DELAWARE RIVER BASIN COMMISSION

Water Management of the Delaware River Basin

A staff compilation of planning assumptions, programs, data, and a means of managing the Basin's water resources.

APRIL 1975

ACKNOWLEDGMENT

Valuable assistance and data used in the preparation of this staff report were contributed by agencies of the Federal Government, and of the States of Delaware, New Jersey, New York, and Pennsylvania; by cities, counties, public districts and authorities; and by private companies and individuals. This cooperation is gratefully acknowledged.

Special mention is made of the helpful contributions of the following:

<u>United States</u>

Corps of Engineers, Department of the Army
Delaware River Master, Supreme Court
Environmental Protection Agency
Federal Power Commission
Geological Survey, Department of the Interior
National Park Service, Department of the Interior
National Weather Service, Department of Commerce
Soil Conservation Service, Department of Agriculture

<u>Delaware,</u> State of

Department of Natural Resources and Environmental Control

<u>New Jersey,</u> State of

Department of Environmental Protection

<u>New York,</u> State of

Department of Environmental Conservation

<u>Pennsylvania,</u> Commonwealth of

Department of Environmental Resources

SPECIAL CONSULTANT FOR ORGANIZATION OF REPORT

William L. Berry, Consulting Engineer

DELAWARE RIVER BASIN COMMISSION

James F. Wright
Executive Director

WATER MANAGEMENT OF THE DELAWARE RIVER BASIN

A staff compilation of planning assumptions, policies, programs, data, and a means of managing the Basin's water resources.

April 1975

DELAWARE RIVER BASIN COMMISSION
P. O. BOX 360
TRENTON, NEW JERSEY 08603

(609) 883-9500

JAMES F. WRIGHT
EXECUTIVE DIRECTOR

HEADQUARTERS LOCATION
25 STATE POLICE DRIVE
WEST TRENTON, N. J.

April 30, 1975

Members of the Delaware River Basin Commission

Gentlemen:

I am pleased to submit this staff report entitled "Water Management of the Delaware River Basin." This report is a compilation of data, planning assumptions, policies adopted by you, and the results of studies conducted by the staff and by public and private water agencies of the Basin community. Through the continuing planning process, the results of these efforts have been combined into a means of managing the water resources of the Basin in accordance with the Commission's adopted policies.

Among the many planning assumptions that necessarily must be made in developing a water management plan, three used in this report are of special significance. These three planning assumptions are as follows:

1. Three thousand cubic feet per second of flow at Trenton is required to meet the duly adopted Federal, State, and Commission maximum limit on sea salts, measured as 250 mg/l of chlorides, at River Mile 92.47, the mouth of the Schuylkill River.

2. New Jersey will perfect an application and the Commission will ultimately grant approval to the exportation of 300 million gallons per day for use beyond the Basin boundaries.

3. The Commission will limit the amount of water which may be evaporated by the electric utility industry to 182 cubic feet per second, the amount needed to operate those facilities listed in the May 1974 "Master Siting Study" as becoming operational by 1982. Availability of water for additional cooling requirements beyond that date cannot be presumed until the Commission has weighed alternative futures and storage probabilities.

The studies and the drafting of this report were started long before the Congress-mandated Tocks Island restudy that is in progress. Hence, it does not and cannot be expected to reflect the outcome of that study. I fully recognize that the current Tocks Island study and other on-going studies of the states, federal agencies, and staff, will lead to modifications of any plan of water management presented herein. This is why we have a continuing planning process, i.e., to reflect changing climatological conditions, technologies, and desires of the populace. Nevertheless, periodically, it is useful for those who are required to meet daily water demands to have a summary of those data, studies and policies, and possible plans for balancing water supply with water demands, such as presented in this report. As major revisions in policies, assumptions and objectives are determined, this staff summary will be adapted to reflect and report them.

Sincerely,

James F. Wright

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

FIGURES

Page

Part One

Part Two

FIGURES

Page

Part Two (continued)

TABLES

Part One Page

TABLES

Part One (continued)

TABLES

Page

Part Two

TABLES

WATER MANAGEMENT OF THE DELAWARE RIVER BASIN

FORMAT OF THE REPORT

In 1961, the Federal Government and the States of Delaware, New Jersey, New York and Pennsylvania - recognizing the water and related resources of the Delaware River Basin as regional assets vested with local, state and national interest for which they have shared responsibilities - entered into a one hundred year compact to provide for the joint exercise of their powers over these resources.

Among other things, the Delaware River Basin Compact requires the Commission to prepare, publish and disseminate information and reports with respect to the water problems of the Basin and for presentation of the needs, resources and policies of the Basin to executive and legislative branches of the signatory parties.

In addition, Sec. 3.1 of the Compact provides that:

> "The commission shall develop and effectuate plans, policies and projects relating to the water resources of the basin. It shall adopt and promote uniform and coordinated policies for water conservation, control, use and management in the basin. It shall encourage the planning, development and financing of water resources projects according to such plans and policy."

A Comprehensive Plan was adopted by the Delaware River Basin Commission on March 28, 1962. Since then, that plan has been amended many times to broaden its original scope and to include water or water-related projects which were found to be consistent with the goals and objectives of the Commission. This staff report is consistent with provisions of the Comprehensive Plan and proposes the best feasible means of implementing policies and achieving the goals prescribed therein.

This staff report consists of a summary and two parts. Part One is a compilation of data emanating from the staff's continuing activities and includes:

(1) estimates of the water crop falling upon the Basin,

(2) estimates of natural and regulated runoff,

(3) appraisals of the general nature and behavior of underground water,

(4) analysis of the quality of surface and underground water,

(5) forecasts of future locations and intensity of population, and

(6) predictions of future water demands.

These data and estimates are presented by the twelve major hydrologic areas, or sub-basins, that comprise the Delaware River Basin. A summary of Part One is contained in Chapter 4.

Part Two of this staff report responds to the problems posed by the conclusions drawn in Part One, and describes those physical facilities and operating criteria which will be required to regulate extremes in high and low stream flows, to manage the water quality of the Basin, and to sustain or enhance the fish, wildlife, and recreational uses of water. A summary of Part Two is presented in Chapter 6 and contains abbreviated discussions of water conditions and problems in the twelve sub-basins of the Delaware River Basin.

The policies which have been adopted by the Commission as broad guidelines for those who wish to plan for and develop water resources within the Basin are presented as "Appendix A - Water Code of the Basin."

Due to the significance of the United States Supreme Court decree of 1954, it is included, verbatim, as Appendix B.

The following summary presents, briefly, the highlights of Parts One and Two.

WATER MANAGEMENT OF THE DELAWARE RIVER BASIN
SUMMARY

The adoption of the Delaware River Basin Compact made possible the joint exercise of sovereign powers over the water resources of the Delaware River Basin in the common interest of the people of the region. Among the duties of the Commission, mandated by the Compact, is the adoption and continual updating of a Comprehensive Plan for the immediate and long-range development and uses of the water resources of the Basin. The Compact (Section 3.6f) also requires the Commission to prepare a "presentation of the needs, resources and policies of the basin to executive and legislative branches of the signatory parties." This staff report responds to that requirement.

Part One

Scope

The scope of activities leading to preparation of this staff report includes (1) estimates of the water crop falling upon the Basin, (2) estimates of natural and regulated runoff, (3) appraisals of the general nature and behavior of underground water, (4) analyses of the quality of surface and underground water, (5) forecasts of future locations and intensity of population, (6) predictions of future water demands, and (7) studies of the alternate means to meet those demands.

This staff report describes those physical facilities and operating criteria which would be required to regulate extremes in high and low stream flows, to manage the water quality of the Basin, and to sustain or enhance the fish, wildlife, and recreational uses of water. The policies which have been adopted by the Commission as broad guidelines for those who wish to plan for and develop water resources within an overall Basin-wide frame of reference are presented as "Appendix A-Water Code of the Basin."

Sub-basins of the Delaware River Basin

For convenient presentation of hydrologic and hydrographic data, the Delaware River Basin has been divided into 12 sub-basins. These sub-basins, shown on Figure 1-3, were delineated to correspond with important points on the Delaware River, or to isolate major tributary drainage areas. The 12 sub-basins are identified by brief descriptions presented in Table 1-1.

Precipitation

The occurrence of precipitation over the Delaware River Basin is fairly uniform both in space and time. Near the mouth of Delaware Bay, the average annual depth of precipitation is about 40 inches, while in a small area of the Catskill Mountains in New York State it is about 60 inches. The areal distribution of precipitation in the Basin is shown in Figure 1-4.

The average annual depth of precipitation over the entire Basin amounts to about 44.6 inches. The highest monthly rainfall usually occurs in July or August, amounting to 10 or 11 percent of the annual total. February and October have the lowest average monthly precipitation, with 6 and 7 percent respectively.

The total average annual precipitation amounts to about 9,800 billion gallons (approximately 30 million acre feet). The losses attributable to the combined processes of evaporation and transpiration result in the depletive use of approximately one-half the precipitation occurring in the Delaware River Basin.

Runoff regulation

Streamflow rates are observed (measured) at many stream gaging stations operated by the U. S. Geological Survey and other agencies throughout the Delaware River Basin. Such observed flows, averaged over the periods of record, are presented in Table 1-3 for selected gaging stations.

Table I-3 lists both the minimum monthly and minimum seven-day flows of record for each of the selected stations.

A few regulatory storage facilities to augment main streams of the Basin during periods of drought have become operative since the times of the observed minimum flows listed in Table I-3. A United States Supreme Court decree mandates that flows at or above 1,750 cfs be maintained in the Delaware River at Montague, New Jersey, by the City of New York in connection with its exportation of water from the Basin. Table I-4 presents for selected stations in the Delaware River Basin estimated minimum monthly flows, modified to reflect conditions as they existed in 1972, that could be expected if the droughts of record were to recur.

Flood flows

The observed peak flood stages and flows of record at selected gaging stations in the Delaware River Basin are presented in Table I-5. Where regulatory flood control storage has been created since the date of the peak observed flood of record, estimates of both the stage and flow which would have occurred under the existing flood operation schedule, are also presented.

With repetition of the historic floods of record, even with the protective facilities available in 1972, substantial areas of inundation of highly developed properties can be expected adjacent to the Delaware, Lehigh, and Schuylkill Rivers and numerous secondary streams. The flood control facilities constructed since the damaging storms of 1955 would reduce the flood stage of the Delaware River at Trenton by only 1.3 feet.

Imported water

During calendar year 1970, total importation of water averaged 30.7 mgd (47.5 cfs). The total authorized importations of water into the Delaware Basin amounts to 66 mgd (102 cfs). (See Table I-6).

Exported water

The amount of water exported from the Basin during 1970 averaged 673 mgd (1,042 cfs), a figure that is expected to increase to 1,211 mgd (1,875 cfs) by the year 2000. The latter total includes the 800 mgd (1,238 cfs) that can be exported to New York City and 100 mgd (155 cfs) to northeastern New Jersey under the U. S. Supreme Court decree of 1954 (See Appendix B). It also includes a proposed - but not yet authorized - additional exportation of 300 mgd (465 cfs) to northeastern New Jersey.

Ground water

The total quantity of water stored in the aquifers of the Basin is estimated to be in the order of 10,000 to 15,000 billion gallons (31 to 46 million acre feet), or three to five times the average annual volume of discharge by the Delaware River at Trenton, New Jersey. This large quantity is not available for total withdrawal and use under any conceivable circumstances. Above the Fall Line sufficient water is generally yielded from the fractures in the rock structures to meet the needs of individual households, and small communities, while below the Fall Line in the areas overlying well defined sand and gravel aquifers, the yields are sufficient to supply water needed by cities of substantial size.

Surface water quality

The quality of fresh water streams throughout the Basin is such that the waters are suitable for all of the higher uses, reflecting a dissolved oxygen content above 4.0 mg/l, pH between 6.0 and 8.5 and total dissolved solids less than 150 mg/l. Variations from this generalization, as depicted in Table I-7, are found,locally, adjacent to the large concentrations of population and industry, and immediately downstream of coal fields in the Lehigh and Schuylkill River watersheds where waters of high acidity are encountered. The tidal Delaware River between Trenton and Wilmington is degraded by excess amounts of organic wastes, reducing the oxygen levels during summer periods to unacceptably low levels. Localized areas of high coliform counts also are encountered in this reach of the River.

Availability of water for reuse

Users of water within the Basin in 1970 depended heavily upon direct withdrawal from streams and aquifers to meet their needs, with relatively little use of regulatory storage. Generally, water was available at the users' intakes in amounts exceeding their pumping rates. With few exceptions, the water withdrawn by public and large private water-supply systems--from either surface or underground sources-- was discharged to surface waterways after use, diminished only by consumptive losses and altered in quality in varying degrees.

Population

The population of the entire Delaware River Basin was about seven million in 1970. Table I-8 lists historic populations of the 12 sub-basins from 1920 to 1970 and those projected through the year 2020. While the projections indicate that the total Basin population will exceed 12.5 million in the year 2020, more than three-quarters of this number will be concentrated in Sub-basins 5 through 8.

Depletive Water Use

Use that puts water into the atmosphere by evaporation or transpiration, or incorporates it in the growth crops or products and does not return it to a surface waterway or an aquifer, is called depletive use.

Estimates of depletive uses of water were made for each of the following five water use categories: (1) rural-domestic, (2) municipal, (3) industrial, (4) agricultural, and (5) exports. Category (3) industrial, was further divided into general industrial and steam electric power generation. Similarly, Category (4) agricultural, was divided into irrigation and livestock.

Municipal water use -- In 1970, average municipal per capita water demand, which reflects commercial, industrial, municipal, and domestic services within the public water service systems, varied from 108 to 177 gallons per capita per day. The Basinwide weighted average was 145 gallons per capita per day.

The upward trend in municipal per capita water demands within the Basin since 1930 has been approximately at a rate of 1 percent per year, without indicating any sign of leveling off or subsiding. However, for conservative planning purposes, this staff report uses a "low estimate" that does not incorporate this increasing trend.

The record of water withdrawals by the City of Philadelphia provides an opportunity to establish a reasonable basis for determining in which months the maximum water demands and resultant maximum depletive uses of water are likely to occur. The average monthly percentages of Philadelphia's total yearly water withdrawals for the five-year period, 1966-1970, are shown under the column "municipal" in Table I-12; the highest monthly demand occurring in July, with August being a close second.

Export of water.--The City of New York obtained its present rights to export up to 800 mgd of water from the Delaware River Basin by means of a United States Supreme Court decision on June 7, 1954. Due to the significance of that decision, it is included, verbatim, as Appendix B of this staff report. The right of the State of New Jersey to export up to 100 mgd from the Basin was also established by the Court in its 1954 decree.

Average annual authorized exports by all agencies are expected to increase from an average of about 673 mgd in 1970 to 911 mgd, the full entitlement, by 1980.

Water exported from the Basin can be grouped with depletive uses of water within the Basin, when considering its impact upon low flow conditions.

Maximum depletive use of water.--In planning for future water development in the Delaware River Basin, the most significant demands upon the water supply are those which deplete low stream flows. Estimates of maximum depletive use of water, including exports, during periods of critically low stream flow therefore provide a basis for determining the remaining water supply available for downstream uses. The maximum depletive use will occur in July.

The maximum monthly average depletive use of water for all purposes throughout the Basin, including exports, other than to New York City, is presented in Table I-18. This summary excludes Sub-basin 1 because those depletive uses are made up by New York City, under terms of the 1954 Supreme Court Decree, by sustaining the required flow at the downstream boundary of Sub-basin 1.

The predicted increase in maximum monthly basinwide depletive use will be moderate during the present decade, rising from 551 mgd in 1970 to 778 mgd in 1980, an increment of about 40 percent. However, with a fivefold increase expected in exports below Montague, N.J., during the following two decades, the maximum monthly basinwide depletive use of water is forecasted to reach an average of over 1,304 mgd by year 2000, increasing at a slower rate thereafter to about 1,353 mgd by 2020.

Instream Uses of Water.--In addition to the withdrawal demands and depletive uses of water discussed in the preceding sections, water is also used within the streams and other surface waterways of the Delaware River Basin, for navigation, hydroelectric power generation, fish propagation and fishing, wildlife management, recreation, waste assimilation, and salinity control in the estuary of the Delaware and its tidal tributaries.

Salinity control.-- Table I-20 shows the extent of sea-water intrusion during the drought emergency of 1964-65, as measured by the location of the tidal waters having a chloride concentration of 250 mg/l, with corresponding combined fresh-water inflows from the Delaware and Schuylkill Rivers for the preceding 30 days. By the use of both hydraulic and mathematical models, the Commission has determined that for the mean level of the sea as of 1970 and for average seasonal conditions of tide, wind, and runoff from the drainage area below Trenton, a sustained Delaware River flow at Trenton of 3,000 cfs (1,939 mgd) during the low-flow season would prevent the 250-mg/l isochlor from penetrating upstream of the mouth of the Schuylkill River.

Relationship of Basin Water Demands to Developed Supplies

A generalized overall assessment of the capability of the water resources of the Delaware River Basin, as developed at any given point in time, to meet the corresponding demands placed upon them for all purposes and uses, may be obtained by comparing the minimum assured discharge of the Delaware River at Trenton to the 3,000 cfs requirement for sustained flow at that station. Implicit in the comparison is the satisfaction of all authorized demands for water both above and below Trenton.

In Table I-4 of Chapter 2, it is pointed out that the estimated minimum monthly average flow in the River at Trenton, modified to reflect conditions of regulation and depletive use existing in 1972, was only 2,700 cfs. It is apparent, therefore, that as of 1972, there was an indicated overall inadequacy in development of water supplies of the Delaware River on the order of 300 cfs (194 mgd).

As illustrated in Figure I-7, the deficit, during critical drought periods, would increase to over 1,130 cfs (730 mgd) by year 2020 without additional storage facilities.

Part Two

Part Two of this staff report proposes a solution to the water resources problems and needs developed in Part One, with particular emphasis on describing those physical facilities and operating criteria which will be required to meet on a timely basis the estimates of future water demands for adequate water supply, for improvement of water quality where needed, for flood damage reduction by structural and nonstructural measures, and for water-related recreation, fish and wildlife needs.

The Delaware River Basin Commission has, through its continuous studies and working with the parties signatory to the Compact, developed its Comprehensive Plan for the immediate and long-range development of the water resources of the Basin. It is this plan and program of basin management, consisting of a Water Code of the Basin which sets forth the guiding policy of the Commission, and a Physical Structure of the Plan which is comprised of both the duly adopted existing water resource facilities of the Basin and the proposed and similarly adopted future water resource projects of the Basin, that is the basis of this staff report.

In implementing the Delaware River Basin Compact, the Commission has from time to time promulgated policies which can serve as guidelines to those agencies and individuals engaged in developing plans for use of the Basin waters. These policies, which were subjected to public hearings and appropriate modification prior to final action, have covered a number of fields and are set forth in the Water Code of the Basin. (See Appendix A).

A project approved by the Commission for incorporation into the Comprehensive Plan, may be modified in location, layout, physical structure, service area or other features as it moves from the planning stage into final design, leading to final review and consideration for approval pursuant to Compact Section 3.8. Further, approval of a proposed physical project does not mandate its construction.

The Comprehensive Plan is built on the premises that: (l) the surface waters of the Basin are to be maintained satisfactorily for domestic, agricultural, industrial, recreational and fish and wildlife uses, except where natural salinity precludes such uses; and that (2) the underground water bearing formations of the Basin, their waters, storage capacity, recharge areas, and ability to convey water shall be preserved and protected.

Objectives

The staff of the Delaware River Basin Commission has established certain principal management objectives:

--The attainment of satisfactory minimum sustained stream flows at key locations in the Basin during critical drought periods.

--The concurrent control to acceptable limits of the intrusion of sea water into the tidal Delaware River Estuary.

--The replacement in the stream system of water depletively used or exported from the Basin during such critical drought periods.

Minimum-flow and Salinity control objectives -- Objectives for minimum streamflows have been specified for three key locations on the Delaware River.

1. Montague, New Jersey.--Sustain a minimum flow of 1,750 cfs at Montague.

2. Trenton, New Jersey.-- A minimum-flow objective of 3,000 cfs at Trenton.

3. Delaware River below the Schuylkill River. --A minimum -flow objective of 3,600 cfs for fresh-water runoff in the Delaware River below the mouth of the Schuylkill River to control sea-water intrusion in the estuary, by maintaining the concentration chlorides at or below 250 mg/l at that point.

Replacement of water depletively used -- The replacement of water evaporated, transpired or exported from the Basin.

The depletive uses of water are projected to increase from a maximum monthly average of 551 mgd in 1970 to 1,353 mgd in 2020. These estimates exclude Sub-basin 1 where depletive uses are replaced by New York City by maintaining a minimum flow of 1750 cfs at Montague, N. J.

Approach and methodology

Base period ----- The drought of the sixties reached its climax during the summer of 1965, when the flow in the Delaware River at Trenton dropped to a low daily average of only 1,240 cfs.

Within this staff report's criteria, reservoir storage capacity constructed after 1965 would be operated with a goal of meeting the minimum-flow objectives of 3,000 cfs at Trenton and 3,600 cfs at the mouth of the Schuylkill River at all times.

The relationships shown by the curve of Figure II-2 can be used to derive the resulting total dependable yield of streamflow from the Delaware River Basin above Trenton at given points in time.

Major Reservoirs ----- Existing major reservoirs have a combined water-supply storage of 1,003,100 acre-feet.

Storage capacity added above Trenton between 1965 and 1972 will now sustain the minimum flow of 2700 cfs at Trenton during an equally severe drought of record.

A minimum observed flow in the Delaware River at Trenton in 1970 was 3,020 cfs, a year when runoff in the Basin was 98 percent of normal.

As of December 31, 1972, there was no excess dependable flow at Trenton to replace increasing depletive uses in the Basin below Trenton. Moreover, the dependable flow will decrease with the passage of time as depletive uses continue to increase, and the inadequacy will become increasingly severe until new capacity of significant size is constructed in the Basin.

Major reservoir projects -----Twelve major authorized reservoir projects would provide a combined water-supply storage capacity of 263 billions of gallons (807,800 acre-feet). Seven of these major projects are to be constructed in the portion of the Basin above Trenton, and thus would regulate the flow of the Delaware at Trenton.

Upon completion of all major reservoirs authorized for construction upstream of Trenton, the post-1965 equivalent storage capacity available to augment low flows in the Delaware River at Trenton would provide a dependable water yield of 4,620 cfs at Trenton, minus post-1965 increments of depletive use above Trenton. This would meet the low-flow objective of 3,000 cfs at Trenton and provide 1,620 cfs for replacement of post-1965 increases in depletive uses of water in the Basin.

The Point Pleasant diversion project is a feature of the Neshaminy Watershed Plan (as amended). The authorized maximum diversion rate from the Delaware River at Point Pleasant would be 105 mgd in 1980, 135 mgd in 1990, and 150 mgd in 1995. This diversion of water would augment low flows of the North Branch of Neshaminy Creek, Neshaminy Creek, the East Branch of Perkiomen Creek, Perkiomen Creek, and the Schuylkill River, improving the water-supply characteristics of those streams.

Ground Water

The overall effect of the use of ground water is to redistribute in time the natural discharge of the ground water to the surface streams, augmenting the low streamflows and reducing the high streamflows. The quantitative measurement of all factors affecting the complex relationships between ground and surface water is extremely difficult, and the overall effect of ground-water use on the total water supply available is largely unknown at present.

Water Quality

The Delaware River Basin Commission has established that the quality of ground water shall be maintained in a safe and satisfactory condition for use as domestic, agricultural, industrial and public water supplies, and as a source of surface water suitable for recreation, wildlife, fish and other aquatic life, except when such uses are precluded by the natural quality of the ground water. Similarly, the quality of surface water shall be maintained in a safe and satisfactory condition for agricultural, industrial, and public water supplies after reasonable levels of treatment, except where natural salinity precludes such uses; for use by wildlife, fish and other aquatic life; for recreation and navigation; and for controlled and regulated waste assimilation to the extent that such use is compatible with other uses. Ocean salinity, as measured as chlorides, shall be controlled in the Delaware River at a maximum 250 mg/l at the mouth of the Schuylkill River (River Mile 92.47).

Maintenance of minimum streamflows in many waterways of the Basin, by releases of stored water from existing and authorized reservoirs during critical drought periods, will provide water-quality benefits by maintaining a dependable assimilative capacity in relation to the residual waste loads in treated effluents. The allocation of these waste loads into the tidal Delaware River has been based upon the assimilative capacity of these waters with a minimum flow of 3,000 cfs at Trenton. This minimum flow also aids in the repulsion of sea water in the Delaware River Estuary.

Flood Control

Floods of major proportions have occured intermittently along the primary and secondary streams of the Delaware River Basin. While some new flood control facilities have since been constructed, a repetition of the highest recorded flood stages of the past would result in major destruction, except in relatively localized areas.

Existing large reservoirs in the Delaware River Basin have a storage capacity of about 59 billions of gallons (179,800 acre-feet) dedicated to flood control, all located on tributaries of the Lackawaxen and Lehigh Rivers. Existing flood-control storage capacity in the many small flood-retarding reservoirs throughout the Basin totals almost 8 billions of gallons (24,000 acre-feet).

The Commission has included 5 large reservoir projects having storage allocated to flood control in its Comprehensive Plan. These projects, when constructed, would add 140 billions of gallons (428,000 acre-feet) of flood control storage to that already in existence. These projects, combined with the extensive flood-plain studies being carried out in cooperation with the Department of Housing and Urban Development and other non-structural programs, being pursued by all authorized agencies, provide a balanced approach toward realistic flood-loss reduction throughout the Basin.

Recreation, Fish and Wildlife

The Delaware River Basin offers excellent recreational opportunities and facilities from the mountain resort areas in the highlands to the shore resorts on Delaware

Bay. The Basin is rich in fish and wildlife resources, including trout streams in the northern area, and an abundance of finfish and shellfish, wild game and waterfowl. Existing recreation facilities are for the most part sustaining maximum use, although Delaware Bay and the tidal segment of the Delaware River can accommodate greatly increased use for boating and many other water-related recreational activities.

The Commission is continuously coordinating development of water-related recreational facilities in a timely manner to insure the availability of adequate facilities to meet existing and projected demands, and to insure adequate quantity and quality of the waters of the Basin to preserve and enhance fish and water-related wildlife resources and habitat.

WATER MANAGEMENT OF THE

DELAWARE RIVER BASIN

PART ONE

CHAPTER I - INTRODUCTION

The waters of the Delaware River Basin (See Figure I-1) have been sought after, used and abused since earliest times. These same waters, which provided passageways for the immigrating people, became the focal point of conflicts between those wishing to variously utilize the waters for sources of potable-water supply, to carry their waste products, to provide water power to the industries, and to serve as navigational links, as well, incidentally, as conflicts between the people and the many species of fish which plied the water course in their efforts to sustain and perpetuate their life cycles. Conflicts over uses of Delaware waters have continued into modern times, bringing with them temporary solutions in the form of court decisions, physical structures and legislative actions. One such legislative action was the adoption of the Delaware River Basin Compact which made possible the joint exercise of sovereign powers over the water resources of the Delaware River Basin in the common interest of the people of the region. The Compact created the Delaware River Basin Commission. Among the duties of the Commission, mandated by the Compact, is the adoption and continual updating of a Comprehensive Plan for the immediate and long-range development and uses of the water resources of the Basin. The initial Comprehensive Plan was adopted on March 28, 1962 and has been updated continuously since that time. However the Compact (Section 3.6f) also requires the Commission to prepare a "presentation of the needs, resources and policies of the the basin to executive and legislative branches of the signatory paties." This staff report responds to that requirement.

Before focusing on management of the water resources of the Delaware River Basin, it will be helpful to review briefly the history and cultural development of the area. Then, in perspective, it will be easier to grasp the magnitude of relating the planning, management, and development of water resources of the 12,765 square miles of drainage area to the social, cultural, and environmental needs and concerns of the Basin's residents. Also relevant to the planning process is the significance of the Basin's economy and ecology to the Nation and the world at large.

Early history

Following the first recorded discovery of the River by Henry Hudson in 1609, the Dutch established the earliest trading posts near what is now Gloucester, New Jersey and Lewes, Delaware. A Swedish expedition in 1638 established forts and colonies in the area where Wilmington and New Castle now are located. The Dutch protested, but were unable to retaliate until 1655, when Governor Stuyvesant of New Amsterdam sent a fleet of seven vessels and the Swedish garrisons surrendered. By 1664 the English had extended their dominion to the Delaware region, and the Duke of York became proprietor of the whole coastal region from Canada to the Delaware, and English colonists began moving into the lower Delaware region from Virginia, Maryland and New Jersey. The river got its present name from Lord De La Warre, a colonial governor of Jamestown.

This was the beginning of the Colonial Period of American history. It was not by accident that the most intensive concentration of population, industry, and transportation in the new colonies developed steadily along the sixty-mile stretch of the

Figure I-1.--Location of the Delaware River Basin.

Delaware from Wilmington to Trenton. There is an imaginary line across the Delaware River Basin from the northeast to the southwest which some geologists and historians call the Fall Line (See Figure I-2). It is the land elevation paralleling the Atlantic Coast where the "fast" land meets the coastal flatlands, where the swift, free-moving streams flow into the tidal estuaries, where the hills and valleys flatten into the coastal plains, wetlands and tidal marshes. The "line" is actually a narrow zone of varying width, and is called the Fall Line because of the common occurrence of falls or rapids where streams enter the coastal plain. It passes through Trenton, where the River flows over the rapids and widens out to form a sluggish, broad navigable waterway to the bay and ocean. From Trenton the imaginary line extends northeasterly across northern New Jersey to New York and Boston; on the other side of the Basin southwesterly to the Susquehanna, Chesapeake Bay, Baltimore, Washington, and Richmond. Early settlers often had to move inland this far to find fresh water supplies and timber.

The parts of the Basin thus divided are dramatically different because of the two extremes of topographic, geologic, and hydrologic characteristics. The Appalachian highlands on the northwest side are heavily forested and characterized by ridges and valleys, plateaus and mountains. Bedrock in most places is hard, dense, and relatively close to the surface. In general, the rock formations are geologically old and structurally complex. Some of the rocks contain numerous cracks and solution channels caused by earth movements and weathering; other rock areas are almost impervious to water. Except for a few favorable localities, it is an area of very limited potential for development and utilization of ground waters.

To the southeast of the Fall Line, the coastal plain is an area of low relief, consisting of clay, silt, sand and gravel overlying the bedrock. The bedrock surface dips toward the Atlantic Ocean at a rate of about 76 feet per mile, and ranges from a depth of a few feet below the land surface near the Fall Line to more than 6,000 feet below the mouth of Delaware Bay. Huge quantities of ground water are stored in the sediments of the coastal plain, and they assume great importance in the general circulation and future use of water in that area.

The Zone of Early Settlement

In the highlands, most of the streams have moderate to steep slopes, whereas in the coastal plain the stream slopes are very flat, and the tidewater extends far inland. As noted, the Delaware crosses the Fall Line at Trenton. It then flows along it to Wilmington. The River is tidal below Trenton. Fresh water mixes with saline water in the lower reaches, with the upper limit of saline water generally near Marcus Hook, at the Pennsylvania-Delaware State line. It was in this area, from the Fall Line to the ocean, where finfish, shellfish, wild fowl and game were most abundant and easily harvested. When communications and transportation of supplies were almost solely dependent on vessels, centers of commerce were necessarily on the navigable streams. But a short distance up the tributaries there was water power available for grist mills and for the early iron works and factories. Along this line, the soils and topography are amendable to agricultural uses, pastures for grazing and tillage for grain and vegetables. As horses and wagons came into use for transporting passengers and cargo between the towns and villages, the Fall Line offered the shortest and flattest route. The early railroads followed the same logic of topography and geography.

Figure I-2.--Map of the Delaware River Basin.

In 1682 William Penn arrived on the ship "Welcome" with a charter to what is now Pennsylvania and Delaware to found a colony for the persecuted Quakers. He was probably the first planner in the Delaware River Basin. Penn mapped out streets and lots and provided for a boat basin at the confluence of the Schuylkill River and the main stem of the Delaware; the birth of Philadelphia. The stage was set for the drama of man and nature to unfold in this valley. Philadelphia quickly assumed a prominent position in international shipping, regional commerce, and manufacturing. The city became a center of culture, with emphasis on education and scientific investigation. Now, three centuries later, there appears to be no slackening.

