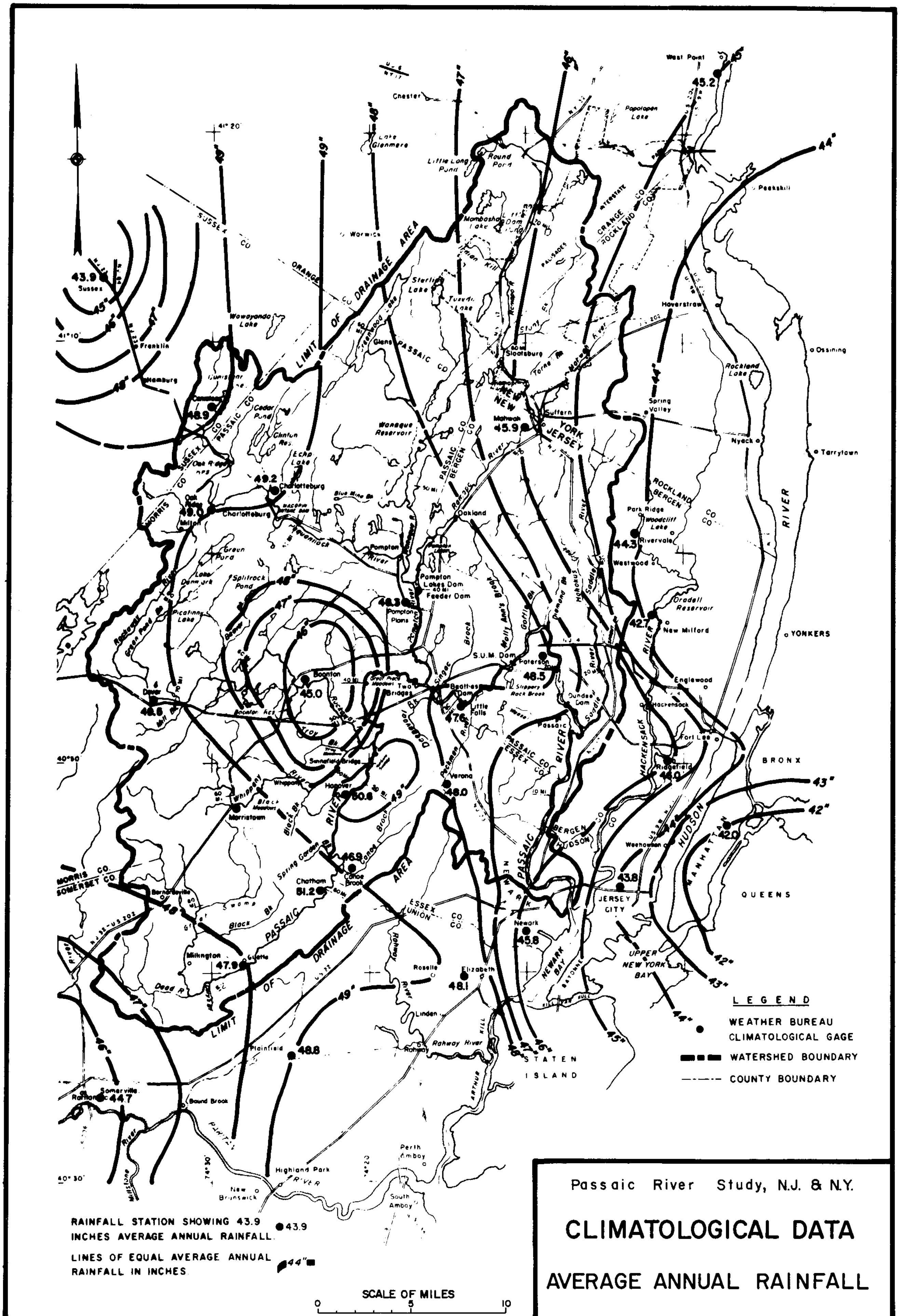

Passaic River Study, N.J. & N.Y.
CLIMATOLOGICAL DATA
AVERAGE ANNUAL RAINFALL
LEGEND
WEATHER BUREAU CLIMATOLOGICAL GAGE
WATERSHED BOUNDARY
COUNTY BOUNDARY
RAINFALL STATION SHOWING 43.9 INCHES AVERAGE ANNUAL RAINFALL. 43.9
LINES OF EQUAL AVERAGE ANNUAL RAINFALL IN INCHES 44"
SCALE OF MILES
0 5 10
LIMIT OF DRAINAGE AREA
NEW YORK
NEW JERSEY
STATEN ISLAND
BRONX
QUEENS
MANHATTAN
HUDSON RIVER
UPPER NEW YORK BAY
NEWARK BAY

FIGURE 5

RAIN GAGES

Nº	STREAM	LOCATION	GAGE EL. FT. MSL.	TYPE GAGE	AGENCY
1	Passaic	Newark	11	R	WB
2	Coast	Jersey City	135	NR	WB
3	Hackensack	Ridgefield	80	NR	WB
4	DO	New Milford	12	R	WB
5	DO	Woodcliff Valley, NY	103	R	WB
6	DO	Spring Valley, NY	454	R	WB
7	Passaic	Paterson	100	NR	WB
8	DO	Little Falls	150	R	WB
9	DO	Cedar Grove	400	NR	WB
10	DO	Rutherford	51	NR	WB
11	DO	Pompton Plains	195	NR	WB
12	DO	Mahwah	253	NR	WB
13	DO	Palisade Park, NY	1050	R	EO
14	DO	Southfields, NY	450	R	EO
15	DC	Raymond Dam (Wanaque)	320	R	WB
16	DO	Ringwood	305	NR	WB
17	DO	Greenwood Lake	560	NR	WB
18	DO	Macopin Dam	584	NR	WB
19	DO	Charlotteburg	760	NR	WB
20	DO	Newfoundland	780	NR	NW
21	DO	Ocean Park	1060	NR	WB
22	DO	Oak Ridge Reservoir	870	NR	WB
23	DO	Canister Reservoir	1040	NR	WB
24	DO	Milton	950	NR	WB
25	DO	Morris Plains	500	NR	WB
26	DO	Boonton	280	NR	WB
27	DO	Brook Valley	680	R	EO
28	DO	Rockaway	522	R	EO
29	DO	Split Rock Pond	800	NR	WB
30	DO	Dover	600	NR	WB
31	DO	Bowling Green Mtn	940	R	EO
32	DO	Hanover	213	NR	WB
33	DO	Morristown Mun. Bldg	352	R	NW
34	DO	Morristown Res	680	R	EO
35	DO	Roseland	369	NR	WB
36	DO	Verona	490	NR	WB
37	DO	Orange	140	R	WB
38	DO	Canoe Brook	180	NR	WB
39	DO	Chatham	185	NR	WB
40	DO	Gillette	400	NR	WB
41	DO	Millington	382	R	EO
42	DO	Suffern, NY	290	NR	WB
43	DO	Midland Park	210	NR	WB
44	DO	Allendale	270	R	WB
45	DO	Bernardsville	240	NR	WB
46	DO	Essex Falls	250	R	WB
47	DO	West Wharton	680	NR	WB
48	Hudson	Sussex	440	NR	WB
49	Delaware	Newtown	565	R	WB
50	Raritan	Somerville	75	NR	WB
51	DO	Watchung	120	R	WB
52	DO	Plainfield	120	NR	WB
53	Rahway	Westfield	138	R	WB
54	DO	Springfield	85	R	WB
55	Coast	Elizabeth	33	NR	WB
56	DO	Elizabethport	10	R	WB
57	DO	New York, NY	132	R	WB
58	Hudson	West Point, NY	360	NR	EO
59	DO	Warwick, NY	680	NR	WB
60	DO	Bear Mountain, NY	1260	R	WB

STREAM GAGES

Nº	STREAM	LOCATION	DRAINAGE SQ.MI.	TYPE GAGE	AGENCY
1	Passaic R.	Erie RR Br. - Newark	925.9	NR	EO
2	Second R.	Belleville	11.6	R	GS
3	Passaic R.	Avondale Bridge	803.6	NR	EO
4	DO	Gregory Avenue Bridge	884.1	NR	GS
5	Weasel Br.	Clifton	0.45	R	GS
6	Saddle Br.	Lodi	54.6	R	GS
6A	HoHoKus Br.	HoHoKus	16.4	R	GS
7	DO	Ridgewood	21.6	R	GS
8	Passaic R.	Ackerman Ave Br.	810.2	NR	EO
9	DO	Dundee Dam	809.9	NR	EO
10	DO	Crooks Ave Br.	809.0	NR	EO
11	DO	Marlot Ave Br.	804.3	NR	EO
12	DO	Moffet Br - E. 19 St	798.6	NR	EO
13	DO	Straight St Br.	788.1	NR	EO
14	DO	Paterson (S.U.M. Dam)	785.0	R	GS
15	DO	Lincoln Br.	775.1	NR	EO
16	DO	Lackawanna Ave Br.	762.9	NR	EO
17	DO	Little Falls	762.0	R	GS
18	DO	Little Falls (Beatties Dam)	762.2	NR	EO
19	DO	Singac Route 23	759.8	NR	EO
20	Pompton R.	Two Bridges	378.1	NR	EO
21	DO	DL & W RR - Lincoln Park	373.1	NR	EO
22	DO	Route 23 Hwy Br.	356.4	NR	EO
23	DO	Pequannock	358.0	R	GS
24	DO	Lower Pompton Tail	353.6	NR	EO
25	DO	Upper Pompton - Head	353.8	NR	EO
26	DO	Upper Pompton - Tail	353.8	NR	EO
27	DO	Pompton Plains	355.0	R	GS
28	Pequannock R.	Macopin intake	63.7	R	GS
29	Macopin R.	Echo Lake Res.	4.35	NR	GS
30	Clinton Br.	Clinton Res.	10.5	NR	GS
31	Pequannock R.	Oak Ridge Res.	27.3	NR	GS
32	Pacock Br.	Canistear Res.	5.6	NR	GS
33	Wanaque R.	Raymond Dam	90.4	NR	GS
34	DO	Raymond Dam	90.4	R	GS
35	Blue Mine Br.	Wanaque	1.71	R	GS
36	West Br.	Wanaque	11.8	R	GS
37	Cupsaw Br.	Wanaque	4.38	R	GS
38	Wanaque R.	Monks	40.4	R	GS
39	DO	Awosting	27.1	R	GS
40	DO	Greenwood Lake	27.1	R	GS
41	Ringwood Cr.	Wanaque	19.1	R	GS
42	Ramapo R.	Pompton Lakes	160.0	R	GS
43	DO	Oakland	148.1	NR	EO
44	DO	Mahwah	118.0	R	GS
45	Passaic R.	Two Bridges	362.7	NR	EO
46	DO	Horseneck Br.	354.0	NR	EO
47	DO	Pine Brook Br.	350.4	NR	EO
48	Rockaway R.	Boonton Dam (Below)	119.0	R	GS
49	DO	Boonton Dam (Above)	116.0	R	GS
50	Beaver Br.	Split Rock Pond	5.5	R	GS
51	Whippany R.	Whippany Dam	33.6	NR	EO
52	DO	Morristown	29.4	R	GS
53	Passaic R.	Chatham	100.0	R	GS
54	DO	Stanley	100.3	R	EO
55	DO	Millington	55.4	R	GS
56	Mahwah R.	Suffern	12	R	GS

LEGEND

MAP:

- STREAM GAGE, RECORDING
- STREAM GAGE, NON-RECORDING
- RAIN GAGE

CHART: RAIN GAGES

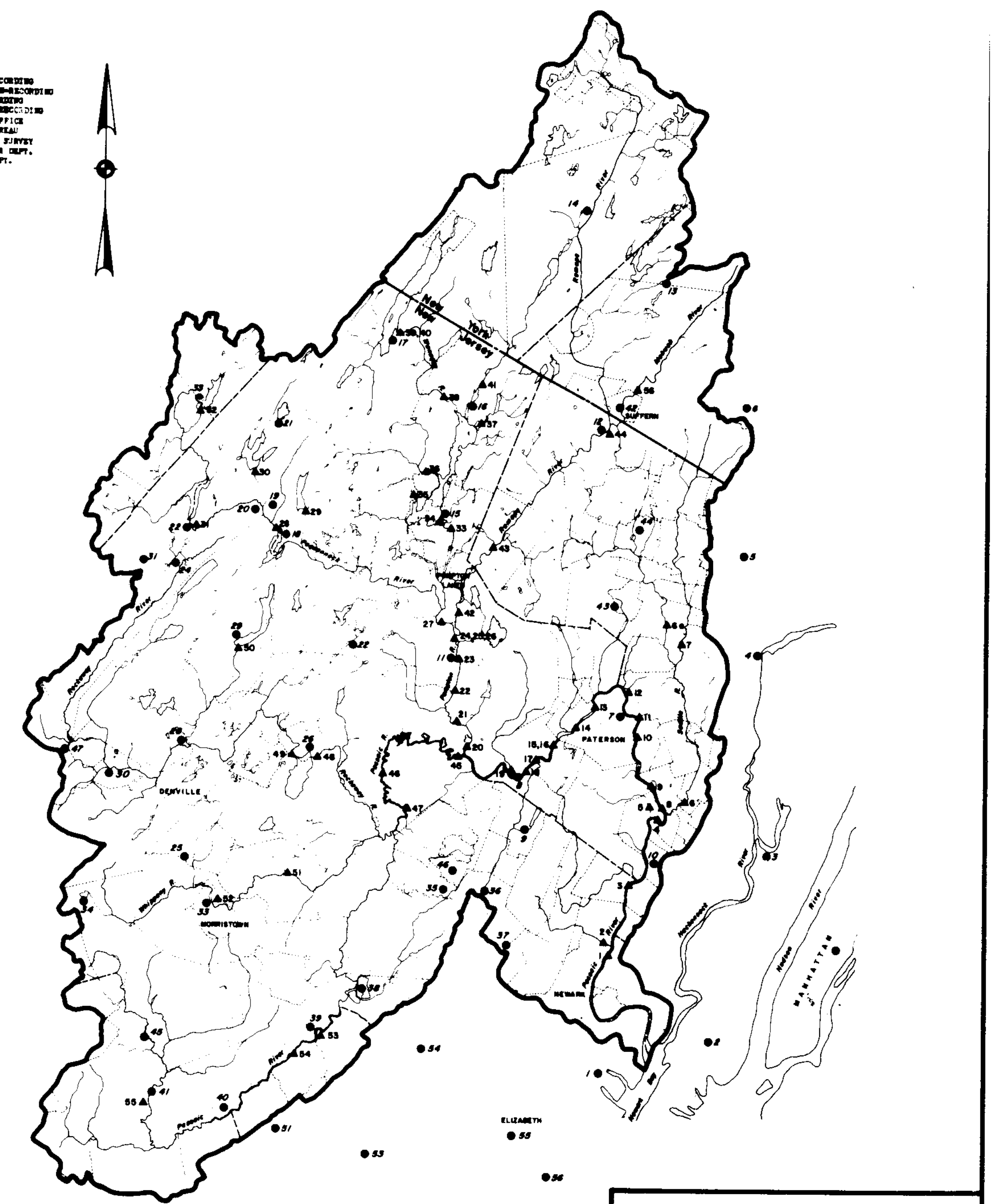
- RAINFALL READINGS

STREAM GAGES

- DISCHARGE AND STAGE READINGS
- STAGE READINGS
- OCCASIONAL STAGE READINGS

TABLE:

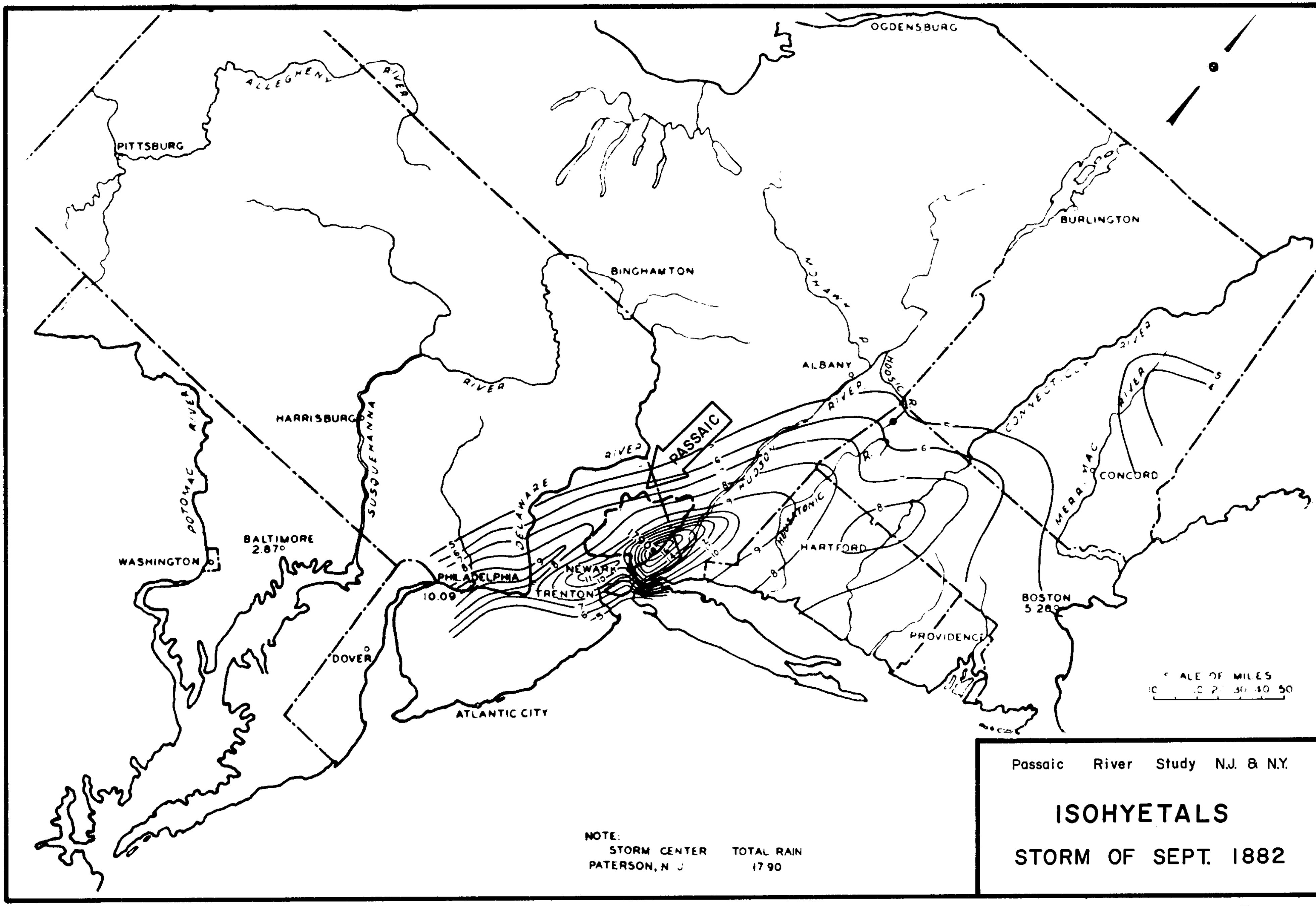
- R STREAM GAGE, RECORDING
- NR STREAM GAGE, NON-RECORDING
- R-R RAIN GAGE, RECORDING
- N-R RAIN GAGE, NON-RECORDING
- E.O. U.S. ENGINEER OFFICE
- W.B. U.S. WEATHER BUREAU
- G.S. U.S. GEOLOGICAL SURVEY
- M.W. MORRISTOWN WATER DEPT.
- N.W. NEWARK WATER DEPT.



Passaic River Study N.J. & N.Y

RAIN AND STREAM GAGES

FIGURE 6



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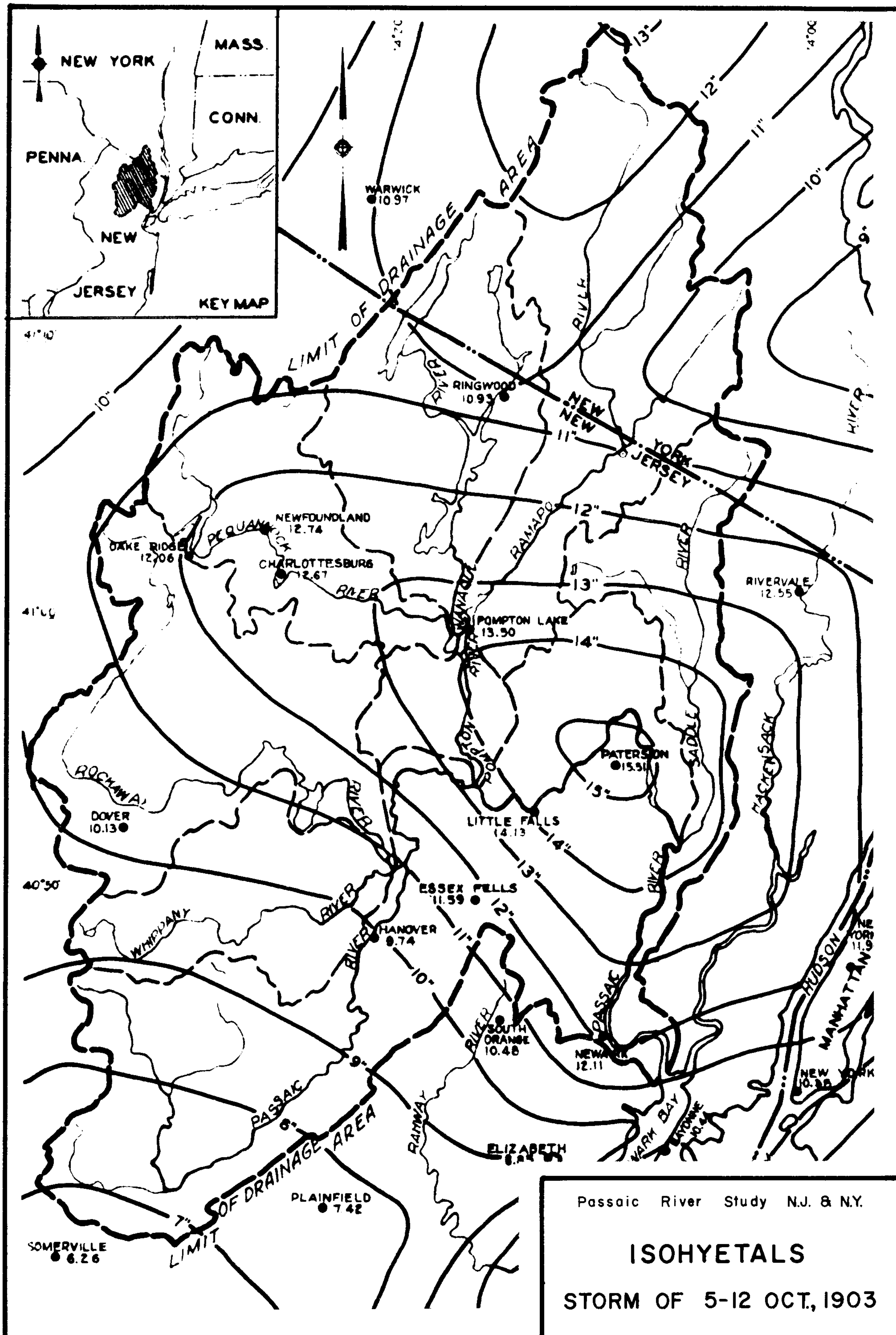
ISOHYETALS

STORM OF SEPT. 1882

FIGURE 7



NEW YORK
MASS.
CONN.
PENNA.
NEW
JERSEY
KEY MAP
LIMIT OF DRAINAGE AREA
WARWICK 10.97
RINGWOOD 10.93
NEW YORK
NEW JERSEY
NEWFOUNDLAND 12.74
OAKE RIDGE 12.06
CHARLOTTESBURG 12.67
PEQUANNOCK RIVER
RAMAPO RIVER
SADDLE RIVER
RIVERVALE 12.55
POMPTON LAKE 13.50
PATERSON 15.51
HACKENSACK
ROCKAWAY
DOVER 10.13
LITTLE FALLS 14.13
ESSEX FELLS 11.59
HANOVER 9.74
WHIPPANY RIVER
PASSAIC RIVER
SOUTH ORANGE 10.48
NEWARK 12.11
HUDSON
MANHATTAN
NEW YORK 10.38
BAYONNE 10.44
NEWARK BAY
RAHWAY
ELIZABETH
PLAINFIELD 7.42
SOMERVILLE 6.26
7"
8"
9"
10"
11"
12"
13"
14"
15"

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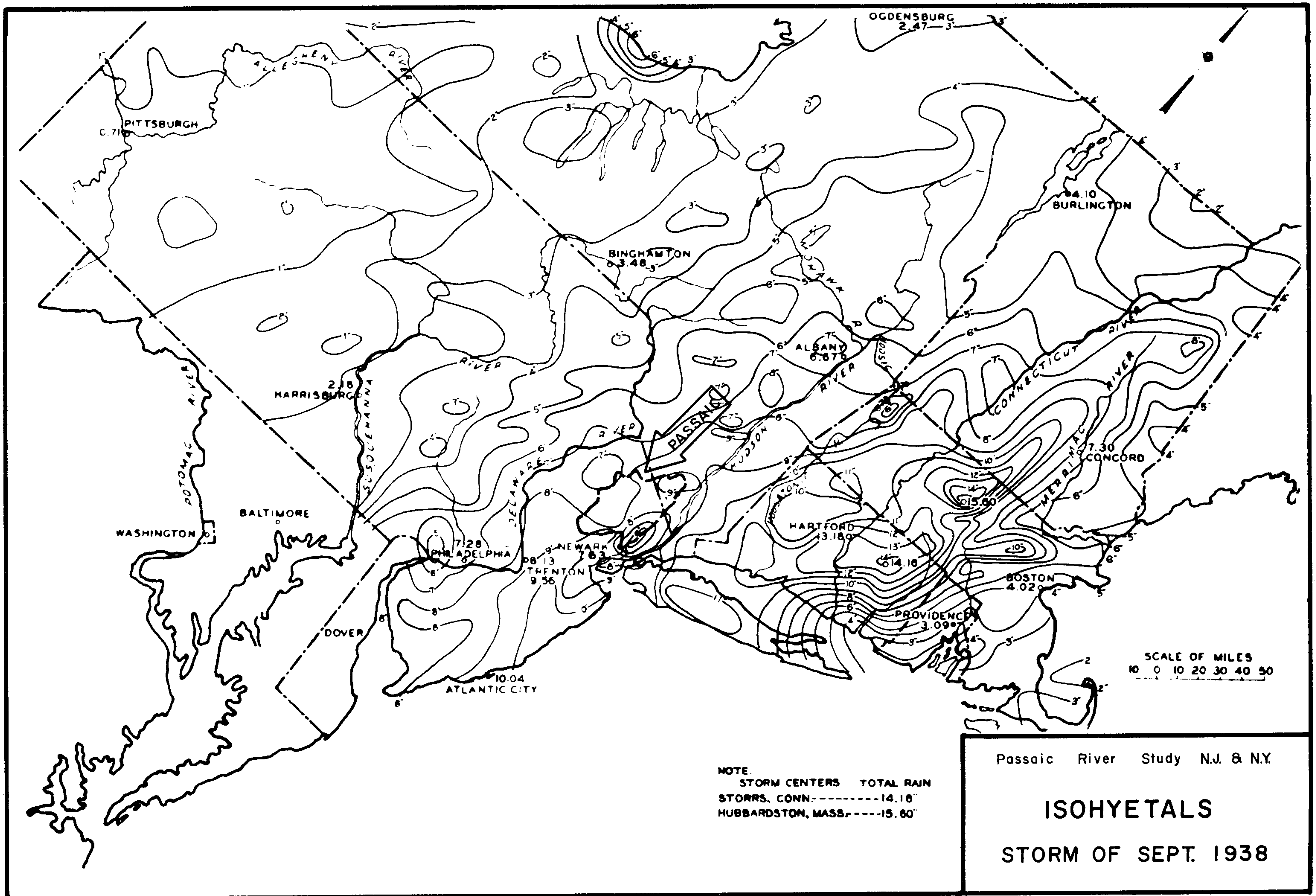
ISOHYETALS
STORM OF 5-12 OCT., 1903

FIGURE 8

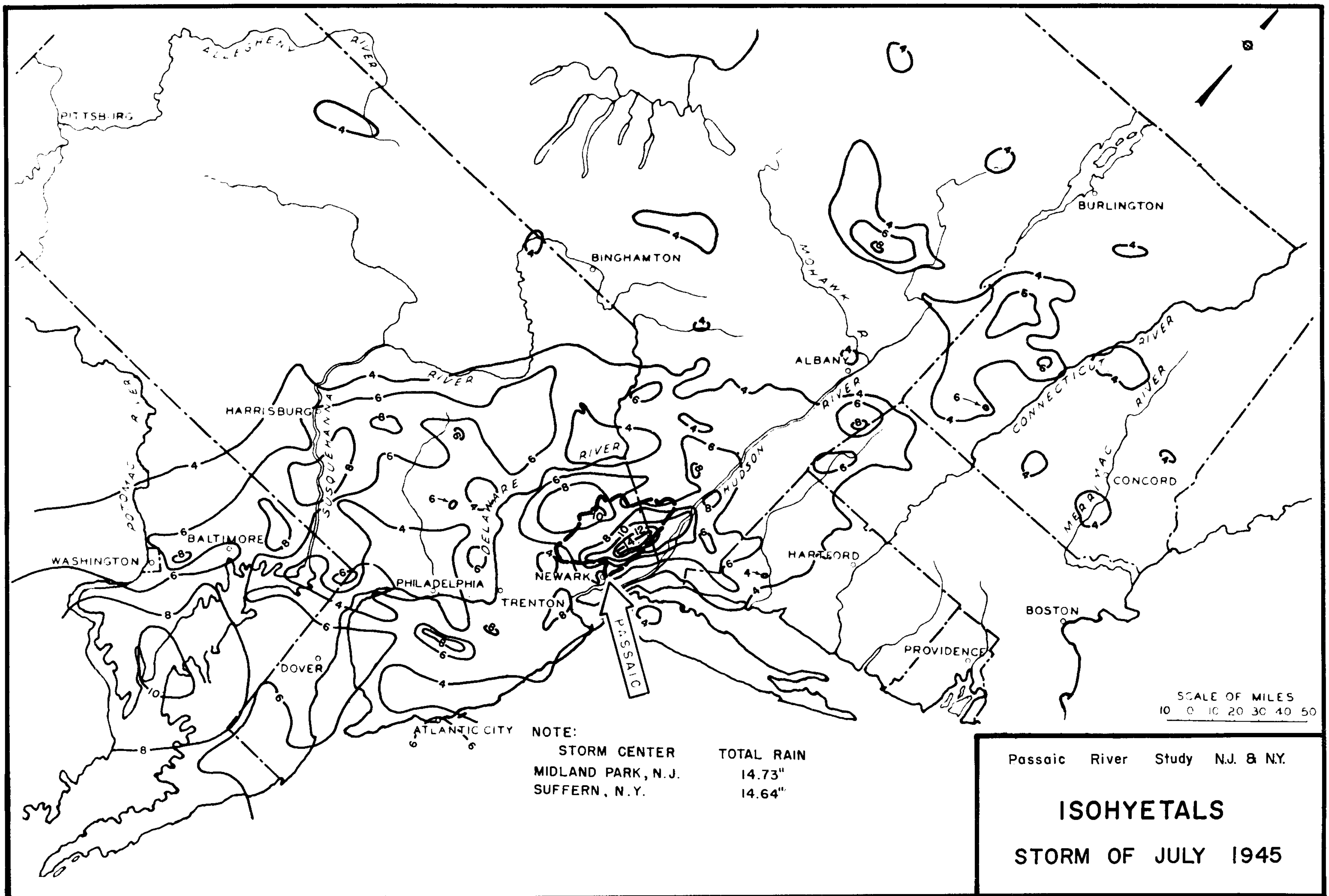


Passaic River Study N.J. & N.Y.

ISOHYETALS

STORM OF SEPT. 1938

FIGURE 9



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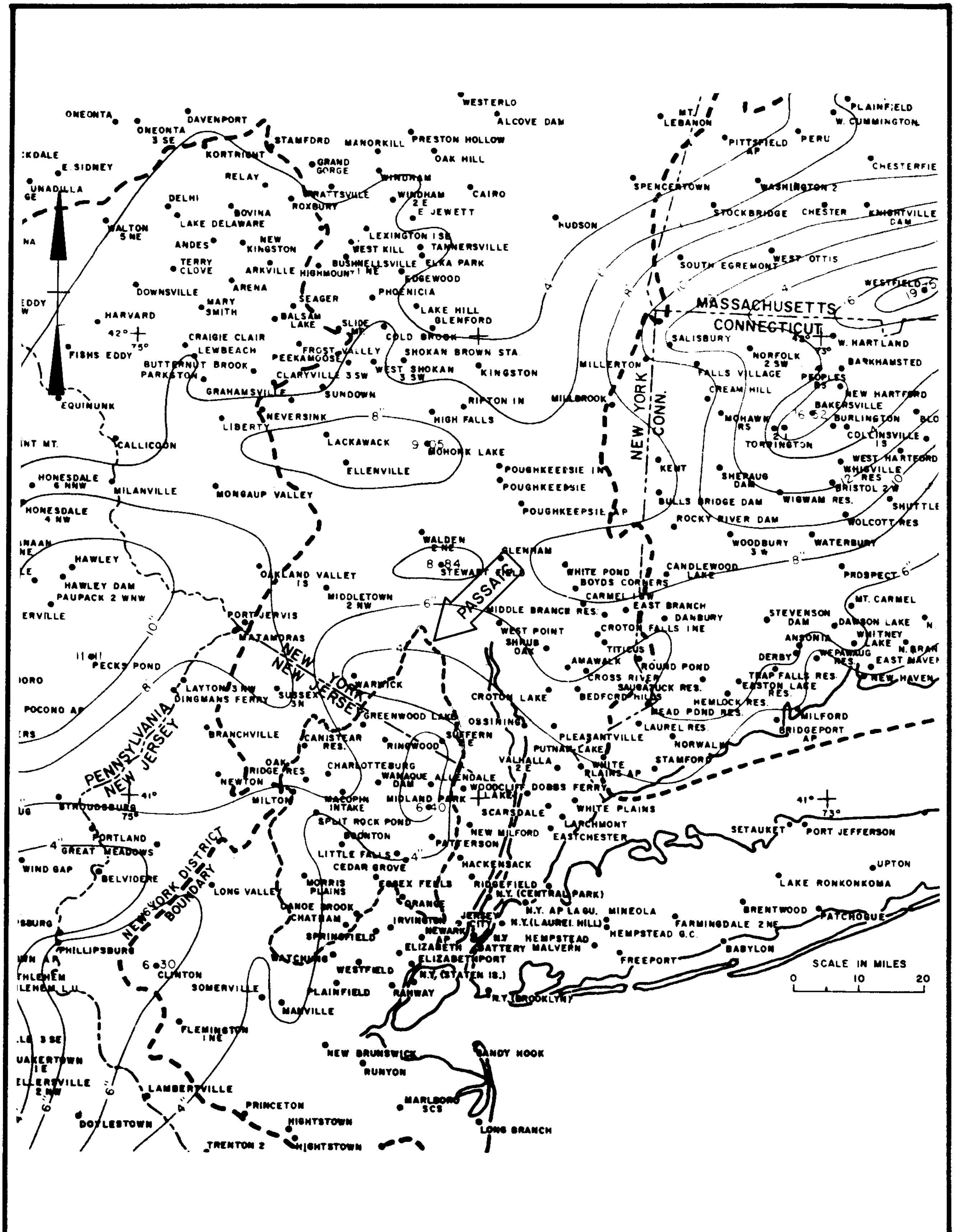
ISOHYETALS

STORM OF JULY 1945

FIGURE 10



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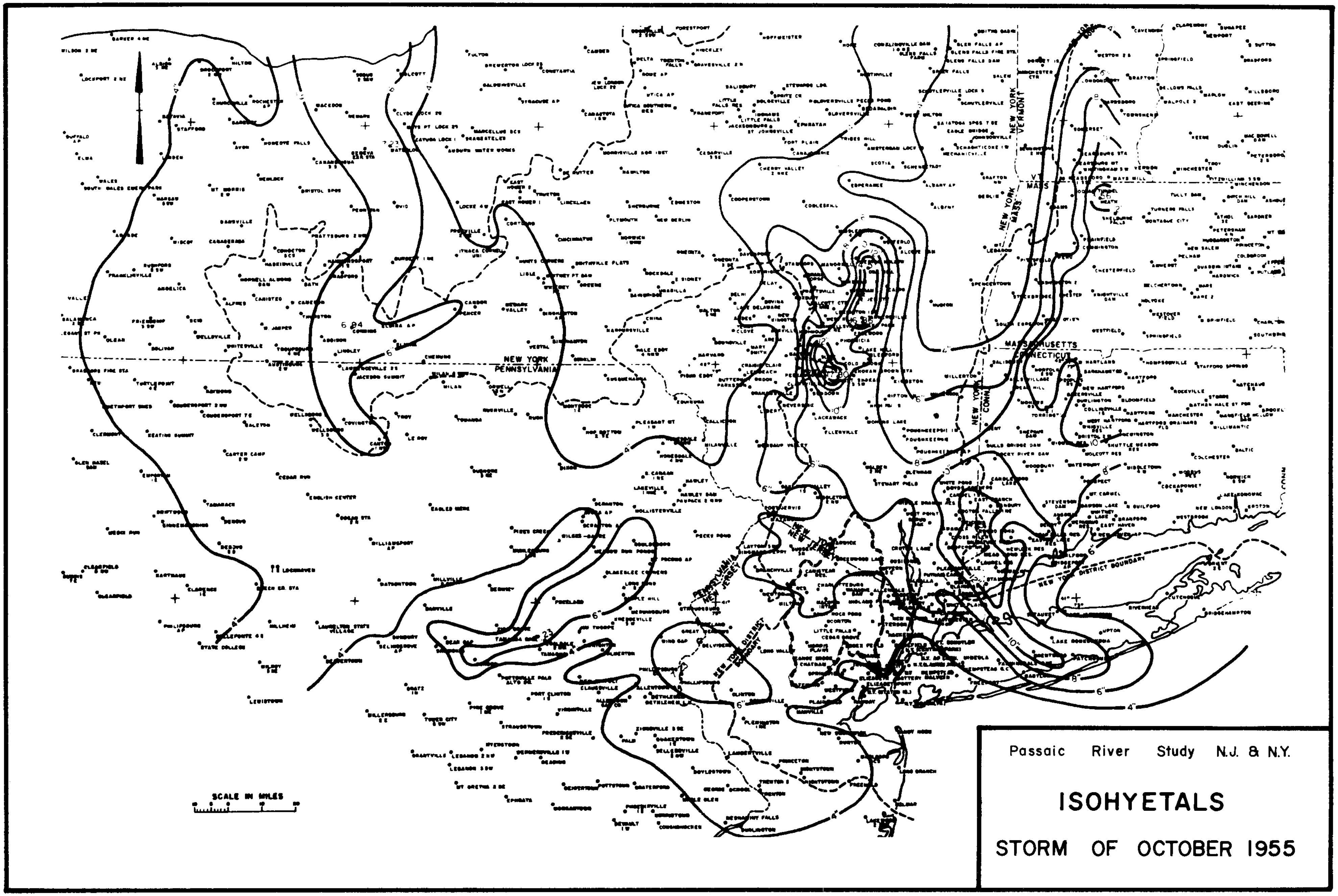
ISOHYETALS

STORM OF AUGUST 1955

FIGURE 11



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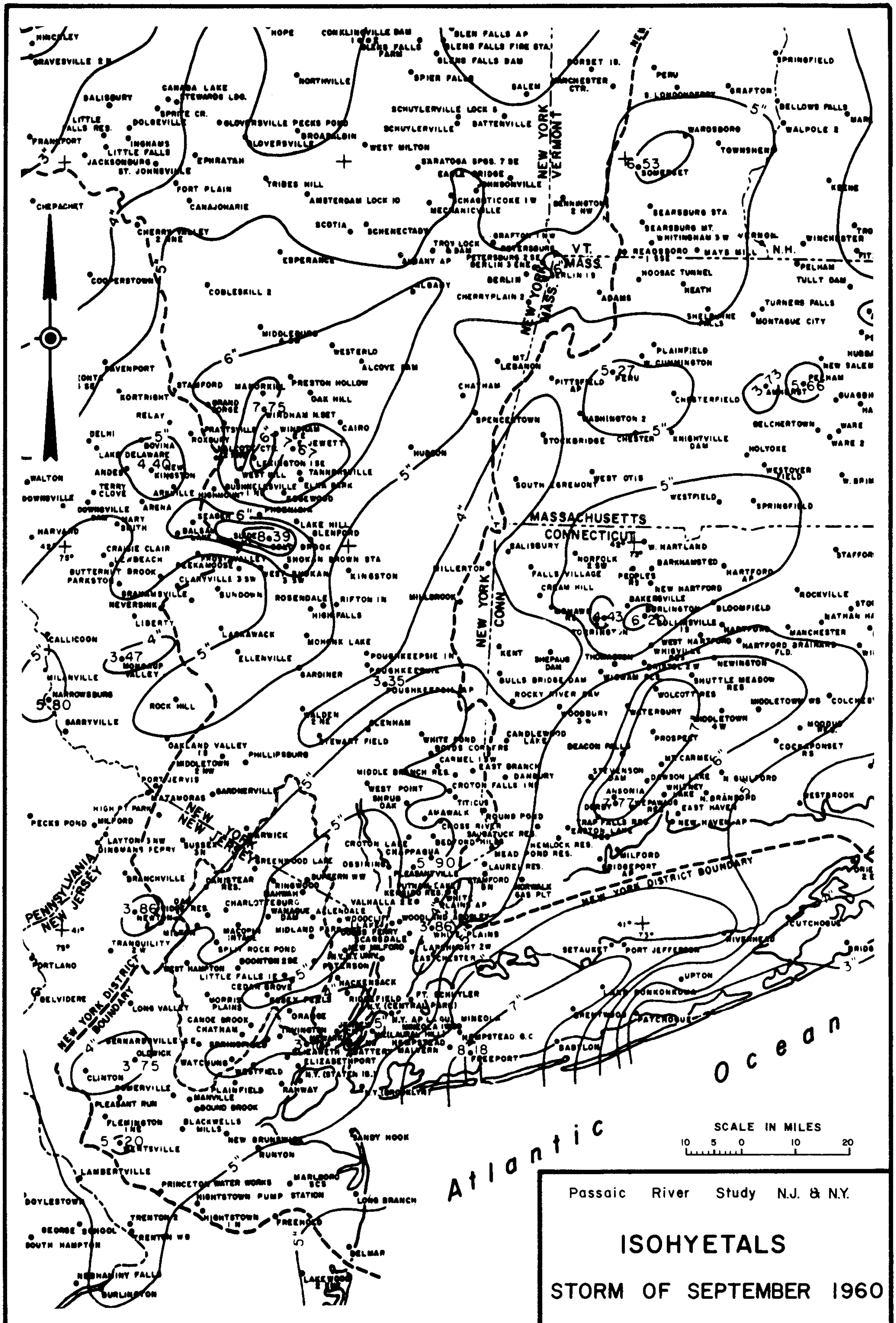
ISOHYETALS

STORM OF OCTOBER 1955

FIGURE 12



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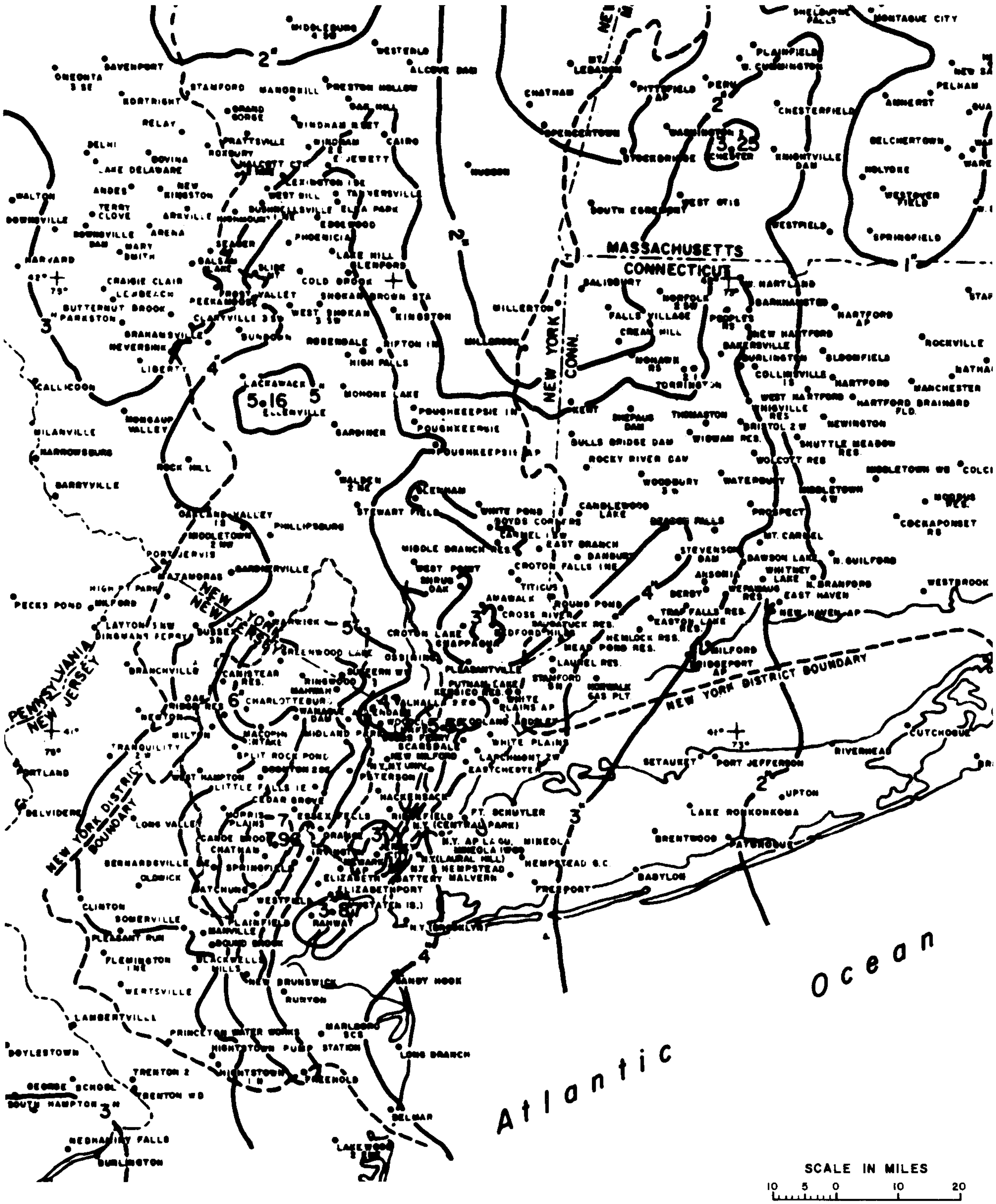
ISOHYETALS

STORM OF SEPTEMBER 1960

FIGURE 13



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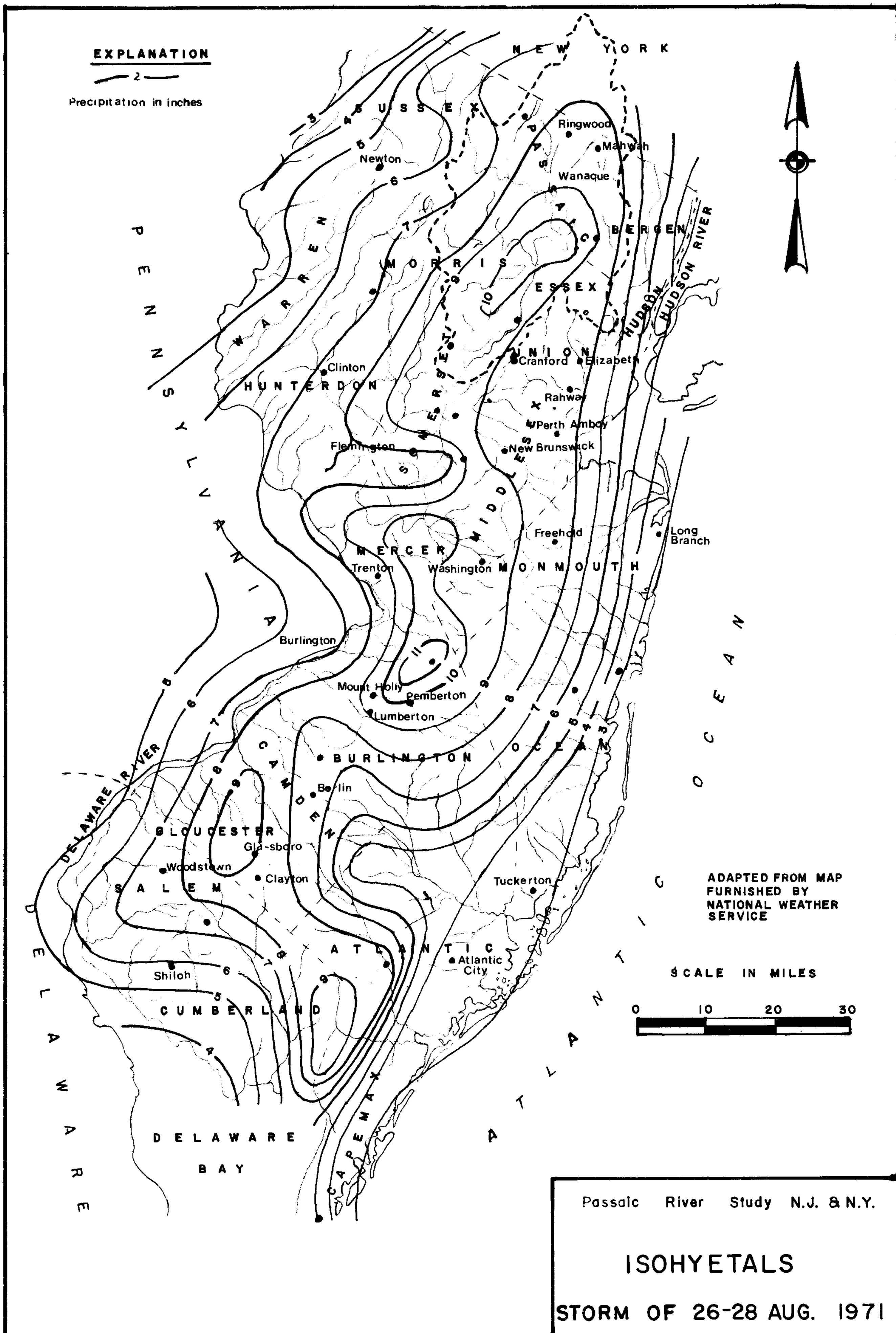
ISOHYETALS

