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PRELIMINARY SURVEY

OF

NEW JERSEY WATER RESOURCES DEVELOPMENT

LEGISLATIVE COMMISSION ON WATER SUPPLY

STATE OF NEW JERSEY

JULY 1955

TIPPETTS-ABBETT-McCARTHY-STRATTON
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July 15, 1955

Legislative Commission on Water Supply
Mr. Mark Anton, Chairman
State of New Jersey
Trenton, New Jersey

Gentlemen:

We are pleased to transmit herewith our report titled "Preliminary Survey of New Jersey Water Resources Development" in accordance with the terms of our contract dated May 3, 1955. Our final report, to be titled "Survey of New Jersey Water Resources Development" is to be submitted to you by December 15, 1955.

This preliminary report was prepared in a period of 10 weeks in order to be of use to the Legislature with the following objectives:

1. By a study of the supply and demand to establish the need for additional water supplies in any part of the State.
2. To examine alternate proposals for water projects that have been put forward for the Northeastern Metropolitan Region.
3. To recommend such specific new water supply projects that the study may reveal as essential.
4. To determine the character and cost of recommended projects in some detail in order to facilitate financing.
5. To recommend the necessary legislative program to implement water development recommendations.

This preliminary report presents a general review and discussion of all aspects of the New Jersey water supply problem and outlines specific recommended developments to meet both short-term and long-term needs.

The major recommendations of the report may be summarized as follows:

1. A new major water supply for the Northeastern Metropolitan Area should be developed on the Raritan River Basin and supplemented by additional withdrawals from the Delaware and Raritan Canal. The Chimney Rock dams and reservoir site are recommended for the development. The estimated cost of the first stage of development, designed to deliver a safe yield of 70 million gallons per day, is \$51,860,000. The completion of the second and final stage of development will result in a total safe yield of 200 million gallons per day with an estimated total cost for both stages of \$102,650,000.

2. In order to be assured of an adequate water supply in the Northeastern Metropolitan Area during the period in which the new major water supply is being developed the following additional supplies to existing systems should be developed.

a. To the City of Newark, Pequannock System, an additional supply of 7.4 million gallons per day at an estimated cost of \$8,640,000.

b. To the City of Jersey City, Rockaway System, an additional supply of 14.6 million gallons per day at an estimated cost of \$3,500,000.

c. To the Passaic Valley Water Commission System, an additional supply of 55 million gallons per day at an estimated cost of \$10,000,000.

These three additions will increase the safe yield of the systems by a total of 77.0 million gallons per day at an estimated total cost of \$22,140,000.

3. The following legislative action is recommended:

a. A bill to establish a State Agency with the power to finance and construct new major water supply systems and to encourage the construction of, or to actually construct, additions to existing systems.

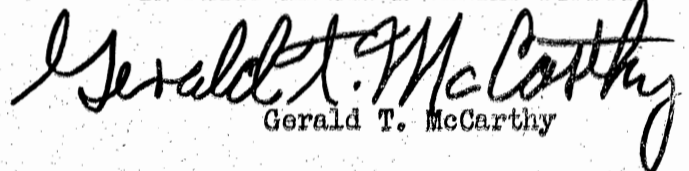
b. A bill providing for a referendum on the bond issues necessary to finance the recommended water supply developments.

c. A bill which will strengthen the control powers of the Water Policy and Supply Council.

We wish to express our appreciation of the cooperation which we received from the Legislative Commission on Water Supply and to the many organizations and individuals who furnished valuable information and assistance to us throughout our work on this survey.

Sincerely yours,

TIPPETTS-ABBETT-McCARTHY-STRATTON


Gerald T. McCarthy

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The following consultants assisted in the investigation and preparation of this report:

Leggette, Brashears & Graham - Ground water data, findings and recommendations presented in Chapters I and IV.

Mr. S. Logan Kerr - Mechanical equipment, pumping and transmission mains.

Mr. Gordon R. Williams - Hydrology and hydraulic engineering.

Mr. William Miller - Legislation

Mr. Morton W. Lieberman directed the survey for Tippetts-Abbett-McCarthy-Stratton.

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INTRODUCTION

AUTHORITY AND SCOPE

This report was prepared under the terms of a contract entered into on May 3, 1955 between the Legislative Commission on Water Supply of the State of New Jersey (hereinafter referred to as the "COMMISSION") and the firm of Tippetts-Abbett-McCarthy-Stratton (hereinafter referred to as the "ENGINEER"). The authority under which this contract was executed and the scope of the work to be performed is given in the portion of the contract quoted below:

WHEREAS: The Legislative Commission on Water Supply of New Jersey has been created, pursuant to Assembly Joint Resolution 4 (1955), for the purpose of making a study of the present and future water resources development of the State, and reporting the results of this study to the Legislature, and

WHEREAS: The Commission has been authorized by Section 4 of said Resolution to engage the services of competent engineering specialists to make surveys of existing resources and of the potentialities of water supply, and has been empowered to make contracts for the payment of the cost of such services within the limits of appropriations made available and

WHEREAS: The Legislative Commission on Water Supply, by resolution adopted at a meeting of the Commission, April 29, 1955 selected the engineering firm of Tippetts-Abbett-McCarthy-Stratton of New York to make the proposed survey, and authorized the Chairman of the Commission to enter into contractual relations with the aforementioned firm on behalf of the COMMISSION.

Now, THEREFORE, the COMMISSION and the ENGINEER, for the considerations hereinafter named, agree as follows:

A. SERVICES TO BE RENDERED

The COMMISSION retains the ENGINEER to make surveys of the potentialities of the water supply resources of the State, including the proposals for the development of the Wharton Tract Water Supply Project, the Round Valley Water Supply Project, the Delaware River Valley Water Supply Project and any other projects or proposals and to report thereon, from time to time, to the COMMISSION with their recommendations as to what areas shall be acquired for water supply purposes and in what order and what type of water supply and storage and conduction and distribution system or systems and facilities shall be constructed in connection with the use of such areas, in the carrying out of an over-all long range plan for the development and use of the water supply resources of the State together with estimates of the probable cost of the acquisition of such areas and of the facilities required for the development thereof and estimates of the probable demand for water supply from such projects and the probable income to be derived from the sale of water delivered therefrom and to make a preliminary report of the results of this Survey on or before July 15, 1955 and a final report on or before December 15, 1955 in accordance with the following outline:

1. Review of reports and studies previously made by various agencies covering existing and potential water supply projects.

2. A general survey of present safe yield and possible future increases of yield of the statewide existing major water supplies including; The North Jersey Metropolitan Area, including the lower Raritan Valley; The South Jersey Metropolitan Area - particularly in the vicinity of Camden; The East Coast Resort Area.

2A. Will feasible conservation measures (meters, higher rates, reclaiming of industrial water) save substantial amounts of water?

3. Present and future water supply requirements projected to the year 2000 in the various areas of the State, for the purpose of public water supply, industry, agriculture, and regulation of stream flow. Forecasts should estimate when and where the increased water need will occur, and the sequence in which areas will need new water supplies.

4. Studies of the various possible future developments, including but not limited to the Wharton Tract, both as to ground and surface water supply, separately and in combination; the investigation of the possibilities of using scientific ground water recharging methods in areas where excessive pumpage may have produced a serious lowering of the ground water table; the Round Valley Project, impounding waters from either the Raritan River, the Delaware River and its tributaries, or both; the proposed Wallpack Bend Dam on the Delaware River, including consideration of interstate rights, responsibilities and benefits; the Delaware and Raritan Canal as an existing source of water supply operated by the State, and as a future supply facility; other possible developments on the Raritan River and on the Delaware River and its New Jersey Tributaries; and alternative new supplies available to Camden and the Camden industrial area, and to the East Coast area.

5. Study of the possibility of joint and interconnected operation of several systems and the evaluation of increased aggregate dependable yields and economies in the cost of construction that may result from such interconnected operation as compared with the aggregate dependable yields and probable higher construction costs, if water systems are developed and operated independent of each other; study of the possibilities for consolidated operation of two or more existing water systems, indicating which agency or agencies should be given control over any consolidated system.

6. Recommendation of the works most suitable to supply water to the various areas, presenting; safe yield of the supply; quality of water and treatment required including salinity control; effect of the development on the upstream watershed area including the redevelopment needs for roads, railways, bridges, housing and other structures that may be dislocated as a result of reservoir construction and on downstream water rights, including the maintenance of proper downstream flow under conditions of water scarcity and flood and study of the effect of major sanitary trunk sewer construction on the sustained flow in certain streams, particularly the Raritan River; evaluation of the incidental power which may be developed without interference with the major objectives of water supply; evaluation of the incidental flood control benefits that will accrue from the construction of water impounding structures; area to be served by recommended works; general plans of project showing all essential features; estimated cost of construction; construction program; suggested method of financing construction - type and term of bonds and probable interest rate (in association with an approved bond counsel); estimated cost of operation, indicating probable or potential sources

of revenue and the possibility of self-liquidation (in what period of time); estimated unit cost of water as delivered, showing operation, maintenance and capital charges separately; suggested form of organizing the financing, construction and operation; and suggestions as to legislation required.

7. Outline and define the most critical short and long range water supply needs of the State, with recommendation of the relative priority of each need.

8. The report shall clearly set forth the nature of the various problems involved and describe the means proposed for solution, indicating the reasoning governing their selection. Drawings and tables shall be used to illustrate recommendations and estimates.

9. One hundred copies of a report shall be submitted to the COMMISSION by July 15, 1955 titled "Preliminary Survey of New Jersey Water Resources Development" presenting a general review and discussion of all aspects of the problem and recommending the facilities immediately to be provided as an appropriate step in the development of a long range plan; and one hundred copies of a final report entitled "Survey of New Jersey Water Resources Development," presenting a complete long range plan, shall be submitted by December 15, 1955

10. The COMMISSION agrees to use its good offices to assist the ENGINEER in obtaining all reports, data, computations, maps, drawings and other information bearing on the water resources of New Jersey which have been prepared by or for the various State, County or other official agencies.

11. The ENGINEER will submit monthly to the COMMISSION a report indicating scope of work being undertaken and progress accomplished. The ENGINEER agrees to inform the Secretary of the COMMISSION of work in progress and work accomplished from time to time on request, and will undertake to answer inquiries directed to the ENGINEER by the COMMISSION or its Secretary.

ACKNOWLEDGMENTS

Acknowledgment is due to many individuals and organizations who furnished valuable information and helpful cooperation during the conduct of the investigations. The members of the New Jersey Legislative Commission worked in close cooperation with members of this firm throughout the investigations and during the preparation of the report. Valuable assistance in locating basic data for the investigation was obtained from the New Jersey Taxpayers Association through unlimited access to their comprehensive bibliography and to their files on the New Jersey Water Supply problem.

A list of individuals and organizations who were consulted during the course of the work follows. Their assistance is gratefully acknowledged.

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Mr. Max E. Anderson

CHAPTER I

BASIC STATEWIDE DATA

All fresh water in the State of New Jersey, both surface and ground water, is dependent on precipitation for replenishment. All water falling on the earth is dissipated in the following manner:

- a. Seepage into the ground.
- b. Evaporation to the atmosphere.
- c. Transpiration by plant life.
- d. Surface runoff.

The proportion of precipitation which will go into each of the above components of distribution will vary widely with geologic, topographic, climatic and seasonal conditions.

Where the geological conditions are favorable very large quantities of water will be stored underground and may be tapped by means of wells without any necessity for creating artificial storage. If the amount of ground water withdrawn does not exceed the yearly replenishment by precipitation, such a supply will be permanent and dependable under all normal circumstances.

Stream runoff consists of the excess water that is not retained in the ground, evaporated, or transpired. It appears in streams as flood water during and shortly after a rainfall or as a result of melting snow. Ground water is also discharged into streams where the stream beds have cut through the water bearing strata or aquifers and constitutes the source of sustained flow in a stream after storm waters have subsided. Except in very large rivers, dependable water supplies of considerable volume cannot be developed without the artificial storage of flood waters.

At the present stage of our technological development the only economical sources of potable water supply are ground water and stream runoff. Since both of these are dependent solely on precipitation it is imperative that the precipitation and runoff patterns of the State be studied together with the occurrence of ground water as a basis for any statewide water resources planning.

The distribution, density, growth and movement of the State's population will, of course, establish the demand for water in various regional areas and at given periods of time. A population study together with a corollary study of industry is therefore the second essential basis for the development of long range statewide water planning.

A study of water usage habits of the population is also an essential element of the basic data needed in order to establish total water requirements, peak demands and trends in per capita consumption.

In the following sections of this chapter these data are presented insofar as their development has been possible for the preliminary report. Refinement and expansion of these data, particularly with respect to industrial consumption, will be made for the final report but it is not anticipated that any major change in the general character of the preliminary results will occur.

DISTRIBUTION OF NATURAL WATER RESOURCES OF THE STATE

PRECIPITATION

In most years, precipitation in New Jersey is adequate to produce satisfactory agricultural yields and to maintain surface runoff and ground water levels sufficient for present water supply needs. A map (Plate 1) of average annual precipitation in New Jersey was prepared for the 31-year period 1923-53. Where station records were less than this period, statistical adjustments were made so that all averages were theoretically comparable.

The average annual precipitation in the northern half of the State is about 46 inches and in the southern half about 45 inches. There are two distinct centers of high annual precipitation in the State. The northern center, which reaches an annual total of 51 inches, is in Morris County in the headwaters of the Passaic and Raritan River Basins. The southern center is in Burlington County in the central portion of the Pine Barrens area. The annual total in the southern center is 49 inches. In many parts of the country any proposal for utilization of the water resources must give adequate consideration to the characteristic distribution of both precipitation and runoff. However, in New Jersey the distribution of the natural water supply is so relatively uniform that variations in supply are not a major consideration in locating water supply sources. Of more importance are the topographic and geologic factors which determine whether collection of water shall be by surface or sub-surface facilities.

The distribution of annual precipitation by months is, on the average, remarkably uniform. The average precipitation for each month is about 8% of the average annual except at higher elevations along the topographic divide between the Delaware River and the Atlantic Coast watersheds where there is a tendency to greater precipitation in July and August because of an increased frequency of thunderstorms. The summer monthly precipitation reaches about 12% of the annual total at some interior stations.

Although the average annual precipitation is ample in most years, there have been periodic droughts in New Jersey when existing water supply facilities were inadequate and failed to develop the anticipated supply. Statistical studies indicate that the annual precipitation has fallen to only 80-85% of the normal in the years 1885, 1895, 1910, 1918, 1930-31, 1941 and 1949 or at average intervals of about once in 11 years. Such decreases in precipitation have resulted in much greater variations in runoff as indicated below.

RUNOFF

The average annual runoff in inches for all stream gaging stations in New Jersey was also compiled for the 31-year period used for the precipitation reports. Statistical adjustments were made to the average for records less than the complete period. The average runoff for each river basin was plotted in the approximate center of the basin and generalized lines of equal runoff were drawn as shown in Plates 2 and 3.

As might be expected, the centers of high runoff correspond in position to the centers of high precipitation. The greatest runoffs in the State are in Morris and Passaic Counties in the headwaters of the Passaic and Raritan River Basin. Average annual runoff depths in excess of 28 inches have been recorded for small areas. Such runoffs are about 150% of the minimum runoffs of 18-19 inches experienced at low elevations and from sandy soils in the southern part of the State. As in the case of precipitation there is a secondary center of high runoff in the southern half of the State in the Cedar Creek Basin and in the headwaters of the Mullica River Basin. The highest average runoff in the area is 25.5 inches from the Cedar Creek Basin.

In the development of dependable water supplies, the extreme variations from year to year, as well as the usual seasonal fluctuations, are important. In the drought periods of 1931-32 and 1949-50, the total annual runoff in many basins fell to 40-50% of the long-term average. Future storage reservoirs must have adequate capacities to hold reserves which may be drawn upon only once in 10 or 15 years. Failure to make such provisions will inevitably result in human hardships and even in economic dislocations.

The seasonal supply of runoff in natural basins does not exhibit the uniformity shown by the precipitation. As runoff is a residual of precipitation - after deductions for plant use, evaporation and retained ground water - it fluctuates more in comparison to the average than does precipitation. Plate 4 shows the magni-

tude and distribution of the annual average difference between precipitation and runoff in New Jersey. In drought periods precipitation for the minimum month may be only 30 to 50% of that for the maximum month, but runoff for the minimum month may be only 5% or less of that for the maximum month. The development of dependable surface supplies, therefore, requires reservoirs to provide storage for seasonal deficiencies as well as to provide emergency storage in severe droughts that may prevail for a year or more. An exception to the above statement may be made when the supply to be drawn from a river is very small in relation to the normal flow.

The average annual runoff for river systems within the State, but excluding the Delaware and Hudson Rivers, is about 22 inches (see Plate 2) or 1.05 million gallons per day (see Plate 3) per square mile. Applying this rate of runoff to the entire area of the State (7500 square miles of land area) indicates that the potential water supply is 7880 million gallons per day. If part of the water supply in the southern part of the State is withdrawn from wells, the present total runoff in the rivers will be reduced but the total potential supply will be essentially as indicated. Even with only 30 percent development, the resulting supply is almost twice the needs of the State as a whole in the year 2000. Therefore, we can say that the total water resources of the State are adequate to meet the total future needs of the State for an indefinite period. The problem is that there are concentrations of population and industry, such as the Northeastern Metropolitan Region, in which the demand for water exceeds the natural yield of the surrounding areas even though sources more than 20 miles away have been tapped. In such a situation it is necessary to go outside the former limits of supply in order to keep pace with demands resulting from normal economic growth and development. Such a situation was recognized many years ago and has been successfully met in other great metropolitan areas such as New York, Boston and Los Angeles.

GROUND WATER

Ground water in New Jersey is a part of the much larger system of circulating water that nature has bestowed upon the State. Water beneath the land surface is in a temporary environmental phase of the gross water supply that can be seen as vapor clouds in the sky, as rain and snow and as water flowing in rivers. Therefore, it differs physically from the other sources of fresh water only in its position. But it differs greatly from other sources with respect to its measurement, storage, movement in and out of underground reservoirs, and so forth. Knowledge of the occurrence and movement of ground water in any locality must be obtained largely

by indirect methods; by piecing together a geologic concept of the subsurface as indicated by well records, by observing the fair-weather flow characteristics of streams, by recording fluctuations of water levels in wells and compiling records of discharge, and by pumping tests, to mention only a few.