Natural features and development

Beginning a 330-mile course to the ocean, the East and West Branches of the Delaware River originate in New York State on the western slopes of the Catskill Mountains, joining near Hancock and serving as a boundary between New York and Pennsylvania; thence the river flows to Port Jervis, where it becomes the boundary between New Jersey and Pennsylvania. The upper watershed is mountainous and heavily forested, a beautiful vacation land of scenic grandeur sparsely settled with farms and small villages. The upper branches of the Delaware River and the Neversink River feed the reservoirs that guarantee the New York Metropolitan area a large supply of pure mountain water. Down to the Delaware Water Gap, near Stoudsburg, Pennsylvania, the river is swift, with riffles and long pools. The area is famous for the opportunities it affords white-water canoeists and sports fishermen. The species of brook trout indigenous to the Upper Delaware waters is highly prized. Other sport fish native to the waters include brown trout, smallmouth bass, largemouth bass, rockbass, sunfish, bluegill, pumpkinseed, crappie, and perch. The American shad makes an annual spawning run from its ocean home to the fresh, swift headwaters of the River and its tributaries. It is reported that in 1896 nearly 20 million pounds of shad were taken from the Delaware. In the first half of this century, they all but disappeared. In the early nineteen sixties they began a comeback, and their numbers now rival the good years of the last century, according to many expert observers. The natural oyster beds in Delaware Bay have sustained a thriving commercial activity over the centuries. From a harvest of 21.9 million pounds in 1887, oyster production declined to 334,000 pounds in 1960, but with the help of State controlled oyster planting ground, better management, and decline of the oyster desease MSX, oysters, too, are making a comeback and increased to over two million pounds harvest in 1972. The Bay and its estuarine tributaries support clamming and crabbing as well.

There are interrelated and interdependent facets of the Basin's economic dependence on natural resources which are interwined with the web of life permeating the physical environment. For example, the discovery and early exploitation of Pennsylvania's seemingly inexhaustible supplies of anthracite coal coincided with the birth of the age of steam power. In the early eighteen hundreds coal was floated down the Lehigh and Delaware Rivers to Philadelphia in huge barges called "arks". After unloading, the arks were stripped and sold for lumber. John Fitch had operated his first successful steamboat on the Delaware in 1790. The next few decades witnessed the early beginning of canals and railroads which expedited coal transport along the Schuylkill, Lehigh and Delaware to the navigable reach and major ports along the lower Delaware River. Over the years, acid drainage from the mine workings polluted the streams. Fortuitously, there are limestone deposits in areas downstream of some more severe sources of acid runoff which measurably neutralize a part of the excessive acidity. The presence of a convenient source of lime adjacent to an abundance of coal, as well as other factors including the occurrence of the Civil War, accelerated the establishment of major iron works, then giant steel mills on the Lehigh, Schuylkill and Delaware Rivers in the late nineteenth and early twentieth century.

By 1800 Philadelphia had become the foremost American port. Shipbuilding was an established industry all along the navigable waterways. The duPont family, wealthy French emigrants, settled in Wilmington in 1802 and established the gunpowder business. This was the cornerstone of the vast petro-chemical complex which now sprawls along both sides of the River and up its tributaries. By the early 1800's New Jersey was becoming a patchwork of truck gardens from which Philadelphia and New York bought their vegetables. With the competition from western wheat, grain farmers in New Jersey and Pennsylvania found greater profit in dairying, meat production, and poultry farms. The rise of cities and rapid growth of railways and canals hastened the growth of prosperous agriculture in all four of the Basin States. New Jersey came to be known as "The Garden State." Delaware became famous for its fruit orchards. South Jersey, with apples, peaches, grapes, and berries, also became a leading fruit producing area. By 1950, urbanization and industrial development began replacing agricultural uses of land, and acreage in agriculture has declined steadily since then. However, new and expanding irrigation in remaining farming operations is offsetting losses in irrigated acreage so that depletive agricultural water uses are projected to rise slightly in the future despite continued reduction in total agricultural acreage.

An inventory of all man's activities in the Basin region could fill many volumes. Sufficient for the purpose at hand is to point out that a River and Bay System of such diversity--from the trout streams in the Catskills, down through the primeval grandeur of the Delaware Water Gap, thence to an industrial reach lined with oil refineries, steel mills, and electrical generating stations, including the historic cities of Trenton, Morrisville, Bristol, Philadelphia, Camden, Chester, Wilmington and New Castle, an area criss-crossed with vital air, rail, highway, and pipeline arteries, on to a Bay the size of an inland sea, with its vast coastal wetlands teeming with wild fowl migrating up and down the Atlantic flyway and the rich animal and plant productivity of estuarine streams, ponds, and swamps, and a system housing a population of 7 million human beings and reaching out with goods and services to another 18 million--presents a challenge to the water resource planning process. It is obviously a matter of complexity, both with respect to the existing uses of the Basin's water and land related resources, and the competing--sometimes mutually exclusive--demands for future uses. It is also a matter of urgency, for in the very near future, what has been a relatively abundant resource may prove to be inadequate to meet upcoming demands requested or inherent with growth, unless provisions for conservation and storage are implemented.

<u>Policy questions</u>

At that point the stage is set for conflict. As an example, serving the more extreme demands of sportsmen, recreationists, and conservationists may preclude the possibility of meeting the land and water needs of expanding municipalities or industries. Yet, the same sportsmen, with the money and leisure to enjoy the recreational resources, may be dependent on a healthy expanding economy to continue in such recreational pursuits. Or, conversely, if industry, development, and population expand too fast or disproportionally in the region, the increased environmental degradation and congestion may downgrade the amenities of life to a level which could trigger devastating social, cultural, and environmental consequences. There are other questions. How far should flood-plain restrictions impinge on existing uses, or further development? Since the tidal areas of the Basin are largely dependent on ground water for drinking water and processes requiring fresh water, how much increase in depletive uses upstream can be supported without depleting or endangering the downstream aquifers which are interdependent with the surface waters? If energy is not generated within the Basin it must be imported by vessels, pipelines, rail, highway, and electrical transmission lines. Leaving aside the relative direct costs, where is the line to be drawn between conservation of the local resources and an inordinately greater depletion of resources occasioned by the lengthened lines of transportation and transmission? Decisions are now being hammered out at the polls and in the decision-making arenas of federal, state and local agencies in response to these and related questions. The resultant adopted policies must reflect in the planning process.

Dynamic equilibrium is the planning goal

Water Management of the Delaware River Basin, an expanding universe comprising one-eighth of the population of the continental United States, is not and cannot be a grandiose fixed blueprint. Rather, it is a process involving continuing inputs from diverse programs, agencies, institutions, individuals and groups representative of every conceivable human and natural interest. It is this planning process for the conservation, utilization, development, management and control of the water and related resources of the Delaware River Basin, responsive to the needs and wants of all the people under a multipurpose concept, which aims at bringing the greatest benefits and the most efficient service, that is here set forth. It is neither static nor rigid. It is a "process" undergoing modification as physical evidence, human needs, and technological advances are presented. The end product sought is a dynamic equilibrium serving the public interest. It is not within the province of this report to define the "public interest", but rather to provide the data to assist legitimate decision makers to formulate the best possible definition at any point in time. Today's long-term projections are not the ones which will be used 10 to 40 years hence. The planning process is continuously building on the best information obtainable and it must correlate with new and amended public laws and Federal-State goals.

Scope

The scope of activities leading to preparation of this staff report includes (1) estimates of the water crop falling upon the Basin, (2) estimates of natural and regulated runoff, (3) appraisals of the general nature and behavior of underground water , (4) analyses of the quality of surface and underground water, (5) forecasts of future locations and intensity of population, (6) predictions of future water demands, and (7) studies of the alternate means to meet those demands.

This staff report describes those physical facilities and operating criteria which would be required to regulate extremes in high and low stream flows, to manage the water quality of the Basin, and to sustain or enhance the fish, wildlife, and recreational uses of water. The policies which have been adopted by the Commission as broad guidelines for those who wish to plan for and develop water resources within an overall Basin-wide frame of reference are presented as "Appendix A-Water Code of the Basin".

Sub-basins of the Delaware River Basin

For convenient presentation of hydrologic and hydrographic data, the Delaware River Basin has been divided into 12 sub-basins. These sub-basins, shown on Figure I-3, were delineated to correspond with important points on the Delaware River, or to isolate major tributary drainage areas. The 12 sub-basins are identified by brief descriptions presented in Table I-1.

River mileage

The Delaware River Basin Commission uses a stream location and identification system based on river mileage. The mileage system for the Delaware River and Bay consists of a "mile zero" at the mouth of Delaware Bay and a line along which distances from mile zero are measured. Mile zero is located at the mouth of Delaware Bay at the intersection of a line between the Cape May Light and the tip of Cape Henlopen with the centerline of the navigation channel extended, as shown on United States Coast and Geodetic Survey Chart No. 1219, published 8 May 1961 and revised 28 January 1963. The position of this point, as scaled from the chart, is latitude 38° 50' 32" N and longitude 75° 03' 18" W. From the "zero" point, to Trenton, New Jersey, the mileage line is the centerline of the navigation channel. Upstream from Trenton, river mileages of the Delaware River as measured along the state boundaries as shown on United States Geological Survey maps, generally approximating the centerline of the River.

A similar mileage system is applicable to each tributary of the Delaware River by establishing a "mile zero" at the mouth of the tributary, and measuring the distance in miles above its mouth to points located on the tributary.

The following are examples of how to apply or interpret the mileage system. (1) The City of Philadelphia's water intake is located on the Delaware River at mile 110.53 and would be referenced as river mile 110.53. (2) The Plymouth Dam across the Schuylkill River is located 20.7 miles above the mouth of the Schuylkill; the mouth of the Schuylkill River is located 92.47 miles upstream of Delaware River mile zero; hence, Plymouth Dam would be referenced as river mile 92.47-20.7. (3) A stream gaging station on Perkiomen Creek, referenced river mile 92.47-32.3-9.9, would be at a point 92.47 miles upstream from mile zero of the Delaware, 32.3 miles upstream for the mouth of the Schuylkill River, and 9.9 miles upstream from the mouth of Perkiomen Creek.

The river mileage system facilitates storage, retrieval, analyses, interpretation, and dissemination of data as it is designed to work within digital computer systems, such as the Federal Environmental Protection Agency's (EPA) STORET system which is used extensively for storage and retrival of water quality data.

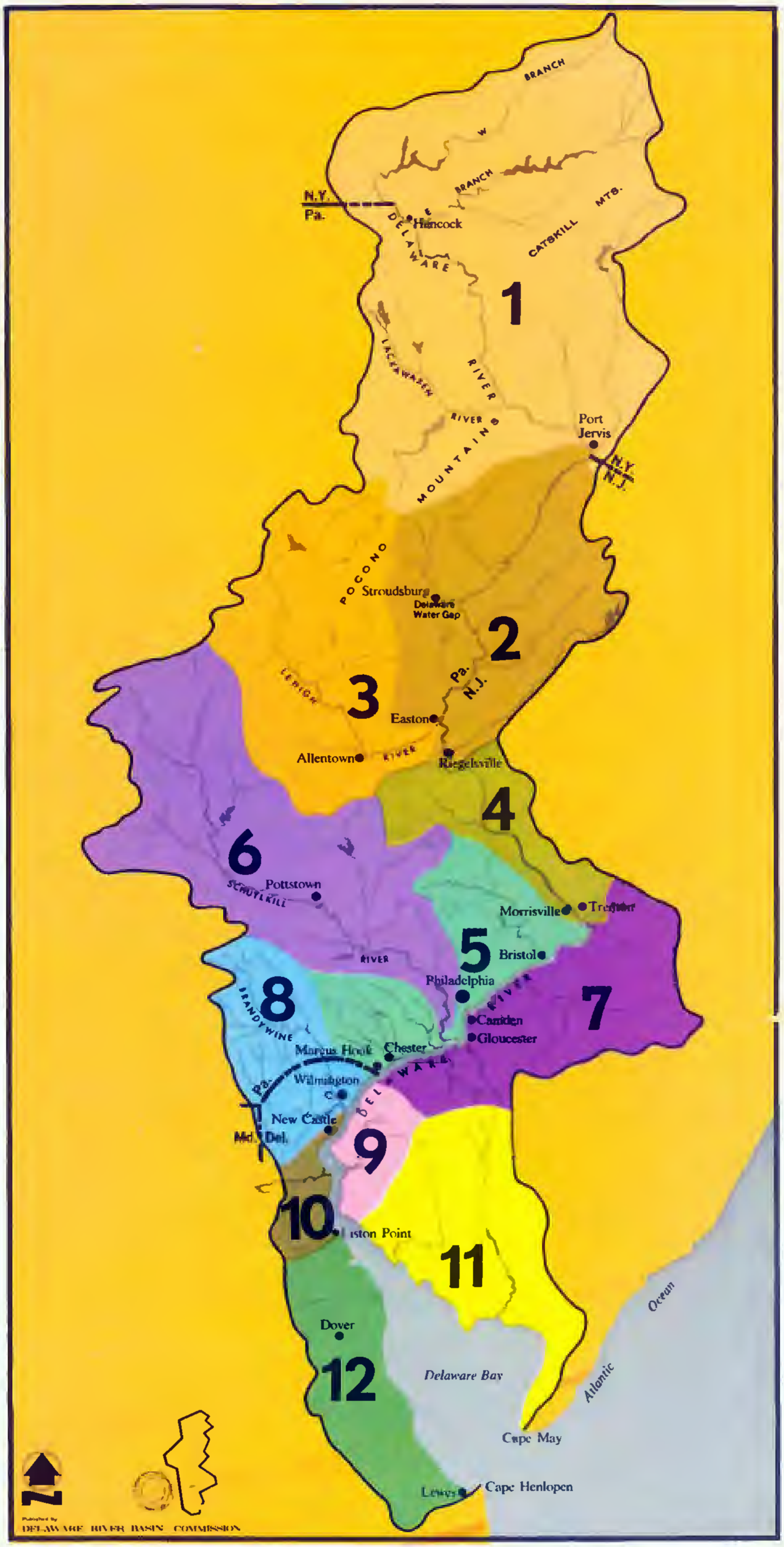


Figure I-3.--Sub-basins of the Delaware River.

Table I-1
Sub-basins of the Delaware River Basin

Sub-basin No.	Sub-basin Name	Description of sub-basin	Drainage area, sq. mi.
1	Upper Basin	Delaware River drainage area above Port Jervis, N. Y. (including Neversink River drainage area.)	3,422
2	Jervis-Riegelsville	Delaware River drainage area between Port Jervis, N.Y., and Riegelsville, N.J. (excluding Lehigh drainage area).	1,542
3	Lehigh Valley	Lehigh River drainage area.	1,364
4	Riegelsville-Trenton	Delaware River drainage area between Riegelsville, N.J. and Trenton, N.J. (Calhoun Street Bridge).	452
5	Pennsylvania-Estuary	Delaware River drainage area in Pa. between Morrisville, Pa., (Calhoun Street Bridge) and Pa.-Del. boundary of Marcus Hook, Pa. (excluding Schuylkill River drainage area above Fairmount Dam).	678
6	Schuylkill Valley	Schuylkill River drainage area above Fairmount Dam.	1,893
7	New Jersey-Estuary	Delaware River drainage area in N.J. between Trenton, N.J. (Calhoun Street Bridge) and N.J.-Del. boundary at Nortonville, N.J. (opposite Marcus Hook).	1,019
8	Brandywine Valley	Delaware River drainage area in Pa. and Del. between Pa.-Del. boundary at Marcus Hook, Pa., and mouth of Christina River (including Christina River drainage area).	591
9	Salem	Delaware River drainage area in N.J. between N.J.-Del. boundary at Nortonville, N.J. (opposite Marcus Hook), and mouth of Delaware River at Hope Creek Monument (opposite Liston Point).	257

Table I-1--Continued

Sub-basin No.	Name	Description of sub-basin	Drainage area sq. mi.
10	New Castle	Delaware River drainage area in Del. between mouth of Christina River and mouth of Delaware River at Liston Point.	166
11	New Jersey-Bayside	Delaware Bay drainage area in N.J. between mouth of Delaware River at Hope Creek Monument (opposite Liston Point) and Cape May.	769
12	Delaware-Bayside	Delaware Bay drainage area in Del. between mouth of Delaware River at Liston Point and Cape Henlopen.	612
	TOTAL--LAND AREA DELAWARE RIVER BASIN		12,765*
	DELAWARE BAY		782
		TOTAL	13,547

* This area is divided among five States as follows:

State	Area (sq. mi.)	Percentage
New York	2,362	18.5
Pennsylvania	6,422	50.3
New Jersey	2,969	23.3
Delaware	1,001	7.9
Maryland	8	0.0

DEFINITIONS

Since many terms used in the text are subject to varying definitions, the following are presented as the definitions to be used in this staff report, and to facilitate accurate understanding of the subject matter:

Acre-feet--	The volume of water required to cover one acre of land, one foot deep; equal to approximately 325,850 gallons.
Anadromous fish--	A marine species of fish that ascends a river to spawn in fresh water. The young remain in the river for a short period of time then go to the sea.
Brackish water--	Water having a mineral content in the general range between fresh and sea water. Water containing from 500 to 10,000 mg/l of dissolved solids.
Consumptive use--	The water used by vegetation in the process of growth, including that stored in the body of the plant and that dissipated from its leaf and body surfaces by transpiration, or water incorporated in a product or animal.
Cubic feet per second (c.f.s.)--	A rate of flow; 1 cfs = 0.646 mgd = 1.983 acre-feet per day.
Depletive water use--	Any use that permanently removes water from the Delaware River Basin, such as by exportation, evaporation, or transpiration.
Dissolved solids--	Solids that are present in water in solution; i.e., solids that cannot be removed by filtering. (See "suspended solids.")
Diversion--	The taking of water from a stream or other body of surface water into a canal, pipe line, or other conduit. (See "water withdrawal".)
Evaporation--	(1) The process by which water passes from a liquid state to vapor; the principal process by which water is converted to atmospheric vapor, either naturally from surface streams, moist soil, or other moist surface, or artificially from cooling devices. (See "transpiration".)

Evapotranspiration--	Loss of water from a given land area by both evaporation and transpiration. (See "evaporation and transpiration".)
Exportation of water--	The transfer of water out of the Delaware River Basin.
Facility--	Any plant, structure, machinery, or equipment that has been constructed and placed in operation and maintained for the beneficial use of water resources or related land uses.
Flood stage--	An arbitrarily fixed but generally accepted gage height above which a rise in water surface elevation is termed a flood, or above which overflow of the normal banks or damage to property would begin.
Flow, natural--	The flow in a stream as it would be if unaltered by activities of man.
Flow, regulated--	The flow in a stream where it is controlled by reservoirs, diversions, exportations, importations, and changes in consumptive use associated with man's activities.
Fresh water--	Water having a relatively low mineral content, generally less than 500 mg/l of dissolved solids. (See "potable water".)
Ground water--	All water beneath the surface of the ground.
Hardness--	A characteristic of water due to the presence of cations, chiefly calcium and magnesium, which causes increased consumption of soap, and deposition of boiler scale.
Imported water--	Water that is transported into the Delaware River Basin.
Million gallons per day (mgd)--	A rate of flow, 1 mgd = 1.547 cubic feet per second= 3.07 acre-feet per day.
pH--	The logarithm of the reciprocal of the hydrogen-ion concentration in the water, a measure of the degree of acidity of the water.
Potable water--	Water that does not contain objectionable pollution, contamination, minerals, or infectious agents, and is considered satisfactory for domestic use.

Project--	Any work, service or activity which is separately planned, financed, or indentified by the Commission, or any separate facility undertaken or to be undertaken within a specified area, for the conservation, utilization, control, development or management of water resources which can be established and utilized independently or as an addition to an existing facility, and can be considered as a separate entity for purposes of evaluation.
Quality of water--	Those characteristics of water affecting its suitability for beneficial uses.
Runoff, natural--	Flow of a stream unaltered by acts of man. (See "flow, natural".)
Runoff, observed--	Flow of a stream as observed at a specific point. Observed runoff normally reflects upstream regulation and uses by man. (See "flow, regulated".)
Saline water--	Water containing more than 250 mg/l of chlorides or more than 500 mg/l of dissolved solids.
Soil moisture--	Water in the soil zone. Available soil moisture is water easily abstracted by roots of plants. Unavailable soil moisture is water held so firmly by adhesion and other forces that it cannot usually be absorbed by plants rapidly enough to produce growth; when soil moisture falls below the "available" level, a condition of "soil-moisture deficiency" is said to occur with respect to vegetation.
Suspended solids--	Solids that either float on the surface of, or are in suspension in, water or waste water, that can be removed by filtering. (See "dissolved solids".)
Tidal current--	The horizontal movement of water caused by the gravitational attraction of the moon and sun action upon the earth. Ebb current: Seaward current. Flood current: Landward current.

Tide-- The periodic rising and falling of a water surface that results from the gravitational attraction of the moon and sun acting upon the rotating earth. (See "tidal current".)

- Ebb tide: Falling tide.
- Flood tide: Rising tide.
- Neap tide: High water at times when sun and moon gravitational forces are opposed, producing less than average tides.
- Spring tide: High water at times when sun and moon gravitational forces are acting in the same direction, producing-greater than average tides.

Transpiration-- The process by which plants dissipate water into the atmosphere from leaves and other surfaces. (See "evapotranspiration".)

Water demand-- The quantity of water necessary to fulfill all requirements, ie., transmission losses, and all depletive and non-depletive uses.

Water withdrawal-- The quantity of water withdrawn from its source for any purpose.

Yield, safe-- The maximum sustained draft which can be made under a specific demand schedule upon a surface or underground source of water supply during a period of years during which the probable driest period of greatest deficiency in water supply is likely to occur.

WATER MANAGEMENT OF THE

DELAWARE RIVER BASIN

PART ONE

CHAPTER 2 - THE WATER OF THE BASIN

A supply of fresh water, whether it is found in deep wells, mountain springs, streams and rivers, or reservoirs and lakes, is derived from and is primarily dependent upon precipitation. Precipitation varies in quantity, duration, type and location. In tropical rain forests, it is usually too much for too long a period in too small an area for most of man's uses. In the deserts, it is usually too little over any reasonable span of time, although sudden storms of high intensity and short duration cause flash-flooding.

In the Delaware River Basin, the dilemma of too much or too little precipitation for all uses all the time is also a problem. However, the variations are not as pronounced as in the deserts and rain forests. The Delaware River Basin has experienced, and despite man's efforts to manage its water resources will continue to experience, droughts and floods as deviations from normal or average precipitation patterns. Thus, in any evaluation of water availability, the capriciousness and extremes of nature must be considered, the economy must be designed to live within them, and measures must be planned and implemented to make the modifications necessary to adjust to the extremes. Total water availability is cyclic in its occurrence and undergoes constant change, while the demands on the available water supplies do not fluctate as drastically in their apparent inexorable growth.

Precipitation

The occurrence of precipitation over the Delaware River Basin is fairly uniform both in space and time. Near the mouth of Delaware Bay, the average annual depth of precipitation is about 40 inches, while in a small area of the Catskill Mountains in New York State it is about 60 inches. The rest of the 12,765 square mile watershed experiences precipitation within these extremes. The areal distribution of precipitation in the Basin is shown in Figure I-4.

Utilizing measurements of the National Weather Service and of other agencies and individuals throughout the Delaware River Basin, it is found that the average annual depth of precipitation over the entire Basin amounts to about 44.6 inches. Table I-2 shows monthly average precipitation values in both inches of depth and percentages of yearly totals for selected locations within the Basin. The highest monthly rainfall usually occurs in July or August, amounting to 10 or 11 percent of the annual total. February and October have the lowest average monthly precipitation, with 6 and 7 percent respectively.

The total average annual precipitation amounts to about 9,800 billion gallons (approximately 30 million acre feet) of fresh water for the Basin. Not all of this, however, is available for direct use by man. Some precipitation falls on saline water bodies, some is evaporated from land and water surfaces, and more of it is transpired by vegetation. The losses attributable to the combined processes of evaporation and transpiration result in the depletive use of approximately one-half the precipitation occurring in the Delaware River Basin. The remainder flows in surface streams or percolates into and through underground water-bearing formations toward the sea.

Figure I-4 --Average annual precipitation in the Delaware River Basin

Table I-2

Monthly average precipitation values
for selected locations within the Basin

Month	Frost Valley, N.Y. Period of record 1941 - 1970		Reading, Pa. Period of record 1878 - 1970		Philadelphia, Pa. Period of record 1872 - 1971		Cape May, N.J. Period of record 1871-1972	
	Inches	Percentage	Inches	Percentage	Inches	Percentage	Inches	Percentage
January	3.67	7	3.19	8	3.15	8	3.32	8
February	3.51	7	3.07	8	3.11	7	3.17	8
March	4.12	8	3.53	9	3.50	9	3.79	9
April	4.61	9	3.35	8	3.26	8	3.16	8
May	4.60	9	3.65	9	3.31	8	3.04	8
June	4.24	8	3.47	8	3.54	9	3.09	8
July	4.99	9	4.27	10	4.13	10	3.58	9
August	4.21	8	3.97	10	4.56	11	4.46	11
September	4.56	9	3.37	8	3.38	8	3.18	8
October	4.33	8	2.97	7	2.79	7	3.02	7
November	4.85	9	3.04	7	3.09	8	2.92	7
December	4.62	9	3.32	8	3.15	7	3.51	9
Yearly average	52.31	100	41.20	100	40.97	100	40.24	100

It is during this oceanward migration that some of the fresh water becomes available for man's uses and is subject to his management. The underground water-bearing formations discharge water into the Delaware River, Delaware Bay, or one or more of their many tributaries. Also, some ground water in the New Jersey coastal plain moves eastward across the Basin divide toward the Atlantic Ocean. Thus, the water flowing in surface waterways in the Basin accounts for practically all natural runoff of precipitation, except for depletive use caused by man's activities. Man also affects the temporal distribution of runoff.

Runoff regulation

Man's activities affecting natural runoff include the construction and operation of surface impoundments. When a stream is dammed to create a reservoir, the natural flow of the stream below the dam is altered--either reduced by storage of runoff or augmented by releases from the reservoir. This is only one example of regulation of runoff. Another occurs in pumping from natural storage capacity in underground aquifers. Even a small well serving a single home alters the natural flow of water through the substructure en-route to the sea. Modified runoff occurs also when land uses are changed or waters are diverted into or out of a drainage area, thus augmenting or reducing the natural runoff. Finally, when water is used consumptively for activities of man, it is denied to the streams, thus decreasing the natural runoff.

Streamflow rates are observed (measured) at many stream gaging stations operated by the U. S. Geological Survey and other agencies throughout the Delaware River Basin. Such observed flows, averaged over the periods of record, are presented in Table I-3

Table I-3
Observed streams flows at selected
gaging stations within the Basin

U.S.G.S. station number	Stream and location	Period of record	Drainage area sq.mi.	Average discharge, cfs	Discharge minimum month mo/yr	cfs	7-day flow of record cfs
4210	East Branch Delaware River at Fishs Eddy, N.Y.	1913-70	783	1,658	8/54	113	77
4265	West Branch Delaware River at Hale Eddy, N.Y.	1913-70	593	1,049	10/63	33	26
4285	Delaware River above Lackawaxen River near Barryville, N.Y.	1941-70	2,023	3,805	8/54	249	141
4340	Delaware River at Port Jervis, New York	1905-70	3,076	5,530	9/08	357	226
4385(1)	Delaware River at Montague, N.J.	1940-70	3,480	5,715	8/54	715	565
4465	Delaware River at Belvidere, N.J.	1923-70	4,535	7,697	8/54	881	782
4530	Lehigh River at Bethlehem, Pa.	1903-04 1910-70	1,279	2,225	9/64	334	260
4570	Musconetcong River near Bloomsbury, N.J.	1904-06 1922-70	143	219	9/65	37	32
4575	Delaware River at Riegelsville, N.J.	1907-70	6,328	10,818	9/08	1,250	975
4635(2)	Delaware River at Trenton, N.J.	1913-70	6,780	11,360	7/65	1,548	1,309
4745	Schuylkill River at Philadelphia, Pa.	1932-70	1,893	2,764	7/66	116	24
4815	Brandywine Creek at Wilmington, Del.	1947-70	314	431	10/63	81	59

(1) Strategic measurement location mandated by U. S. Supreme Court in 1954. N.Y.City, as compensation for exports from the Basin, must maintain a minimum flow of 1750 cfs at Montague through reservoir operation.

(2) Strategic measurement location chosen by DRBC.

for selected gaging stations (See Figure 1-5 for location of additional gaging stations). Observed streamflow rates reflect the combined effects of all upstream regulations by man, and in most cases are not a measure of natural flows.

Neither instantaneous nor long-time average observed flows are generally useful as a measure of the water available for development and use. Rather, in order to determine the amount of water available to meet further increases in demands, the minimum observed flows, as averaged over some critical short period of time, must be considered. As will be developed in Chapter 3, the rate of fresh-water inflows and their duration are related to the degree of sea-water intrusion into the tidal Delaware River. The 30-day low flows show an approximate correlation with the location of any given salinity concentration. For some purposes other than salinity control, shorter periods of low flow are considered. Table 1-3 lists both the minimum monthly and minimum seven-day flows of record for each of the selected stations.

A few regulatory storage facilities to augment main streams of the Basin during periods of drought have become operative since the times of the observed minimum flows listed in Table 1-3. As will be discussed in some detail later, a United States Supreme Court decree mandates that flows at or above 1,750 cfs be maintained in the Delaware River at Montague, New Jersey, by the City of New York in connection with its exportation of water from the Basin. Table 1-4 presents for selected stations in the Delaware River Basin estimated minimum monthly flows, modified to reflect conditions as they existed in 1972, that could be expected if the droughts of record were to recur.

Figure I-5 -- Selected gaging stations in the Delaware River Basin

Table 1-4
Estimated minimum monthly average stream flows
at selected gaging stations in the Delaware River Basin
under 1972 conditions of development

(In cfs)

Stream and Location	Minimum monthly flow
Delaware River at Montague, New Jersey	1,750
Lehigh River at Bethlehem, Pennsylvania	450
Delaware River at Trenton, New Jersey	2,700
Schuylkill River at Philadelphia, Pennsylvania	116
Brandywine Creek at Wilmington, Delaware	81

Flood flows

The vagaries of nature are impressed upon the student of Delaware River Basin runoff when he discovers that the months of the year in which historical low flows have occurred have usually also been the months in which destructive floods have occurred. This observation leads him to discover that it has been, for the most part, the intensive, warm, tropical type of storm that has caused the streams to overflow their banks and cause both loss of life and property damage. The relative infrequency and unpredictability of this type of storm add to the problems of the water resource manager in that a generation may pass without a flood occurring, thus engendering the "false sense of security".

The observed peak flood stages and flows of record at selected gaging stations in the Delaware River Basin are presented in Table I-5. Where regulatory flood control storage has been created since the date of the peak observed flood of record, estimates of both the stage and flow which would have occurred under the existing flood operation schedule, are also presented.

With repetition of the historic floods of record, even with the protective facilities available in 1972, substantial areas of inundation of highly developed properties can be expected adjacent to the Delaware, Lehigh and Schuylkill Rivers and numerous secondary streams. The flood control facilities constructed since the damaging storms of 1955 would reduce the flood stage of the Delaware River at Trenton by only 1.3 feet. Substantial urban development has subsequently taken place on lands inundated in 1955 along the Lehigh, Schuylkill and Delaware Rivers.