STORM OF 28-31 MAY 1968

FIGURE 14



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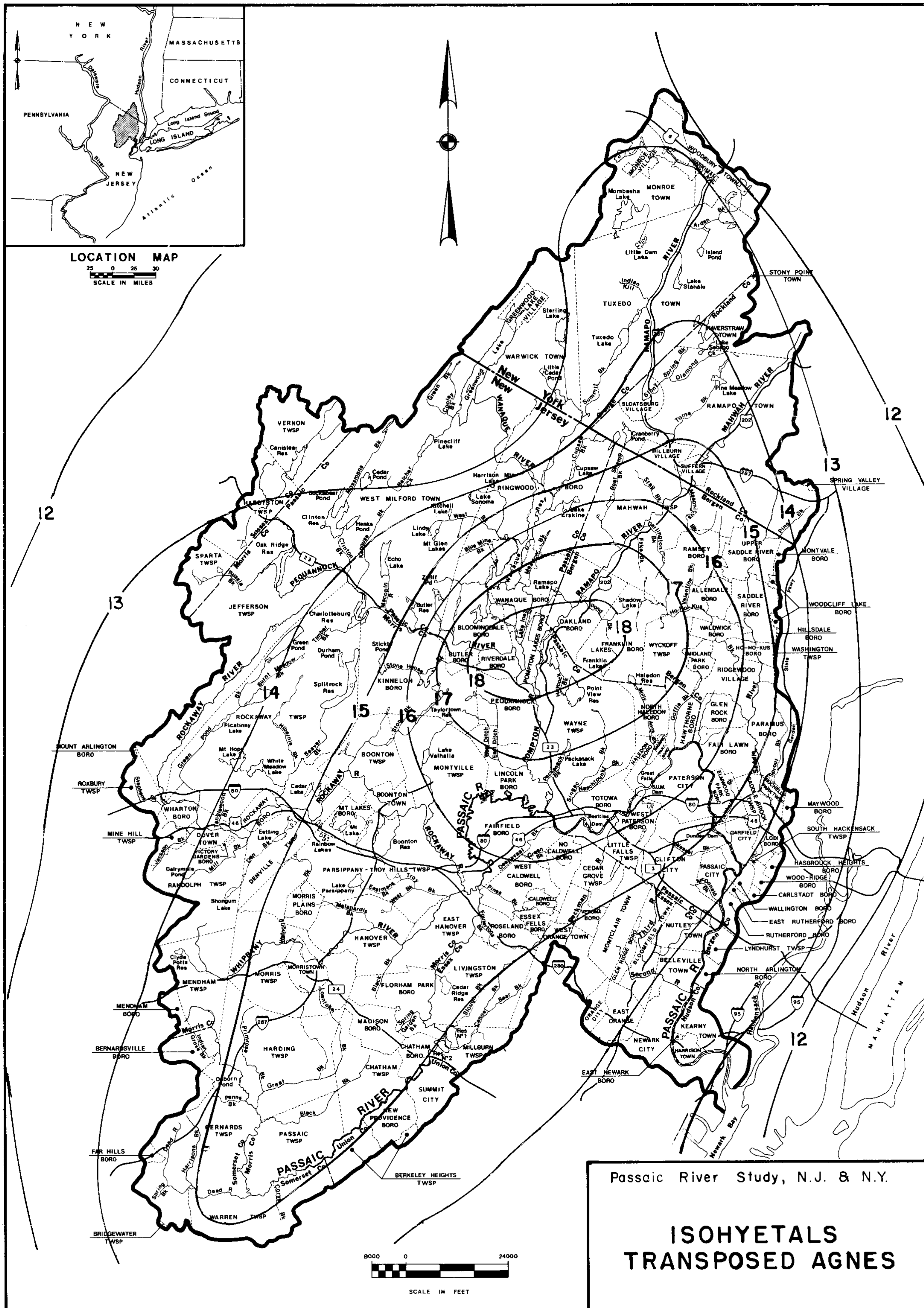
ISOHYETALS

STORM OF 26-28 AUG. 1971

FIGURE 15



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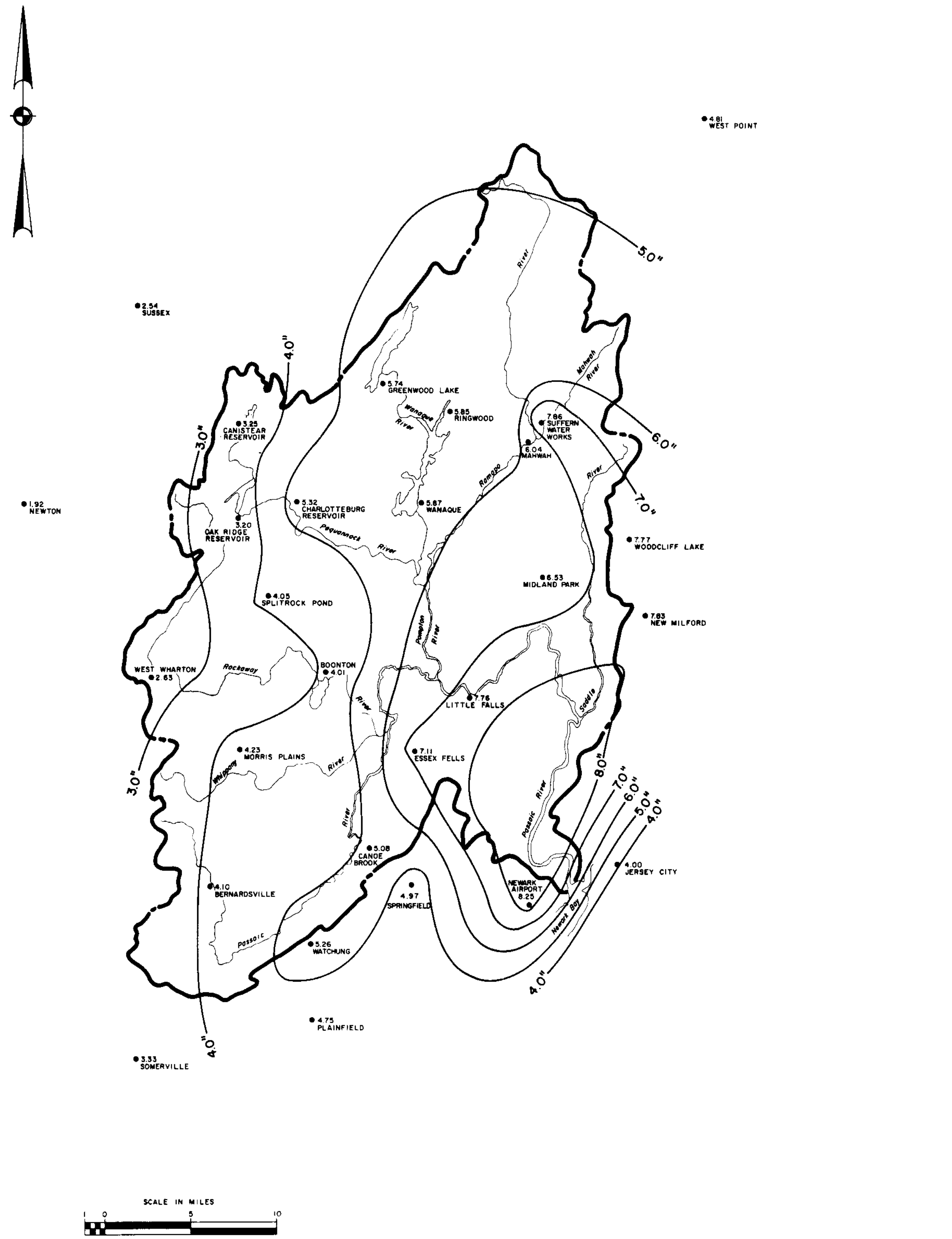
ISOHYETALS
TRANSPOSED AGNES

FIGURE 16



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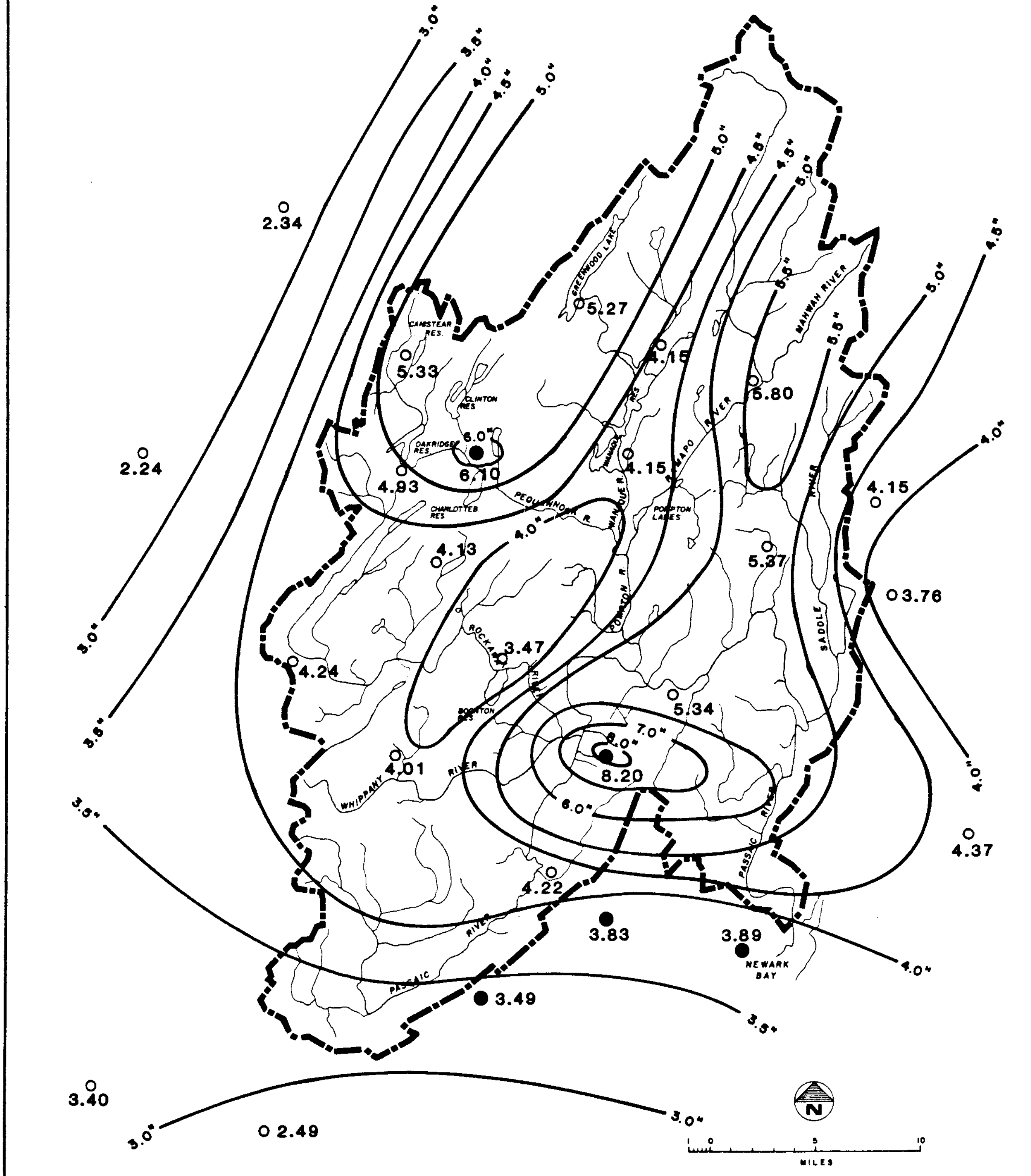
ISOHYETALS

STORM OF 7-8 NOV. 1977

FIGURE 17



LEGEND

● RECORDING PRECIPITATION STATION

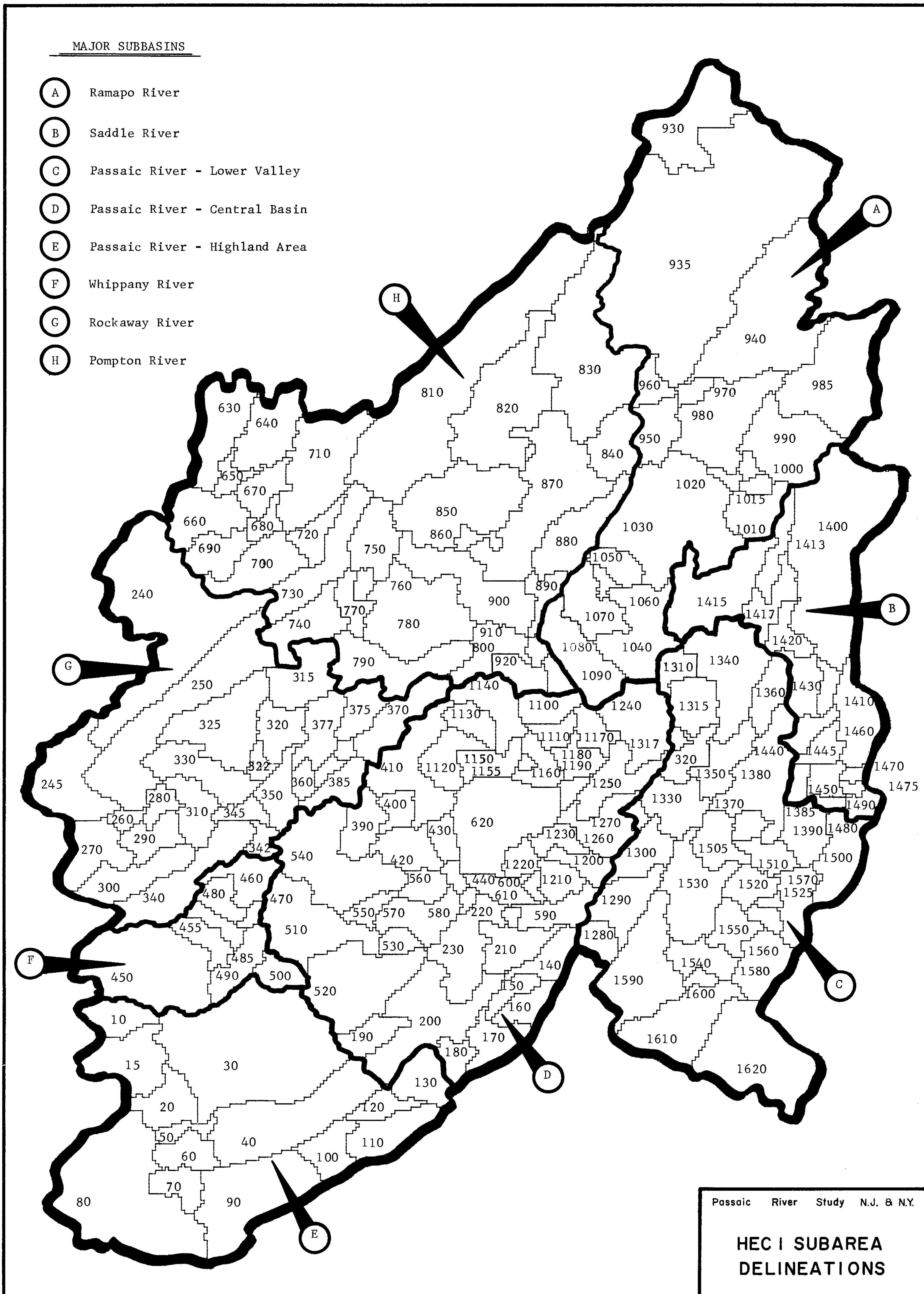
○ NON-RECORDING PRECIPITATION STATION

PASSAIC RIVER STUDY N.J. AND N.Y.

ISOHYETALS

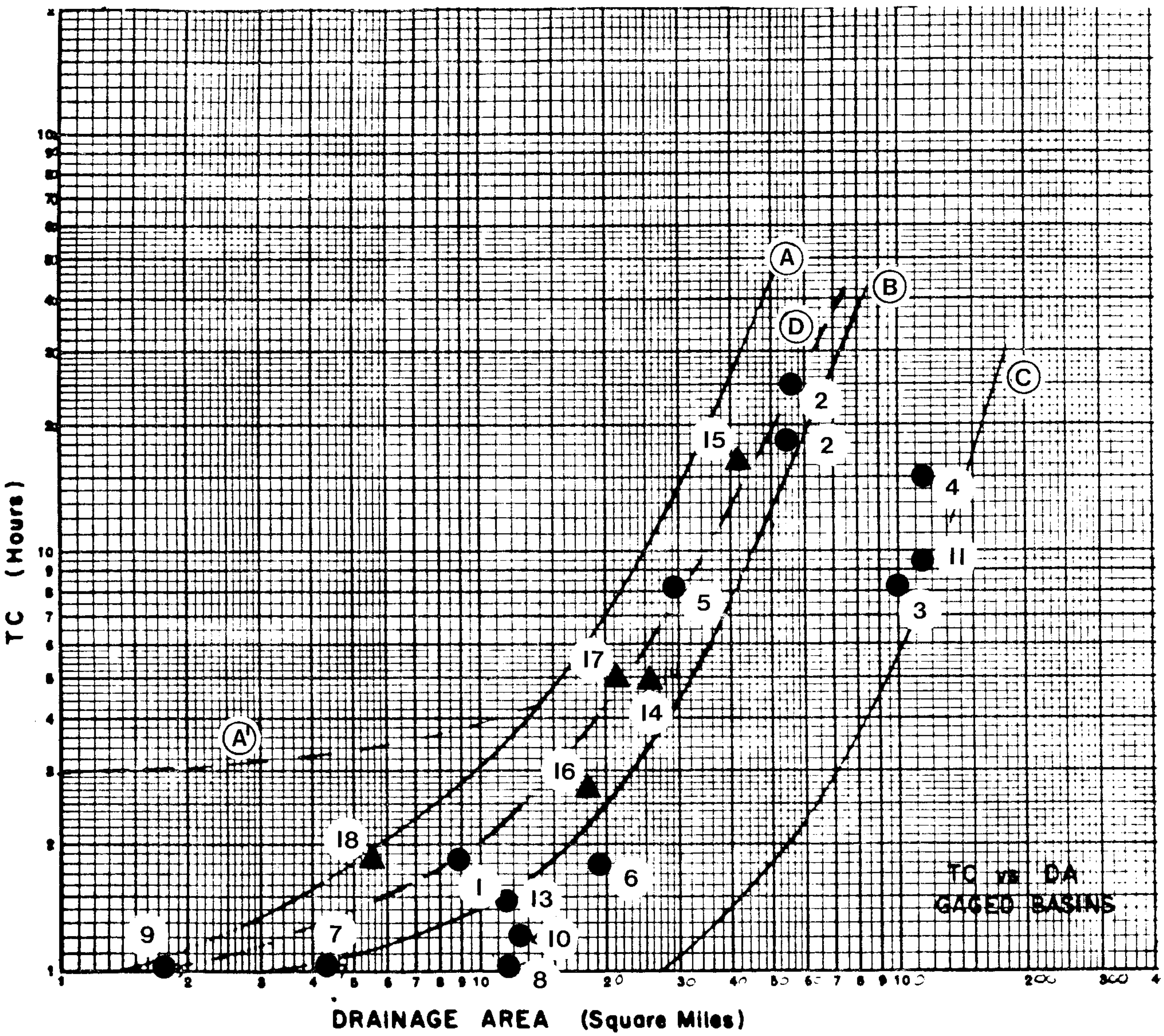
STORM OF 4-7 APR. 1984

FIGURE 18



MAJOR SUBBASINS
A Ramapo River
B Saddle River
C Passaic River - Lower Valley
D Passaic River - Central Basin
E Passaic River - Highland Area
F Whippany River
G Rockaway River
H Pompton River
Passaic River Study N.J. & N.Y.
HEC I SUBAREA DELINEATIONS

FIGURE 19



Plot N°	U.S.G.S.	Gages
1	137869	Passaic R, Bernardsville
2	137900	Passaic R, Millington
3	137950	Passaic R, Chatham
4	138050	Rockaway R, above Boonton
5	138150	Whippany R, Morristown
6	138450	Ringwood Br, Wanaque
7	138500	Cupsaw Br, Wanaque
8	138600	West Br, Wanaque
9	138650	Blue Mine Br, Wanaque
10	138745	Mahwah R, Suffern
11	138750	Ramapo R, Mahwah
12	139150	Saddle R, Lodi
13	139221	Third R, at Passaic R.
14	139450	Rahway R., Springfield
15	139500	Rahway R., Rahway
16	139350	Elizabeth R., Elizabeth
17	139600	Robinson's Br., Rahway
18	140354	Stony Br., Watchung

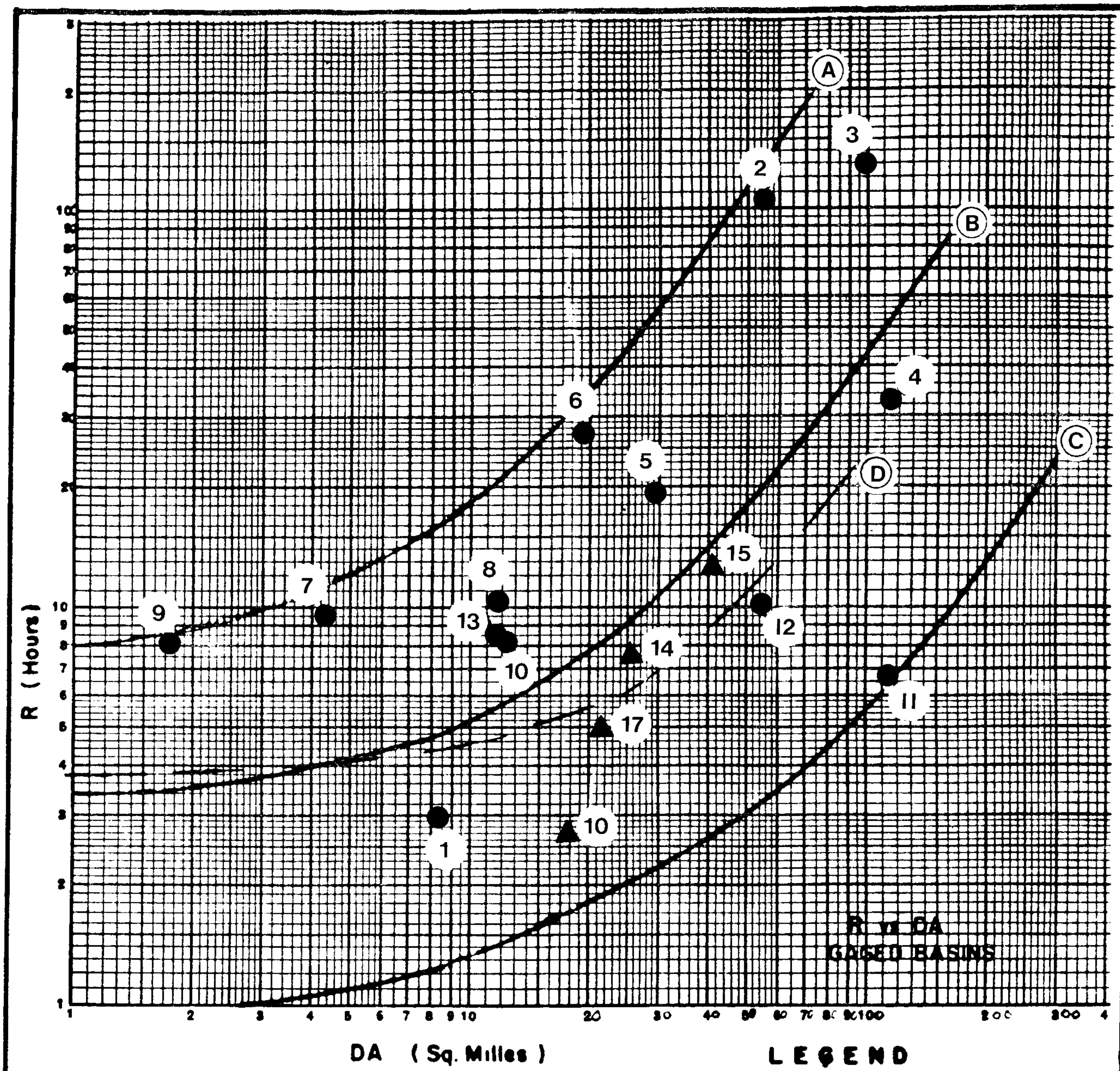
LEGEND

A = UPPER LIMIT OF ENVELOPE CURVE.
A' = MAXIMUM ENVELOPE OF FINAL TC'S IN HIGHLAND AREAS.
B = BEST FIT BY EYE CURVE.
C = LOWER LIMIT OF ENVELOPE CURVE.
D = ORIGINAL ESTIMATES OF TC AND R FOR THE LOWER VALLEY ONLY.
⊙ = HEC 1 OPTIMIZATION RUNS.
△ = POINTS OBTAINED FROM C.O.E. RAHWAY RIVER STUDY.

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

TC vs DA
GAGED BASINS

FIGURE 20



LEGEND

A = UPPER LIMIT OF ENVELOPE CURVE.

A' = MAXIMUM ENVELOPE OF FINAL TC'S IN HIGHLAND AREAS.

B = BEST FIT BY EYE CURVE.

C = LOWER LIMIT OF ENVELOPE CURVE.

D = ORIGINAL ESTIMATES OF TC AND R FOR THE LOWER VALLEY ONLY.

⊙ = HEC 1 OPTIMIZATION RUNS.

△ = POINTS OBTAINED FROM C.O.E. RAHWAY RIVER STUDY.

NOTE: See Figure 20 for Plot N° Identification.

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

R vs DA
GAGED BASINS

FIGURE 21

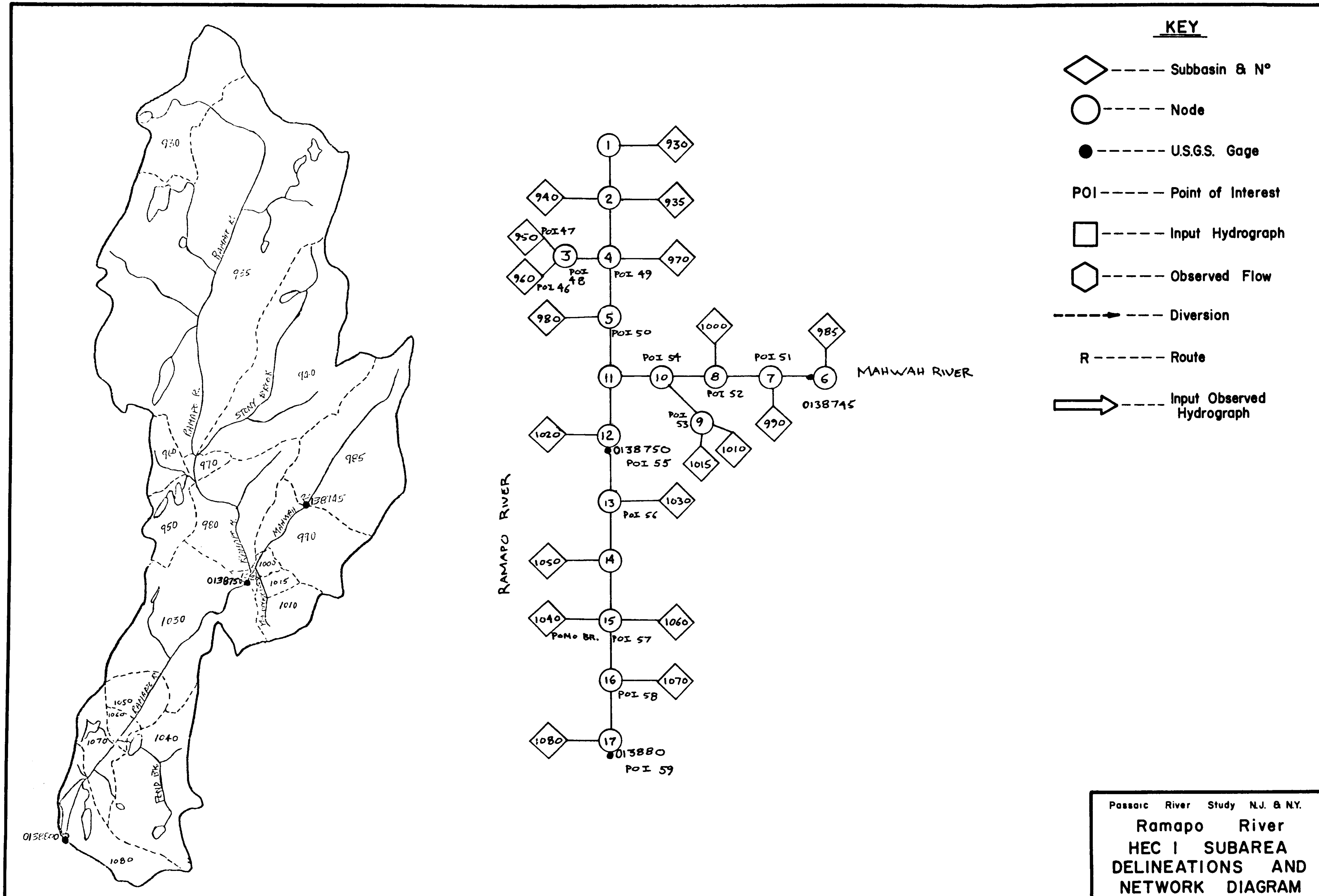
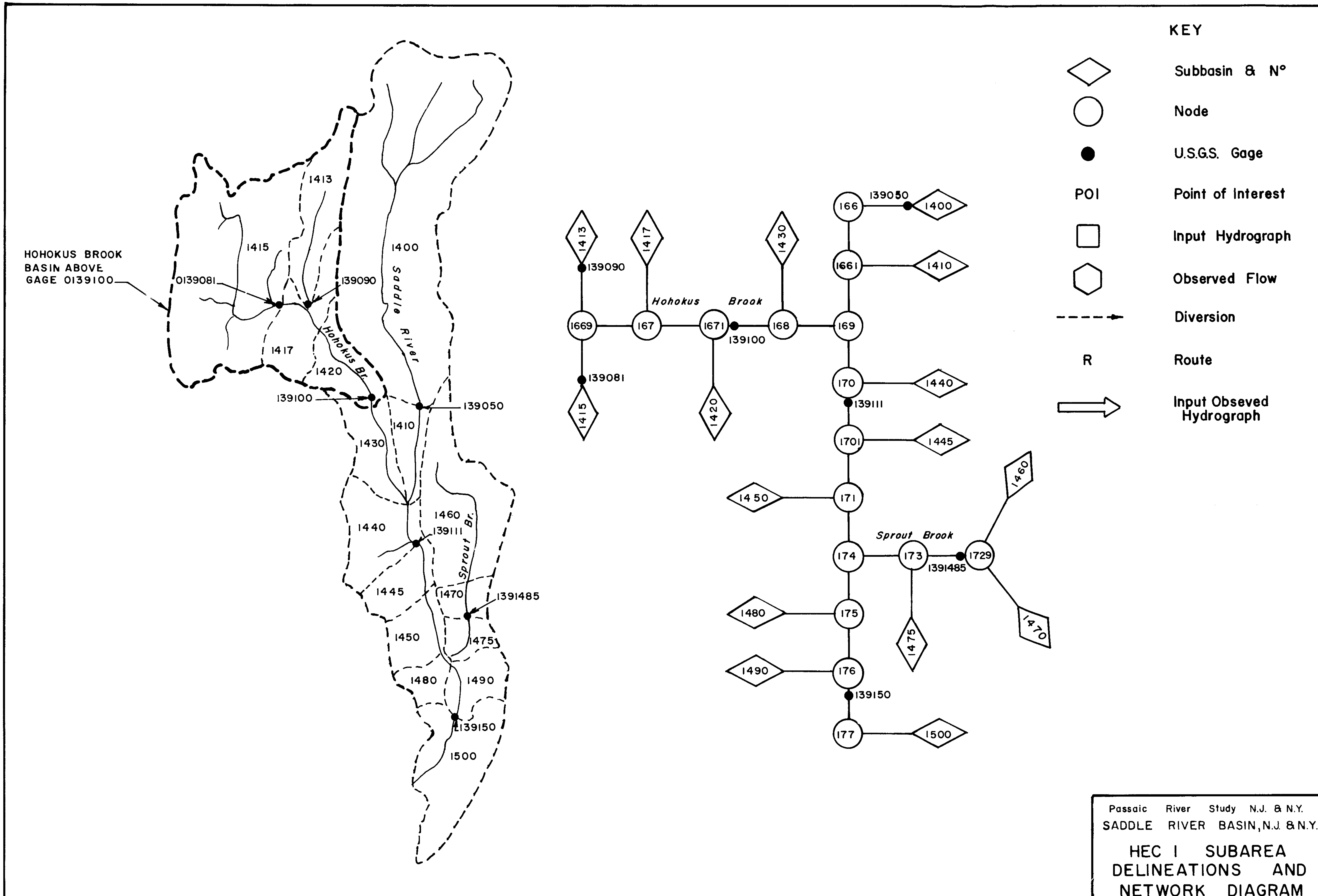

KEY
Subbasin & N°
Node
U.S.G.S. Gage
POI Point of Interest
Input Hydrograph
Observed Flow
Diversion
R Route
Input Observed Hydrograph
RAMAPO RIVER
MAHWAH RIVER
0138745
0138750
013880
POI 46
POI 47
POI 48
POI 49
POI 50
POI 51
POI 52
POI 53
POI 54
POI 55
POI 56
POI 57
POI 58
POI 59
POMO BR.
STONY BROOK
Passaic River Study N.J. & N.Y.
Ramapo River
HEC I SUBAREA DELINEATIONS AND NETWORK DIAGRAM

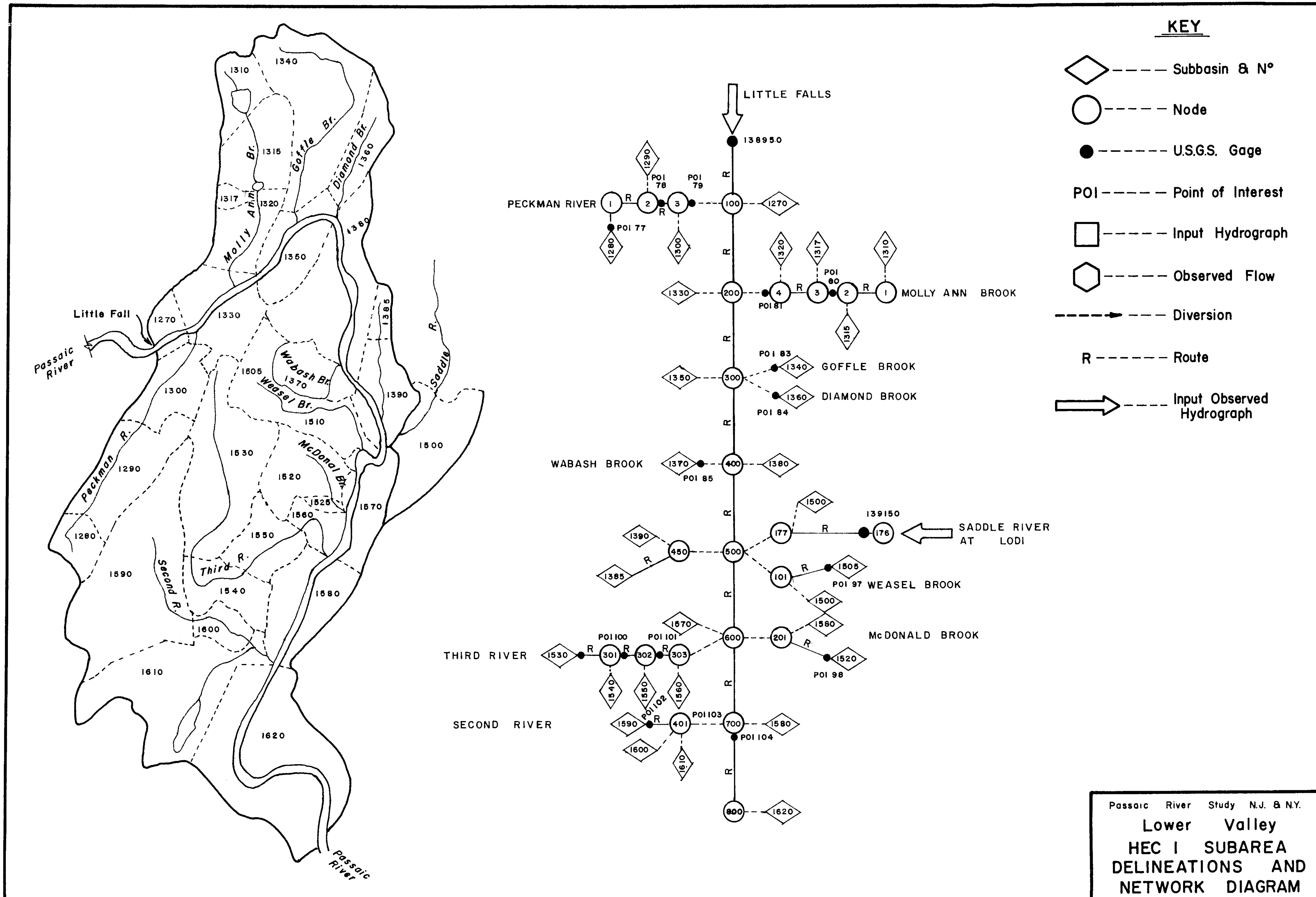
FIGURE 22



Passaic River Study N.J. & N.Y.
SADDLE RIVER BASIN, N.J. & N.Y.

HEC I SUBAREA DELINEATIONS AND NETWORK DIAGRAM

FIGURE 23

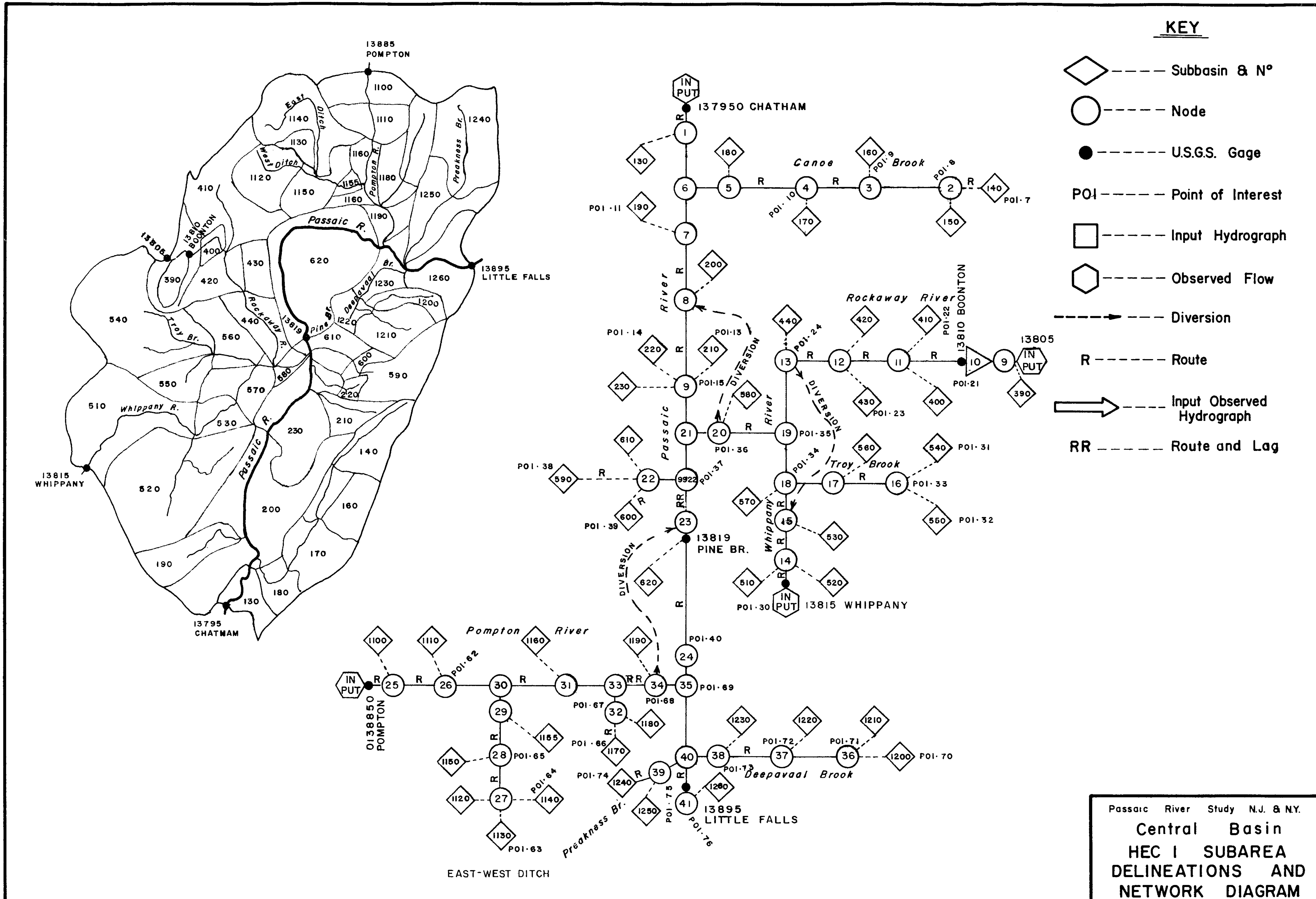


Passaic River Study N.J. & N.Y.

Lower Valley

HEC I SUBAREA DELINEATIONS AND NETWORK DIAGRAM

FIGURE 24

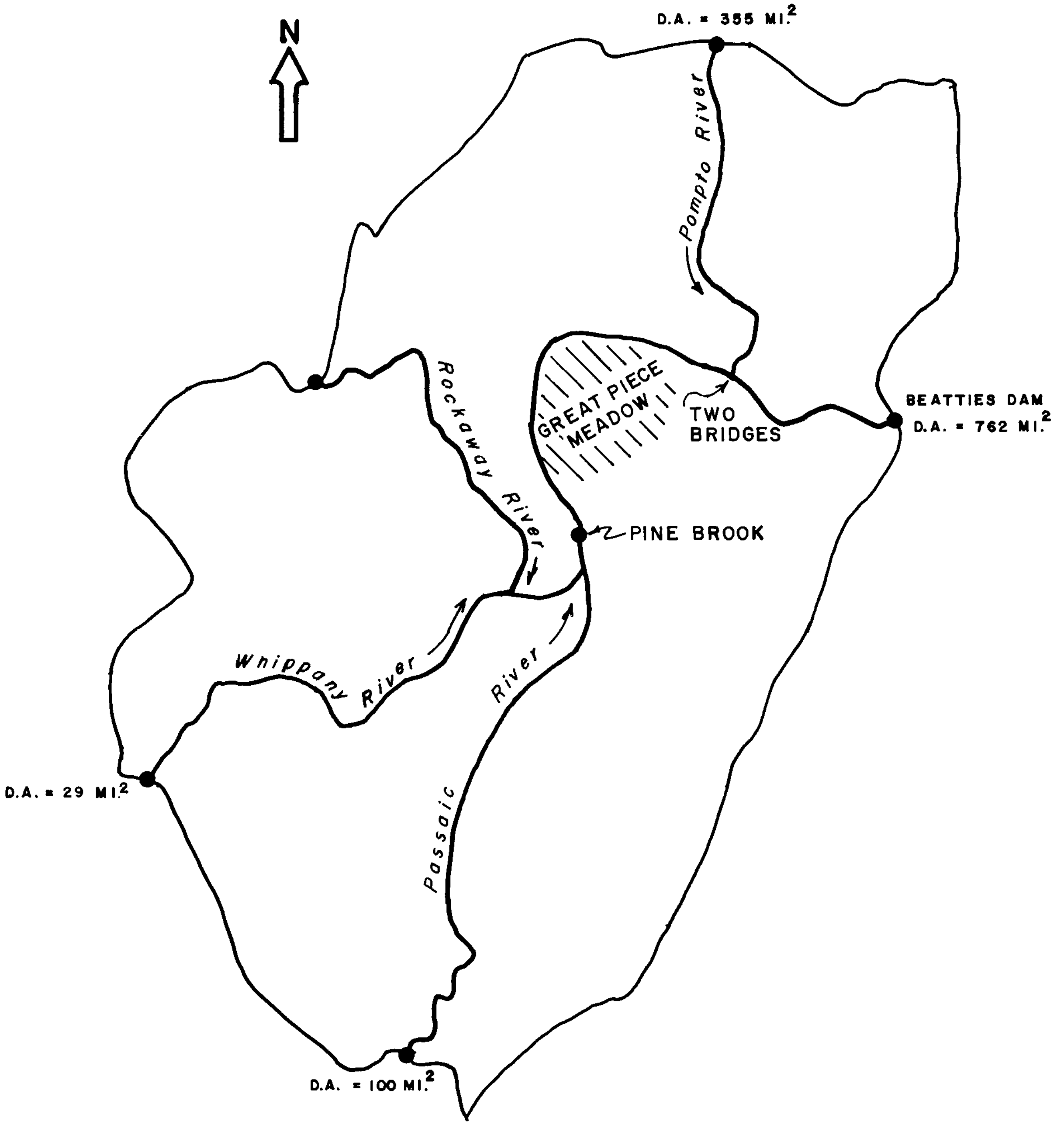


Passaic River Study N.J. & N.Y.

Central Basin

HEC I SUBAREA DELINEATIONS AND NETWORK DIAGRAM

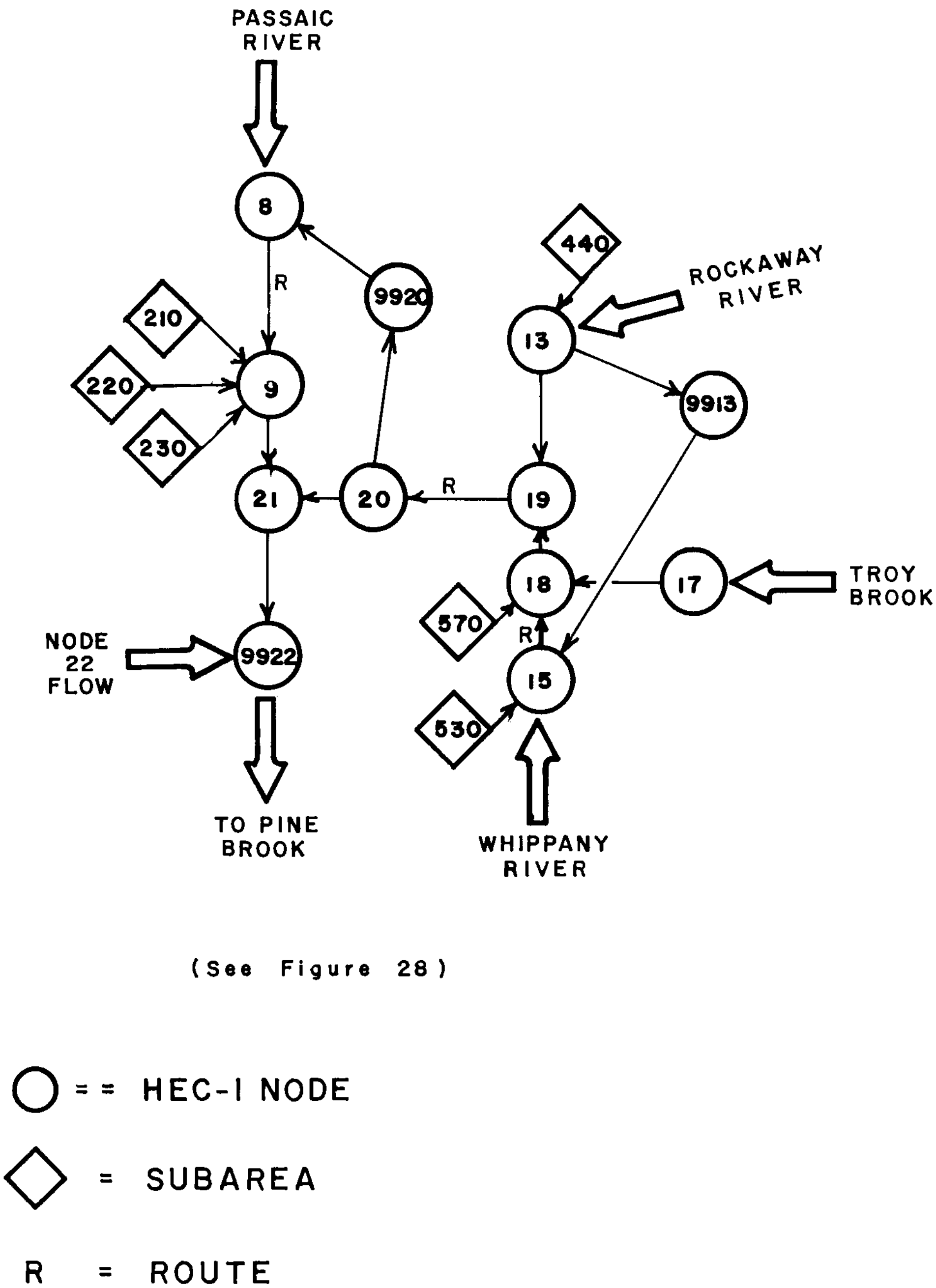
FIGURE 25



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

PASSAIC RIVER CENTRAL BASIN HEC-1 SUBBASIN

FIGURE 26

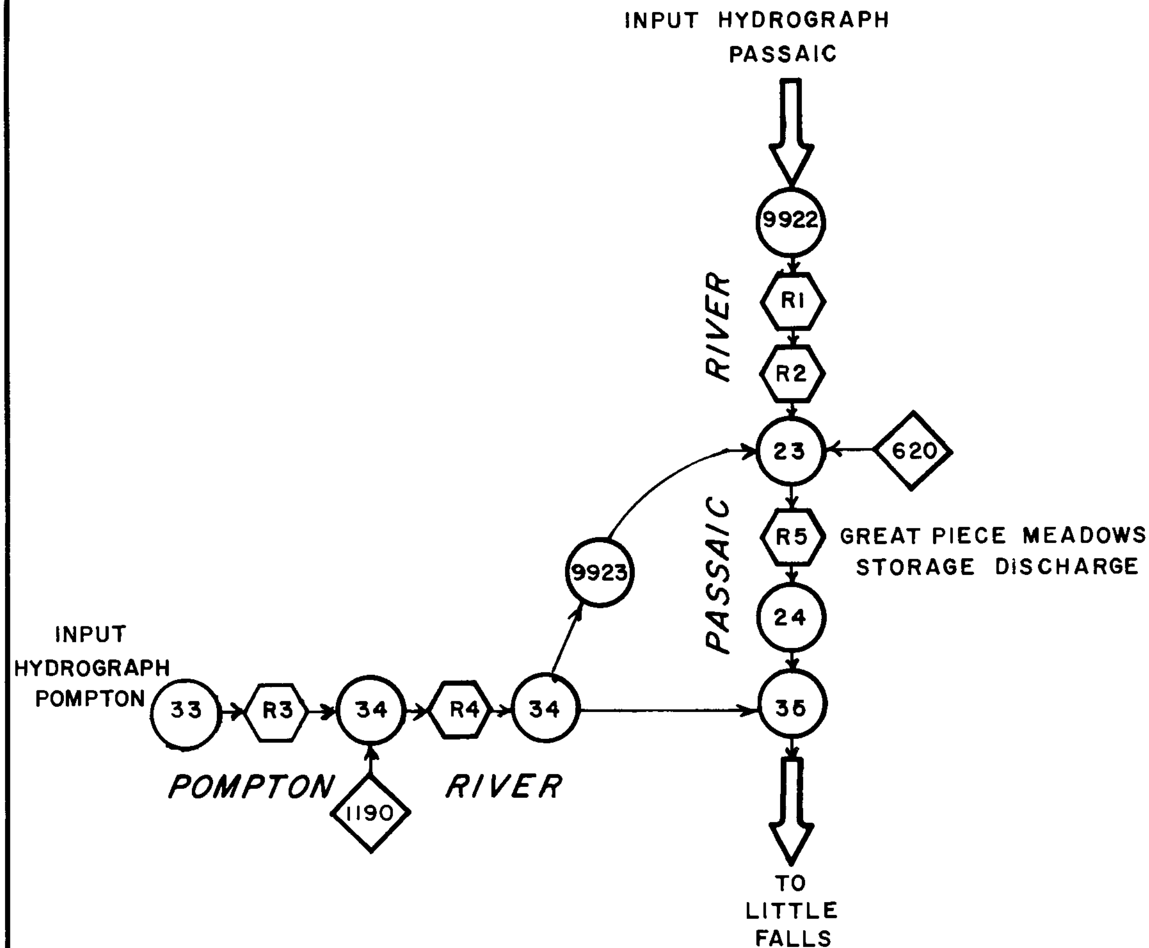


(See Figure 28)

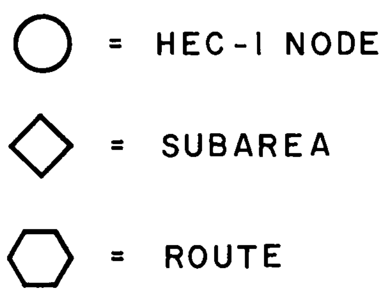
Passaic River Study N.J. & N.Y.