There is a pronounced difference between geologic formations as to the amount of water they contain and the rate at which this water can move through these formations and into wells. Therefore, the geology of New Jersey is one of the most important factors controlling the occurrence of ground water supplies. There are several regional geologic provinces that make up New Jersey. These are the Coastal Plain, the Piedmont Plain, the Highlands and the Appalachian Valley. The surface features that characterize each of these regions were produced chiefly by differences in the type and age of geologic formation and degree of weathering. The differences in rock characteristics typical of these regions have resulted in three major ground water provinces as shown on Plate 5.

The Coastal Plain lies between the Atlantic Ocean and a line through Trenton and New Brunswick. It is underlain by gently dipping layers of sands, gravels and clays of which the coarser sediments are very favorable for the storage and movement of ground water. Large supplies of fresh water can be obtained from the wells almost anywhere within this province except along its borders where salt water occurs. A large percentage of the regional precipitation enters the soil in this province, and a considerable part of it is transmitted through the porous sedimentary formations to the banks and beds of nearby streams. Not only is there a very large amount of water moving through the formations, but the total quantity stored in the sediments of the Coastal Plain is vast, aggregating many billions of gallons.

The Piedmont Plain province is bounded on the east by the Coastal Plain and on the west by the Ramapo and other mountains, including the southeastern portions of Hunterdon, Morris and Passaic counties and all of Union, Essex, Hudson and Bergen counties. This province is underlain by sandstones, shales and trap rock. In the northern portion there is a mantle of unconsolidated glacial deposits. The sandstones and shales generally yield small to moderate supplies to wells. In the Central part of the province, in Eastern Somerset County and in western Union County, moderate to large yields have been obtained. The trap rock is one of the poorest of all rocks for obtaining ground water supplies. The glacial deposits are favorable for ground water development only in areas where these deposits consist

of stratified sands and gravels. Such occurrences are spotty. In general, much of the area of the glacial deposits is composed of clayey drift which is unfavorable for ground water supply.

The Highlands province is a mountainous belt 10 to 25 miles wide that crosses the northern part of the State southeast of the Kittatinny Valley and lies chiefly in northern Hunterdon, Morris and Passaic counties, and the southeastern parts of Warren and Sussex counties. In this area crystalline metamorphic and igneous rocks predominate, while in the Appalachian Valley the rocks are composed of limestone, shale and sandstone or quartzite. None of these rocks are generally favorable for the production of large supplies of ground water. All of this region has been glaciated and it is probable that in isolated localities stratified sands and gravels of glacial age are capable of yielding moderate to large supplies. Conditions relating to the occurrence of ground water in this province are less favorable for the development of water supplies than in the other geologic provinces.

The Appalachian Valley Province, in New Jersey, lies between the Highland Province and the northwestern border of the State and includes the northwestern parts of Warren and Sussex counties. From the standpoint of ground water, this province is similar in characteristics to the Highland Province and therefore is not discussed separately.

POTENTIAL GROUND WATER RESOURCES

The Atlantic Coastal Plain may be divided into three subdivisions with respect to ground water resources. These are the Coastal Area, the Interior Plain, and the lower Delaware River Valley (see Plate 5). The quantity of water that may be withdrawn from sand and gravel aquifers along the Atlantic Coast is very large. However, the nearness of salty or brackish water in the ocean, the inland bays and tidal rivers that border this subdivision, very greatly restricts the amount of fresh water than can be withdrawn at any given locality without the threat of producing contamination from bodies of salty water. There is still available a potential of unknown quantity in most sections of the Coastal Area, but if salt-water contamination is to be avoided, the withdrawal of additional large supplies of ground water should not be concentrated in small areas. By dispersing the centers of pumping, drawdown of water levels over large areas can be minimized and excessive contamination from salt water sources can generally be avoided.

The Interior Plain is underlain by water-bearing sands and gravels, which form vast ground water reservoirs containing water of relatively good quality. It

is not improbable that if ground water developments are ultimately planned so as to utilize the major portion of the water that annually recharges these reservoirs, more than 2000 million gallons per day of ground water can be considered as a potential for the future.

The lower Delaware River Valley contains highly permeable sands and gravels at shallow depths bordering the river. Most of the present ground water withdrawn within this subdivision is obtained from water-bearing beds that are hydraulically connected to the river and receive a part of their water by infiltration from the river. It is quite probable that many additional occurrences of permeable sand and gravel that are connected with the river can be found and developed in that segment of the Valley between Trenton and the lower Delaware Bay. The quantity of water potentially available may be as much as 300 million gallons per day, or about twice that now being obtained. However, because the Delaware River is the chief source of well fields near the river, the character of the water in the surface stream is of great importance. From about Camden, south toward the mouth, salt water is likely to enter wells drilled in aquifers near the stream. Throughout all of the lower Delaware Valley, industrial wastes in the surface water control in part the quality of ground water.

The Piedmont Plain does not have a favorable potential for large future ground water developments throughout most of its extent but river infiltration in areas containing stratified sand and gravel deposits of glacial age will permit local developments, possibly of considerable magnitude. Because of the advanced state of municipal and industrial development throughout much of the Piedmont Plain, these localized occurrences of gravels suitable for inducing surface water infiltration, are of greater importance to the region and constitute an asset of unknown magnitude that has received inadequate study up to the present time.

The ground water potential of the Highlands and Appalachian Valley provinces is comparably small. Localized occurrences of stratified sand and gravel offer the only promise of obtaining moderate to large yield.

POPULATION STUDY

The future requirements for water in New Jersey will be determined largely by the expected growth in the State's population. Increases in the number of New Jersey residents will be reflected both in the household use of water and in industrial and commercial water consumption. For the purpose of estimating future water demand, therefore, preliminary forecasts have been prepared for each of the

twenty-one counties of the State. These county forecasts are tabulated for ten-year intervals to the year 2000 in Table 1. A brief discussion of each county's growth outlook is presented in a later part of this section.

Table 1
NEW JERSEY POPULATION
PRELIMINARY PROJECTIONS
1950 - 2000

(Thousands of Persons)

<u>Regions and Counties</u>	<u>1950</u>	<u>1960</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>
New Jersey Total:	4,835	5,700	6,509	7,085	7,561	8,000
Northeastern Metropolitan Region:	<u>3,092</u>	<u>3,562</u>	<u>3,980</u>	<u>4,260</u>	<u>4,495</u>	<u>4,704</u>
Bergen	539	716	880	980	1,060	1,128
Essex	906	1,000	1,060	1,100	1,120	1,136
Hudson	647	647	640	630	625	608
Middlesex	265	351	440	500	550	616
Passaic	337	377	420	460	500	536
Union	398	471	540	590	640	680
Southwestern Metropolitan Region:	<u>808</u>	<u>1,000</u>	<u>1,200</u>	<u>1,345</u>	<u>1,460</u>	<u>1,576</u>
Burlington	136	192	240	280	310	344
Camden	301	343	400	440	470	504
Gloucester	92	126	160	185	210	232
Mercer	230	274	320	350	370	392
Salem	50	65	80	90	100	104
Coastal Region:	<u>540</u>	<u>631</u>	<u>730</u>	<u>810</u>	<u>880</u>	<u>936</u>
Atlantic	132	144	155	160	165	168
Cape May	37	43	55	65	70	72
Cumberland	89	106	120	135	145	152
Monmouth	225	268	310	340	370	392
Ocean	57	70	90	110	130	152
Northwestern Region:	<u>395</u>	<u>507</u>	<u>599</u>	<u>670</u>	<u>726</u>	<u>784</u>
Hunterdon	43	49	51	53	55	56
Morris	164	219	270	310	340	368
Somerset	99	137	170	195	215	240
Sussex	34	39	42	44	46	48
Warren	54	63	66	68	70	72

STATE SUMMARY

New Jersey is located astride the heaviest concentration of population and transportation in the country, which extends from Boston to Washington, D. C. In this strategic position it enjoys a thriving and steadily expanding economy.

The population of New Jersey was estimated to be 5,250,000 in July 1954. This represented a 180% increase over the 1.9 million people at the turn of the century; the population of the United States as a whole increased only 115% during the same period. In fact, New Jersey's share of the country's population grew from 2.5% in 1900 to 3.3% in 1930, but has since declined to 3.2%. It is unlikely that

New Jersey can hold on to this share of the population in the future as the western states continue their growth.

The population of New Jersey is composed primarily of the following occupational groups:

1. Employees of the large number of manufacturing industries in the State.
2. Employees in retail, wholesale, and service trades serving the State's residents.
3. Retired persons.
4. Commuters who live in the State but work outside its borders.

A high proportion of New Jersey's population lives in urban areas, 86.6% in 1950 according to the United States Census, as compared to 64.0% for the country as a whole. A large share of the labor force is locally employed in manufacturing work, but out-of-state commuters populate vast urbanized sections served by an extensive network of interstate transportation facilities. Agriculture, transportation and tourism also contribute to the basic economy of the State.

The birth rate in New Jersey has remained consistently below the national average. Both State and National rates fell from the World War I high to a low in the mid-1930 depression period; since that time birth rates have generally increased to their present high levels. For the purpose of this study it is reasonable to accept the United States Census forecast to 1975 which assumes a constant birth rate to 1965 followed by a gradual decline. During 1975 to 2000 the Social Security Administration's estimates based upon the mean of the 1940 and 1948 birth rates appear to be most suitable. From these United States estimates and New Jersey's past relationship, birth rates were forecast for the State as shown in Table 2.

Table 2

BIRTH AND DEATH RATES, 1900-2000

(per 1,000 Population)

<u>Recorded:</u>	<u>Birth Rates</u>		<u>Death Rates</u>	
	<u>New Jersey</u>	<u>United States</u>	<u>New Jersey</u>	<u>United States</u>
1900	17.6	*	16.1	17.2
1910	21.3	*	15.6	14.7
1920	24.2	27.7	12.8	13.0
1930	16.9	21.3	10.7	11.3
1940	14.3	19.4	10.9	10.8
1950	20.2	24.1	10.1	9.6
<u>Estimated:</u>				
1960	19.0	22.0	10.0	9.5
1970	17.5	20.5	10.2	9.7
1980	16.0	19.0	10.1	9.6
1990	15.5	18.0	9.9	9.4
2000	15.5	18.0	9.7	9.2

*Not Available.

United States death rates were derived from the same sources and were then adapted to New Jersey's population in a similar manner.

Migration into the State of New Jersey has been growing during the past quarter century. An estimated total of approximately 310,000 net migrants moved into New Jersey during the decade 1940-50 to take advantage of the attractive residential areas and the abundant opportunities for industrial employment (see Table 3). The United States Census Department expects migration into New Jersey to continue at least until 1965 at an annual rate between 26,000 and 40,000 persons.

Table 3

COUNTY POPULATION INCREASES

NET MIGRATION COMPARED WITH TOTAL INCREASES

1940-1950

	<u>Total Increase</u>	<u>Net Migration</u> (Estimated Gain)
Atlantic	8,333	5,000
Bergen	129,493	86,000
Burlington	38,897	30,000
Camden	45,016	22,000
Cape May	8,212	8,000
Cumberland	15,413	9,000
Essex	68,609	1,000
Gloucester	19,508	12,000
Hudson	4,603 (Decrease)	54,000 (Loss)
Hunterdon	5,970	4,000
Mercer	32,463	16,000
Middlesex	47,795	23,000
Monmouth	64,089	51,000
Morris	38,639	26,000
Ocean	18,916	16,000
Passaic	27,740	3,000
Salem	7,234	2,000
Somerset	24,662	15,000
Sussex	4,791	2,000
Union	69,794	32,000
Warren	<u>4,193</u>	<u>1,000</u>
Total	675,164	310,000

Recent forecasts of United States population in the year 2000 have ranged from 210 million (the lowest projection by the Social Security Administration) to 273 million (by the Stanford Research Institute). Estimates which were prepared prior to the 1950 census may be disregarded because they lacked sufficient current data. The most reasonable projection for consideration in this study appears to be that of the Social Security Administration which predicts a population of 254 million in the year 2000, based upon assumed relatively high fertility, low mortality and 100,000 annual immigration.

Forecasts of population have been made for various New Jersey counties by several agencies, but for the State as a whole only the following two have been

published since the 1950 census:

Source	Forecast	
	Date	Population
N. J. Department of Conservation and Economic Development (May 1952)	1960	5,857,000
U. S. Census Bureau (Feb. 1955)	1960	5,653,000-5,797,000
	1965	5,954,000-6,247,000

The sum of the forecasts for each county which are described below indicates a total New Jersey population of 8 million in the year 2000, or approximately 3.1% of the predicted United States total for that year. Table 1 lists the estimates for the intervening decades.

REGIONAL CHARACTERISTICS

The State of New Jersey may be divided conveniently into four regions: Northeastern, Southwestern, Coastal and Northwestern. Each region is generally homogenous, but has one or more characteristics which distinguish it from the others.

The Northeastern Metropolitan Region has been defined as including Bergen, Essex, Hudson, Middlesex, Passaic and Union Counties. It contains the most highly industrialized section of the State and the most densely populated area (see Table 4).

Table 4

POPULATION DENSITY

1950

<u>County</u>	<u>Area (Sq. Miles)</u>	<u>Density (Population per Sq. Mile)</u>
Atlantic	565.55	234.1
Bergen	235.08	2,239.4
Burlington	819.30	165.9
Camden	222.16	1,353.7
Cape May	265.34	139.9
Cumberland	502.40	176.3
Essex	127.44	7,108.8
Gloucester	328.60	279.1
Hudson	44.10	14,681.1
Hunterdon	437.00	97.8
Mercer	226.00	1,016.7
Middlesex	308.79	857.7
Monmouth	477.01	472.4
Morris	477.70	344.1
Ocean	641.00	88.3
Passaic	192.20	1,753.9
Salem	343.02	144.3
Somerset	305.10	324.7
Sussex	526.30	65.4
Union	103.39	3,850.8
Warren	362.00	150.2

Source: New Jersey Department of Conservation and Economic Development.

The earliest and most intensely industrialized areas are centered in Hudson, Essex, Passaic and Union Counties, with newer industries located in the peripheral counties

(see Table 5). The entire Region, except for Middlesex, is heavily urban, providing most of the residences for the hundreds of thousands of commuters who travel daily to the industrialized counties of New Jersey and to New York City. As the trend toward decentralization of the New York Metropolitan Area continues, the fringe counties should experience substantial growth of population and industry.

The Southwestern Metropolitan Region, which includes Burlington, Camden, Gloucester, Mercer and Salem Counties, is an urban and industrial area along the Lower Delaware River. It is linked economically to the heavily developed region across the river including Wilmington, Chester, Philadelphia and Morrisville. Although not as thickly settled as the Northeastern Region, this portion of New Jersey is expected to experience the highest rate of growth of the four New Jersey regions, in terms of both population and industry. This Region, near the richest eastern markets, is particularly attractive to industry because of much suitable land which is served by rail, water and highway transportation. At present, Camden and Mercer Counties are the most heavily industrialized counties of this Region.

Monmouth, Ocean, Atlantic, Cape May, and Cumberland Counties comprise the Coastal Region which derives much of its support from resorts and recreation areas. It is a popular retreat for retired people, a center for business conventions, and a summer vacation area. The recent completion of the Garden State Parkway makes the Region more accessible and attractive than heretofore. No substantial influx of industry is anticipated.

The rural Northwestern Region is composed of Hunterdon, Morris, Somerset, Sussex, and Warren Counties. It is generally mountainous and sparsely settled except in the easternmost sections, and derives much of its support from farming. The numerous lakes, mountains, and State Parks make this an attractive recreational Region. Morris and Somerset Counties presently contain a few industries and residents who commute to other areas.

COUNTY POPULATION

The preliminary county projections shown in Table 1 were formulated after analysis had been made of the various components involved. Trends in U. S., State and county population, birth rates and death rates were tabulated and plotted from 1900 to 1950 by decades. Net migration was computed for each county between 1940 and 1950. A summary of population densities was made. Manufacturing employment trends by county were tabulated and plotted, and commuter traffic to the cities of New York and Philadelphia were reviewed. The number of people from out-of-state

TABLE 5

COVERED JOBS* - December 1953

County	All Industries	Manu- facturing	Trade	Transpor- tation	Communica- tions and Utilities	Small Services Hotels and Amusements	Finance Insurance Real Estate	Construc- tion	Mining Agri- culture and Others
Atlantic	28,183	5,968	8,907	843	1,976	6,628	1,371	2,434	56
Bergen	137,530	85,164	24,132	5,668	3,536	6,609	2,376	9,694	351
Burlington	23,816	13,296	4,224	543	1,179	1,019	399	2,992	164
Camden	83,146	49,288	15,732	1,874	3,047	5,968	2,678	4,364	195
Cape May	5,127	1,571	1,554	253	449	355	169	727	49
Cumberland	28,564	17,749	4,851	1,118	685	1,164	321	1,010	1,666
Essex	318,383	152,638	74,096	14,012	14,281	24,506	28,004	10,618	228
Gloucester	16,653	9,840	3,169	572	666	613	337	1,348	108
Hudson	224,161	143,810	33,971	22,008	4,173	9,814	4,463	5,869	53
Hunterdon	6,430	3,417	1,559	167	402	322	101	352	110
Mercer	72,418	41,232	15,779	2,183	2,142	5,344	2,241	3,295	202
Middlesex	98,220	68,365	15,234	3,397	2,460	2,512	1,199	4,626	427
Monmouth	39,158	14,915	11,280	971	2,883	3,791	1,054	4,063	201
Morris	35,941	17,914	7,631	807	1,910	3,146	570	2,591	1,372
Ocean	7,416	1,163	2,816	174	638	1,415	182	897	131
Passaic	120,866	76,708	22,560	4,072	3,468	5,985	2,991	4,609	473
Salem	13,454	10,549	1,552	234	485	184	63	387	-
Somerset	23,887	15,807	4,147	523	452	841	196	1,422	499
Sussex	5,939	2,089	1,328	75	220	269	499	388	1,071
Union	135,191	81,932	24,019	3,283	4,425	11,727	3,189	6,343	273
Warren	14,539	10,963	1,987	148	386	441	99	359	156
Undistributed	25,963	106	9,113	448	1,178	971	849	12,855	443
State Total	1,464,985	824,484	289,641	63,373	51,041	93,624	53,351	81,243	8,228

*Jobs which are covered by the New Jersey Unemployment Compensation Law.

Source: New Jersey Department of Labor and Industry, Division of Employment Security.

who are attracted to the resort areas were considered, as well as intra-state migration and decentralization. Various existing forecasts of population and birth and death rates for the United States, New Jersey and each county also were evaluated. The characteristics of each county are discussed below.

Northeastern Metropolitan Region

Bergen County has exhibited spectacular increases since 1940 in both population and industry, and holds promise of continued rapid growth for many years to come. Because many new homes are being established in the county by young families, the birth rate is higher than the State average and the death rate is correspondingly low. The resulting natural increases, combined with the extensive migration which has been taking place, assure a rapid population expansion until much of the available land is utilized.