Table I-5

Observed peak flood stages and flows at selected gaging stations
in the Delaware River Basin

U.S.G.S. station number	Stream and location	Flood stage feet (1)	Date	Peak flood: Observed Stage feet	Observed Flow cfs	Regulated* Stage feet	Regulated* Flow cfs
4210	East Branch Delaware River at Fishs Eddy, N.Y.	11	10/03	23.6	70,000	Not available	
4265	West Branch Delaware River at Hale Eddy, N.Y.	11	10/03	20.3	46,000	Not available	
4315	Lackawaxen River at Hawley, Pa.	11	8/55	20.6	51,900	17.1	38,300
4465	Delaware River at Belvidere, N.J.	20	8/55	30.2	273,000	30.1	271,000
4530	Lehigh River at Bethlehem, Pa.	16	5/42	23.5	92,000	19.5	69,000
4570	Musconetcong River near Bloomsbury, N.J.	4 (2)	10/03	8.0(3)	6,960	8.0	6,960
4635	Delaware River at Trenton, N.J.	20 (4)	8/55	28.6	329,000	27.3	295,000
4745	Schuylkill River at Philadelphia, Pa.	11	10/1869	17.0	135,000	17.0	135,000
4815	Brandywine Creek at Wilmington, Del.	11	6/72	15.5(5)	29,000(5)	15.5	29,000

* Estimated stage and flow which would occur with recurrence of flood regulated by flood control facilities in existence in 1972.

(1) Flood stage, in feet, is measured above the datum of the gage. The datum of each gage, above mean sea level, is published in United States Geological Survey Water Resources Data, Part I, Surface Water Records, for the respective State.

(2) Bank full.

(3) Datum then in use, approximating present datum.

(4) Datum of gage changed from 7.77 feet above mean sea level to mean sea level (0.00) as of October 1, 1964.

(5) Provisional.

Imported water

The water resources available naturally within the Basin were augmented as of 1970 by relatively minor importations of water by three public water systems.

1. The Town of Newton, Sussex County, New Jersey, in the Paulins Kill watershed of Sub-basin 2, imports water into the Delaware River Basin from a surface impoundment on a tributary of the Wallkill River in the Hudson River Basin. This importation averaged about 0.9 mgd (1.4 cfs) in 1970.

2. The Octoraro Water Company imports water from Octoraro Creek in the Susquehanna River Basin, and serves this water to several small communities in Chester County, Pennsylvania, in Sub-basin 8. During calendar year 1970, this importation of water averaged about 1.7 mgd (2.6 cfs).

3. The most significant importation of water into the Delaware Basin is by the Chester Municipal Authority in Sub-basin 5. The Authority takes water from a reservoir on Octoraro Creek, a tributary of the Susquehanna River, to serve water customers in the City of Chester and surrounding municipalities in Delaware County, Pennsylvania. The Chester Authority also delivers water to the General Water Company, which serves areas in New Castle County, Delaware. The Chester Municipal Authority holds a permit authorizing a diversion of 30 mgd (46 cfs) from Octoraro Creek. Also, in 1965, the Authority obtained a permit to take 30 mgd directly from the Susquehanna River. In 1970, the Authority imported an average of 28.1 mgd (43.5 cfs).

During calendar year 1970, total importation of water by all three of these parties averaged 30.7 mgd (47.5 cfs). The total authorized importations of water into the Delaware Basin by these three entities, when fully implemented, will amount to 66 mgd (102 cfs), a relatively small addition to the water available from sources within the Basin. See Table I-6.

Table 1-6
Authorized and actual 1970 and estimated future average annual
Importation of water to the Delaware River Basin, 1970-2020

(in million gallons per day)

		1970		1980	2000	2020	
Sub-basin	Importer	Authorized	Imported	Estimated	Estimated	Estimated	From
1	Newton Water and Sewer Authority, Newton, N.J.	2.0	0.9	1.6	1.6	1.6	Morris Lake, NJ (Hudson River Basin)
8	Octoraro Water Co. Claymont, Del.	4.0	1.7	2.0	4.0	6.0	Octoraro Creek, (Susquehanna Riber Basin)
5	Chester Water Authority Chester Pa.	60.0	28.1	43.8	60.0	60.0	Octoraro Creek and Susquehanna River, Pa. (Susquehanna River Basin)
	Total (rounded) mgd	66	31	47	66	68	
	Total cfs	102	48	73	102	105	

Exported water

The amount of water exported from the Basin (discussed in some detail in Chapter 3) is sizeable. During 1970 combined exports averaged 673 mgd (1,042 cfs), a figure that is expected to increase to 1,211 mgd (1,875 cfs) by the year 2000. The latter total includes the 800 mgd (1,238 cfs) that can be exported to New York City under the U. S. Supreme Court decree of 1954 (See Appendix B). The New York City export is made up of water stored in three reservoirs during periods of relatively high runoff, so that the critical low flows in the Delaware River--as measured at Montague, New Jersey--are not reduced by this diversion. Moreover, the Supreme Court decree mandates that New York City make releases from its Delaware Basin reservoirs as necessary to sustain a minimum flow of 1,750 cfs at the Montague stream gage--as compensation to Delaware Basin interests for the high-flow water stored and exported.

The total export projected for the year 2000 also includes an export of 100 mgd (155 cfs) to northeastern New Jersey. This export was also authorized by the 1954 decree of the Supreme Court. Thus, of the projected total export of 1,211 mgd, 900 mgd (1,393 cfs) was provided for by the 1954 decree. The remainder, 311 mgd, includes a proposed-but not yet authorized--additional exportation of 300 mgd to northeastern New Jersey.

The effects of storage, exports, and compensating downstream releases from reservoirs on the water available for various purposes in the Delaware Basin are reflected in the stream-flows observed at downstream gaging stations. The overall effect of the current (1973) exportation system is to reduce high flows in the affected Basin streams and to increase critical low flows.

Ground water*

Ground water is that part of the total water resource that is currently stored in, or moving through, the interstices between the solid materials that constitute the earth's crust. At other times, this same water has been and will again be a part of the surface water resource and of the water vapor in the atmosphere. An understanding of the nature and behavior of ground water and its relation to surface water is essential to the development of a plan for managing the total water resources of the Delaware River Basin.

Ground water in the Delaware River Basin is recharged almost entirely from precipitation within the Basin. A very small part of the total recharge is derived from bodies of surface water such as temporary streams, or artificial ponds that lie above the water table. An even smaller part is derived from induced infiltration where the water table has been drawn down by pumping adjacent to surface waterways.

In the Delaware River Basin ground-water recharge is seasonal, occurring mainly during the nongrowing season for vegetation. During most of the growing season, the potential evaportranspiration normally exceeds precipitation. The roots of plants draw upon water stored in the soil, and a soil-moisture deficiency is created. Until the soil-moisture deficiency is eliminated, no water can move down through the soil to recharge the ground water. Consequently, except in very wet periods, little ground-water recharge occurs during the growing season.

---

* This discussion of ground water is excerpted from:
Barksdale, H.C. 1970. A Program for the Investigation and Managment of Ground Water in the Delaware River Basin. Consultant's Report, Delaware River Basin Commission, Trenton, N. J., 120 pp.

Throughout the Delaware River Basin, as in other parts of the Northeast, the general slope (or gradient) of the water table is toward the channels of the surface waterways, and ground water discharges into these waterways. Thus, ground water maintains the flow of streams between periods of precipitation, and it constitutes a significant part of the flow at all times (Stuart et al. 1967).* In an average year, ground water discharge accounts for about 40 percent of the flow of major streams in the Northeast, and possibly as much as 60 percent in years of drought. During the growing season of a dry year, it may account for as much as 80 percent of the total streamflow.

The total quantity of water stored in the aquifers of the Basin is estimated to be in the order of 10,000 to 15,000 billion gallons (31 to 46 million acre feet), or three to five times the average annual volume of discharge by the Delaware River at Trenton, New Jersey. This large quantity is not available for total withdrawal and use under any conceivable circumstances. However, above the Fall Line sufficient water is generally yielded from the fractures in the rock structures to meet the needs of individual households, and small communities, while below the Fall Line in the areas overlying well defined sand and gravel aquifers, the yields are sufficient to supply water needed by cities of substantial size. The stored ground water is also important because in some localities it can absorb the shock of short term, large withdrawals (even in excess of average replenishment rates) during times of drought.

---

* Stuart, W.T., Schneider, W.J., and Crooks, J.W. 1967. Swatara Creek Basin of Southeastern Pennsylvania, an Evaluation of its Hydrologic System. Geological Survey Water Supply Paper 1829, U.S. Department of the Interior, Washington, D.C., 79 pp.

Surface water quality

Data showing the general quality characteristics of surface waters in the Delaware River Basin are presented in Table I-7. These data show typical analyses of four water quality parameters for selected stream locations in each of the 12 sub-basins. The analyses indicate the significant differences that exist among the quality characteristics of different locations in the Basin. Not shown, however, is the equally significant variability of the quality of water at different times at many of the individual sampling locations.

During periods of high flow, the tributary streams and the Delaware River also carry significant sediment loads. An example of the extremes of suspended-sediment volumes is found in the United States Geological Survey data collected during tropical storm Doria in August 1971. During this moderately severe storm, the sediment load of the Delaware River at Trenton increased from 104 tons per day to 78,700 tons per day in two days.

As a generalized overview, the quality of fresh water streams throughout the Basin is such that the waters are suitable for all of the higher uses, reflecting a dissolved oxygen content above 4.0 mg/l, pH between 6.0 and 8.5 and total dissolved solids less than 150 mg/l. Variations from this generalization, as depicted in Table I-7, are found, locally, adjacent to the large concentrations of population and industry, and immediately downstream of coal fields in the Lehigh and Schuylkill River watersheds where waters of high acidity are encountered. The tidal Delaware River between Trenton and Wilmington is degraded by excess amounts of organic wastes, reducing the oxygen levels during summer periods to unacceptably low levels. Localized areas of high coliform counts also are encountered in this reach of the River.

Table 1-7
Typical water quality analyses for summer stream-flow conditions at selected locations in Delaware River sub-basins

Sub-Station	Stream	Location	Dissolved Oxygen mg/l	pH	Hardness mg/l	Total Dissolved Solids mg/l
1.	W. Br. of Del. River	At Delaware River below Hancock, N.Y.	8.3	7.2	35	50
2.	Delaware R.	at Milford-Montague Brdg.	8.0	7.1	27	40
2.	Delaware R.	at E. Stroudsburg	8.5	7.0		
2.	Delaware River	at Easton	8.0	7.9		
3.	Lehigh River	at Walnutport, Pa.	7.9	6.7	59	140
3.	Lehigh River	at Easton, Pa.	6.9	7.7	123	140
4.	Delaware River	at Riegelsville, N.J.	7.5	7.0	64	140
4.	Delaware River	at Trenton, New Jersey	8.7	7.9	70	115
5.	Delaware River	at Burlington-Bristol Bridge	5.0	6.8	70	185
5.	Delaware River	at Torresdale	5.3			
5.	Delaware River	at Benjamin Franklin Bridge	1.7*	6.7	100	140
6.	Schuylkill River	at Berne, Pa.	8.7	4.7*	298	610
6.	Schuylkill River	at Belmont	6.2	7.3	214	310
5.	Delaware River	at Chester	1.2*	6.5	207	208
8.	Brandywine Creek	at Chadds Ford	8.4	7.3	82	140
8.	Delaware River	at Delaware Memorial Bridge	3.1*	6.5	420	2000
9.	Salem River	at Sharptown	5.3	7.0	85	185
10.	Delaware River	at Reedy Island	5.4	6.7	1700	3000
11.	Maurice River	at Millville	7.0	6.9	25	50

NOTES: State of Delaware, Department of Natural Resources and Environmental Control;
New Jersey State Department of Environmental Protection;
Commonwealth of Pennsylvania, Department of Environmental Resources
Geological Survey, U.S. Department of the Interior

* Values do not meet water quality standards.

One of the more significant quality characteristics of the tidal waters of the Basin is the salinity caused by the intrusion of sea water. Sea salts in detectable concentrations have been observed in the tidal Delaware River as far upstream as Philadelphia during low-flow periods, within a few miles of that City's water intake at the Torresdale Filtration Plant. Such intrusions of sea water limit the uses that industries and municipalities along the estuary can make of the river water. For example, years ago advancing sea-water intrusions during periods of drought forced the City of Chester to abandon its use of the Delaware River as its dependable source of potable water.

Underground water quality

Due to its slowness of movement, and the great unknowns regarding the continuity of groundwater between fractures or aquifers, the use of records of individual wells as indicative of generalized groundwater quality is more hazardous than is the use of spot records to appraise the quality of surface streams. Nevertheless, it is possible to reach certain conclusions with regard to the quality of under-ground waters after observing the general characteristics as revealed by analyses of well waters over a period of time. The very brief discussions of the quality of under-ground water in the following paragraphs, for all of the sub-basins, are intended only as general guidelines, or warnings, in terms of what may be expected, or what may be encountered in an individual well.

Sub-basin 1. The quality is sufficiently high that the ground water is generally usable for all purposes. The water ranges from very soft to moderately hard (1 to 120 mg/l as $CaCO_3$) and usually has very low to moderate concentrations of dissolved solids (25 to 200 mg/l).

Sub-basins 2, 3, and upper Sub-basin 6. The quality is such that the ground water is generally usable for all purposes. The water ranges from soft to hard (1 to 120 mg/l as $CaCO_3$) and contains low to moderate concentrations of dissolved solids (25 to 200 mg/l).

Two notable exceptions are: those areas underlain by carbonate rocks where ground water tends to be more highly mineralized (75 to 600 mg/l of dissolved solids), slightly alkaline (30 to 300 mg/l in terms of bicarbonate,) and generally hard to very hard (121 to greater than 200 mg/l as $CaCO_3$); and secondly, those localized areas in the mine regions of Sub-basins 3 and 6 where the water is even more highly mineralized (greater than 600 mg/l of dissolved solids), highly acidic (pH as low as 3), and high in sulfates (up to 800 mg/l).

Sub-basins 4, 5, 8, and lower Sub-basin 6. The ground water is of a quality making it generally usable for all purposes. The water is moderately mineralized and may range from soft to hard (1 to 120 mg/l as $CaCO_3$). Some wells produce water containing excessive amounts of iron in solution (greater than 10 mg/l) but most have low iron concentrations (less than 0.3 mg/l) and are slightly alkaline (less than 30 mg/l) in terms of bicarbonate). Softening or iron removal is required prior to use of some well water.

Sub-basins 7, 9, 10, 11, and 12. These sub-basins lie almost entirely within the Coastal Plain portions of New Jersey and Delaware. Salt-water encroachment is a threat to the quality of the water in the shallow aquifers adjacent to or underlying saline surface waters, and when such encroachment has occurred it limits usability of the ground water. Elsewhere the ground water quality is variable, but the water is usually treatable for application to the higher uses.

The Coastal Plain is underlain by aquifers of varying permeability and hydrostatic head, some of which contain salt water in their deeper parts, and the opportunity for inland spread of salt water varies accordingly. Salt-water intrusion generally takes place in those araas where large-scale pumping of ground water occurs adjacent to salt-and brackish-water bodies. Communities in or near the Basin that have already experienced the loss of once-usable wells include Cape May and Penns Grove, New Jersey, and Lewes and Rehoboth Beach, Delaware. Elsewhere, the water is usually soft (less than 6 mg/l) and not highly mineralized (less than 100 mg/l of dissolved solids), but localized high concentrations of iron (1 to 20 mg/l) are occasionally found. The near-surface ground waters of the Coastal Plains are highly susceptible to contamination by the activities of man, and there are numerous occurrences of degraded water quality due to poor practices of storage, handling, and disposal of materials on the earth surface.

Availability of water for reuse

Users of water within the Basin in 1970 depended heavily upon direct withdrawal from streams and aquifers to meet their needs, with relatively little use of regulatory storage. Generally, water was available at the users' intakes in amounts exceeding their pumping rates. With few exceptions, the water withdrawn by public and large private water-supply systems--from either surface or underground sources--was discharged to surface waterways after use, diminished only by consumptive losses and altered in quality in varying degrees. In most cases, the waste water was discharged near the point of withdrawal, so that the quantity of water in the area of withdrawal and in downstream areas was reduced only by consumptive use. Thus, except for impaired quality, most of the water withdrawn and used in the Basin remained available for other instream and withdrawal uses, an important factor to be considered in evaluating the needs for future water supply developments.

Water withdrawn from streams and aquifers that is not available for reuse includes that portion used consumptively and water exported from the Basin. Similarly, waste waters discharged into the saline reaches of the tidal Delaware River, Delaware Bay, and their saline tributaries are not reusable for purposes requiring fresh water. However, these waste waters do assist in controlling sea-water intrusion in the tidal waterways.

WATER MANAGEMENT OF THE

DELAWARE RIVER BASIN

PART ONE

CHAPTER 3--PRESENT AND FUTURE WATER DEMANDS

The Delaware River Basin has not escaped the impact of the tremendous surge of economic growth experienced in the United States since World War II. Megalopolis, a strip of almost continuous heavily developed and densely populated land between Boston and Washington, traverses the lower half of the Delaware Basin, predominantly in Sub-basins 5, 6, and 7. Industrial, urban, and suburban expansions in these sub-basins have resulted in greater concentrations of people--greater population densities -- where the greatest densities already existed. Lands that were formerly open spaces, forests and farms, are now suburbia, dotted with residential subdivisions of all sizes, shapes, and types, and the trend is continuing.

In the upper portion of the Basin, where there were fewer people--lower population densities--to begin with, the changes have not been as dramatic. There are more people than ever before, but their activities rather than being related primarily to agriculture, are more involved with the bourgeoning recreation and second-home industry.

Obviously, the greatest demands on the Basin's water resources are, and will continue to be in the areas of greatest population density. Thus, population trends, areal distributions, and concentrations take on a very important role in determining present and projected future water demands.

Population

The population of the entire Delaware River Basin was about seven million in 1970. Table I-8 lists historic populations of the 12 sub-basins from 1920 to 1970 and those projected through the year 2020. Clearly, Sub-basins 5, 6, and 7 will continue to have the greater proportionate share of population density, with Sub-basin 8 also becoming much more densely populated with time. While the projections indicate that the total Basin population will exceed 12.5 million in the year 2020, more than three-quarters of this number will be concentrated in Sub-basins 5 through 8.

Depletive use of water

Estimates have been made to determine whether adequate supplies of water are available in the Delaware River Basin to meet present and future water demands. Depletive use of water was taken as the primary test of the adequacy of the supply. Minimum historic flows, adjusted for regulation by existing reservoirs and for imports and exports, less the depletive uses at a given point in time provide a measurement of the flow remaining for other uses, including repulsion of ocean salinity.

Use that puts water into the atmosphere by evaporation or transpiration, or incorporates it in the growth crops or products and does not return it to a surface waterway or an aquifer, is called depletive use. Depletive water use is a better measure than the amount of water actually withdrawn from a source in determining the need for development of water supplies, because most of the water withdrawn for various uses normally is not lost but is returned to the source from which it was withdrawn, or to some other water body, usually in a location that makes it available for reuse.

Table I-8

Estimated population of the Delaware River Basin,
by sub-basins, 1920-2020

(in thousands)

Sub-basin No.	Name	1920	1940	1950	1960	1970	1980	2000	2020
1	Upper Basin	108	114	117	120	123	125	135	145
2	Jervis-Riegelsville	142	164	181	213	246	296	468	655
3	Lehigh Valley	326	373	399	434	464	493	554	622
4	Riegelsville-Trenton	64	71	82	96	109	124	155	185
5	Pennsylvania-Estuary	1,747	2,024	2,295	2,603	2,843	3,101	3,685	4,379
6	Schuylkill Valley	866	1,005	1,085	1,201	1,287	1,367	1,549	1,769
7	New Jersey-Estuary	401	545	646	867	1,151	1,411	2,010	2,701
8	Brandywine Valley	201	242	284	378	477	574	799	1,102
9	Salem	33	39	45	53	65	75	99	131
10	New Castle	12	15	23	37	55	75	124	190
11	New Jersey-Bayside	67	77	91	143	172	201	269	357
12	Delaware-Bayside	37	43	49	80	107	137	213	323
	Total	4,004	4,712	5,297	6,225	7,099	7,979	10,060	12,559

Without development of water storage capacity to provide releases of water to offset increases in depletive use, streamflows during critical dry periods would be gradually diminished to intolerable levels. In time, if permitted, uncompensated depletive use would convert some perennial non-tidal streams into dry channels during the summer seasons of dry years.

Because tidal waterways are at sea level and are directly connected to the ocean, there is no danger that depletive use of tidal water will affect the quantity of water available. However, if the depletive use is not replenished by fresh water, the quality of water throughout the tidal system will undergo changes, sometimes subtle and sometimes extreme; the resultant quality will determine the utility of the water for both instream and withdrawal uses.

In the Delaware River estuary, one of the most important quality characteristics of the water is its salinity. The salinity, measured as chlorides, varies from very low values--(less than 10 mg/l)--at Trenton, caused by minerals dissolved in the runoff from the drainage area above Trenton, to that of sea water (19,000 mg/l) at the mouth of the Delaware Bay. During periods of low fresh-water flow into the Delaware Estuary sea water intrudes up the tidal river against the weak fresh-water flow until a state of equilibrium is reached between the upstream mixing forces of tides and winds on the one hand, and the repulsion and dilution forces of the fresh-water inflow on the other hand.

Increased depletive use of the fresh water inflow to the estuary during periods of low flow, unless replaced, will shift the state of equilibrium so that sea water will move faster and farther up the estuary toward Trenton. Such increased sea water intrusion in the Delaware Estuary would have severe detrimental effects on the ecology of the upper portion of the tidal River, and would drastically reduce the availability of fresh water in this reach for municipal and industrial purposes. Further, underground aquifers supplying large areas in New Jersey are, at one point or another, in hydraulic continuity with the upper reaches of the tidal river, and would be rendered useless if contaminated by the saline waters. For these reasons, it is essential that the seasonal inland movement of ocean salinity not be permitted to penetrate above some specific point. As will develop later in this chapter the Delaware River Basin Commission has determined that ocean salinity, as measured in chlorides, shall be controlled in the Delaware River at a maximum of 250 mg/l at the mouth of the Schuylkill River.

Measurement of the net oceanward flow of fresh water is nearly impossible in the ebb and flow of tidal streams. Therefore, the Delaware River at Trenton, before the river becomes tidal has, by historic use, become the reference point for measuring the effective flow to repel ocean salinity. The basic flow long considered needed at Trenton for this purpose is 3,000 cfs. Many studies on tangential matters, such as determination of the tidal river's waste assimilative capacity, have used this rate of flow. The minimum flow objectives at key locations are shown in Figure I-6.

Estimates of depletive uses of water were made for each of the following five water use categories: (1) rural-domestic, (2) municipal, (3) industrial, (4) agricultural, and (5) exports. Category (3) industrial, was further divided into general industrial and steam electric power generation. Similarly, Category (4) agricultural, was divided into irrigation and livestock. The bases for making these estimates, and the present and projected consumptive uses, for the five categories were as follows:

Rural-domestic water use -- In 1970, approximately 1,100,000 persons were served by private wells or other individual household water-supply systems in the

Delaware River Basin. The estimated breakdown of this population, by sub-basins, is given in Table I-9. This type of water service is common to developing areas surrounding the more intensively urbanized communities.

The rural-domestic population served by private wells was projected to remain relatively constant during the 1970-2020 period, i.e., as new rural residents using self-supplied water develop, an approximate equal number will be abandoning such sources as public water systems expand into their areas.

The quantitative estimates for rural-domestic water use were based upon an average per capita demand of 50 gallons per day, with the depletive use being 10 percent of the average daily demand. The depletive use was assumed to be relatively constant throughout the year.

The estimated average annual depletive use of the rural-domestic category for the 1970-2020 period is shown in Table I-9.

Municipal water use-- Estimates of municipal water use were derived from total population estimates (Table I-8) less the rural-domestic populations (Table I-9). As the first step, rates of municipal water demand per capita were developed for each sub-basin and applied to 1970 population data. In 1970, average municipal per capita water demand, which reflects commercial, industrial, municipal, and domestic services within the public water service systems, varied from 108 to 177 gallons per capita per day. The Basinwide weighted average was 145 gallons per capita per day. These 1970 per capita water demand factors of the 12 sub-basins are presented in Table I-10.

The upward trend in municipal per capita water demands within the Basin since 1930 has been approximately at a rate of 1 percent per year, without indicating any sign of leveling off or subsiding. As a means of projecting future demands, the 1 percent

Figure I-6.--Minimum flow objectives at key locations in the Delaware River system, with existing and authorized major reservoirs.

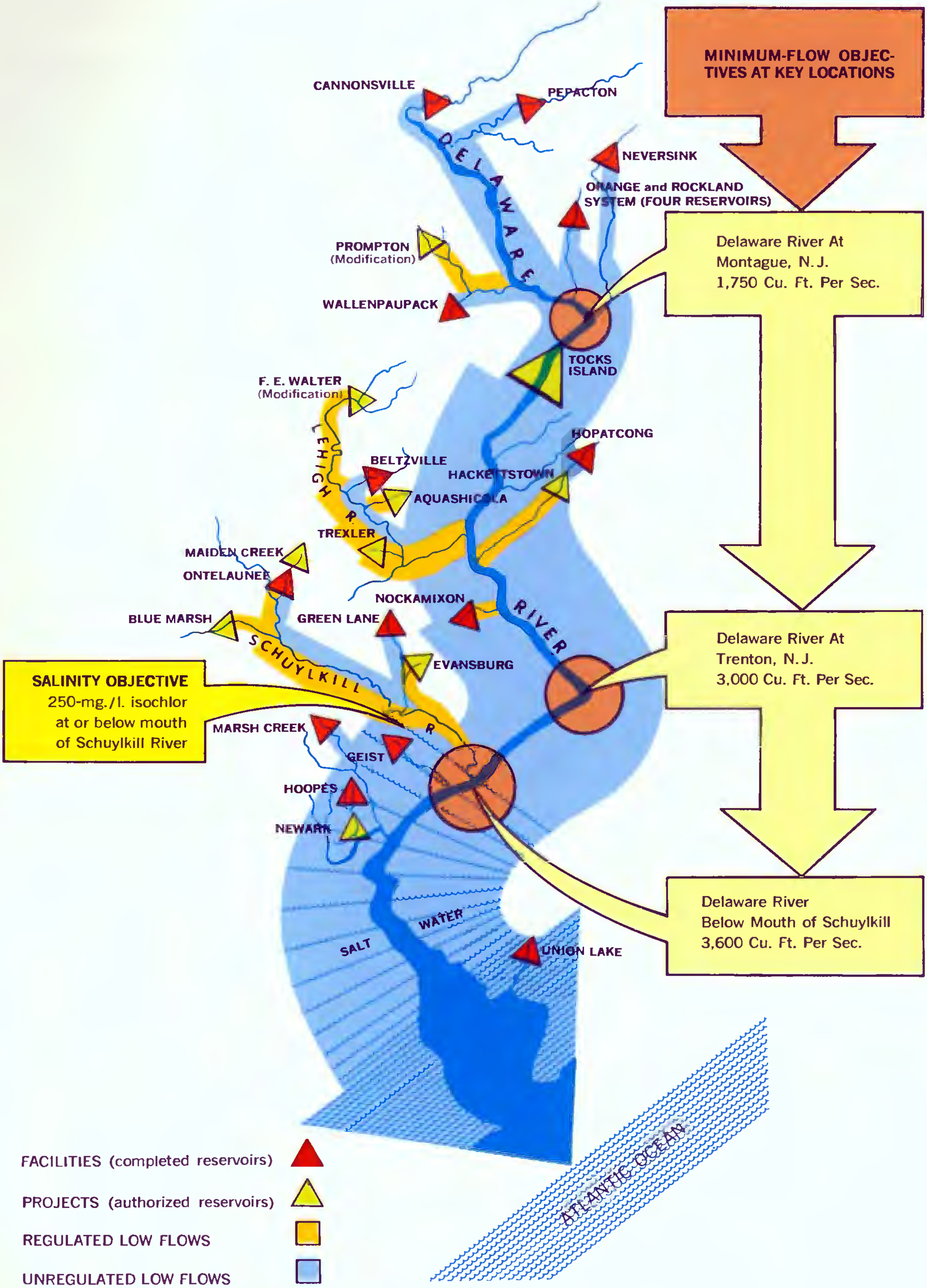


Table I-9
Estimated average annual rural-domestic
population and depletive use of water, 1970-2020

Sub-basin No.	Name	Population in thousands	Depletive use in MGD
1	Upper Basin	60	0.3
2	Jervis-Riegelsville	100	0.5
3	Lehigh Valley	45	0.2
4	Riegelsville-Trenton	45	0.2
5	Pennsylvania-Estuary	60	0.3
6	Schuylkill Valley	370	1.8
7	New Jersey-Estuary	220	1.1
8	Brandywine Valley	20	0.1
9	Salem	20	0.1
10	New Castle	40	0.2
11	New Jersey-Bayside	60	0.3
12	Delaware Bayside	60	0.3
		Total 1,100	5.4
		Rounded at	5.

Table I-10
Probable maximum municipal per capita rates of water demand, 1970 - 2020

(in gallons per capita per day)

Sub-basin No.	Name	Probable Maximum Rates 1970	1980	2000	2020
1	Upper Basin	145	160	189	217
2	Jervis-Riegelsville	134	147	174	201
3	Lehigh Valley	143	157	186	215
4	Riegelsville-Trenton	124	136	161	186
5	Pennsylvania-Estuary	152	167	198	228
6	Schuylkill Valley	155	171	202	233
7	New Jersey-Estuary	133	146	173	200
8	Brandywine Valley	108	119	140	162
9	Salem	127	140	165	190
10	New Castle	139	153	181	209
11	New Jersey-Bayside	177	195	230	265
12	Delaware-Bayside	115	127	150	173
	Weighted average	145	(158)	(186)	(213)

annual increase was applied to the 1970 unit rate for each sub-basin, with the results considered to be probable maximum per capita rates of future water demand. These unit rates are also shown in Table I-10.

Municipal depletive use of water was assumed to be 10 percent of the amount of water to meet demands. However, two estimates were made of municipal depletive use, one assuming the 1970 per capita rates of demand to be constant over the 1970-2020 period (low estimate), and the other based upon the projected maximum rates shown in Table I-10 (high estimate). The high and low estimates of average annual municipal depletive use of water are presented in Table I-11. This staff report utilizes the "low estimate" for conservative planning purposes. The "high estimate " is presented to illustrate a probable maximum demand.

The record of water withdrawals by the City of Philadelphia, serving a large population together with its supporting industrial, commercial, and municipal activities, provides an opportunity to establish a reasonable basis for determining in which months the maximum water demands and resultant maximum depletive uses of water are likely to occur. The average monthly percentages of Philadelphia's total yearly water withdrawals for the five-year period, 1966-1970, are shown under the column "municipal" in Table I-12. It may be seen that the highest monthly demand of Philadelphia has occurred in July, with August being a close second. The maximum-month use totals will be developed later in this chapter.

Industrial water use-- Estimates of industrial water use were separated into (a) general industrial enterprises utilizing their own sources of water, and (b) steam electric power stations, also utilizing self-supplied water.

The estimates of 1970 water use by self-supplied industries were based on unpublished waste-discharge data provided by agencies of the Basin States; on industrial

Table I-11

Estimated average annual municipal depletive use of water, 1970-2020

(in million gallons per day)

Sub-basin No.	Name	1970	1980 Low	1980 High	2000 Low	2000 High	2020 Low	2020 High
1	Upper Basin	1	1	1	1	1	1	2
2	Jervis-Riegelsville	2	3	3	5	6	7	11
3	Lehigh Valley	6	6	7	7	9	8	12
4	Riegelsville-Trenton	1	1	1	1	2	2	3
5	Pennsylvania-Estuary	42	46	51	55	72	66	98
6	Schuylkill Valley	14	16	18	18	24	22	33
7	New Jersey-Estuary	12	16	17	24	31	33	50
8	Brandywine Valley	5	6	7	8	11	12	18
9	Salem	1	1	1	1	1	1	2
10	New Castle	0	1	1	1	2	2	3
11	New Jersey-Bayside	2	3	3	4	5	5	8
12	Delaware-Bayside	1	1	1	2	2	3	5
	Total	87	101	111	127	166	162	245

Table I-12

Estimated monthly distribution of water demands by category of use
1966-1970

(percentage of total annual)

Month	Municipal	Industrial	Electrical	Irrigation	Exportation	Importation
January	8.1	7.6	6.9	--	9.0	8.2
February	8.2	7.2	6.9	--	7.9	8.3
March	7.9	7.2	7.3	--	8.6	8.1
April	7.7	8.0	8.0	--	6.9	8.0
May	8.0	8.4	8.7	6.8	7.8	8.0
June	8.9	9.5	10.1	33.5	8.7	8.4
July	9.3	10.0	10.0	34.9	9.6	8.6
August	9.1	10.1	10.0	21.2	9.0	8.8
September	8.6	10.0	9.0	3.6	8.4	8.7
October	8.2	9.1	8.5	--	8.1	8.5
November	8.0	6.2	7.7	--	8.1	8.2
December	8.0	6.7	7.0	--	7.9	8.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

water-use data published by the Bureau of the Census; on unpublished data collected by the Delaware River Basin Commission; on industrial statistics available in publications of the New Jersey Department of Labor and Industry, the New York State Department of Labor, and the Pennsylvania Department of Internal Affairs; and on a New Jersey study by Grossman and Sherman for the New Jersey Division of Water Policy and Supply on use of water by manufacturing industries. Industrial water use was projected to grow at a rate of 1.8 percent per year, compounded annually. Although the rate of increase in withdrawals may decelerate as a result of more stringent pollution control laws and other factors, there is less reason to expect a deceleration in the rate of growth in depletive water use, which is the critical measure of use.