SCHEMATIC OF ROCKAWAY AND WHIPPANY RIVERS DIVERSIONS

FIGURE 27



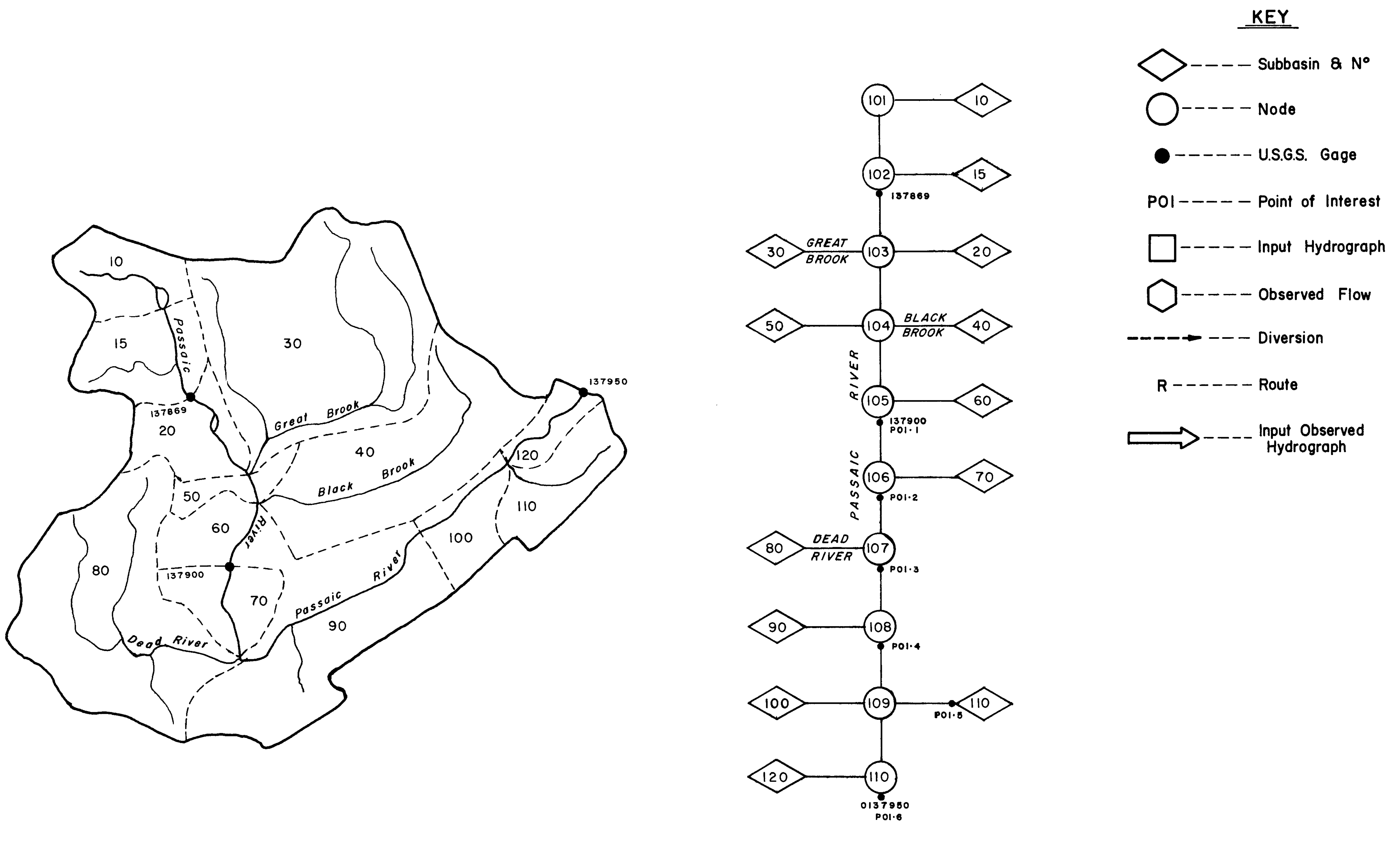
(See Figure 28)



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

SCHEMATIC OF POMPTON RIVER DIVERSION

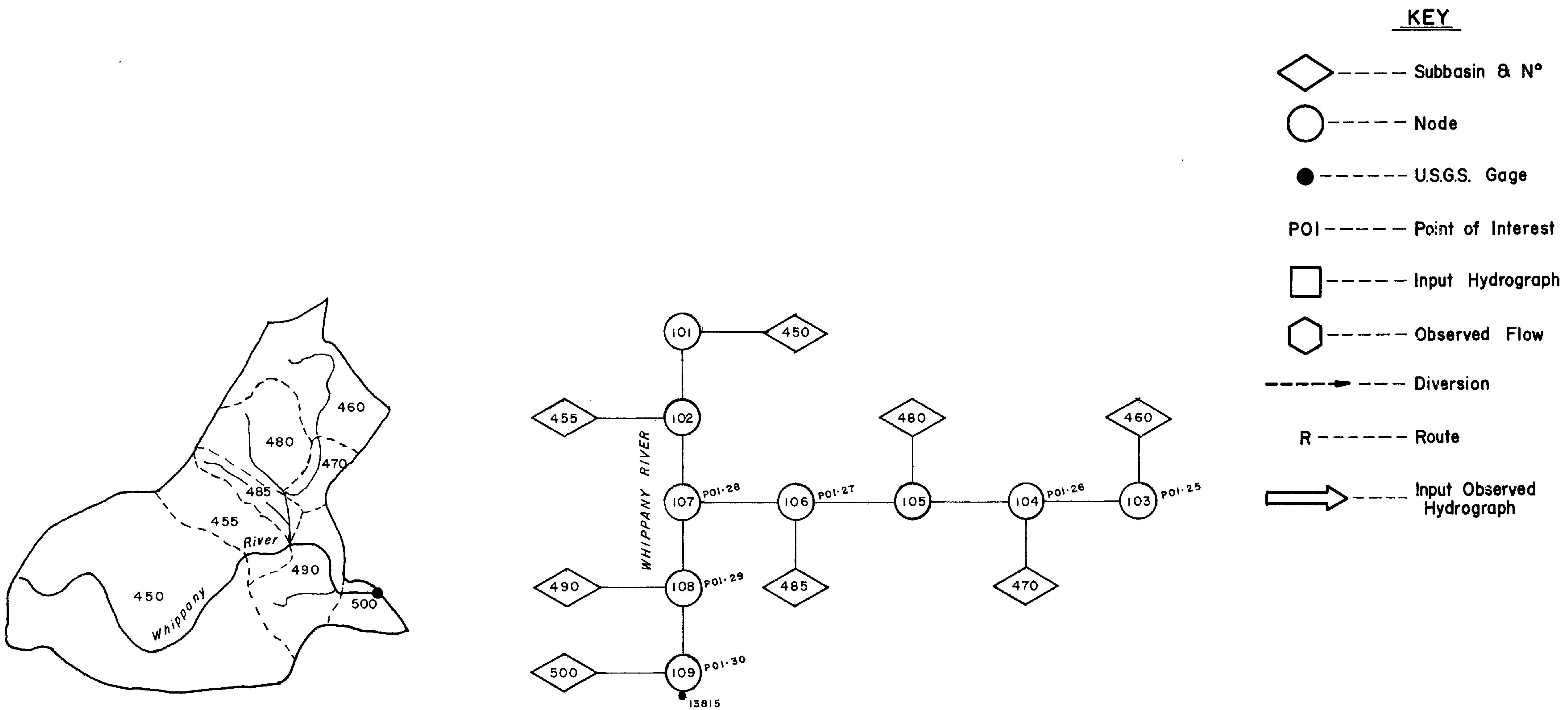
FIGURE 28



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

Highland Area
HEC I SUBAREA
DELINEATIONS AND
NETWORK DIAGRAM

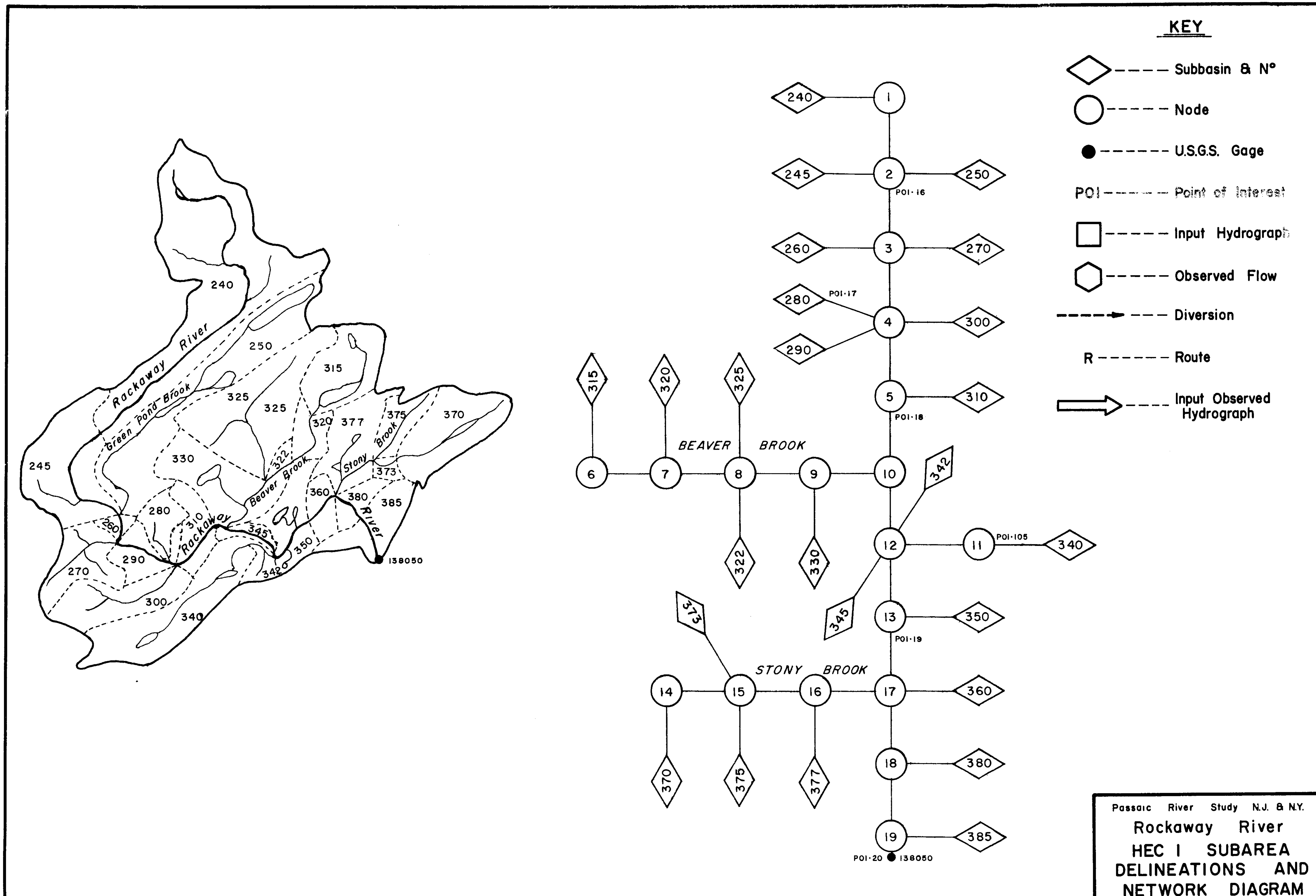
FIGURE 29



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

Whippany River
HEC I SUBAREA
DELINEATIONS AND
NETWORK DIAGRAM

FIGURE 30

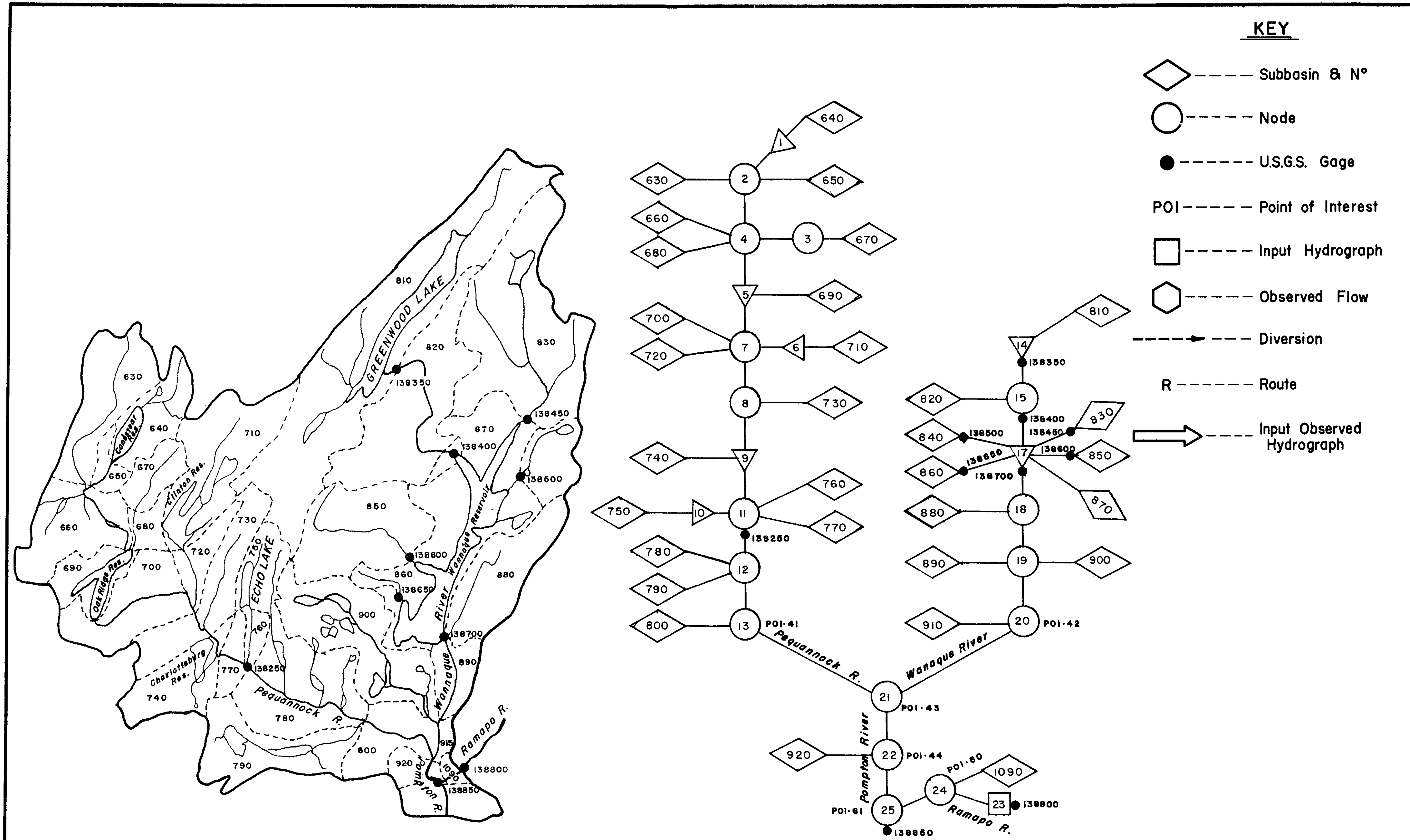


Passaic River Study N.J. & N.Y.

Rockaway River

HEC I SUBAREA DELINEATIONS AND NETWORK DIAGRAM

FIGURE 31



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

Pompton River

HEC I SUBAREA DELINEATIONS AND NETWORK DIAGRAM

FIGURE 32

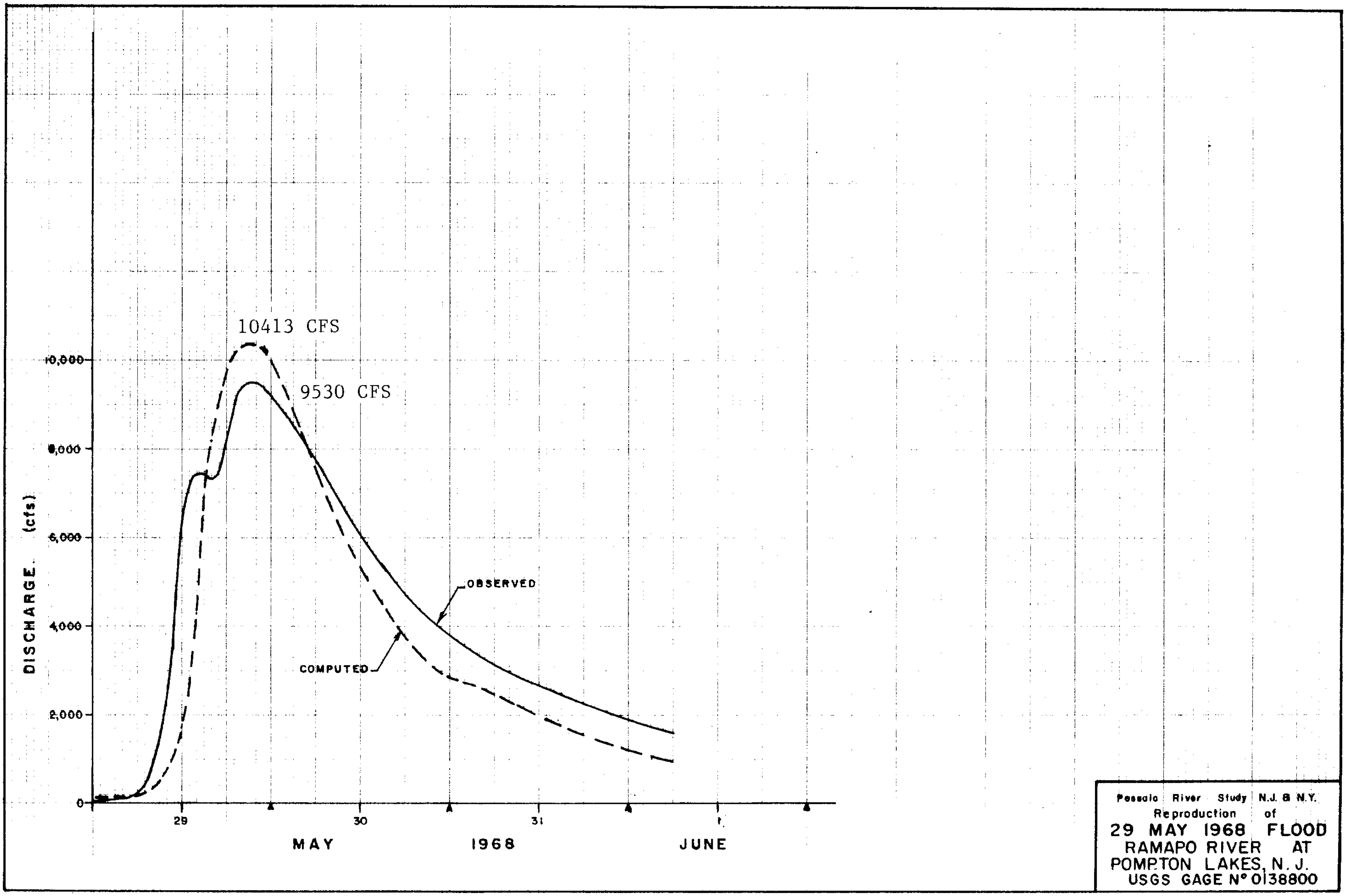

10413 CFS
9530 CFS
10,000
8,000
6,000
4,000
2,000
0
DISCHARGE (cfs)
OBSERVED
COMPUTED
29
30
31
1
MAY 1968 JUNE
Passaic River Study N.J. & N.Y.
Reproduction of
29 MAY 1968 FLOOD
RAMAPO RIVER AT
POMPTON LAKES, N. J.
USGS GAGE N° 0138800

FIGURE 33

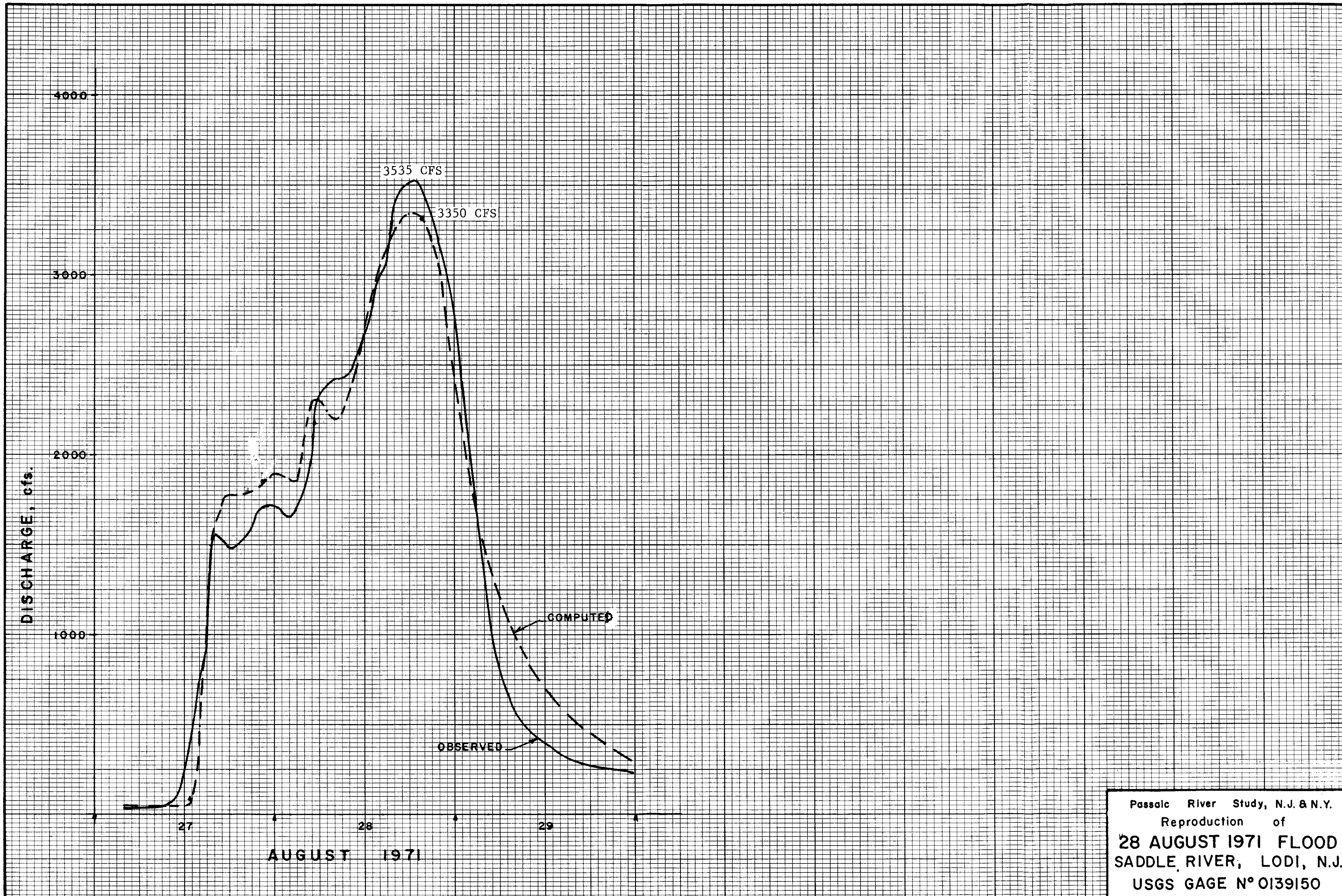

4000
3000
2000
1000
DISCHARGE, cfs.
3535 CFS
3350 CFS
COMPUTED
OBSERVED
27
28
29
AUGUST 1971
Passaic River Study, N.J. & N.Y.
Reproduction of
28 AUGUST 1971 FLOOD
SADDLE RIVER, LODI, N.J.
USGS GAGE N° 0139150

FIGURE 34

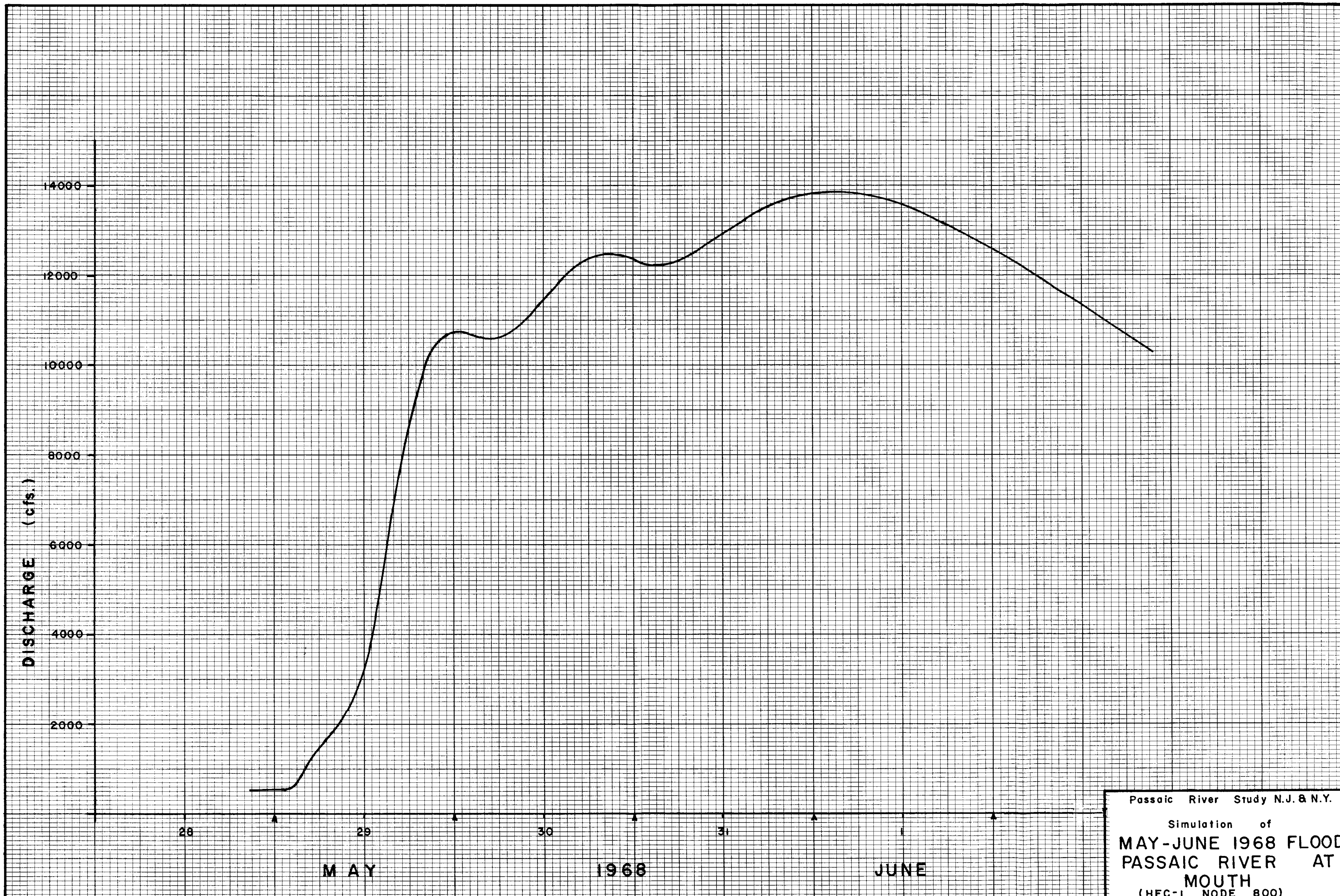
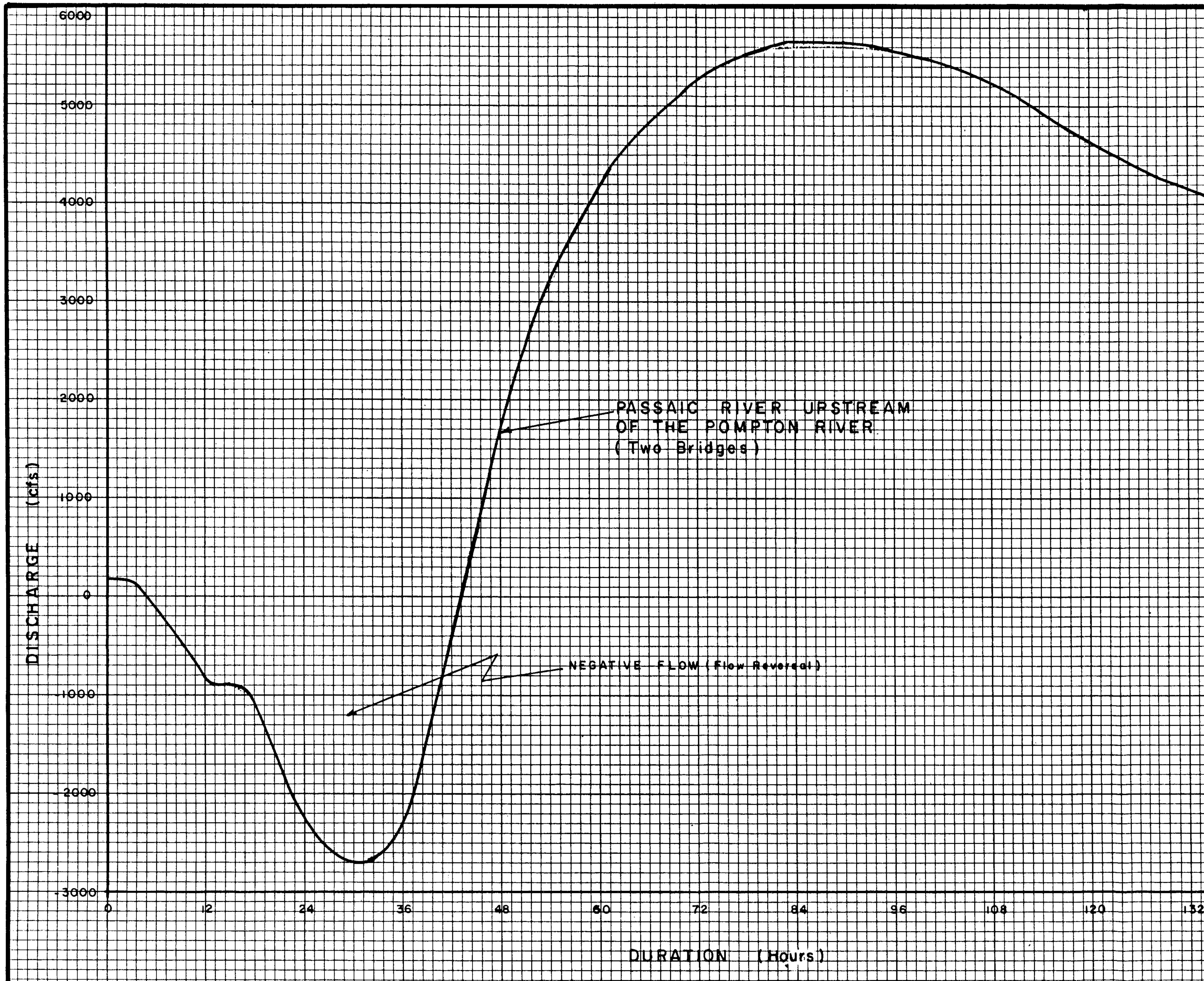

14000
12000
10000
8000
6000
4000
2000
DISCHARGE (cfs.)
28
29
30
31
1
MAY
1968
JUNE
Passaic River Study N.J. & N.Y.
Simulation of
MAY-JUNE 1968 FLOOD
PASSAIC RIVER AT
MOUTH
(HEC-1 NODE 800)

FIGURE 35



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

"DWOPER" HYDROGRAPH
SIMULATION OF
MAY 1968 EVENT

FIGURE 36

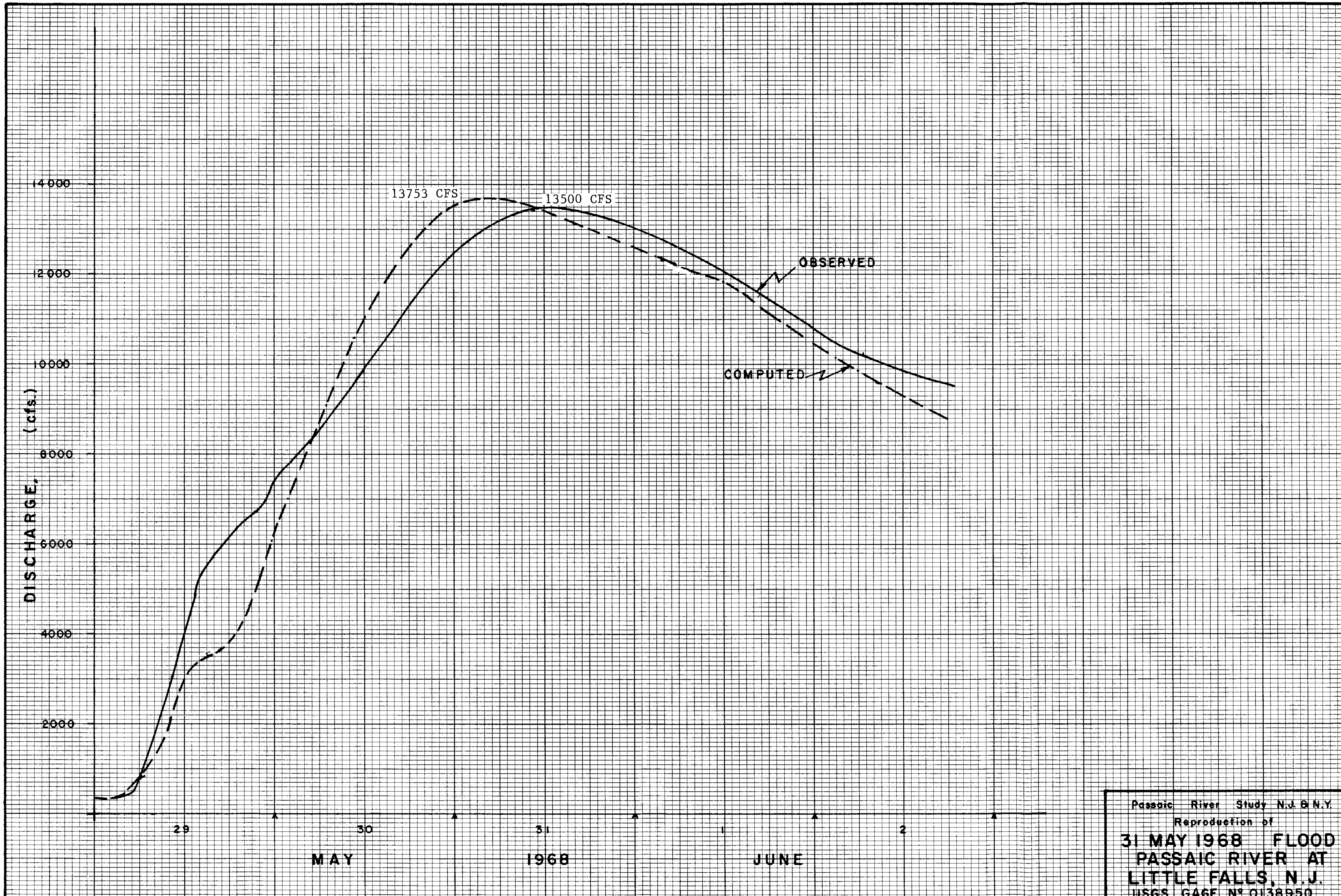

14000
12000
10000
8000
6000
4000
2000
DISCHARGE, (c.f.s.)
13753 CFS
13500 CFS
OBSERVED
COMPUTED
29
30
31
1
2
MAY
1968
JUNE
Passaic River Study N.J. & N.Y.
Reproduction of
31 MAY 1968 FLOOD
PASSAIC RIVER AT
LITTLE FALLS, N.J.
USGS GAGE Nº 0138950

FIGURE 37

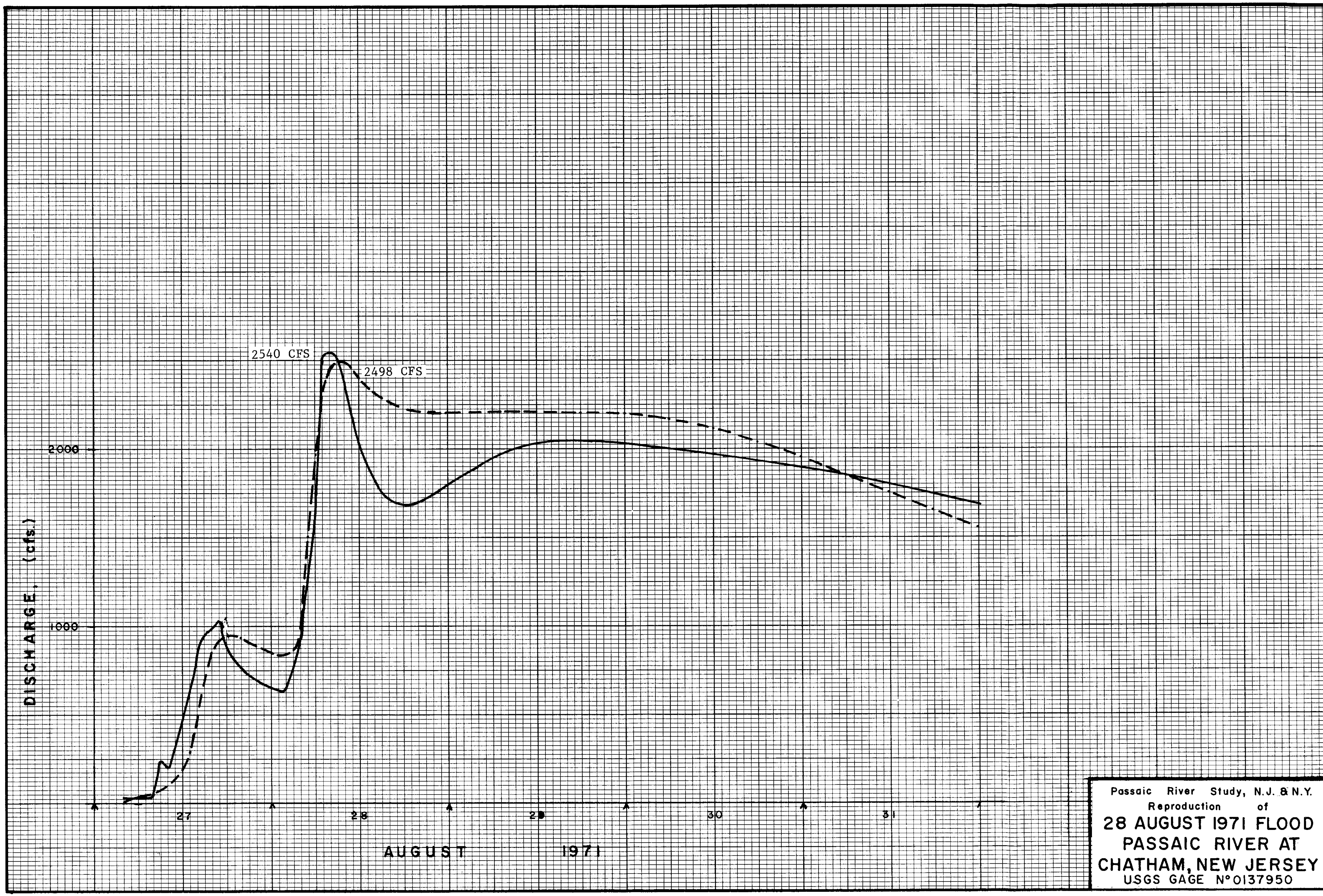
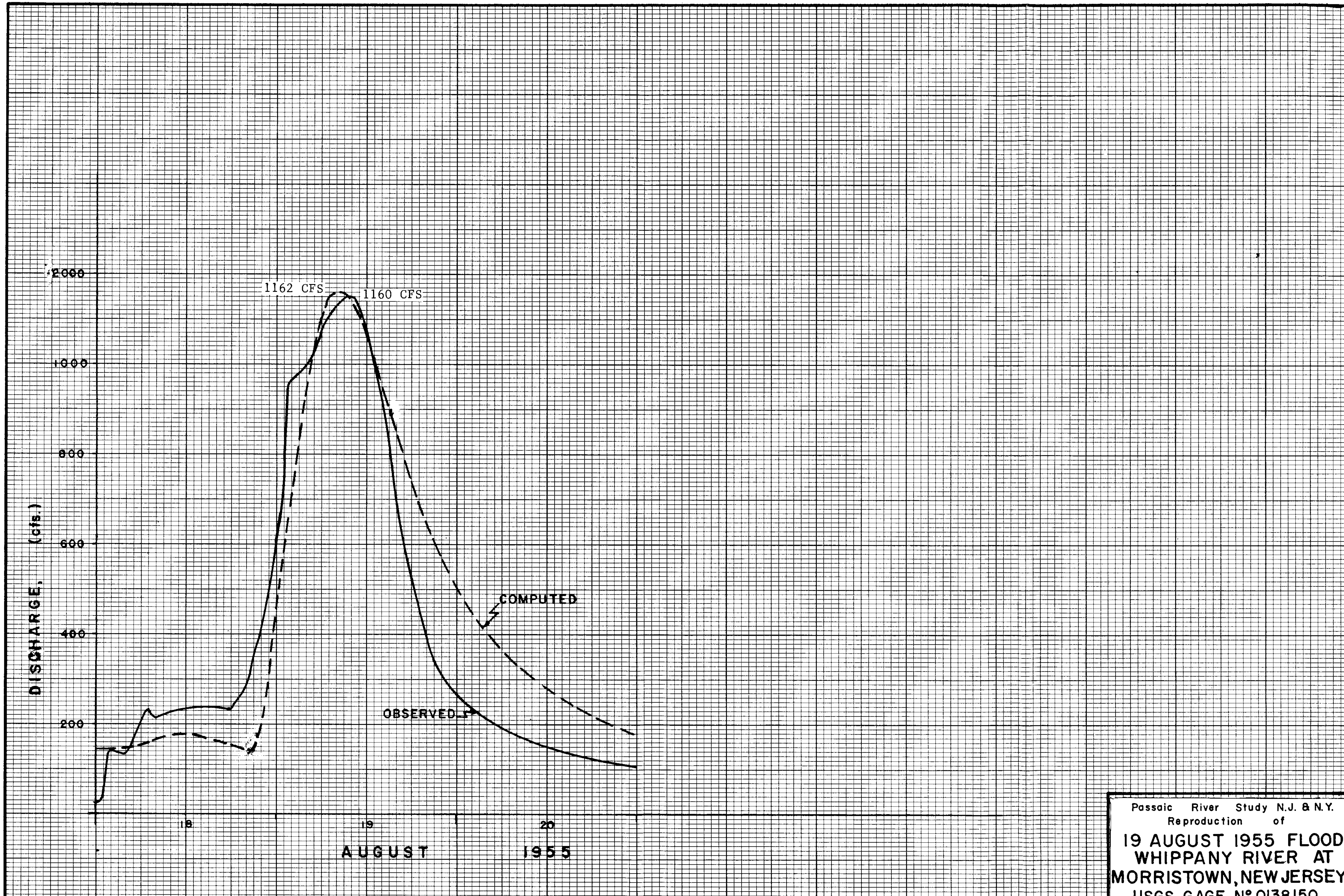

2540 CFS
2498 CFS
2000
1000
DISCHARGE, (cfs.)
27
28
29
30
31
AUGUST 1971
Passaic River Study, N.J. & N.Y.
Reproduction of
28 AUGUST 1971 FLOOD
PASSAIC RIVER AT
CHATHAM, NEW JERSEY
USGS GAGE N°0137950

FIGURE 38



Passaic River Study N.J. & N.Y.
Reproduction of
19 AUGUST 1955 FLOOD
WHIPPANY RIVER AT
MORRISTOWN, NEW JERSEY
USGS GAGE N° 0138150

FIGURE 39

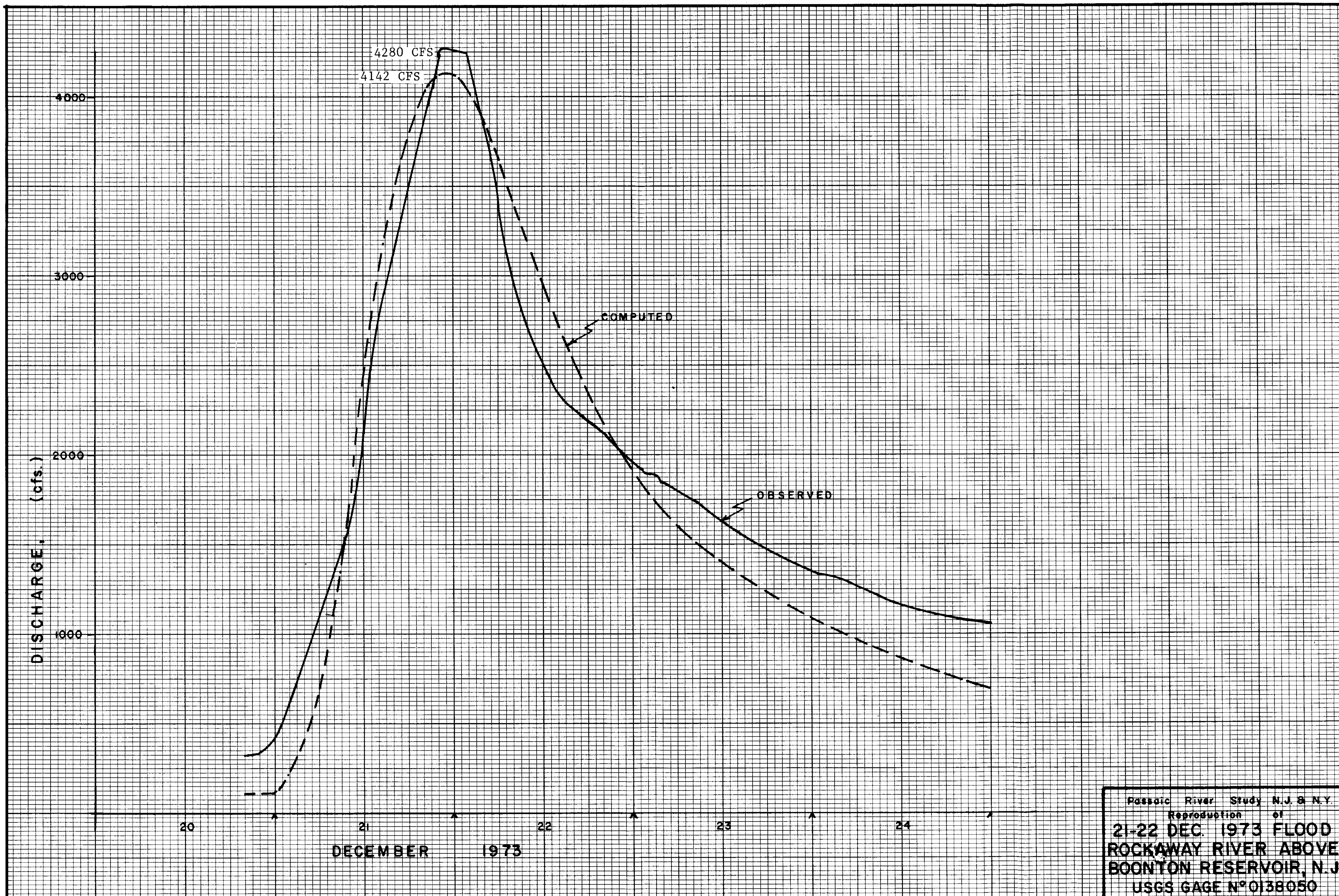
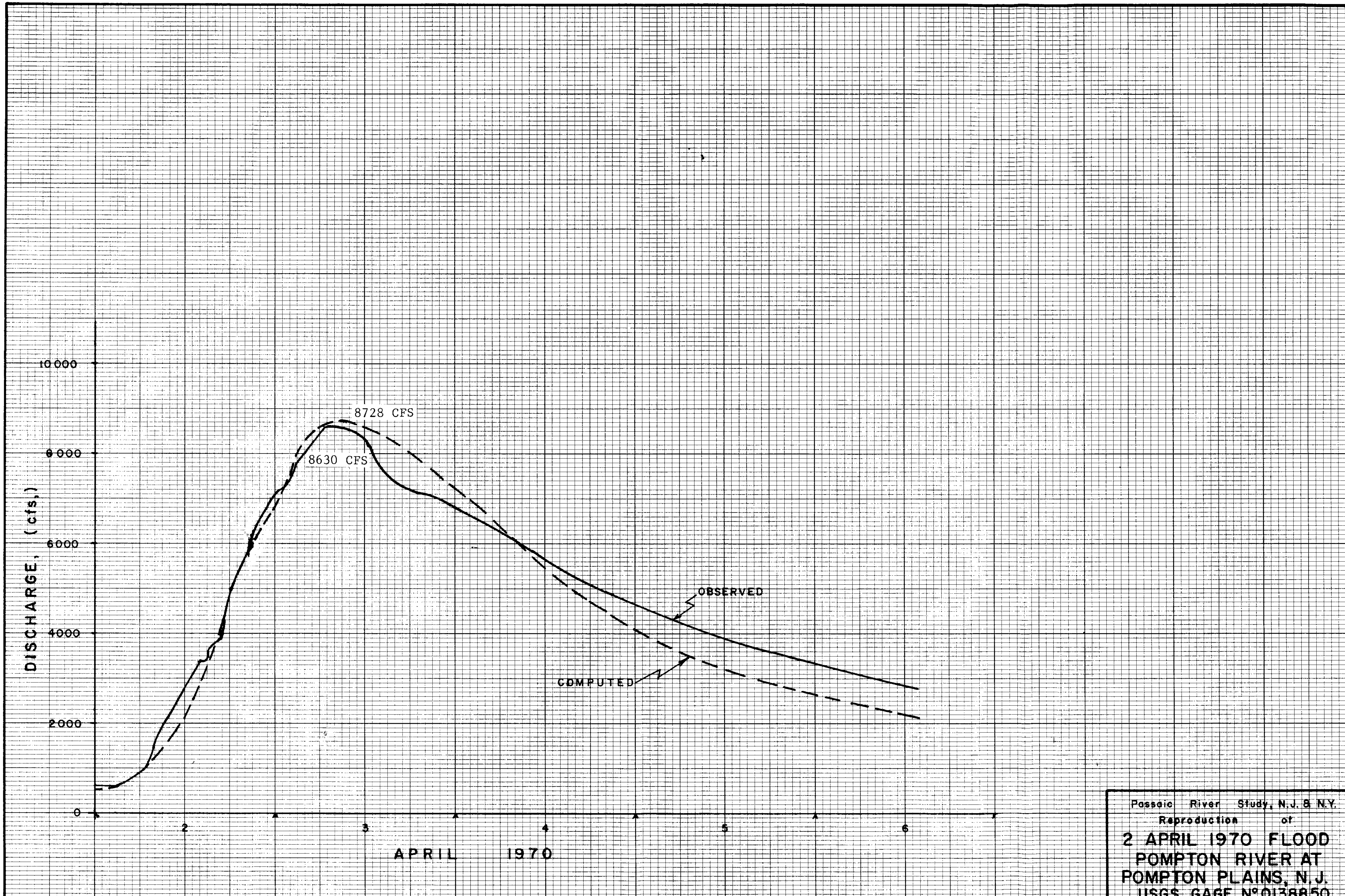
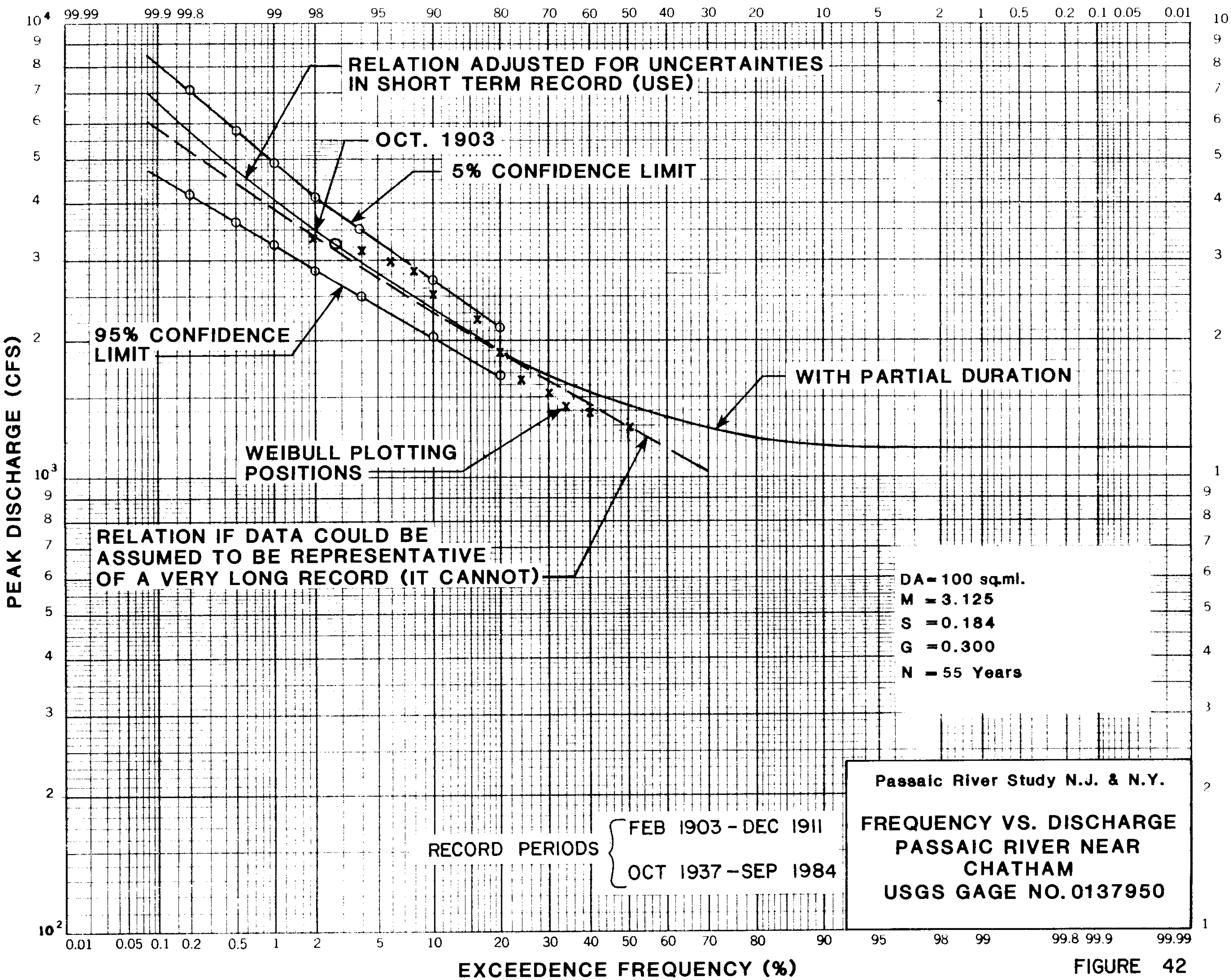