Essex has the greatest population (905,949 in 1950) of any of the counties in the State. Many commuters live in all parts of the county, but almost half of the population is contained within the City of Newark, accounting for the County's high population density. There is only limited space still available for new industry and population, so that the rate of growth of the county is expected soon to decline.

Hudson County is the most densely populated of all New Jersey Counties and actually experienced a slight decline in population between 1940 and 1950. It is heavily industrialized, but may be expected to receive still more industry as the remaining marshland areas are utilized and low grade residential areas are converted. Its relatively low natural population increase will be offset by out-migration.

Middlesex County can be expected to profit from its advantageous location with respect to transportation, resulting in a substantial growth in manufacturing. The need for many new workers, and the abundant areas available for residential development should cause the already large volume of migration into the county to increase. With birth rates above, and death rates below, the State averages, natural increases in Middlesex will contribute substantially to the population growth.

Passaic County is geographically divided into two dissimilar sections: the northwest is rural with many mountains and lakes, and the southeast is congested with well-established manufacturing industries and dense population. There is promise of but little growth in the largely unsettled northwest section due to its inaccessibility, but new industries in the central portion should attract some migrants.

Union County experienced a tremendous influx of new industry in recent

years as Hudson and Essex Counties became increasingly congested. Its large available industrial sites and desirable residential areas, which are interlaced with many railroads and highways, and the adjacent waterways, make Union very attractive to manufacturers who wish to locate in the enormous New York market area. Population has increased steadily, but as industry moves in, residential development will be pushed further into the suburbs. Even now average population density for the county is high.

Southwestern Metropolitan Region

Burlington County is expected to acquire new industry along the Delaware River at a rapid pace. With the excellent water, rail and highway transportation which is available, and with the many suitable industry locations, the attractions are unusually strong; indeed, reports of manufacturers' present plans in the area are most impressive. Two-thirds of Burlington, however, is occupied by the extensive pine forests which are mostly uninhabited and undesirable for industrial sites. Only in the past decade did the County's population begin its fast rate of growth which promises to continue with the enlarging requirements for industrial workers.

Camden is the most populated of the Southwestern counties, being directly adjacent to Philadelphia. Besides its many residents who commute across the river, however, Camden has much industry of its own. Some in-migration of residents is expected, more to fill jobs in local industry than to commute to Philadelphia. A new vehicular bridge across the Delaware is now under construction in the vicinity of Gloucester City which will stimulate added growth in Camden County.

Gloucester County, which has the least manufacturing in the Region, is best characterized as agricultural, with over half of its area under cultivation. There is a fringe of industry along the Delaware River, and the possibility of a new steel mill has stirred much speculation about the further displacement of farmland. It is likely that this industrial growth will take place slowly, with increases in population also caused by new commuters to Camden and Philadelphia.

Mercer County is dominated by the State Capital at Trenton and the surrounding long-established manufacturing industries. It is now densely-populated and industrialized, although its growth has not been rapid. The stimulation of Mercer which will come from the extensive development of Bucks County across the river should enliven its growth in the near future. Industry will also be encouraged if the Delaware Channel is deepened as far north as Trenton.

Salem County is the least populated of the Southwestern counties. It

lies at the southern end of New Jersey Turnpike and is linked with Wilmington by the Deepwater Bridge. The DuPont Company and glass manufacturing represent the large majority of Salem's industry, although more industry and migration will surely come as Camden and Gloucester Counties become overburdened.

Coastal Region

Atlantic has long been a resort county in which most of its activity centers on famous Atlantic City. A low percentage of its population is employed in manufacturing. Because of its dependency on resort activity, Atlantic's population actually declined during the 1930-40 decade, but business conventions and other off-season activities are now being promoted to improve economic stability. As with other coastal counties, the Garden State Parkway increases the accessibility of this resort area. The county is attractive to retired people, which accounts for the very low rate of natural increase. Little manufacturing is expected ever to come to Atlantic County.

Cape May County, at the southernmost tip of the State, is a peaceful ocean resort of long standing which still has much undeveloped waterfront. Its population is next to the smallest in the State and is rising only slowly. Lying at the southern end of the Garden State Parkway, Cape May should experience gradual gains as a place for vacation and retirement.

Cumberland, on Delaware Bay, is predominantly a farming county, supplemented by oystering and some well-established industries. Population increases have been slow but may be stimulated eventually as manufacturing reaches out. Much of lower Cumberland is tidewater land.

Monmouth County is an unusual mixture of resorts, farming, industry and commuters. Agriculture provides the leading sources of income, but the seashore, assisted by improved highway access from the North has attracted a rapidly growing number of persons. It is doubtful that much new industry will come to Monmouth, but the expected spread of new plants in Middlesex eventually will make northern Monmouth a convenient and desirable residential area for commuters. The large immigration which the county experienced between 1940 and 1950 is not likely to be repeated in the immediate future.

Ocean, another resort and agricultural county, has the longest shore front. Practically no industry exists here; a few new plants are being constructed. Large undeveloped areas are expected to attract many residents. Population already shows signs of rapid growth.

Northwestern Region

Hunterdon County consists of nearly 70% farmland, mostly dairy and poultry farms. Many of its new residents are gentlemen farmers who commute to business or have retired. Its relatively old population results in a low rate of natural increase. A gradual rise in population of this rural county is foreseen.

Morris County is located on the outer fringe of the New York Metropolitan Area where it will undoubtedly absorb much new industrial and population growth. Sufficient suitable land is available for light manufacturing in the eastern portion, while both that area and the hilly country to the west are attractive for residences. Proposed east-west and north-south expressways crossing the county should provide a strong stimulant for future development. The past steady rate of population increase is thus expected to persist.

Somerset County has experienced rapid growth in manufacturing activity, even when others were suffering set-backs during the depression. Although still predominantly agricultural and residential today, this county will certainly follow in the footsteps of neighboring Middlesex as a place for much new industry. It is well situated with respect to rail and highway transportation and offers plentiful sites. Its growing population will provide manpower for industry, both local and in the entire expanding area.

Sussex, a dairy county, has the smallest population in New Jersey. It offers many recreational attractions with its lakes and forests. A zinc mine constitutes the only industry. There is little prospect for rapid growth of the county in the near future.

Warren County is largely farmland and forests, with some industry centered in Phillipsburg. Vacationers may find many attractions here. Its population has risen slowly and evenly and shows little promise of changing pace as local industry gradually spreads. Some impetus to population growth may result from increases in industry in the Allentown-Bethlehem-Easton area across the Delaware River.

AREAS OF DEMAND

Using the four regional divisions of the State described in the Population Study, the statistical projections of population growth were extended by estimated water consumption to obtain the anticipated demand for each of the regions at various time intervals until the year 2000. The results are shown in Table 6 and Plate 6.

The greatest demand for water supply in New Jersey is in the Northeastern Metropolitan Region, particularly in the strip of land about 40 miles long in a north-

south direction and extending about 13 miles west from the Hudson River and New York Bay. This region includes also that portion of the State in which the water demand most closely approaches the dependable yield of the developed supplies.

The current water consumption in each region as compared with the consumption for the entire state, on the basis of records of system potable water deliveries in 1953, is as follows:

<u>Region</u>	<u>Estimated Consumption Million Gallons Per Day</u>	<u>Approx. Percent of State Total</u>
Northeastern Metropolitan	420	71
Southwestern Metropolitan	87	15
Coastal	47	8
Northwestern	<u>39</u>	<u>6</u>
Total for State	593	100

Estimates of future water requirements in each region have been prepared on the basis of preliminary analysis of future per capita water consumption (including industrial use) and on the foregoing predictions of population growth. After considering the individual characteristics of the communities represented, an appreciable increase in the rate of water use has been assumed for each region, which reflects the probable replacement of individual supplies by connections to private or public systems as the density of population increases, as well as the trend toward greater per capita domestic use and increased industrial useage. The following tabulation summarizes the approximate use rates in 1953, and the estimated use rates in the year 2000, by regions:

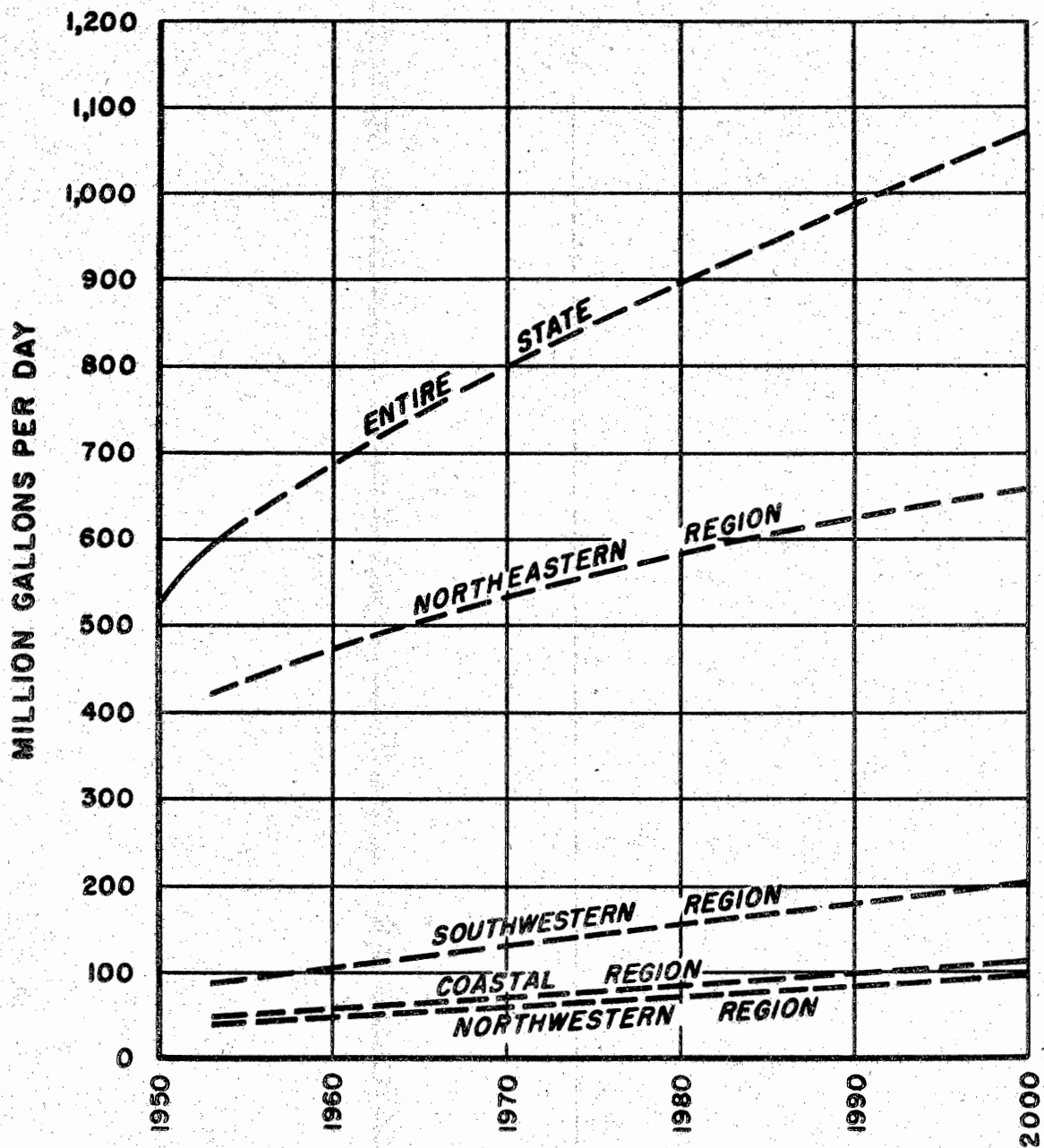
<u>Region</u>	<u>Rate of Use Gallons Per Day Per Capita</u>	
	<u>1953</u>	<u>2000</u>
Northeastern Metropolitan	130	140
Southwestern Metropolitan	100	130
Coastal	83	120
Northwestern	92	120

The estimated future private and public water system requirements, by regions, resulting from the several assumptions, are listed below:

Table 6

<u>Region</u>	<u>Estimated Average Requirement Million Gallons Per Day</u>					
	<u>1953</u>	<u>1960</u>	<u>1970</u>	<u>1980</u>	<u>1990</u>	<u>2000</u>
Northeastern	420	471	526	583	621	659
Southwestern	87	105	130	157	180	205
Coastal	47	56	69	84	98	112
Northwestern	<u>39</u>	<u>49</u>	<u>60</u>	<u>72</u>	<u>83</u>	<u>94</u>
Total for State	593	681	785	896	982	1070

**PRELIMINARY SURVEY OF
NEW JERSEY WATER RESOURCES DEVELOPMENT
ESTIMATED CONSUMPTION OF PUBLIC POTABLE WATER**



**TIPPETTS - ABBETT - MCCARTHY - STRATTON
ENGINEERS**

NEW YORK

PLATE

6

USE OF WATER FOR SUPPLEMENTAL IRRIGATION

Recent development of equipment for sprinkler irrigation and comparatively high prices for agricultural products have resulted in an appreciable increase in the use of water for irrigation in the Eastern United States. Crop failures or reduced yields due to lack of rainfall at critical periods during the growing season may be economically eliminated by the utilization of portable sprinkler type irrigation equipment. Portable sprinkler equipment can be removed from storage and placed in service on any land suitable for farming in a matter of hours by a crew of two men. Previously, supplemental irrigation was not practicable in normally humid regions because most of the land was not suited topographically for conventional row or flooding irrigation from ditches and the drought periods were too infrequent to justify extensive land leveling and the maintenance of ditches and specialized irrigation equipment. It has been demonstrated that supplemental irrigation, which can provide the water needed to maintain optimum growth of crops, not only removes much of the risk from farming by eliminating crop failure due to water shortage, but can actually increase crop yields in average years by providing water to the crops at the critical time.

In the decade ending in 1954, the acreage under sprinkler irrigation in New Jersey has grown from practically zero to in excess of 50,000 acres. Garden vegetables, potatoes and sweet corn are the principal crops irrigated by sprinkler systems. In addition, about 3,000 acres of cranberries are flooded during each winter to prevent frost damage. This latter use is of small consequence, since the water is taken from local swamp areas at a time when water is usually plentiful.

In a year of average precipitation about 7,500 million gallons of water would be required to supplement natural rainfall to maintain optimum plant growth on an area of 50,000 acres. Actual deliveries of water probably failed to provide a full supply on much of the area served; hence, the average use now is estimated at about 5,000 million gallons. The relative importance of such an amount of water may be gained by considering that it would be adequate for the needs of an average city of 100,000 people.

It may be anticipated that an appreciable increase in water use for supplemental irrigation will occur in the future. Such increases will depend upon the sale price of farm produce in relation to the cost of purchasing and operating sprinkler irrigation equipment.

About 40 percent of the water now used for sprinkler irrigation comes

from wells or springs. Considering that adequate surface water flows are not available on or adjacent to most farms, and that ground water can be obtained from wells in the majority of farming areas of the state, it is probable that an increasing portion of irrigation supplies will be drawn from wells. Furthermore, experience with shallow wells for irrigation supplies has been unsatisfactory in some areas and the tendency will be for deep well sources to be utilized for the principal farm supplies. Of the water supplies used for irrigation, a large percentage will continue to be drawn from sources not utilized for system water supplies. Consequently, it is anticipated that at least for a considerable time irrigation water use will not be in competition with potable water systems.

CHAPTER II

PRESENT SOURCES OF SUPPLY

MAJOR SOURCES OF SUPPLY BY REGIONS

As an initial step in an appraisal of the future water supply needs of New Jersey, it was necessary to make a survey of the existing water supply systems and to consider the possibility of expanding these systems. The question of expansion is covered in a later section of this chapter. The major sources of existing supplies are discussed below in the regional groupings previously used.

NORTHEASTERN METROPOLITAN REGION

The major water supplies for the Northeastern Metropolitan Region are obtained from the surface waters of the Hackensack and Passaic River Basins. Greatest reliance is placed in stored water on the upstream tributaries of the Passaic Basin, namely the Wanaque, Pequannock and Rockaway Rivers. A portion of the Ramapo River, another Passaic tributary is diverted to storage in Wanaque Reservoir and diversion without storage is made directly from the Passaic River at Little Falls. The Hackensack Basin above Oradell is the principal source of supply of the Hackensack Water Company and works providing for greater utilization of the river are in progress. Despite this concentration of water development in the Hackensack and Passaic Basins, additional expansion of these supplies is still practicable.

The only other river of considerable size that drains the Northeastern Metropolitan Area is the Raritan. This stream is the largest intrastate river in New Jersey and represents the greatest undeveloped water resource available within the Northern part of the State. Diversions without storage are made for both potable and industrial supplies in the vicinity of Bound Brook, but the potentialities of the Raritan River are largely unexploited.