Estimates of average annual depletive use of water for general industrial purposes, exclusive of water used for generation of electric power, are presented in Table I-13. Depletive uses of fresh and brackish water are shown separately for those sub-basins that include brackish waters. This separation is mainly to facilitate computation--not to suggest that the effects of consuming one type of water are more significant than consuming the other type. In either case, it is fresh water that is lost from the available resource, which is important from the standpoint of the availability of water needed to dilute dissolved solids from man-made or natural sources, including salts in sea water that intrudes into the Delaware Estuary.

The estimates of fresh-water depletive use were computed by taking one percent of the portion of self-supplied "nonelectric" industrial fresh-water withdrawals used for cooling purposes, and by taking ten percent of the remainder of these withdrawals. It was assumed that all brackish water withdrawn is used for cooling, and the one-percent factor was applied to these withdrawals to obtain an estimate of the depletive use.

Table I-13
Estimated average annual industrial depletive use of water*
1970-2020

(in million gallons per day)

Sub-basin No.	Sub-basin Name	Type of water	1970	1980	2000	2020
1	Upper Basin	Fresh	0.7	0.7	0.7	0.8
2	Jervis-Riegelsville	Fresh	5.1	6.1	8.9	12.7
3.	Lehigh Valley	Fresh	6.1	6.5	7.4	8.5
4	Riegelsville-Trenton	Fresh	0.6	0.7	1.01	1.4
5	Pennsylvania-Estuary	Fresh	35.1	38.4	47.6	59.8
6	Schuylkill Valley	Fresh	6.9	7.5	9.1	11.4
7	New Jersey-Estuary	Fresh	17.9	22.2	34.0	53.1
8	Brandywine Valley	Fresh	11.7	14.7	22.4	34.9
8	Brandywine Valley	Brackish	0.0	0.0	0.0	0.0
9	Salem	Fresh	13.4	15.7	21.9	30.7
9	Salem	Brackish	0.4	0.5	0.6	0.9
10	New Castle	Fresh	0.1	0.2	0.3	0.6
10	New Castle	Brackish	4.9	6.8	12.0	22.4
11	New Jersey-Bayside	Fresh	0.5	0.6	1.0	2.4
11	New Jersey-Bayside	Brackish	0.0	0.0	0.0	0.0
12	Delaware-Bayside	Fresh	0.8	1.1	1.9	3.7
12	Delaware-Bayside	Brackish	0.0	0.0	0.0	0.0
	Total Fresh		98.9	114.4	156.2	220.0
	Total Brackish		5.3	7.3	12.6	23.3
	Grand Total		104.2	121.7	168.8	243.3

* Exclusive of water used in the generation of electric power

An analysis was made of the 1966-1970 monthly distribution of annual water uses of several major industries in the Basin to determine the month of probable greatest demand. The resultant average monthly percentages are shown under the "Industrial" column in Table I-12.

Estimates of average annual depletive use of water for steam-electric power generation, mainly for cooling purposes, are presented in Table I-14. The estimates presented in Table I-14 for the year 1970, were derived from studies made in cooperation with the New York Regional Office of the Federal Power Commission and include an accounting of all existing electric generating facilities for steam-electric power in the Basin.

Additionally, the estimates of projected depletive water use for steam-electric power generation were taken from the "Master Siting Study," a report to the Delaware River Basin Commission by the Delaware River Basin Electric Utilities Group, dated May, 1974. Specifically, the estimates of depletive water use in Table I-14 represent a combination of the Commission's 1970 estimate of water use and the water use projected by the utilities as presented in the cited report.

Steam-electric generating plants with "once-through" evaporative cooling systems are characterized by relatively high rates of water withdrawal demand, but low depletive use during the time of passage. Nearly all of the water withdrawn from the source is returned as waste water immediately after passing through the cooling system, carrying with it, however, a large concentrated heat load. The heat is then dissipated by the receiving stream through processes of advection, convection, evaporation and radiation. The most important of these processes, in terms of managing the Basin's supply of water, is evaporation.

Table I-14

Estimated average annual steam-electric power depletive use of water, 1970-2020

(in million gallons per day)

Sub-basin No.	Name	1970	1980	1982-2020 *
1	Upper Basin	0	0	0
2	Jervis-Riegelsville	3.2	20.6	20.6
3	Lehigh Valley	.2	0	0
4	Riegelsville-Trenton	.6	11.2	11.2
5	Pennsylvania-Estuary	11.8	14.4	14.8
6	Schuylkill Valley	4.5	25.2	42.7
7	New Jersey-Estuary	5.3	3.5	3.5
8	Brandywine Valley	1.8	2.7	2.7
9	Salem	1.3	6.4	16.1
10	New Castle	.4	3.3	5.8
11	New Jersey-Bayside	.3	0	0
12	Delaware-Bayside	.2	0	0
	Total mgd	29.6	87.3	117.4
	cfs	45.8	135.1	181.6

* Note : The staff report assumes that no new quantities of water will be dedicated solely to the electric utility industry beyond that which will be required for power installations to be operational by the year 1982.

This "instream induced" evaporation, caused by the rejected heated water, is included in the estimates of depletive water use shown in Table I-14.

New steam-electric generating plants, with capacities exceeding 1,000 megawatts, are expected to be required to be equipped with cooling towers to minimize thermal pollution of streams. This use of closed circuit "wet tower" cooling systems involves recirculation of condenser cooling water and markedly reduces water withdrawals from streams and waste heat loads to these streams as compared to those associated with the "once-through" cooling systems. Wet tower cooling systems, however, do result in higher depletive uses of water. To continue to evaporate waters of the Delaware River Basin in large quantities in the cooling of electrical generating stations appears to be inconsistent with the doctrine of equitable apportionment of these waters. Therefore, it has been assumed for purposes of this staff report that no new quantities of water will be available for the electric utility industry beyond that which will be required for power installations to be operational by the year 1982. By that time, the utilities' advanced planning should be capable of including nonevaporative -dry tower cooling systems or the use of noncondensing generating capacity, such as that produced by internal combustion, hydroelectric gas turbine, and diesel power; or would site future water-requiring plants adjacent to saline waters or outside of the boundaries of the Delaware River Basin.

The maximum demands for electrical power are likely to occur in the warm summer periods, when air conditioners are in use and when surface water temperatures are at or near their annual highs. Estimates of the monthly distribution of average annual depletive water use for electric power generation were developed by the electric utilities of the Basin as an input to their Master Siting Study, responsive to a Delaware River Basin Commission requirement.

These monthly percentages are presented under the "electrical" column in Table I-12.

All estimates of electrical generating capacity, and associated water requirements are presented herein as factors which must be considered in the planning process; however, they are not to be interpreted as water allocations for use for electric generating purposes.

Agricultural water use.--The practice of irrigating high value crops during critical periods in their growth cycle is increasing in the Delaware River Basin. While the total amount of water used for this purpose is not large, it is important because (1) irrigated crops transpire a large proportion of the water applied, and (2) the demand for such applications normally occur during critical low stream flow periods of the summer.

About 90 percent of the irrigation demand is concentrated in the three months of June through August, coinciding with the period of relatively low stream-flow. The peak demands for irrigation water usually occur in July, which can be expected to account for about 35 percent of the annual irrigation demand. (See "Irrigation" column, Table I-12.)

Although the projected demands for water use in other categories show steadily increasing trends until the year 2020, irrigation demands are expected to reach a peak in about the year 2000, after which a decline is indicated, due to gradual urbanization of agricultural land.

Estimates of depletive use of water for irrigation were based upon an assumed 60 per cent irrigation efficiency, i.e., approximately 40 percent of the water applied to the land either returns to surface streams or percolates to underground acquifers; the remainder of the water applied, 60 percent, is depleted in growth of the crop or evaporation from the land surface.

The estimates of average annual irrigation depletive water uses are presented in Table I-15.

A second type of agricultural water use is that required for livestock watering. The basinwide estimates and projections of livestock water demands were taken from the report, "Rural Domestic and Livestock Water Requirements," prepared by the U. S. Department of Agriculture for the North Atlantic Regional Water Resources Study Coordinating Committee, issued in December, 1968. The Basin totals were apportioned among the 12 sub-basins in proportion to the farm area in each sub-basin. The sub-basin farm areas were estimated from County farm areas as reported by the Bureau of Census (1964, VI, parts 7, 8, 9, and 22).

Depletive use of water for livestock watering was assumed to be 75 percent of the withdrawal demand for that purpose. As in the case of "rural-domestic" demands, it was assumed that the livestock uses would be relatively constant throughout the year. The estimates of average annual depletive use of water for livestock watering are presented in Table I-16.

Export of water. -- The City of New York obtained its present rights to export up to 800 mgd of water from the Delaware River Basin by means of a United States Supreme Court decision on June 7, 1954. Due to the significance of that decision, it is included, verbatim, as Appendix B of the this staff report. The right of the State of New Jersey to export up to 100 mgd from the Basin was also established by the Court in its 1954 decree.

Among the several conditions imposed upon the City of New York by the Court is the requirement that in order to export water from the Basin, the City must sustain a flow of 1,750 cfs in the Delaware River at Montague, New Jersey. This condition has the effect of augmenting natural flows during the periods of lower rates of runoff, and coincidentally, highest rates of water demands.

Table I-15

Estimated average annual irrigation depletive use of water, 1970-2020

(millions of gallons per day)

Sub-basin No.	Name	1970	1980	2000	2020
1	Upper Basin	1.9	2.4	2.3	2.4
2	Jervis-Riegelsville	1.3	1.6	1.6	1.6
3	Lehigh Valley	1.3	1.6	1.6	1.6
4	Riegelsville-Trenton	.6	.8	1.6	.8
5	Pennsylvania-Estuary	.6	.8	1.6	.8
6	Schuylkill Valley	1.3	2.4	3.2	1.6
7	New Jersey-Estuary	8.7	11.3	12.8	10.4
8	Brandywine Valley	.6	1.6	3.2	.8
9	Salem	3.1	4.9	5.6	4.0
10	New Castle	2.5	4.0	6.4	3.2
11	New Jersey-Bayside	13.0	17.0	18.5	16.0
12	Delaware-Bayside	11.8	16.2	17.6	14.4
	Total*- mgd	46.5	64.8	76.4	57.7
	cfs	71.9	100.3	118.2	89.3

*May not add due to rounding.

Table I-16

Estimated average annual livestock depletive use of water, 1970-2020

(in million gallons per day)

Sub-basin No.	Name	1970-2020
1	Upper Basin	2.0
2	Jervis-Riegelsville	.8
3	Lehigh Valley	.8
4	Riegelsville-Trenton	.4
5	Pennsylvania-Estuary	.3
6	Schuylkill Valley	1.7
7	New Jersey-Estuary	.2
8	Brandywine Valley	.7
9	Salem	.2
10	New Castle	.2
11	New Jersey-Bayside	.2
12	Delaware-Bayside	.2
	Total *mgd	7.6
	cfs	11.8

*May not add due to rounding

As the result, the pattern of expcrtations by the City of New York is not directly related to observed low-flow conditions in the Delaware River. The City, under conditions specified by the State of New York must also release water from each of its three Delaware Basin reservoirs to sustain specified minimum flows immediately downstream therefrom.

As the last of the City's three reservoirs was constructed and placed in operation after the historic low flows of record, the flow, mandated by the Court, at Montague, New Jersey must be substituted for the observed critical low flow at that point, and flows at downstream locations adjusted accordingly for comparisons of basic water supplies with the demands thereon. Estimates of future demands for exportation of water out of the Delaware River Basin were developed based upon conditions set forth in duly authorized permits, or court decisions, except in the case of a proposed but as yet unauthorized export for New Jersey.

Those agencies that, in the past, have become involved in estimating future water requirements for the heavy concentrations of population and industry in the northern portions of New Jersey, principally the area having Newark as its centroid, have concluded that the local sources of water are inadequate to meet the growing demands of the area. Further, most have concluded that the Delaware River would be the most economic source of imported water. An import of 300-million gallons per day has frequently been used to quantify this need. These conclusions were reflected by the U. S. Army Corps of Engineers in reports resulting from studies conducted in the late 1950's, published in House Document 522-87th Cong. 2nd Session, and again in its North Atlantic Regional Water Resources Study, published in June 1972.

In a letter dated October 24, 1966, the Governor of New Jersey advised the Delaware River Basin Commission of New Jersey's intention to seek an allocation of 300 mgd from the Delaware River for exportation to the northern portion of the State. Former Governor Cahill also had noted the need for three hundred million gallons of water per day from the Delaware River for this section of New Jersey. However, the Commission has not authorized this exportation of water.

The June 7, 1954 Decree of the United States Supreme Court (see Section V, Appendix B) specifically prohibits the State of New Jersey from exporting more than 100 mgd from the Delaware River Basin without compensating releases to the Basin, unless it builds and utilizes "one or more reservoirs to store waters of the Delaware River or its tributaries for the purpose of diversion to another watershed ...," and the Delaware River Basin Compact (Article II and Section 3.8) requires the Commission's approval of any water allocation or project prior to the expenditure of public funds leading to the implementation of such a project.

While a need and desire exist for exportation of water to the northern portion of New Jersey, the legal requirements of the Court and Compact have not yet been satisfied. Nevertheless, since the purpose of this chapter is to identify and present reasonable estimates of future demands upon the waters of the Delaware River upon which a specific plan of management may follow, the potential export of 300 mgd is considered.

Hence, in view of the foregoing, and recognizing that it will be physically impossible to construct sufficient water storage within the Basin prior to 1980 to fulfill the requirements of the United States Supreme Court, it has been postulated, <u>for estimating water requirements only,</u> that all the legal requirements will have been fulfilled and that 300 mgd will be exported from the Basin for use by New Jersey by the year 2000.

Further, it is presumed that the water would be diverted from the Delaware River at Frenchtown, N. J.

The State of New Jersey has been exporting water through its Delaware and Raritan Canal for use in the vicinity of New Brunswick, N.J. since 1834 and is authorized by the United States Supreme Court to continue this exportation up to a limit of 100 mgd.

Average annual authorized exports by all agencies are expected to increase from an average of about 673 mgd in 1970 to 911 mgd, the full entitlement, by 1980. The total 1970 export rate is less than the combined rates approved as of 1970, as some agencies were not yet taking their full entitlements. The projected rates for 2000 and 2020 are equal to the combined 1970 export entitlements, plus a diversion of 300 mgd to northeastern New Jersey. These estimates are presented in Table I-17.

Water exported from the Basin can be grouped with depletive uses of water within the Basin, when considering its impact upon low flow conditions. An analysis of the 1966-1970 monthly rate of use of water from New Jersey's Delaware and Raritan Canal was prepared as an aid in projecting the impact of exportations, other than those of the City of New York, upon the Delaware River at Trenton. The result of that analysis is presented under the column headed "exportation" in Table I-12.

Maximum depletive use of water. -- In planning for future water development in the Delaware River Basin, the most significant demands upon the water supply are those which deplete low stream flows. Such demands characteristically occur where users take water from a stream or other source, evaporate or transpire a portion and then return the remainder to the water body. Similarly, demands for water to be exported from the Basin have a depletive effect on stream flows.

Table I-17
Authorized 1970 and estimated future average annual exportation of water from the Delaware River Basin, 1970-2020

(In million gallons per day)

Sub-basin	Exporter	1970 Authorized	1970 Exported	1980 Estimated	2000-2020 Estimated
1	City of New York, N. Y.	800	600	800	800
	Otisville State Training School, Otisville, N. Y.	0.5	0.3	0.5	0.5
	Village of Woodridge, N. Y.	0.5	0.4	0.5	0.5
	Subtotal	801	600.7	801	801
2	None	0	0	0	0
3	Pa. Gas and Water Co.	3	1	3	3
	Hazleton Joint Sewer Authority	3	2	3	3
	Subtotal	6	3	6	6
4	Flemington, N. J.	0.5	0.5	0.5	0.5
	State of New Jersey (Delaware and Raritan Canal)	100	65	100	100
	State of New Jersey (Frenchtown Diversion)	None	0	0	300
	Subtotal	100.5	65.5	100.5	400.5
5	None	0	0	0	0
6	Mahanoy Twp. Authority	0.1	0.05	0.1	0.1
7 thru 10	None	0	0	0	0
11	Wildwood, N. J.	3.5	3.5	3.5	3.5
12	None	0	0	0	0
	Total (rounded) mgd	911	673	911	1211
	Total cfs	1,410	1,041	1,410	1,874

Estimates of maximum depletive use of water, including exports, during periods of critically low stream flow therefore provide a basis for determining the remaining water supply available for downstream uses. The maximum depletive use will occur in July.

A summary of expected maximum monthly average depletive use of water for all purposes throughout the Basin, including exports, other than to New York City, is presented in Table I-18. This summary excludes Sub-basin I because those depletive uses are made up by New York City, under terms of the 1954 Supreme Court Decree, by sustaining the required flow at the downstream boundary of Sub-basin I. In addition, natural low flows would be lower during critical periods of highest rates of water demands, if it were not for the requirement that the City sustain a minimum flow of 1,750 cfs in the Delaware River at Montague, N.J., as one of the conditions for exporting water from the Basin.

Quantitatively, the predicted increase in maximum monthly basinwide depletive use will be moderate during the present decade, rising from 551 mgd in 1970 to 778 mgd in 1980, an increment of about 40 percent. However, with a fivefold increase expected in exports below Montague, N.J., during the following two decades, the maximum monthly basinwide depletive use of water is forecasted to reach an average of over 1,304 mgd by year 2000, increasing at a slower rate thereafter to about 1,353 mgd by 2020. For purposes of comparison, Tables I-19 A & B show the estimated maximum month total basin-wide depletive uses and gross water withdrawal demands, including exportations out of Sub-basin I. As noted above, under terms of the Supreme Court Decree, such withdrawals are offset by the requirement for sustaining a minimum flow of 1,750 cfs at Montague, N.J. Even so, total basinwide gross water withdrawal demands nearly double from 1970 to 2020, while losses by depletive uses more than double below Montague, N. J.

Table I-18

Estimated maximum month (July)[a] depletive uses of water 1970-2020[b]

(in million gallons per day)

Type of use		1970	1980	2000	2020
Rural domestic		5	5	5	5
Municipal-low projection		94	110	138	176
Industrial - self supplied		122	143	198	286
Steam electric power		59	134	190	190
Irrigation		183	256	304	227
Livestock water		6	6	6	6
Exportation		82	124	463	463
Total	mgd	551	778	1,304	1,353
	cfs	853	1,204	2,018	2,093

[a] The July percentage of total annual water use is estimated for the years 1966-1970 (See Table I-12).

[b] Excluding Sub-basin I, where depletive uses are made up by New York City under terms of the 1954 Supreme Court Decree.

Table I-19A

Estimated maximum month (July)
Basinwide depletive uses of water 1970-2020

(in million gallons per day)

Type of use	1970	1980	2000	2020
Rural domestic	5	5	5	5
Municipal-low projection	95	111	139	177
Industrial - self supplied	123	144	199	287
Steam electric power	59	134	190	190
Irrigation	191	266	314	237
Livestock water	8	8	8	8
Exportation	761	1,030	1,369	1,369
Total Basinwide mgd	1,242	1,698	2,224	2,273
Total Basinwide cfs	1,921	2,627	3,441	3,519

Note: For average annual daily rates, see Table I-21.

Table I-19B

Estimated maximum month (July)
Basinwide gross water demands 1970-2020

(in million gallons per day)

Type of use	1970	1980	2000	2020
Rural domestic	53	53	53	53
Municipal-low projection	953	1,106	1,391	1,774
Industrial - self supplied	3,119	3,676	5,180	7,671
Steam electric power	7,650	10,462	10,656	10,656
Agricultural irrigation	318	444	523	395
Livestock water	10	10	10	10
Exportation	761	1,030	1,369	1,369
Total Basinwide mgd	12,864	16,781	19,182	21,928
Total Basinwide cfs	19,902	25,963	29,678	33,927

Estimates of depletive use for the electric utility industry assume limitations on development of power due to the inability of the water resources to absorb such large consumptive losses and attendant heat loads.

Instream Uses of Water. -- In addition to the withdrawal demands and depletive uses of water discussed in the preceding sections, water is also used within the streams and other surface waterways of the Delaware River Basin. Instream uses include those for navigation, hydroelectric power generation, fish propagation and fishing, wildlife management, recreation, waste assimilation, and salinity control in the estuary of the Delaware and its tidal tributaries.

Navigation. -- The Delaware River and its tributaries were once important highways of commerce over the entire length of the Basin from the headwaters to the Capes and contributed to the economic growth of the region. However, navigation above Trenton by rafts, barges, and other shallow-draft vessels declined with the advent of competing transportation facilities. There is at present little indication of either need or desire for navigation improvements in the Basin above Trenton, and there appears to be little prospect at this time that a demand will develop. The Delaware River from Trenton to the sea remains an important navigable waterway and the existing and authorized navigation projects in the tidal sections of the Delaware River and tributaries continue to make positive contributions to the Basin's economy. The port area of the tidal Delaware River ranks second nationally, and third worldwide, in total water-borne commerce. Authorized Federal navigation projects provide for a channel 40-feet deep from the sea for 126.3 miles to Newbold Island, thence 35-feet deep for about 5 ½ miles to the Trenton Marine Terminal, thence 12-feet deep for about 1 ¼ miles to the Penn Central Railroad

Bridge at Trenton. Appurtenant facilities and numerous tributary channels on both sides of Delaware River and Bay are also provided under the existing projects.

The volume of river fresh water discharge, below Trenton, is small compared to volume of tidal flow. Stream discharges at Trenton have little effect on stages in the estuary except in the upper reaches during periods of extremely high runoff. Additional fresh water released from reservoirs during periods of low flow would tend to raise the normal water elevations in the river above Trenton during those periods. However, these increases in discharge would provide no appreciable benefit to navigation, as their effect on river stages would be undetectable below Trenton.

Hydroelectric power.-- There were 10 hydroelectric power generating plants operating in 1972 with a total installed capacity of 441 megawatts. Nine of these facilities are conventional hydroelectric stations, and the tenth is a pumped-storage facility on Yards Creek in Warren County, N.J.

The conventional stations represent an instream, nondepletive use of water at a potential maximum rate of 3,217 mgd and an average rate of 935 mgd. The flows needed to sustain the generation of peaking power at these plants will be taken from storage reservoirs in Lake Wallenpaupack and Mongaup system and do not represent the need for continuous river flow at any site.

Fish and Wildlife. -- Instream water needs for the preservation and enhancement of fish and wildlife are an important part of the overall water requirements in the Delaware Basin. Many parts of the Basin provide excellent fishing opportunities. The economy of some regions, particularly in the Poconos and Catskills, is closely linked to the seasonal influx of tourists who visit the area to fish and hunt in a natural setting.

Both sport and commercial fisheries are found in the lower estuary, and anadromous species must pass through the estuary on their way to and from spawning grounds in fresh water. An important commercial shell fishery is found in Delaware Bay. Throughout both the upstream and tidal portions of the Delaware River, as well as in Delaware Bay, the critical demand is for maintenance or enhancement of water quality.

Recreation. -- The Delaware River is presently a water-oriented recreational service area available to approximately 25,000,000 people. A considerable proportion of this population is already utilizing Basin facilities to satisfy many of its demands for outdoor recreational opportunities. Virtually all existing water-oriented recreation facilities in the Basin are sustaining near maximum use. Because of population growth, increasing personal income, greater leisure time, and easy travel, the recreational demands for water-oriented facilities are increasing. The 1970 demand for water-associated recreation in the Basin is estimated to have amounted to about 90-million man-days per year. By the year 2020, this demand upon the Basins's water resources is expected to at least double, and possibly triple.

Nearly all forms of water-oriented recreation have experienced an increasing popularity, resulting in a growing instream demand for water quantity and quality adequate for their support. These activities include boating, fishing, bathing, skin-diving and sightseeing. While recreation seekers place a heavy demand upon the existing streams, lakes and the estuary of the Delaware River, there is a latent demand for water-based recreation in presently water-scarce areas of the Basin.

The scarcity of water surfaces and water depths adequate for desired recreational pursuits in portions of the upper Basin is reflected by vacation trips by many residents of the Basin and nearby areas to more distant but better-watered regions.

Attainment of the full recreational potential of Basin waters will require more access to the waterways, additional impoundments dedicated to recreational uses and, in some places, improved water quality in the river and bay.

Waste assimilation. -- The assimilation of treated waste waters is an instream use of Basin waterways recognized by the Delaware River Basin Commission. One of the objectives of this staff report must be to insure adequate streamflows at all times so that the quantities of organic residual wastes, discharged after prescribed degrees of treatment in sewage treatment plants, are assimilated to the degree necessary to protect other water uses. Added to these organic loads are vast quantities of mineral dissolved solids in industrial wastes discharged to the surface waterways of the Delaware River Basin, either directly or via public sewers.

Dissolved inorganic solids are not reduced significantly by most conventional waste treatment works so that with present technology, instream dilution of these mineral dissolved solids must be depended upon to maintain stream standards of water quality. This will require regulation of natural streamflows to augment the natural assimilative capacity or to offset reductions of natural flows by depletive use or exports of water.

Salinity control. -- One of the most significant problems in the tidal Delaware River is the control of salinity caused by the intrusion of sea water from the Atlantic Ocean. Although sea-water intrusion is a natural phenomenon, it decreases the utility of the tidal waterway as a source of water supply for most withdrawal uses, and affects the ecology of the tidal waterway. These effects can be aggravated or reduced by man's activities.

The penetration of sea water up the Delaware estuary depends primarily upon the flood tidal currents that occur twice daily. During periods of tides that are higher than normal (spring tides), the intrusion force increases, and during lower-than-normal tides (neap tides), this force decreases. In some estuaries, an additional factor -- the density difference between saline water and fresh water -- causes vertical stratification of the water and landward intrusion of the saline water. This phenomenon has been observed near the head of Delaware Bay, but in the upper portion of the tidal Delaware River the estuary is vertically well mixed, and no salt water underflow occurs.

The principal force opposing sea-water intrusion is the flow of fresh-water runoff into the tidal river, which dilutes the sea water and, during periods of relatively high runoff, pushes the sea water back toward the ocean. During periods of low fresh-water flow into the estuary, the diluting and repelling forces are lowered, and the sea water is carried farther up the estuary on each flood tide until a new equilibrium between opposing forces is reached. Depending on its force and direction, the wind will, at times, increase or decrease the concentration of sea salts in the estuary by pushing the salt water into or out of the estuary. Over long periods of time, changes in mean sea level could also influence the system.

Under any combination of the various forces aiding and opposing sea-water intrusion, a considerable period of time is required for the system to reach equilibrium, and usually before that equilibrium is reached, one or more of the forces changes, creating a new equilibrium toward which the system then begins to move. The distance that a given concentration of sea salts will move under the influence of the combined intrusion-repulsion forces depends upon (1) the location of that concentration (isohaline or isochlor) relative to the equilibrium location for that concentration and combination of forces, and (2) the duration of that combination of forces.

Observations of salt-water movements in the estuary have revealed the dynamic nature of the system, as evidenced by the ever-changing salt concentrations. This unsteady characteristic makes it extremely difficult to determine the exact relationship between any of the forces influencing salt concentrations in the estuary and the concentration at any given location. For this reason, man has generally depended upon hydraulic and mathematical models of the estuary to determine these relationships.

By regulating the flow of fresh water into the Delaware Estuary man can influence the concentration of sea salts in the estuary. Reductions of freah water inflow caused by exportation of water out of the Delaware River Basin and by consumptive use of water, increase sea-water intrusion. Storage of natural runoff in upstream reservoirs and increased evaporation of water from the estuary itself caused by waste heat discharged into the estuary, also increase the salt concentrations. On the other hand, augmentation of the natural flow of fresh water by releases of water previously stored in reservoirs results in lower concentrations of sea salts in the tidal waterways. Table I-20 shows the extent of sea-water intrusion during the drought emergency of 1964-65, as measured by the location of the tidal waters having a chloride concentration of 250 mg/l, with corresponding combined fresh-water inflows from the Delaware and Schuylkill Rivers for the preceding 30 days.

In order to maintain reasonable levels of salinity throughout the upper tidal portion of the Delaware River from Trenton to Wilmington, for the protection of both instream and withdrawal uses of water, the staff of the Delaware River Basin Commission has postulated that the concentration of chlorides at the mouth of the Schuylkill River, Delaware River mile 92.47, should not exceed 250 mg/l.

Table I-20

Estimated locations of the 250 mg/l chloride line in the Delaware River estuary, 1964 and 1965, and precedent fresh-water inflow[a]

Date	Location of 250-mg/l chloride line, river mile		Average combined fresh-water inflow from Delaware River and Schuylkill River for preceding 30 days, cfs.	
	1964	1965	1964	1965
May 31	70	77	14,229	5,902
June 30	76	85	5,521	2,833
July 31	82	91	3,743	1,837
August 31	96	95	2,695	2,062
September 30	96	98 [c]	2,258	2,298
October 31	100	94	2,350	3,917
November 30	101 [b]	--	2,167	--

[a] Based on data provided by the U. S. Geological Survey.

[b] Maximum upstream penetration of 250-mg/l isochlor in 1964 at mile 102 on November 20.

[c] Maximum upstream penetration of 250-mg/l isochlor in 1965 at mile 99 on October 1.

By the use of both hydraulic and mathematical models, the staff has determined that for the mean level of the sea as of 1970 and for average seasonal conditions of tide, wind, and runoff from the drainage area below Trenton, a sustained Delaware River flow at Trenton of 3,000 cfs (1,939 mgd) during the low-flow season would prevent the 250-mg/l isochlor from penetrating upstream of the mouth of the Schuylkill River. This required flow at Trenton will vary somewhat as the actual combination of tide, wind, and contributions of fresh water from downstream tributaries varies, and as the mean sea level changes from its 1970 level.

Sea-water intrusion is also important in the upper Delaware Bay. Natural oyster seed beds are located in this area. The oyster is susceptible to predation by oyster drills. The oysters can sustain lower levels of salinity than the drills. Therefore, it is important to control the salinity as much as practical, especially during the early stages of growth of the oysters, when their shells are thin and therefore more vulnerable.