4280 CFS
4142 CFS
4000
3000
2000
1000
DISCHARGE, (cfs.)
COMPUTED
OBSERVED
20
21
22
23
24
DECEMBER 1973
Passaic River Study N.J. & N.Y.
Reproduction of
21-22 DEC. 1973 FLOOD
ROCKAWAY RIVER ABOVE
BOONTON RESERVOIR, N.J.
USGS GAGE N° 0138050

FIGURE 40



10 000
8 000
6000
4000
2000
0
DISCHARGE, (cfs.)
2
3
4
5
6
APRIL 1970
8728 CFS
8630 CFS
OBSERVED
COMPUTED
Passaic River Study, N.J. & N.Y.
Reproduction of
2 APRIL 1970 FLOOD
POMPTON RIVER AT
POMPTON PLAINS, N.J.
USGS GAGE N°0138850

FIGURE 41



RELATION ADJUSTED FOR UNCERTAINTIES IN SHORT TERM RECORD (USE)
OCT. 1903
5% CONFIDENCE LIMIT
95% CONFIDENCE LIMIT
WITH PARTIAL DURATION
WEIBULL PLOTTING POSITIONS
RELATION IF DATA COULD BE ASSUMED TO BE REPRESENTATIVE OF A VERY LONG RECORD (IT CANNOT)
DA = 100 sq.mi.
M = 3.125
S = 0.184
G = 0.300
N = 55 Years
RECORD PERIODS
FEB 1903 - DEC 1911
OCT 1937 - SEP 1984
PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)
Passaic River Study N.J. & N.Y.
FREQUENCY VS. DISCHARGE
PASSAIC RIVER NEAR
CHATHAM
USGS GAGE NO. 0137950

FIGURE 42

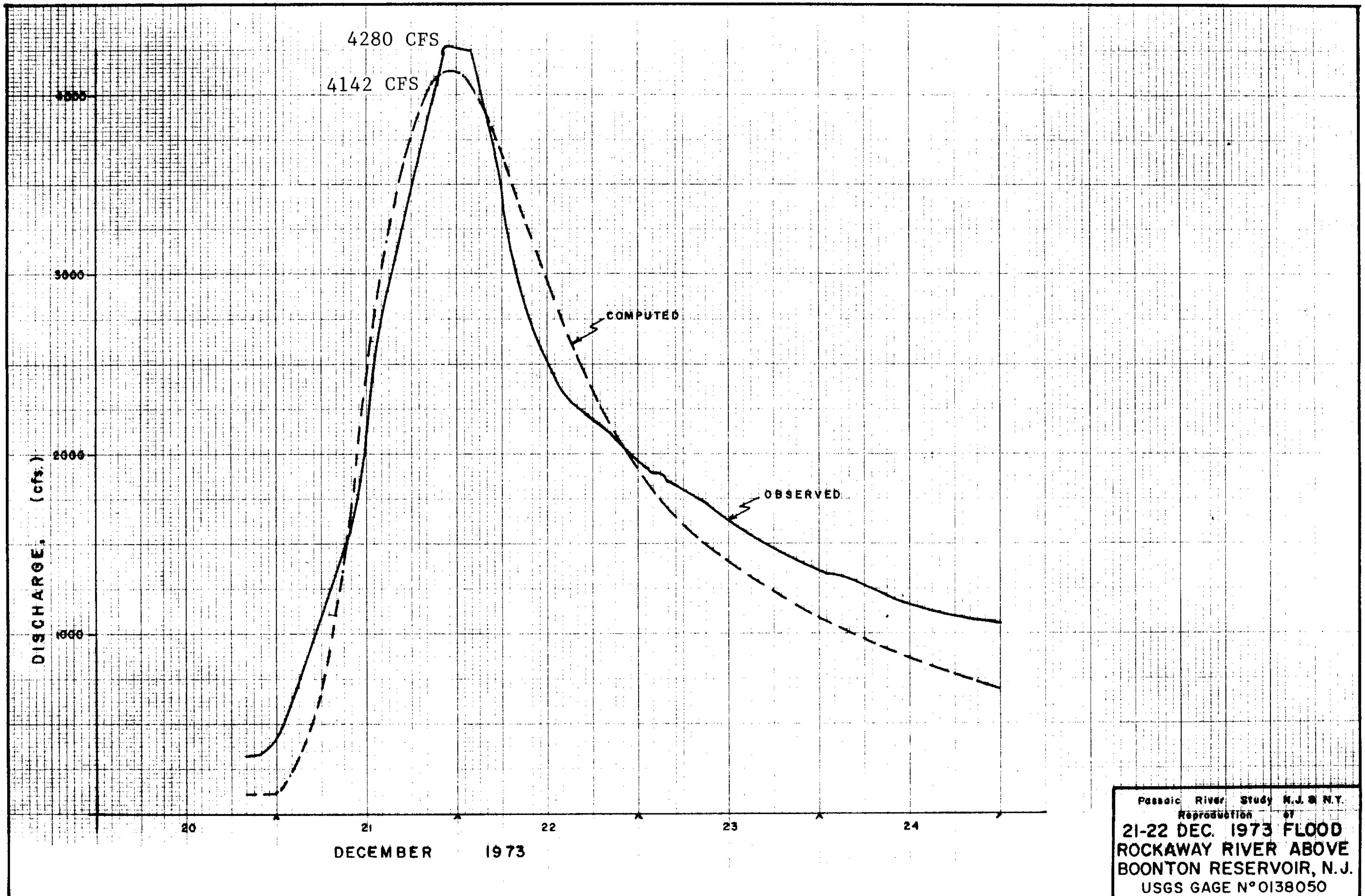
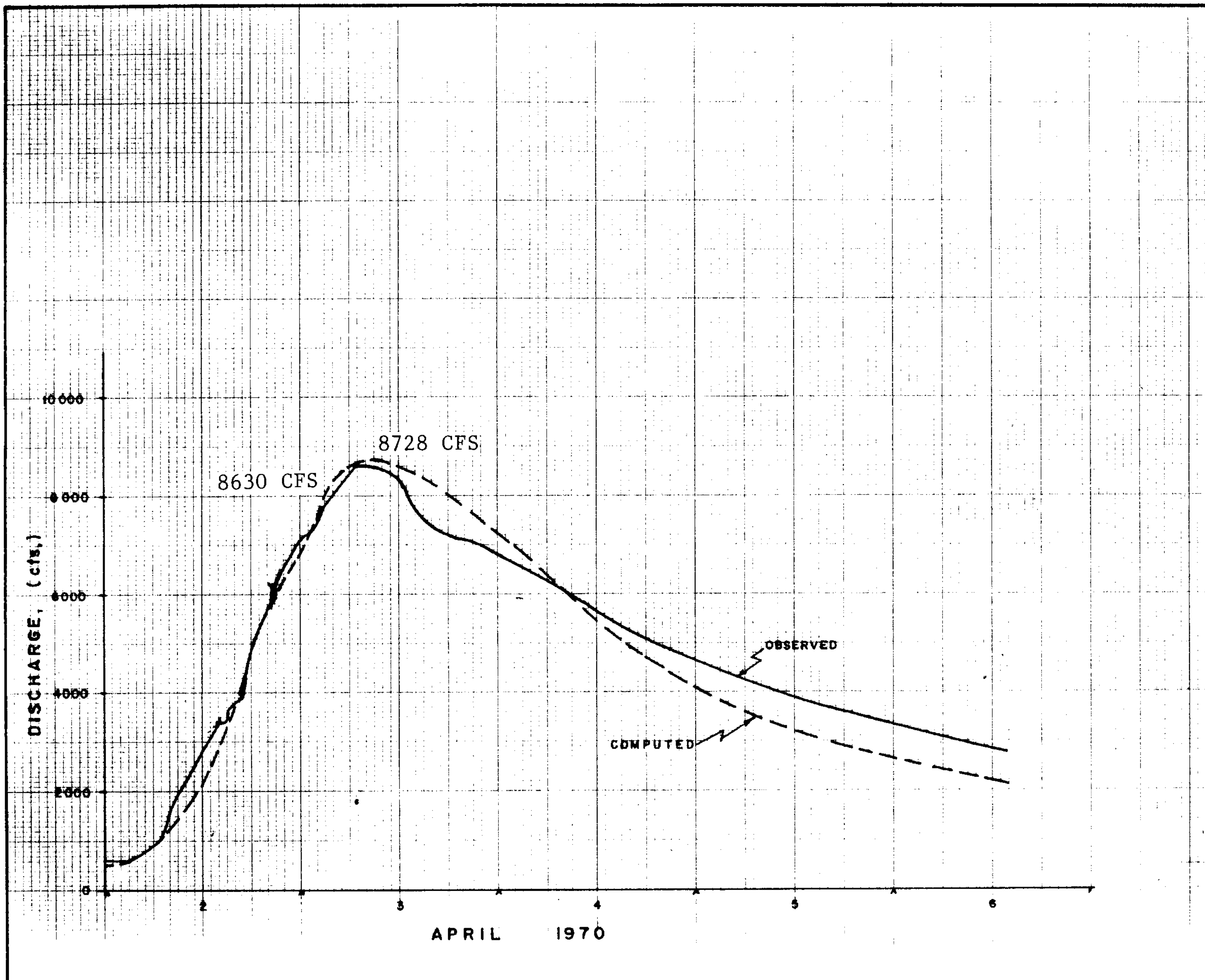
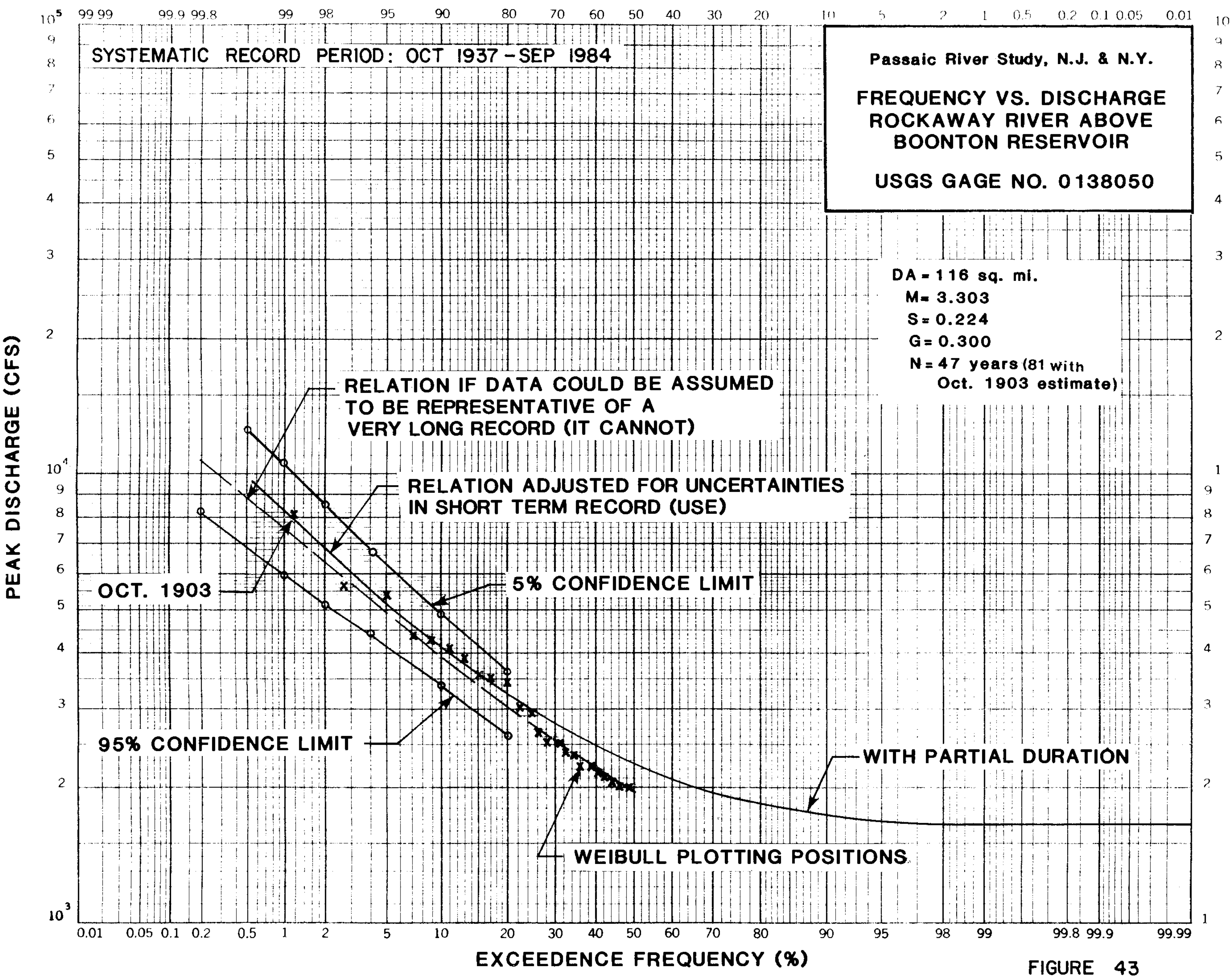

4280 CFS
4142 CFS
4000
3000
2000
1000
DISCHARGE, (cfs.)
COMPUTED
OBSERVED
20
21
22
23
24
DECEMBER 1973
Passaic River Study N.J. & N.Y.
Reproduction of
21-22 DEC. 1973 FLOOD
ROCKAWAY RIVER ABOVE
BOONTON RESERVOIR, N.J.
USGS GAGE N°0138050

FIGURE 40



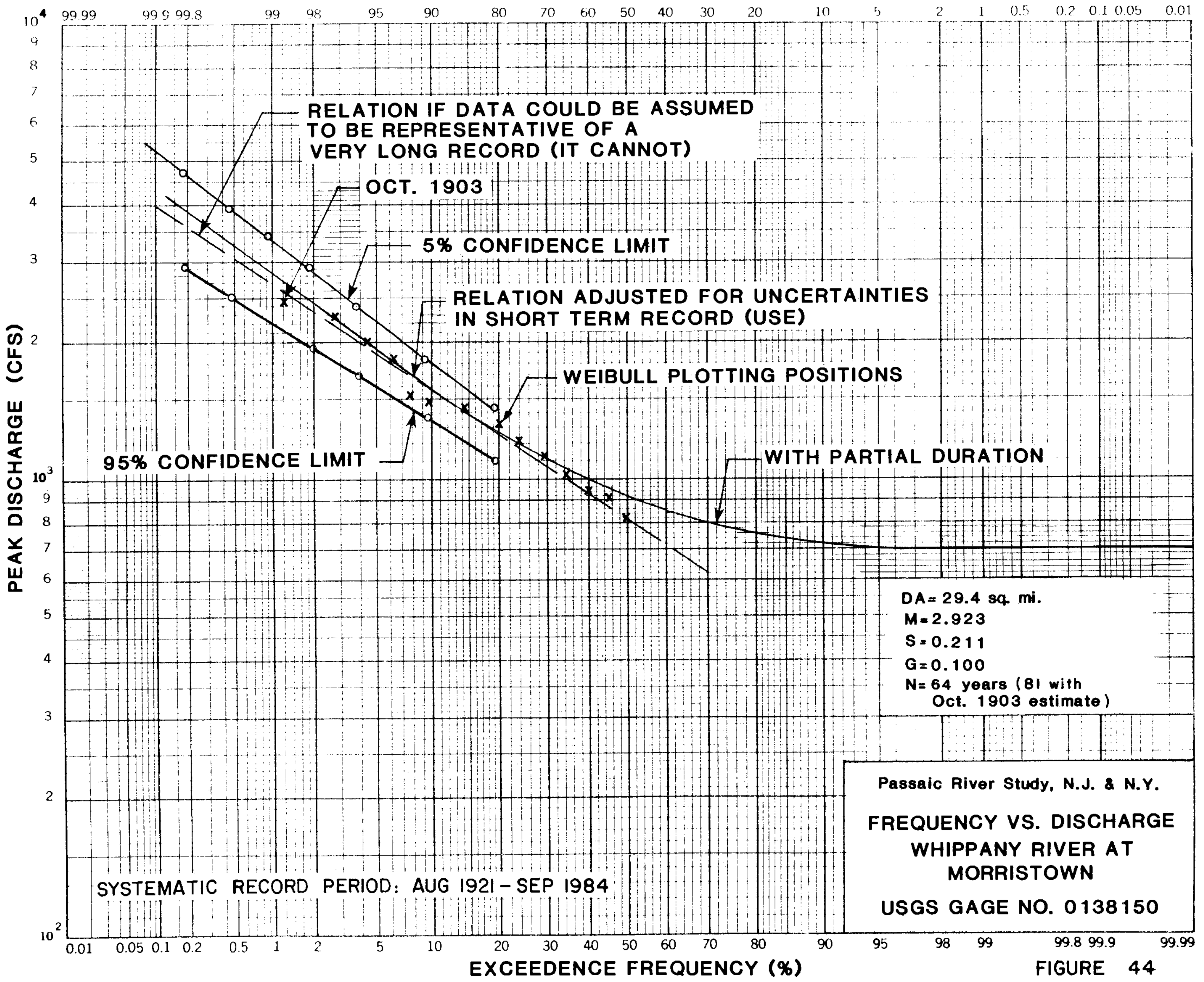
Passaic River Study, N.J. & N.Y.
Reproduction of
2 APRIL 1970 FLOOD
POMPTON RIVER AT
POMPTON PLAINS, N.J.
USGS GAGE N° 0138850

FIGURE 41



SYSTEMATIC RECORD PERIOD: OCT 1937 - SEP 1984
Passaic River Study, N.J. & N.Y.
FREQUENCY VS. DISCHARGE
ROCKAWAY RIVER ABOVE
BOONTON RESERVOIR
USGS GAGE NO. 0138050
DA = 116 sq. mi.
M = 3.303
S = 0.224
G = 0.300
N = 47 years (81 with Oct. 1903 estimate)
RELATION IF DATA COULD BE ASSUMED TO BE REPRESENTATIVE OF A VERY LONG RECORD (IT CANNOT)
RELATION ADJUSTED FOR UNCERTAINTIES IN SHORT TERM RECORD (USE)
OCT. 1903
5% CONFIDENCE LIMIT
95% CONFIDENCE LIMIT
WITH PARTIAL DURATION
WEIBULL PLOTTING POSITIONS
PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)

FIGURE 43

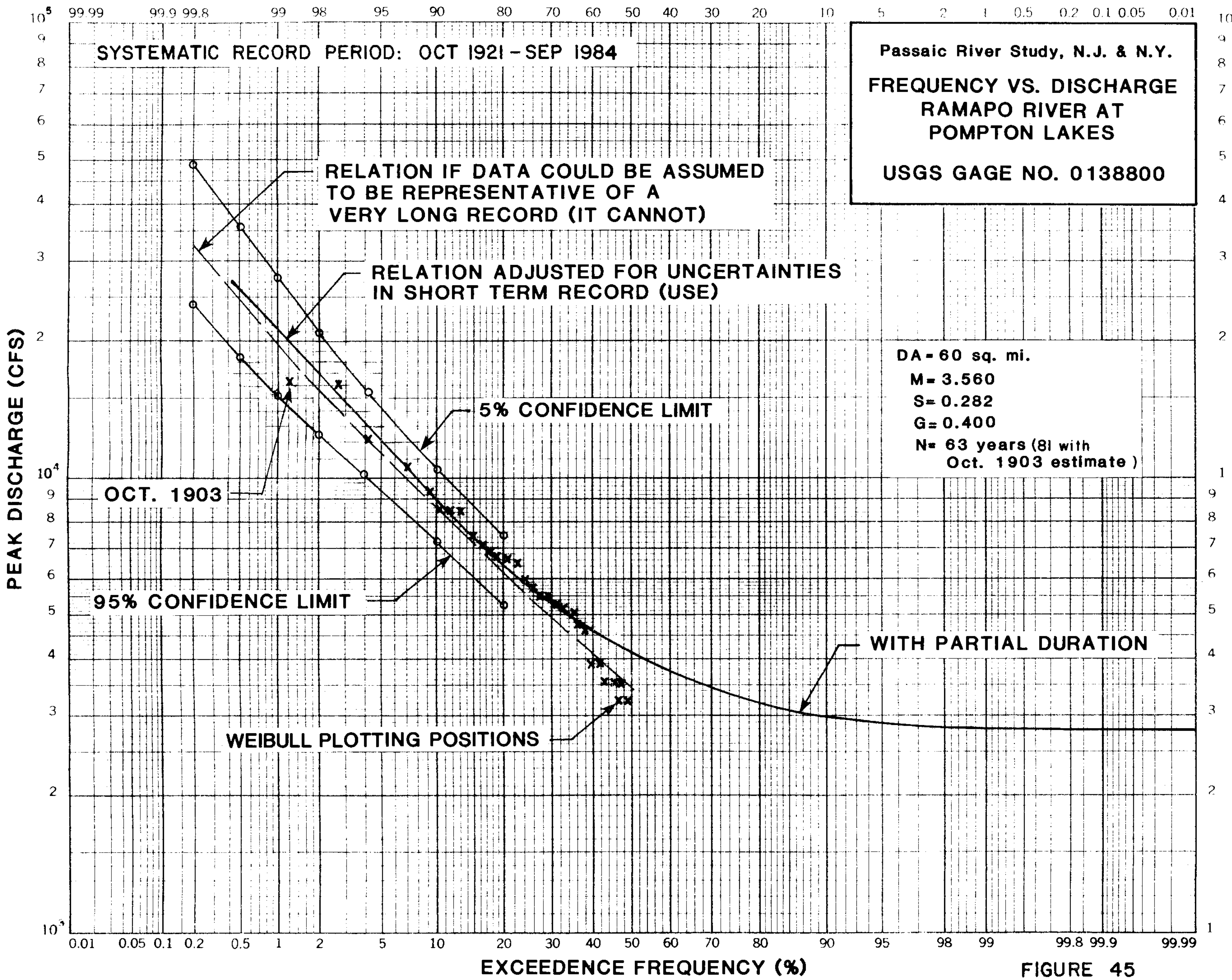


Passaic River Study, N.J. & N.Y.

FREQUENCY VS. DISCHARGE
WHIPPANY RIVER AT
MORRISTOWN

USGS GAGE NO. 0138150

FIGURE 44


SYSTEMATIC RECORD PERIOD: OCT 1921 - SEP 1984
Passaic River Study, N.J. & N.Y.
FREQUENCY VS. DISCHARGE
RAMAPO RIVER AT
POMPTON LAKES
USGS GAGE NO. 0138800
RELATION IF DATA COULD BE ASSUMED TO BE REPRESENTATIVE OF A VERY LONG RECORD (IT CANNOT)
RELATION ADJUSTED FOR UNCERTAINTIES IN SHORT TERM RECORD (USE)
DA = 60 sq. mi.
M = 3.560
S = 0.282
G = 0.400
N = 63 years (81 with Oct. 1903 estimate)
5% CONFIDENCE LIMIT
OCT. 1903
95% CONFIDENCE LIMIT
WITH PARTIAL DURATION
WEIBULL PLOTTING POSITIONS
PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)
FIGURE 45

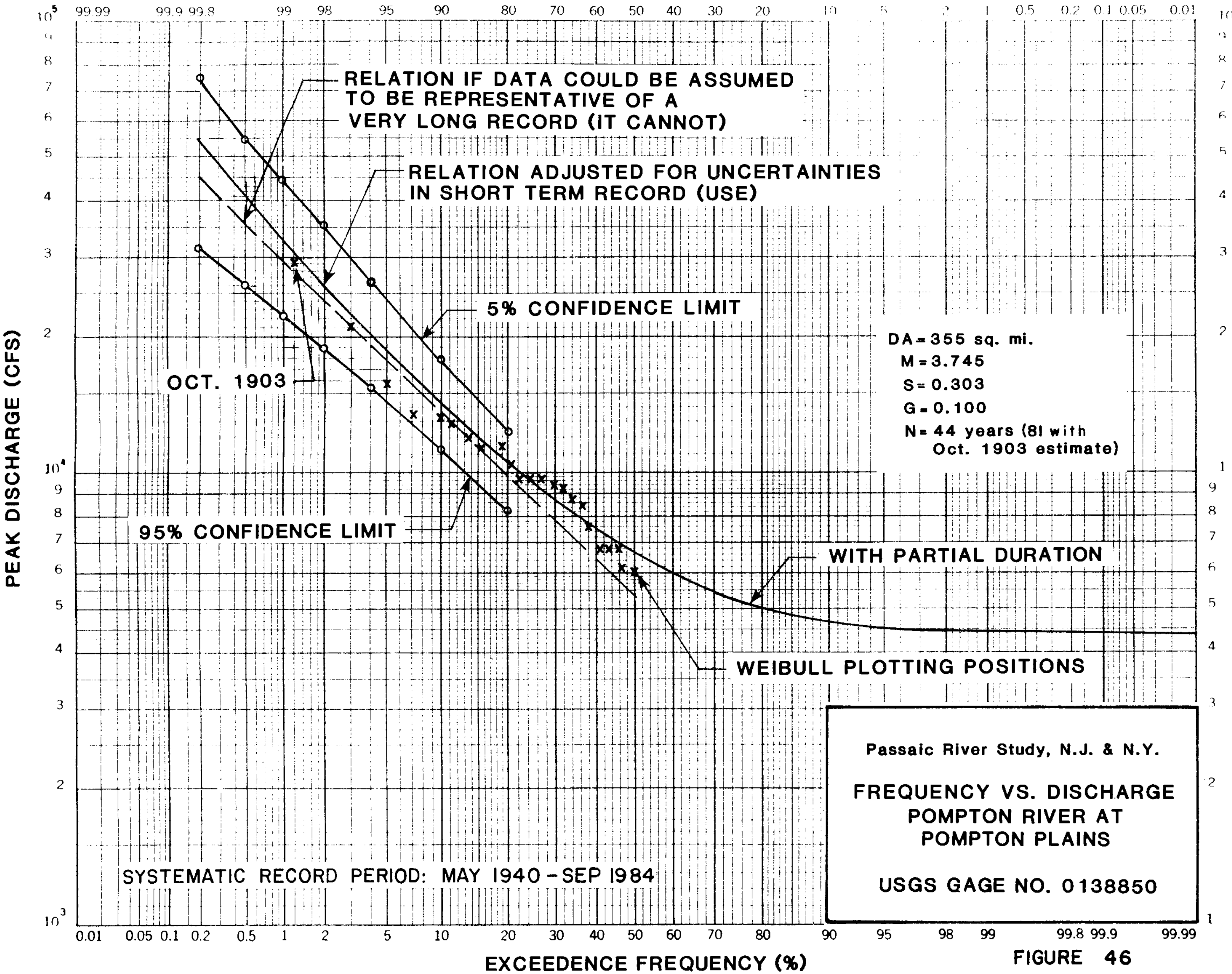

RELATION IF DATA COULD BE ASSUMED TO BE REPRESENTATIVE OF A VERY LONG RECORD (IT CANNOT)
RELATION ADJUSTED FOR UNCERTAINTIES IN SHORT TERM RECORD (USE)
5% CONFIDENCE LIMIT
OCT. 1903
95% CONFIDENCE LIMIT
DA = 355 sq. mi.
M = 3.745
S = 0.303
G = 0.100
N = 44 years (81 with Oct. 1903 estimate)
WITH PARTIAL DURATION
WEIBULL PLOTTING POSITIONS
SYSTEMATIC RECORD PERIOD: MAY 1940 - SEP 1984
PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)
Passaic River Study, N.J. & N.Y.
FREQUENCY VS. DISCHARGE
POMPTON RIVER AT
POMPTON PLAINS
USGS GAGE NO. 0138850

FIGURE 46

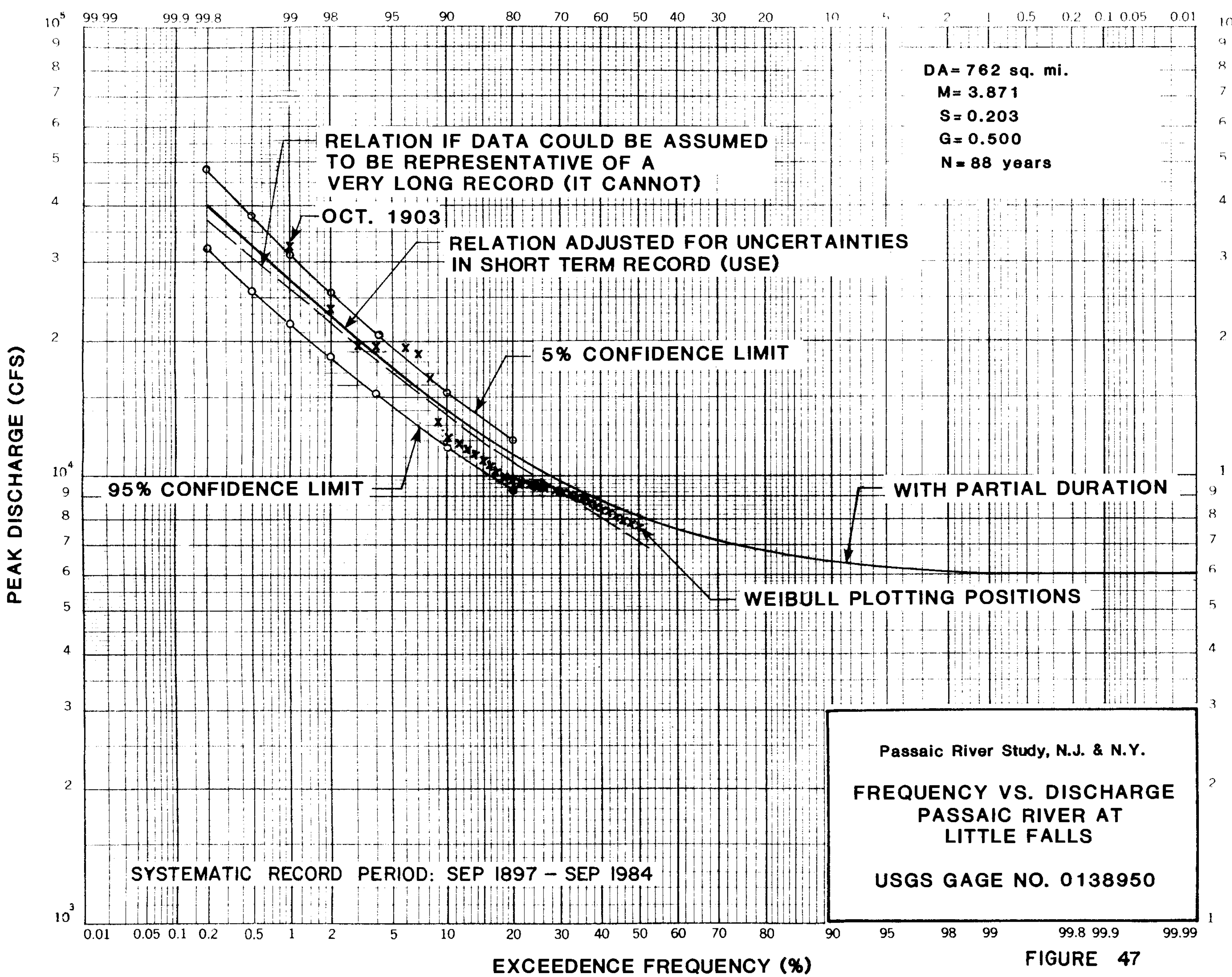
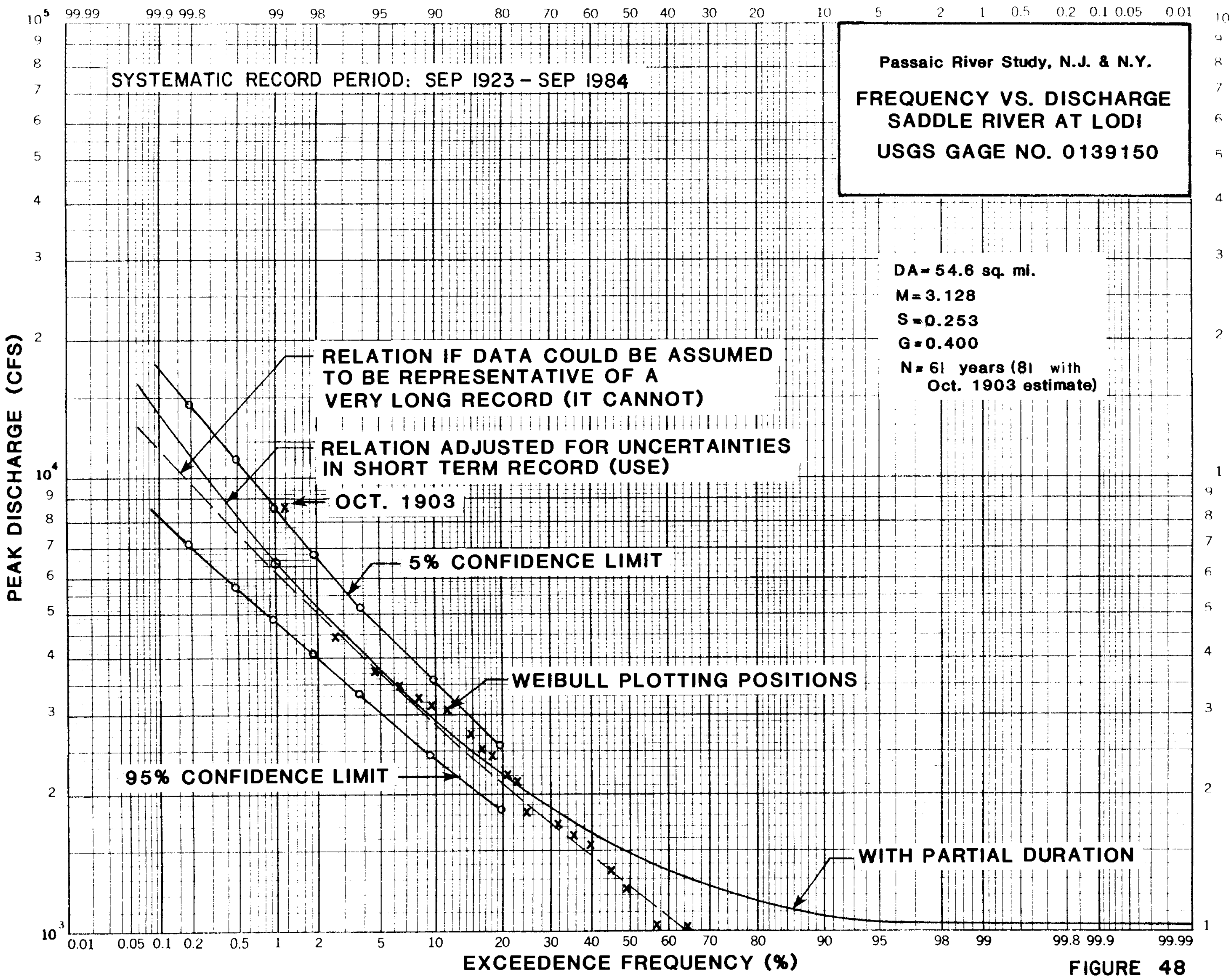
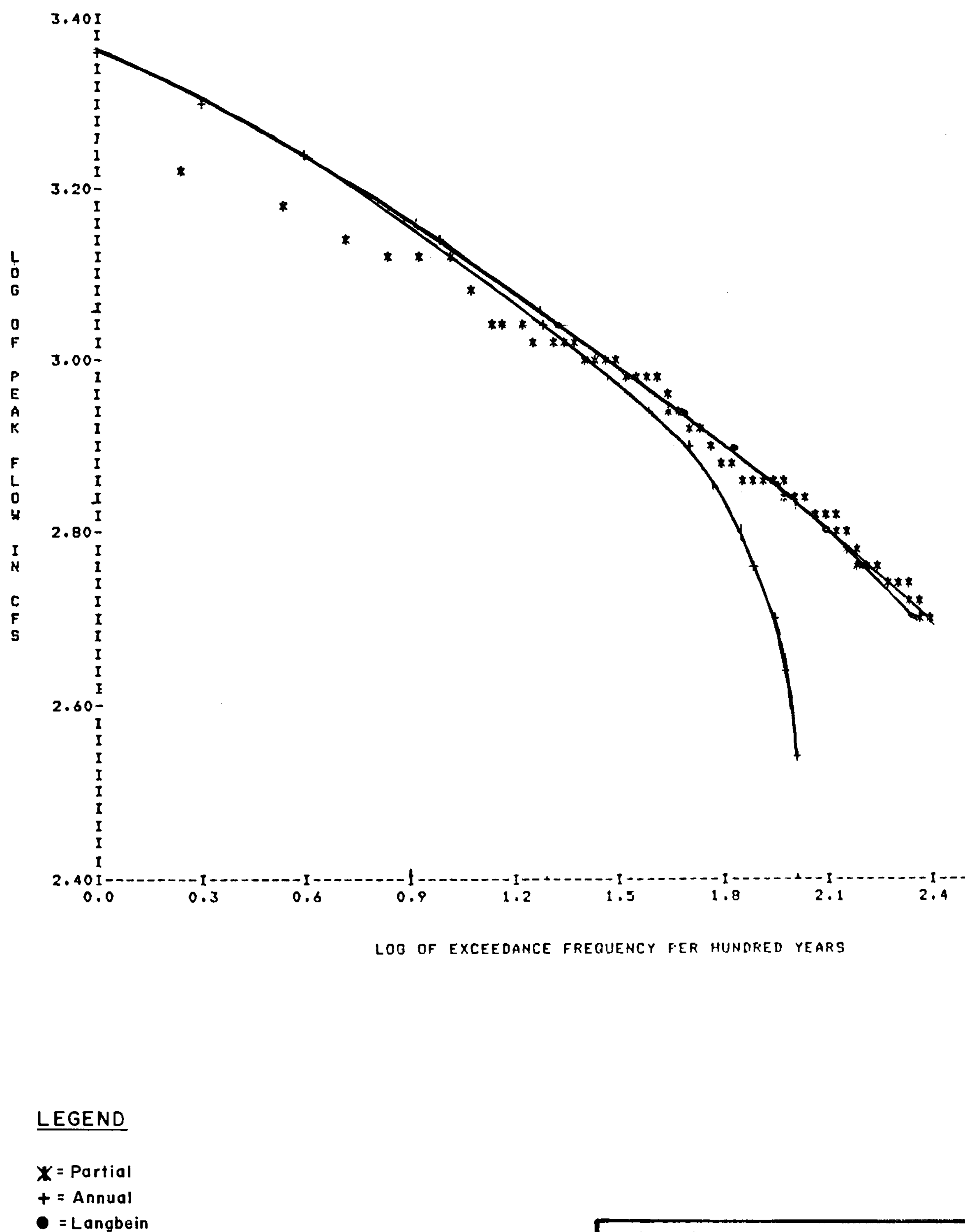

DA= 762 sq. mi.
M= 3.871
S= 0.203
G= 0.500
N= 88 years
RELATION IF DATA COULD BE ASSUMED TO BE REPRESENTATIVE OF A VERY LONG RECORD (IT CANNOT)
OCT. 1903
RELATION ADJUSTED FOR UNCERTAINTIES IN SHORT TERM RECORD (USE)
5% CONFIDENCE LIMIT
95% CONFIDENCE LIMIT
WITH PARTIAL DURATION
WEIBULL PLOTTING POSITIONS
PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)
SYSTEMATIC RECORD PERIOD: SEP 1897 – SEP 1984
Passaic River Study, N.J. & N.Y.
FREQUENCY VS. DISCHARGE
PASSAIC RIVER AT
LITTLE FALLS
USGS GAGE NO. 0138950

FIGURE 47



Passaic River Study, N.J. & N.Y.
FREQUENCY VS. DISCHARGE
SADDLE RIVER AT LODI
USGS GAGE NO. 0139150
SYSTEMATIC RECORD PERIOD: SEP 1923 - SEP 1984
DA = 54.6 sq. mi.
M = 3.128
S = 0.253
G = 0.400
N = 61 years (81 with Oct. 1903 estimate)
RELATION IF DATA COULD BE ASSUMED TO BE REPRESENTATIVE OF A VERY LONG RECORD (IT CANNOT)
RELATION ADJUSTED FOR UNCERTAINTIES IN SHORT TERM RECORD (USE)
OCT. 1903
5% CONFIDENCE LIMIT
WEIBULL PLOTTING POSITIONS
95% CONFIDENCE LIMIT
WITH PARTIAL DURATION
PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)

FIGURE 48

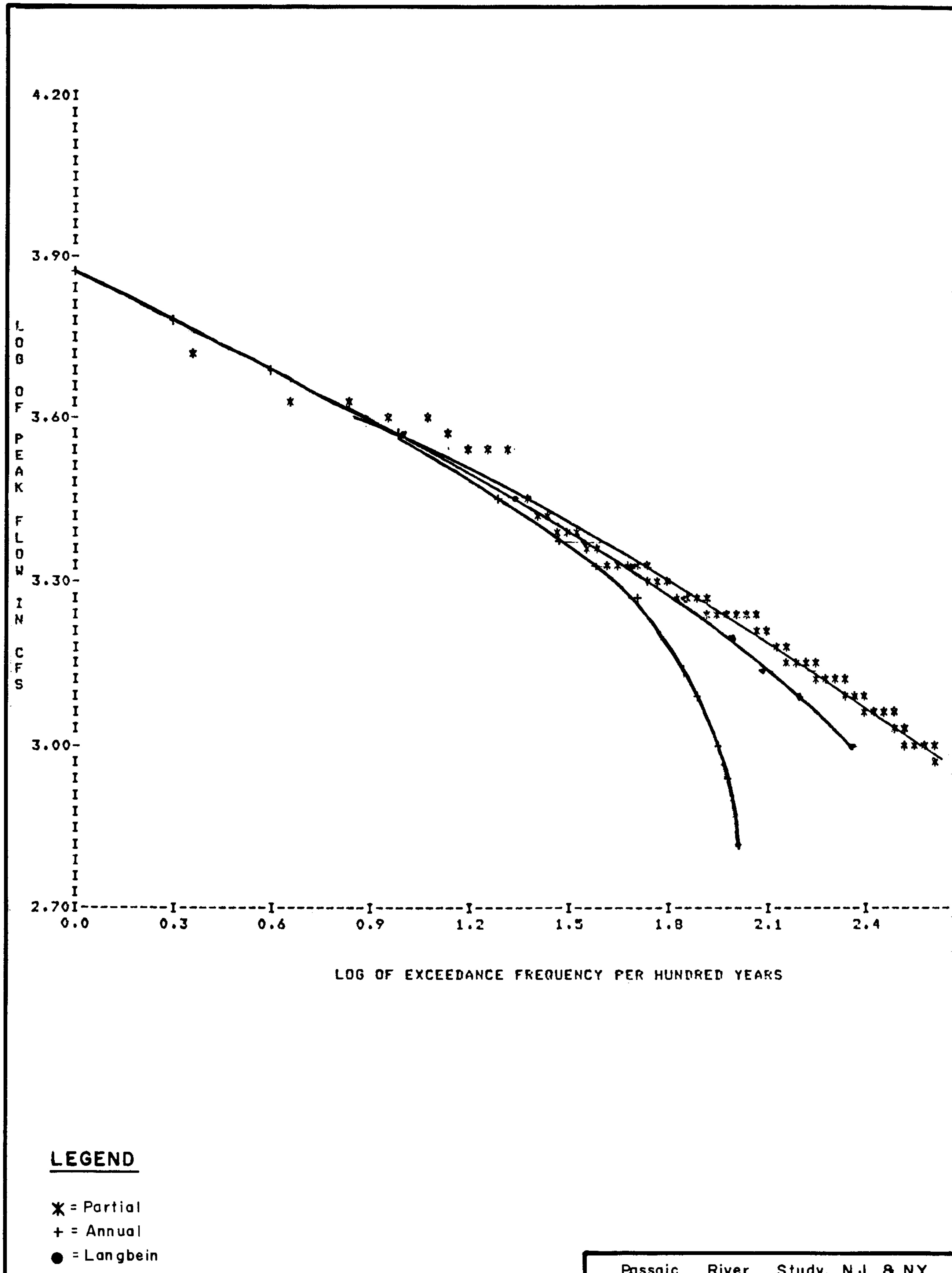


Passaic River Study, N.J. & N.Y.

PARTIAL DURATION VS. ANNUAL EVENTS PASSAIC RIVER AT MILLINGTON, N.J.