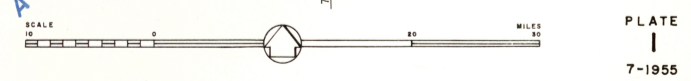
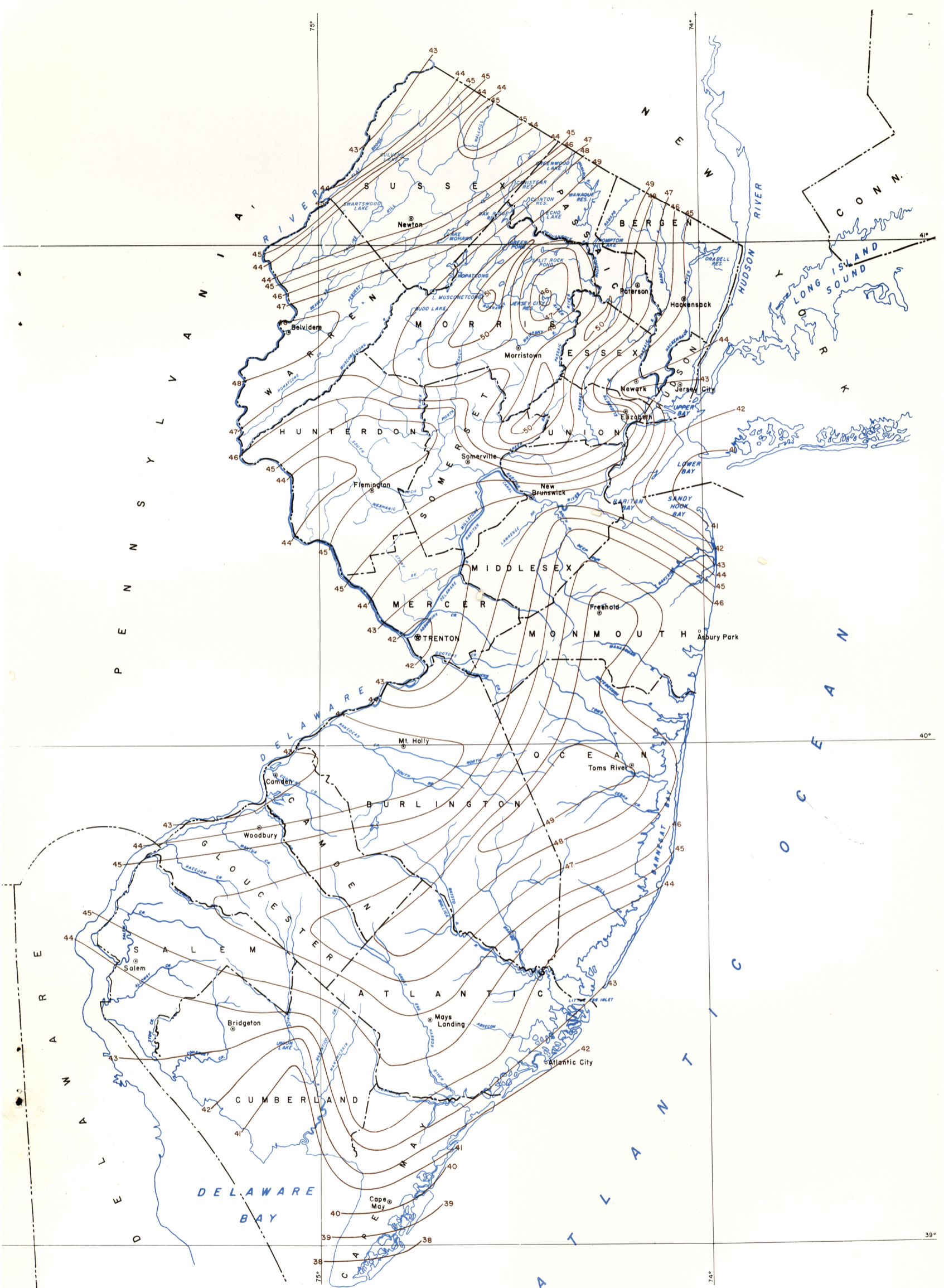
Ground water is an important source of supply for many smaller communities and the amount obtained from this source is about 20 percent of the total demand of the region of 420 million gallons per day. The Delaware and Raritan Canal has contracts to supply 48 million gallons per day but 26 million gallons per day go directly to industries and are in a large part returned to the Raritan. The principal water supply systems in the Northeastern Metropolitan Region are listed in Table 7.

TABLE 7

EXISTING WATER SUPPLIES IN NORTHERN NEW JERSEY

<u>System Operator</u>	<u>Source of Water</u>		<u>Drainage Area of Sub-Basin (Square Miles)</u>	<u>Dependable Yield In Million Gallons Per Day</u>	<u>Water Delivered In 1953</u>	<u>Population Served</u>
	<u>Main River Basin</u>	<u>Sub-Basin</u>				
North Jersey Water Supply Commission <u>1/</u>	Passaic	Wanaque	94.4	106	93.2	750,000
City of Jersey City <u>2/</u>	Passaic	Rockaway	121.5	68	61.0	415,000
City of Newark <u>3/</u>	Passaic	Pequannock	63.7	46	56.6	439,000
Hackensack Water Co.	Hackensack	Hackensack	116	50 <u>4/</u>	49.5	500,000
Passaic Valley Water Commission <u>5/</u>	Passaic	Passaic	762 <u>6/</u>	35	37.6	360,000
Elizabethtown Water Co.	Raritan	(Raritan Millstone)	770	52 <u>7/</u>	23.7	100,000
Minor Systems				99 <u>8/</u>	98.4	786,000
TOTAL				456	420.0	3,350,000

- 1/ System serves Newark, Elizabeth, Bayonne, Passaic, Paterson, Kearney, Montclair, Clifton, Bloomfield, and Glen Ridge.
- 2/ System also serves Hoboken, Township of Lyndhurst, Borough of Arlington and other communities.
- 3/ System also serves Bloomfield, Belleville and other smaller municipalities.
- 4/ Includes 5 Million Gallons per Day from ground water supplies.
- 5/ Supplies Paterson, Passaic, Clifton, Harrison, Nutley and other communities.
- 6/ Includes 280 Sq. Mi. already developed for water supply.
- 7/ Includes 22.5 Million Gallons per Day from Delaware and Raritan Canal and 10 Million Gallons per Day from Groundwater.
- 8/ Includes 7.5 Million Gallons per Day from Delaware and Raritan Canal to New Brunswick.



STATE OF NEW JERSEY | NEW JERSEY WATER RESOURCES DEVELOPMENT
 LEGISLATIVE COMMISSION ON WATER SUPPLY
 TIPPETTS - ABBETT - MCCARTHY - STRATTON
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AVERAGE ANNUAL PRECIPITATION
 (INCHES)

Even with a high degree of development of the water resources of northeastern New Jersey, the total usable supplies will be unable to meet the demand in less than 50 years. The total surface drainage area of rivers flowing into New York Bay from New Jersey is only 1880 square miles. The average annual runoff, in water supply units is 1.1 million gallons per square mile (see Plate 3) or 2100 million gallons per day for the total contributing area. As a considerable part of the average runoff may occur as flood flows which cannot be stored even in the most extensive reservoir systems, a large portion of the runoff can not be recovered for potable use. With this limited drainage area and because of existing developments in possible reservoir areas together with river channel developments and pollution, it is not feasible to develop through storage a sufficient part of the total average runoff to meet the estimated demand in the year 2000. Therefore, the Northeastern Metropolitan Region must eventually seek water supplies beyond its natural topographic boundaries.

SOUTHWESTERN METROPOLITAN REGION

In this report the Southwestern Metropolitan Region includes the urban centers of Camden and Trenton. With the exception of Trenton, which uses Delaware River water directly, water supplies are in the main withdrawn from wells. Many of the wells are located close to the river and receive direct infiltration from the river channel. There is no question of shortages at the present time, but there are problems of quality resulting from salt water intrusion and industrial pollution.

COASTAL REGION

The communities along the Atlantic Coast obtain their water largely from well systems. The supplies are adequate if the wells are not located too close to the coast and are not overpumped. Overpumping has resulted in contamination by saline waters. A great potential ground water supply exists in interior areas to the west, such as the Wharton Tract, and there appears to be little danger of shortages for the region as a whole.

NORTHWESTERN REGION

The Northwestern Region has a small average population density and limited industrial development. Existing surface waters, supplemented by use of very limited ground water supplies adequately meet present water supply needs and no shortages are anticipated under the foreseeable rate of growth.

REVIEW OF MAJOR SYSTEMS SUPPLYING THE NORTHEASTERN METROPOLITAN REGION

Analysis of the available and developed water supplies for the entire State reveals that for the present, at least, only the Northeastern Metropolitan Region faces a critical situation with consumption approaching the dependable yield of existing supply systems. A more detailed study was, therefore, undertaken of the major supplies for this Region with the view of determining the possibility and feasibility of increasing their yields. The following is a brief description of the systems studied:

WANAQUE SYSTEM

This system, completed in March 1930, is operated by the North Jersey District Water Supply Commission. Storage is provided at Wanaque Reservoir on Wanaque River (Passaic River Basin) near the northern boundary of New Jersey. The reservoir is formed by Raymond Dam and seven dikes, and drains an area of 94.4 square miles. The available storage capacity is 28 billion gallons, but it can be increased to 29.5 billion gallons by flashboards. The Ramapo diversion project, which was placed in service in December 1953, provides facilities for diverting water by pumping to Wanaque Reservoir from the Ramapo River at Pompton Lake (drainage area, 160 square miles). This addition increases the dependable yield of the system from about 82.5 million gallons per day to 106 million gallons per day.

The supply from the Wanaque system, including the Ramapo Diversion supply, is allocated to the participating communities as follows:

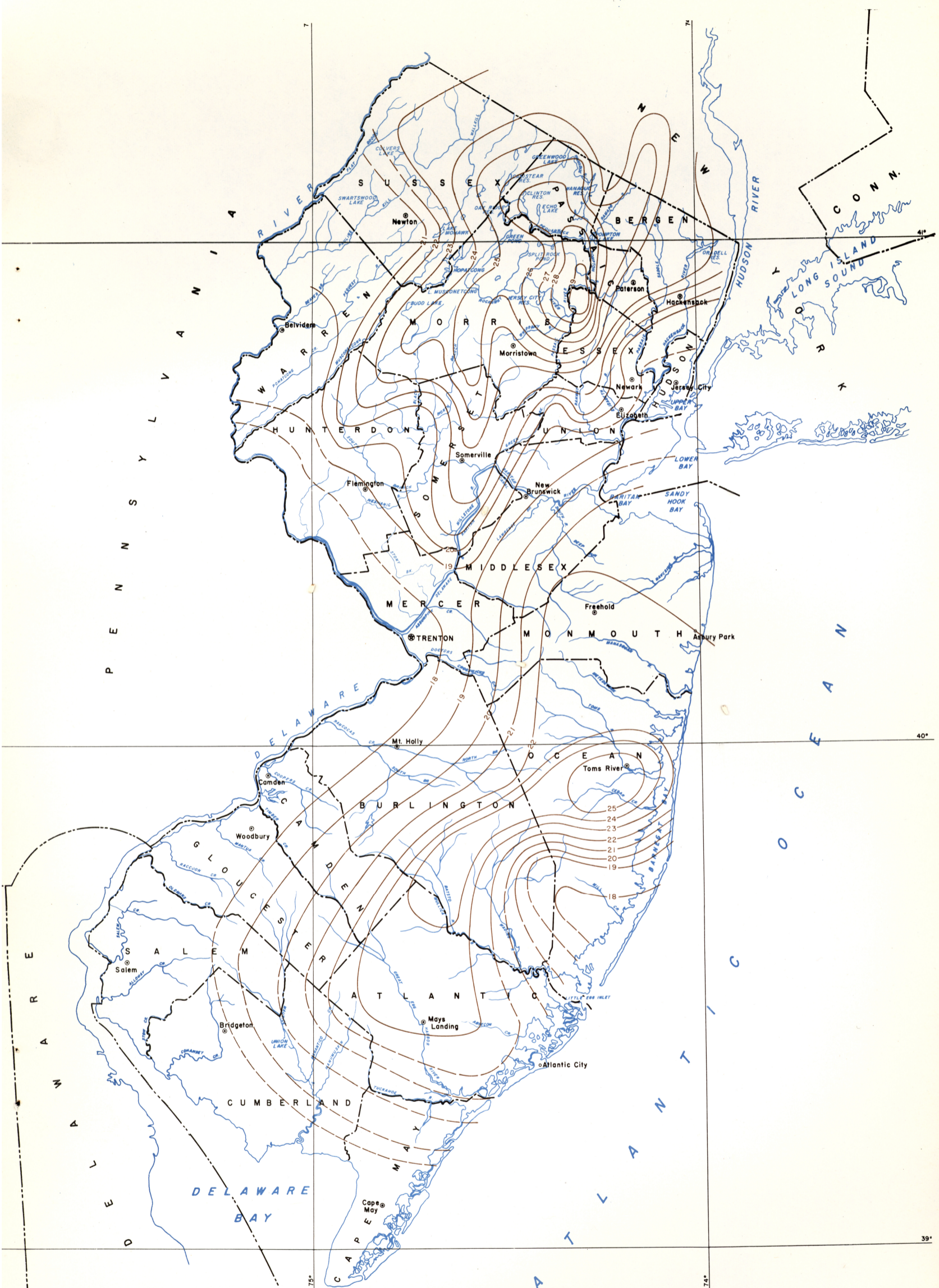
Cities of Newark, Bayonne, and Elizabeth	40.5%
Passaic Valley Water Commission for Passaic, Paterson and Clifton	37.75%
Town of Kearny	12.0%
Town of Montclair	5.0%
Town of Bloomfield*	4.0%
Borough of Glen Ridge	0.75%

TOTAL 100.00%

* Transferred its allotment to Newark

The transmission system extends 20.6 miles from Wanaque Reservoir to Belleville Reservoir with interconnections enroute to (1) the Pequannock Aqueduct of the Newark system, (2) the Little Falls pumping station of the Passaic Valley Water Commission, (3) the Jersey City Aqueduct, (4) the Montclair pumping station, (5) Bloomfield and (6) Belleville. Glen Ridge is supplied through meters from the Montclair distribution system.

The greatest average annual delivery on the system was 95.4 million gallons per day in 1948 compared with an average delivery of 89.3 million gallons



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NEW JERSEY WATER RESOURCES DEVELOPMENT
 AVERAGE ANNUAL RUNOFF
 (INCHES)

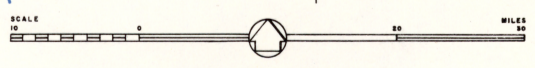
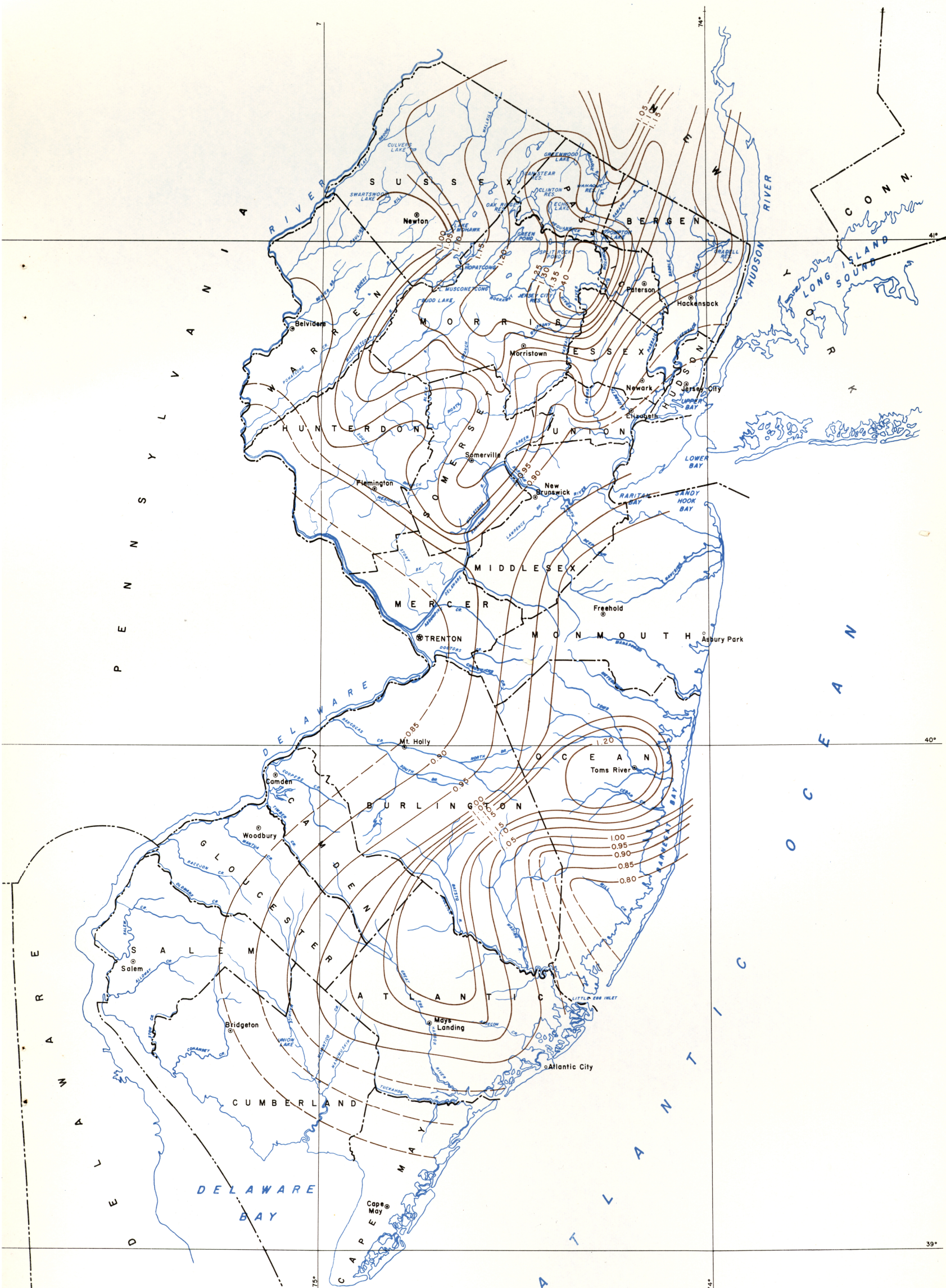


PLATE
 2
 7-1955



STATE OF NEW JERSEY
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 ENGINEERS

NEW JERSEY WATER RESOURCES DEVELOPMENT

AVERAGE ANNUAL RUNOFF
 (MILLION GALLONS PER DAY PER SQUARE MILE)

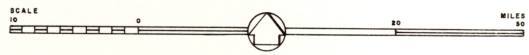
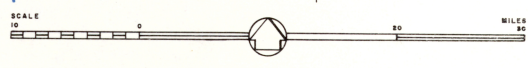


PLATE
 3
 7-1955



STATE OF NEW JERSEY
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NEW JERSEY WATER RESOURCES DEVELOPMENT
 AVERAGE ANNUAL WATER LOSS
 (DIFFERENCE BETWEEN PRECIPITATION AND RUNOFF)
 (INCHES)

PLATE
 4
 7-1955

per day in 1954. The greatest monthly delivery was 107.2 million gallons per day in September 1953. The greatest single day draft in that month was 137.6 million gallons per day.

Operation studies were made for the system for the most critical dry period of record (1930-33) and it was found that, with 25 percent of the storage capacity held as reserve, the dependable yield was 82.5 million gallons per day from Wanaque flows only and 106 million gallons per day for the present system including the Ramapo diversion.

The full amount of storage in Wanaque Reservoir considered usable during the study period was assumed to be utilized in supplying the dependable yields quoted above. Accordingly, no further advantage can be gained by Wanaque storage--other than very short term regulation--and any additional water delivered to the reservoir from new sources would only increase the system yield by the amount of water delivered during the critical period. For this reason it has been assumed that no enlargements of the Wanaque system are practicable at the present time.