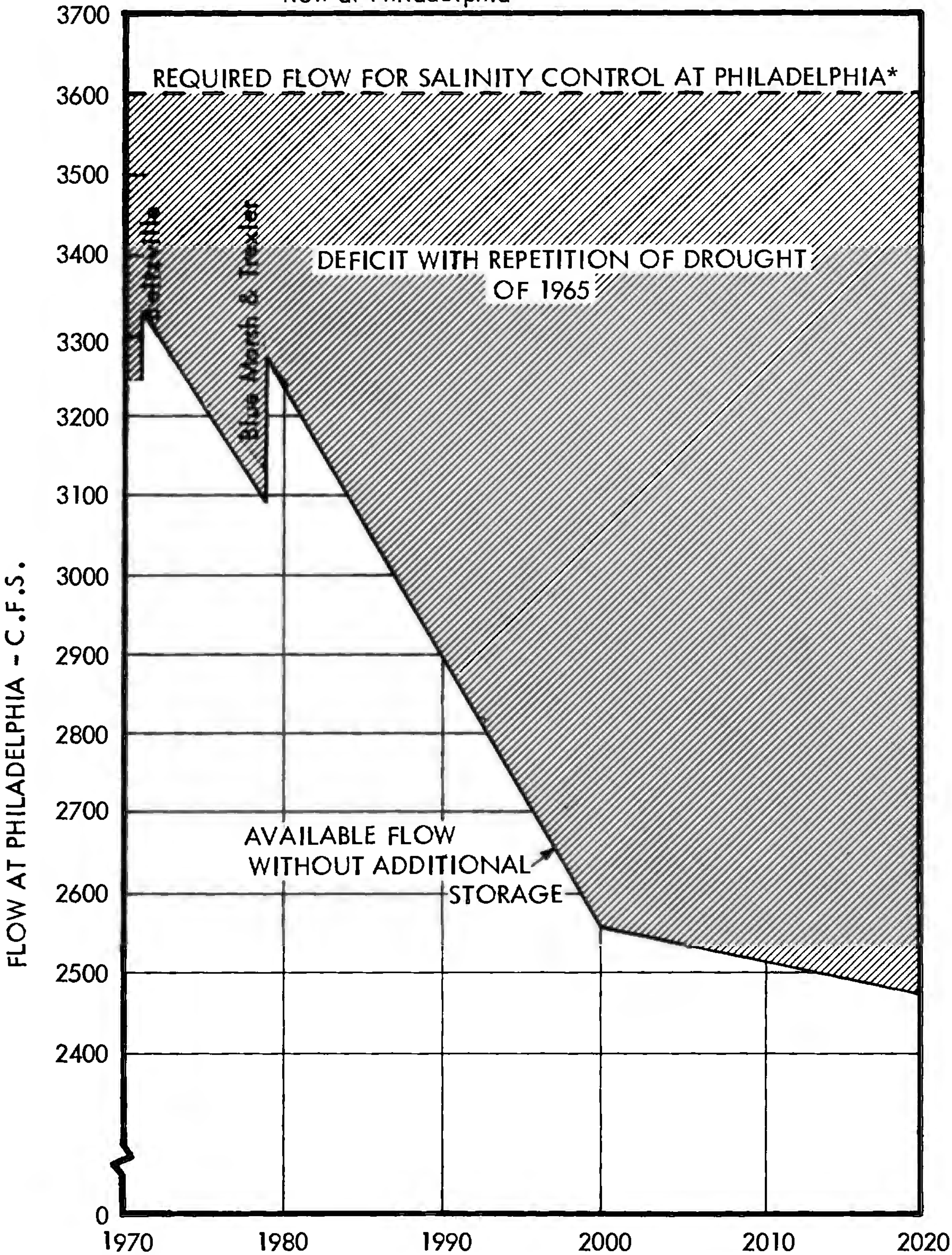
It has been shown that the invasion of sea water into the estuary is controlled largely by the inflow rates of fresh water from the main stem of the Delaware above Trenton and from the downstream tributaries, and that the regulation of streamflows is one potential method of controlling sea-salt concentrations in the tidal river for beneficial purposes. To control sea-water intrusion to the degree necessary to protect beneficial uses of the waters of the estuary, streamflow regulation will be necessary not only to augment the natural fresh-water inflow to the estuary, but also to make up apparent, therefore, that as of 1972, there was an indicated overall inadequacy in development of water supplies of the Delaware River on the order of 300 cfs (194 mgd).

This inadequacy of 300 cfs can be related to the desired location of salinity control, River Mile 92.47, as shown in Figure 1-7. Similar comparisons projected into the future, taking into account those projects under construction, such as Blue Marsh, and those recently recommended for construction in the near future, such as Trexler, indicate that the deficit in flow of the river would continue to increase due to increasing depletive uses. As illustrated in Figure 1-7, the deficit, during critical drought periods, would increase to over 1,130 cfs (730 mgd) by year 2020 without additional storage facilities.

apparent, therefore, that as of 1972, there was an indicated overall inadequacy in development of water supplies of the Delaware River on the order of 300 cfs (194 mgd).

This inadequacy of 300 cfs can be related to the desired location of salinity control, River Mile 92.47, as shown in Figure 1-7. Similar comparisons projected into the future, taking into account those projects under construction, such as Blue Marsh, and those recently recommended for construction in the near future, such as Trexler, indicate that the deficit in flow of the river would continue to increase due to increasing depletive uses. As illustrated in Figure 1-7, the deficit, during critical drought periods, would increase to over 1,130 cfs (730 mgd) by year 2020 without additional storage facilities.

Figure I-7 -- Effect of maximum monthly depletive uses on available flow at Philadelphia*



*Mouth of Schuylkill River - River Mile 92.47

WATER MANAGEMENT OF THE DELAWARE RIVER BASIN

PART ONE

CHAPTER 4 - SUMMARY AND CONCLUSIONS

Waters of the Delaware River have been sought after, used and abused since earliest times. The very first uses of the Delaware River were for navigation, and by 1800 Philadelphia had become the foremost American Port. In the early 1800s, coal was floated down the the Lehigh and Delaware Rivers to Philadelphia. The presence of a convenient source of lime, in addition to an abundance of coal, accelerated the establishment of major ironworks, then giant steel mills along the Lehigh, Schuylkill and Delaware Rivers in the late nineteenth and early twentieth centuries. The duPont family settled in Wilmington, Delaware in 1802 and established the gunpowder business. This was the cornerstone of the vast petro-chemical complex which now sprawls along both sides of the Delaware River Estuary.

In 1896, it is reported that nearly 20,000,000 pounds of American shad were taken from the Delaware River. By the middle of the Twentieth Century, the shad had almost disappeared but recently started a comeback. Similarly, the commercial harvest of oyster meat from the Delaware Bay was nearly 22 million pounds in 1887, had declined to 334,000 pounds in 1960 but has increased to over 2 million pounds in 1972.

The Basin has supported a thriving agriculture since colonial days, but by 1950 pressures of commercial and residential development began forcing prime farmland out of production. Acreage in agricultural uses has declined steadily since then but new and expanding irrigation in remaining farming operations has increased production, thus offsetting losses in acreage.

This staff report is designed to facilitate planning for the immediate and long range development and uses of the water resources of the Basin. The water carried by the surface streams of the Delaware River Basin that has seemed to be so abundant in the past will, in the face of population increase and industrial expansion, be inadequate to meet anticipated demands in the near future without additional regulation. The vagaries of nature in supplying the Basin with water must be accommodated by regulation and management, and the conflicts among competing users of that water must be resolved by policy makers. Thus, this staff report is flexible and responsive to human needs and environmental protection and enhancement.

The average annual depth of precipitation falling upon the Delaware River Basin is about 44.6 inches, occurring relatively uniformly throughout the year. Of the basic average annual water crop, 9,800 billion gallons (30 million acre feet), approximately one-half remains potentially available for use by man after normal evaporation from land and water surfaces and consumptive use by native vegetation.

The average rate of runoff of the Delaware River, over the 1913-1970 period of record at Trenton, New Jersey, was 11,360 cfs. Seven-day minimum flows as low as 1,309 cfs in 1914, and peak flows as high as 329,000 cfs in 1955 have occurred, bringing with them the distresses of drought and flood havoc.

Existing flood control storage, while providing protection on streams near the facilities, collectively provides almost no relief on the Delaware River above Trenton. Relatively few storage facilities are presently available to augment the main streams of the Basin during periods of drought.

During 1970, water was imported into the Delaware River Basin at an average rate of 30.7 mgd (47.5 cfs) and exported at an average rate of 673 mgd (1,042 cfs). A condition set forth by the United States Supreme Court (See Appendix B) for exporting water from the Basin now requires the City of New York to sustain a flow of 1,750 cfs in the Delaware River at Montague, New Jersey. Since 1953, water released into the Delaware by the City has augmented summer levels of flow.

Throughout the Delaware River Basin, the general slope of the ground water is toward the channels of the surface waterways. Thus, ground water maintains the flow of streams during periods of low precipitation and constitutes a significant part of the flow at most times. The total quantity of water stored in geologic substructure underlying the Basin is estimated to be 10,000 to 15,000 billion gallons (31 to 46 million acre feet). Approximately a one year average water crop. Only a portion of this stored water is available for withdrawal and use.

The quality of surface waters within the Delaware River Basin is generally acceptable for most uses of man, for maintenance and propagation of fish, and for the full range of water sports. Exceptions to this generalization will be found in those streams receiving drainage from coal fields where highly acidic water will be encountered, and in the reach of the Delaware River adjacent to the heavily populated centers extending from Trenton, New Jersey to Wilmington, Delaware where excessive discharges of organic waste seasonally depress the dissolved oxygen content of the water below levels necessary to sustain fish and their food chain. Localized areas of high coliform also are encountered in the Trenton-Wilmington reach of the River.

The underground waters of the Basin are of acceptable quality for nearly all uses of man. Locally, water may require softening or removal of iron. Both the tidal Delaware River and those aquifers in hydraulic continuity therewith are, to varying degrees, subject to intrusion of ocean salts.

Use and reuse of water have long been practiced in the Delaware River Basin. Water is withdrawn from surface or underground sources of supply, treated as necessary, used, and then - except for the quantity evaporated or transpired in the process - returned to surface streams after appropriate levels of treatment. The cycle is then renewed by downstream users. The last use of fresh water in this continuing cycle is for salinity repulsion in the estuary of the Delaware River.

In evaluating water available for future use, the extremes of nature must be considered. Appropriate measures must be planned and implemented to make the modifications in the existing pattern of stream flows necessary to accommodate further increases in water use occasioned by growth in the population and supporting economy.

The principal demands upon the waters of the Basin are occasioned by man, his production and the service agencies from which he extracts a livlihood. Approximately 7,000,000 people resided within the Basin in 1970. This population is expected to grow to 10,000,000 by the year 2000 and to exceed 12,000,000 by the year 2020. It is estimated that man, plus all of his industrial and agricultural activities within the Basin, caused an average annual daily rate of depletive water use (evaporation, transpiration and exportation) of 954 mgd (1,474 cfs)in 1970, and that this rate will reach 1,804 mgd (2,793 cfs) by the year 2020. The growth of depletive uses will be reflected by lowered (1) water table and (2) minimum river flows unless counteracting measures are taken.

The depletive water uses of the Delaware River Basin are summarized in Table 1-21.

Table I-21

Summary of estimated depletive water uses
Delaware River Basin
1970-2020

(average annual daily rates)
(in million gallons per day - mgd)

Type of Use	1970	1980	2000	2020
Rural domestic	5	5	5	5
Municipal-low projection	87	101	127	162
Industrial-self-supplied	104	122	169	243
Steam electric power	30	87	117	117
Agricultural irrigation	47	65	76	58
Livestock water	8	8	8	8
Exportation	673	911[a]	1211[b]	1211
Total Basinwide-mgd	954	1299	1713	1804
Total Basinwide - cfs	1474	2011	2652	2793

a Includes New York City exportation increase from 600 mgd in 1970 (644 in 1973) to the maximum of 800 mgd in 1980, and New Jersey exportation from 65 mgd in 1970 and 1973 to 100 in 1980. These are levels authorized by the 1954 Supreme Court Decree (See Appendix B)

b Includes an additional 300 mgd exportation to New Jersey, not yet authorized.

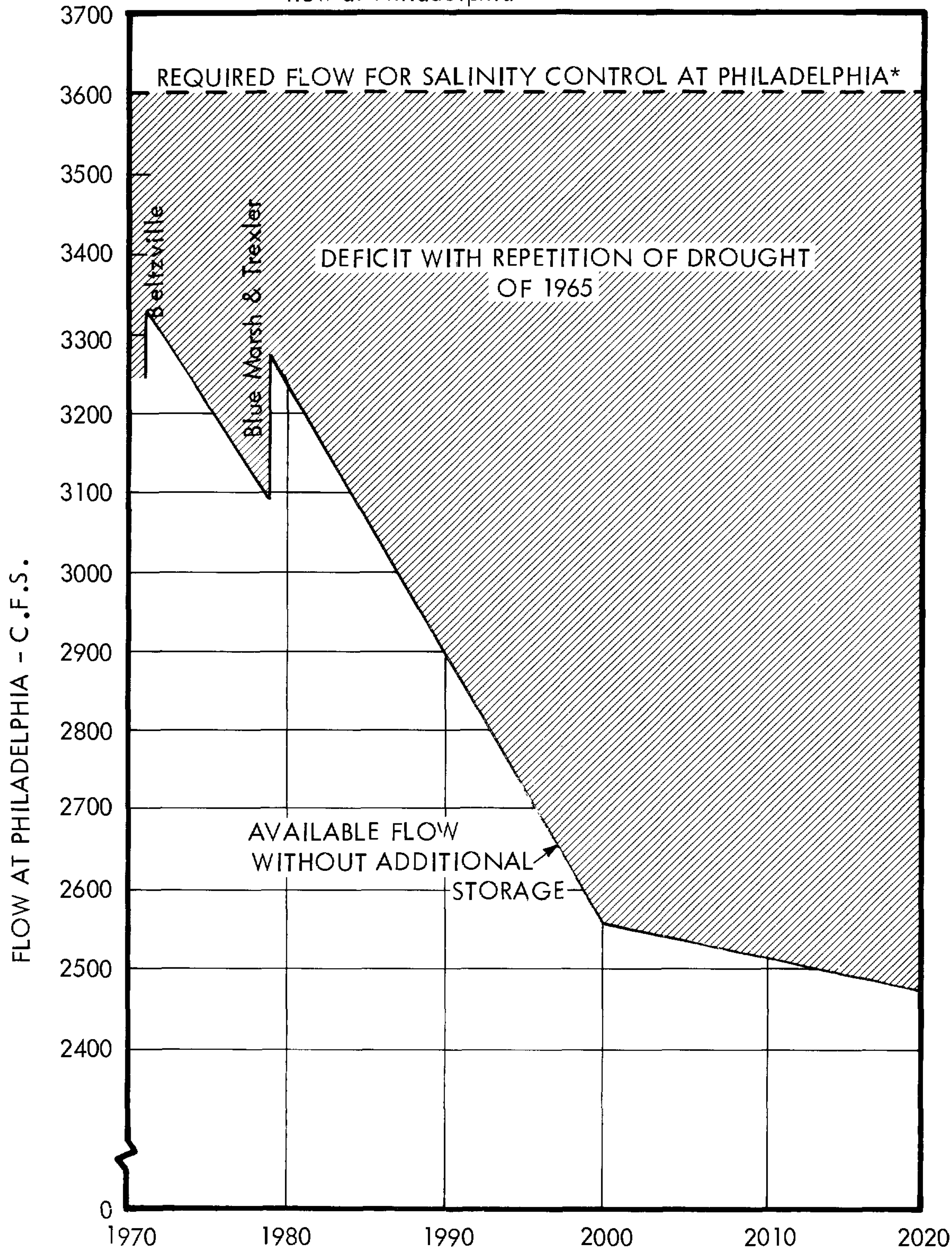
Note: For maximum month rates, see Table I-19A

Water quality control, particularly for prevention of unacceptable levels of salinity in the tidal River, will require the passage of at least 3,000 cfs from the Delaware River at Trenton, New Jersey and at least 3,600 cfs below the mouth of the Schuylkill River. In addition to providing a positive control over salinity intrusion, these minimum flows will provide a seaward direction of movement for particles introduced into the waterways by actions of nature and man.

The heaviest depletive use takes place in the month of July. Figure 1-8 is a graphic display of the resulting minimum river-flow conditions estimated to occur during a recurrence of the 1965 drought. Although recent developments and those projects either under construction or recommended for early construction have been considered in these estimates, the declining curve illustrates the effects of the ever-increasing depletive use of water without any new developments to augment the flow. The desired minimum sustainable flow of 3,600 cfs at the mouth of the Schuylkill decreases from 3,300 cfs in 1972 to 2,470 cfs by the year 2020.

The greatest growth in water demands is to be expected in Sub-basins 5, 6, 7 and 8, where water already is in short supply during periods of drought. In addition to insuring sufficient volumes of water of suitable quality, this staff report makes provision for such waters to be available at given locations at a specific time. Surplus water occuring during and following storms cannot be utilized, in most instances, unless facilities are provided for their storage and subsequent release, conveyance and withdrawal.

Figure;I-8 -- Effect of maximum monthly depletive uses on available flow at Philadelphia*



*Mouth of Schuylkill River - River Mile 92.47

The estimates of the water available in the Basin and predictions of future water demands, when appraised in the light of historical experience and probable future development, lead to the following conclusions:

Conclusions

1. Water supply.

   With a repetition of the severest drought of record, natural runoff of surface streams of the Basin would be inadequate to supply all depletive uses and provide salinity protection to surface and ground waters in the estuary. This inadequacy in 1972, in terms of stream flow during the critical month of July, at Trenton, would have amounted to 194 mgd (300 cfs).

2. Water quality.

   In general, the quality of surface and underground waters of the Basin is suitable for all of the higher uses, except where degraded naturally by intrusion of ocean salts, and in reaches of the Delaware, Schuylkill and Lehigh Rivers, where remedial programs are in various stages of implementation or planning.

3. Flooding.

   With a repetition of historic floods of record, substantial areas of inundation could be expected in highly developed areas adjacent to the Delaware, Lehigh, and Schuylkill Rivers, and numerous secondary streams, including lands which were inundated in 1955 and were subsequently urbanized.

4. Base flows

   The maintenance of base flows adequate to control levels of salinity and provide a positive flushing of sediments toward the ocean is the most important need. These base flows cannot be maintained unless provisions are made for additional water storage and timely release.

WATER MANAGEMENT OF THE
DELAWARE RIVER BASIN
PART TWO
CHAPTER I - INTRODUCTION

Part Two of this staff report proposes a management solution to the water resources problems and needs developed in Part One, with particular emphasis on describing those physical facilities and operating criteria which will be required to meet on a timely basis the estimates of future water demands for adequate water supply, for improvement of water quality where needed, for flood damage reduction by structural and nonstructural measures, and for water-related recreation, fish and wildlife needs.

This introduction to Part Two further defines (1) the function of this staff report in relation to the Comprehensive Plan of the Delaware River Basin Commission, which is a legal and regulatory document; and (2) the planning role of the commission in relation to the planning agencies of the Federal Government, the four signatory States, and other governmental and private planning agencies.

First, as mentioned in Part I - Introduction, this report responds to those sections of Article 3 of the Compact mandating a leading, directing and coordinating role by the Delaware River Basin Commission in all water resource and water related land use planning throughout the Delaware River Basin. Before defining the function of this staff report in relation to the Comprehensive Plan, it is necessary to describe the latter in brief detail. Section 13.1 of the Delaware River Basin Compact provides that: "The commission shall develop and adopt, and may from time to time review and revise a comprehensive plan for the immediate and long range development and use of the water resources of the basin. The plan shall include all public and private projects and facilities which are required, in the judgment of the commission, for the optimum planning, development, conservation, utilization, management and control of the water resources of the basin to meet present and future needs; provided that the plan shall include any projecrs required to conform with any present or future decree or judgment of any court of competent jurisdiction. The commission may adopt a comprehensive plan or any revision thereof in such part or parts as it may deem appropriate, provided that before the adoption of the plan or any part or revision thereof the commission shall consult with water users and interested public bodies and public utilities and shall consider and give due regard to the findings and recommendations of the various agencies of the signatory parties and their political subdivisions...."

To carry out this legislative mandate, the Delaware River Basin Commission has, through its continuous studies and working with the parties signatory to the Compact, developed its Comprehensive Plan for the immediate and long-range development and use of the water resources of the Basin. It is this plan and program of basin management, consisting of two principal interlocking elements, a Water Code of the Basin, and the Physical Structure of the Plan, comprised of both the duly adopted existing water resource facilities of the Basin and the proposed and similarly adopted future water resource projects of the Basin, that is the basis of this staff report.

Water Code of the Basin

The Water Code is comprised of both policy and specific water quality standards. The Delaware River Basin Compact, in addition to establishing the Delaware River Basin Commission and outlining its authority and area of jurisdiction, contains a number of directives which are fundamental to a plan of water resource management. For example, Section 3.3 provides that the Commission may allocate the waters of the Basin to and among the states signatory to the Compact, but may not, without the unanimous consent of the parties, modify any conditions contained in the United States Supreme Court decree in New Jersey v. New York, 347 U.S. 995 (1954). Due to the impact of this Court decree upon the flexibility of the Commission to manage the water resources of the Basin, the decree is included in this staff report verbatim, as Appendix B.

A second example of specific guidelines is found in Section 5.3 of the Compact which, in part, states that each of the signatory parties agrees to maintain the waters of the Basin" ... in a satisfactory condition, available for safe and satisfactory use as public and industrial water supplies after reasonable treatment, suitable for recreational usage, capable of maintaining fish and other aquatic life, free from unsightly or malodorous nuisances due to floating solids or sludge deposits and adaptable to such other uses as may be provided by the comprehensive plan." Hence, these legislatively mandated goals are fundamental features of the Commission's Water Code of the Basin and this staff report.

In implementing the Delaware River Basin Compact, the Commission has from time to time promulgated policies which can serve as guidelines to those agencies and individuals engaged in developing plans for use of the Basin waters, or plans which in some way will have an impact upon the Basin waters. These policies, which were subjected to public hearing and appropriate modification prior to final action, have covered a number of fields and are set forth in the Water Code of the Basin (See Appendix A).

As an example of the legal interties between the Compact and the duly adopted policy of the Commission, with regard to all levels of government, Article 11 of the Compact provides that "no expenditure or commitment shall be made for or on account of contruction, acquisition or operation of any project or facility nor shall it be deemed authorized, unless it shall first have been included by the commission in the [its] comprehensive plan, " while Section 1.10 of the Water Code of the Basin sets forth the fundamental policy against which specific projects must be tested for inclusion within the Comprehensive Plan: (a) the project must provide beneficial development of the water resources in a given locality, or region; (b) it must be economically and physically feasible; (c) it must not adversely influence the present or future use and development of the water resources of the Basin; and (d) it must conform to accepted public policy. Where the Commission may have a financial interest in the timing of construction of a project, additional guidelines are set forth in Code Section 2.10.3 which must be met before final clearance can be gained pursuant to Compact Section 3.8. Simply stated, Section 2.10.3 requires a deomonstration of economic justification, and encourages utilization of local supplies, prior to importation of water.

Other sections of the Code enunciate the Commission's policy on water quality, use and protection of underground waters, and environmental review of projects. Many of these policies find direct application in formulating this staff report. Other policies adopted by the Commission are used to test projects which may be proposed by any person or agency, and are subject to review under Section 3.8 of the Compact. As an example of this latter category are those policies relating to regional approaches to waste treatment (Code Section 3.50). In many areas, detailed physical plans have not been developed, nor is it timely to consider massive systems, yet it can be projected that at some future date the economies of scale and the need for better protection of water resources will result from a regional system. Hence, regionalization should be considered at the earliest possible planning stage.

The basic problem of an organization created to administer the waters of a complex basin, involving lands and governments of five States (including 8 square miles of Maryland - not a signatory State) and also sovereign powers of the Federal Government, is to establish a frame of reference within which all can function while maintaining flexibility to accommodate changing times. This is accomplished through the broad statements of policy in the Water Code. Even a project approved by the Commission, as required by Compact Article II, may be modified in location, layout, physical structure, service area or other features as it moves from the planning stage into final design, leading to final review and consideration for approval pursuant to Compact Section 3.8. Further, approval of a proposed physical project does not mandate its construction. In some cases, a project may be described in technical detail to provide an understanding of its capability to perform a given function. By the time construction becomes imminent, a better method may have developed for reaching this goal and, hence, the goal rather than the physical description may be controlling.

In general, the Comprehensive Plan is built on the premises that: (l) the surface waters of the Basin are to be maintained satisfactorily for domestic, agricultural, industrial, recreational and fish and wildlife uses, except where natural salinity precludes such uses; and that (2) the underground water bearing formations of the Basin, their waters, storage capacity, recharge areas, and ability to convey water shall be preserved and protected.

In addition to basic planning policy, the Water Code establishes certain criteria to which the Plan must accommodate. As one example, recognizing the inherent danger which uncontrolled ocean salinity intrusion would cause for nearly one-half of the people dependent upon the tidal Delaware River for water supply, either directly or via underground aquifers, a location has been established at the mouth of the Schuylkill River upstream of which salinity should not be permitted to exceed a chloride concentration of 250 mg/l.

As noted, the Delaware River Basin Compact specifies that the Comprehensive Plan which the Commission is mandated to develop and adopt "shall include all public and private projects and facilities which are reguired....for optimum planning, development, conservation, utilization, management and control of the water resources of the basin to meet present and future needs..." The inclusion of these projects and facilities into the Comprehensive Plan bestows upon them protection against the inroads of later projects or uses as may be provided under terms of the Compact. As an example, the water supply intake of the City of Philadelphia, located at River Mile 111, was included in the Comprehensive Plan on July 25, 1962. Hence, all other plans and projects which might reduce either the quantity or quality of water at that location, which have been either developed by or subject to the review of the Delaware River Basin Commission since 1962, have taken as one criterion the protection of Philadelphia's responsibility to its constituency in connection with the intake facility as well as its capital investment therein.

Existing facilities

The term facility refers to those structures that are in existence and are operable. In general, the majority of existing facilities subject to the jurisdiction and protection of the Commission are related to the direct use of the water more than to its development. A very large number of surface and underground facilities designed to withdraw water for subsequent distribution for municipal, industrial, agricultural, and other uses are in existence. Similarly, hundreds of waste water treatment facilities are in existence, which place demands upon the assimilative capacity of the Basin's water resources. Also, there are numerous encroachments upon the waterways of the Basin, designed to utilize the navigation potential afforded by the rivers, bays and other channels.

It should be noted that with the passage of time since their adoption, some of the existing facilities would not meet current tests for approval. For example, some existing waste treatment plants will not produce an effluent of the quality level now specified in the Water Code. Where conflicts of this nature emerge, the current policy of the Commission as set forth in the Water Code shall take precedence, and the facilities in question are subject to modification.

Approval of projects

The term "project" refers to physical works that have been proposed but not yet constructed or placed in operation. To meet the needs of their constituencies and to comply with the order of the Delaware River Basin Commission and its signatories, all governmental agencies must plan their water projects in consultation with the Commission, and have the projects included in the Commission's Comprehensive Plan prior to making an expenditure or commitment toward acquisition, construction or operation of the projects. Accordingly, the Commission is continuously working with the governmental agencies, and when their projects are ready for review, hearings are called to determine whether said projects meet all of the tests for inclusion in the Comprehensive Plan. These include tests against the Water Code, existing facilities, and other approved projects.

The projects that have met the tests, and have been subjected to public hearing and gained entry into the Commission's Comprehensive Plan form, in part, the basis on which projections for future water resource development and utilization are predicated in this staff report. As was noted in the discussion of "facilities," the preponderance of the approved projects are designed to make direct use of the waters of the Basin rather than the development of those waters.

Report to the Commission

From the foregoing description of the Comprehensive Plan, it is clear that its policies, criteria, and physical structures, existing and proposed, are necessarily firm and fixed, at least until such time as changed conditions and circumstances in the physical world require amendment or modification, because the Comprehensive Plan is designed by the Compact to serve as a regulatory document whose provisions have the weight of law and are instruments both for enforcement and the testing of new policies, criteria, and physical structures which expand and improve the Plan consistent with and in harmony with all the goals and purposes mandated by the Compact. This staff report is not a legal, regulatory document. Rather, it is a summary data bank, and its function is to provide an ordered compendium of basic current data on water and water related resources, plus information on present and anticipated needs of the Basin community, essential for the Delaware River Basin Commission and all other agencies having political jurisdiction or legal responsibilities concerned with these resources and present and future needs for them to most effectively plan, develop and manage the available resources within the framework of the Comprehensive Plan.

Planning role of the Commission

Second, numerous agencies are continuously planning ways and means of regulating the extremes in stream flows of the Basin, in order that those who make demands upon the waters can depend upon a given quantity of water of a given quality to be available at a given location at all times. The Delaware River Basin Commission is one such agency, and it utilizes the end products of many others. In the final analysis, the Commission integrates into a single plan of water management those plans, programs, facilities and projects which will meet it's overall goals and duly adopted policies for management of the Basin's waters.

In this respect, the Delaware River Basin Commission serves as an extension of the water and related resource jurisdiction exercised by the States and the Federal Government. It provides a cooperative forum for interstate activities, eliminates duplication, protects projects and plans through the Comprehensive Plan and carries out an extensive public participation program on behalf of all signatory parties.

Close working relationships exist, on a day-to-day basis, between the DRBC staff and the signatory State departments such as: The Department of Natural Resources and Environmental Control of the State of Delaware; The Department of Environmental Protection of the State of New Jersey; The Department of Environmental Conservation of the State of New York; and The Department of Environmental Resources of the Commonwealth of Pennsylvania. Administrative agreements with these and related departments of each signatory State provide the framework necessary to maintain this cooperative forum. Additionally these agreements allow the Commission to serve as a centralized agency to channel Federal and State grants and services to all signatory parties thereby supplementing their programs and activities.

This multi-purpose role of the Commission is enhanced by active participation with several advisory committees and effective cooperative relationships with the many related Federal agencies. Significant among these are:

The Environmental Protection Agency. Cooperation includes consultative planning, implementation of the results of the Delaware Estuary Comprehensive Study, and assistance in carrying out the requirements of P.L. 92-500 and P.L. 91-190.

The U. S. Corps of Engineers. Cooperation includes consultative planning, assistance with review of applications for permits affecting navigation and issuance of Water Quality Certificates, and coordination of the finance, control and operation of Federal water supply projects.

The Council on Environmental Quality. Cooperation includes preparation and review of environmental impact statements as required by P.L. 91-190 in accordance with the guidelines and requirements of CEQ.

The U. S. Geological Survey. Cooperation includes funding of streams gaging and monitoring stations, assistance with special studies, and participation in the inter-agency telecommunication system.

The U. S. Department of Housing and Urban Development - Federal Insurance Administration. Cooperation includes a contract agreement to prepare flood insurance studies for communities in the Basin as authorized by the National Flood Insurance Act of 1968.

The U. S. Soil Conservation Service. Cooperation includes consultative planning and review of SCS Watershed Work Plans for incorporation into the Comprehensive Plan.

The National Park Service and Bureau of Outdoor Recreation. Cooperation includes planning in consultation with these agencies, particularly with regard to the formulation of recreation plans for the major Federal reservoirs in the Comprehensive Plan and study of the upper Delaware River for inclusion into the National Wild and Scenic River program.

The U. S. Fish and Wildlife Service and National Marine Fisheries Service. Cooperation includes evaluating the fish and wildlife needs of the Basin through the Fish and Wildlife Technical Assistance Committee (FAWTAC) which has a wide-ranging participation by many State and Federal agencies.

The National Weather Service. Cooperated in implementation of expanded services including an automated data collection and forecasting network.

The Water Resources Council. Cooperation includes consultative planning and arranging for future Section 209 efforts in preparing the Level B plan for the Basin.

The Water Management of the Delaware River Basin is discussed in the following chapters under headings of water supply, water quality, flood control and recreation, fish and wildlife. A summary of Part Two is presented in Chapter 6 and contains abbreviated discussions of water conditions and problems in the twelve sub-basins of the Delaware River Basin.

WATER MANAGEMENT OF THE

DELAWARE RIVER BASIN

PART TWO

CHAPTER 2 - WATER SUPPLY MANAGEMENT

General

The purpose of the planning and operating criteria and programs for water-supply management, as described in this chapter, is to guide and provide for the timely development and operation of both structural and nonstructural measures to insure the availability of water in adequate quantities in surface waterways and underground aquifers whenever needed in the Delaware River Basin for municipal, industrial, agricultural, and other beneficial purposes. During the most severe drought of record in the Delaware River Basin, that which occurred from 1961 through 1965, the water supply available for all purposes was sorely tested and emergency powers and measures had to be exercised. The water supply shortages were manifested in two ways: by dangerously depleted streamflows, and by inadequate facilities. For example, in certain locations, water supplies were deficient or reduced due to inability to interconnect adjacent systems or by inadequate pumping stations or distribution lines. In other locations, single purpose storage was inadequate so that some communities were actually overdrawing developed supplies and they eventually had to look for other emergency surface or ground sources. The most obvious deficiency was in carryover water supply storage capacity to provide the principal tool for corrective action by the basinwide manager.