USGS GAGE N° 0137900

FIGURE 49



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

PARTIAL DURATION VS. ANNUAL EVENTS
ROCKAWAY RIVER ABOVE BOONTON RESERVOIR
USGS GAGE Nº 0138050

FIGURE 50

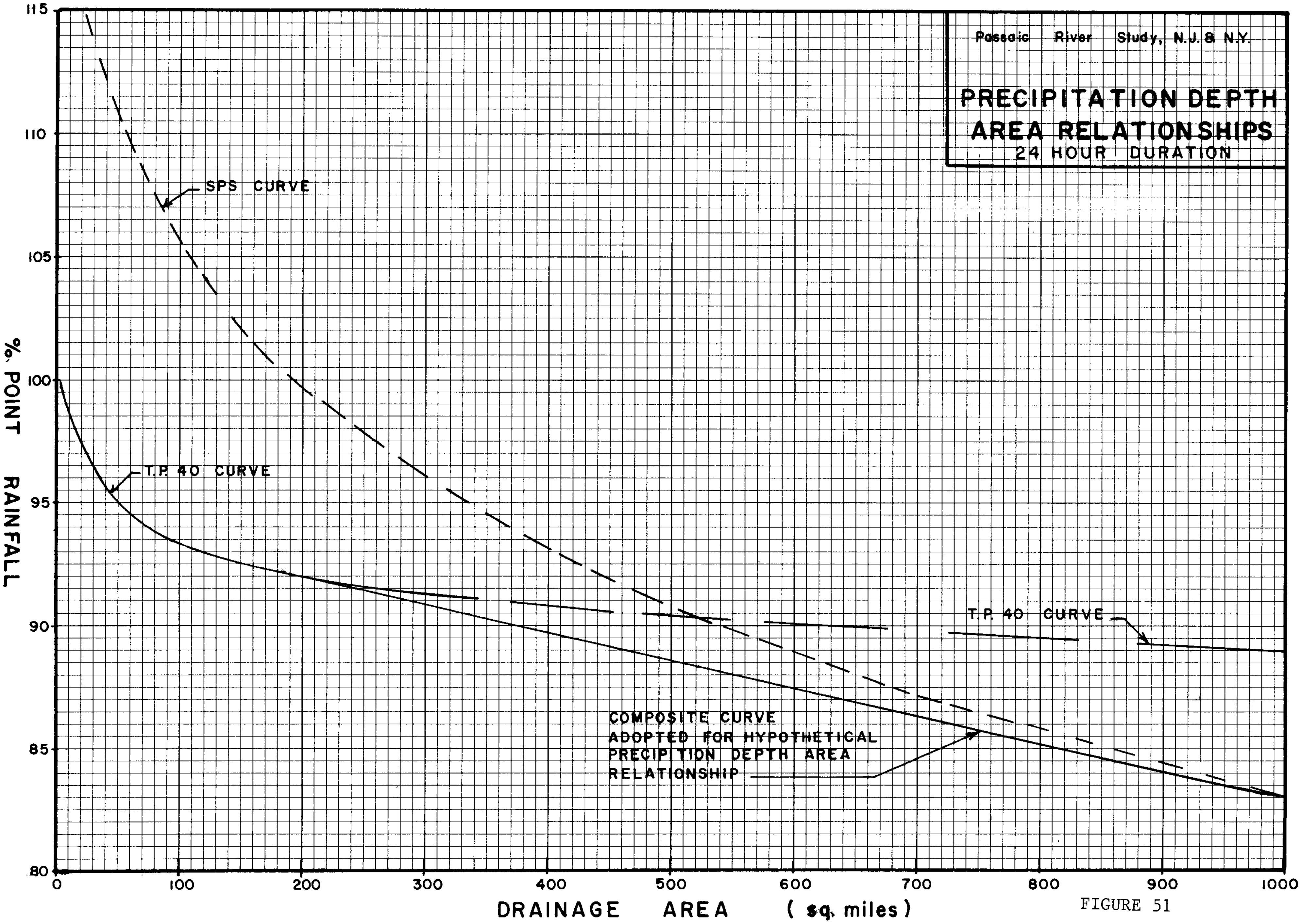
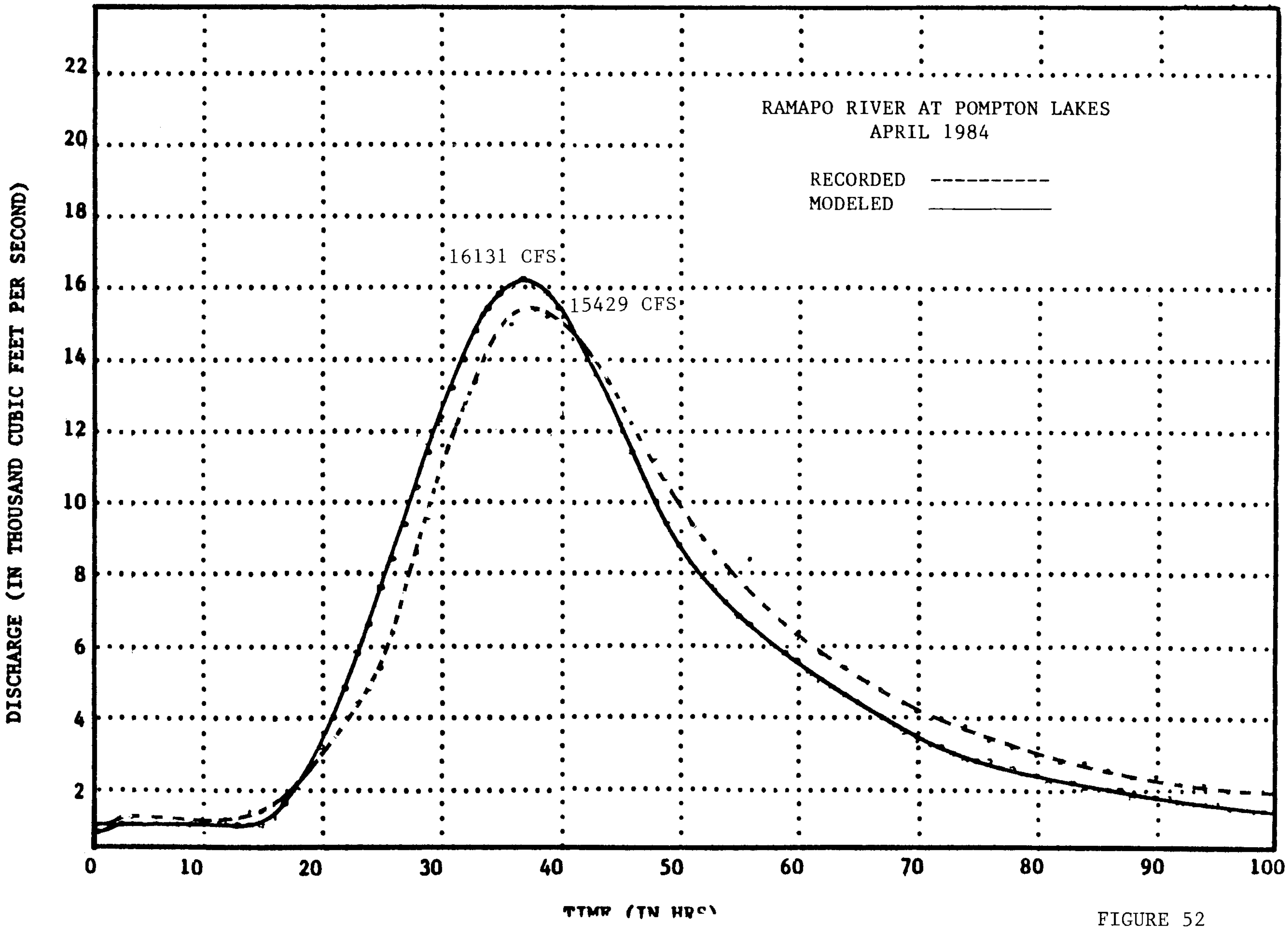
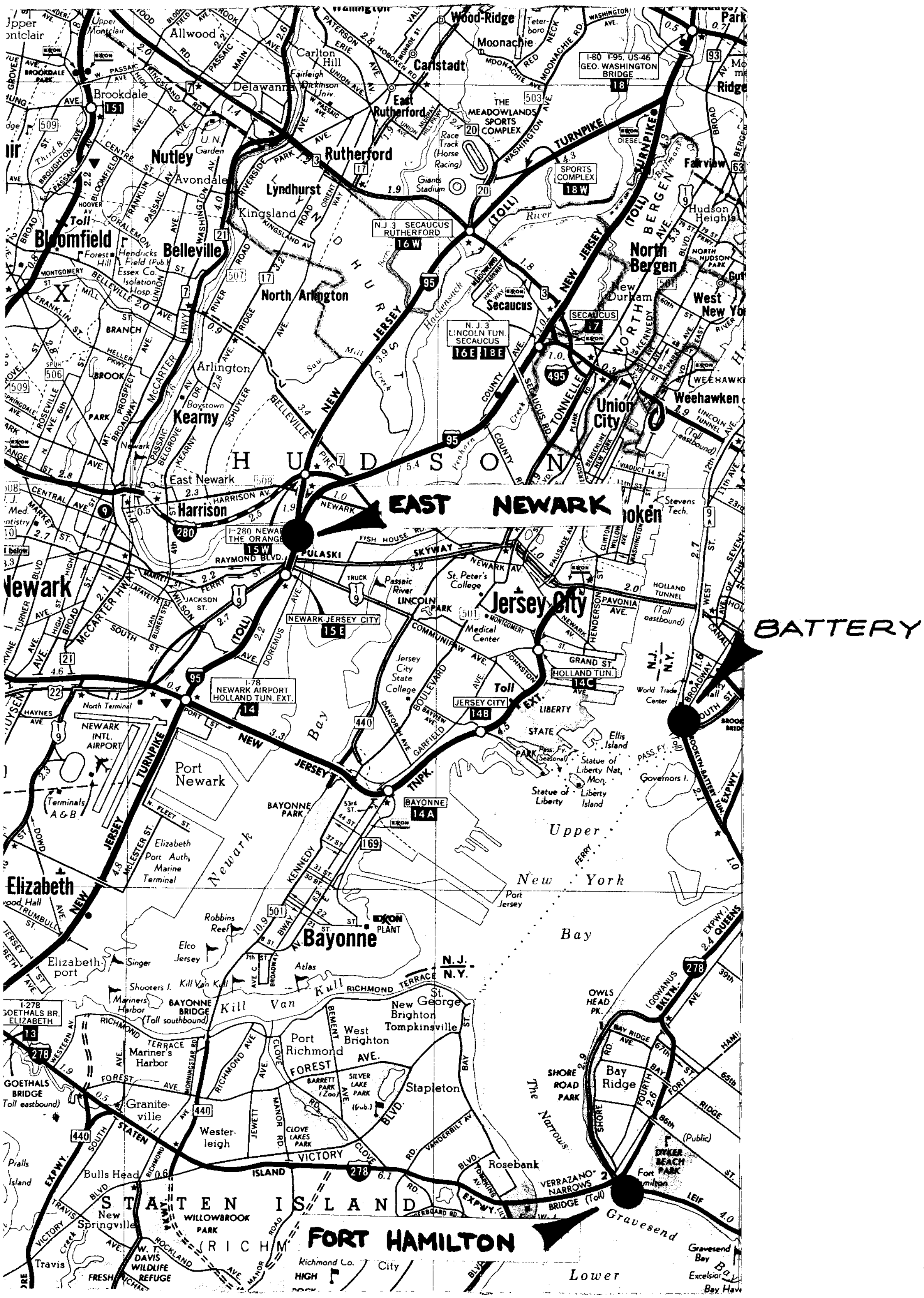

Passaic River Study, N.J. & N.Y.
PRECIPITATION DEPTH
AREA RELATIONSHIPS
24 HOUR DURATION
SPS CURVE
T.P. 40 CURVE
T.P. 40 CURVE
COMPOSITE CURVE
ADOPTED FOR HYPOTHETICAL
PRECIPITION DEPTH AREA
RELATIONSHIP
% POINT RAINFALL
115
110
105
100
95
90
85
80
0
100
200
300
400
500
600
700
800
900
1000
DRAINAGE AREA (sq. miles)

FIGURE 51



RAMAPO RIVER AT POMPTON LAKES
APRIL 1984
RECORDED
MODELED
16131 CFS
15429 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
22
20
18
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100

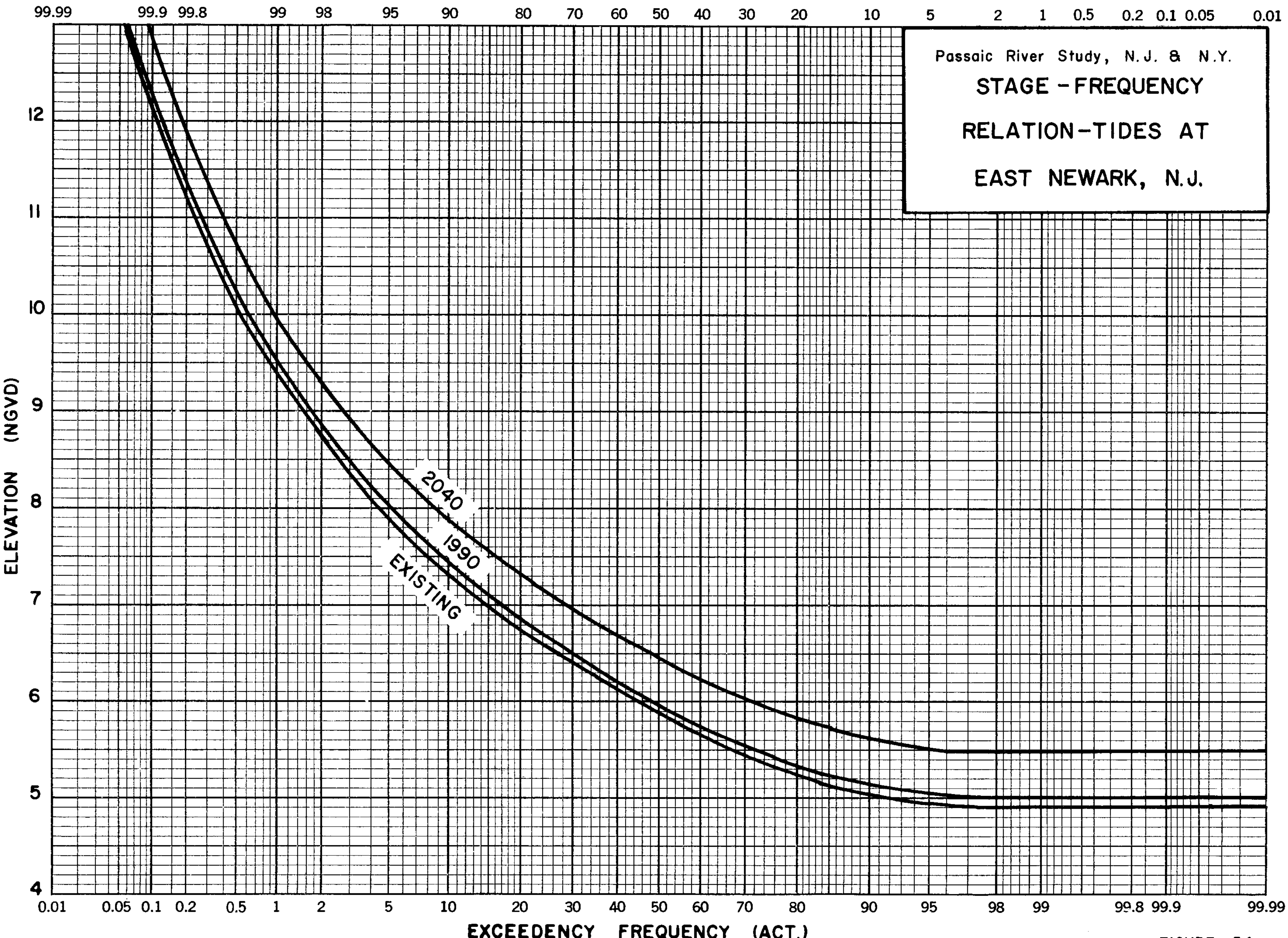
FIGURE 52



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

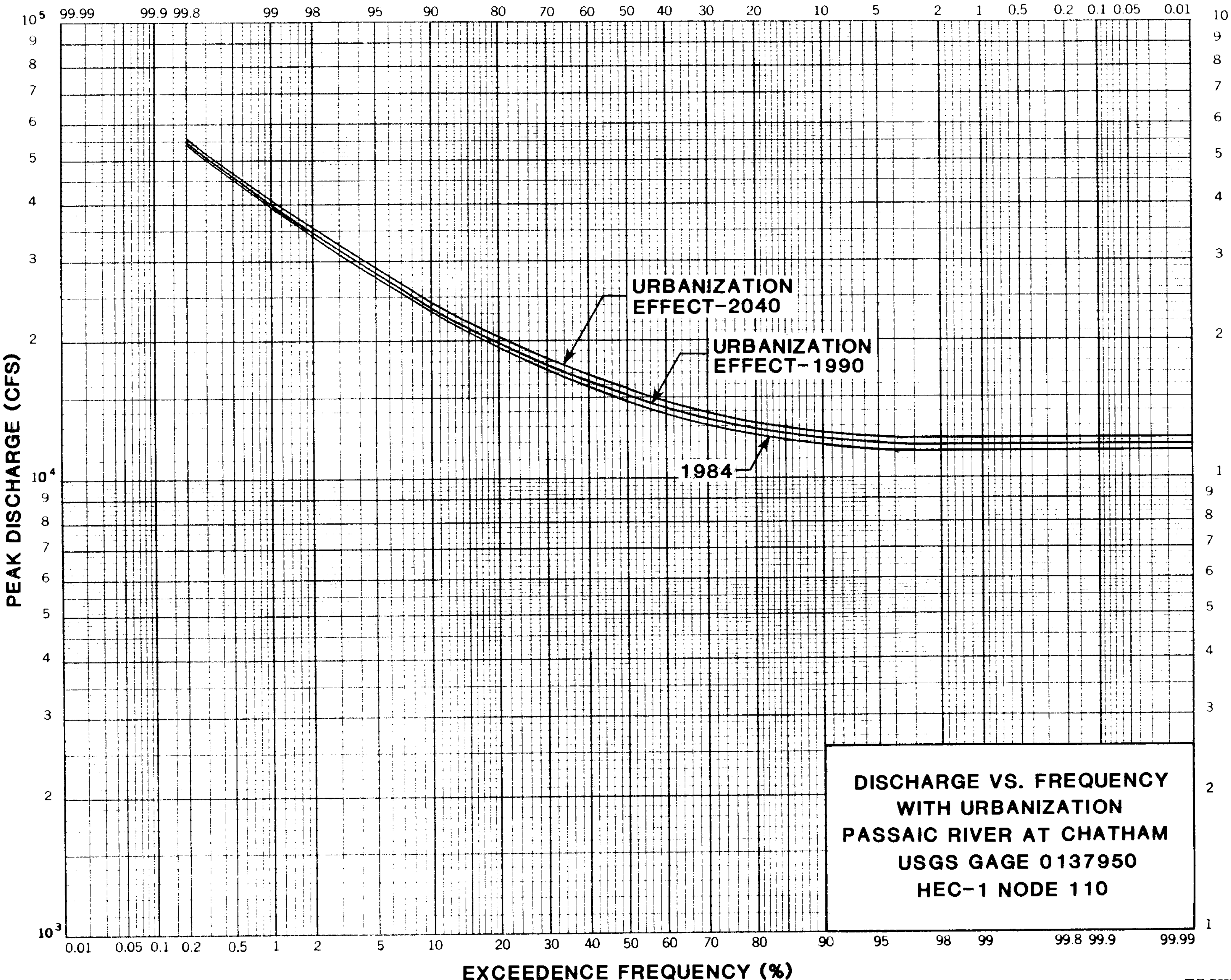
TIDAL GAGE LOCATIONS

FIGURE 53



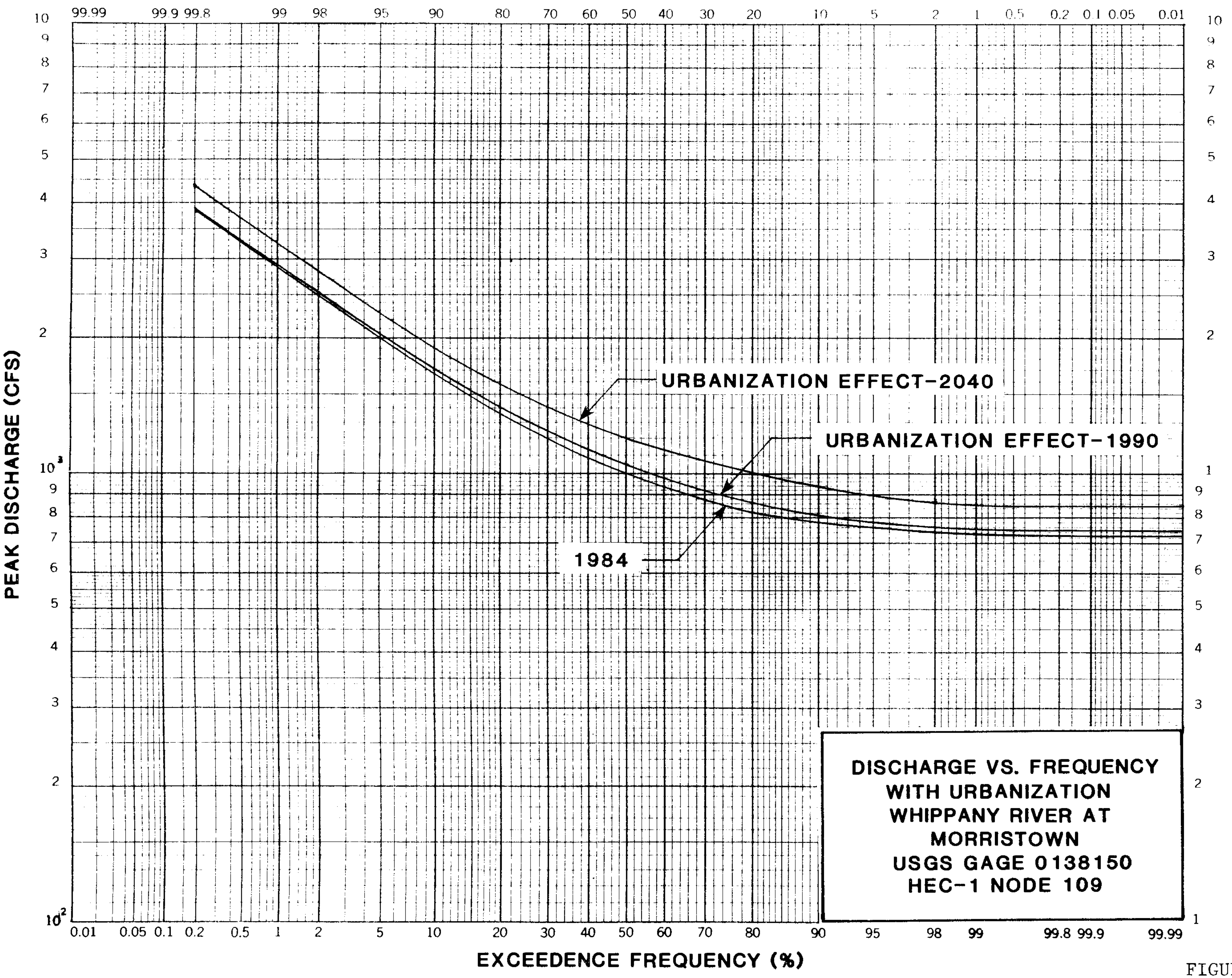
Passaic River Study, N.J. & N.Y.
STAGE - FREQUENCY
RELATION-TIDES AT
EAST NEWARK, N.J.
2040
1990
EXISTING
ELEVATION (NGVD)
EXCEEDENCY FREQUENCY (ACT.)
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
4 5 6 7 8 9 10 11 12

FIGURE 54



URBANIZATION EFFECT-2040
URBANIZATION EFFECT-1990
1984
DISCHARGE VS. FREQUENCY
WITH URBANIZATION
PASSAIC RIVER AT CHATHAM
USGS GAGE 0137950
HEC-1 NODE 110
PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)

FIGURE 55



URBANIZATION EFFECT-2040
URBANIZATION EFFECT-1990
1984
DISCHARGE VS. FREQUENCY
WITH URBANIZATION
WHIPPANY RIVER AT
MORRISTOWN
USGS GAGE 0138150
HEC-1 NODE 109
PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)

FIGURE 56

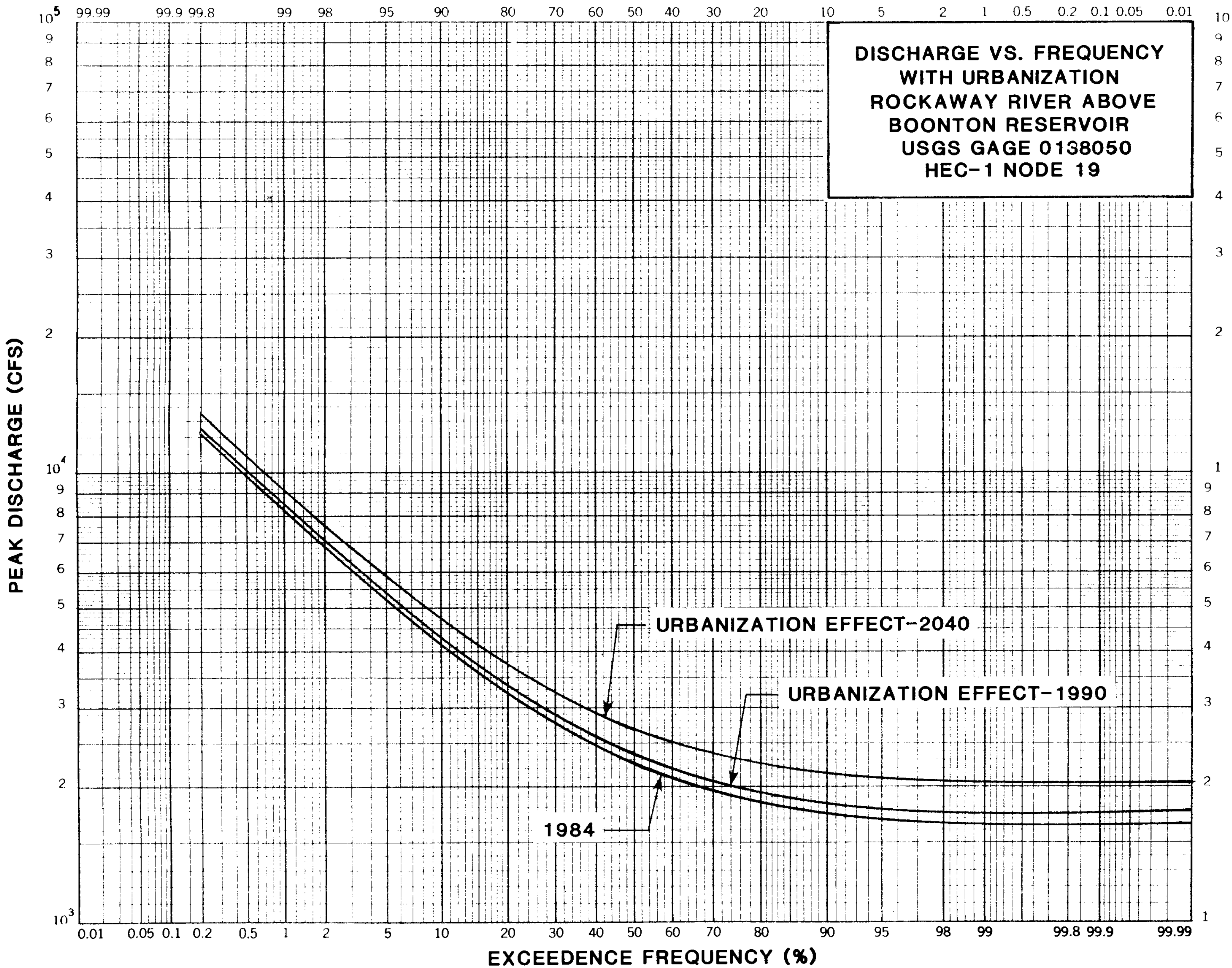

DISCHARGE VS. FREQUENCY
WITH URBANIZATION
ROCKAWAY RIVER ABOVE
BOONTON RESERVOIR
USGS GAGE 0138050
HEC-1 NODE 19
URBANIZATION EFFECT-2040
URBANIZATION EFFECT-1990
1984
PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)

FIGURE 57

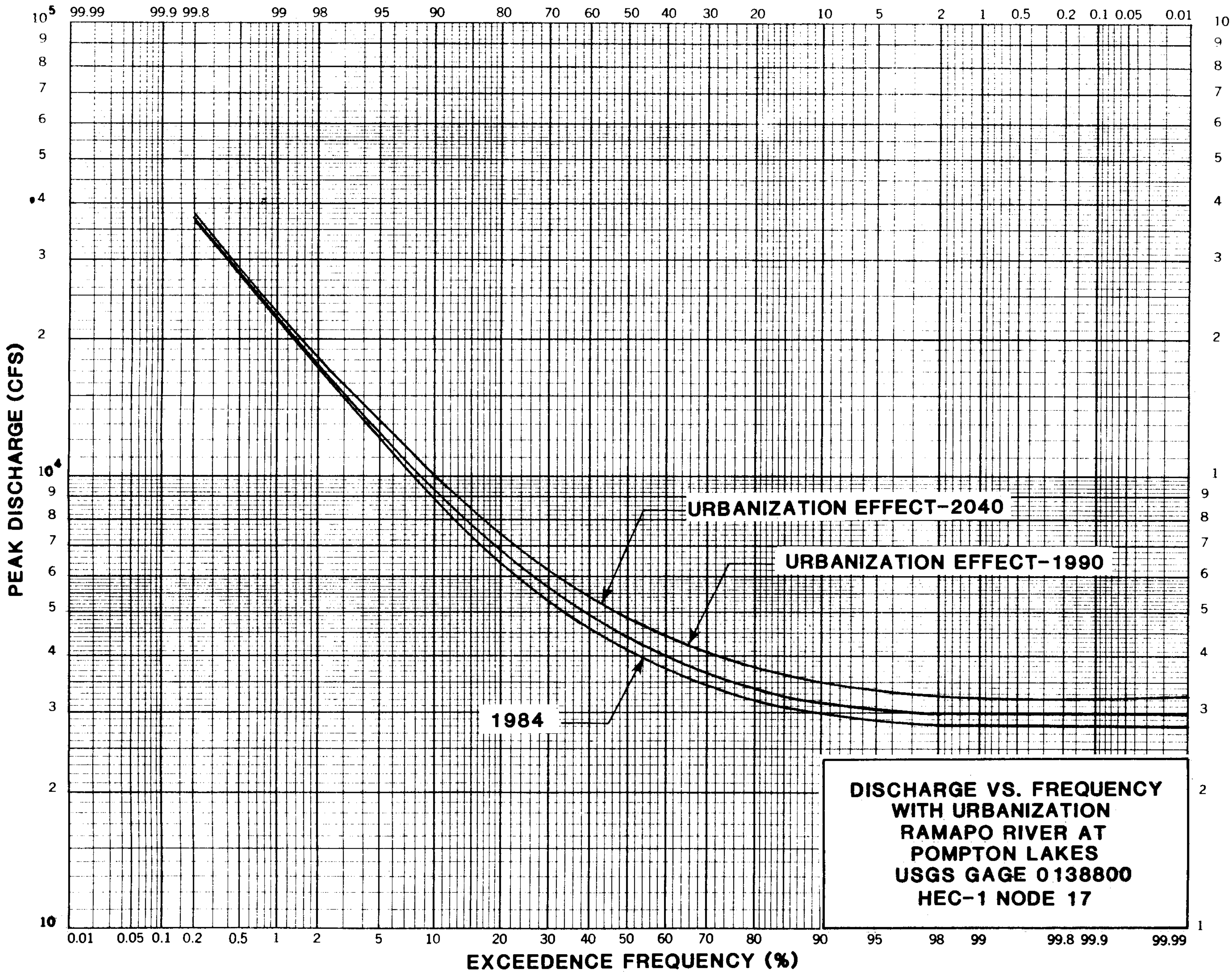
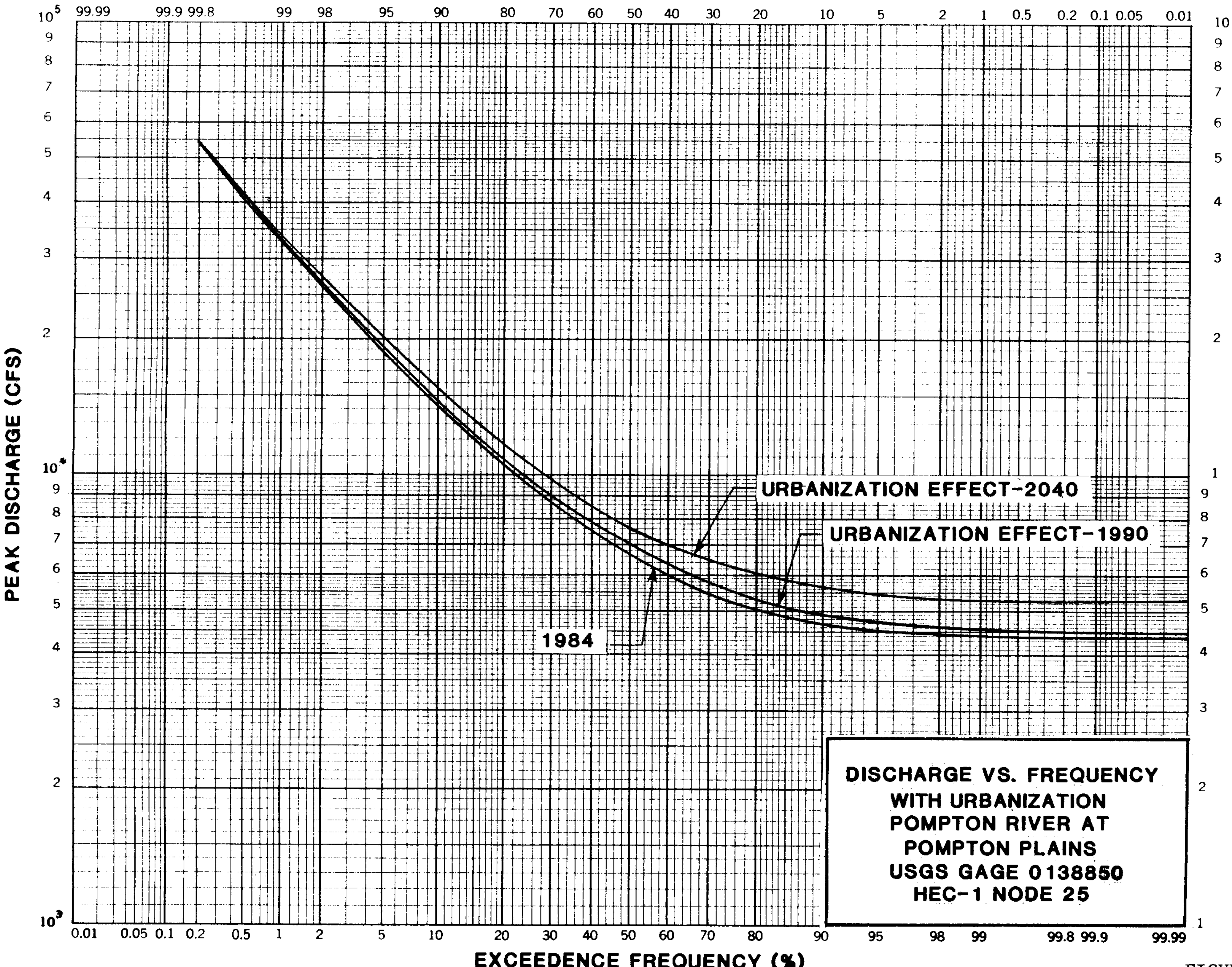
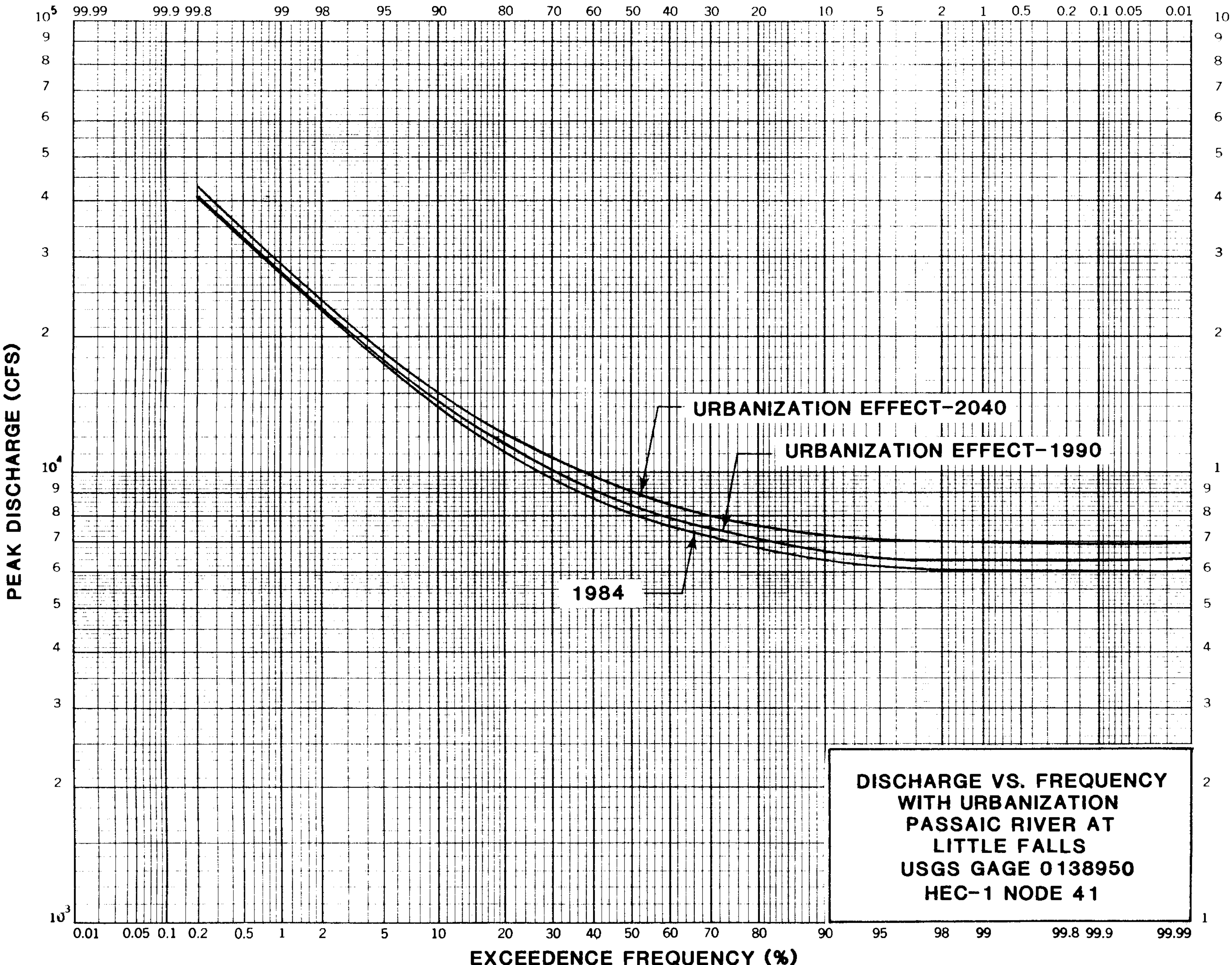

PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)
URBANIZATION EFFECT-2040
URBANIZATION EFFECT-1990
1984
DISCHARGE VS. FREQUENCY
WITH URBANIZATION
RAMAPO RIVER AT
POMPTON LAKES
USGS GAGE 0138800
HEC-1 NODE 17

FIGURE 58



PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)
URBANIZATION EFFECT-2040
URBANIZATION EFFECT-1990
1984
DISCHARGE VS. FREQUENCY
WITH URBANIZATION
POMPTON RIVER AT
POMPTON PLAINS
USGS GAGE 0138850
HEC-1 NODE 25

FIGURE 59



PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)
URBANIZATION EFFECT-2040
URBANIZATION EFFECT-1990
1984
DISCHARGE VS. FREQUENCY
WITH URBANIZATION
PASSAIC RIVER AT
LITTLE FALLS
USGS GAGE 0138950
HEC-1 NODE 41

FIGURE 60

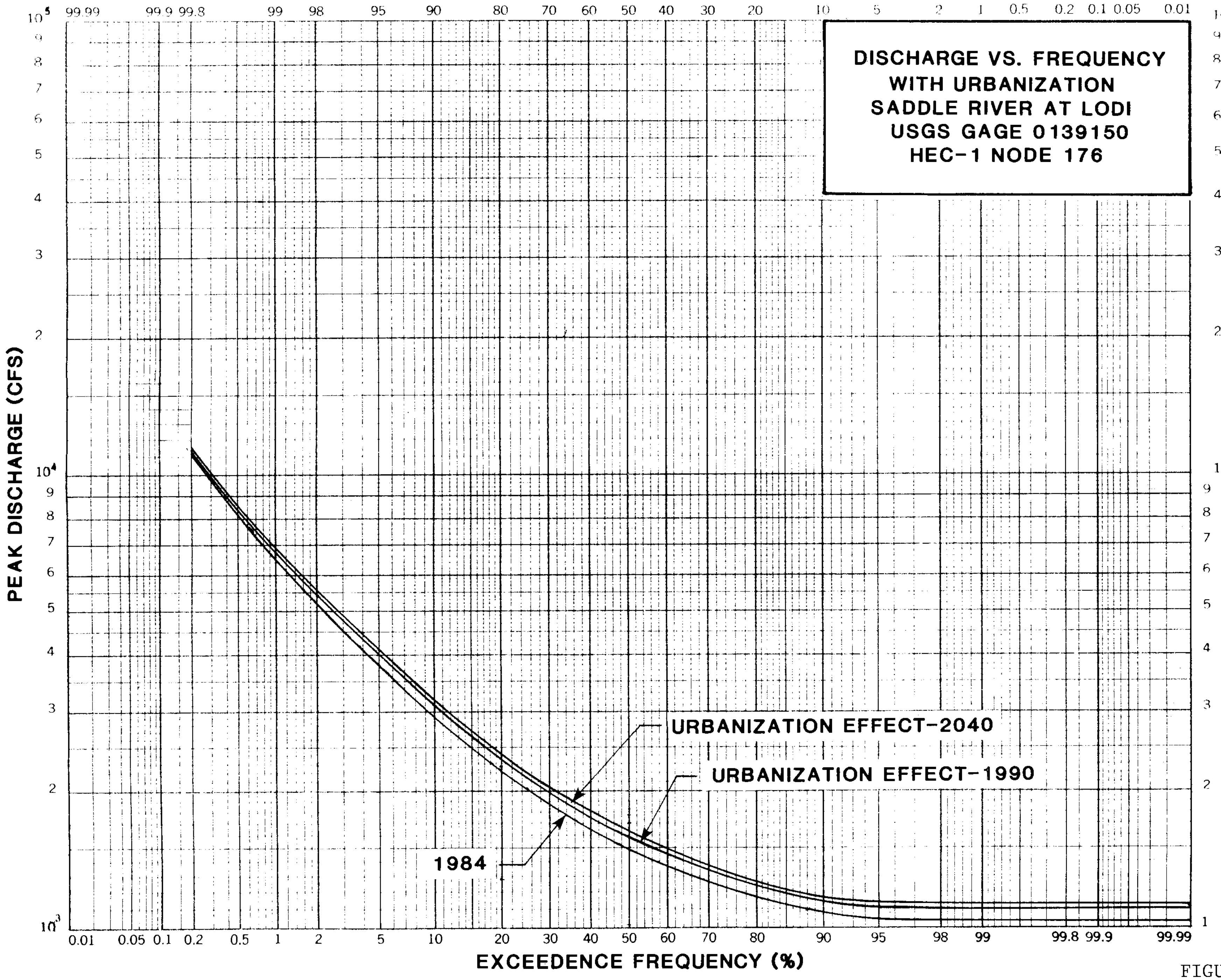
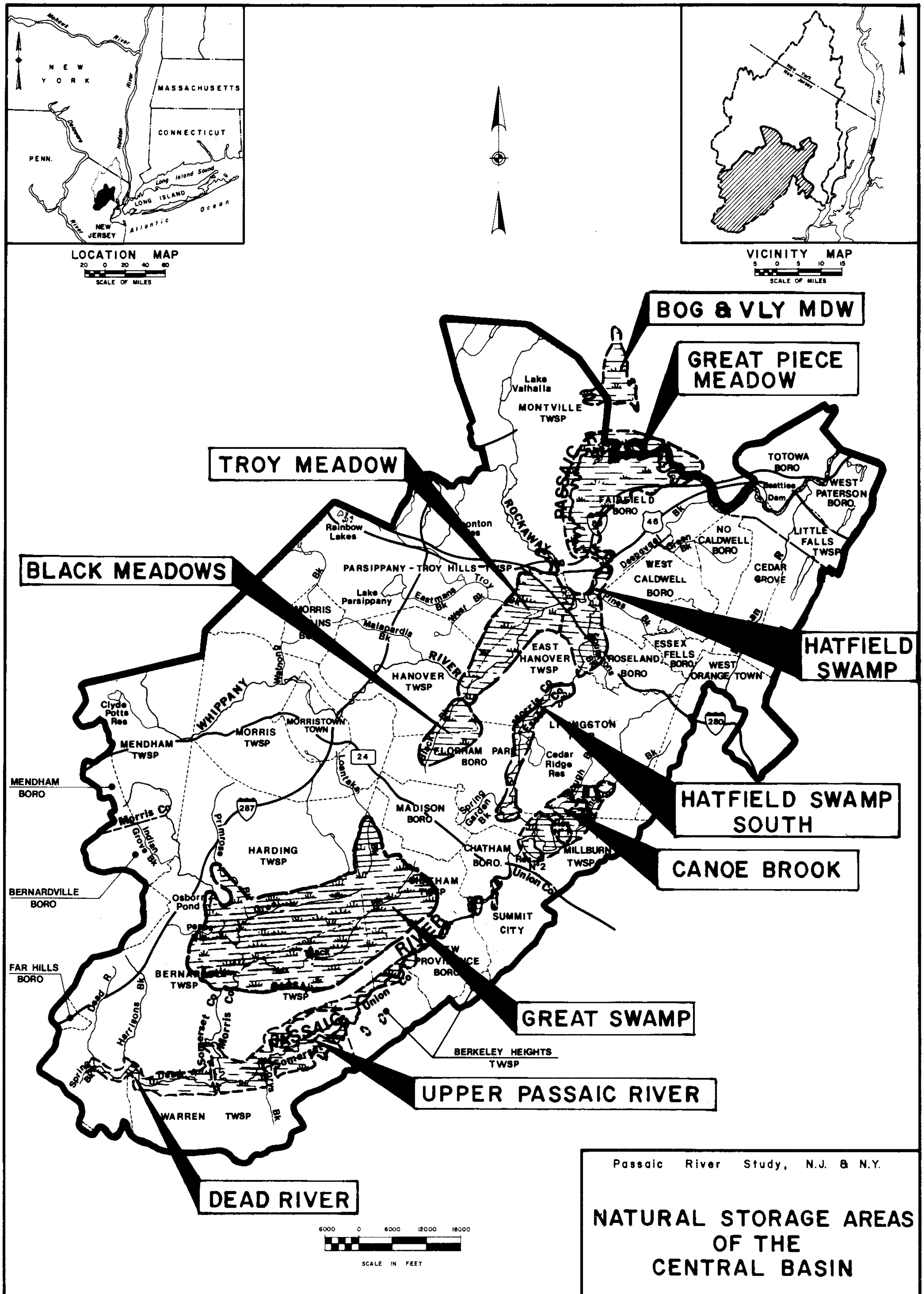
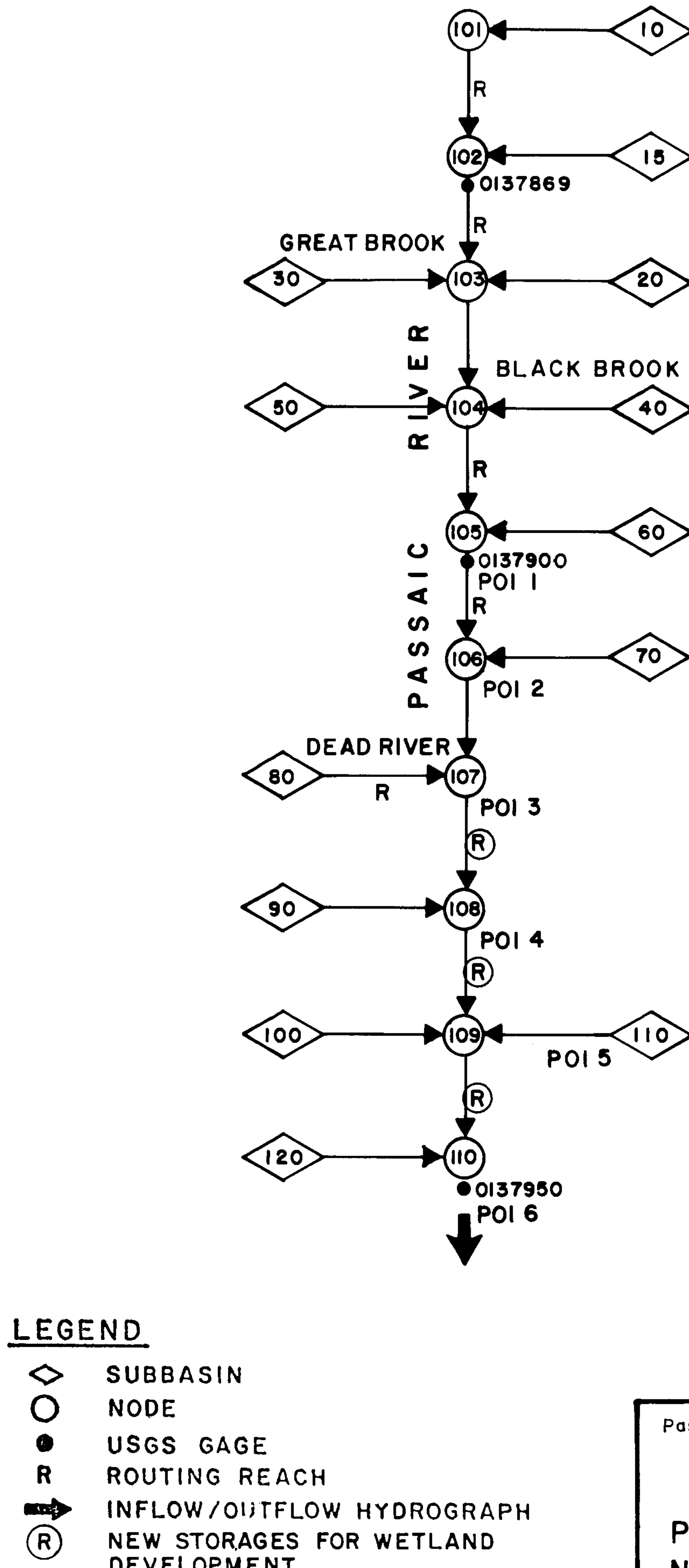

DISCHARGE VS. FREQUENCY
WITH URBANIZATION
SADDLE RIVER AT LODI
USGS GAGE 0139150
HEC-1 NODE 176
URBANIZATION EFFECT-2040
URBANIZATION EFFECT-1990
1984
PEAK DISCHARGE (CFS)
EXCEEDENCE FREQUENCY (%)

FIGURE 61



LOCATION MAP
SCALE OF MILES
NEW YORK
MASSACHUSETTS
CONNECTICUT
PENN.
NEW JERSEY
LONG ISLAND
Long Island Sound
Atlantic Ocean
VICINITY MAP
SCALE OF MILES
BOG & VLY MDW
GREAT PIECE MEADOW
TROY MEADOW
BLACK MEADOWS
HATFIELD SWAMP
HATFIELD SWAMP SOUTH
CANOE BROOK
GREAT SWAMP
UPPER PASSAIC RIVER
DEAD RIVER
Lake Valhalla
MONTVILLE TWSP
TOTOWA BORO
WEST PATERSON BORO
LITTLE FALLS TWSP
FAIRFIELD BORO
NO CALDWELL BORO
WEST CALDWELL BORO
CEDAR GROVE
Rainbow Lakes
PARSIPPANY - TROY HILLS TWSP
Lake Parsippany
EAST HANOVER TWSP
ROSELAND BORO
ESSEX FELLS BORO
WEST ORANGE TOWN
HANOVER TWSP
MORRIS TWSP
MORRISTOWN TOWN
MENDHAM TWSP
MENDHAM BORO
Clyde Potts Res
FLORHAM PARK BORO
Cedar Ridge Res
MADISON BORO
CHATHAM BORO
MILLBURN TWSP
HARDING TWSP
BERNARDVILLE BORO
Osborn Pond
SUMMIT CITY
NEW PROVIDENCE BORO
FAR HILLS BORO
BERKELEY HEIGHTS TWSP
WARREN TWSP
ROCKAWAY
PASSAIC
WHIPPANY
RIVER
Passaic River Study, N.J. & N.Y.
NATURAL STORAGE AREAS OF THE CENTRAL BASIN
SCALE IN FEET