ROCKAWAY RIVER SYSTEM

Owned and operated by the City of Jersey City, this system derives its supply from the Rockaway River (Passaic River Basin) at Boonton Reservoir which was completed in 1904, has a capacity of 7.5 billion gallons and a drainage area of 121.5 square miles. Split Rock Reservoir, which was completed in 1948 with a capacity of 3.3 billion gallons, impounds the flow of Beaver Brook, a tributary of the Rockaway River. The supply from the latter reservoir is delivered by gravity flow through natural channels to Boonton Reservoir.

An aqueduct 22.8 miles long extends from Boonton Reservoir to Jersey City, where it connects to the distribution system. Interconnections along the aqueduct permit interchange of water from the Wanaque, Pequannock (Newark) and Passaic Valley Water Commission systems. The Jersey City system also supplies water to the City of Hoboken, the Township of Lyndhurst and the Borough of North Arlington as well as eight major and a number of smaller consumers outside of Jersey City. The average delivery rate for the system in 1954 was 62.8 million gallons per day. Operation studies made for the most critical dry period of record show that the dependable yield of the existing systems is 68 million gallons per day. Other operation studies show that expansion of the Rockaway River system to the practicable maximum, by construction of Longwood Valley Reservoir and installation of flashboards to increase the capacity of Boonton Reservoir, will increase the

dependable yield to 82.6 million gallons per day. The contemplated expansion is discussed in greater detail later in the report.

PEQUANNOCK SYSTEM

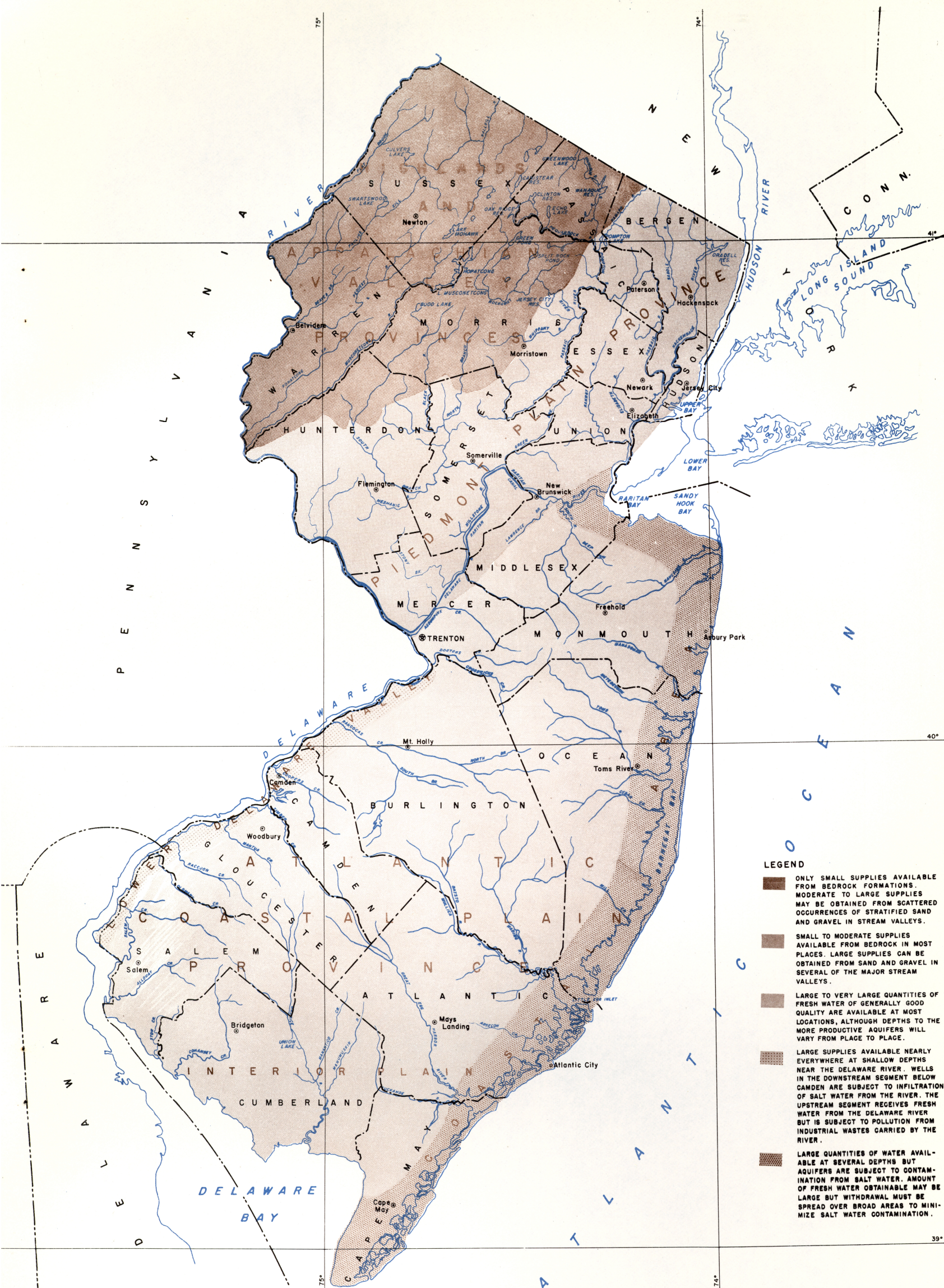
This system is owned and operated by the City of Newark and supplies parts of the City of Newark, the Towns of Bloomfield and Belleville and a number of other municipalities and consumers along the aqueduct. Construction of the key works was initiated in 1889 and completed in 1896 by the East Jersey Water Company. The City acquired these properties in 1900 and made major improvements and additions in 1904 and 1943.

The supply is impounded in four storage reservoirs (Canistear, Oak Ridge, Clinton and Echo Lake) located in the Pequannock River Basin, a tributary of the Passaic River. The reservoir delivers water by natural stream channel to the Macopin intake reservoir and is taken from there by gravity through an aqueduct to Newark and the other municipalities. The Pequannock River has a drainage area of 63.7 square miles above Macopin Dam.

From the gate house at Macopin intake, the Pequannock aqueduct extends 21.2 miles to Belleville Reservoir. A distributing reservoir with a capacity of about 700 million gallons is located near Cedar Grove. Under normal operating conditions, all water is delivered to the consumers via Cedar Grove Reservoir. However, that reservoir is automatically bypassed in the event of an exceptionally large draft or emergency. A second distributing reservoir, located in Belleville, has a capacity of 14 million gallons and serves a high level district in that town.

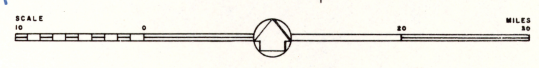
The greatest average annual rate of delivery was 63 million gallons per day in 1951 compared with an average delivery of 50 million gallons per day in 1954. The greatest average monthly draft was 71.5 million gallons per day in June 1950 of which 13.4 million gallons per day were delivered to the Wanaque system. The greatest daily delivery to the Newark system alone was 95.5 million gallons per day on June 26, 1952. The greatest total daily draft was 99.4 million gallons per day in May 1953, of which the Wanaque system received 35.0 million gallons per day.

Operation studies made for the most critical dry period of record show that the dependable yield of the system with existing reservoirs is 46 million gallons per day assuming that 25 percent of the storage capacity would be held as reserve. Additional studies show that the dependable yield of the system may be increased to 53.4 million gallons per day by construction of



LEGEND

- ONLY SMALL SUPPLIES AVAILABLE FROM BEDROCK FORMATIONS. MODERATE TO LARGE SUPPLIES MAY BE OBTAINED FROM SCATTERED OCCURRENCES OF STRATIFIED SAND AND GRAVEL IN STREAM VALLEYS.
- SMALL TO MODERATE SUPPLIES AVAILABLE FROM BEDROCK IN MOST PLACES. LARGE SUPPLIES CAN BE OBTAINED FROM SAND AND GRAVEL IN SEVERAL OF THE MAJOR STREAM VALLEYS.
- LARGE TO VERY LARGE QUANTITIES OF FRESH WATER OF GENERALLY GOOD QUALITY ARE AVAILABLE AT MOST LOCATIONS, ALTHOUGH DEPTHS TO THE MORE PRODUCTIVE AQUIFERS WILL VARY FROM PLACE TO PLACE.
- LARGE SUPPLIES AVAILABLE NEARLY EVERYWHERE AT SHALLOW DEPTHS NEAR THE DELAWARE RIVER. WELLS IN THE DOWNSTREAM SEGMENT BELOW CAMDEN ARE SUBJECT TO INFILTRATION OF SALT WATER FROM THE RIVER. THE UPSTREAM SEGMENT RECEIVES FRESH WATER FROM THE DELAWARE RIVER BUT IS SUBJECT TO POLLUTION FROM INDUSTRIAL WASTES CARRIED BY THE RIVER.
- LARGE QUANTITIES OF WATER AVAILABLE AT SEVERAL DEPTHS BUT AQUIFERS ARE SUBJECT TO CONTAMINATION FROM SALT WATER. AMOUNT OF FRESH WATER OBTAINABLE MAY BE LARGE BUT WITHDRAWAL MUST BE SPREAD OVER BROAD AREAS TO MINIMIZE SALT WATER CONTAMINATION.



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NEW JERSEY WATER RESOURCES DEVELOPMENT

GENERALIZED GROUND-WATER YIELD CHARACTERISTICS OF THE MAJOR GEOLOGIC PROVINCES OF NEW JERSEY

Charlotteburg Reservoir and the diversion of flows of Farber Brook to Canistear Reservoir. These enlargements are discussed in greater detail later in the report.

PASSAIC VALLEY WATER COMMISSION

The Passaic Valley Water Commission was formed in 1927 to provide and operate water supply facilities for the cities of Paterson, Passaic and Clifton. It also provides all of the supplies for the municipalities of Harrison, Nutley, Prospect Park and Totowa, and through the New Jersey Water Service Company for the Township of Little Falls. The Commission also furnishes part of the supply for the municipalities of Garfield, Haledon, East Paterson, West Paterson, Lodi and the Hackensack Water Company.

The Commission contracts for 37.75% of the supply from the Wanaque system which gives its consumers a safe annual yield of 40 million gallons per day from that source. In addition the Commission has the right to divert 75 million gallons per day from the Passaic River at Little Falls whenever it is available. However, the flow of the river drops as low as 35 million gallons per day during drought periods. The combined dependable yield available to consumers served by the Commission is, therefore 75 million gallons per day.

Operation studies show that by the development of storage at the Point View site, for use during drought periods, the dependable yield of the Commission's own facilities (exclusive of their Wanaque supply) may be increased to 90 million gallons per day. The proposed expansion is discussed in greater detail later in this report.

HACKENSAACK WATER COMPANY SYSTEM

The Hackensack Water Company is a privately owned water utility serving areas in Bergen and Hudson Counties, New Jersey. Regulation of the runoff from 116 square miles of the Hackensack River drainage basin is provided by Oradell Reservoir, constructed in 1922 with a capacity of 3,080 million gallons, and Woodcliff Reservoir on Pascaek Creek, capacity 890 million gallons. The dependable supply of the existing system is reported to be 45 million gallons per day. In addition, the Company has recently developed a well field with a rated capacity of 5 million gallons per day.

The system has physical interconnections with the Jersey City and Passaic Valley Water Commission systems. Under the terms of short-term agreements, up to 8 million gallons per day from Passaic Valley and up to 4 million gallons per day from Jersey City may be obtained in emergencies.

The purification and pumping plants of the Company are capable of handling 100 million gallons per day. In 1954 the average delivery rate for the system from all sources including the interconnections was 53.7 million gallons per day and the maximum daily delivery rate was 78.3 million gallons per day.

Additional storage capacity is now under construction in New York State by the Spring Valley Water Works and Supply Company, a subsidiary of the Hackensack Water Company. The capacity of the new reservoir -- to be named "deForest Lake Reservoir" -- will be 5.6 billion gallons. This reservoir will control a drainage area of about 26 square miles in the upper reaches of the Hackensack River. The new project will develop a dependable yield of 20 million gallons per day, all of which may initially be available to New Jersey consumers, but will also be used for the Company's supply area in New York when required by the demand.

The Company reports that a total yield greater than 20 million gallons per day may be obtained by coordinated operation with Oradell Reservoir. The Company further estimates that an additional supply of 10 million gallons per day may feasibly be developed in the Hackensack Basin.

ELIZABETHTOWN WATER COMPANY SYSTEM

The Elizabethtown Water Company is a privately owned utility which serves areas in Middlesex and Union Counties. The Company is authorized to divert 20 million gallons per day from the Raritan and Millstone Rivers at their intake facilities at the junction of the two streams, where the total drainage area is 770 square miles. In addition, the Company is buying 22.5 million gallons per day from the Delaware and Raritan Canal and operates three well fields with a dependable yield of 10 million gallons per day in the Union-Hillside area. At present, the Company has no storage facilities other than tanks required for load factoring and the maintenance of distribution pressures. The total dependable supply of the system from the three sources is 52.5 million gallons per day. The capacity of the surface water filter plant near Bound Brook is 40 million gallons per day. The average rate of delivery by the Company in 1954 was 26 million gallons per day.

The Company has advanced the proposal to increase its dependable supply by the construction of a system of small reservoirs on the Raritan River and its tributaries and by enlargement of its well fields. Operation studies, discussed in greater detail later in the report, show that the full construction of the proposed reservoir system would increase the dependable

yield of the Raritan supply from the present authorized direct flow diversion rate of 20 million gallons per day to 144 million gallons per day.

DELAWARE AND RARITAN CANAL

The Delaware and Raritan Canal, originally constructed in 1830 as a navigation canal, was deeded to the State of New Jersey by its private owners in 1937. In 1944, by enactment of Chapter 172, the canal was dedicated to industrial water supply and recreational use. That law was supplemented in 1949 by Chapter 168, to include sales to water supply systems for potable and public use. Rehabilitation of the canal to restore carrying capacity permitted water deliveries to consumers in 1951. At least 75 million gallons per day can be transported via the canal, from its intake on the Delaware River at Raven Rock, to Bound Brook and New Brunswick.

The State of New Jersey is permitted by decree of the U. S. Supreme Court to divert 100 million gallons per day from the Delaware River without compensation. Of this amount, only 47.7 million gallons per day have been committed for use. It is estimated that losses in transit amount to 25 million gallons per day. Accordingly, an additional 27.3 million gallons per day are available for delivery without flow compensation, in addition to the current commitments. This assumes that no credit may be taken for transit losses in the portion of the canal in the Delaware Basin, which losses presumably are returned to the Delaware River.

If not already underway, a program of stream gaging on the Delaware and Raritan Canal should be initiated by the Division of Water Policy and Supply for the purpose of determining the magnitude and location of canal losses, in relation to rate of flow being maintained in the several sections of the canal. The object of the program would be to determine the overall canal loss and the portion of such loss which occurs in the Delaware Basin under various flow conditions. Seasonal variations in rates of loss should be studied also. Presumably, losses which can be shown to occur from the canal between the intake at Raven Rock and the point where the canal leaves the Delaware Basin, are not chargeable against the 100 million gallons per day restriction on deportation of water from that basin.

CHAPTER III

PROPOSALS TO MEET FUTURE WATER NEEDS

REVIEW OF PREVIOUS PROPOSALS

Numerous schemes for developing additional water supplies have been prepared in the past and a thorough review has been made of all available literature and other pertinent data. Many of the storage sites proposed in earlier reports are no longer feasible because of extensive urban development or because of their dependence on interstate cooperation (see Plate 7.)

It is not possible in this report to present all of the data reviewed, but the following is a brief discussion, by river basins, on the material covered:

DELAWARE RIVER BASIN

The Wallpack Bend site on the Delaware River was included in the INCODEL Plan. The development of this site would require the cooperation of the State of Pennsylvania and does not appear to be feasible for the near future. For the Northeastern Regional supply alone, the construction of the long tunnel from Wallpack Bend is definitely uneconomical. Numerous reservoir sites have been proposed in the INCODEL and other reports, for Flat Brook, Paulins Kill, Beaver Brook, Pequest River, Pohatcong Creek and the Musconetcong River, all New Jersey tributaries of the Delaware River. These proposed developments are all relatively small, relatively expensive due to the great distance from the centers of use, and would require Supreme Court approval for diversion of water from the Delaware Basin.

A study was also made of the Tock's Island site proposed by the Delaware River Development Corporation. The major objective of this proposal was the development of power with water supply as an auxiliary feature. This project does not appear to be an economic solution for present needs. Studies were also made of the possibility of both pumping and gravity diversion from the Delaware to the Raritan Basin. These studies may have considerable significance in connection with supplies adequate to the year 2000 and will be presented in more detail in the Final Report.

PASSAIC RIVER BASIN

The Passaic Great Reservoir located above Little Falls (surface area nearly 40,000 acres) and the Long Hill site located above Millington (surface area over 15,000 acres) are no longer feasible due to extensive development

within the reservoir areas. The Corps of Engineers' proposed Conservation Pool near Little Falls is primarily a flood control project. The Charlotteburg site on the Pequannock River, the Point View site on a tributary of the Ramapo River, and the Longwood Valley site on the Rockaway River are discussed in detail elsewhere in the report.

RARITAN RIVER BASIN

The Raritan Reservoir site at the confluence of the North and South Branches (surface area over 30,000 acres), the Bunnvale, Long Valley and Vernoy sites on the South Branch, and the Ralston and Pleasant Valley sites on the North Branch were studied both in the field and office. These sites for a variety of reasons are no longer considered to be economically feasible.

The Dock Watch Hollow site, in the Second Watchung Mountains was studied in some detail, but is considered to have insufficient capacity for the type of supply required. The six small dam sites on the Raritan River and its tributaries as proposed by Elizabethtown Water Co. were thoroughly checked by operational studies and preliminary estimates of construction costs prepared.