This chapter discusses specific objectives of water-supply management and describes the existing facilities and authorized future projects designed to contribute to attainment of those objectives. Also presented in this chapter are evaluations of the capabilities of the existing facilities and authorized projects to meet the long-range water supply needs of the Basin, and finally, certain operating requirements designed to promote optimum use of the facilities and projects, not only to make maximum use of scarce water supplies, but also to insure minimum interference with other water uses provided for by the Comprehensive Plan and with needs of the environment in general.

Objectives

Toward fulfillment of the broad goal of assured adquate water supplies throughout the Basin at all times, the Delaware River Basin Commission staff has assumed certain management objectives, each of which is corollary to or dependent upon the others, as follow:

--The attainment of satisfactoryminimum sustained stream flows at key locations in the Basin during critical drought periods.

--The concurrent control to acceptable limits of the intrusion of sea water into the tidal Delaware River Estuary.

--The replacement in the stream system of water depletively used or exported from the Basin during such critical drought periods.

By the realization of these objectives, water will be made available at all times in sufficient quantities to satisfy all authorized withdrawal and instream demands throughout the Basin. And, at these same times, satisfactory quality of the water supplies will be assured through maintenance of stream flows adequate for dilution and assimilation of wastes entering the system, and for repulsion of salinity from sea water intrusion in the Delaware River Estuary and its tidal tributaries. The objectives are discussed in more detail in the following sections.

Minimum-flow objectives. -- As shown in Figure II-1, objectives for minimum sustained streamflows have been specified for three key locations on the Delaware River.

1. Montague, New Jersey. -- The stream gaging station on the Delaware River at Montague, New Jersey, is the checkpoint used by the Delaware River Master appointed by the U. S. Supreme Court to supervise the operation of New York City's three Delaware Basin water-supply reservoirs in accordance with the Supreme Court's amended decree of 1954 (Appendix B). The decree requires that water be released downstream as necessary from Cannonsville Reservoir on the West Branch Delaware River, Pepacton Reservoir on the East Branch Delaware River, or Neversink Reservoir on the Neversink River to sustain a minimum flow of 1,750 cfs at Montague. This specification of the Supreme Court decree was designed to compensate water users within the Delaware River Basin for water diverted from the Basin by the City of New York.

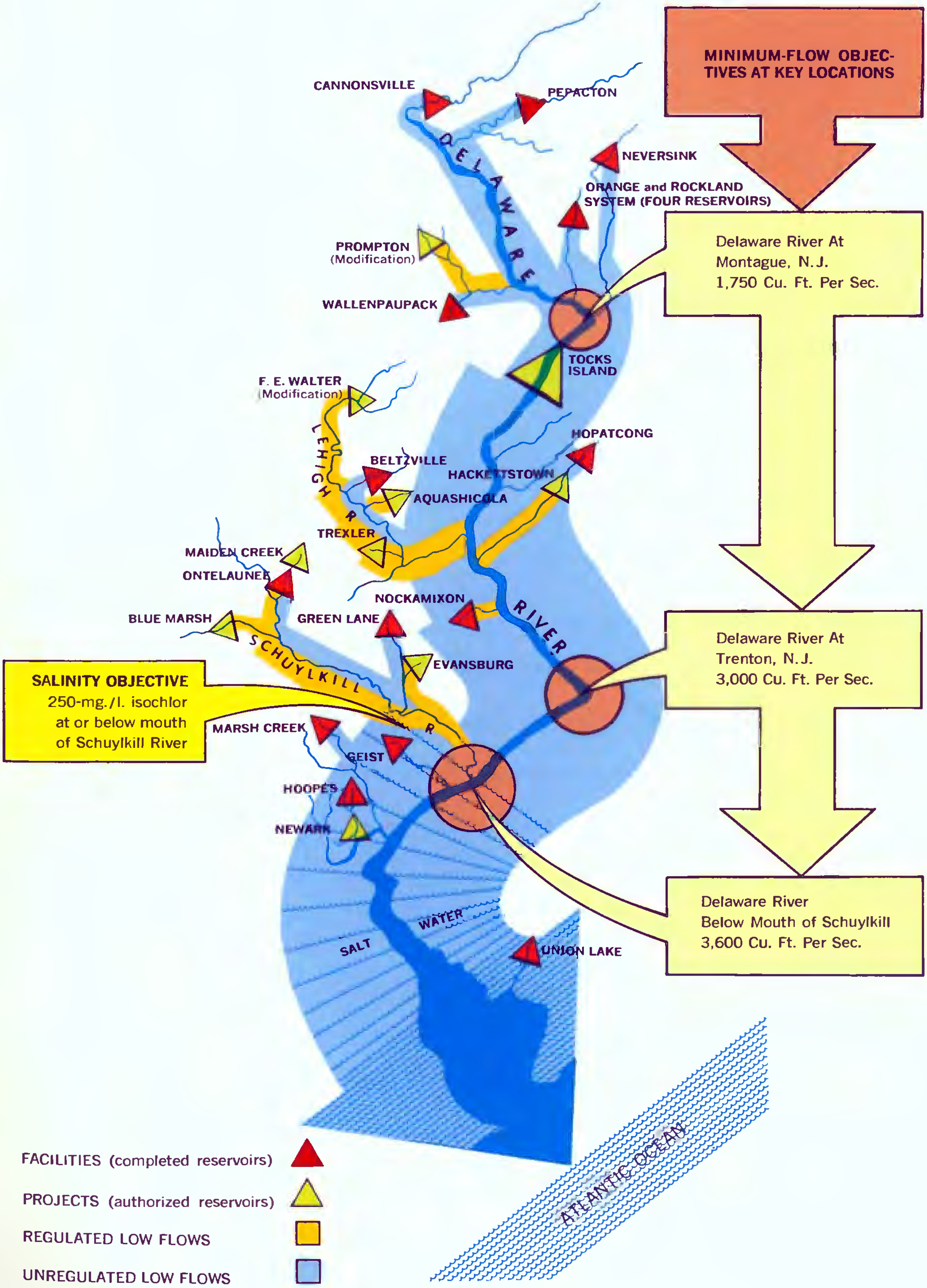
2. Trenton, New Jersey. --The most important flow-control point in the Basin is on the Delaware River at Trenton, New Jersey, where a minimum-flow objective of 3,000 cfs has been established . This objective is designed to protect water supplies withdrawn from the upper reaches of the tidal Delaware River and from aquifers recharged by the river in these reaches that are subject to the intrusion of sea water during extended dry periods. Studies conducted during the drought years of 1965 and 1966 indicated that a flow of 3,000 cfs at Trenton, in addition to the fresh-water runoff from tributaries downstream of Trenton, would be necessary to hold the salt front--as identified by the location of 250 mg/l isochlor--at or below the mouth of the Schuylkill River. This base flow must be increased by an amount equal to the downstream depletive uses to provide the flow necessary to control salinity at the mouth of the Schuylkill River.

3. Delaware River below the Schuylkill River.--The Commission has established a minimum-flow objective of 3,600 cfs for fresh-water runoff in the Delaware River below the mouth of the Schuylkill River, including flows of the Schuylkill River and all upstream tributaries (See Figure II-1). The aggregate low flow of 3,600 cfs is designed to control sea-water intrusion in the estuary for the protection of surface and ground water supplies along the tidal Delaware River above the mouth of the Schuylkill River.

Salinity control objective.--To protect the quality of municipal and industrial water supplies withdrawn from the upper reach of the tidal Delaware River and from the ground water aquifers that are recharged by the river in this reach, the Commission has established an objective of limiting the intrusion of sea water in the Delaware River estuary. The control point for this purpose is at the mouth of the Schuylkill River, where it is the goal to maintain the concentration of chlorides at or below 250 mg/l. With the attainment of this objective, the water in the Delaware River upstream of the Schuylkill River would meet the standard for chlorides in potable water as promulgated by the Public Health Service (1962). Also, meeting this objective would provide benefits to users of estuarine water downstream of the Schuylkill River by minimizing the occurrences of detrimentally excessive salinity in their raw water source, and would protect underground aquifers heavily used for municipal and irrigation purposes in New Jersey.

Replacement of water depletively used. -- A primary objective of water-supply management for the Delaware River Basin is the replacement in the stream system, during critical periods of need, of water evaporated, transpired or exported from the Basin.

Figure II-1.--Minimum flow objectives at key locations in the Delaware River system with existing and authorized major reservoirs.



Such replacement will be necessary if the low flows in streams are not to be reduced to levels that would be inadequate to provide needed water supplies and also to satisfactorily dilute and assimilate the waste waters from the many natural and manmade sources in the Basin.

The depletive uses of water, as discussed in detail in Part One and as summarized in Table I-18 which excludes Sub-basin I are projected to increase from a maximum monthly average of 551 mgd in 1970 to 1,353 mgd in 2020. The replacement of this water will require the release of water from regulating reservoirs during periods of low streamflows -- water that is stored in such impoundments during preceding periods of high runoff. The releases required for replacement of depletive uses of water below Trenton will be in addition to the releases required to meet the minimum-flow objectives at Trenton, in order to provide the needed salinity control flow at the mouth of the Schuylkill River.

The United States Supreme Court, in its 1954 decree, requires the City of New York to make releases into the Delaware River as compensation for the privilege of exporting water from the Basin. Since these releases are included as water which can be depended upon by the Basin communities during periods of low stream-flow into the indefinite future, no further replacement is required in connection with the New York City exportation. Therefore, the depletive uses in Sub-basin I are excluded from the above estimates.

Approach and methodology

As indicated, the objectives of sustaining minimum streamflows for water supply, salinity repulsion and replacing consumed and exported water in the stream system will require construction of water storage capacity in reservoirs, and operation of this storage in concert with natural runoff. Storage capacity in reservoirs will be needed to retain water during periods when the water is available in excess of needs, so that it can be released later during periods of water shortage.

1. Base period.-- The drought of the sixties, the most severe on record in the Delaware River Basin above Trenton, reached its climax during the summer of 1965, when the flow in the Delaware River at Trenton dropped to a low daily average of only 1,240 cfs. This flow reflected the net effect upon natural flow of all depletive uses and streamflow regulation by all facilities upstream of Trenton at that time. As Trenton is the key location for control of fresh-water flow into the Delaware Estuary, the low-flow conditions at Trenton in 1965 provide a convenient base against which to measure needed and projected changes, and have been used in the development of plans for water supply management for determining subsequent increments of demand for both reservoir storage capacity and water yield.

Under this staff recommendation, reservoir storage capacity constructed after 1965 would be operated, in part, to replace depletive uses of water below Montague, N.J. during critical periods of low flow in the Delaware River at Trenton, with a goal of meeting the minimum-flow objectives of 3,000 cfs at Trenton and 3,600 cfs at the mouth of the Schuylkill River at all times.

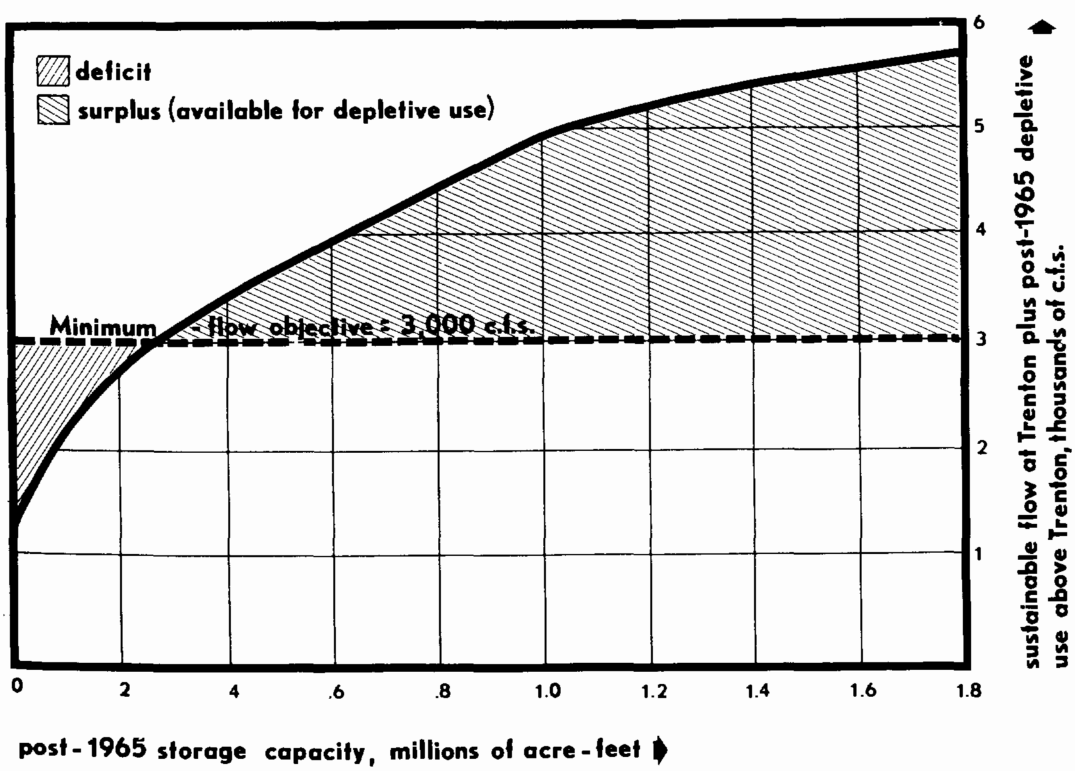
2. Theoretical storage capacity.-- Based upon the mass diagram approach, the curves shown in Figures II-2 and II-4 have been developed to portray graphically the varying theoretical post - 1965 relationships between present and future water storage capacity in the Delaware River Basin above Trenton, depletive uses of water in the upper Basin, and the dependable flow in the River at Trenton, assuming a

repetition of the drought conditions of 1965. The graphs are for illustrative purposes only and are not intended for accurate interpretations.

The low points on the graphs represent the minimum flow actually observed in the Delaware River in Trenton in 1965, which was 1,240 cfs. This flow reflected the net effect of all depletive uses of water and regulation by all facilities upstream of Trenton at that time.

The dashed horizontal line in Figure II-2 represents the adopted objective of maintaining a minimum flow of 3,000 cfs in the River at Trenton, as previously discussed. This horizontal line intersects the storage-yield curve at the storage value of 260,000 acre-feet. This is the theoretical post-1965 reservoir storage capacity upstream of Trenton required to sustain a flow of 3,000 cfs in the River at Trenton during a recurrence of the drought of the 1960's.

Figure II-2 Sustainable low flow plus post-1965 depletive water use above Trenton versus assumed post-1965 reservoir storage capacity added.



It neglects post-1965 increments in upstream depletive uses of water. To determine the corresponding actual stream-flow yield at Trenton, the post-1965 increase in upstream depletive uses of water should be subtracted from the theoretical yields indicated by the curve.

The shaded area in Figure II-2 below the 3,000 cfs flow line represents the amounts of upstream reservoir storage capacity and corresponding sustainable flows at Trenton that would fall short of the adopted minimum flow objective. The shaded area above the 3,000 cfs flow line represents the yields of streamflow that would be available for satisfying post-1965 increments in depletive uses of water, as a result of development of upstream reservoir storage capacity in excess of the amount required to meet the 3,000 cfs minimum flow objective at Trenton. It should be noted that minimum flows at Trenton greater than 3,000 cfs could be used to replace depletive uses of water either upstream or downstream of Trenton.

The relationships shown by the curve of Figure II-2 are, of course, independent of the timing of reservoir construction. However, with known or projected amounts of reservoir storage capacity added or to be added after 1965, the curve can be used to derive the resulting total dependable yield of streamflow from the Delaware River Basin above Trenton at given points in time.

Existing Facilities

Existing facilities that serve the function of water supply management in the Delaware River Basin have been tabulated and listings include existing reservoirs, many of which are used for water supply, public surface-water withdrawal facilities, and existing public ground water supplies. These lists, which are too lengthy for incorporation into this report, are available at the offices of the Delaware River Basin Commission. Only the major facilities that provide significant contributions to meeting objectives of this staff report will be described in the following sections.

Major Reservoirs. -- Existing major reservoirs having significant allocations of storage capacity for water supply are listed in Table II-1 and their locations are shown on Figure II-3. These large impoundments have a combined water supply storage capacity of 1,003,100 acre-feet. Six of the reservoirs, with a combined water-supply capacity of 925,060 acre-feet, are located in the portion of the Basin above Trenton, and therefore regulate the flow of the Delaware River as measured at Trenton. Of these six, only four, with an aggregate capacity of 595,180 acre-feet, were in existence before the critical drought of the sixties. Cannonsville Reservoir, with a storage capacity of 302,000 acre-feet was completed and placed in full operation in 1967 after the end of that severe drought. Beltzville Reservoir, with a capacity of 27,880 acre-feet allocated to water supply, was completed in 1971.

In addition to the flow regulation provided by the four major water-supply reservoirs of the upper Delaware Basin during the critical drought year of 1965, many smaller water-supply reservoirs and large and small hydroelectric reservoirs in the upper Basin contributed to flow regulation of the Delaware River at that time. Further, except during periods of declared "state of emergencies," of those reservoirs listed in Table II-1, only the three New York City reservoirs (Cannonsville, Pepacton and Neversink) and Beltzville Reservoir are designed to augment low flows of the Delaware at Trenton. The remaining reservoirs are designed and operated to supply water to a specific clientele, or are located so that they have little or no effect on the flow of the Delaware at Trenton.

As has been noted, during the drought of the sixties, the net result of surface-reservoir operation, underground-reservoir operation, depletive uses of water in the upper Basin, and diversions of water into or out of the Basin was an observed minimum flow of 1,240 cfs in the Delaware River at Trenton in 1965. Increments of storage capacity added above

Table II-1

Major reservoirs and water supply capacity

Name of facility	Location of dam, stream, (river mile)	Water-supply storage Billions of gallons	acre-feet
Cannonsville Reservoir	West Branch Delaware River (330.71-18.0)	98	302,000
Pepacton Reservoir	East Branch Delaware River (330.7-33.3)	148	454,000
Neversink Reservoir	Neversink River (253.64-41.9)	36	109,200
Penn Forest Reservoir	Wild Creek (183.66-41.1-10.39-4.5)	7	19,980
Wild Creek Reservoir	Wild Creek (183.66-41.1-10.39-1.8)	4	12,000
Beltzville Reservoir[a]	Pohopoco Creek (183.66-41.1-5.2)	9	27,880
North Branch Reservoir	N.Branch Neshaminy Creek (115.63-40.0-3.0)	2	5,000
Still Creek Reservoir	Still Creek (92.47-102.1-30.15-1.0)	3	8,290
Ontelaunee Reservoir	Maiden Creek (92.47-86.7-3.0)	4	11,640
Green Lane Reservoir	Perkiomen Creek (92.47-32.3-19.3)	4	13,430
Geist Reservoir	Crum Creek (84.9-11.1)	4	10,780
Edgar Hoopes Reservoir	Tributary of Red Clay Creek (70.73-10.00-2.6-6.3-0.3)	2	6,750
Marsh Creek Reservoir	Marsh Creek (70.73-1.5-20.01-12.05-0.5)	4	12,400
Union Lake	Maurice River (21.03-24.6)	3	9,750
	TOTAL	327*	1,003,100

* May not add due to rounding

[a]In addition, Beltzville Reservoir provides 4 billions of gallons (11,950 acre-feet) of storage capacity for low-flow augmentation for water-quality control.

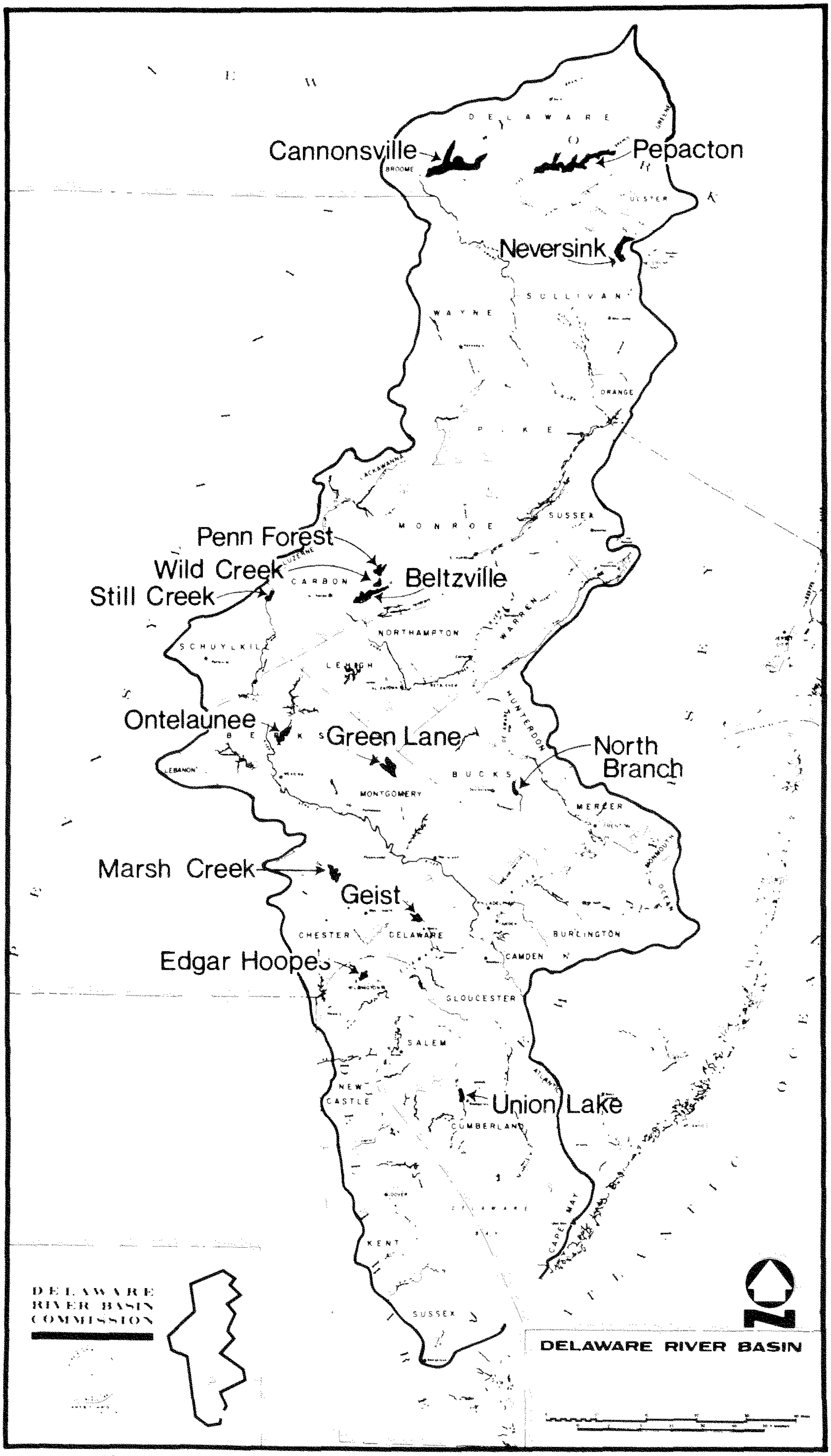
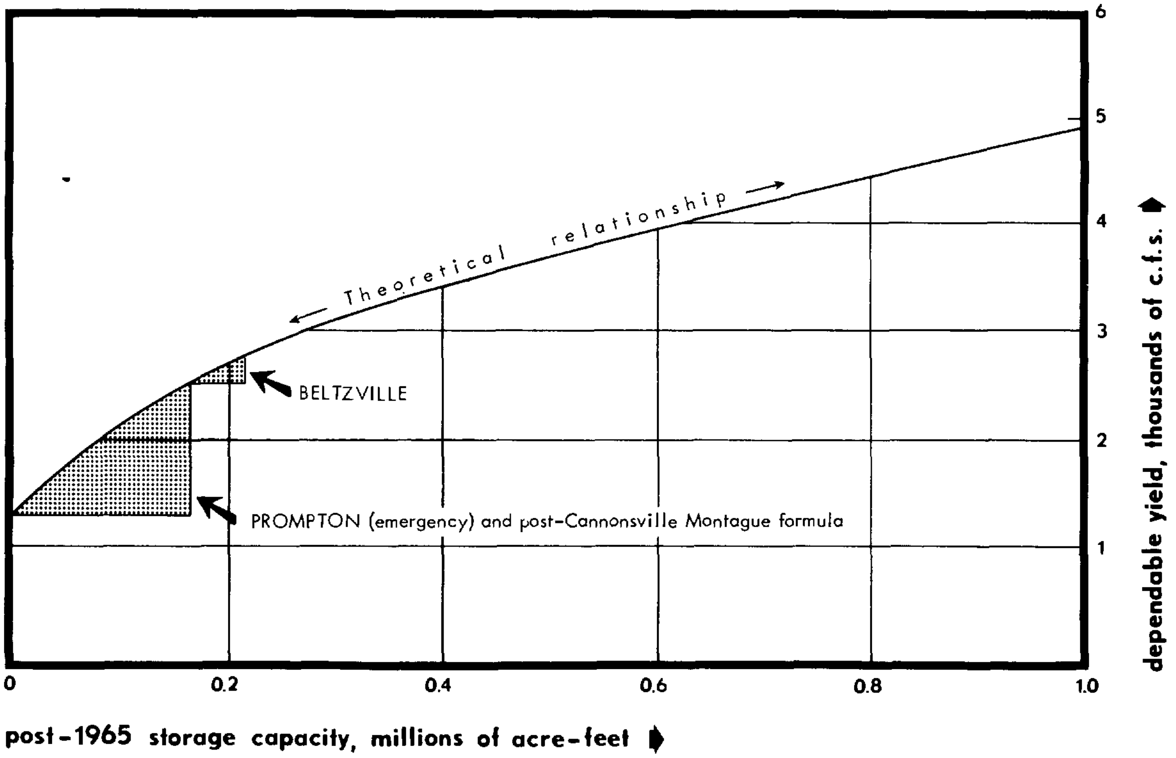


Figure II-3 -- Location of existing major reservoirs

Trenton between 1965 and 1972 will increase the minimum flow at Trenton during an equally severe drought in the future to 2,700 cfs with the incremental depletive uses of water that have occurred during the same interval.

Figure II-2 can be used to derive the sustainable flow in the Delaware River at Trenton for any time after 1965, provided that the post-1965 water supply storage additions and the post 1965 increase in depletive uses above Trenton are known. For convenience, a portion of the theoretical curve from Figure II-2 is reproduced in Figure II-4, which also shows increments of storage capacity actually added above Trenton since 1965.

Figure II-4 Dependable water yield at Trenton as a function of post-1965 reservoir storage capacity added.



Post 1965 Reservoirs. The following sections describe briefly the reservoirs built after 1965.

1. Prompton Reservoir.-- The first significant increment of water-supply storage capacity constructed in the Delaware River Basin subsequent to 1965 is a temporary facility provided for emergency use in severe droughts. This emergency storage capacity is provided in the U. S. Army Corps of Engineers' Prompton Reservoir on the West Branch Lackawaxen River, in Wayne County, Pennsylvania. The existing reservoir, a flood-control facility of 20,300 acre-foot storage capacity, providing incidental recreation use, had no control gates when constructed in 1960; the outflow from the reservoir entered a 535 - foot long conduit through an uncontrolled funnel-shaped inlet structure. However, in 1966 the inlet structure was modified by the construction of a 10-foot tower containing manually operated gates. With this structure, it is possible to control releases through 10 feet of depth in the reservoir, providing 3,600 acre-feet of water supply storage capacity for emergency use. This is a temporary arrangement; this emergency storage capacity will be replaced when Prompton Reservoir is modified as authorized. Because of its small size, the temporary water-supply capacity in Prompton Reservoir is not shown separately in Figure II-4, but is combined with the equivalent capacity of Cannonsville Reservoir.

Under the provision of Section III B 3 of the Supreme Court decision relating to the conditions of use of the Delaware River by the City of New York (see Appendix B), some question exists whether the 3,600 acre-feet of water supply storage would be contributory to the base flows of the Delaware River below Montague, New Jersey, unless a "state of emergency" existed and the provisions of Compact Sections 3.3 and 10.4 were in force. Nevertheless, it is worth noting that the limited amount of water supply storage capacity now available in Prompton Reservoir, was not available as an operating tool during the most critical drought of record, and would have been quite helpful.

2. Cannonsville Reservoir.-- The completion of Cannonsville Reservoir by the City of New York, and its filling in 1967 shortly after the critical drought year of 1965, made a large increment of new water supply storage capacity available in the Basin. Under the terms of the 1954 decree of the United States Supreme Court, this single purpose water supply impoundment project on the West Branch Delaware River will be operated in conjunction with Pepacton and Neversink Reservoirs to maintain a minimum flow of 1,750 cfs in the Delaware River at Montague. Meeting this Supreme Court specification during any future recurrence of a drought equivalent to that of the sixties would result in a minimum flow of 2,570 cfs at Trenton, after adjustment for post-1965 increase in Basin depletive uses above Trenton. When measured at Trenton, the combined effect of the addition of Cannonsville Reservoir and the above-cited post-Cannonsville "Montague formula" is equivalent to the addition of 160,000 acre-feet of water supply storage capacity, the remainder of the reservoir's 302,000 acre-feet capacity being operated in the interest of export to New York City. Added to the emergency water-supply capacity provided in 1966 in Prompton Reservoir, the post-Cannonsville Montague formula brought the post-1965 equavalent water supply storage capacity above Trenton up to 163,600 acre-feet. This combined volume is shown on a post-1965 increment of added capacity in Figure II-4.

It is of interest to note that the minimum observed flow in the Delaware River at Trenton in 1970 was 3,020 cfs, a year when runoff in the Basin was 98 percent of normal.

3. <u>Beltzville Reservoir</u>.-- Beltzville Reservoir, completed in 1971 by the U. S. Army Corps of Engineers, has added another significant increment of water supply storage capacity to the Basin above Trenton. This multipurpose facility provides 27,880 acre-feet of storage capacity allocated to the function of water supply, and 11,950 acre-feet of additional capacity for low stream-flow augmentation for water quality control, as well as 27,000 acre-feet for flood control, and 1,390 acre-feet of storage for sediment accumulation for a total storage of 68,250 acre-feet. The water-supply storage capacity has a net yield at the site of 36 mgd, or 56 cfs. That capacity will be operated in part to meet water withdrawal needs in local areas of Franklin and Towamensing Townships, Carbon County, Pennsylvania, along the Lehigh River, and along the Delaware River below the mouth of the Lehigh. The Beltzville water-supply capacity will also serve in part to replace depletive use and exports of water from any part of the Basin when necessary during critical periods, to meet minimum-flow objectives at key locations.

The costs of the water supply features of Beltzville Reservoir are being repaid by the Delaware River Basin Commission. Thus, Beltzville Reservoir has become the first tool directly available to the Commission for operation to augment flow at downstream points. As such, when operated in concert with other flows of the stream system, a greater yield can be obtained at downstream locations, such as at Trenton, than the yield at the dam site because water need only be released from storage when the flow at Trenton falls below the established minimum, i.e., 3,000 cfs. This is because water would only need to be released intermittently, rather than continually. This increased yield of Beltzville Reservoir resulting from integrated operation with other facilities will vary with time, depending upon other reservoirs brought into the system. However, in terms of a safe yield at any downstream point, the yield of any reservoir will not be less than at the dam site. In the case of Beltzville, if the total water supply storage including the storage dedicated to low-flow augmentation for quality purposes were operated soley to supplement the lowest flow at Trenton, and without considering the added efficiency of operating in concert with any other reservoir, the net yield at Trenton would be increased to 130 cfs.

For the purpose of evaluating the effect of Beltzville Reservoir on the minimum flow at key locations downstream, it is necessary to consider the capacity allocated to both water supply and water-quality control. Beltzville provides a total storage capacity of 39,830 acre-feet for these two purposes. This has been shown as an added increment of existing capacity superimposed on the theoretical curve in Figure II-4 showing the sustainable flow at Trenton as related to upstream storage capacity. As shown by this graph, Beltzville Reservoir has increased the dependable "Trenton" yield--after adjustment for depletive uses-- to approximately 2,700 cfs.