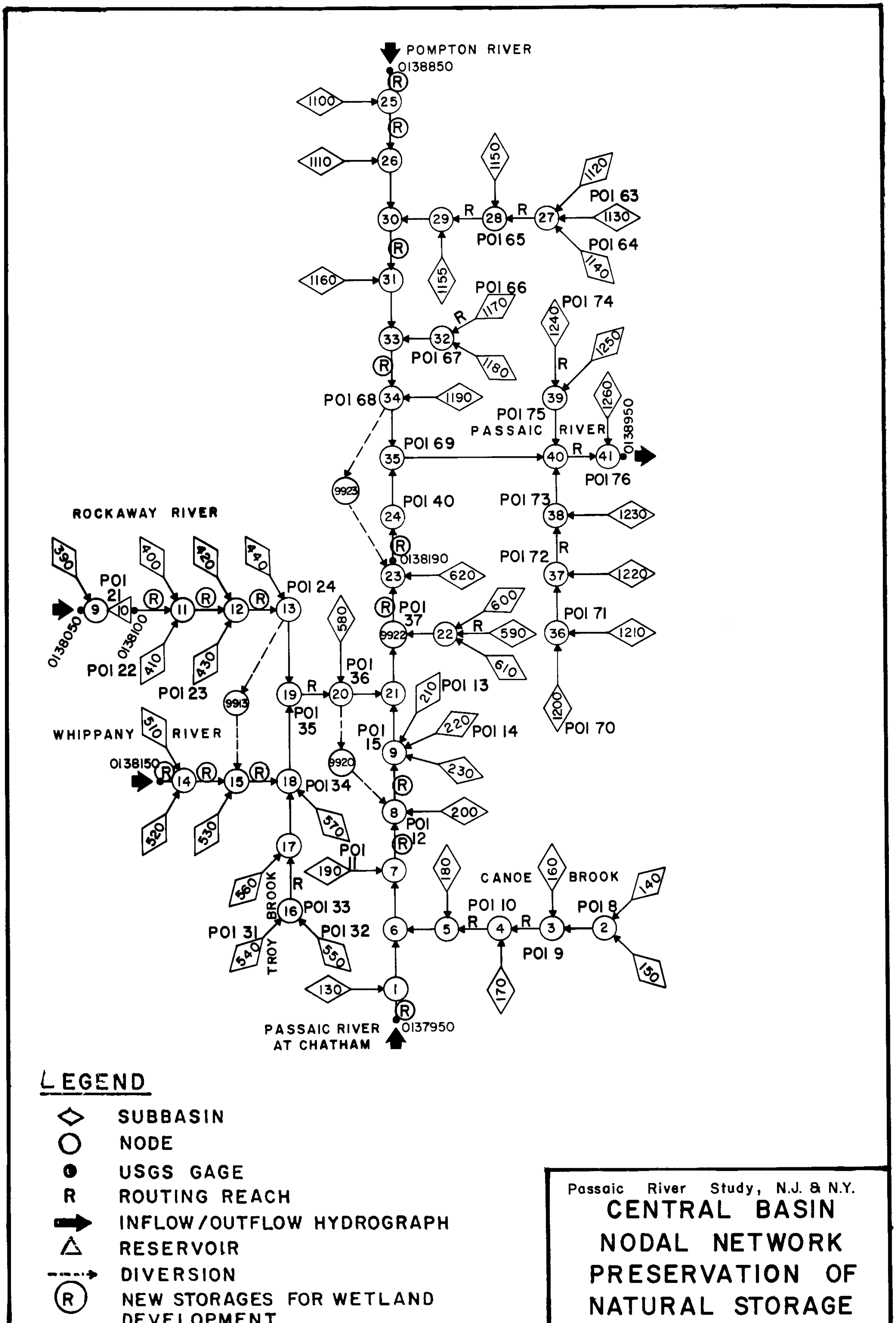
FIGURE 62



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

NODAL NETWORK ABOVE CHATHAM PRESERVATION OF NATURAL STORAGE

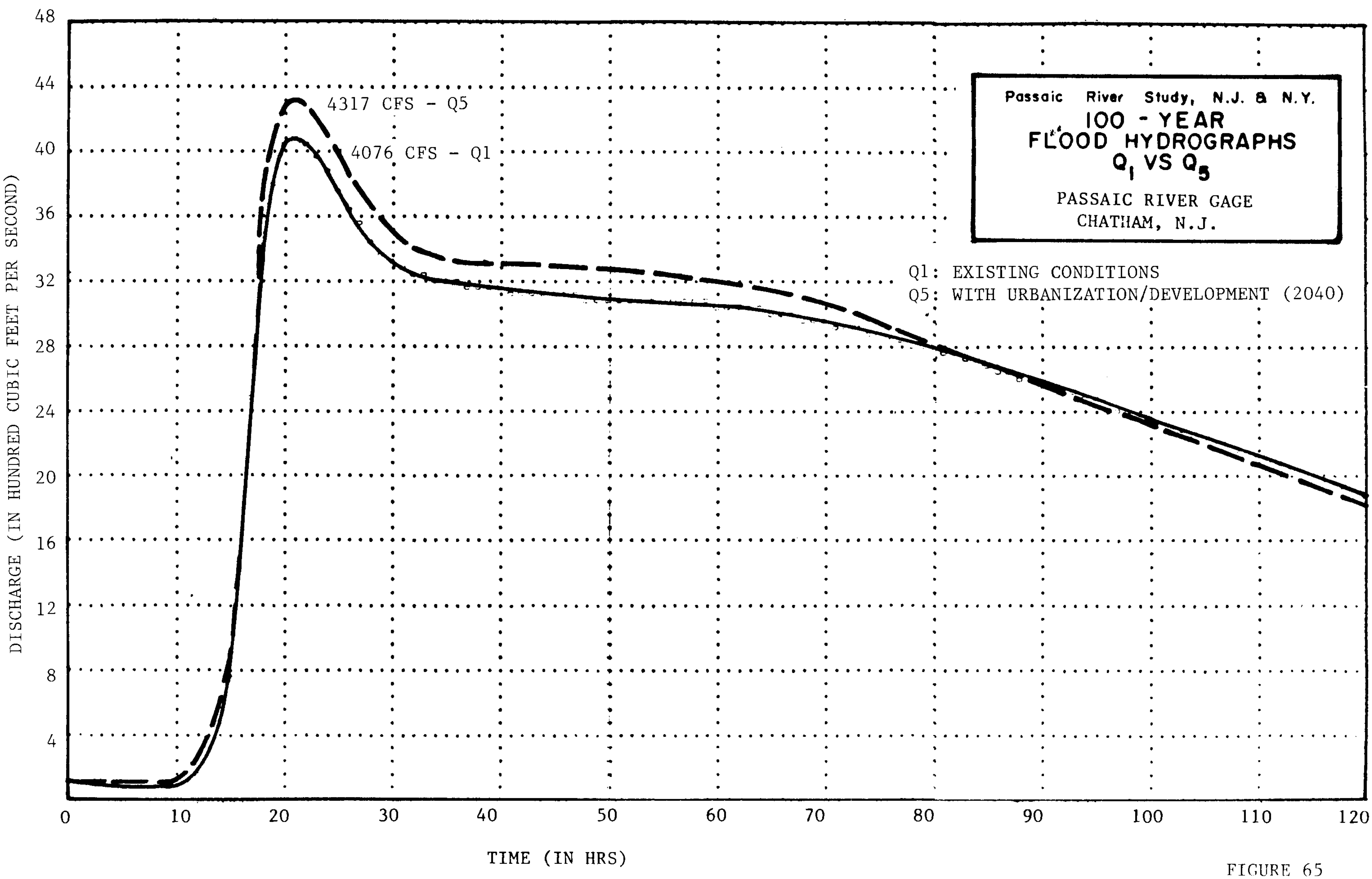
FIGURE 63



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

CENTRAL BASIN NODAL NETWORK PRESERVATION OF NATURAL STORAGE

FIGURE 64



Passaic River Study, N.J. & N.Y.
100 - YEAR
FLOOD HYDROGRAPHS
Q_1 VS Q_5
PASSAIC RIVER GAGE
CHATHAM, N.J.
4317 CFS - Q5
4076 CFS - Q1
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)
DISCHARGE (IN HUNDRED CUBIC FEET PER SECOND)
TIME (IN HRS)
48
44
40
36
32
28
24
20
16
12
8
4
0
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 65

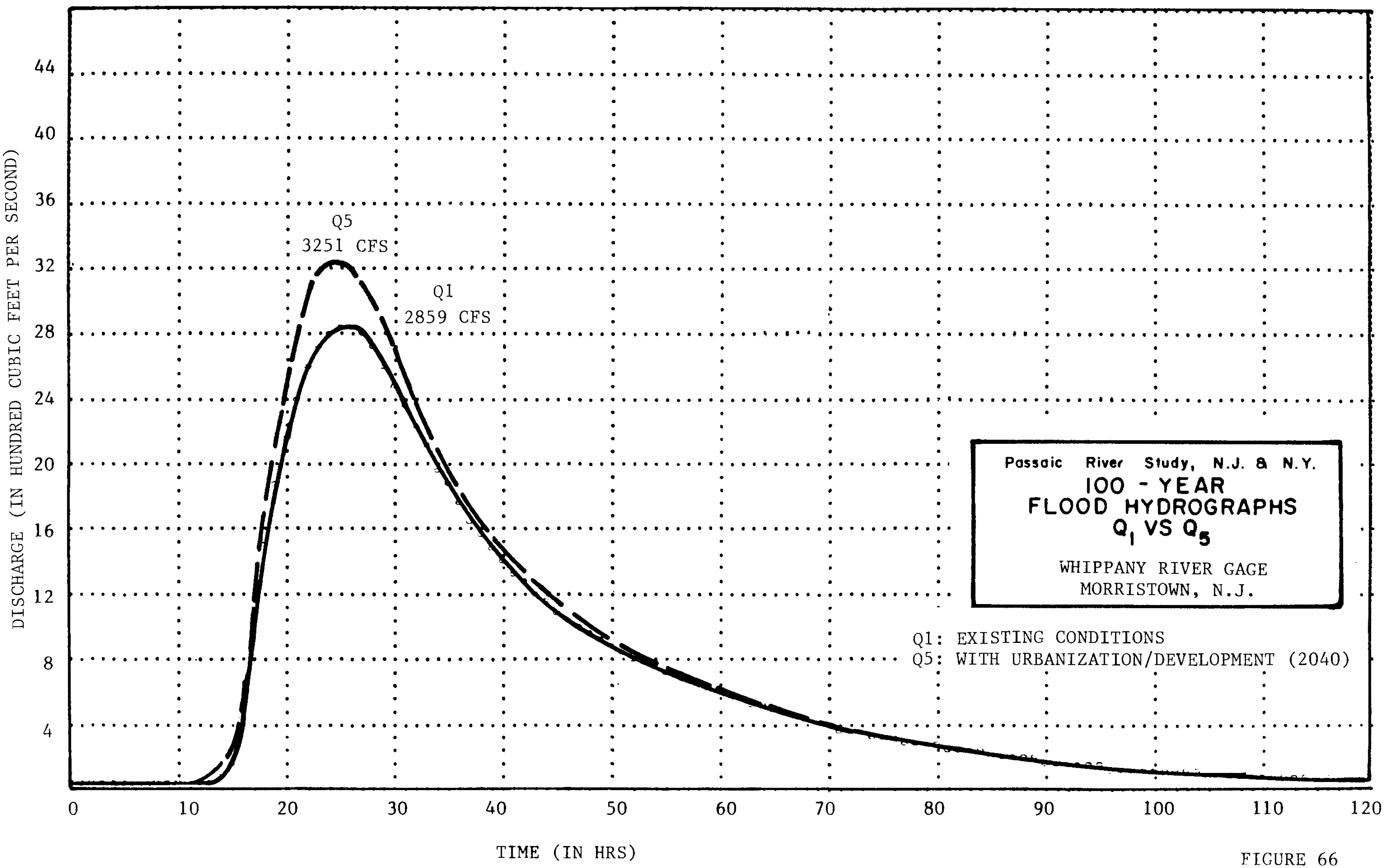

Passaic River Study, N.J. & N.Y.
100 - YEAR
FLOOD HYDROGRAPHS
Q_1 VS Q_5
WHIPPANY RIVER GAGE
MORRISTOWN, N.J.
Q5
3251 CFS
Q1
2859 CFS
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)
DISCHARGE (IN HUNDRED CUBIC FEET PER SECOND)
TIME (IN HRS)
4
8
12
16
20
24
28
32
36
40
44
0
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 66

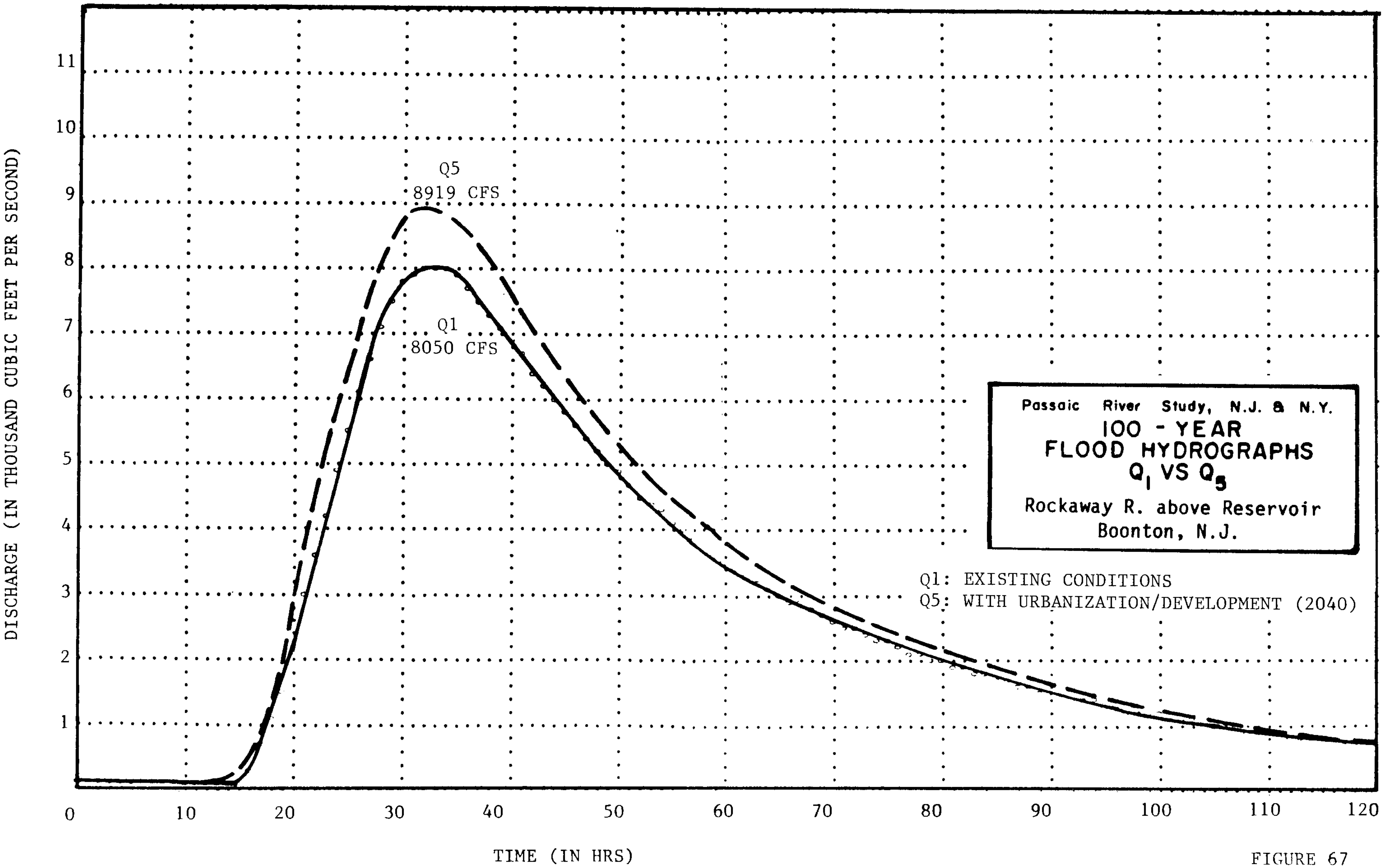
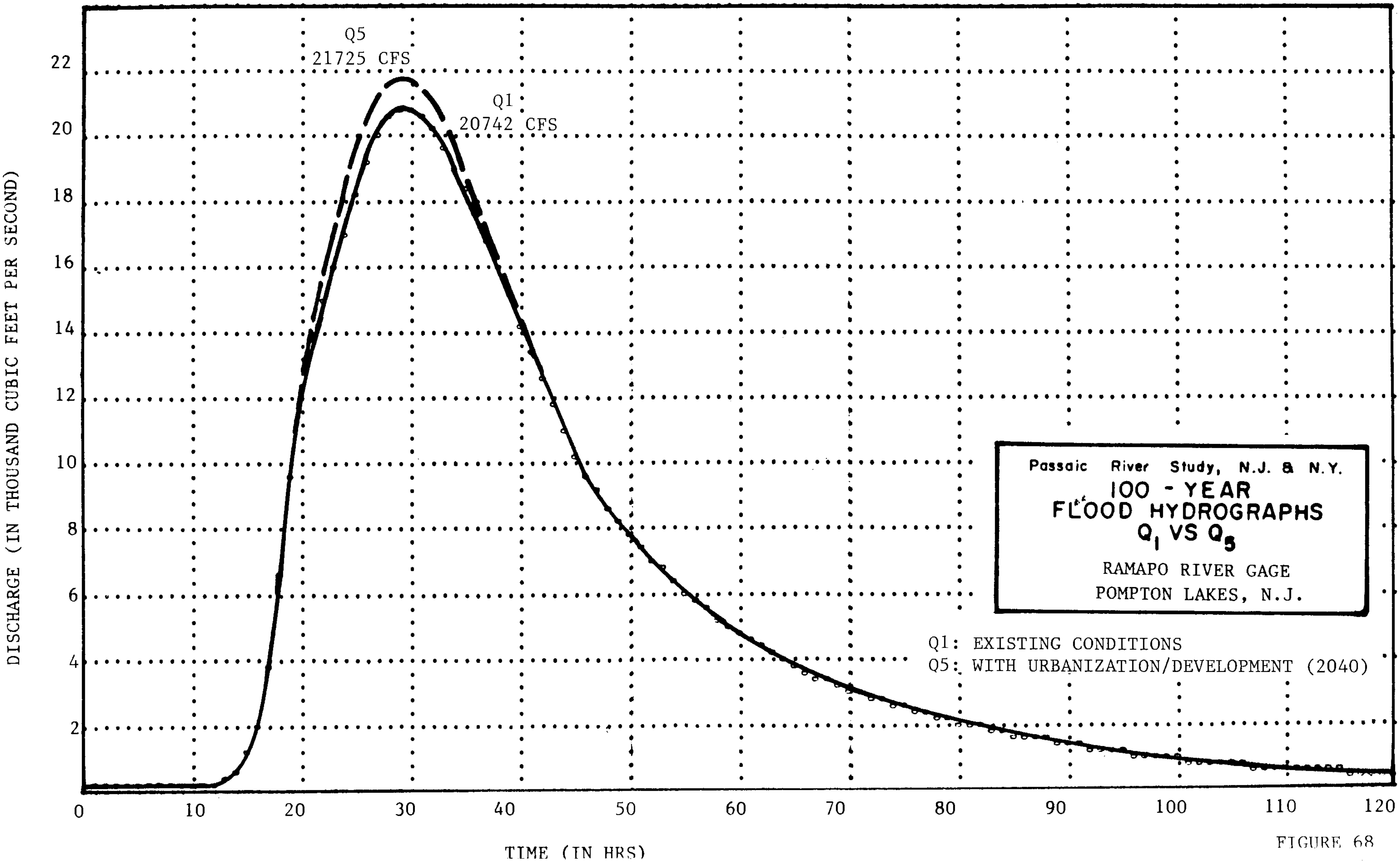

Passaic River Study, N.J. & N.Y.
100 - YEAR
FLOOD HYDROGRAPHS
Q_1 VS Q_5
Rockaway R. above Reservoir
Boonton, N.J.
Q5
8919 CFS
Q1
8050 CFS
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
TIME (IN HRS)
0
10
20
30
40
50
60
70
80
90
100
110
120
1
2
3
4
5
6
7
8
9
10
11

FIGURE 67



Q5
21725 CFS
Q1
20742 CFS
22
20
18
16
14
12
10
8
6
4
2
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
0
10
20
30
40
50
60
70
80
90
100
110
120
TIME (IN HRS)
Passaic River Study, N.J. & N.Y.
100 - YEAR
FLOOD HYDROGRAPHS
Q1 VS Q5
RAMAPO RIVER GAGE
POMPTON LAKES, N.J.
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)

FIGURE 68

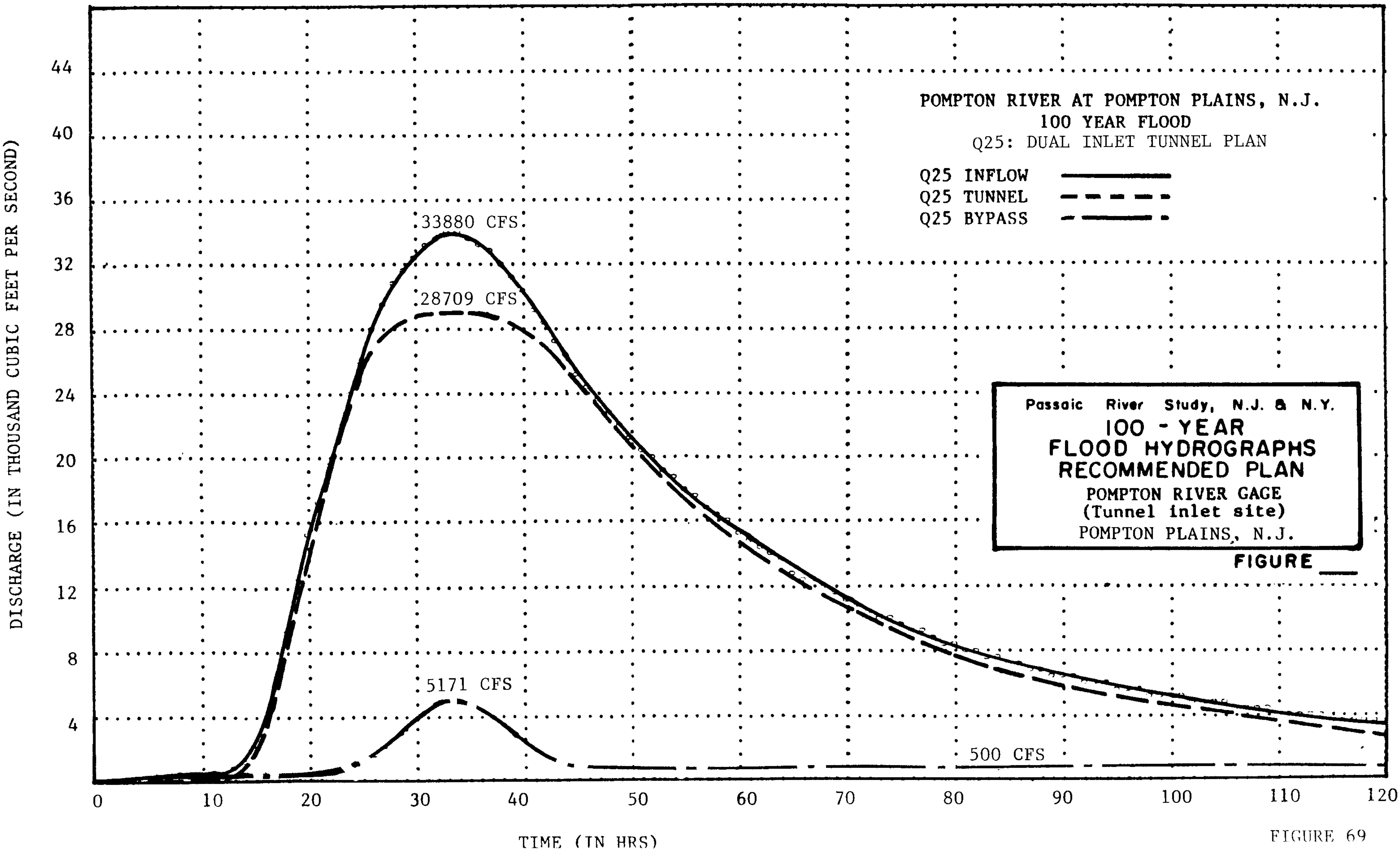

POMPTON RIVER AT POMPTON PLAINS, N.J.
100 YEAR FLOOD
Q25: DUAL INLET TUNNEL PLAN
Q25 INFLOW
Q25 TUNNEL
Q25 BYPASS
33880 CFS
28709 CFS
5171 CFS
500 CFS
Passaic River Study, N.J. & N.Y.
100 - YEAR
FLOOD HYDROGRAPHS
RECOMMENDED PLAN
POMPTON RIVER GAGE
(Tunnel inlet site)
POMPTON PLAINS, N.J.
FIGURE
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
44
40
36
32
28
24
20
16
12
8
4
0
10
20
30
40
50
60
70
80
90
100
110
120
TIME (IN HRS)

FIGURE 69

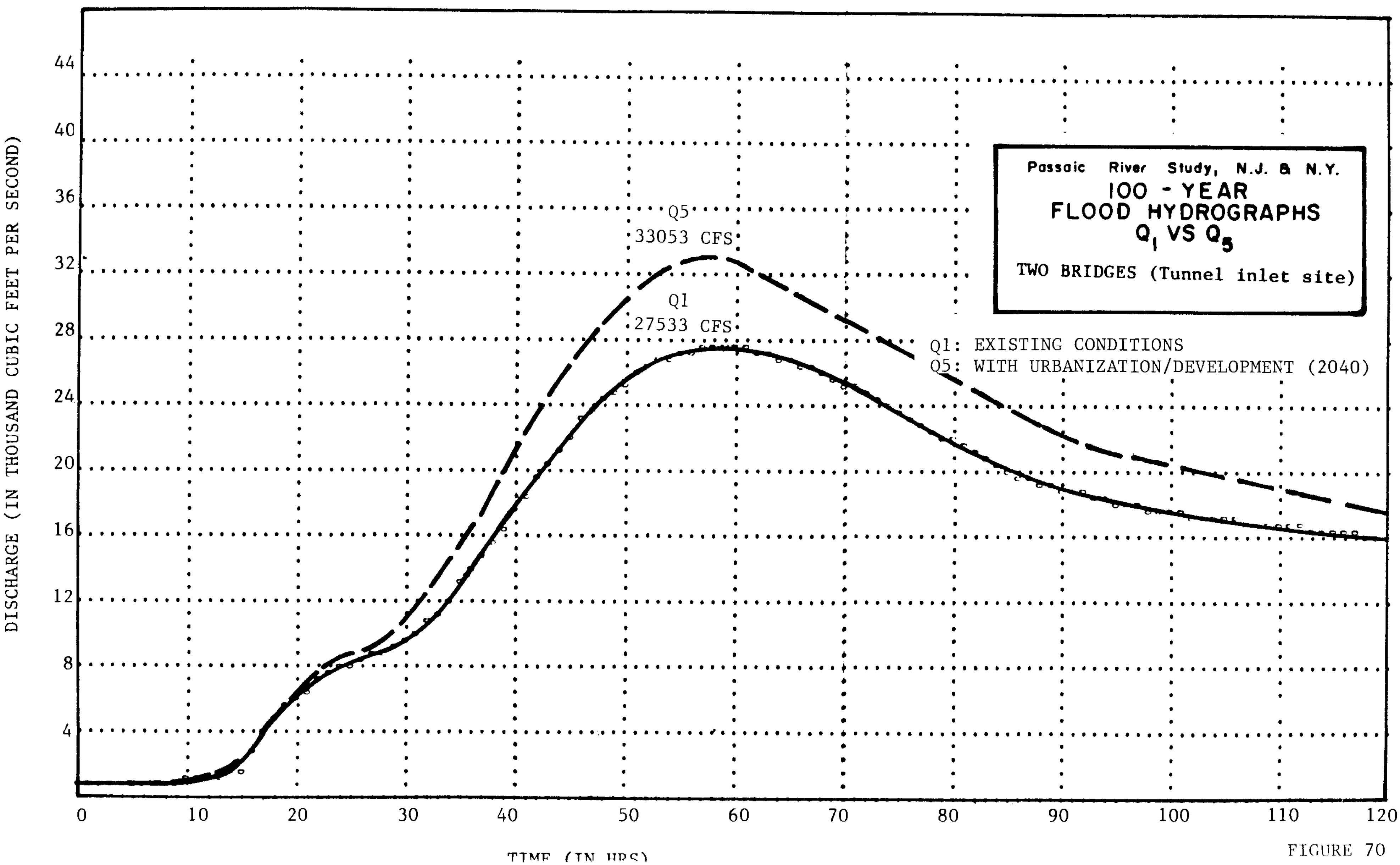

Passaic River Study, N.J. & N.Y.
100 - YEAR
FLOOD HYDROGRAPHS
Q1 VS Q5
TWO BRIDGES (Tunnel inlet site)
Q5
33053 CFS
Q1
27533 CFS
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
44
40
36
32
28
24
20
16
12
8
4
0
10
20
30
40
50
60
70
80
90
100
110
120
TIME (IN HRS)

FIGURE 70

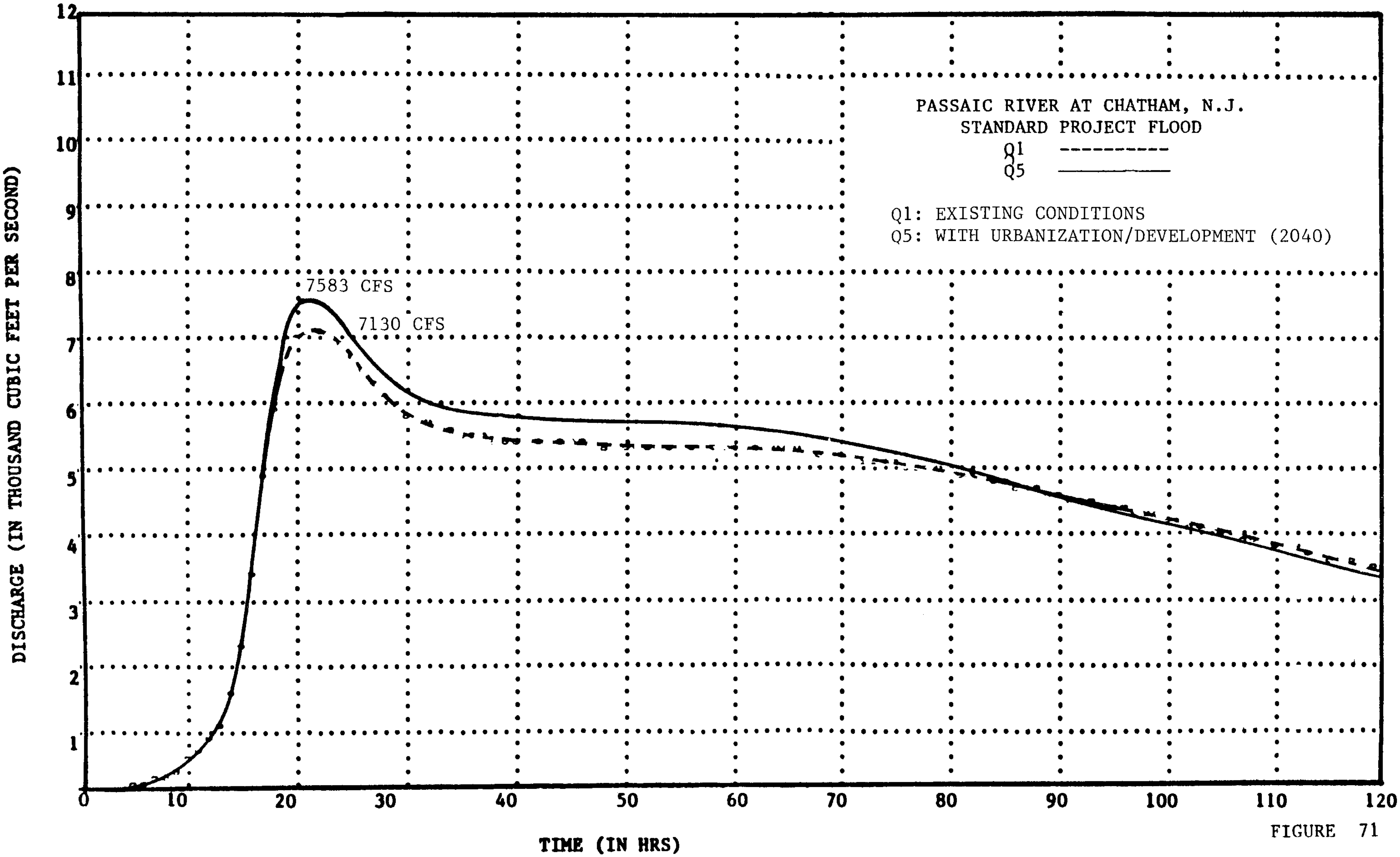
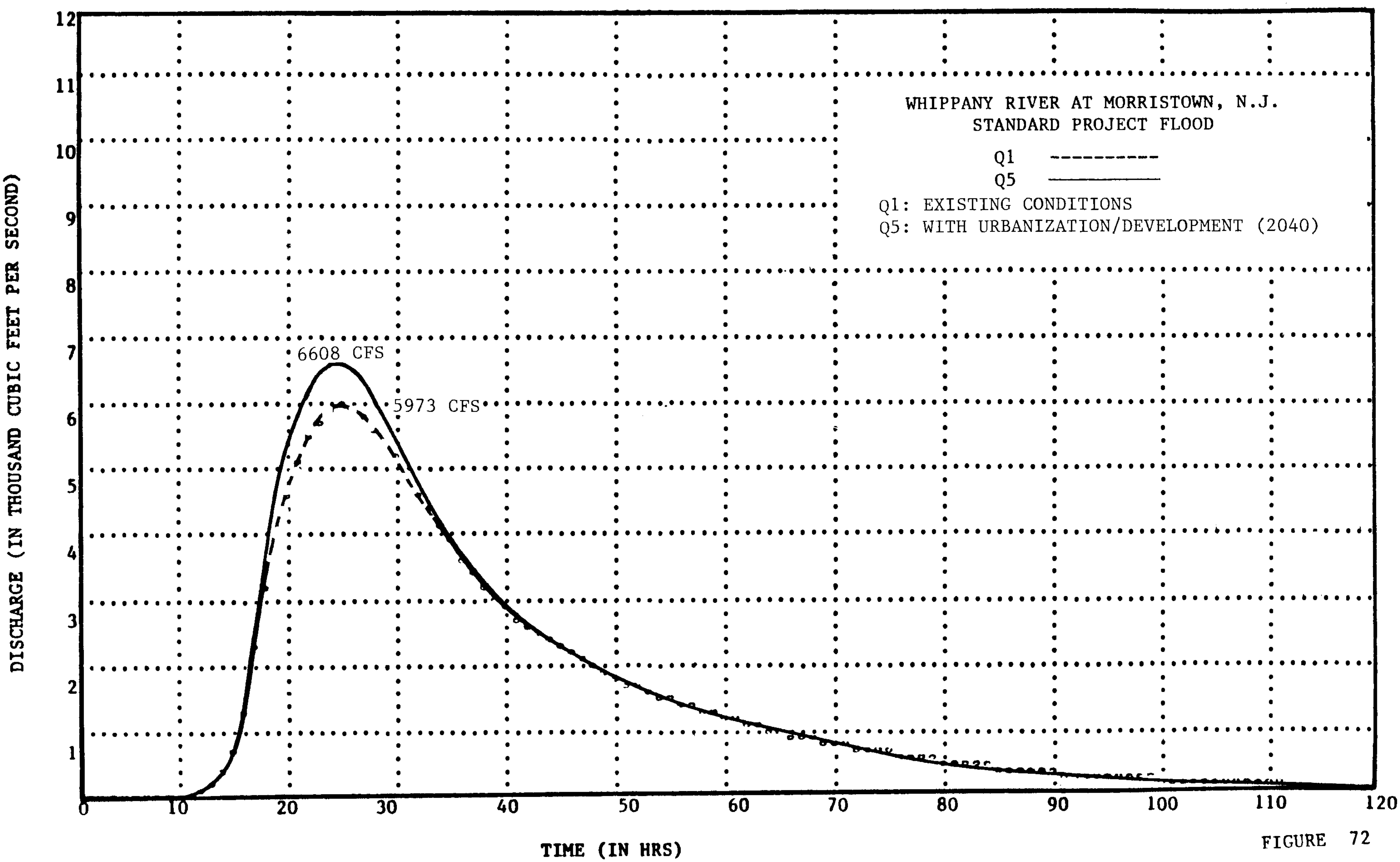
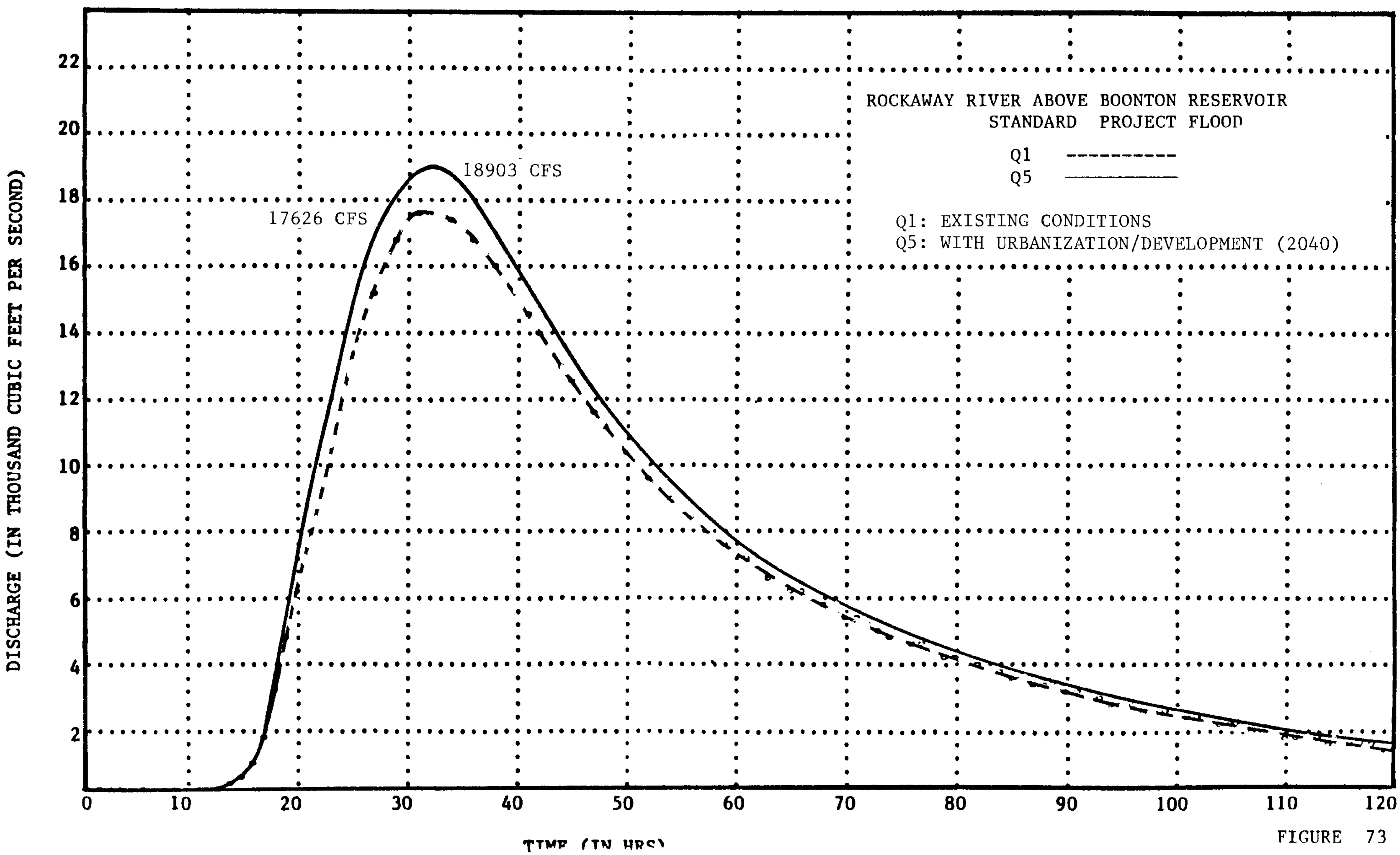

PASSAIC RIVER AT CHATHAM, N.J.
STANDARD PROJECT FLOOD
Q1
Q5
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)
7583 CFS
7130 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
TIME (IN HRS)
0
1
2
3
4
5
6
7
8
9
10
11
12
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 71



WHIPPANY RIVER AT MORRISTOWN, N.J.
STANDARD PROJECT FLOOD
Q1
Q5
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)
6608 CFS
5973 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
TIME (IN HRS)
0
10
20
30
40
50
60
70
80
90
100
110
120
1
2
3
4
5
6
7
8
9
10
11
12

FIGURE 72



ROCKAWAY RIVER ABOVE BOONTON RESERVOIR
STANDARD PROJECT FLOOD
Q1 ----------
Q5 ———————
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)
18903 CFS
17626 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
22
20
18
16
14
12
10
8
6
4
2
0
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 73

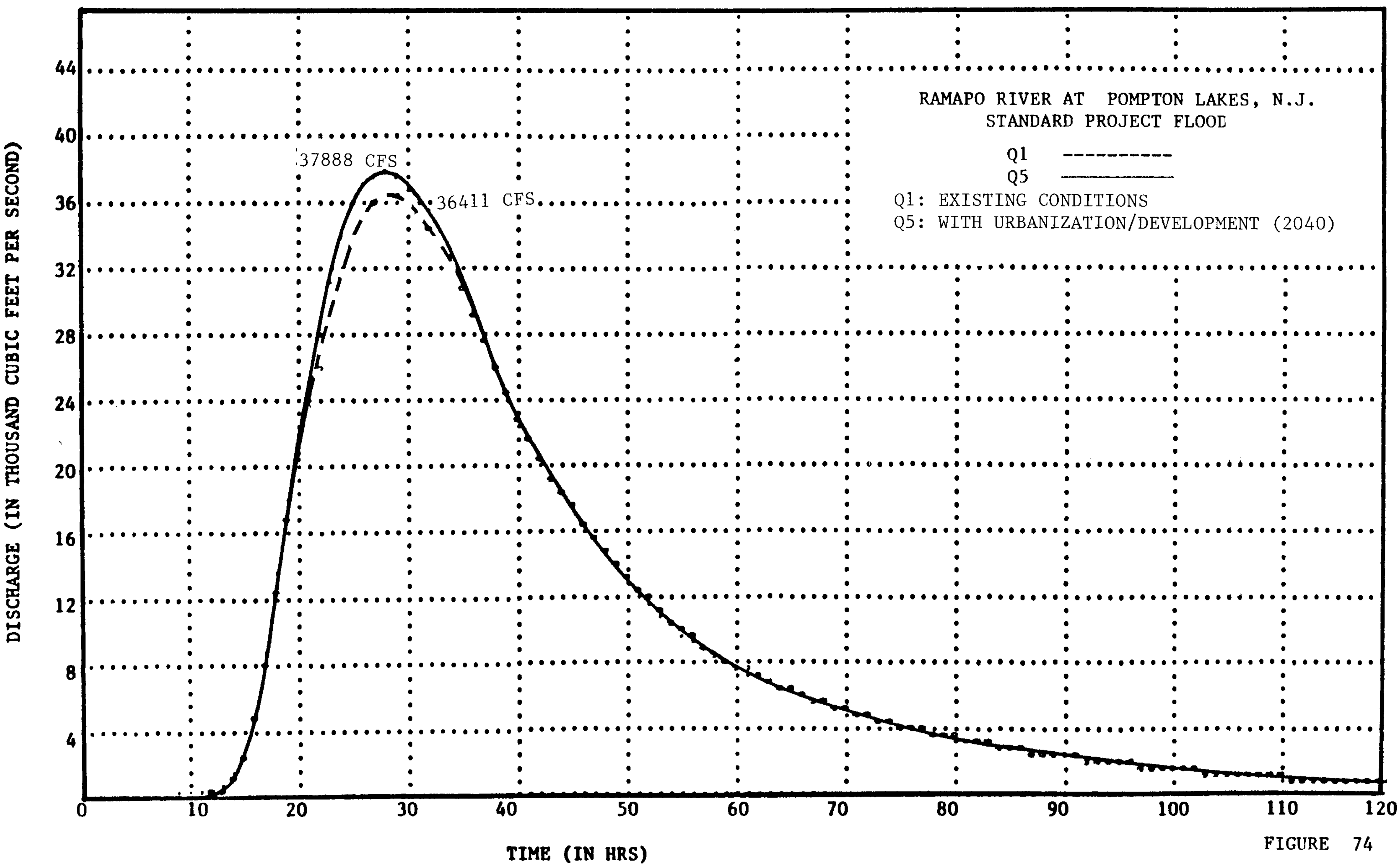
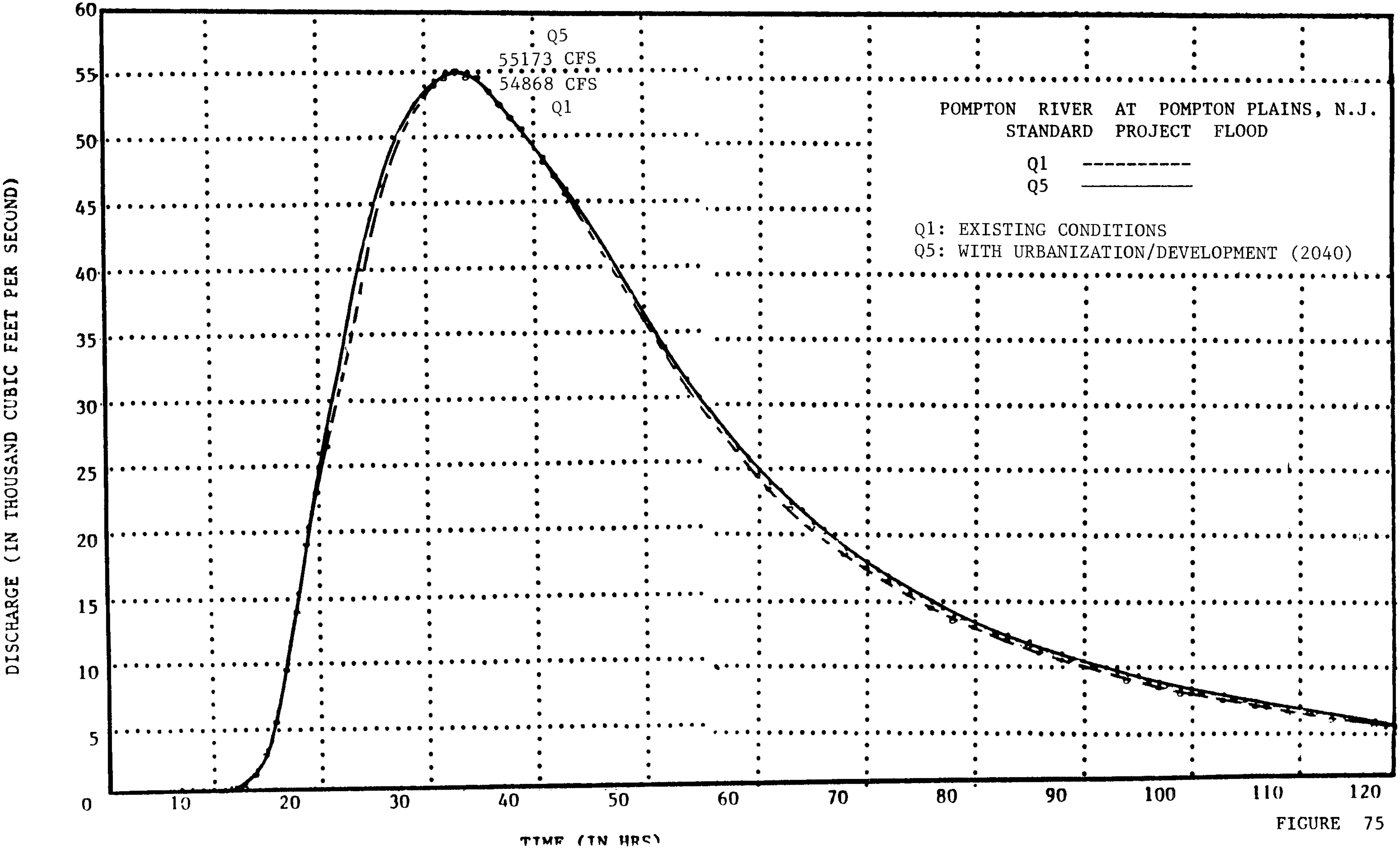
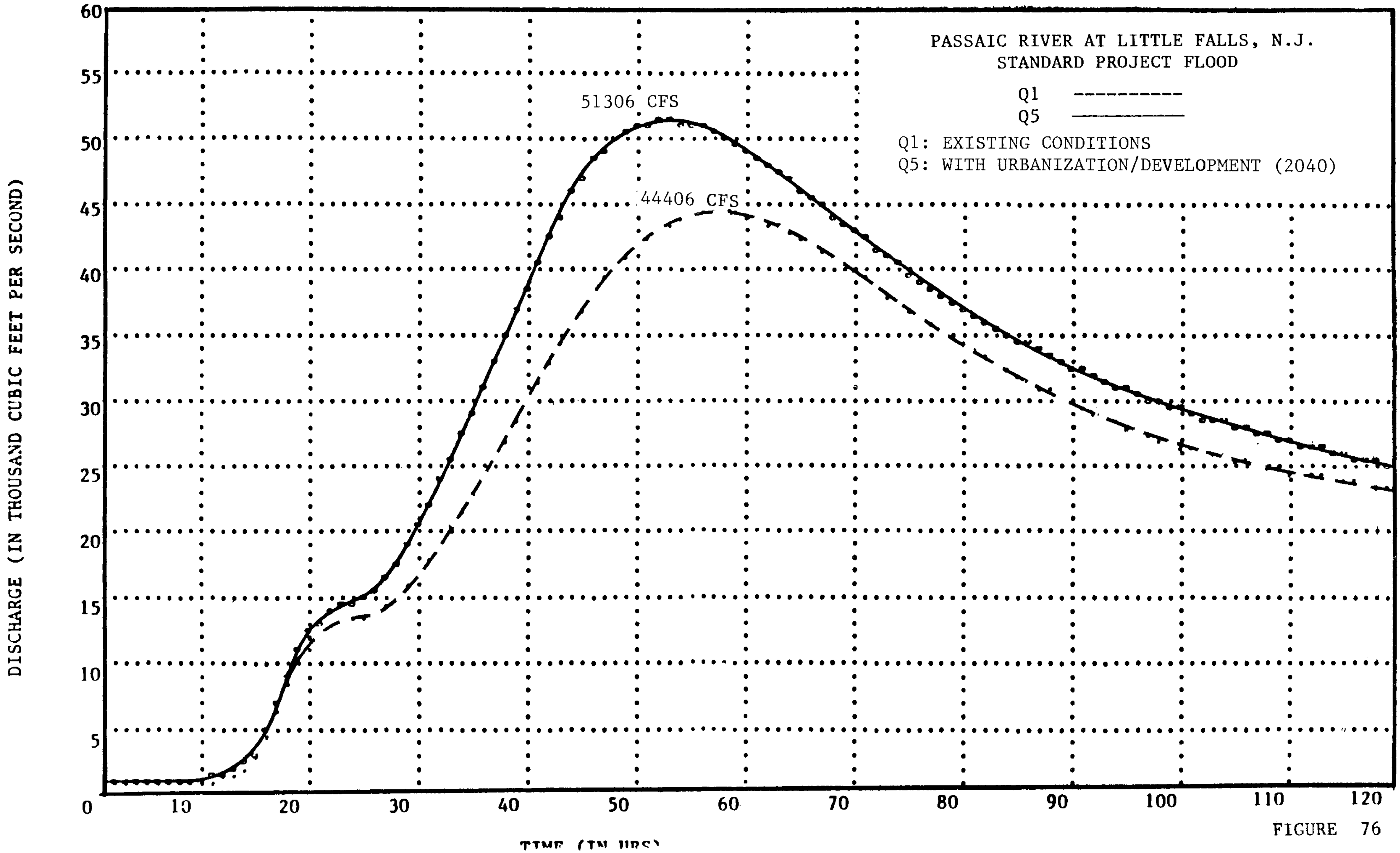

RAMAPO RIVER AT POMPTON LAKES, N.J.
STANDARD PROJECT FLOOD
Q1 ----------
Q5 ———————
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)
37888 CFS
36411 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
44
40
36
32
28
24
20
16
12
8
4
0
10
20
30
40
50
60
70
80
90
100
110
120
TIME (IN HRS)

FIGURE 74



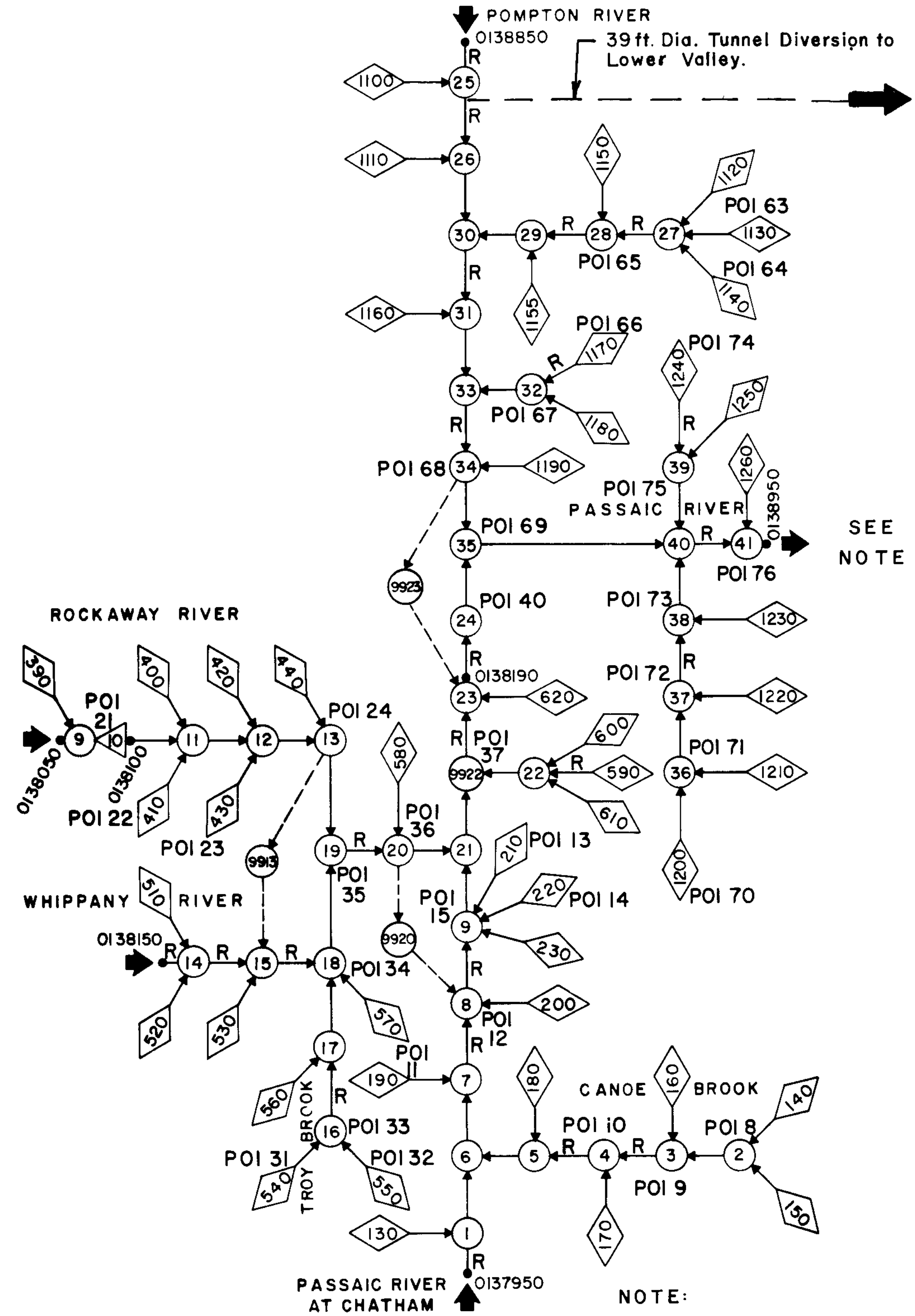
Q5
55173 CFS
54868 CFS
Q1
POMPTON RIVER AT POMPTON PLAINS, N.J.
STANDARD PROJECT FLOOD
Q1 ----------
Q5 ——————
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
0
5
10
15
20
25
30
35
40
45
50
55
60
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 75



PASSAIC RIVER AT LITTLE FALLS, N.J.
STANDARD PROJECT FLOOD
Q1
Q5
Q1: EXISTING CONDITIONS
Q5: WITH URBANIZATION/DEVELOPMENT (2040)
51306 CFS
44406 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
0
5
10
15
20
25
30
35
40
45
50
55
60
10
20
30
40
50
60
70
80
90
100
110
120
TIME (IN HRS)

FIGURE 76



NOTE:

22ft. Dia. Spur Tunnel from Two Bridges is modeled at Node 41 and is shown on Lower Valley Nodal Network, Figure 78.