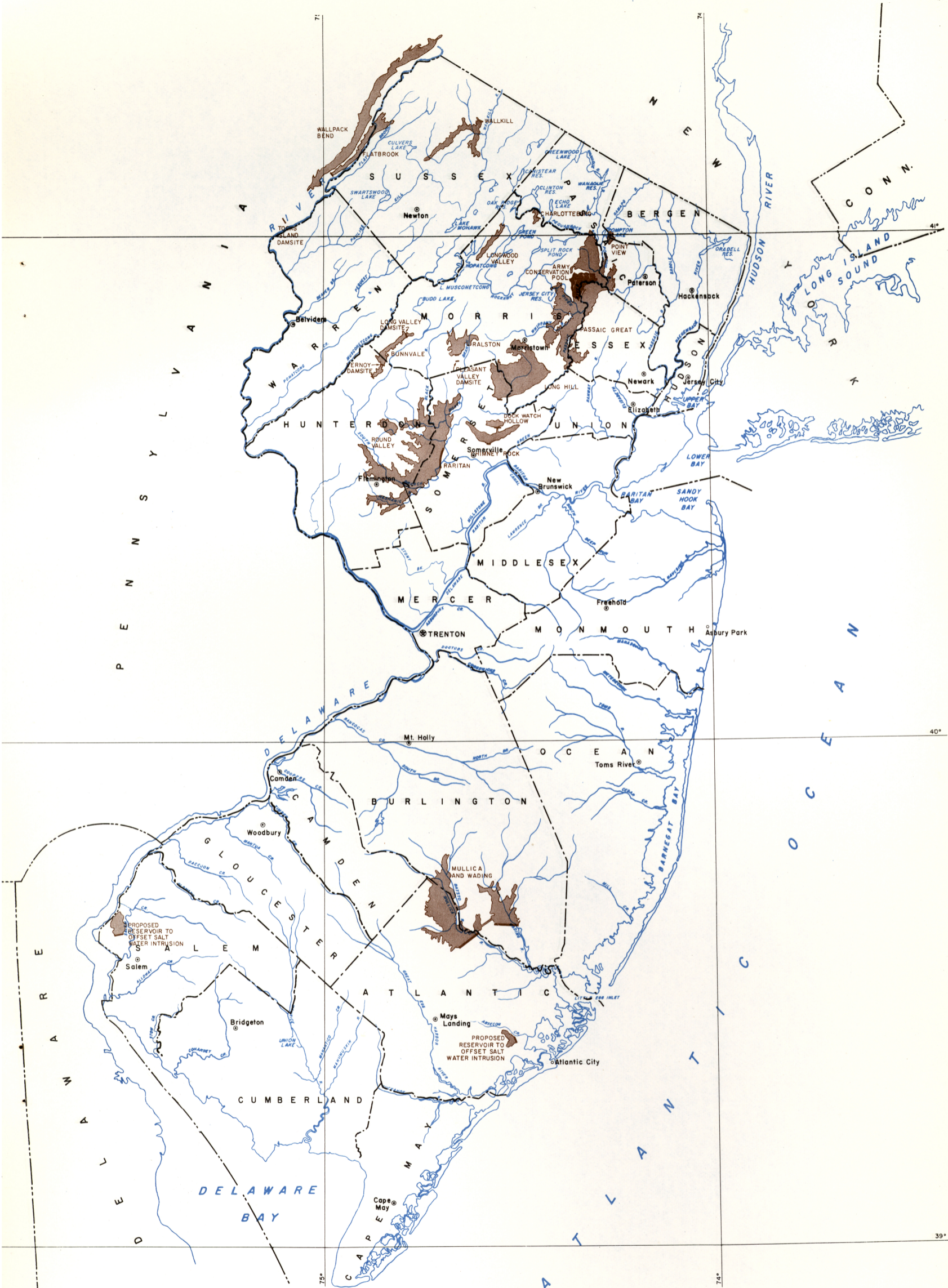
OTHER RIVER BASINS

A proposed site on the Wallkill River near Sussex indicates a dependable yield of 100 million gallons per day. However, the project appears not to be practicable due to development in the reservoir area, to the long, costly tunnel required to deliver the water to Wanaque Reservoir, and to the poor quality of the water requiring high treatment costs.

Reservoirs on the Mullica and Wading Rivers interconnected by a canal have been proposed for South Jersey. Further consideration of this proposal will involve the alternative of developing ground water supplies in this area which is discussed in the ground water section of Chapter IV and will be treated in greater detail in the Final Report.

PROPOSALS TO MEET NEEDS OF NORTHEASTERN METROPOLITAN REGION

The population and water consumption studies in Chapter I indicate that the only critical area at the present time is the Northeastern Metropolitan Region. These studies likewise indicate that the demand may exceed available dependable supplies by 1960 or 1961 when a major new system can be completed and that even with the completion of a new 200 million gallons per day supply the demand may again approach dependable yields, less reasonable reserve, by 1975. Therefore, in order to satisfy the needs of the Northeastern Metropolitan Region until the year 2000, three stages of development are necessary:



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NEW JERSEY WATER RESOURCES DEVELOPMENT

GENERAL LOCATION OF PREVIOUSLY
 PROPOSED RESERVOIR SITES

PLATE
 7
 7-1955

1. Immediate expansion of existing supplies to provide for needs to 1960.
2. A major new supply to provide for an intermediate stage to the year 1975.
3. Additional major supplies to provide for needs to the year 2000.

In this Preliminary Report recommendations designed to cover only the first two stages are made, the third stage being a subject left for the Final Report.

PROPOSED EXPANSION OF EXISTING SYSTEMS

Officials responsible for operation of the existing water supply systems, both public and private, are cognizant of the need for development of additional supplies to meet the needs of increased population and industrial expansion in their own or adjacent service areas. Numerous projects have been proposed, but to date none have been executed or started, with the exception of preliminary work on the deForest Lake Reservoir on the Hackensack River. The major proposals for expansion which have been considered are explained briefly in the following paragraphs. The increased yields of the various systems are summarized in Table 8.

PEQUANNOCK SYSTEM

A report has been prepared for the City of Newark on a new reservoir with a storage capacity of 2.9 billion gallons at Charlotteburg Pond and for diversion of flows from Farber Brook to the existing Canistear Reservoir. With the construction of these two enlargements, the maximum economic development of the Pequannock basin will have been achieved.

Operation studies show that the yield of the system during the most severe drought of record (1900-01), assuming that 25 percent of the storage capacity will be held in reserve, could be increased from 46 to 53.4 million gallons per day by these proposed projects, which are estimated to cost about \$8,640,000. Included in the estimated cost are funds for construction of a new treatment plant and pipe lines from Charlotteburg and Echo Lake reservoirs to the existing Pequannock aqueduct. The proposed arrangement will increase the aqueduct capacity from 81 to 90 million gallons per day by increasing the hydraulic gradient.

PASSAIC VALLEY SYSTEM

The Passaic Valley Water Commission's supply from the Passaic River at Little Falls depends upon direct flow diversion without benefit of reservoir storage. A report has been prepared for the Commission on the feasibility of increasing the dependable yield of the system through the construction of a reservoir at Point View on a tributary of the Ramapo River. The reservoir, with a capacity of 2.8 billion gallons, would be filled during periods of high flows by pumping from the Passaic River at Little Falls. Stored water would be withdrawn when the river flow at Little Falls is below system requirements.

In determining the dependable yield of the system after construction of Point View Reservoir, it was assumed that the proposed expansions of the Pequannock and Rockaway systems would have been completed and that the flows available at Little Falls would be reduced from the historic rates by operation of the expanded upstream systems. After the reduction, the dependable yield of the Passaic Valley Water Commission system could be increased during the driest period of record from 35 to 90 million gallons per day. The existing direct flow authorization limits the Commission to a diversion of 75 million gallons per day and the additional supply would be obtained from flood waters stored in Point View Reservoir.

The cost of the proposed project, including the cost of additional pipe lines, pumping equipment, and enlargement of the coagulation basin and filter plant, to serve an average demand of 90 million gallons per day, is estimated to be \$10,000,000.

In the event additional sites for storage reservoirs can be found at a reasonable cost in the Passaic River basin, additional potable supplies could be developed by regulation of flood flows. The Army Conservation Pool, proposed as a feature of a flood control project, would develop an additional supply of 120 million gallons per day of potable water. This project, however requires a major federal appropriation for flood control and substantial State or Local funds.

ROCKAWAY SYSTEM

Plans for expansion of the Jersey City system include the installation of flashboards to increase the usable capacity of Boonton Reservoir and construction of an additional reservoir on the upper Rockaway River at Longwood Valley. This construction will complete the development of the Rockaway River basin. The flashboards, for which a contract has recently been awarded, will

raise Boonton Reservoir level 3 feet and increase the usable capacity from 7.5 to 8.3 billion gallons. Preliminary estimates are being prepared for the Longwood Valley development, which is expected to cost approximately \$3,500,000.

Operation studies indicate that the proposed expansions will increase the dependable yield of the Jersey City system from 68 to about 82.6 million gallons per day. The capacity of the Jersey City aqueduct leading from Boonton Reservoir is reported to be 100 million gallons per day. It is probable that increased balancing reservoir capacity will be necessary to properly service peak load periods at the expanded delivery rate.

HACKENSACK SYSTEM

Additional storage capacity is now under construction in New York State by the Spring Valley Water Works and Supply Company, a subsidiary of the Hackensack Water Company. The capacity of the new reservoir - to be named "deForest Lake Reservoir" - will be 5.6 billion gallons and it will control a drainage area of approximately 26 square miles of the upper reaches of the Hackensack River. The new project will develop a dependable yield of 20 million gallons per day. It is understood that the full 20 million gallons per day will be available to the Hackensack Water Company for a few years until required by the Spring Valley system in New York State.

Water will be delivered from the new reservoir to Oradell Reservoir via natural stream channels and, through coordinated operation of the two reservoirs, a yield greater than 20 million gallons per day may possibly be obtained.

ELIZABETHTOWN WATER COMPANY SYSTEM

The Company has proposed the development of storage facilities on the Raritan River and its tributaries upstream from its diversion point. Available topographic maps indicate that a total usable storage capacity of about 33 billion gallons could be developed at six reservoir sites. The estimated dependable yield of the complete development, on the basis of preliminary studies, is 144 million gallons per day, at the diversion point near Bound Brook, assuming that 25 percent of the storage capacity would be held in reserve and that the flow below the diversion point would be maintained at not less than 130 million gallons per day. This would represent an increased supply of 124 million gallons per day over the existing supply of 20 million gallons per day taken without storage from the Raritan River. This proposed development cannot be considered entirely as an expansion of an existing supply, since the

final withdrawal would be more than seven times the amount now taken from the river. This project could not be carried out simultaneously with another major development depending on Raritan water.

Preliminary cost estimates of the Elizabethtown proposal indicate that the six dams and reservoirs alone, including land acquisition, would aggregate about \$22,000,000. Insufficient information is available about the transmission and distribution plans of the Elizabethtown Water Co's proposal to prepare an accurate estimate of the total project. However, the distances involved are approximately the same as for the Chimney Rock Project and, therefore, the total costs, including the construction of new pumping, treatment and transmission facilities will be at least the same and probably higher than for the comparable features of Chimney Rock.

The project is a feasible one and has some desirable features, particularly the maintenance of a minimum flow of 130 million gallons per day in the Raritan River. However, due to the shallow storage in most of the proposed reservoirs and the large area of water surface (6,300 acres) the quality of the water would not be equal to either Chimney Rock or Round Valley. Operation and Maintenance costs for the Elizabethtown proposal are certain to be higher and will result in a higher unit cost of water compared with Chimney Rock. Finally, the Elizabethtown proposal has more limited possibilities than Chimney Rock for the development of the Raritan River as a major water resource.

For the above reasons, the Elizabethtown proposal was eliminated as an alternate method for development of the Raritan. It is likely however, that one or more of the reservoirs proposed under the scheme would be useful in the future for augmenting the flow in the river during dry periods. It is also believed that additional supplies for the Elizabethtown Water Co. can be made available from the Delaware and Raritan Canals and that water can be wholesaled to the Company from Chimney Rock at an attractive price.

DELAWARE AND RARITAN CANAL

The State of New Jersey has the right, by U.S. Supreme Court decree, to divert 100 million gallons per day from the Delaware River Basin without compensation. Existing contracts for water deliveries from the Delaware and Raritan Canal chargeable to this allocation amount to 47.7 million gallons per day and total losses throughout the length of the canal are estimated to amount to 25 million gallons per day. The total length of the canal from the diversion point on the Delaware River at Raven Rock to New Brunswick is about 58 miles, of which about 35 miles are situated in the Delaware Basin. It may be assumed that the

losses which occur from the canal in the Delaware Basin are not subject to the 100 million gallons per day restriction. On this basis, and assuming adequate carrying capacity, the canal could be utilized to deliver 27.3 million gallons per day, plus any portion of the 25 million gallons per day loss not chargeable to the limitation, in addition to the presently contracted flows.

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System Operator	Source of Water		Dependable Yield Million Gallons Per Day		Increase in Yield Million Gallons Per Day
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Passaic Valley Water Commission	Passaic	Passaic	35	90	55
State of New Jersey <u>1/</u>	Delaware	Delaware	47.7 ^{2/}	90 ^{3/}	42.3
Elizabethtown Water Co.	Raritan	(Millstone (Raritan)	20	144	124.0

1/ Delaware and Raritan Canal

2/ Total of existing contracts, which are less than the supply which is legally and physically deliverable.

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PROPOSALS FOR FIRST MAJOR SUPPLY DEVELOPMENT

After examining the merits, under 1955 conditions, of the developments previously proposed, including expansions of existing systems, it was concluded that the relatively undeveloped Raritan River is the logical source to meet the intermediate future needs of the Northeastern Metropolitan Region. Furthermore, the Round Valley and Chimney Rock sites were found to be the only major storage sites capable of supplying the demand at reasonable cost. Plate 8 shows the general locations of the Round Valley and Chimney Rock Reservoirs and the intake and transmission aqueducts for these schemes. The primary problem in connection with the new Raritan River supply was, therefore, the necessity to make a thorough comparative study of these two reservoir sites. This study was carried out in detail on the basis of the two stages of development proposed for Round

Valley, 70 million gallons per day in the first stage and 200 million gallons per day in the second stage. The result of this study in summary are as follows:

Water Sources, Pumping Stations and Pumping Mains

Round Valley would take an average of 70 million gallons per day from the South Branch of the Raritan River at Hamden and will require for this first stage a pumping capacity of 200 million gallons per day. The distance from Hamden to Round Valley is 3.3 miles and the static lift is 200 feet. This is the limit of the supply that can be taken from the South Branch of the Raritan River. For further development the Round Valley Project must go to the Delaware River. The second stage proposal is to divert 130 million gallons per day from the Delaware River at Frenchtown, a distance of over 14 miles from the reservoir with nearly six miles of required tunnel construction. The Delaware diversion will necessitate an additional 200 million gallons per day of pumping capacity. The pumping head from Frenchtown to Round Valley is approximately 260 feet.

The Chimney Rock Project would take water from the Main Branch of the Raritan River at Bound Brook and also have available to it at approximately the same location the flow of the Millstone River and Delaware and Raritan Canal. In order to provide a safe yield of 70 million gallons per day, pumping capacity of 110 million gallons per day will be required. A dependable supply of 200 million gallons per day can be provided with 380 million gallons per day of pumping capacity. The Chimney Rock Project would be able to take up to an average 180 million gallons per day from the Raritan River without lowering the downstream flow below 130 million gallons per day. The remaining 20 million gallons per day of the 200 million gallons per day project would be taken from available surpluses in the Delaware and Raritan Canal. The static lift from Bound Brook to Chimney Rock is approximately 240 feet and the distance 2.6 miles. The average pumping head at Chimney Rock is the same for

STATE OF NEW JERSEY
 LEGISLATIVE COMMISSION ON WATER SUPPLY
 TIPPETTS - ABBETT - MCCARTHY - STRATTON
 ENGINEERS

NEW JERSEY WATER RESOURCES DEVELOPMENT
 LOCATION OF PROPOSED CHIMNEY ROCK AND ROUND VALLEY SCHEMES
 AND RECOMMENDED EXPANSIONS OF EXISTING SYSTEMS

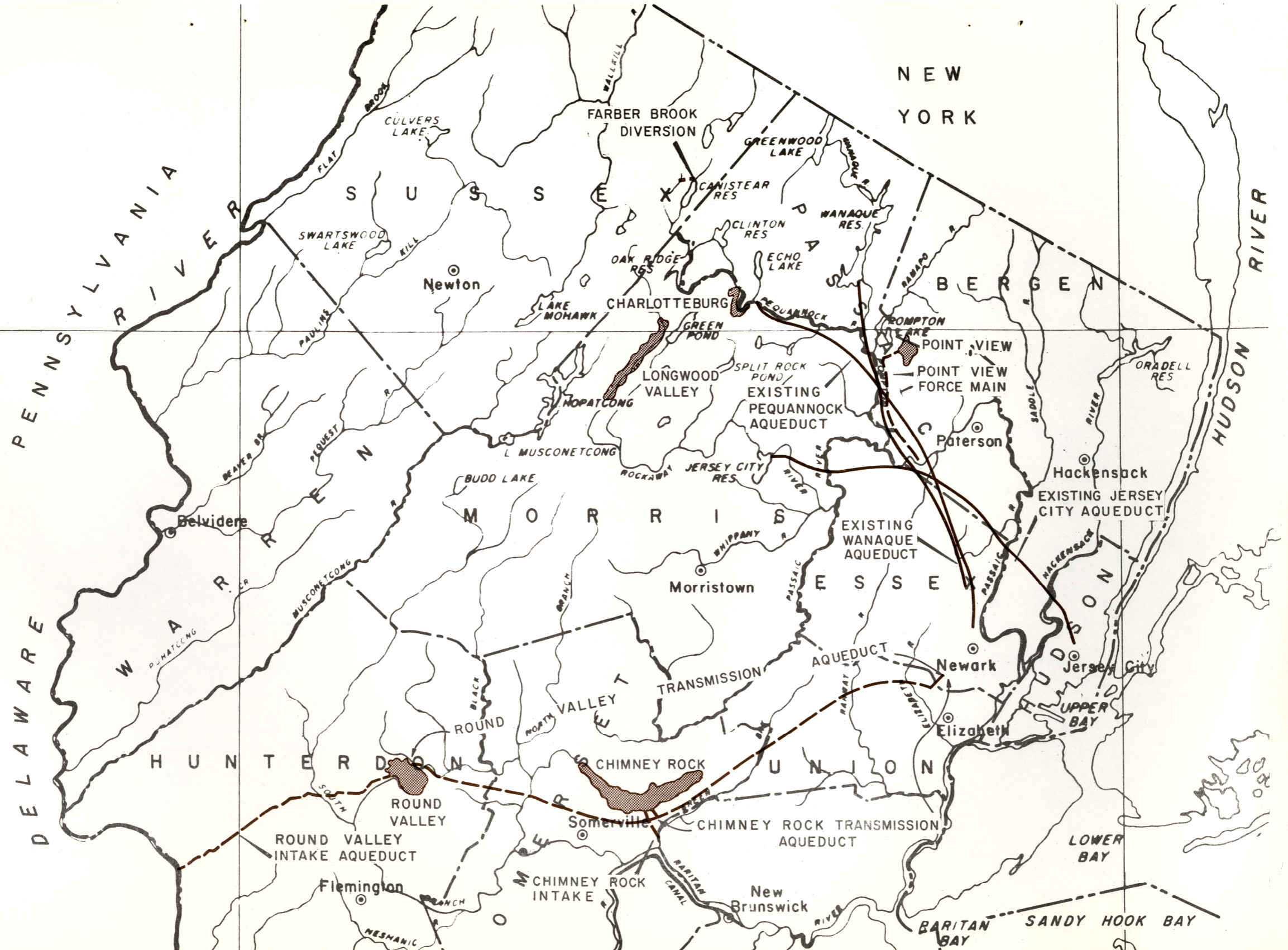


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1. Immediate expansion of existing supplies to provide for needs to 1960.
2. A major new supply to provide for an intermediate stage to the year 1975.
3. Additional major supplies to provide for needs to the year 2000.