4. Marsh Creek Reservoir.-- The Marsh Creek Reservoir (PA-437), completed in 1973, is a feature of the Brandywine Creek Watershed Plan, sponsored by the Chester County Commissioners, the Chester County Soil Conservation District, the New Castle County Soil Conservation District, the Pennsylvania Department of Environmental Resources, and the Pennsylvania Fish Commission. The watershed plan, prepared with the assistance of the Soil Conservation Service of the U. S. Department of Agriculture, and the Fish and Wildlife Service of the U. S. Department of the Interior, was adopted as part of the Comprehensive Plan for the Delaware River Basin in 1962. Details of the watershed plan are contained in reports issued by the Soil Conservation Service (1962, 1966) and the

Pennsylvania Department of Forests and Waters (1958,1959).

Marsh Creek Reservoir is located in Chester County Pennsylvania, on Marsh Creek, a tributary of the East Branch of Brandywine Creek. It is a multipurpose impoundment for flood prevention, fish and wildlife development and water supply. The reservoir provides 4 billions of gallons (12,400 acre-feet) of storage capacity for water supply to augment the low streamflows of the East Branch of Brandywine Creek and to provide water to meet withdrawal demands as follow:

Purpose	Water to be made available, mgd
Low flow augmentation through Downingtown[a]	2.0
Withdrawal supply for Downingtown area	15.9
Withdrawal supply for West Chester[a]	3.3
Withdrawal supplies for irrigation	0.6
Total [b]	21.8

[a]To be supplied from storage in Marsh Creek Reservoir.

[b]To be supplied from Marsh Creek Reservoir and from the East Branch of Brandywine Creek.

In granting approval of the Marsh Creek Project in 1966, the Delaware River Basin Commission required, among other things, that whenever the flow of the Brandywine Creek at the Chadds Ford gaging station is less than 140 cfs, the release from Marsh Creek Reservoir be not less than (1) the unregulated flow of Marsh Creek at the dam, plus (2) any diversion from the East Branch of Brandywine Creek to the Borough of West Chester. Operation requirements for the Marsh Creek Reservoir are specified in the decision of the Delaware River Basin Commission set forth in Docket No. D-64-15 CP, adopted January 26, 1966.

5. North Branch Reservoir.--The North Branch Reservoir (PA-617) is a feature of the Neshaminy Creek Watershed Plan sponsored by Bucks and Montgomery Counties, Pennsylvania, and the Soil and Water Conservation Districts of these two counties. The watershed plan, prepared with the assistance of the Soil Conservation Service and the Forest Service of the U. S. Department of Agriculture, was adopted as part of the Comprehensive Plan for the Delaware River Basin in 1965. Details of the watershed plan are contained in reports issued by the Soil Conservation Service (1966), the Pennsylvania Department of Forests and Waters (1966), and the Delaware River Basin Commission (Bourquard Associates, Inc. 1970).

The North Branch Reservoir, located on the North Branch of Neshaminy Creek in Bucks County, is a multipurpose project for flood prevention, water supply, water-quality control and public recreation. The long-term storage capacity for water supply is 2 billions of gallons (5,000 acre-feet). The yield from this capacity, 9 mgd (14 cfs), is used to serve the Doylestown-Chalfont area of Bucks County and an area in central Montgomery County covering four boroughs and eleven townships. To meet the long-term water demands of these two areas, the supply from North Branch Reservoir will be supplemented by water from other sources, including underground aquifers and the Delaware River via the Point Pleasant Project, discussed later in this chapter. The water taken from storage in North Branch Reservoir will serve in part to replace depletive use of water during critical periods as necessary to meet the objective of minimum fresh-water flow into the tidal Delaware River above the key location just below the mouth of the Schuylkill River.

6. Summary of existing storage facilities.-- With the completion of North Branch Reservoir in 1974, the combined water-supply capacity of major reservoirs constructed after 1965 was 350,880 acre-feet. This total includes 3,600 acre-feet of Prompton emergency use and added to the pre-1965 capacity in large water-supply reservoirs brings the Basin total to 1,006,700 acre-feet. This is augmented slightly by 11,950 acre-feet allocated to water-quality control in Beltzville Reservoir. After adjustment to take into account increased exportations to New York City, the total large-reservoir capacity added above Trenton between 1965 and 1971 had an equivalent capacity -- in terms of its potential effect on the dependable yield of the drainage area above Trenton -- of approximately 203,430 acre-feet. This equivalent capacity increased the dependable flow of the Delaware River at Trenton from 1,240 cfs in 1965 to about 2,700 cfs in 1972, after adjustment for minor increases in depletive uses that occurred during this period.

Although a considerable improvement over the low flows observed in 1965, the post-Beltzville dependable river flow at Trenton is still short of the objective of 3,000 cfs. As of December 31, 1972, there was no excess dependable flow at Trenton to replace increasing depletive uses in the Basin below Trenton. Moreover, the dependable flow will decrease with the passage of time as depletive uses continue to increase. It is clear that the total reservoir storage capacity existing in the Delaware River Basin above Trenton following the completion of Beltzville Reservoir is inadequate to meet the needs of 1972 for insurance against water shortages, and the inadequacy will become increasingly severe until new capacity of significant size is constructed in the Basin.

Future Projects

Authorized projects that will serve the purpose of water supply in the Delaware River Basin include major reservoir and diversion projects, public surface-water withdrawal projects and public ground-water withdrawal projects. Complete listings of these projects are available at the offices of the Delaware River Basin Commission. The following sections describe the projects that would make significant contributions to meeting the objectives of this staff report.

Major reservoir projects. -- Twelve major authorized reservoir projects that would include significant amounts of storage capacity for water supply are listed in downstream hydrologic sequence in Table II-2. See Figure II-5 for their locations. These large projects would provide a combined water-supply storage capacity of 263 billions of gallons (807,800 acre-feet). Seven of these major projects, with a combined water-supply capacity of 214 billions of gallons (657,700 acre-feet), are to be constructed in the portion of the Basin above Trenton, and thus would regulate the flow of the Delaware at Trenton.

Three large reservoir projects with water-supply capacities ranging in size from 3 to 24 billions of gallons (8,000 to 74,000 acre-feet) are to be located in that part of the Basin draining into the tidal Delaware River between Trenton and the key location at the mouth of the Schuylkill River. These projects would provide a combined total water-supply capacity of 34 billions of gallons (105,500 acre-feet).

The remaining two significantly large reservoir projects have been authorized to be built in the portion of the Basin which drains to the Delaware below the mouth of the Schuylkill River. These two projects, to be located within the Christina River Basin, would provide a combined water-supply storage capacity of 15 billions of gallons (44,600 acre-feet).

Table II-2

Major water-supply reservoir projects in the Delaware River Basin

Name of project	Location of dam, stream (river mile)	Water-supply storage billions of gallons	Water-supply storage acre-feet	Safe yield mgd	Safe yield cfs
Prompton Reservoir modification[a]	West Branch Lackawaxen River (277.7-27.11-4.9)	10	30,900	38	59
Tocks Island Reservoir[a]	Delaware River (217.2)	139	425,600	633	980
Francis E. Walter Reservoir modification[a]	Lehigh River (183.66-77.8)	23	70,000	127	196
Aquashicola Reservoir[a]	Aquashicola Creek (183.66-36.3-4.6)	8	24,000	39	61
Trexler Reservoir [a]	Jordan Creek (183.66-16.4-0.41-0.3-17.5)	13	40,000	31	48
Hackettstown Reservoir	Musconetcong River (174.6-35.4)	10	30,400	42	65
Nockamixon Reservoir	Tohickon Creek (157.0-11.0)	12	36,800	26	41
Maiden Creek Rservoir[a]	Maiden Creek (92.47-86.7-9.6)	24	74,000	87	134
Blue Marsh Reservoir [a]	Tulpehocken Creek (92.47-76.8-6.5)	3	8,000	31	47
Evansburg Reservoir	Skippack Creek (92.47-32.3-3.0-1.0)	8	23,500	23	36
Icedale Reservoir (Pa.-436)	W.Br.Brandywine Creek (70.73-1.5-20.00-25.6)	5	14,600	14	21
Newark Reservoir	White Clay Creek (70.73-10.00-12.0)	10	30,000	28	43
	TOTAL	263*	807,800		

* May not total due to rounding

[a]Federal multipurpose reservoirs to be constructed by the Corps of Engineers

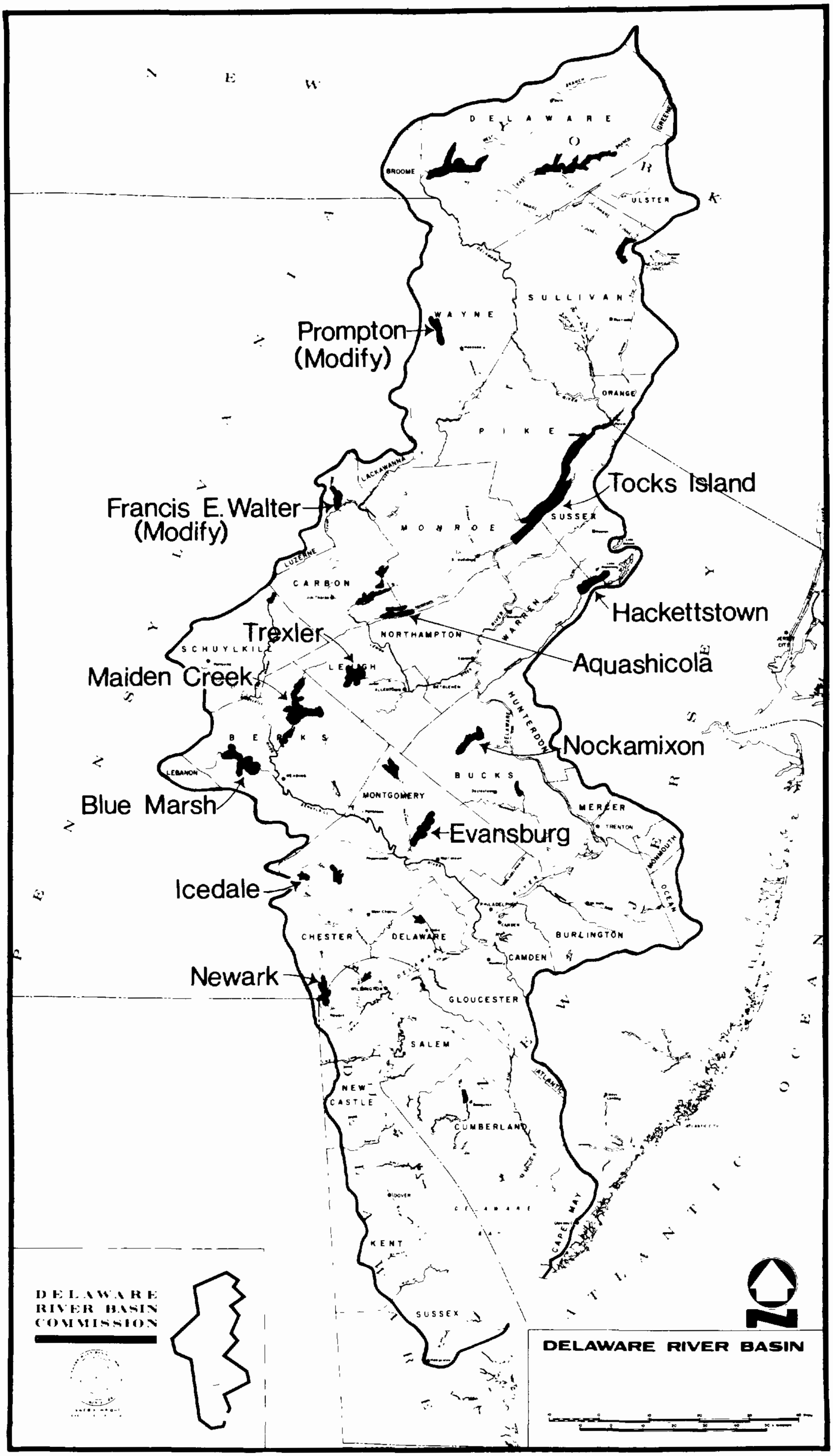


Figure II-5 -- Location of major reservoir projects

In the following descriptions of major water-supply reservoir projects, the reservoirs are discussed in downstream hydrologic sequence. Later herein, they are arranged in their currently scheduled chronological order, and their effect on the dependable flow of the Delaware River at the key location of Trenton is estimated.

1. Prompton Reservoir modification.-- The existing Prompton Reservoir on the West Branch Lackawaxen River in Wayne County, Pennsylvania, has been authorized for modification to provide a permanent water-supply capacity of 30,920 acre-feet. This will replace the existing capacity of 3,600 acre-feet provided in 1966 for emergency water-supply use. Studies based on the drought of the sixties have indicated that the modified reservoir would have a net yield of 59 cfs at the site. This controlled yield would be available to augment the low flows in the Delaware River below the mouth of the Lackawaxen River, and to meet water withdrawal needs in the area nearthe reservoir or as far downstream as the Trenton-Philadelphia area. It would also be available to replace some of the depletive water uses throughout the Delaware River Basin during periods of critical low-flows. Costs of the water supply features of this project would be repaid by the Delaware River Basin Commission, and the Commission would specify the operation plan for water supply releases.

The Prompton Reservoir modification project is planned for construction when justified by the economic demand for water supply, weighed with the benefits to be provided by its other functions.

2. Tocks Island Reservoir.-- Authorized by Congress in 1962 for construction by the U. S. Army Corps of Engineers and added to the Comprehensive Plan in the same year, the Tocks Island Reservoir Project on the Delaware River between Port Jervis, New York,

and the Delaware Water Gap, would provide water supply, flood control, power and recreational benefits. Storage capacity allocated to water supply would account for 139 billions of gallons (425,600 acre-feet) of the total reservoir volume of 275 billions of gallons (845,400 acre-feet).

The net yield of the water-supply storage capacity has been computed to be 633 mgd (980 cfs) at the damsite, based on runoff observed during the drought period of the sixties. The storage capacity would be operated to augment low flows in the Delaware River below the dam, for withdrawal uses of water, to replace consumptive uses and diversions of water from any part of the Delaware Basin as necessary to help meet the minimum-flow objectives at key locations between the damsite and the mouth of the Schuylkill River, and to control salinity in the Delaware Estuary. The Tocks Island Project is the only project that alone would yield sufficient water to overcome present deficiencies for repulsion of salinity and provide a modest surplus toward meeting the ever-increasing depletive water demands of the Basin in the planning future. Costs of the water supply features of this project would be repaid by the Delaware River Basin Commission, and the Commission would specify the operation plan for water-supply releases.

The design of the Tocks Island Project has been completed. However, final approval for construction will be dependent upon the results of a comprehensive study commissioned by Congress to be completed by August 1975.

3. Francis E. Walter Reservoir modification. -- The existing Francis E. Walter Reservoir, a Federal flood-control facility that also provides incidental recreation use, was completed in 1961. Located on the Lehigh River about 78 miles above the river mouth, the present dam spans the Lehigh between Luzerne and Carbon Counties, Pennsylvania,

about 200 feet below the mouth of Bear Creek, and creates a reservoir with storage capacity of 35 billions of gallons (108,000 acre-feet). The Corps of Engineers was authorized by Congress in 1962 to raise the dam to provide 23 billions of gallons (70,000 acre-feet) of storage capacity for supplies of water, while preserving the presently designed flood control function and adding recreation benefits. The net yield at the site that can be obtained from operation of the additional water-supply storage capacity is 127 mgd (196 cfs). This controlled yield would be available to meet the water withdrawal needs in the project area and in the Lehigh and Delaware Rivers, and to replace depletive uses of water in any part of the Delaware River Basin when needed to sustain critical low flows at key locations. Future studies during the detailed-design period would determine whether any portion of the authorized future long-term storage capacity should be allocated to low-flow augmentation for water-quality control. The costs of the water-supply features of this project would be repaid by the Delaware River Basin Commission, and the Commission would specify the operation plan for water-supply releases.

The Francis E. Walter Reservoir modification project is planned for construction when justified by the economic demand for water supply, weighed with the benefits to be provided by its other functions.

4. Aquashicola Reservoir.-- The Aquashicola Reservoir Project proposed by the Corps of Engineers and authorized by Congress in 1962 to be constructed on Aquashicola Creek, a tributary of the Lehigh River, in Monroe and Carbon Counties, Pennsylvania, would provide water-supply, flood-control and recreational benefits. The reservoir, with total storage capacity of 15 billions of gallons (45,000 acre-feet), would include a storage capacity of 8 billions of gallons (24,000 acre-feet) for supplies of water and

recreation. Based on Commission studies carried out in 1969, this storage capacity would be able to provide a net yield of 39 mgd (61 cfs) at the site. The capacity would be operated to meet water withdrawal demands in the project area in Monroe, Carbon and Northampton Counties, in the Lehigh River, and in the Delaware River below the mouth of the Lehigh River. Yield of the project would also serve to replace depletive uses of water in any part of the Delaware River Basin as necessary to meet the minimum-flow objectives at key locations. Future studies during the detailed-design period, would determine whether a portion of the long-term storage capacity should be allocated to low-flow augmentation for water-quality control. The costs of the water supply features of this project would be repaid by the Delaware River Basin Commission, and the Commission would specify the operation plan for water supply releases.

The Aquashicola Project is planned for construction when justified, based upon the economic demand,for water supply weighed with the benefits to be provided by its other functions.

5. Trexler Reservoir.-- The Trexler Reservoir Project, proposed by the Corps of Engineers, was authorized by Congress in 1962 and adopted by the Delaware River Basin Commission as part of its Comprehensive Plan in the same year. This multipurpose project, to be located on Jordan Creek in Lehigh County, Pennsylvania, is designed to provide flood control, water supply, and recreation. The authorized project calls for a total storage capacity of 12 billions of gallons (38,000 acre feet) including 8 billions of gallons (24,000 acre-feet) of storage capacity for water supply. However, as a result of the drought experienced in the sixties, a higher dam has been designed by the Corps to provide, during such a drought, a safe yield equal to that previously computed on the basis of a less-severe drought.

The proposed revised water-supply storage capacity of 13 billions of gallons (40,000 acre-feet) would have a net yield at the site of 31 mgd (48 cfs).

It is contemplated that the Trexler Project would provide water supplies for use in the Lehigh County area. Water from the project would also be available to meet demands from the Lehigh River and the Delaware River below the mouth of the Lehigh, and to replace depletive uses and exports of water from any part of the Delaware River Basin as necessary during critical periods to meet minimum-flow objectives at key locations. The costs of the water supply features of this project would be repaid by the Delaware River Basin Commission, and the Commission would specify the operation plan for water supply releases.

The Trexler Project obtained final approval by the Commission in July, 1974 and is planned for construction when funds are appropriated by Congress. The Lehigh County Authority has expressed a desire for this project to be constructed in the immediate future in order for the Authority to meet local water needs. The Authority is expected to enter into a contract with the Commission in which it agrees to pay the total annual debt service and other project feature obligations incurred by the Commission.

6. Hackettstown Reservoir.-- Originally recommended by the Corps of Engineers in 1962 as a non-Federal undertaking, the Hackettstown Reservoir Project was adopted as part of the Comprehensive Plan for the Delaware River Basin in March 1962. This project, to be located on the Musconetcong River in Sussex, Morris and Warren Counties, New Jersey, is to be developed by the State of New Jersey to provide water supply and recreation. The reservoir would provide 10 billions of gallons (30,400 acre-feet) of storage capacity for water supply. This capacity would have a net yield of 42 mgd (65 cfs)

at the site, based on the critical drought of the sixties, for withdrawal water uses in the Musconetcong River valley, and for streamflow augmentation in the Musconetcong and Delaware Rivers. Augmentation of critical low flows in the Delaware River by releases of water from Hackettstown Reservoir could partially compensate for proposed future diversions of water out of the Basin to northern New Jersey. Future regional pollution-abatement programs in the Musconetcong River valley would require the use of part of the project yield for low-flow augmentation for water-quality control.

Lands are being acquired for the Hackettstown Reservoir-Allamuchy Mountain Project by the State of New Jersey. The reservoir is scheduled for development by the State of New Jersey after 1980.

7. Nockamixon Reservoir.-- Located on Tohickon Creek in Bucks County, Pennsylvania, the Nockamixon Reservoir was completed in 1973 by the General State Authority of Pennsylvania as a dual-purpose development.

The Nockamixon Reservoir has been developed for immediate recreation use as part of Nockamixon State Park. Initial operating objectives will be to maintain maximum pool levels during the recreation season. A minimum release of 7 mgd (11 cfs) will be made to maintain streamflows in Tohickon Creek adequate for conservation of fish and wildlife.

A firm date has not been established for use of the water-supply potential of the reservoir. However, it has been developed to provide 12 billions of gallons (36,800 acre-feet) of storage capacity with a net yield of about 26 mgd (41 cfs) at the site. This yield would be available for future water withdrawal demands and for replacement of depletive water uses during critical periods, as necessary to meet minimum-flow objectives.

8. Maiden Creek Reservoir.-- The Maiden Creek Reservoir Project, proposed by the Corps of Engineers as a multipurpose project for flood control, water supply and recreation, was authorized by Congress and was incorporated in the Comprehensive Plan for the Delaware River Basin in 1962. The project, to be built on Maiden Creek upstream of Lake Ontelaunee, an existing reservoir in Berks County, Pennsylvania, is planned to include 24 billions of gallons (74,000 acre-feet) of storage capacity for supplies of water. This capacity, with a net yield of 87 mgd (134 cfs) at the site, would be operated to meet withdrawal water demands in the project area and in the Schuylkill River downstream, and to replace depletive water uses from any part of the Delaware River Basin as necessary to meet the minimum-flow objectives of 3,600 cfs in the Delaware River below the mouth of the Schuylkill River. The costs of the water supply features of this project would be repaid by the Delaware River Basin Commission, and the Commission would specify the operation plan for water supply releases.

The Maiden Creek Project is planned for construction when justified by the economic demand for water supply weighed with the benefits to be provided by its other functions.

9. Blue Marsh Reservoir.-- The Blue Marsh Reservoir Project, proposed by the Corps of Engineers, authorized by Congress in 1962, and adopted as part of the Comprehensive Plan for the Delaware River Basin in the same year, is planned to provide water-supply, low-flow augmentation for water-quality control, flood control and recreation. The impoundment, being constructed on Tulpehocken Creek, a tributary of the Schuylkill River, six miles northwest of Reading in Berks County, Pennsylvania, will have 5 billions of gallons (14,600 acre-feet) of long term storage capacity. Of this, 3 billions of gallons (8,000 acre-feet)

have been allocated to water supply, and 2 billions of gallons (6,600 acre-feet) to low-flow augmentation for water-quality control.

The water-supply capacity, with a net yield of 31 mgd (47 cfs) will be operated to meet water withdrawal needs in the project area, specifically those of the Western Berks Water Authority for its service area in western Berks County. A 48-inch waterline is being constructed as an integral component of the reservoir outlet works for this purpose. The yield will also serve to meet municipal and industrial water demands in the lower Schuylkill River Basin, and will contribute to replacement of depletive water uses throughout the Delaware River Basin during critical periods to meet the minimum-flow objectives established for the tidal Delaware River at the mouth of the Schuylkill River. Operation of the storage allocated to water-quality control will also help meet these minimum-flow objectives. The costs of the water supply features of this project will be repaid by the Delaware River Basin Commission, and the Commission will specify the operation plan for water supply releases.

The Blue Marsh Project is scheduled for completion of construction in 1979.

10. Evansburg Reservoir.-- The Evansburg Reservoir Project is to be located on Skippack Creek, about a mile above its confluence with Perkiomen Creek, in the Schuylkill River Valley and about two miles southeast of Collegeville, in Montgomery County, Pennsylvania. Proposed by the Corps of Engineers for non-Federal development, the Evansburg Project is being planned by the General State Authority of Pennsylvania to provide water supply and recreation. The project was incorporated in the Comprehensive Plan of the Delaware River Basin Commission in March 1962.

Evansburg Reservoir would provide 8 billions of gallons (23,500 acre feet) of storage capacity for water supply. An initial operating objective would be to limit the maximum drawdown during recreation seasons to about five feet. This operating constraint would limit the net yield to 7 mgd (26cfs) at the site. Further use of all of the capacity for water supply would provide a net yield of 23 mgd (36 cfs). The project yield would be available for water withdrawal uses in the project area. Any excess of yield beyond the local needs would be available for withdrawal from the lower Schuylkill River and for replacement of depletive water use in any part of the Delaware River Basin during critical periods to meet minimum-flow objectives.

The Evansburg Reservoir Project is planned for construction after 1977. The estimated completion date is 1982. Full use of the water supply features are not contemplated before the end of the twentieth century.

11. Icedale Reservoir.-- The Icedale Reservoir Project (PA-436) is a feature of the Brandywine Creek Watershed Plan, mentioned earlier in connection with the Marsh Creek Reservoir. The Icedale Reservoir Project is planned as a multipurpose impoundment for flood control, recreation and water supply. The dam site is on the West Branch of Brandywine Creek near the village of Brandywine Manor, in Chester County, Pennsylvania. The impoundment would include 5 billions of gallons (14,600 acre-feet) of storage capacity for water supply. This capacity would be operated to augment streamflows for downstream withdrawals of water along the West Branch and the main stem of Brandywine Creek. The operation would also augment fresh-water flows into the Delaware River during critical periods when needed to repel sea water. Yield of the reservoir, 14 mgd (21 cfs) would also contribute to restoration of fresh-water flow into the estuary during critical periods by replacing water used depletively from any part of the Delaware River Basin.

A definite time schedule has not been established for construction of the Icedale Reservoir Project, nor has the project sponsor, constructor or operator been established.

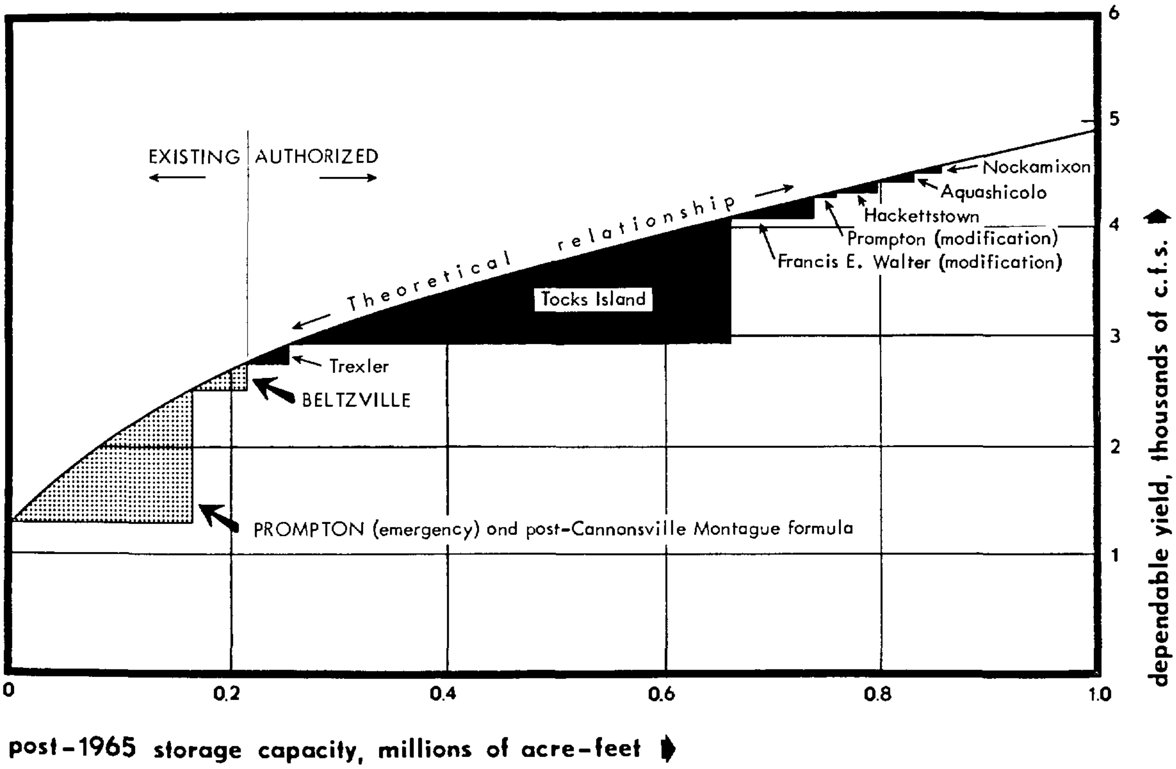
12. Newark Reservoir -- The Newark Project was proposed by the Corps of Engineers for non-Federal development on White Clay Creek in southeastern Pennsylvania and northern Delaware. The dam site is located about a mile and a half north of Newark, in New Castle County, Delaware. This multipurpose project is planned to provide water supply and recreation. State and local officials in Delaware are reviewing alternative arrangements for development of the site as a single-purpose water-supply impoundment for northern Delaware.

The project, as authorized in the Delaware River Basin Commission's Comprehensive Plan in 1962, would provide 10 billions of gallons (30,000 acre feet) of storage capacity for water supply. This capacity would provide a net yield of 28 mgd (43 cfs) at the site. The yield would help meet the future demands for withdrawal supplies in the project area, and would augment fresh-water flow into the Delaware River Estuary during critical periods when needed to repel sea water. The yield would also contribute to restoration of fresh water flow into the estuary during critical periods by replacing depletive water use in any part of the Delaware River Basin.

No definite time schedule has been established for construction of the Newark project on White Clay Creek in the Christina River Basin.

Effect of major reservoirs -- Figure II-6 shows graphically the gross water yield that will be available from the Delaware River Basin above Trenton, as a result of authorized additions to the storage capacity for supplies of water, assuming that all capacity added after 1965, except Cannonsville Reservoir, is operated to provide maximum augmentation of low flows in the Delaware River at Trenton. Figure II-6 does not reflect the expected increased consumptive uses of water in the Basin, nor increased exportations to New Jersey. As explained earlier, the post- Cannonsville operation of New York City's three reservoirs will provide at all times a minimum flow of 1,750 cfs in the Delaware River at Montague. This operation will provide a minimum flow of 2,570 cfs at Trenton, after adjustment for post-1965 to 1972 increases in upstream consumptive uses and exports of water. This adjustment has been accounted for in the graph presented in Figure II-6.

Figure II-6 -- Gross dependable water yield at Trenton as a function of authorized post-1965 reservoir storage capacity to be added.



Upon completion of all major reservoirs authorized for construction upstream of Trenton, the post-1965 equivalent storage capacity available to augment low flows in the Delaware River at Trenton would provide a dependable water yield of 4,620 cfs at Trenton, minus post-1965 increments of depletive use above Trenton. This would meet the low-flow objective of 3,000 cfs at Trenton and provide 1,620 cfs for replacement of post-1965 increases in depletive uses of water in the Basin.

Authorized reservoirs to be constructed in the Basin below Trenton, in addition to meeting increasing withdrawal demands for water in their respective areas and downstream therefrom, would augment the quantities of water available for replacement of depletive uses of water. These impoundments would delay the time when increasing depletive uses throughout the Basin would seriously reduce the fresh-water flow into the Delaware River Estuary during critical drought periods.

When they are operational, these major reservoir projects would significantly increase the yield of water now available from natural sources and existing reservoir facilities. The combined storage capacity for water supply to be provided by these future projects, 807,800 acre feet, would constitute an 81 percent increase in the water-supply storage capacity of large reservoirs in the Basin since completion of North Branch Reservoir in 1974.

If the post-1965 major reservoirs already completed in the Basin are grouped with the authorized large reservoirs not yet built, the total post-1965 water-supply storage capacity equals 1,155,100 acre-feet. This brings the total large-reservoir capacity for water supply to 1,810,900 acre-feet, a 176 percent increase over that existing during the critical drought of the sixties.

Major diversion project.-- This subsection describes a major project that has been authorized --but has not been constructed-- for the diversion of water from the Delaware River, and its use within the receiving watershed.

Point Pleasant diversion-- The Point Pleasant diversion project is a feature of the Neshaminy Watershed Plan (as amended), sponsored by Bucks and Montgomery Counties, Pennsylvania, and the Soil and Water Conservation Districts of these two counties (see discussion of the Neshaminy Watershed Plan under "North Branch Reservoir").