LEGEND

- ◇ SUBBASIN
- ○ NODE
- ● USGS GAGE
- R ROUTING REACH
- ➡ INFLOW/OUTFLOW HYDROGRAPH
- △ RESERVOIR
- - - -➝ DIVERSION

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

CENTRAL BASIN
NODAL NETWORK
RECOMMENDED PLAN

FIGURE 77

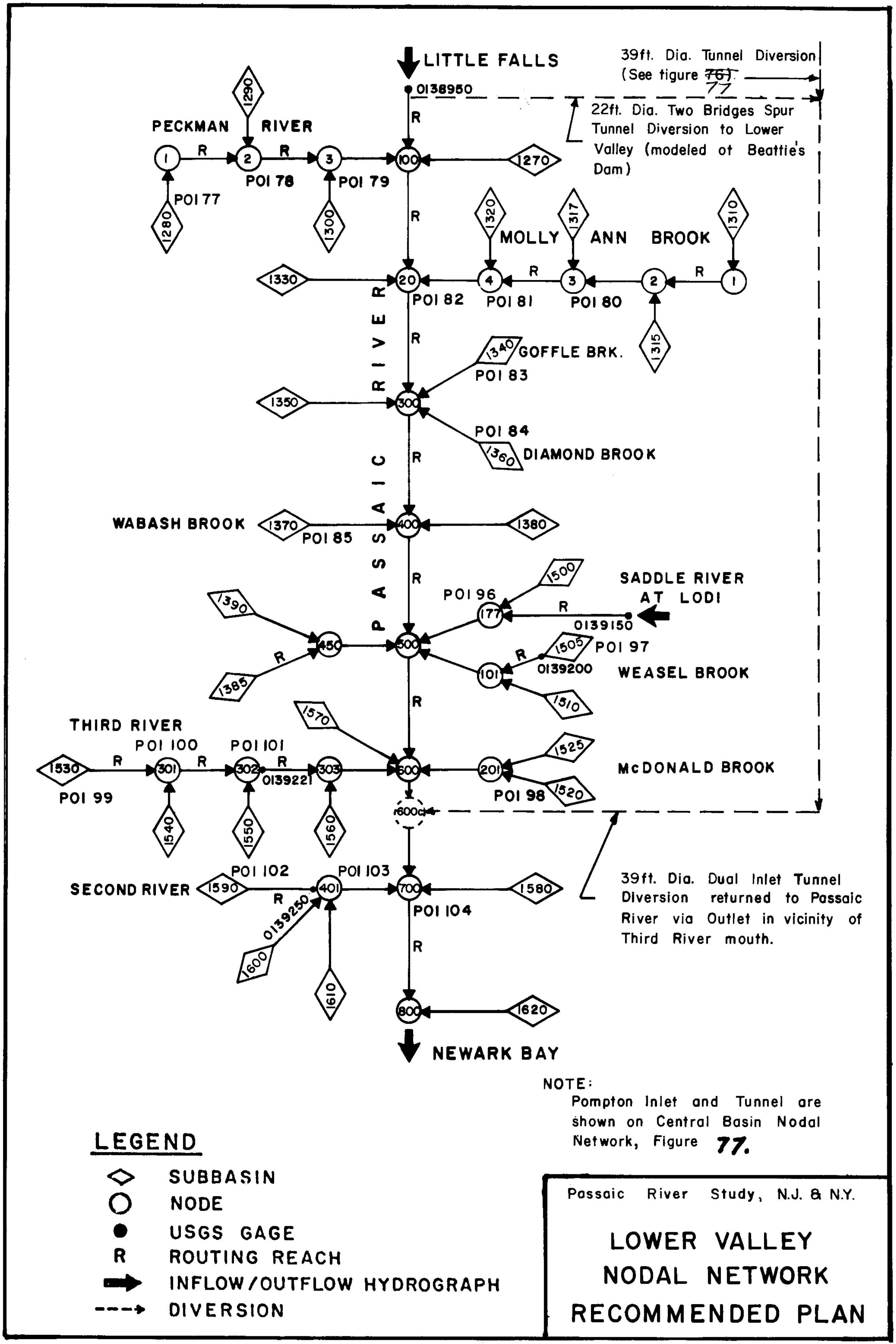

LITTLE FALLS
0138950
39ft. Dia. Tunnel Diversion (See figure 76) 77
22ft. Dia. Two Bridges Spur Tunnel Diversion to Lower Valley (modeled at Beattie's Dam)
PECKMAN RIVER
1290
1270
POI 77
POI 78
POI 79
1280
1300
MOLLY ANN BROOK
1320
1317
1310
1330
POI 82
POI 81
POI 80
1315
GOFFLE BRK.
1340
POI 83
1350
POI 84
1360
DIAMOND BROOK
PASSAIC RIVER
WABASH BROOK
1370
POI 85
1380
1500
SADDLE RIVER AT LODI
POI 96
0139150
1390
1505
POI 97
0139200
WEASEL BROOK
1385
1510
1570
THIRD RIVER
POI 100
POI 101
1525
McDONALD BROOK
1530
0139221
1520
POI 99
POI 98
1540
1550
1560
600c
39ft. Dia. Dual Inlet Tunnel Diversion returned to Passaic River via Outlet in vicinity of Third River mouth.
POI 102
POI 103
SECOND RIVER
1590
0139250
1580
POI 104
1600
1610
1620
NEWARK BAY
NOTE:
Pompton Inlet and Tunnel are shown on Central Basin Nodal Network, Figure 77.
LEGEND
SUBBASIN
NODE
USGS GAGE
R ROUTING REACH
INFLOW/OUTFLOW HYDROGRAPH
DIVERSION
Passaic River Study, N.J. & N.Y.
LOWER VALLEY
NODAL NETWORK
RECOMMENDED PLAN

FIGURE 78

30 SEP 86

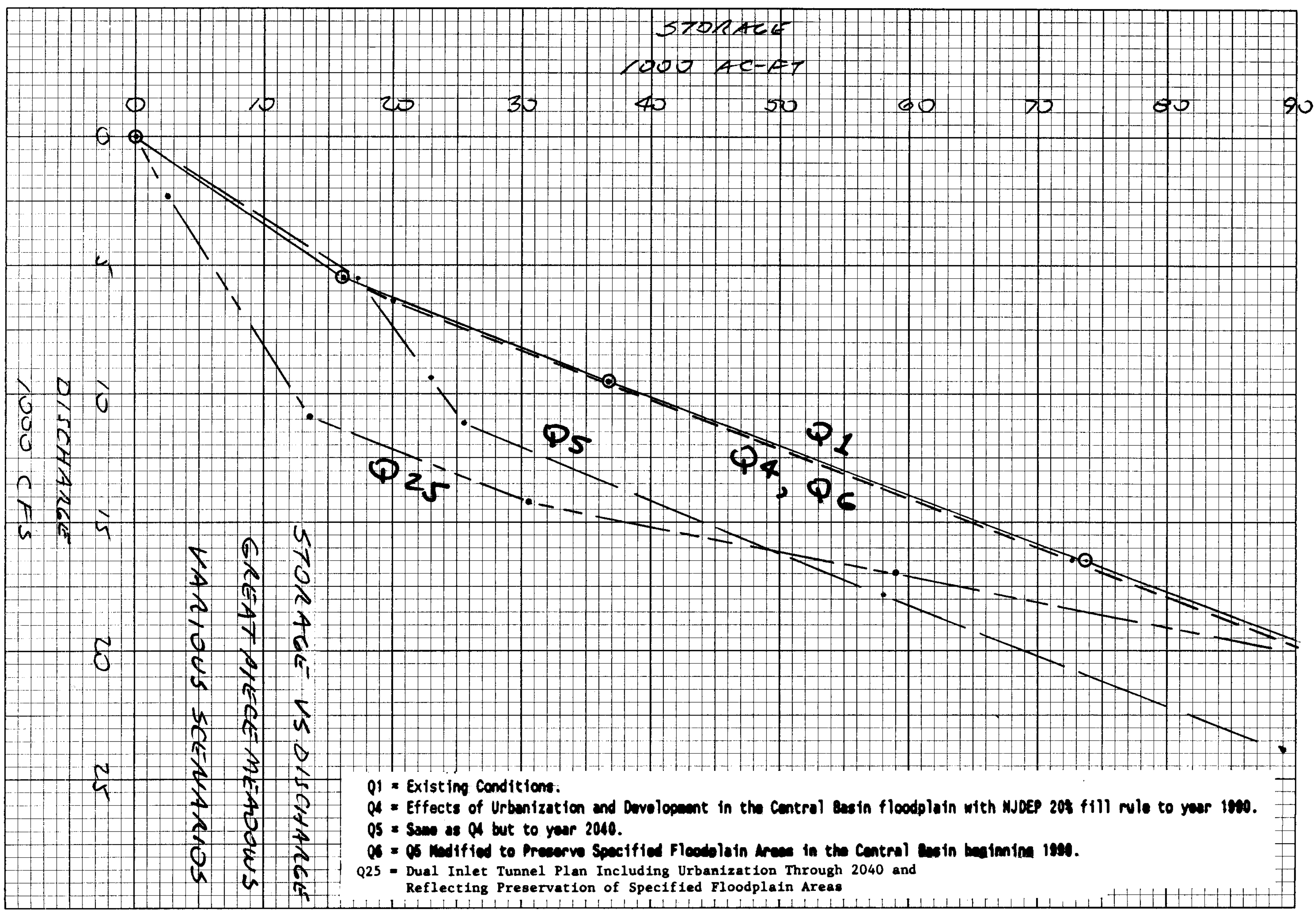


FIGURE 79

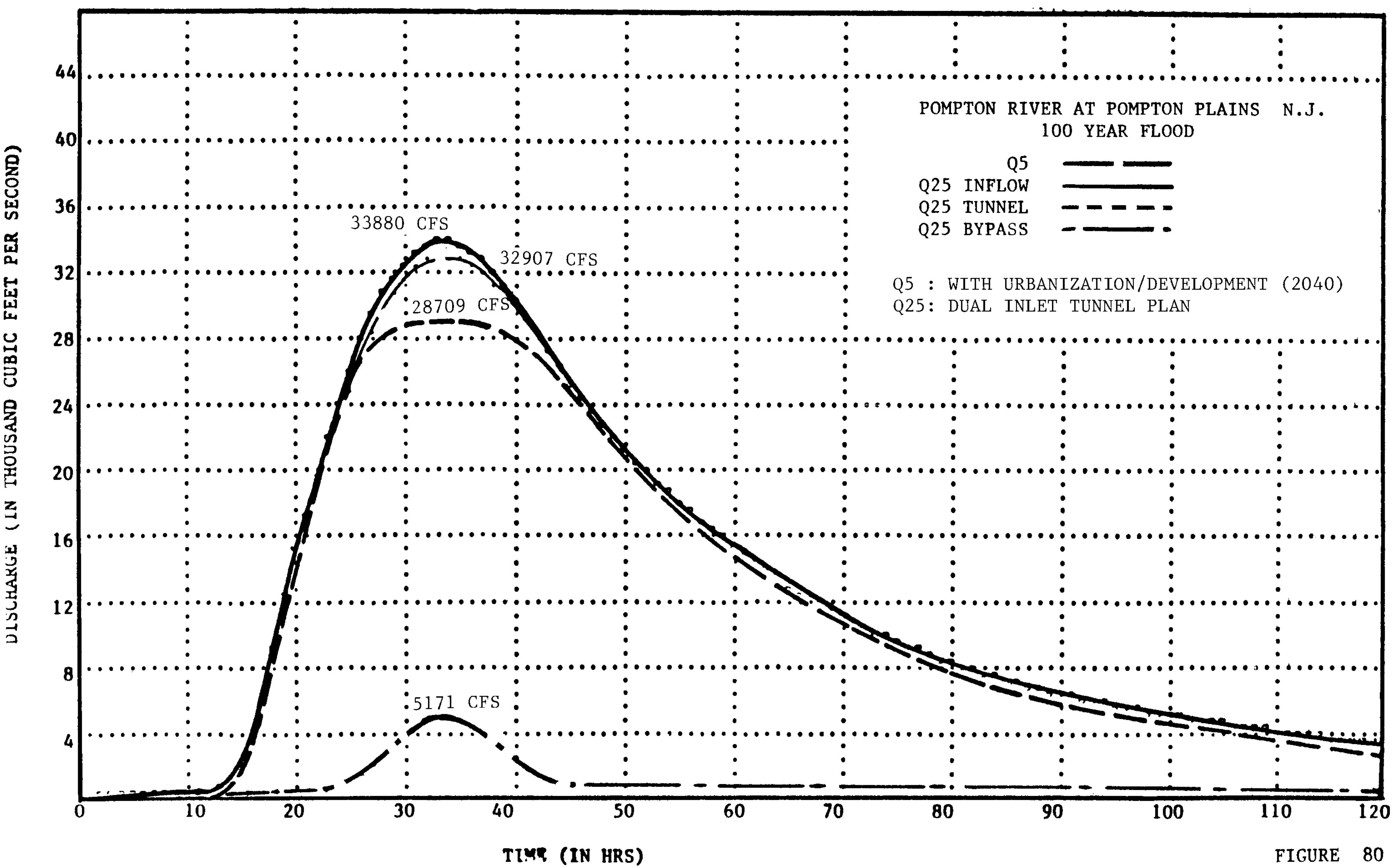

POMPTON RIVER AT POMPTON PLAINS N.J.
100 YEAR FLOOD
Q5
Q25 INFLOW
Q25 TUNNEL
Q25 BYPASS
Q5 : WITH URBANIZATION/DEVELOPMENT (2040)
Q25: DUAL INLET TUNNEL PLAN
33880 CFS
32907 CFS
28709 CFS
5171 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
44
40
36
32
28
24
20
16
12
8
4
0
10
20
30
40
50
60
70
80
90
100
110
120
TIME (IN HRS)

FIGURE 80

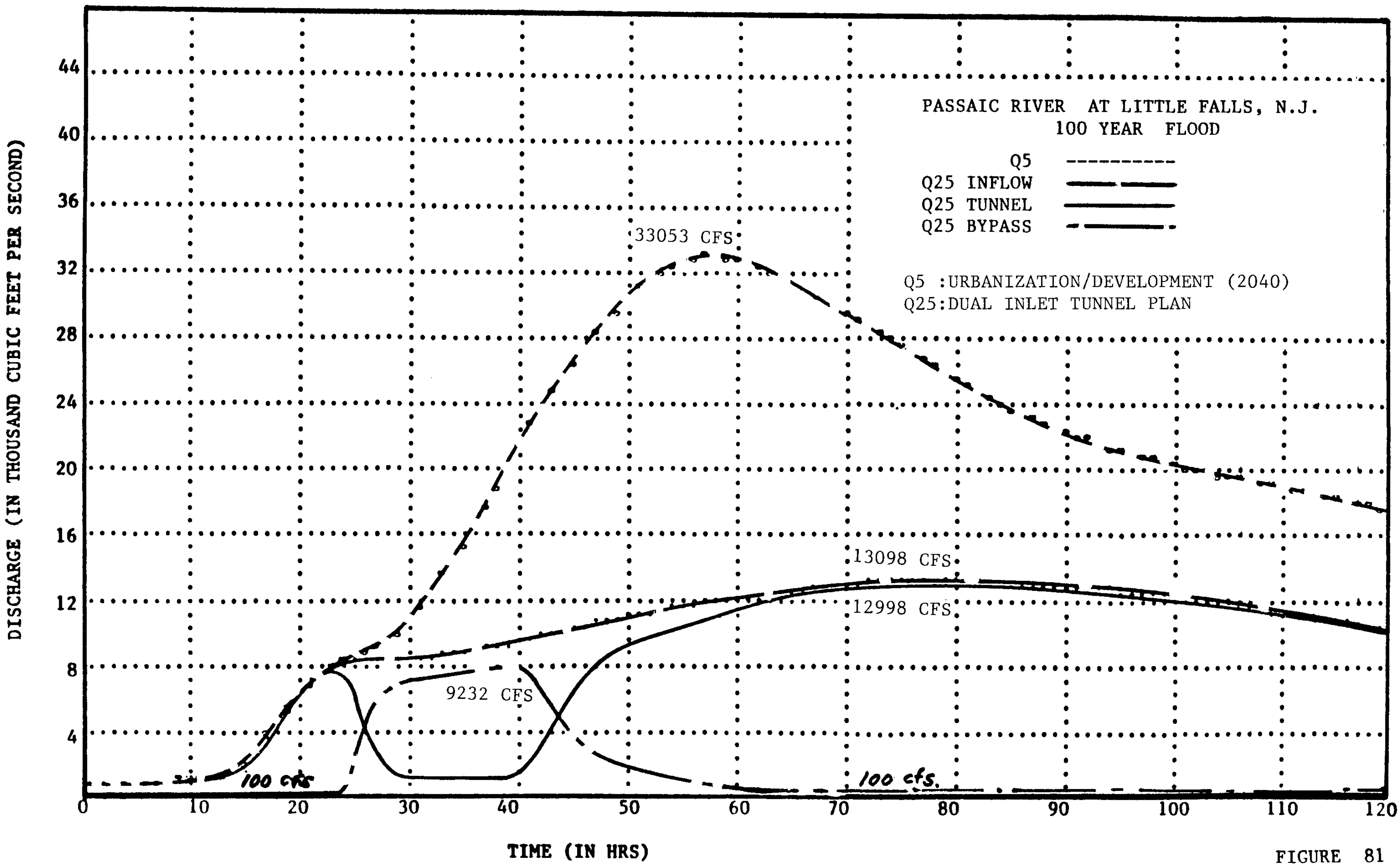
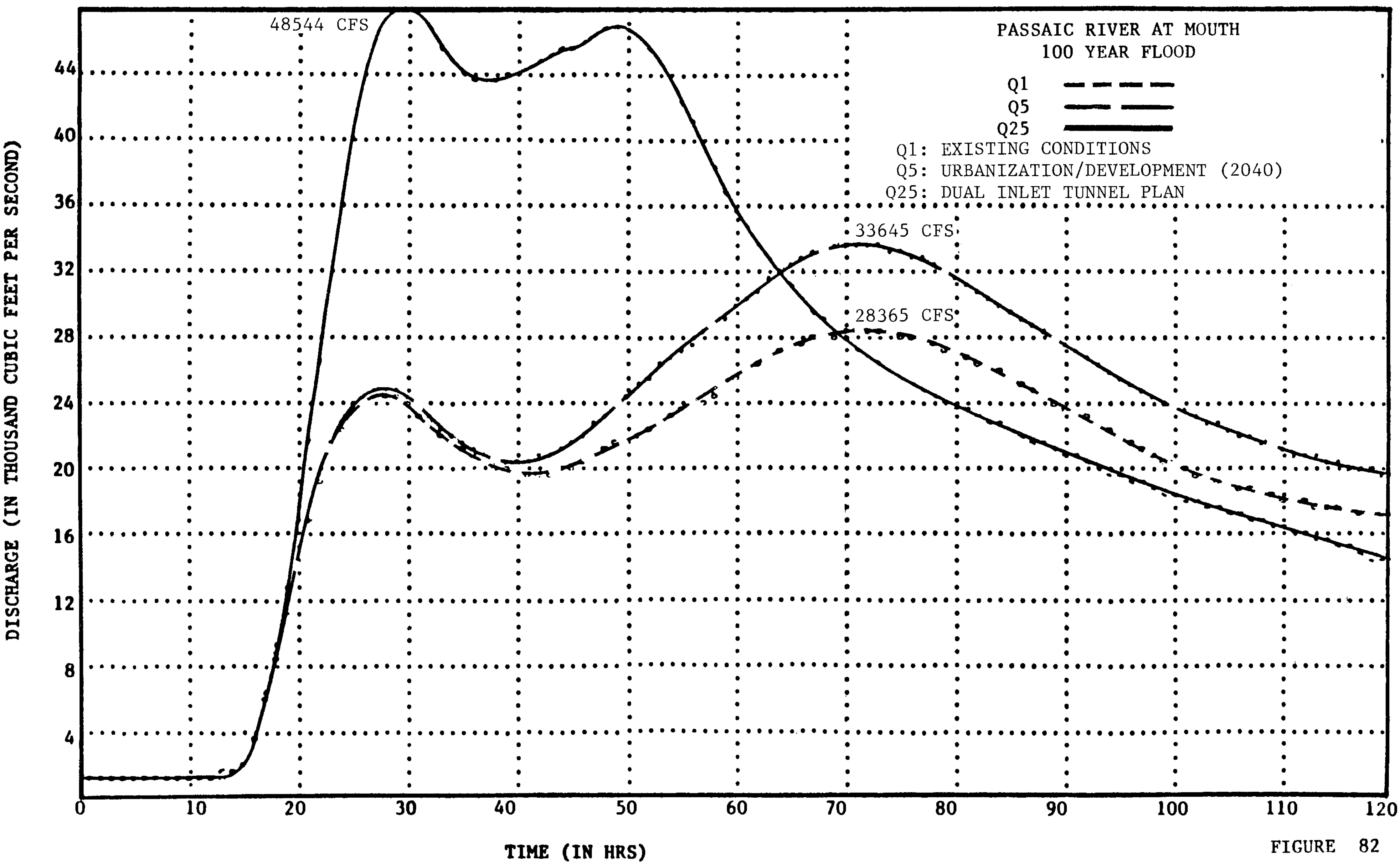

PASSAIC RIVER AT LITTLE FALLS, N.J.
100 YEAR FLOOD
Q5
Q25 INFLOW
Q25 TUNNEL
Q25 BYPASS
Q5 :URBANIZATION/DEVELOPMENT (2040)
Q25:DUAL INLET TUNNEL PLAN
33053 CFS
13098 CFS
12998 CFS
9232 CFS
100 cfs
100 cfs.
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
TIME (IN HRS)
0
10
20
30
40
50
60
70
80
90
100
110
120
4
8
12
16
20
24
28
32
36
40
44

FIGURE 81



PASSAIC RIVER AT MOUTH
100 YEAR FLOOD
Q1
Q5
Q25
Q1: EXISTING CONDITIONS
Q5: URBANIZATION/DEVELOPMENT (2040)
Q25: DUAL INLET TUNNEL PLAN
48544 CFS
33645 CFS
28365 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
44
40
36
32
28
24
20
16
12
8
4
0
10
20
30
40
50
60
70
80
90
100
110
120
TIME (IN HRS)

FIGURE 82

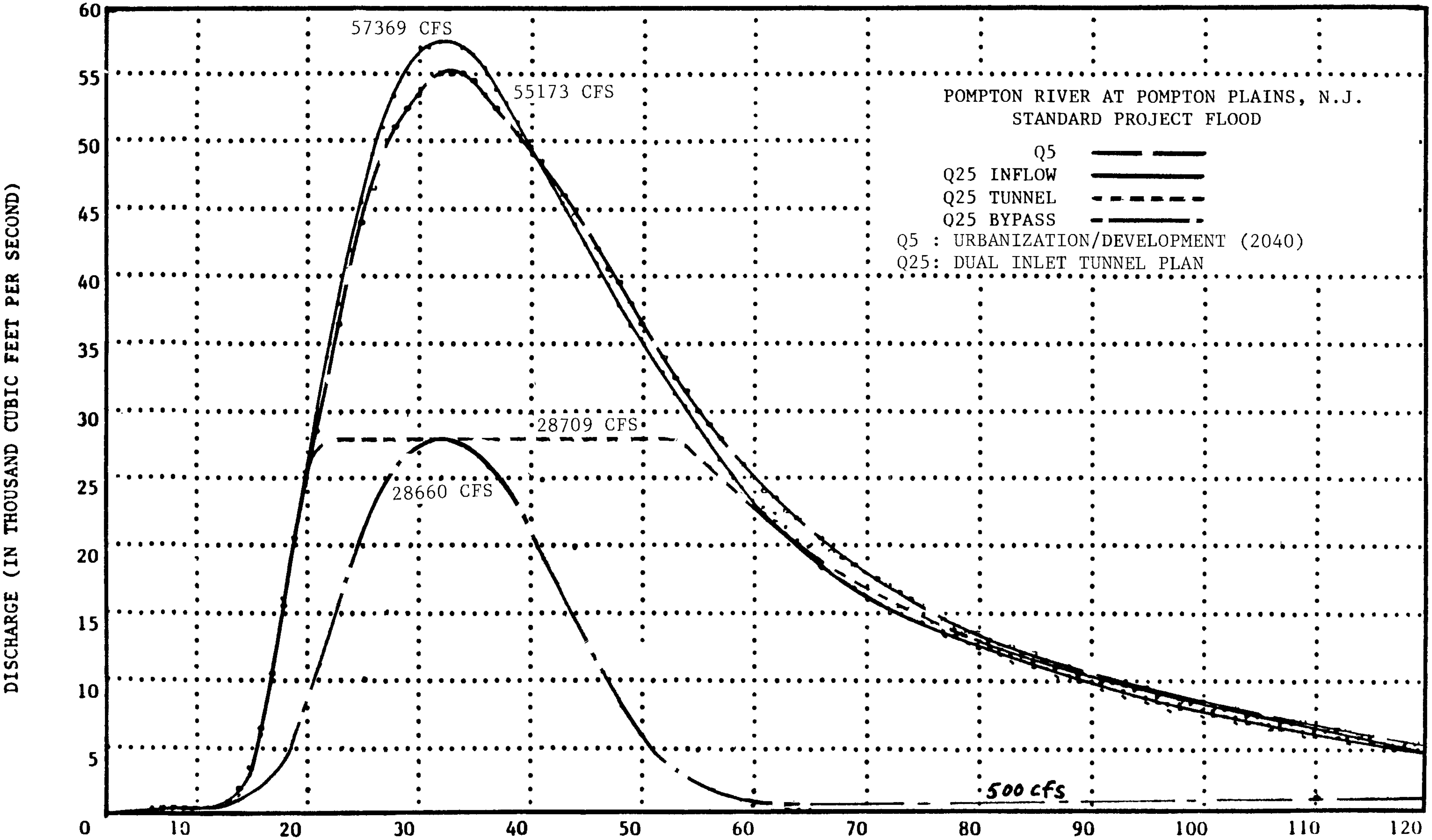

POMPTON RIVER AT POMPTON PLAINS, N.J.
STANDARD PROJECT FLOOD
Q5
Q25 INFLOW
Q25 TUNNEL
Q25 BYPASS
Q5 : URBANIZATION/DEVELOPMENT (2040)
Q25: DUAL INLET TUNNEL PLAN
57369 CFS
55173 CFS
28709 CFS
28660 CFS
500 cfs
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
0
5
10
15
20
25
30
35
40
45
50
55
60
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 83

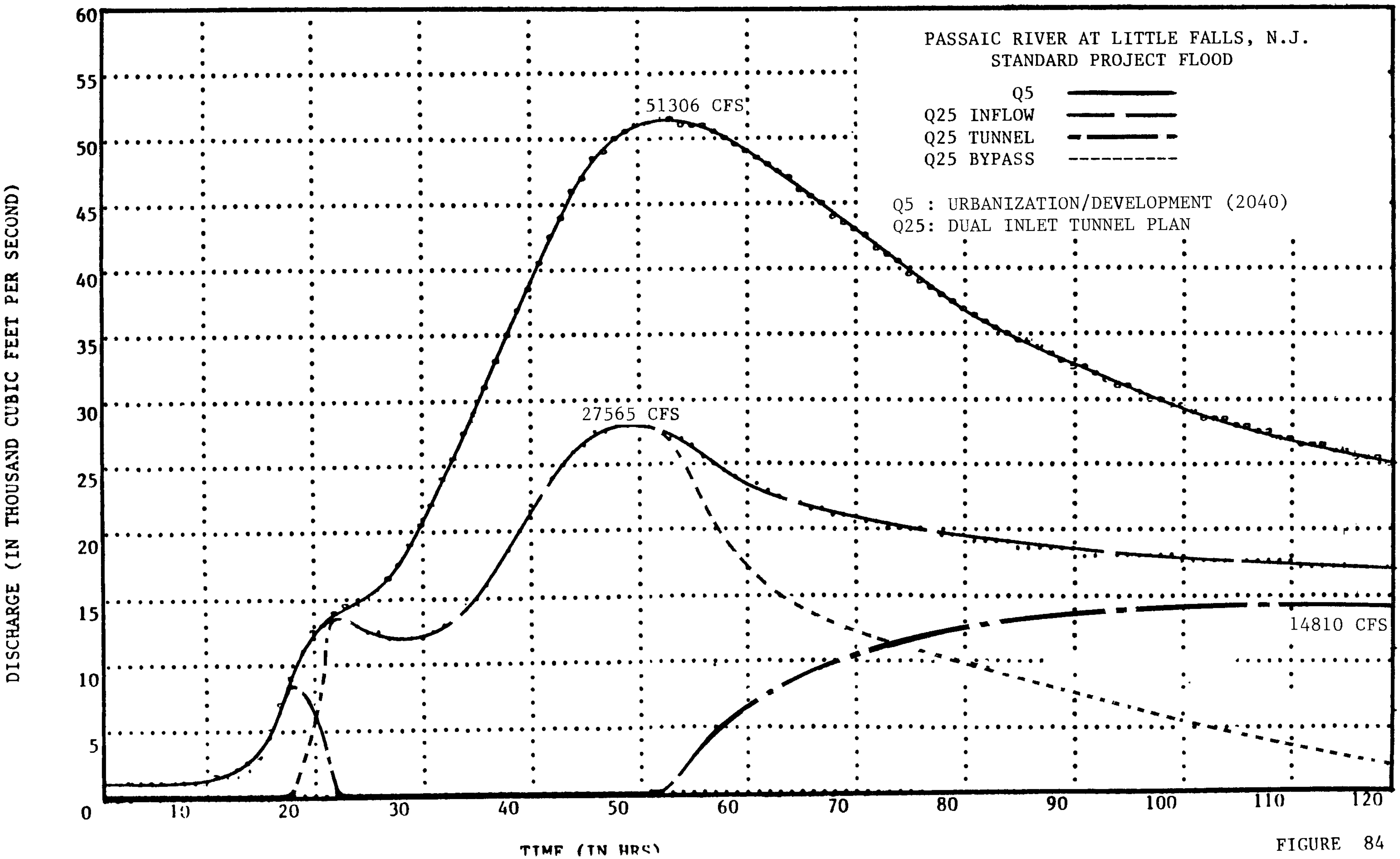

PASSAIC RIVER AT LITTLE FALLS, N.J.
STANDARD PROJECT FLOOD
Q5
Q25 INFLOW
Q25 TUNNEL
Q25 BYPASS
Q5 : URBANIZATION/DEVELOPMENT (2040)
Q25: DUAL INLET TUNNEL PLAN
51306 CFS
27565 CFS
14810 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
0
5
10
15
20
25
30
35
40
45
50
55
60
10
20
30
40
50
60
70
80
90
100
110
120
TIME (IN HRS)

FIGURE 84

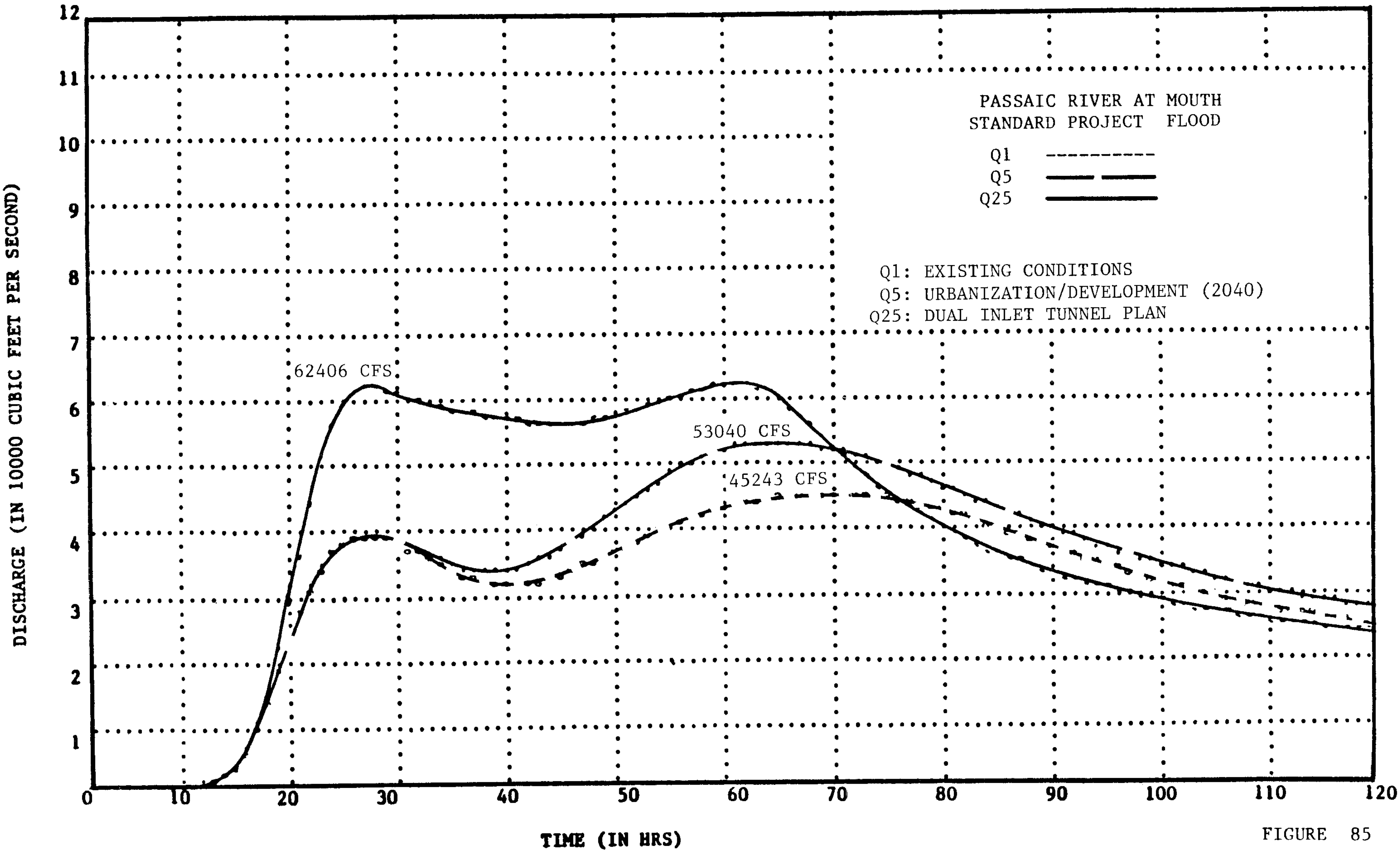

PASSAIC RIVER AT MOUTH
STANDARD PROJECT FLOOD
Q1
Q5
Q25
Q1: EXISTING CONDITIONS
Q5: URBANIZATION/DEVELOPMENT (2040)
Q25: DUAL INLET TUNNEL PLAN
62406 CFS
53040 CFS
45243 CFS
DISCHARGE (IN 10000 CUBIC FEET PER SECOND)
TIME (IN HRS)
0
10
20
30
40
50
60
70
80
90
100
110
120
1
2
3
4
5
6
7
8
9
10
11
12

FIGURE 85

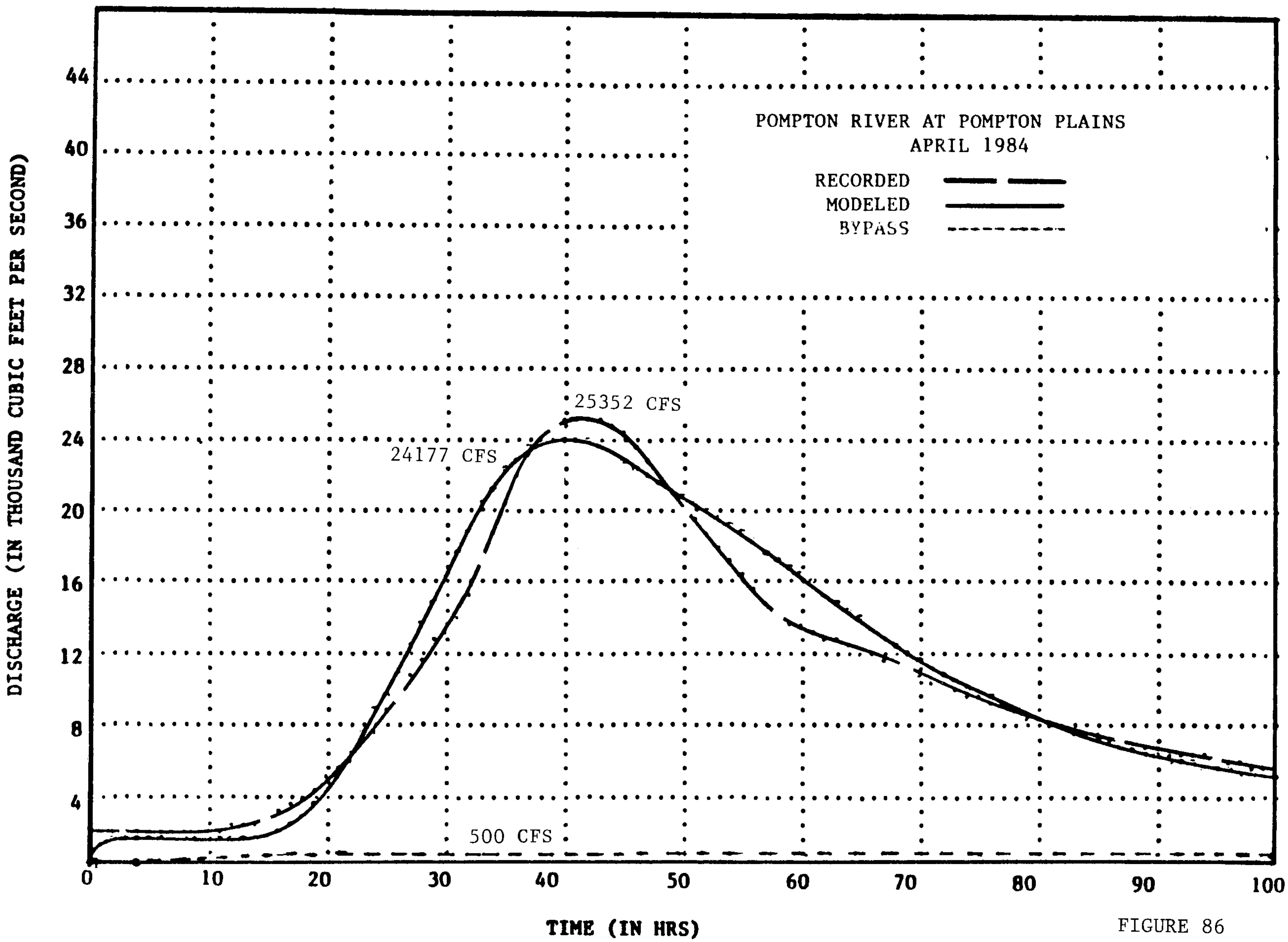

POMPTON RIVER AT POMPTON PLAINS
APRIL 1984
RECORDED
MODELED
BYPASS
25352 CFS
24177 CFS
500 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
44
40
36
32
28
24
20
16
12
8
4
0
10
20
30
40
50
60
70
80
90
100
TIME (IN HRS)

FIGURE 86

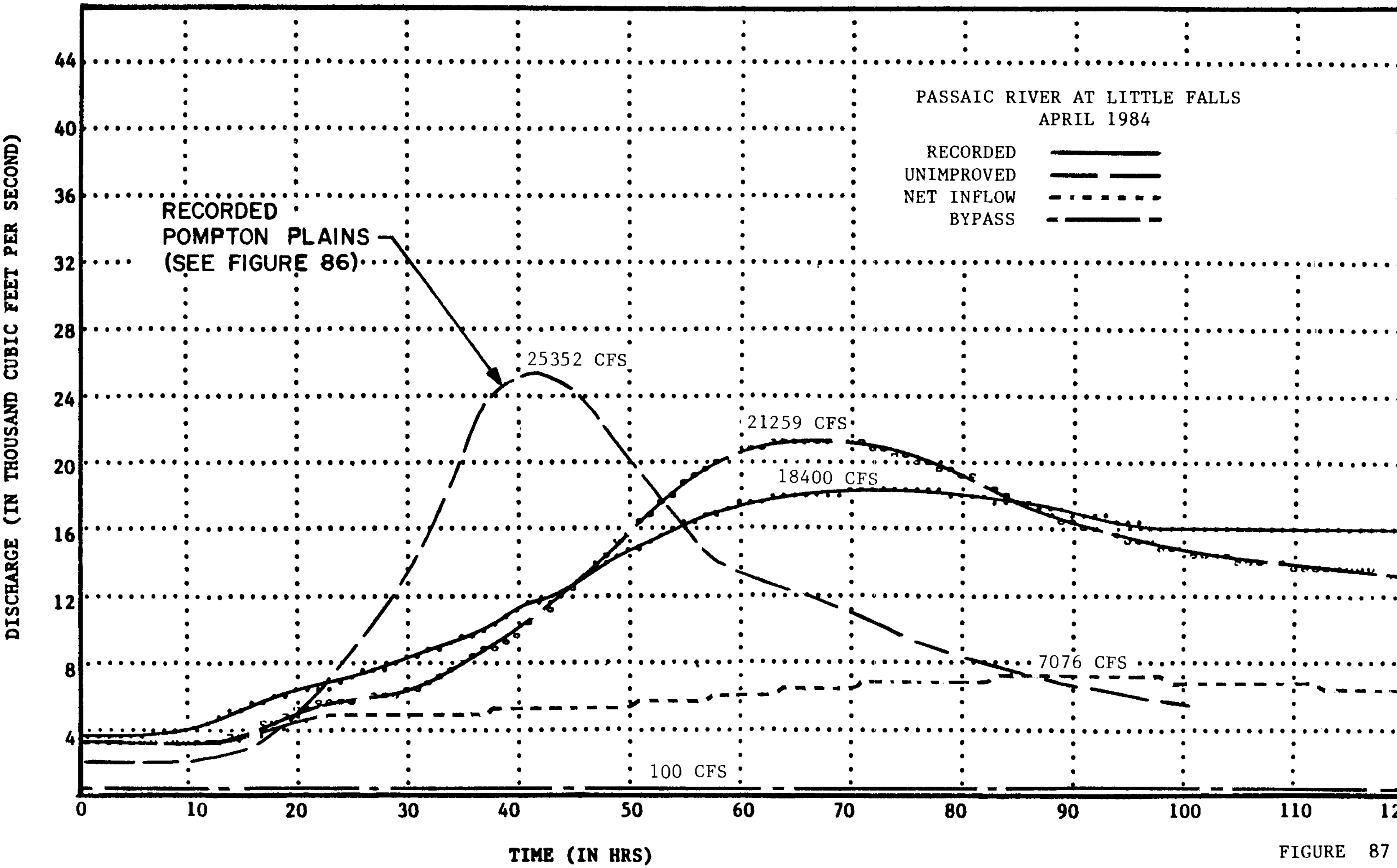
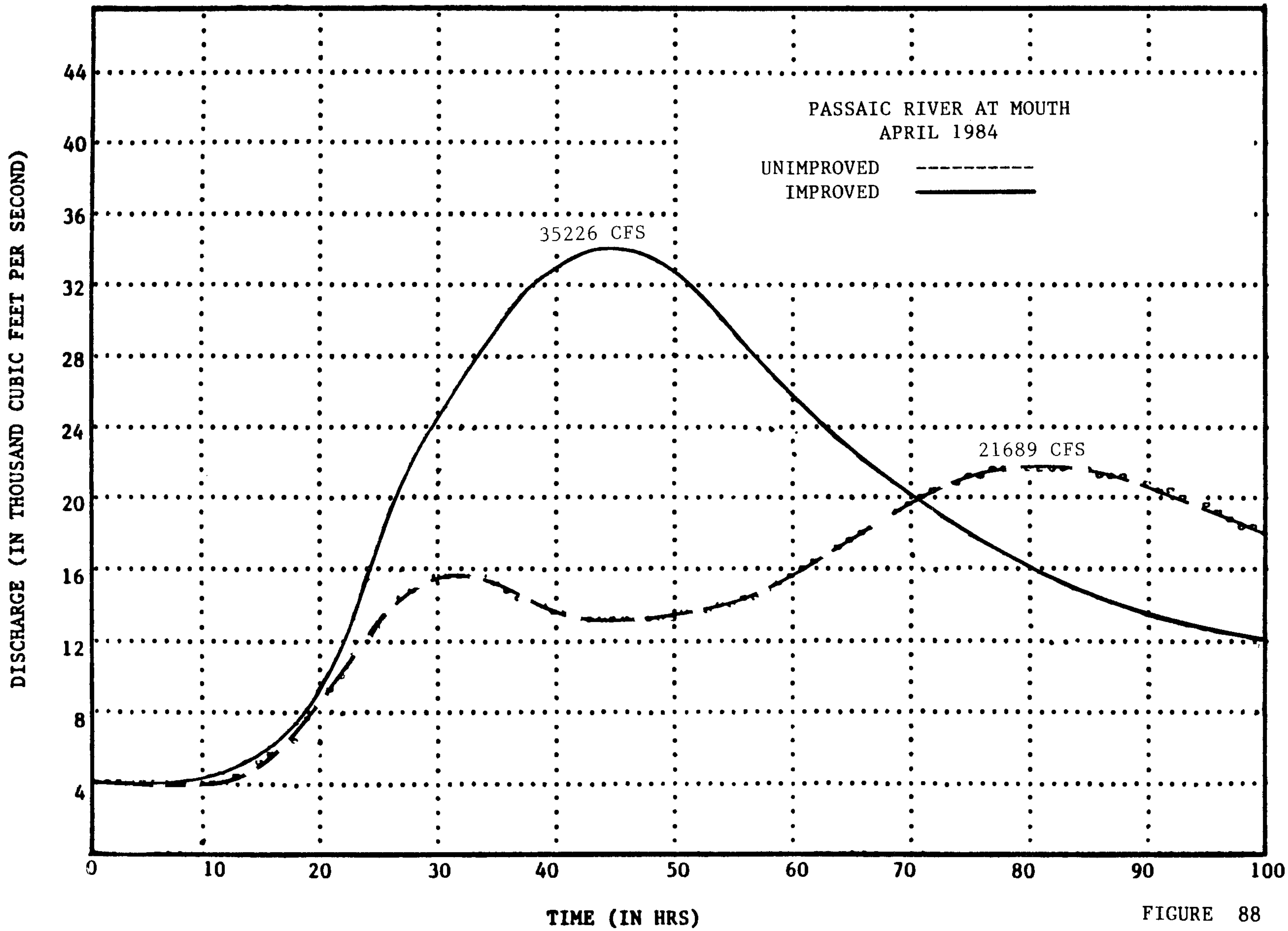
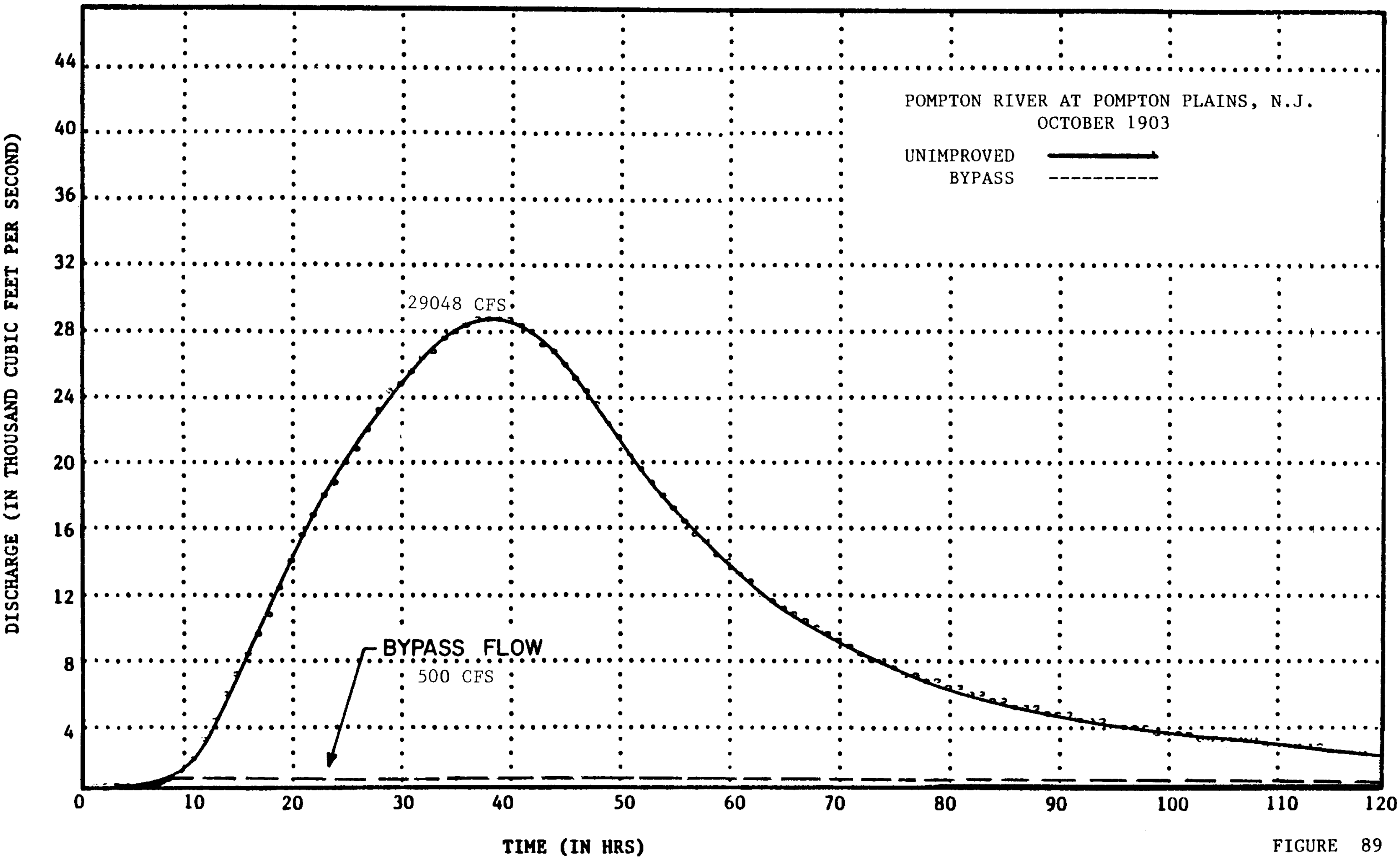