In this Preliminary Report recommendations designed to cover only the first two stages are made, the third stage being a subject left for the Final Report.

PROPOSED EXPANSION OF EXISTING SYSTEMS

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For the above reasons, the Elizabethtown proposal was eliminated as an alternate method for development of the Raritan. It is likely however, that one or more of the reservoirs proposed under the scheme would be useful in the future for augmenting the flow in the river during dry periods. It is also believed that additional supplies for the Elizabethtown Water Co. can be made available from the Delaware and Raritan Canals and that water can be wholesaled to the Company from Chimney Rock at an attractive price.

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losses which occur from the canal in the Delaware Basin are not subject to the 100 million gallons per day restriction. On this basis, and assuming adequate carrying capacity, the canal could be utilized to deliver 27.3 million gallons per day, plus any portion of the 25 million gallons per day loss not chargeable to the limitation, in addition to the presently contracted flows.

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After examining the merits, under 1955 conditions, of the developments previously proposed, including expansions of existing systems, it was concluded that the relatively undeveloped Raritan River is the logical source to meet the intermediate future needs of the Northeastern Metropolitan Region. Furthermore, the Round Valley and Chimney Rock sites were found to be the only major storage sites capable of supplying the demand at reasonable cost. Plate 8 shows the general locations of the Round Valley and Chimney Rock Reservoirs and the intake and transmission aqueducts for these schemes. The primary problem in connection with the new Raritan River supply was, therefore, the necessity to make a thorough comparative study of these two reservoir sites. This study was carried out in detail on the basis of the two stages of development proposed for Round

Valley, 70 million gallons per day in the first stage and 200 million gallons per day in the second stage. The result of this study in summary are as follows:

Water Sources, Pumping Stations and Pumping Mains

Round Valley would take an average of 70 million gallons per day from the South Branch of the Raritan River at Hamden and will require for this first stage a pumping capacity of 200 million gallons per day. The distance from Hamden to Round Valley is 3.3 miles and the static lift is 200 feet. This is the limit of the supply that can be taken from the South Branch of the Raritan River. For further development the Round Valley Project must go to the Delaware River. The second stage proposal is to divert 130 million gallons per day from the Delaware River at Frenchtown, a distance of over 14 miles from the reservoir with nearly six miles of required tunnel construction. The Delaware diversion will necessitate an additional 200 million gallons per day of pumping capacity. The pumping head from Frenchtown to Round Valley is approximately 260 feet.

The Chimney Rock Project would take water from the Main Branch of the Raritan River at Bound Brook and also have available to it at approximately the same location the flow of the Millstone River and Delaware and Raritan Canal. In order to provide a safe yield of 70 million gallons per day, pumping capacity of 110 million gallons per day will be required. A dependable supply of 200 million gallons per day can be provided with 380 million gallons per day of pumping capacity. The Chimney Rock Project would be able to take up to an average 180 million gallons per day from the Raritan River without lowering the downstream flow below 130 million gallons per day. The remaining 20 million gallons per day of the 200 million gallons per day project would be taken from available surpluses in the Delaware and Raritan Canal. The static lift from Bound Brook to Chimney Rock is approximately 240 feet and the distance 2.6 miles. The average pumping head at Chimney Rock is the same for

the 70 million gallons per day scheme as for the 200 million gallons per day scheme. Although Round Valley would have an initial pumping head advantage this would be eliminated at the second stage of development with pumping from Frenchtown.

Differences in pumping costs for the first stage development will also be negligible due to the shorter pumping line from Chimney Rock and the smaller pumping capacity required. Chimney Rock has the advantage of being practically independent of Delaware water in both stages of development. No agreement with the State of Pennsylvania, permission of the United States Supreme Court or compensating reservoirs on Delaware River tributaries will be required in order to develop 200 million gallons per day at Chimney Rock. Chimney Rock has the further advantage of being capable of development for any quantity of supply between 70 and 200 million gallons per day.

Reservoir Sites

The Round Valley Reservoir site is occupied by approximately 50 farm families. There are no important roads, railways, utility lines or buildings in the site. When full, the water level of the proposed reservoir would be at elevation 380 above mean sea level for both the 70 and the 200 million gallons per day scheme. Three dams, the highest of which will have an overall height of 160 feet and the lowest 90 feet above the valley floor will be required to seal off the reservoir. The distance from Round Valley to the proposed terminal connection in Elizabeth is approximately 38 miles. The land area of the proposed Round Valley site is approximately 3,500 acres and at elevation 380 feet it will impound 49 billion gallons of water.

The Chimney Rock Reservoir Site (see Plate 9) contains approximately 350 farm and suburban residences. There are no important highways or railroads in the site, but the amount of road relocation will be greater than for Round Valley. There are no important public buildings in the proposed flooded area. For the 70 million gallons per day scheme the maximum water level in the

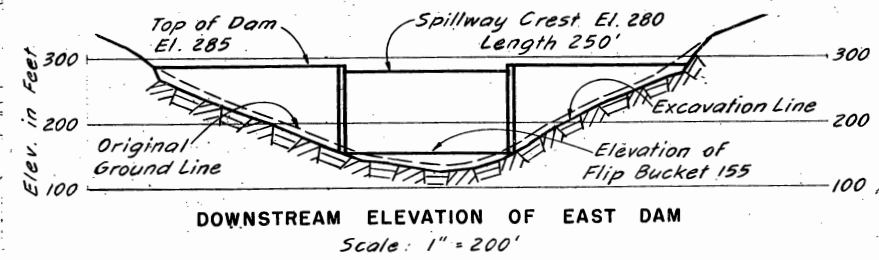
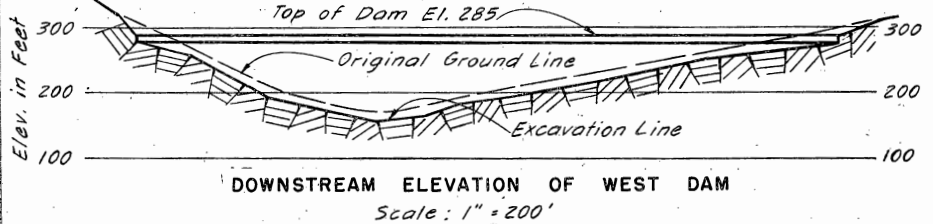
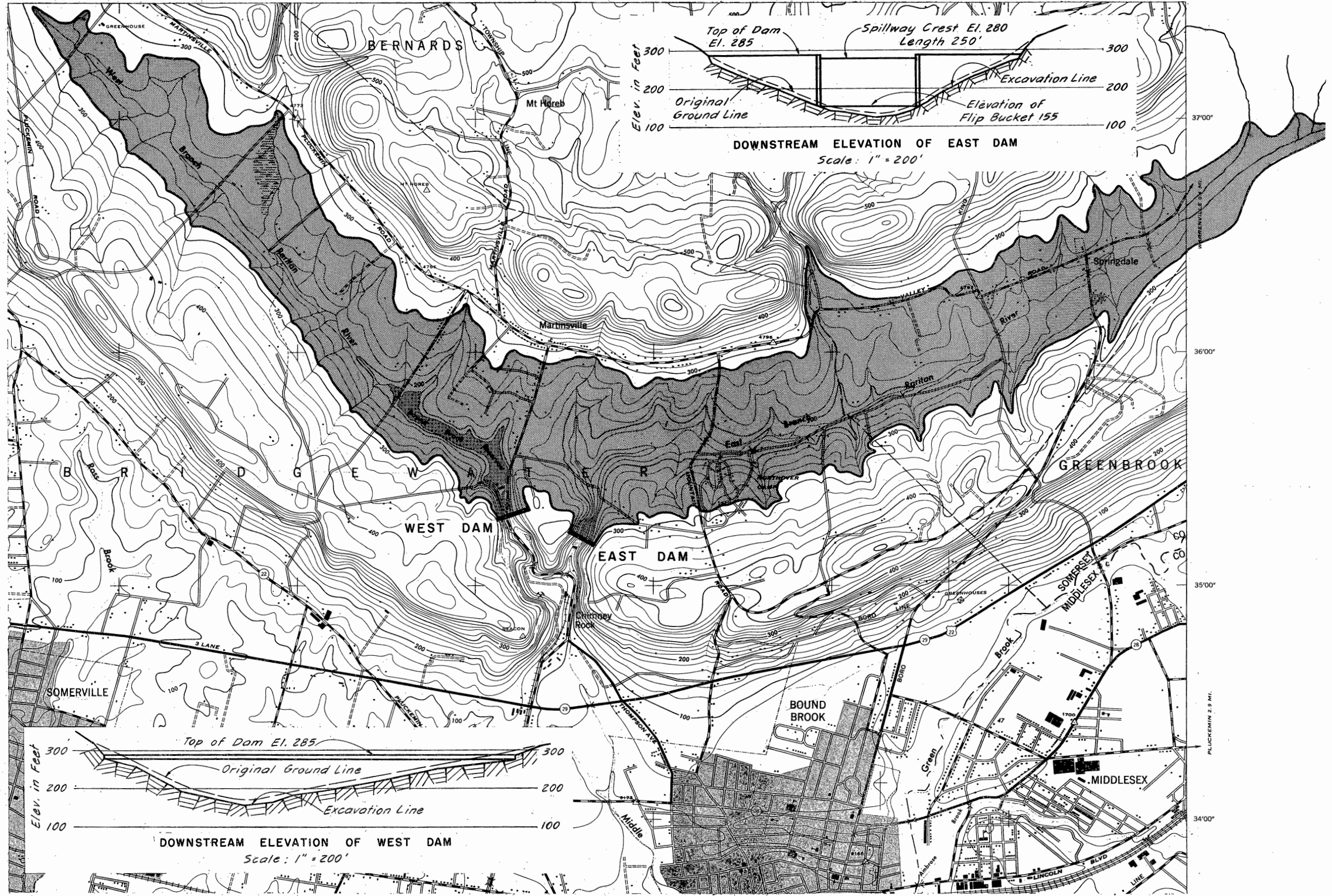
reservoir would be at elevation 260 above mean sea level and for 200 million gallons per day at elevation 280. Two dams, one 165 feet high and the other 125 feet high will be needed to form the reservoir. These dams will have considerably shorter crests than those for Round Valley and consequently will be less costly to construct. The distance from Chimney Rock to the Elizabeth connection is approximately 20 miles. The area of the proposed Chimney Rock Site is 3,000 acres and the water impounded for the 70 million gallons per day scheme is 16 billion gallons at elevation 260 and for the 200 million gallons per day scheme, 32 billion gallons at elevation 280.

The Round Valley scheme has the advantages of elevation and will displace fewer families. On the other hand both of these advantages are largely off-set by the much shorter distance between Chimney Rock and the area of water use. Booster stations will be needed for both installations and cost differentials for construction, and operation of the boosters will be small. Both sites are geologically suitable for reservoir development and entirely feasible from an engineering standpoint. Land acquisition will be considerably more costly at Chimney Rock.

Transmission Lines

The transmission line to convey water from Round Valley to Elizabeth will be 38 miles long. For the 70 million gallons per day stage the line will be 72 inches in diameter to the balancing reservoir and 96 inches in diameter from the balancing reservoir to Elizabeth. For the 200 million gallons per day supply, two additional lines similar to the one above would be required, or a total of 114 miles of pipeline.

The Chimney Rock aqueduct would be 20 miles long and for the 70 million gallons per day scheme would also require 72 inch diameter pipe to the balancing reservoir and 96 inch diameter pipe from the balancing reservoir to Elizabeth. For the 200 million gallons per day scheme, 2 additional lines would have to be laid or a total of 60 miles of pipeline.



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Since the transmission lines are the most costly item of the proposed water developments, Chimney Rock has a very large advantage because of its closer proximity to the area of water use. Some saving in the construction of the second stage development may be effected by using a single transmission line of larger diameter, but this would only be economically feasible if there was an immediate demand for the greater part of the additional water supply.

Quality of Water

The quality of water taken at Hamden will in the first stage Round Valley scheme be better than that taken at Bound Brook for the Chimney Rock scheme. However, treatment will be required for both waters and with modern methods an equally potable water supply can be obtained in both instances with negligible differences in cost. When water is taken from the Delaware River for the second stage of Round Valley, the quality will decline and be about the same as at Bound Brook.

COMPARATIVE CONSTRUCTION COSTS70 MILLION GALLONS PER DAY SCHEME

	<u>Round Valley</u>	<u>Chimney Rock</u>
Real Estate and Rights of Way	\$ 4,895,000	\$ 12,760,000
Reservoir Construction	14,145,000	9,100,000
Pumping Station and Pumping Main	4,450,000	3,200,000
Headworks including Treatment and Booster Pumps	5,500,000	5,500,000
Transmission Main and Balancing Reservoir	<u>23,450,000</u>	<u>14,950,000</u>
Total of Real Estate, Rights of Way And Construction	\$ 52,440,000	\$ 45,510,000
Engineering, Legal and Administrative Costs	3,600,000	3,000,000
Interest During Construction 5 years 2.5%	<u>3,900,000</u>	<u>3,300,000</u>
Total Estimated Cost of Project	<u>\$ 59,940,000</u>	<u>\$ 51,810,000</u>
Cost Per Million Gallons of System Capacity	\$ 856,300	740,100

200 MILLION GALLONS PER DAY SCHEME

Real Estate and Rights of Way	\$ 5,485,000	\$ 14,810,000
Reservoir Construction	14,145,000	9,290,000
Pumping Stations and Pumping Mains	22,550,000	9,000,000
Headworks including Treatment and Booster Pumps	12,500,000	12,500,000
Transmission Main and Balancing Reservoir	70,350,000	44,850,000
Compensating Reservoir	<u>2,000,000</u>	
Total Real Estate, Rights of Way And Construction	\$127,030,000	90,450,000
Engineering, Legal and Administrative Costs	7,800,000	5,700,000
Interest During Construction 10 years 2.5%	<u>8,800,000</u>	<u>6,500,000</u>
Total Estimated Cost of Project	<u>\$143,630,000</u>	<u>\$102,650,000</u>
Cost Per Million Gallons of System Capacity	\$ 718,150	\$ 513,250

CHAPTER IV

FINDINGS AND RECOMMENDATIONS

STATE-WIDE WATER SUPPLY CONDITIONS

Hydrologic studies show that taking surface and ground water supplies together, there is ample water within the State of New Jersey to provide for foreseeable needs. The question of whether or not all future requirements shall be developed entirely from intra-state waters will require careful economic comparison with proposals for the use of inter-state waters. This question will be dealt with in the Final Report.

While localized water problems of minor magnitude exist in various parts of the State, the only critical condition at present that requires attention of the State Government is the supply problem for the Northeastern Metropolitan Region.

RECOMMENDATION FOR NORTHEASTERN METROPOLITAN REGION

1. For Augmenting Existing Supplies

As set forth in Chapter III, the water requirements of the Northeastern Metropolitan Region should be met by three separate stages of development. The first stage would provide for the needs until 1960 or 1961 during the period required for the construction of a major addition to the North Jersey supply. To accomplish this it is recommended that steps be taken to encourage the owners to construct or for the State to undertake the construction of enlargements of three of the major public water supplies in the region.

These improvements are:

	<u>Additional Safe Yield Million Gallons Per Day</u>	<u>Estimated Cost</u>
Newark-Pequannock	7.4	\$ 8,640,000
Jersey City-Rockaway	14.6	3,500,000
Passaic Valley Water Commission	<u>55.0</u>	<u>10,000,000</u>
Total	77.0	\$22,140,000

These improvements would add 77 million gallons per day to the total dependable supply of the Region at the low cost of \$287,000 per million gallons of capacity.

In order to realize the full benefit from the recommended Passaic Valley Water Commission development it will be necessary for the State Water Policy Council to approve an increase in the Commission's taking from the Passaic River from 75 to 90 million gallons per day.

2. For the Major Intermediate Supply

In order to assure an ample supply of water for the estimated demands after 1960 it will be necessary at the earliest possible moment to undertake the planning, acquisition of land for and construction of a major new water supply system. For this development the execution of the 70 million gallon per day scheme of the Chimney Rock Project is recommended. This finding was reached after careful consideration of all of the factors set forth in the preceding Chapter, particularly the differences in the availability of water and the large cost differential in both stages of development in favor of Chimney Rock.

In conjunction with this development it is also recommended that the dams be constructed to full height needed for the second stage and that land takings for this stage be made at this time. The estimated cost for this is as follows:

Total Cost for 70 million gallons per day Chimney Rock Development Including Dam Construction for 200 million gallons per day Stage	\$51,810,000
Additional Land Takings	<u>2,050,000</u>
Total Cost	\$53,860,000

The system should later be expanded to the 200 million gallons per day stage either in appropriate sub-stages or at one time as the growth of the Region may require.

3. For Major Supply to Year 2000

In the studies for this development the utilization of the Round Valley Reservoir site will be considered with other alternate possibilities. The Round Valley site could assume important local significance if the indications pointed to a large industrial and urban expansion in Somerset County. Recommendations for water developments adequate to the year 2000 will be made in the Final Report.

FINDINGS AND RECOMMENDATIONS ON THE EXPANDED USE OF GROUND-WATER

An estimate of the use of ground-water in New Jersey in 1950 indicates that somewhat more than 500 million gallons are used each day for all purposes.

Of this, about one-third is used for municipal supplies, one-half is withdrawn by industry and approximately one-sixth for rural and irrigation uses combined.

Most ground-water problems in New Jersey result from the local demand exceeding the capacity of the local water-supply installations, or because of pollution or contamination of the supply, rather than because of any widespread inadequacy of the ground-water resource itself. However, overdevelopment has occurred in a few places where the quantity of ground-water available is less than the requirements of the locality. For the most part, areas in which the demand has exceeded the supply are underlain by rocks of the Piedmont Plain or the Highlands and Appalachian Valley Geologic Provinces in which the storage and movement of ground-water are generally unfavorable.