PASSAIC RIVER AT LITTLE FALLS
APRIL 1984
RECORDED
UNIMPROVED
NET INFLOW
BYPASS
RECORDED
POMPTON PLAINS
(SEE FIGURE 86)
25352 CFS
21259 CFS
18400 CFS
7076 CFS
100 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
44
40
36
32
28
24
20
16
12
8
4
0
10
20
30
40
50
60
70
80
90
100
110
120
TIME (IN HRS)

FIGURE 87



PASSAIC RIVER AT MOUTH
APRIL 1984
UNIMPROVED
IMPROVED
35226 CFS
21689 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
44
40
36
32
28
24
20
16
12
8
4
0
10
20
30
40
50
60
70
80
90
100
TIME (IN HRS)

FIGURE 88



POMPTON RIVER AT POMPTON PLAINS, N.J.
OCTOBER 1903
UNIMPROVED
BYPASS
29048 CFS
BYPASS FLOW
500 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
TIME (IN HRS)
0
10
20
30
40
50
60
70
80
90
100
110
120
4
8
12
16
20
24
28
32
36
40
44

FIGURE 89

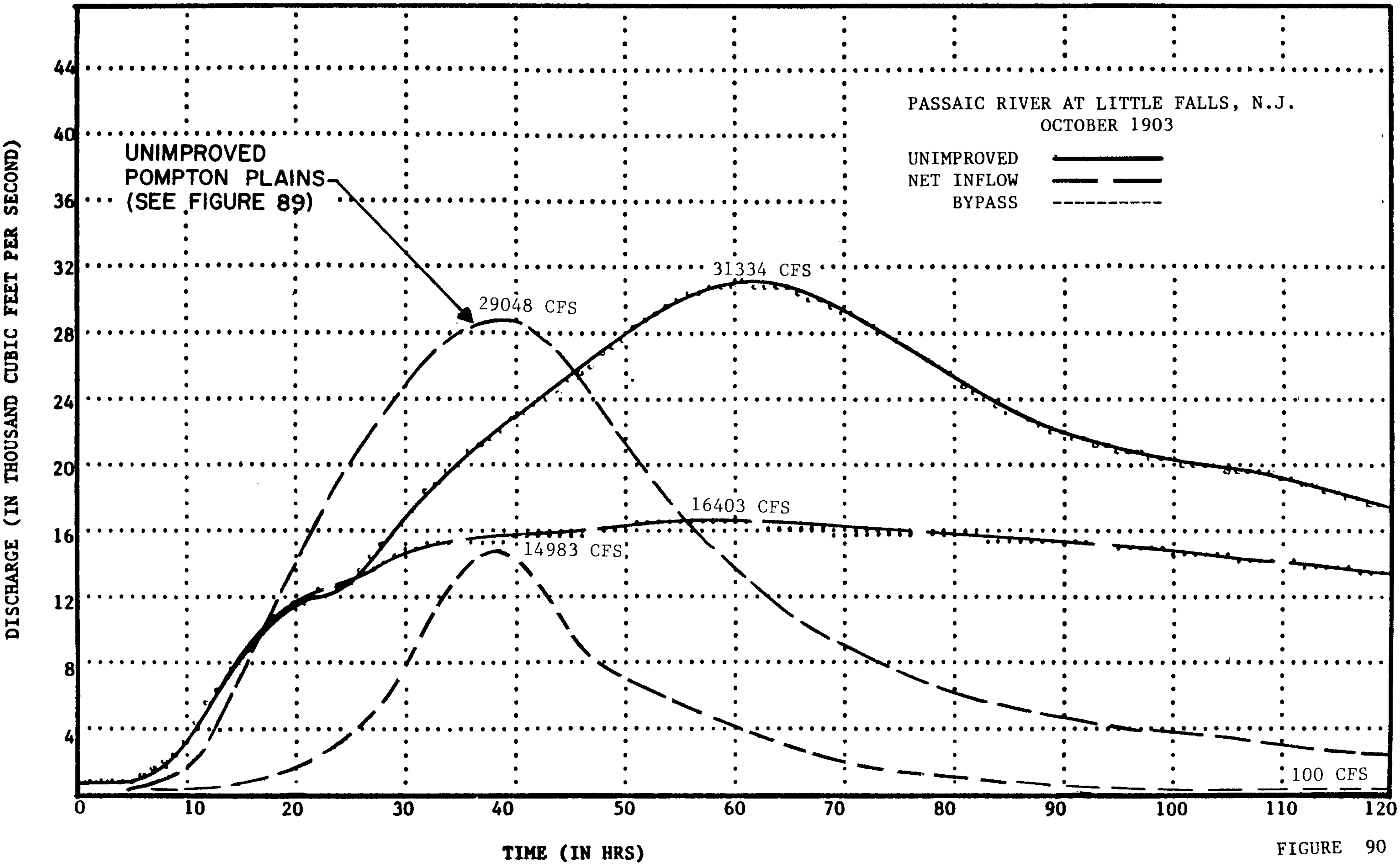
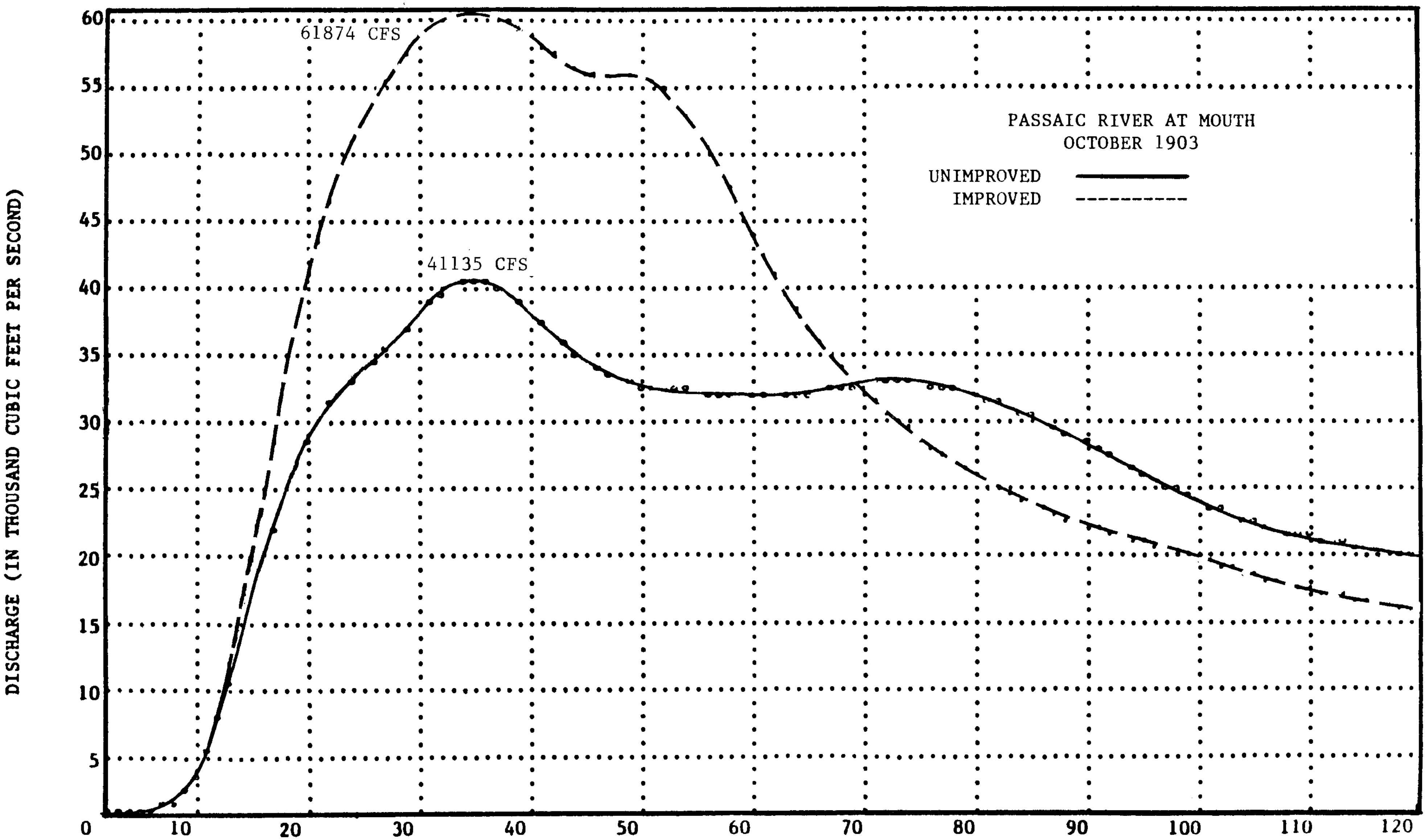
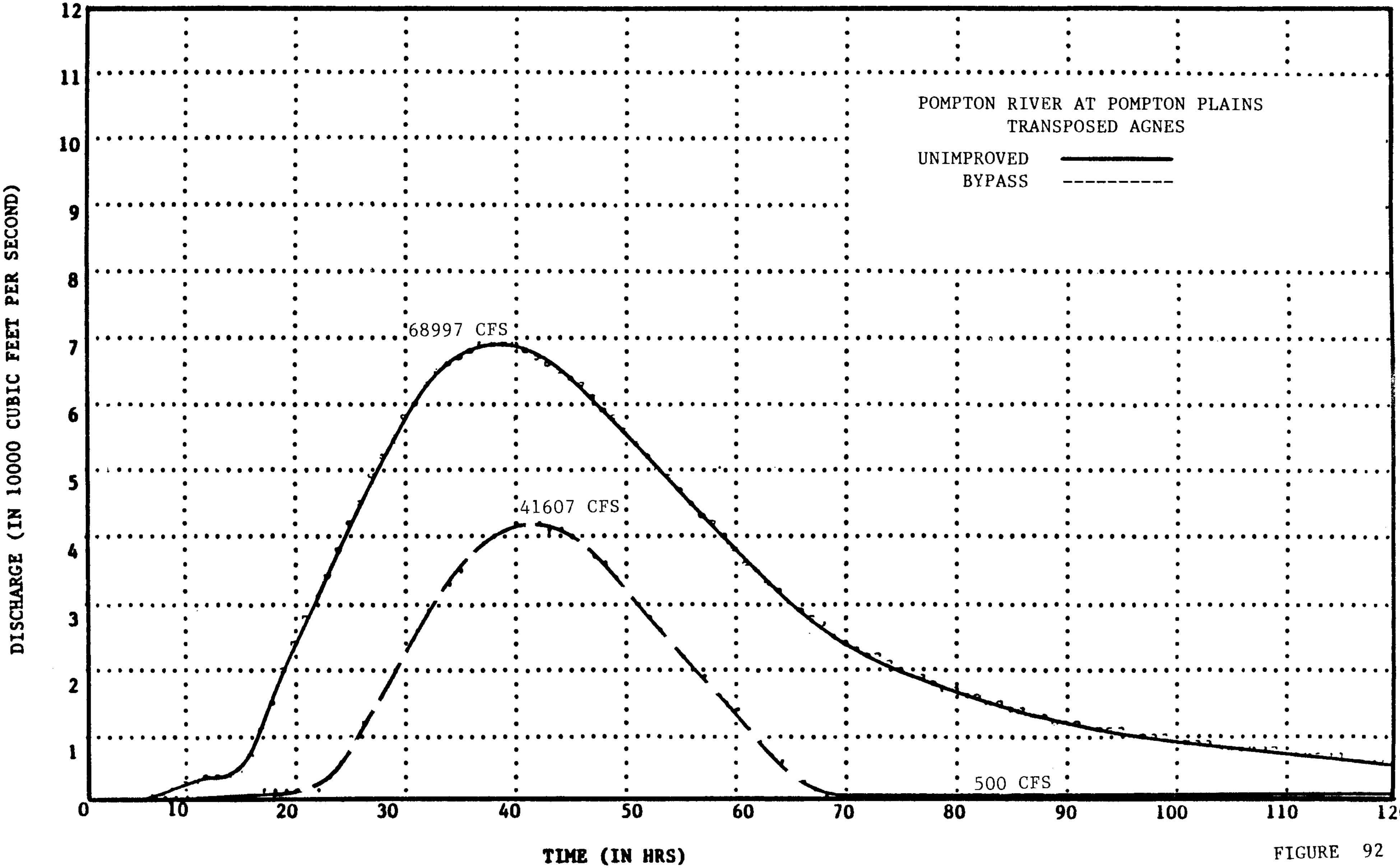

PASSAIC RIVER AT LITTLE FALLS, N.J.
OCTOBER 1903
UNIMPROVED
NET INFLOW
BYPASS
UNIMPROVED
POMPTON PLAINS
(SEE FIGURE 89)
29048 CFS
31334 CFS
16403 CFS
14983 CFS
100 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
TIME (IN HRS)
0
10
20
30
40
50
60
70
80
90
100
110
120
4
8
12
16
20
24
28
32
36
40
44

FIGURE 90



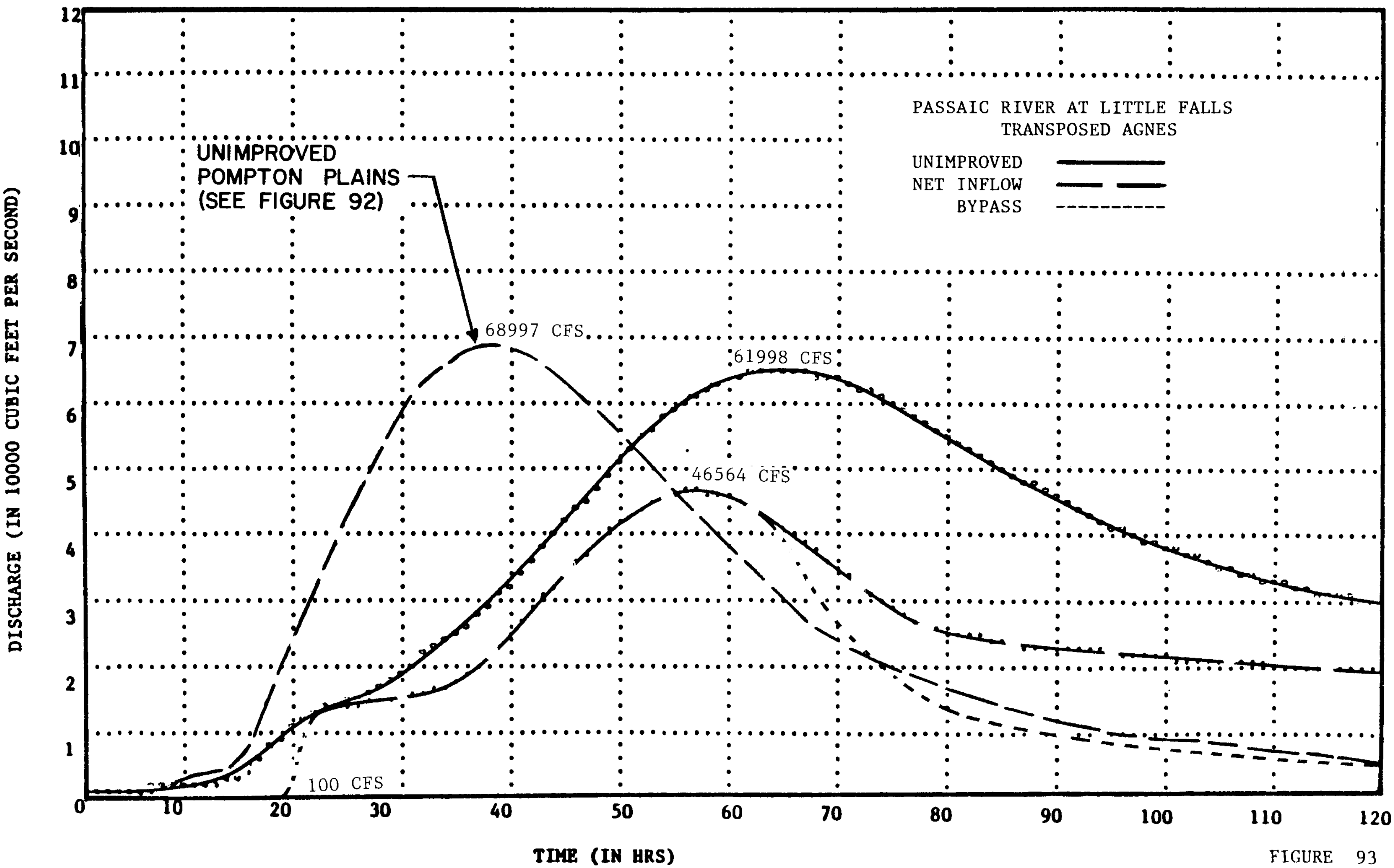
PASSAIC RIVER AT MOUTH
OCTOBER 1903
UNIMPROVED
IMPROVED
61874 CFS
41135 CFS
DISCHARGE (IN THOUSAND CUBIC FEET PER SECOND)
0
5
10
15
20
25
30
35
40
45
50
55
60
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 91



POMPTON RIVER AT POMPTON PLAINS
TRANSPOSED AGNES
UNIMPROVED
BYPASS
68997 CFS
41607 CFS
500 CFS
DISCHARGE (IN 10000 CUBIC FEET PER SECOND)
TIME (IN HRS)
0
10
20
30
40
50
60
70
80
90
100
110
120
1
2
3
4
5
6
7
8
9
10
11
12

FIGURE 92



PASSAIC RIVER AT LITTLE FALLS
TRANSPOSED AGNES
UNIMPROVED
NET INFLOW
BYPASS
UNIMPROVED
POMPTON PLAINS
(SEE FIGURE 92)
68997 CFS
61998 CFS
46564 CFS
100 CFS
DISCHARGE (IN 10000 CUBIC FEET PER SECOND)
TIME (IN HRS)
0
1
2
3
4
5
6
7
8
9
10
11
12
20
30
40
50
60
70
80
90
100
110
120

FIGURE 93

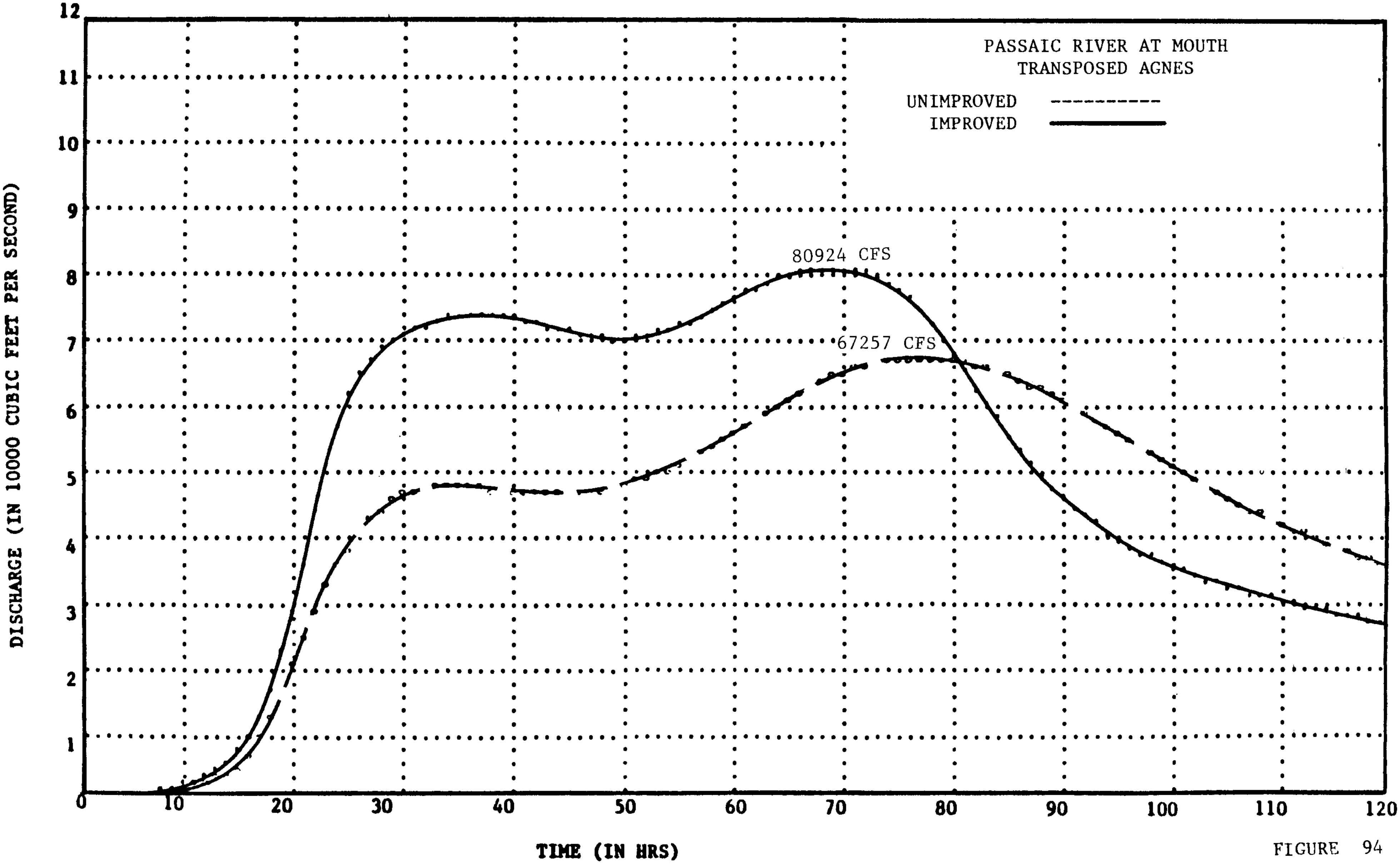
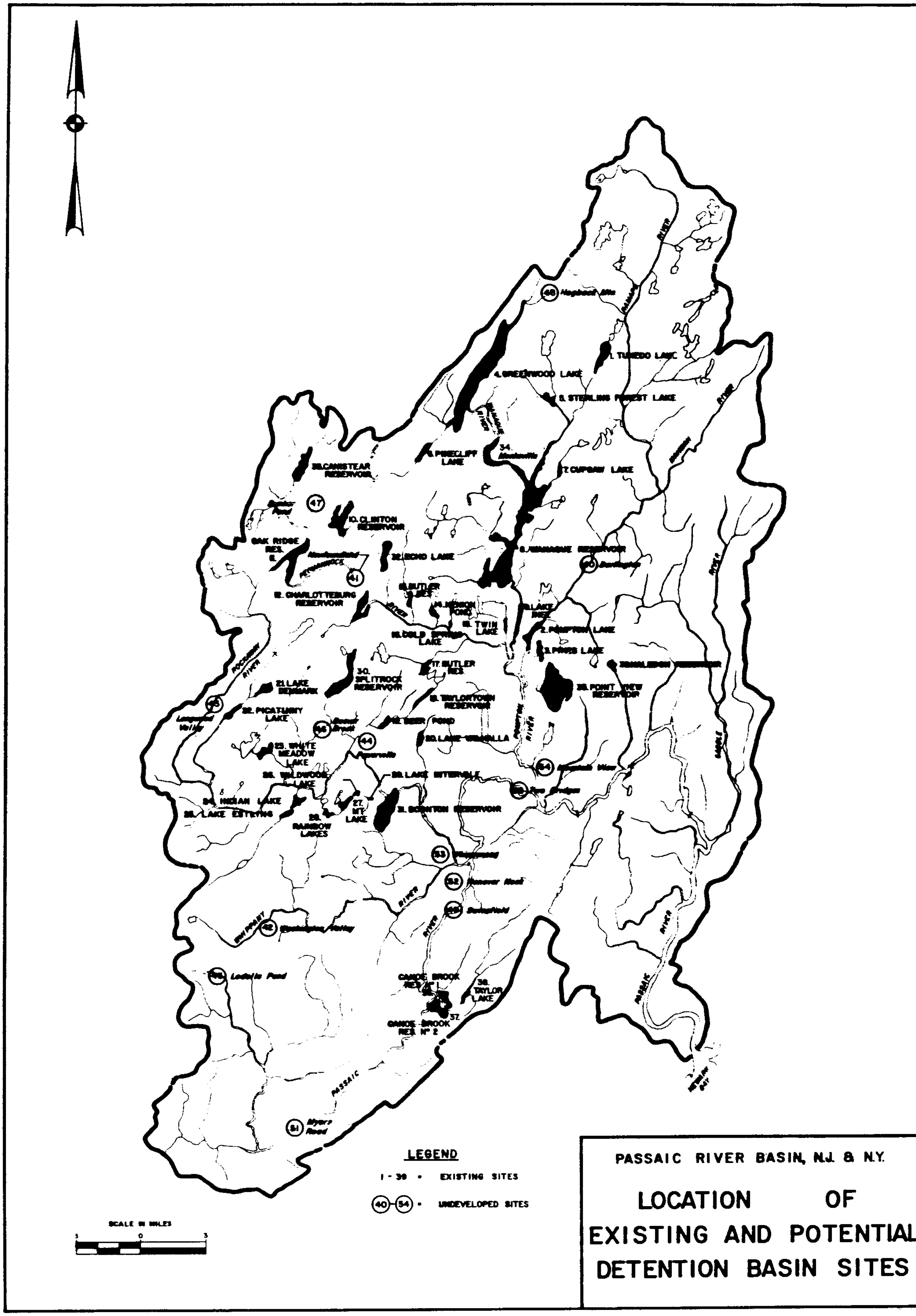
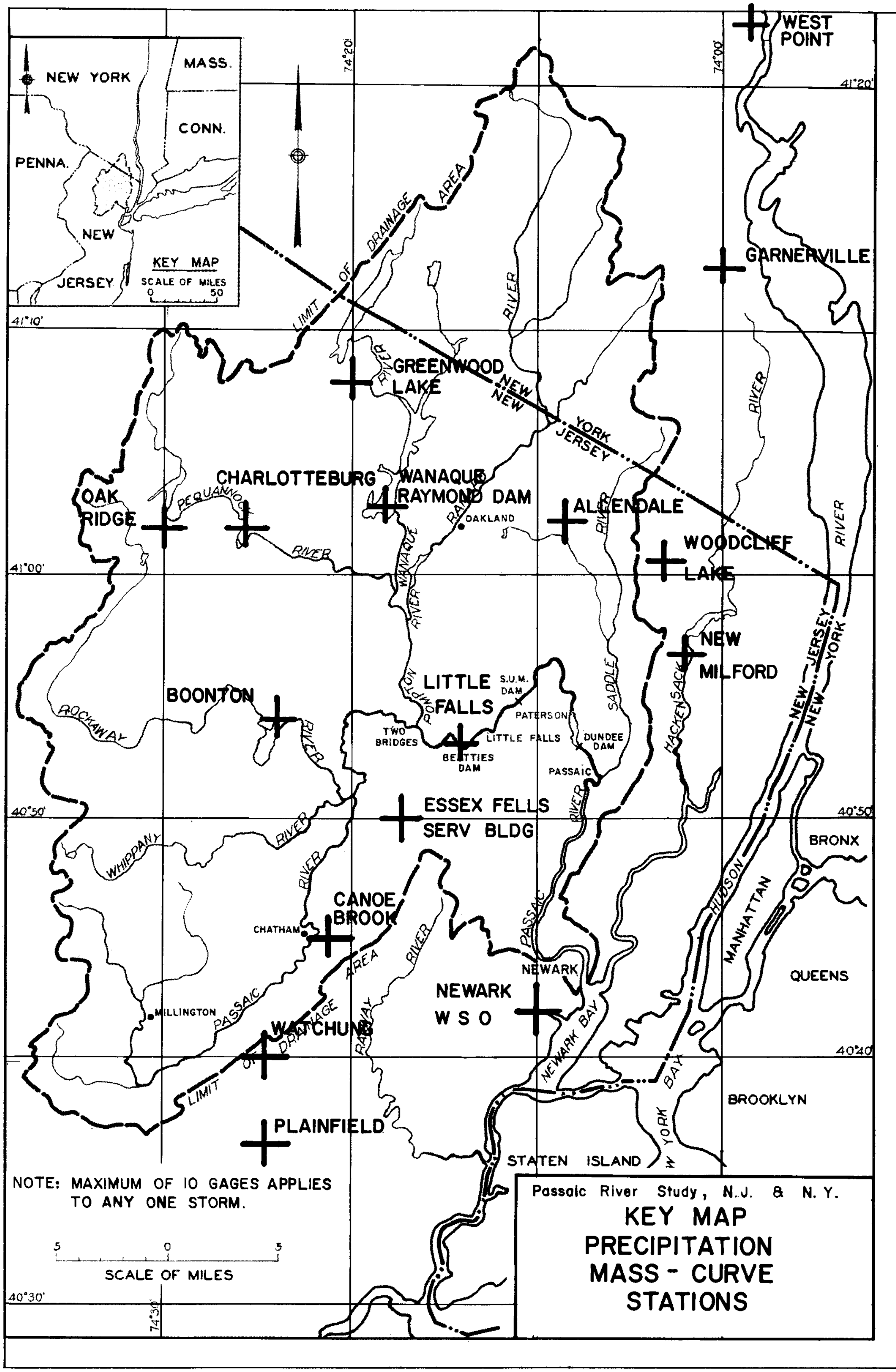

PASSAIC RIVER AT MOUTH
TRANSPOSED AGNES
UNIMPROVED
IMPROVED
80924 CFS
67257 CFS
DISCHARGE (IN 10000 CUBIC FEET PER SECOND)
TIME (IN HRS)
0
1
2
3
4
5
6
7
8
9
10
11
12
10
20
30
40
50
60
70
80
90
100
110
120

FIGURE 94



PASSAIC RIVER BASIN, N.J. & N.Y.
LOCATION OF EXISTING AND POTENTIAL DETENTION BASIN SITES
LEGEND
1 - 39 = EXISTING SITES
40 - 54 = UNDEVELOPED SITES
SCALE IN MILES
1. TUXEDO LAKE
4. GREENWOOD LAKE
5. STERLING FOREST LAKE
7. CUPSAW LAKE
10. CLINTON RESERVOIR
12. CHARLOTTEBURG RESERVOIR
21. LAKE DENMARK
22. PICATINNY LAKE
25. WHITE MEADOW LAKE
27. MT. LAKE
28. RAINBOW LAKES
30. SPLITROCK RESERVOIR
31. BOONTON RESERVOIR
32. ECHO LAKE
35. POINT VIEW RESERVOIR
37.
38. TAYLOR LAKE
CANOE BROOK RES. Nº 1
CANOE BROOK RES. Nº 2
PASSAIC RIVER
POMPTON RIVER

FIGURE 95



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

KEY MAP
PRECIPITATION
MASS - CURVE
STATIONS

FIGURE 96

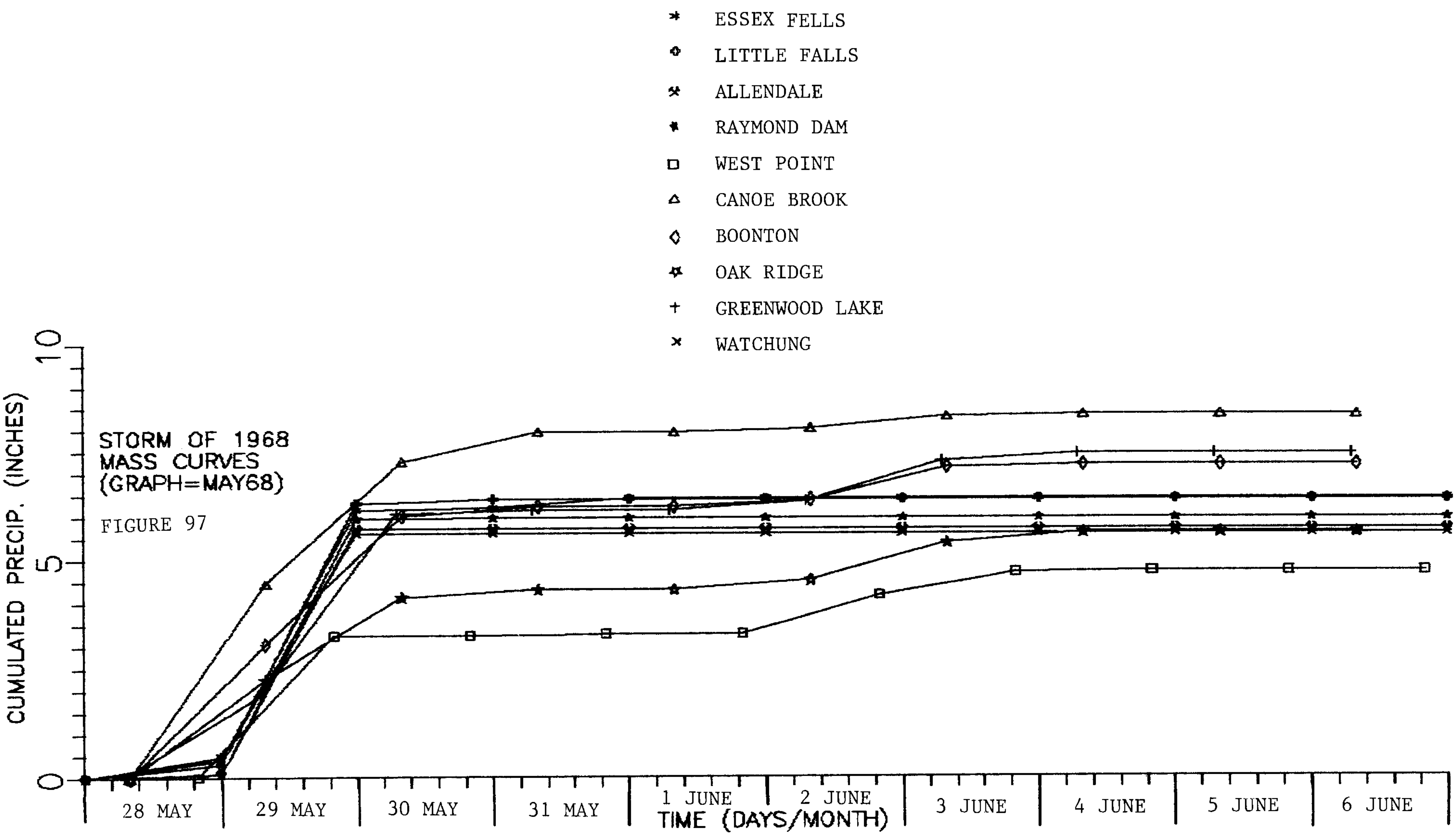
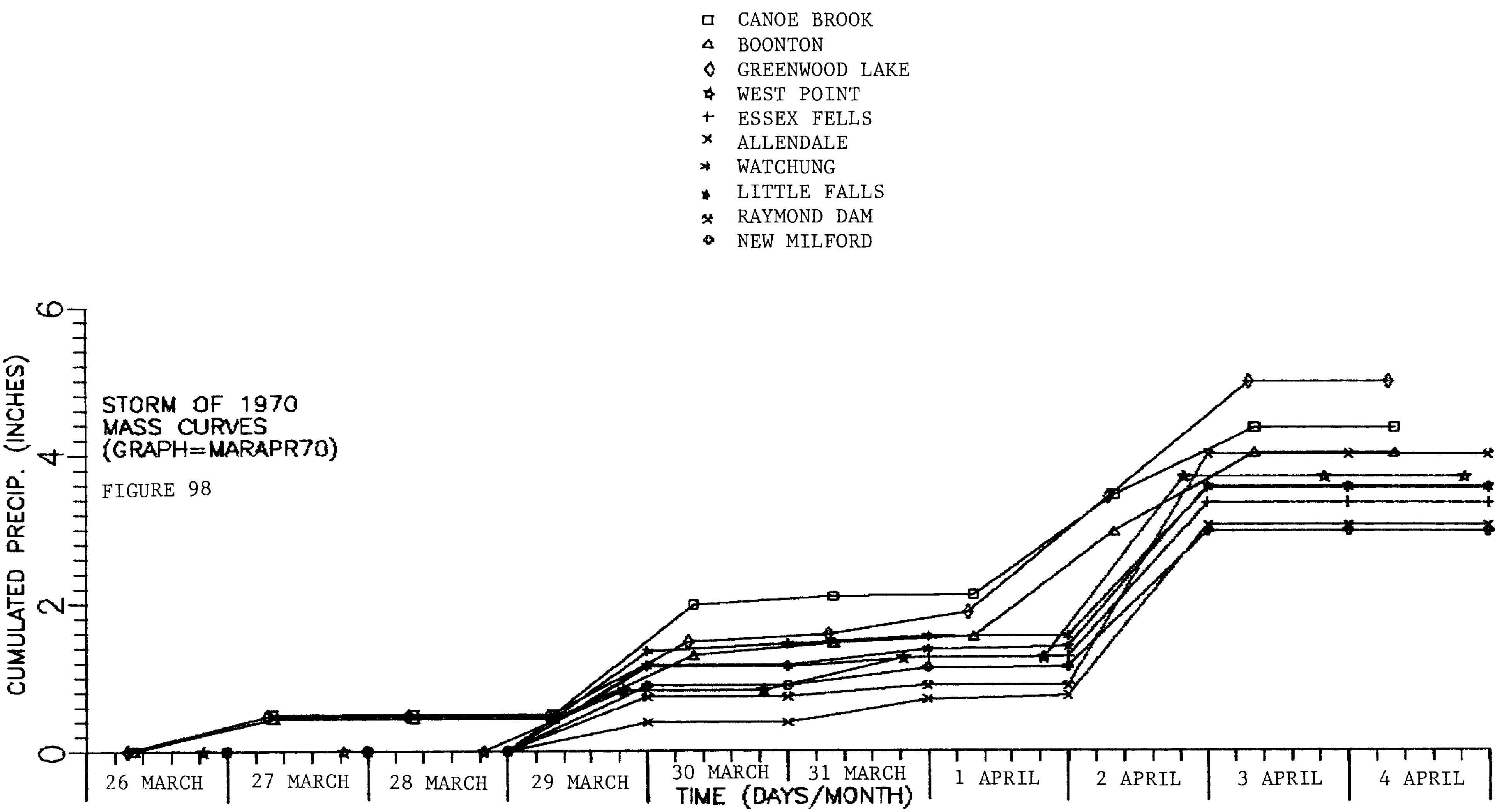
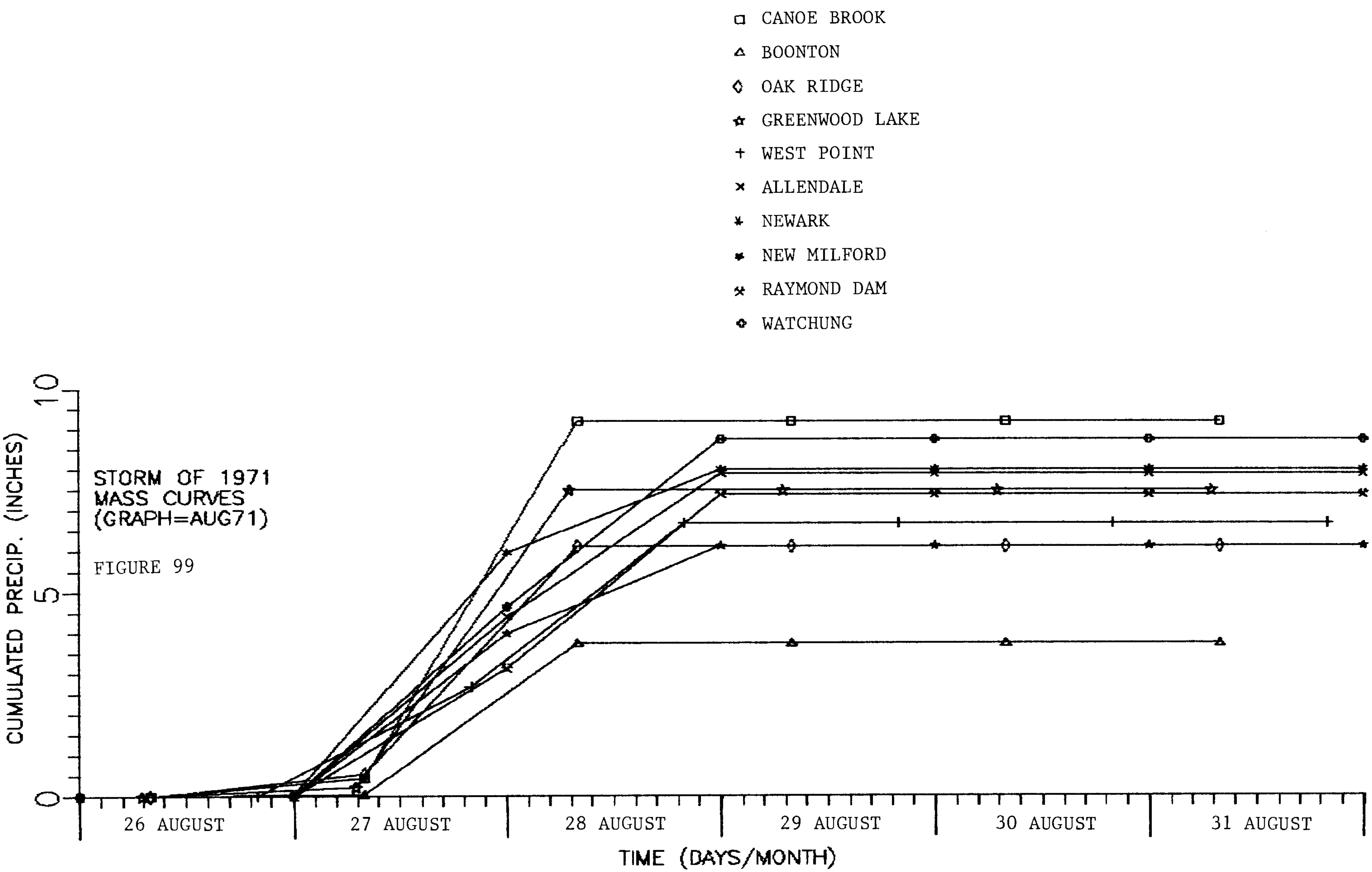

ESSEX FELLS
LITTLE FALLS
ALLENDALE
RAYMOND DAM
WEST POINT
CANOE BROOK
BOONTON
OAK RIDGE
GREENWOOD LAKE
WATCHUNG
STORM OF 1968
MASS CURVES
(GRAPH=MAY68)
FIGURE 97
CUMULATED PRECIP. (INCHES)
0
5
10
28 MAY
29 MAY
30 MAY
31 MAY
1 JUNE
2 JUNE
3 JUNE
4 JUNE
5 JUNE
6 JUNE
TIME (DAYS/MONTH)

FIGURE 97



CANOE BROOK
BOONTON
GREENWOOD LAKE
WEST POINT
ESSEX FELLS
ALLENDALE
WATCHUNG
LITTLE FALLS
RAYMOND DAM
NEW MILFORD
STORM OF 1970
MASS CURVES
(GRAPH=MARAPR70)
FIGURE 98
CUMULATED PRECIP. (INCHES)
0
2
4
6
26 MARCH
27 MARCH
28 MARCH
29 MARCH
30 MARCH
31 MARCH
1 APRIL
2 APRIL
3 APRIL
4 APRIL
TIME (DAYS/MONTH)



CANOE BROOK
BOONTON
OAK RIDGE
GREENWOOD LAKE
WEST POINT
ALLENDALE
NEWARK
NEW MILFORD
RAYMOND DAM
WATCHUNG
STORM OF 1971
MASS CURVES
(GRAPH=AUG71)
FIGURE 99
CUMULATED PRECIP. (INCHES)
0
5
10
26 AUGUST
27 AUGUST
28 AUGUST
29 AUGUST
30 AUGUST
31 AUGUST
TIME (DAYS/MONTH)

FIGURE 99

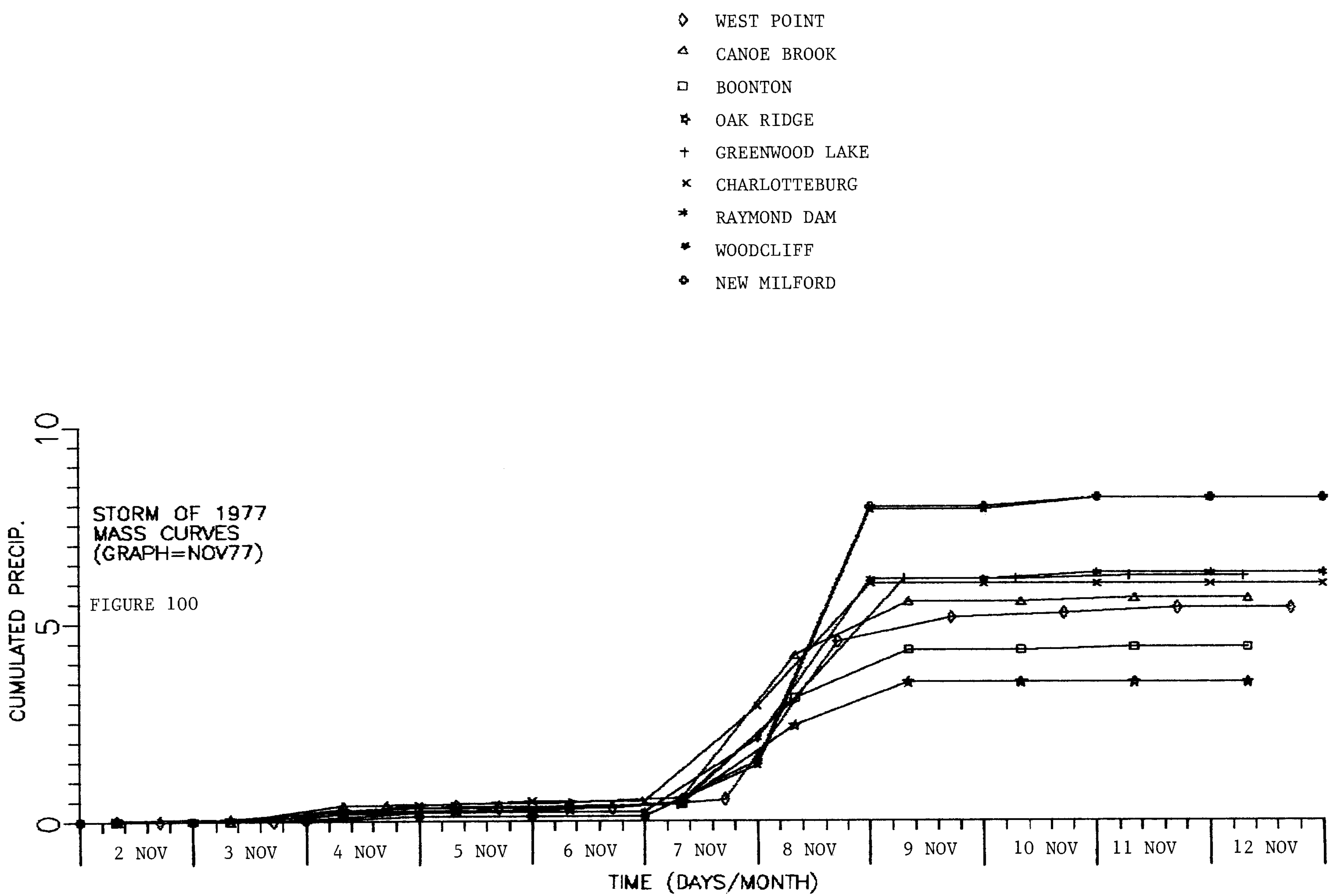

WEST POINT
CANOE BROOK
BOONTON
OAK RIDGE
GREENWOOD LAKE
CHARLOTTEBURG
RAYMOND DAM
WOODCLIFF
NEW MILFORD
STORM OF 1977
MASS CURVES
(GRAPH=NOV77)
FIGURE 100
CUMULATED PRECIP.
0
5
10
2 NOV
3 NOV
4 NOV
5 NOV
6 NOV
7 NOV
8 NOV
9 NOV
10 NOV
11 NOV
12 NOV
TIME (DAYS/MONTH)

FIGURE 100

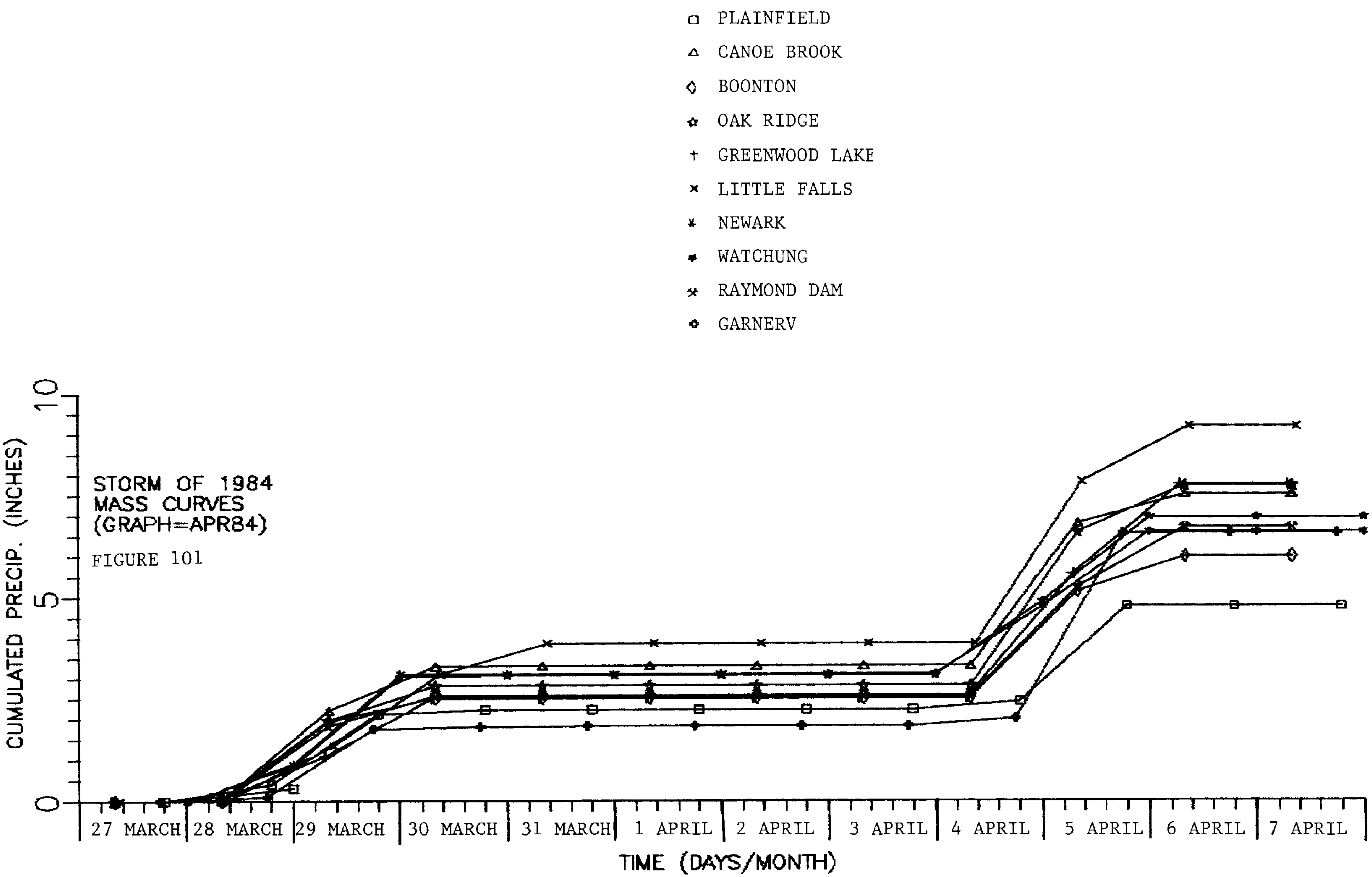

PLAINFIELD
CANOE BROOK
BOONTON
OAK RIDGE
GREENWOOD LAKE
LITTLE FALLS
NEWARK
WATCHUNG
RAYMOND DAM
GARNERV
STORM OF 1984
MASS CURVES
(GRAPH=APR84)
FIGURE 101
CUMULATED PRECIP. (INCHES)
0
5
10
27 MARCH
28 MARCH
29 MARCH
30 MARCH
31 MARCH
1 APRIL
2 APRIL
3 APRIL
4 APRIL
5 APRIL
6 APRIL
7 APRIL
TIME (DAYS/MONTH)

FIGURE 101