In New Jersey, except perhaps in the Piedmont Plain, changes in the chemical quality of ground-water supplies appear to be a more serious problem at present than that of exceeding the dependable yield. The withdrawal of ground-water is always accompanied by a lowering of water levels. If water of undesirable quality is present near wells, the gradient that is established toward the wells as soon as withdrawal begins may cause the undesirable water to enter the wells. As a result, many wells near the coast or adjacent to areas of brackish water, such as inland bays and tidal streams, no longer produce fresh water. Occurrences of contamination by salt water are numerous along the Atlantic Coast from Cape May to Newark and along Delaware Bay below the Camden area.

Wells polluted by industrial wastes are more spotty in their occurrence but as would be expected, they are more likely to present problems in the manufacturing areas of the Northeastern Metropolitan Region, and along the Delaware River below Camden. In some cases, industrial pollution is so limited as to affect only the wells of the industry responsible for the pollution, but in other cases, a single source of pollution may be evident throughout a neighborhood of considerable size. Where water infiltrating from streams or rivers furnishes an appreciable part of the water obtained from wells, pollution of the surface sources may seriously detract from the usability of the ground-water. In the Philadelphia-Camden area, where well supplies are maintained in considerable part by recharge from the Delaware River, the industrial pollution in the river water is of increasing concern.

Although a large amount of information has been gathered in numerous local areas, knowledge of New Jersey's ground-water resources on a state-wide

4. Provision should be made to obtain and hold in reserve for future use some of the more favorable ground-water reservoir areas in the interior Plain of Central and Southern New Jersey. The Pine Barrens area, of which the Wharton Tract is a part, is one of the most favorable ground-water provinces in the Eastern United States. The undeveloped nature of the terrain, the abundance of ground-water in storage, the quantity and quality of water perennially available from recharge and the nearness to present and future large centers of population and industry are justification for action now by the State to obtain and hold for water-supply purposes tracts that will supplement the needs of such areas as Camden, Atlantic City, Asbury Park and others. The remainder of the Wharton Tract not now owned by the State should be purchased and consideration should be given to reserving one or more tracts in the Northern Pine Barrens for future ground-water developments.

The feasibility of such large-scale ground-water developments is enhanced by several factors. Chief among these are:

- a. The utilization of the water resources beneath the land surface can be accomplished without loss of the land area itself, except that zoning compatible with good watershed management should be maintained.
- b. Use of the natural underground reservoir rather than an open body of water on the land surface will greatly reduce evaporation losses.
- c. After the major pipe lines are installed, the actual production of the water supply can proceed as needed, section by section, without the necessity of reservoir construction based on design requirements of some period far in the future.
- d. Problems of color and turbidity control will generally be absent in ground-water supplies from these areas, whereas, water treatment to overcome these problems will be required if water from surface reservoirs is used.
- e. In areas such as the Wharton Tract, greater maximum utilization of the available water can be made by means of well fields rather than surface reservoirs.

The topography of the area is such that shallow surface

reservoirs would develop only a small part of the water supply. When the surface reservoir is drawn down, the underlying ground water reservoir would still be essentially full of water to a depth of perhaps 200 feet. This vast quantity of water in underground storage could be withdrawn only by means of a ground water development.

RECOMMENDATIONS FOR LEGISLATION

The suggested steps to be taken by the New Jersey Legislature in order to implement the execution of the recommended program is set forth in detail in Chapter V which follows.

CHAPTER V

LEGISLATIVE ACTION

The engineering objectives and recommendations outlined in the preceding chapters will require a legislative program to provide for their legal, administrative and financial requirements. In general, this includes legislation:

- A. To authorize the development, design and construction of a major water supply or supplies to solve the long-range water needs of the State, and also to permit service and operating responsibility to remain in the various public and private water supply and distribution systems within their respective service areas;
- B. To provide immediate relief of current water shortages by facilitating the increase of water supply from existing systems through additional development and improved distribution of the total available supply; and
- C. To strengthen the police powers of the Division of Water Policy and Supply, so as to assure the most efficient use of existing supplies in light of local needs and safe yields.

ADMINISTRATIVE AGENCY

The nature of these legislative powers, as well as the financial requirements to be developed, practically dictate the need for a state water agency to administer the construction program and arrange for its financing. This does not mean, however, that the state must go into the business of selling water at retail. From an engineering standpoint a clear choice of methods is open:

1. The state agency may be authorized to acquire, construct, finance, operate and maintain new water supply systems; or
2. The state agency may be authorized to acquire, construct, and finance new water supplies, but to turn them over for operation to an appropriate district, regional or municipal operating system, as determined by the legislature.

The choice between these two alternatives is a matter of legislative policy. In the selection of that policy, however, it should be pointed out that the State's water problem can be resolved most effectively and economically

but the matter is principally one of legislative policy rather than of engineering necessity.

A brief summary of the arguments pro and con may be convenient as a matter of public information. Normally an existing state agency would be the first choice. In the present case this would be the Division of Water Policy and Supply, which is headed by a Director responsible to the Commissioner of Conservation and Economic Development. This has the obvious advantage of turning the work over to a division which has long been associated with the State's water problems, and which is already integrated within the State's administrative structure.

A newly constituted water agency, also established within the same department, would permit the legislature to create a board or commission as its head. This would offer the opportunity, if desired, of giving representation to the various counties, municipalities and water supply systems most directly interested. As a new administrative unit, such a water agency might have greater flexibility of organization, staffing, and policy.

From the viewpoint of administration, either choice would require an essentially new administrative unit with respect to personnel, office space, legal, engineering and other technical services. In either case, also, the actual design, construction and supervision of the work would undoubtedly be accomplished through the usual contractual arrangements. In brief, the choice is principally in the type of top policy-making body which would be most satisfactory from the viewpoint of the Governor and the legislature.

POWERS OF THE STATE WATER AGENCY

The principal powers of whatever state water agency is selected will necessarily include power:

1. To design, construct and operate one or more new major water supplies as may be authorized by law, but not to operate any local distribution system.

This would require legal authority not only to construct and finance the new supply system but also to select and acquire sites in North, South and Central Jersey for conservation and development of water sheds, for dams, reservoirs and pumping stations, and rights of way for transmission lines and for the acquisition of additional ground water preserves. Legislative policy with respect to the choice among these expenditures could, if

desired, be carried out through the annual control of appropriations.

2. To construct, or to advance capital to existing public systems to construct, approved extensions and additions to existing systems; and to arrange by contract the control and disposition of the additional water made available by such construction for use where needed.

This would facilitate complete development of existing water systems similar to the recommendations made in this report for augmenting the existing Northeastern Metropolitan Region supplies. This power together with Item No. 3 below, appears well adapted to eliminate the reasons why existing public systems have not yet built the reservoirs which could with comparative speed augment the dependable supply available to the Northeastern Metropolitan Region. The reasons for past delay may possibly be classified as follows:

(1) The system itself does not require the additional supply; (2) The system itself requires the additional supply only if it continues to sell water to non-members, with the appearance that the system in fact is expanding its resources for the benefit of others; (3) The system does not need an additional supply except to meet shortages in times of extreme drought, and it is uneconomical to make a major investment for such limited use; (4) The system in fact has a sufficient supply but has a poor distribution system to meet peak loads, the correction of which would require such a great capital outlay that it would not produce a commensurate return to the private operator; and (5) The interchange of water between surplus and deficit systems is limited either by lack of inter-connections or by cost differentials between the two systems.

3. To integrate the total water supply resources of the state for its total needs through the construction and operation of inter-connections, reservoirs and booster stations; the making of contracts with existing systems for transmission of water and for the exchange between existing and new supply systems.

This will provide increased efficiency in the operation of both existing and proposed new supplies.

4. To enter into agreements with public and private water systems for the joint construction or operation of inter-connecting facilities by such public and private systems, and to transfer water between operating systems at established rates, with the approval of the State Water Policy Council.

This would permit the equalization, for purposes of inter-change of water, of water rates within a supply district and would have the effect of

eliminating an economic deterrent to the exchange of water between systems due to differences in cost.

5. To acquire for public use, upon payment of just compensation, the surplus water in any public or private system and the unused water shed rights of any such system when needed to prevent regional shortages.

This would permit the recapture of unused water shed rights, as a last resort, where the owner of such rights declines to use or permit the use of them for the benefit of the general area served. This would prevent the hoarding of water rights which places an unfair burden on the area as a whole by making it necessary to bring water from greater distances and at much higher costs.

6. To acquire additional ground water reserves, and to construct and maintain water conservation facilities, as it may find necessary and desirable.

This would permit the acquisition of preserves similar to the Wharton Tract for the purpose of serving other areas of the State.

7. To enter into contracts, and to pledge its revenues and property as further security therefor.

8. To acquire real and personal property for its authorized purposes by gift, purchase, lease or condemnation.

FINANCIAL REQUIREMENTS

The recommended program of short-range improvements and long-range development will require immediate capital funds, which may be provided in whole or in part through bond issues, and continuing current income, which may be provided in whole or in part from water charges. It is the purpose here to review alternative methods for meeting these requirements. The choice of method largely depends upon what is deemed to be a fair allocation of total cost.

1. General Credit and General Revenues

In most of the past proposals it has been assumed that the development of new supplies will require the use of the general credit of the state, supported by general tax revenues as long as the new supplies operate at a deficit. Since the only efficient way to build new supplies is to anticipate the needs of future years, it should be expected that any new supply may operate initially at a deficit, and certainly will be unable to

meet debt service charges out of revenues for a number of years if an excessively high initial rate for the new water is to be avoided. It is, of course, feasible to finance all of the requirements of the new program in this way, provided existing or foreseeable State tax revenues are available for this purpose.

In view of the fact that the first expenditures of a major character will be of special benefit to the Northeastern Metropolitan Region, and in consideration of the advantages of avoiding a new burden on the State's treasury, alternative ways of financing the program, based upon an equitable allocation of its costs, may well be considered.

2. General State credit supported by three special revenue sources

An equitable system of financing may be based upon a recognition of the benefits received from an adequate water supply, beyond those realized by water users. These benefits may be realized by persons and property as follows:

- a. The community being better served, each individual property owner within the area of the improvement is indirectly benefited because of the availability of water for potential use, which enhances the value of his property.
- b. Each person realizes benefits from improved fire protection, health, industrial prosperity, and civic improvement, all of which require adequate water supply.

In view of these non-user benefits, a method of financing the cost of the water supply which places the entire cost upon users may well be questionable. In the present state of development of the New Jersey program, moreover, a method of financing which places the burden of operating deficits and unearned fixed charges on general State revenues may also be open to question. If the Legislature desires to recognize these questions of equity, it may apportion the various elements of cost according to a statement of policy which has been adopted by a professional study group consisting of water engineers, investment bankers, lawyers, governmental administrators and public utilities commissioners, as follows: 1/

1/ Fundamental Considerations in Rates and Rate Structures for Water and Sewage Works. A Joint Report of Committees of the American Society of Civil Engineers and of the Section of Municipal Law of the American Bar Association and Representatives of the American Water Works Association and various other associations.

"The needed total annual revenue of a water works shall be contributed by users and non-users (or by users and properties) for whose use, need and benefit the facilities of the works are provided approximately in proportion to the cost of providing the use and the benefits of the works".

This statement of policy should be applied in recognition of the natural division of the costs of a water supply system into the following three types of cost:

- a. Acquisition and construction of major structures, dams, reservoirs, main pumping stations and transmission mains - these benefit non-users as well as users;
- b. Local distribution including booster pumps, lateral mains, distributing reservoirs and standpipes - these are of local benefit only;
- c. Current operation and maintenance including pumping and treatment - these benefit consumers only.

It has been assumed that the most favorable method of financing would be upon the general credit of the State - but this does not necessarily mean support by general revenues of the State. In fact, the types of cost and benefits to non-users would make it inequitable to use either all general revenues (which do not recognize special benefit to users) or all service charges (which do not recognize benefits to non-users).

Capital costs are especially suitable for some support from non-user revenues. If such support is not provided, those who use the facility will pay the capital costs and those who do not have immediate use but do have ultimate need and present benefit would escape a fair part of the Capital burden.

In the case of any single improvement, moreover, the non-users will enjoy benefits which are different in kind and degree depending upon their location with respect to the improvement. It would be fair and equitable to recognize the difference in non-user benefits in establishing the method of finance and allocation of the cost.

These considerations suggest three sources of revenue to support the immediate, and long-range programs:

1. Water Service Charge

This is the basic charge to the users of water. In the past this charge has included all costs in connection with the supply of water except in the cases where operational deficits were covered by general taxation. The service charge still remains the simplest and most direct, though not the most equitable means of collecting water revenues.

It is obvious, however, that whichever means may be chosen to produce water revenues, the service charge should include the interest charges on the capital cost of the water facility, plus all costs of operation, maintenance, pumping, treatment and management.

2. Special State Assessment to be Levied Upon Benefited Property

In accordance with the principle that users and non-users alike, within the area served by a water supply receive benefits from the water supply, a special State assessment based on property values or other equitable determination might be levied to finance the capital costs (principal only) of the water development.

Since the needs and benefits of non-users vary widely in different sections of the State, it may not be considered equitable to use general state revenues to provide the needed capital. Instead this need can be equitably treated by analogy to the special benefit assessment for local improvement. The difference is that in the present case the Legislature, rather than a local governing body, will authorize the assessment and define the benefited area for each improvement. The State water agency will then spread the assessment according to the legislative mandate. It is likely that, for the sake of convenience of administration, the Legislature would desire to include entire counties within the area of assessment - and for legal reasons should preferably do so - and require each county to raise its apportioned share of the cost by a special water millage added to the general tax rate.

The water millage will be extremely small since it could spread the acquisition and construction cost over 40 years while the interest would be charged to water users as part of the water rate. For example, a \$50,000,000 water development amortized on a straight line basis would require \$1,250,000 to be raised yearly from the benefited area. In the Northeastern Metropolitan Region this would amount on the average to about 25 cents on each \$100 of tax paid by property owners. In other words a person who pays a tax of \$400 per year would pay an assessment of one dollar.

3. A Uniform Water Use and Diversion Fee:

This would extend the existing tax on "excess" diversion of R.S. 58: 2-1 et. seq.) to include all present users of water. Funds raised in this manner would support over-all planning, surveys and tests and help to finance immediate extensions and additions to existing public systems. Of most importance, it could be used to make up operating deficits without resort to general revenues.

It is the present users of water who have the primary interest in protecting present supplies against shortage and drought. The precise interest of any one consumer cannot be measured. If we follow the policy, however, that every user is protected in his use only because someone else is not permitted to divert surface waters or overpump ground waters, under State regulatory law, (e.g. R.S. 58: 4A-1 et. seq.) the common interest of all present users in protecting and increasing present supplies is plain. This justifies placing some cost on all water users, whether or not they are immediate users of any new supply.

The present tax, imposed by R.S. 58:2-1 et. seq., is levied at a rate of not less than \$1 nor more than \$10 per million gallons, as fixed by the Water Policy and Supply Council. In North Jersey alone, with the proposed amendments, it could yield approximately \$765,000 for each \$5.00 of rate charged per million gallons of water based on present consumption.

If all three of these sources of revenue were available, the water supply projects would not represent any burden at all upon general taxation.

Of most importance, the provision for paying amortization out of a State special assessment, would assure an attractive selling price for the new water.

Using as examples the estimated costs for both construction and operation of the proposed Round Valley and Chimney Rock Projects, the comparative costs of water with different methods used for making water charges are as follows:

	Service Charge Bearing All Costs Except Deficit Oper. <hr/> Cost Per Mil- lion Gallons	With Special Assessment for Capital Cost plus Diversion Tax <hr/> Cost Per Mil- lion Gallons	With 50% Deficit Operation	
			Service Charge Carrying All Costs <hr/> Cost Per Million Gallons	With Special Assessment for Capital Cost <hr/> Cost Per Million Gallons
Round Valley 70 million gallons per day project	\$163	\$105	\$304	\$187
Chimney Rock 70 million gallons per day project	147	86	270	169
Round Valley 200 million gallons per day project	135	97	249	151
Chimney Rock 200 million gallons per day project	103	68	186	116

WORKING CAPITAL

The state water agency should, if possible, have some working capital so that it may begin immediately the short-range improvement of existing systems, through interconnections, dams, reservoirs, etc. with a minimum addition to the needed bond issue. To this end, the Legislature may wish to consider the transfer of balances from other State funds, which may no longer be needed for their original purposes.

In summary, alternative financing would be feasible as follows:

1. General state credit and general revenues could properly underwrite the capital cost and operating deficits of the new supplies.
2. General state credit and a three-way special revenue program could equitably apportion the capital costs and operating deficits among users and non-users roughly in proportion to their respective use, need, and benefit; a uniform water use and diversion

fee (extending the present diversion tax) in recognition of the state-wide general need and benefit of the program; a state special assessment for amortization of capital costs upon property within the area of special benefit of each project; and water rates charged directly to users in recognition of their direct use and benefit thereupon.

3. Working capital provided from existing State funds in recognition of the general state interest in the problem.

ADDITIONAL LEGISLATION

Two additional bills will be required to complete the program, a bond referendum bill and an amendatory bill to strengthen the powers of the Water Policy and Supply Council.

1. The amount of the bond referendum, including \$53,910,000 for Chimney Rock, and \$22,140,000 for the recommended short-range projects, should be \$76,050,000. The method of financing to be included in this bill will depend upon the choice outlined above.
2. To strengthen the powers of the Water Supply Council, as recommended, a bill will be required as follows:
 - a. To establish legislative formulae to compel compensating flows in streams which are to be used for water supply -- this would give residents along affected streams a guarantee that their rights will be protected, and should allay the fears of injury from any proposed reservoir construction. It would require a formula which might be based on a percentage of average flow, on a fixed rate per square mile of drainage area, or similar method. As a fixed legislative rule, it would provide a firm assurance of minimum riparian flows, which the present power of the State Water Policy and Supply Council, to establish minimum releases in streams that are dammed for water supplies, may not necessarily offer.
 - b. To assure that the franchises of water supply systems now operating are being used in accordance with their terms, and particularly that local supply and distribution facilities are fully adequate to meet all requirements, including those in peak demands. This may in part be an economic problem

where improvement in local distribution would require large capital expenditures without greatly increasing revenues. However, legislation should provide assurance that the terms of existing franchises be maintained, with adequate penalties for failure to do so over any extended period of time, even to the extent of revocation for repeated and prolonged violation.

- c. To assure that ground water supplies contemplated and reserved for public development, as well as existing supplies from sub-surface sources, will not be jeopardized or encroached upon by large users or sources of pollution. This will require a review of existing "protected area" legislation so as to expand and strengthen its effect.
- d. To clarify the respective responsibilities of the Water Policy and Supply Council and the Public Utilities Commission in the field of water utility regulation.