This project provides for a pumping station to be located on the Delaware River at Point Pleasant, Pennsylvania, below the mouth of Tohickon Creek, and transmission mains from the pumping station to the North Branch of Neshaminy Creek and the East Branch of Perkiomen Creek. A 66-inch transmission main would convey the total pumpage from the Point Pleasant station to the terminus of this main near Bradshaw Road, where the pumpage would be divided, part going to the North Branch of Neshaminy Creek, and part flowing into a 35-million-gallon open storage reservoir, from which it would be pumped to the drainage divide between the watersheds of Neshaminy and Perkiomen Creeks. From the divide, this water would flow by gravity through a 36-inch concrete culvert pipe into the East Branch of the Perkiomen.

The authorized maximum diversion rate from the Delaware River at Point Pleasant would be 105 mgd in 1980, 135 mgd in 1990, and 150 mgd in 1995. These quantities are allocated to public water supply and low-flow augmentation for water-quality control in the Neshaminy Creek watershed; maintenance of recreation-pool elevations in the North Branch Reservoir on the North Branch of Neshaminy Creek; public water supply in central Montgomery County; and subject to the final decision constraints of Docket No. D-69-210CP, to replacement of depletive use of water by the proposed Limerick nuclear power generating station of the Philadelphia Electric Company. The depletive use by the nuclear power station is estimated to average 35 mgd, with peak use up to 42 mgd. Depletive uses for municipal purposes within the Bucks County portion of the Perkiomen Creek watershed are projected to be about 3.0 mgd in 1980, 5.4 mgd in 1990, and 6.6 mgd in 1995. Except for depletive use, the diverted water would return to the Delaware River via either Neshaminy Creek or the Schuylkill River. To prevent reduction of critical low flows in the Delaware River below the Point Pleasant pumping station, the pumpage during periods of low flow would be replaced from water stored in Beltzville Reservoir or other impoundments.

This diversion of water would augment low flows of the North Branch of Neshaminy Creek, Neshaminy Creek, the East Branch of Perkiomen Creek, Perkiomen Creek, and the Schuylkill River, improving the water-supply characteristics of those streams.

Underground water

As noted in Part One, there is a very large amount of water in storage in the sub-strata of the Basin. Studies conducted by the United States Geological Survey and the four Basin States have established the interconnection between these underground waters and surface streams in a general sense, but the interrelationship has not been well established in specific terms.

Observations made during the 1961-65 drought seemed to confirm the conclusions of prior investigations that in those portions of the Basin underlain by consolidated rock at relatively shallow depths, the depletion of underground water by either natural or manmade means is generally almost immediately reflected in decreased streamflows.

The intertie between the well defined aquifers underlying the Coastal Plan with overlying surface streams and adjacent rivers and bays is less understood. However, it has been established that drawdown of the wells supplying water to the Camden, New Jersey, metropolitan area causes the water to enter these aquifers from the Delaware River.

Investigations have drawn the conclusion that for the most part throughout the Basin the underground aquifers are full, are replenished in part from precipitation falling on the overlying land, and contribute to the base flows of surface streams. Under these conditions, with little or no historical drawdown of the water table, it is not possible to predict with any reliability the consequences of utilizing these underground water resources to the full extent of their safe yield. However, the development of wells and use of the underground-water storage capacity, with consequent lowering of the water levels in significant portions of the aquifers during dry periods, will augment the dry-period flows in those streams receiving the waste waters resulting from the use of the ground water. This effect of using ground - water storage is similar to that of using surface storage reservoirs. Also, just as surface reservoirs are refilled during periods of relatively high runoff, the ground-water reservoirs (aquifers) are also refilled during wet periods. The overall effect of the use of ground water is to redistribute in time the natural discharge of the ground water to the surface streams, augmenting the low streamflows and reducing the high streamflows. The augmentation of the low flows is reduced by any depletive use involved. The quantitative measurement of all factors affecting the complex relationships between ground and surface water is extremely difficult, and the overall effect of ground-water use on the total water-supply available is largely unknown at present.

To insure that plans for water supply management will err or the side of safety, this staff report baseline has been developed on the premises that (1) with the exception of a few existing cases, ground waters will not be developed for diversion via man-made facilities beyond the boundaries of the sub-basins in which they are placed by nature; and (2) ground-water development and use will not augment low flows in surface streams more than that necessary to replace the depletive use of ground water during the low-flow periods; i.e., the freshwater flow into the estuary--needed for water-quality control, including salinity repulsion-- is not augmented by waste waters from uses of ground water. These conservation assumptions are most consequential in the sub-basins of the Coastal Plains of Delaware and New Jersey (Sub-basins 7,9,10,11 and 12). In these areas, close observations must be made of the behavior of the underground resources, and appropriate adjustments made in the plans for water supply management as more knowledge of the characteristics of groundwater is gained in the future.

WATER MANAGEMENT OF THE

DELAWARE RIVER BASIN

PART TWO

CHAPTER 3 - WATER QUALITY MANAGEMENT

General

The basic purpose of the planning and operating criteria and programs for water-quality management, as described in this Chapter, is to maintain and improve the quality of the waters of the Delaware River Basin in a condition satisfactory for the beneficial uses specified in Article 3 of the Water Code of the Basin. The functions and activities of water quality management are carried out in concert with the Basin States and Federal agencies in compliance with the requirements of the Compact and the Federal Water Pollution Control Act Amendments of 1972. Specific objectives of water quality management are presented, as well as discussions of existing facilities, nonstructural measures and programs, and authorized future projects designed to contribute to attainment of the management objectives. Evaluations of the capabilities of the existing facilities and future projects to meet the long-range needs for water-quality control are also presented in this Chapter.

Objectives

As fully set forth in Article 3 of the Water Code of the Basin, the Delaware River Basin Commission has established that the quality of ground water shall be maintained in a safe and satisfactory condition for use as domestic, agricultural, industrial and public water supplies, and as a source of surface water suitable for recreation, wildlife, fish and other aquatic life, except when such uses are precluded by the natural quality of the ground water. Similarly, the quality of surface water shall be maintained in a safe and satisfactory condition for agricultural, industrial, and public water supplies after reasonable levels of treatment, except where natural salinity precludes such uses; for use by wildlife, fish, and other aquatic life; for recreation and navigation; and for controlled and regulated waste assimilation to the extent that such use is compatible with other uses.

It is the policy of the Commission to maintain the quality of interstate waters, where existing quality is better than the established stream quality objectives, unless it can be affirmatively demonstrated to the Commission that change is justifiable as a result of necessary economic or social development or to improve significantly another body of water. In implementing this policy, the Commission requires the highest degree of waste treatment determined to be practicable.

Furthermore, it is policy that the quality of water in streams tributary to interstate streams shall be at least equal to the water quality criteria specified for the receiving interstate waters immediately above the confluence with tributaries.

Ocean salinity, as measured as chlorides, shall be controlled in the Delaware River at a maximum 250 mg/l at the mouth of the Schuylkill River (River Mile 92.47).

With respect to groundwater quality, the Commission requires the level of water quality management determined to be practical. No quality change is permitted which in the judgment of the Commission may be injurious to any designated present or future ground or surface water use.

The Commission's published "Basin Regulations - Water Quality" provides requirements and guidelines for those seeking to discharge waste into Basin waters. The waters of the Basin are classified further within the Regulations with regard to the expected uses. Specific criteria are given for stream quality objectives in terms of dissolved oxygen, temperature, pH, phenols, synthetic detergents, fluorides, alkalinity, radioactivity, turbidity, fecal coliform and total dissolved solids. The Regulations also provide information on the effluent quality requirements. Additional assistance is provided in the Commission's Interpretive Guideline No. 1, where effluent quality requirements are quantified for suspended solids, temperature, oil, selected heavy metals and odor and procedures are set forth for limiting discharges of toxic materials utilizing bioassay techniques.

Needs of the protected water uses are the paramount criteria in judging adequacy of the stream water quality standards, and these stream standards in turn are the basis for determining whether the effluent constituents after waste treatment are acceptable. Minimum waste treatment standards have been established, however, where water uses require greater protection than that afforded by either the stream or minimum effluent standards, the assimilative capacity of the waterways affected will be allocated among present and future waste dischargers.

Programs

To bring the quality of Delaware River Basin waters to the desired levels, water quality management involves several lines of attack. First, many of the existing waste treatment facilities must be upgraded to comply with legal requirements of appropriate sections of the Water Code of the Basin and laws of the signatory parties. Second, newly proposed waste water treatment projects must be tested against all aspects of the Commission's Comprehensive Plan, to determine their compatibility with existing facilities, the Water Code of the Basin, duly adopted regional plans, and with the other future projects designed to remedy pollution problems or to sustain currently acceptable qualities of surface and underground waters. Finally, the Commission must undertake investigations of water quality problems, and where determined necessary, must construct and/or cause projects to be operated toward the end that water quality goals can be attained.

The Water Quality Standards of the Delaware River Basin, Article 3 of the Water Code - Appendix A, were developed in concert with the Basin States, and with the U. S. Environmental Protection Agency. Accordingly, they are designed to be compatible with the water quality standards of each of the States and the Federal Government, as they relate to the Delaware River watershed. However, recognizing that on occasions the States may wish to impose higher standards within selected areas under their jurisdictions than those in force by the Delaware River Basin Commission, the higher state standards are controlling within such specified areas, but not Basinwide.

The Water Quality Standards of the Delaware River Basin are enforced with respect to effluent quality requirements in accordance with schedules adopted by the Commission prior to October 1, 1973 and in compliance with requirements of the appropriate signatory parties on and after Oct. 1, 1973. It is intended that enforcement procedures will be administrered with due recognition of the laws and requirements of the signatory parties and with the utilization to the maximum practical extent of the functions, powers, and duties of water pollution control agencies of the signatory parties to the Delaware River Basin Compact, and in accordance with administrative agreements which may be entered into by and between the Commission and such agencies.

Program for allocation of waste assimilative capacity.-- The Delaware River Basin Commission has determined that the carbonaceous oxygen demand of waste effluents entering the tidal Delaware River between Trenton, New Jersey, and Liston Point, Delaware, exceed the waste assimilative capacity of these waters. As this section of the river serves as state boundaries, New Jersey-Pennsylvania and Delaware-New Jersey, and as the boundary between Regions II and III of the U. S. Environmental Protection Agency, the

Commission has accepted the responsibility for allocating the carbonaceous waste assimilative capacity of these waters among the dischargers. A complete tabulation of the dischargers and their allocations is available at the Commission's offices. The allocation process, which is discussed in some detail in the Commission's " Basin Regulations-Water Quality," results in a fixed unit amount of the pollutant being assigned to a discharger with the understanding that he must take whatever steps are necessary to limit his discharge of that pollutant within the assigned amount.

Normal growth of the waste discharge must be accommodated by increased efficiencies of treatment. Major changes in the discharger's plant such as those caused by annexations to cities of new sewage loads, or by subsatantial additions to industrial plants, qualify for consideration of supplemental allocations. In such cases, supplemental allocations of waste assimilative capacity are made from a reserve set aside for that purpose. When the reserve approaches exhaustion, the assimilative capacity is reallocated among all the existing dischargers, and a new reserve created. Under the allocation procedure, once the water quality of a stream has been brought up to standards, it will remain there. The allocation program for the tidal Delaware River has been based upon the assimilative capacity of these waters with an inflow of 3,000 cfs at Trenton.

Through the voluntary action of a discharger or through the legal enforcement procedures of the signatory parties including punitive measures authorized by the Compact and other avenues open to the Commission, acceptable quality levels of liquid discharge from existing waste treatment facilities will be achieved.

Review program.-- The Delaware River Basin Compact states in Section 3.8 that "No project having a substantial effect on the water resources of the basin shall ....

be undertaken by any person, corporation or governmental authority unless it shall have been first submitted to and approved by the commission....The commission shall approve a project whenever it finds and determines that such project would not substantially impair or conflict with the comprehensive plan and may modify and approve as modified, or may disapprove any such project whenever it finds and determines that the project would substantially impair or conflict with such plan.."

Among the most significant of the many types of water and water related projects which are subject to review pursuant to Section 3.8 of the Compact, are those which would discharge waste waters, such as projects designed to intercept and transport sewage to a common point of discharge, or projects for the direct discharge of industrial waste waters to surface or ground water and certain petroleum products pipelines. To gain approval of such projects, the sponsors file an application with the Commission. The application for project approval is accompanied by exhibits which cover such matters as the sponsor's legal authority to construct the project, the project location and general dimensions, maps showing the watershed affected, a detailed description of the proposed structures or of nonstructural remedies, an engineer's report describing, among other things, the proposed plan of operation, a description of the lands to be acquired or occupied, tabulations of cost estimates, a commentary on the method of financing, and a description of the construction procedures to be followed. Following an investigation by the staff and determination by the Executive Director that the project will not impair or conflict with the Comprehensive Plan, the application, together with the Executive Director's recommendation, is placed before the Commission for its formal action at a public hearing.

The Commission encourages regional solutions to waste water treatment problems. The use of regional water pollution control facilities frequently results in economies of scale, more efficient operation, greater reliability and, hence, a healthier receiving stream. These and other factors are considered during the reviewing process in order that only those waste treatment and other projects relating to sound water management practices will be approved for implementation.

NPDES Program -- The Commission does not have a formal role in the National Pollutant Discharge Elimination System (NPDES). These permits are issued, at this time, by Regions II and III of EPA and the State of Delaware. Nevertheless, the proposed effluent limitations in draft NPDES permits, considered to be of most significance, are reviewed for consistency with Commission water quality standards and regulations, including allocations, as well as other effluent and waste treatment requirements.

Primary direction has been to discharges to the main stem Delaware River, especially to those having an allocation of FSOD, and major discharges on tributaries having known major or suspected impact on the Basin's waters. Permit issuing agencies of the signatory parties have the obligation under the Compact, Commission regulations, and current laws to enforce these requirements. The Commission becomes a party to such enforcements proceedings only as necessary to protect the Basin waters.

Monitoring program -- The Commission's monitoring program is designed to provide data for the Basin's pollution control program for the main stem of the Delaware River, in full concert with the programs of the agencies of the signatory parties. Through cooperative contracts with the States of Delaware, New Jersey and Pennsylvania and the U. S. Geological Survey, water quality is monitored via fixed stations, boat run sampling, and waste discharges sampling. This continuous collection and analysis of data allows the Commission to evaluate the effectiveness of current programs of abatement and control and provides the data base to verify modelling techniques, substantiate program changes and coordinate future planning requirements.

Special Programs.-- Several water-quality problems of a special nature have been identified in the Delaware River Basin, and this staff report includes programs for correcting or controlling these problems.

(1) Acid mine drainage.-- In the upper watershed areas of the Lehigh and Schuylkill Rivers, significant degradation of the quality of water in streams results from drainage of acid waters from coal mines. Approximately 80 miles of streams in the Lehigh River system and 120 miles in the Schuylkill River are degraded by mine drainage, making then unsuitable habitats for fish and other aquatic life, and for withdrawal water supply unless extensive water treatment is provided. The Pennsylvania Department of Environmental Resources has undertaken a Statewide program of controlling or correcting acid mine drainage pollution.

(2) Salinity control. -- As has been discussed earlier, one of the most significant water-quality problems of the Basin results from the seasonal intrusion of sea water in the Delaware River estuary during periods of low fresh-water flow. During the critical drought of the sixties, sea salts were detected within ten miles of Philadelphia's water intake at Torresdale, Pennsylvania, on the Delaware River, threatening that major city's water supply as well as the groundwater supplies that are recharged by the Delaware River in the Camden, New Jersey, area.

In addition to water supplies dependent upon fresh water in the upper reach of the tidal Delaware River, the shellfish industry in Delaware Bay also is influenced by salinity of the estuary. Shellfish experts (Stauber, 1939; Haskin, 1954; Nelson, 1954) have stated that oysters are capable of withstanding lower sea water concentrations than their chief enemies, the oyster drills. These drills attack oysters in their natural seed beds near the head of Delaware Bay when salinity concentrations over the beds are relatively high. Available evidence indicates that the area subject to invasion by the oyster drills is directly related to the fresh-water flows into the estuary. Hence, the operational plan for the Tocks Island Project, the largest and most effective of the proposed reservoirs of the Basin, anticipates the release of the inflows to the reservoir during the months of April, May and June. This mode of reservoir operation is expected to sustain the current levels of salinity, and therefore, the inhibiting force against the drills, over the natural oyster seed beds during the spawning period.

(3) Water Pollution Emergencies .-- The heavy concentration of industry, the large volume of shipping, and the numerous pipelines, railroads, and highway truck routes in the Delaware River Basin result in a high probability of accidental discharges that could be injurious to water quality and to water users. To minimize the damages caused by such accidental discharges, the Delaware River Basin Commission established a water quality emergency-alert system. The purposes of this alert system are to notify water users likely to be affected of the location, time, and nature of accidental discharges or dumpings of harmful substances into streams; to disseminate information on possible remedial measures for dealing with such discharges; to allow timely corrective measures by appropriate agencies and others concerned; to assure that necessary water samples are collected; and to

inform appropriate regulatory agencies. In fiscal 1974, these activities were terminated in light of U. S. Environmental Protection Agency's program. Nevertheless the Commission is still called upon in water pollution emergencies for assistance in disseminating or transmitting information to other regulatory agencies or to the public and the press.

(4) Thermal pollution-- Previous studies, based only on major sources of waste heat, have indicated the need for a more thorough evaluation of thermal loads on the Delaware Estuary. Additional studies will include a complete listing of waste heat sources, evaluation of the accumulative effects of waste heat discharges, and make recommendations, if necessary, for the need to restrict waste heat discharge to the estuary in order to assure compliance with Commission temperature standards.

Existing facilities

Existing facilities that serve the function of water-quality management have been tabulated and complete listings are available at the Commission offices. The majority of these facilities are public waste-water discharge facilities. Identification of the communities and areas served by each public waste-water disposal system and the population served by the system is maintained. As indicated earlier, a number of the existing waste-water disposal systems are not producing an effluent that complies with the Commission's Water Quality Standards, Article 3 of the Water Code of the Basin, at the present time, and these must be replaced or modified to conform.

Existing reservoirs, many of which provide planned or incidental benefits to water quality management, are also listed and their major contributions to meeting the objectives of water-quality management are described below.

Major reservoirs.-- Several of the existing large reservoirs in the Delaware

River Basin are designed to be used partly for low streamflow augmentation for water-quality management. These include the three New York City impoundments, Cannonsville Reservoir on the West Branch Delaware River, Pepacton Reservoir on the East Branch Delaware River, and Neversink Reservoir on the Neversink River. These reservoirs are required to provide downstream releases of water as necessary to insure a flow of at least 1,750 cfs in the Delaware River at Montague, New Jersey, as compensation for water diverted out of the Delaware River Basin by New York City. This minimum flow at Montague, specified by the U. S. Supreme Court in 1954, contributes toward the flow needed in the river to assimilate organic wastes, and in the tidal reach below Trenton, to help repel sea water.

Several hydroelectric power reservoirs, located in the upper watershed on tributaries of the Delaware River upstream from Port Jervis, New York, provide seasonal flow regulation, augmenting critical low flows of the lower Delaware River with resulting incidental improvements in water quality. Some of these reservoirs provided special releases during the 1965 and 1966 drought emergency for salinity control in the estuary.

Beltzville Reservoir, completed in 1971, is the first Federal impoundment in the Delaware River Basin to include storage capacity allocated to low-stream flow augmentation for water-quality control, under the provisions of Public Law 87-88. This law allows the inclusion of such storage capacity as a nonreimbursable Federal expense, provided the benefits of water-quality control are widespread and general. Beltzville Reservoir includes 11,950 acre-feet (3.9 billion gallons) of storage capacity allocated to water-quality control. Water released as a result of this storage capacity will improve the quality of low flows in the Lehigh River Basin, including those degraded to some extent by acid drainage from coal fields. It must be noted that release of this storage capacity is not intended nor is it used as a substitute for adequate treatment of waste at the source.

Like most large deep reservoirs, Beltzville Reservoir exhibits vertical density stratification at times. This stratification results from the different densities of the near-surface and deep layers resulting from heat absorption by the former during the warmer season, or from heat loss by the surface area during the colder months when the deep layers are at their maximum density (at a temperature of 4°C). Various water-quality problems are associated with such stratification. In addition to the temperature and density variations from top to bottom, other water quality parameters, including dissolved-oxygen concentrations and concentrations of algal nutrients, vary with depth in the stratified reservoir. During periods of stratification in Beltzville Reservoir, selective withdrawal of releases for water-quality control is possible by means of a multiple-level water-intake tower near the dam. This feature for the release of water will be useful for providing optimum quality control both within the reservoir and downstream.

The North Branch Reservoir, constructed on the North Branch of Neshaminy Creek, provides a water-quality control function, in that it will maintain minimum streamflows in Neshaminy Creek to insure assimilative capacity for treated effluents discharged into that waterway. Part of the quality-control water released from the reservoir will result from drawdown of the facility's storage capacity, and part would be diverted from the Delaware River by the authorized Point Pleasant pumping station on the Delaware River, stored temporarily in North Branch Reservoir, and then released downstream. To avoid decreasing the natural or regulated low flows in the Delaware River below Point Pleasant, the water diverted to the Neshaminy would be replaced from storage in reservoirs upstream of Point Pleasant during low-flow periods. Except for depletive use, the water diverted from the Delaware River at Point Pleasant to the North Branch Reservoir will be returned to the Delaware River via Neshaminy Creek or the Schuylkill River, and thus will contribute to the fresh-water flow into the Delaware Estuary as needed for salinity control.

Major diversion facilities.-- As of 1972, there were no major facilities for importing water to the Delaware River Basin for the specific purpose of augmenting low stream flows for water-quality control. Neither were there any major intra-Basin diversions among sub-basins of the Delaware River Basin for this purpose.

Future Projects

Complete listings of authorized projects that would serve the purpose of water-quality management in the Delaware River Basin are available at the Commission offices. Again, the majority of these projects are public waste-water disposal systems that are being upgraded,combined, replaced or newly installed. Major reservoirs, diversion projects and regional waste treatment systems are included. Some of these are described briefly in the following sections.

Major reservoir projects -- As listed earlier in Table II-2, there are 12 large reservoir projects authorized for construction. Seven of these are Federal multipurpose projects, which may include storage capacity allocated to water-quality control under provisions of P.L. 92-500, provided that releases from such storage in the reservoirs do not serve to dilute wastes in lieu of adequate treatment of such wastes at their sources, and provided also that the benefits from water-quality control resulting from the releases are widespread and general.

Among the six major reservoir projects authorized but not yet constructed in the Delaware River Basin above Trenton, five are Federal projects. Of these five, only two have been fully studied with respect to their potential use for water-quality control. Studies by the Federal Water Pollution Control Administration in 1966 concluded that no allocation of storage capacity should be made for water-quality control at Federal expense in the Tocks Island and Trexler Reservoirs. Nevertheless, the storage capacity allocated to water supply in these reservoirs would provide incidental benefits to water-quality control by maintaining minimum flows during critical drought periods. Previous studies by the Public Health Service have indicated the need for additional storage for water-quality control in the Lehigh River Basin, some of which may be provided by Francis E. Walter and Aquashicola Reservoirs. Future studies will determine whether specific allocations of storage capacity for water-quality control should be made in Prompton Reservoir.

One non-federal project in the Basin above Trenton, Hackettstown Reservoir, would also provide low-streamflow augmentation for water-quality control.

All six projects above Trenton would contribute to attainment of the minimum flow objectives for the Delaware River at Trenton and at the mouth of the Schuylkill River, 3,000 cfs and 3,600 cfs, respectively. Sustaining these minimum flows would provide water-quality benefits by repulsion of sea water and by affording a dependable capacity to assimilate the treated wastes discharged into the tidal river below Trenton. As previously, stated, the allocation program for the tidal Delaware River has been based upon the assimilative capacity of these waters with an inflow of 3,000 cfs at Trenton.

Among the three reservoir projects authorized but not yet constructed in the Schuylkill River Basin, two are Federal multipurpose projects. These are the Blue Marsh Reservoir, which is already under construction, and Maiden Creek Reservoir. These two reservoirs would provide a combined storage capacity of 88,620 acre-feet for supplies of water. Of this total, only 6,620 acre-feet, all in the Blue Marsh Reservoir Project, has been specifically allocated to water-quality control in the Tulpehocken Creek and in the lower Schuylkill River. Some of the 74,000 acre-feet capacity of the Maiden Creek Project may be eligible for that purpose in the Schuylkill River. However, when compared with the projected demands, as estimated by the Public Health Service, of 3,200,000 acre-feet of storage capacity needed for water-quality control in the Schuylkill River Basin by the year 2020, based on primary and secondary treatment of waste waters, the total capacity of the two Federal projects-- even assuming all of it to be used for water-quality control-- is quite inadequate. Therefore, other quality-control practices such as land-use control, advanced waste treatment and, possibly, importation of high quality water may be necessary if water quality of the river is to be maintained.

The remaining Schuylkill River Basin project, Evansburg Reservoir, is sponsored by the Commonwealth of Pennsylvania to provide water supply and recreation. None of the storage capacity to be provided in this project is allocated to low-streamflow augmentation for water quality control. Nevertheless, releases from storage for water supply purposes would provide incidental benefits to water quality in the Schuylkill River, and along with the two Federal projects, would aid in the repulsion of sea water in the Delaware River Estuary.

The two remaining large reservoir projects which are authorized but not constructed, Newark and Icedale, and one project recently completed, Nockamixon, do not include allocations of storage for water-quality control and probably would have no significant bearing on water-quality management.

Major diversion project.-- This sub-section discusses a major project for diversion of water from the Delaware River that has been authorized but not constructed, and is designed in part to provide water-quality control.

The Point Pleasant diversion project would provide for pumping water from the Delaware River into the Neshaminy Creek and Perkiomen Creek watersheds, and would serve the purposes of water supply, recreation, fish enhancement, and water-quality control. The water diverted to the Neshaminy watershed would be stored temporarily in North Branch Reservoir and released downstream as needed for water withdrawal supply and water-quality control. Although the diversion to Perkiomen Creek and thence to the Schuylkill River is planned for water supply only, the water from the Delaware River would augment low-flows in the East Branch of Perkiomen Creek and in Perkiomen Creek, thus providing incidental benefits to fish, recreation and water-quality control.

Regional waste treatment systems

It is the policy of the Delaware River Basin Commission to promote and encourage planning for regional solutions to water quality problems. Further, the Commission may provide planning and, when necessary, the construction, financing and operating services required for regional solutions to such problems when other appropriate agencies do not provide these services.

A number of regional sewerage systems are currently(1974) in operation, and several others are in the planning process. The City of Philadelphia's sewage collection and waste water treatment plants constitute a regional system for providing service to the entire City and to some of its neighbors. In Delaware, New Castle County and the City of Wilmington have joined forces and have an operating regional waste treatment system. The areas covered by these two systems and others that are in existence, or have been approved by the Commission and adopted as features of its Comprehensive Plan, are shown on Figure II-7.

With regard to the Regional Water Quality Management System for the Tocks Island and Delaware Water Gap National Recreation Area, the Delaware River Basin Commission will undertake the construction, and provide for the operation of the system unless local or state authorities agree to undertake and provide substantially the same service. This system is described in the following sections.

The area immediately adjacent to the Tocks Island Reservoir project and the Delaware Water Gap National Recreation Area have been studied in depth, and a regional waste system adopted to protect the quality of water to be stored in the reservoir. This regional water quality management system, consisting of units providing service within the States of New Jersey, New York, and Pennsylvania, is based on the objective of providing necessary sewerage service to prevent pollution and health hazards, including both free-flowing streams and the Tocks Island Reservoir.

The area to be protected is that portion of the Delaware River Basin in Orange County, N. Y., Pike and Monroe Counties, Pa., and Sussex and Warren Counties, N.J., above the Tocks Island dam site, as shown in Figure II-8.

The areawide wastewater treatment management plan is based upon (a) waste flows from recreation use areas inside the Delaware Water Gap National Recreation Area having a combined design capacity of 42,000 persons per day and an estimated recreation load of four million visitors per year, and (b) municipal waste flows outside the Delaware Water Gap National Recreation Area as projected in the Tocks Island Region Environmental Study report or the 1968 Comprehensive Sewerage Study prepared for Orange County by the

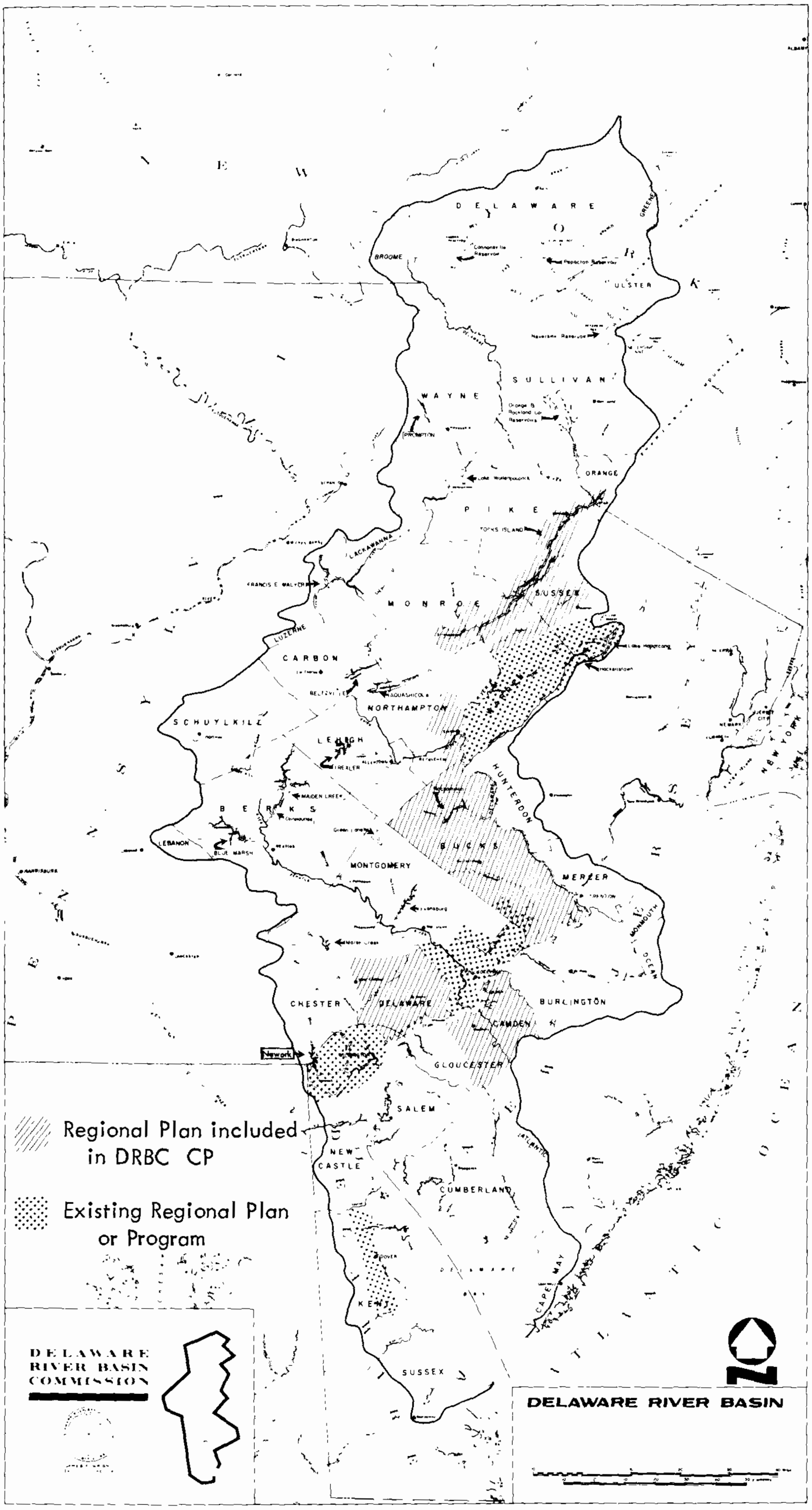


Figure II-7 --Regional waste treatment systems

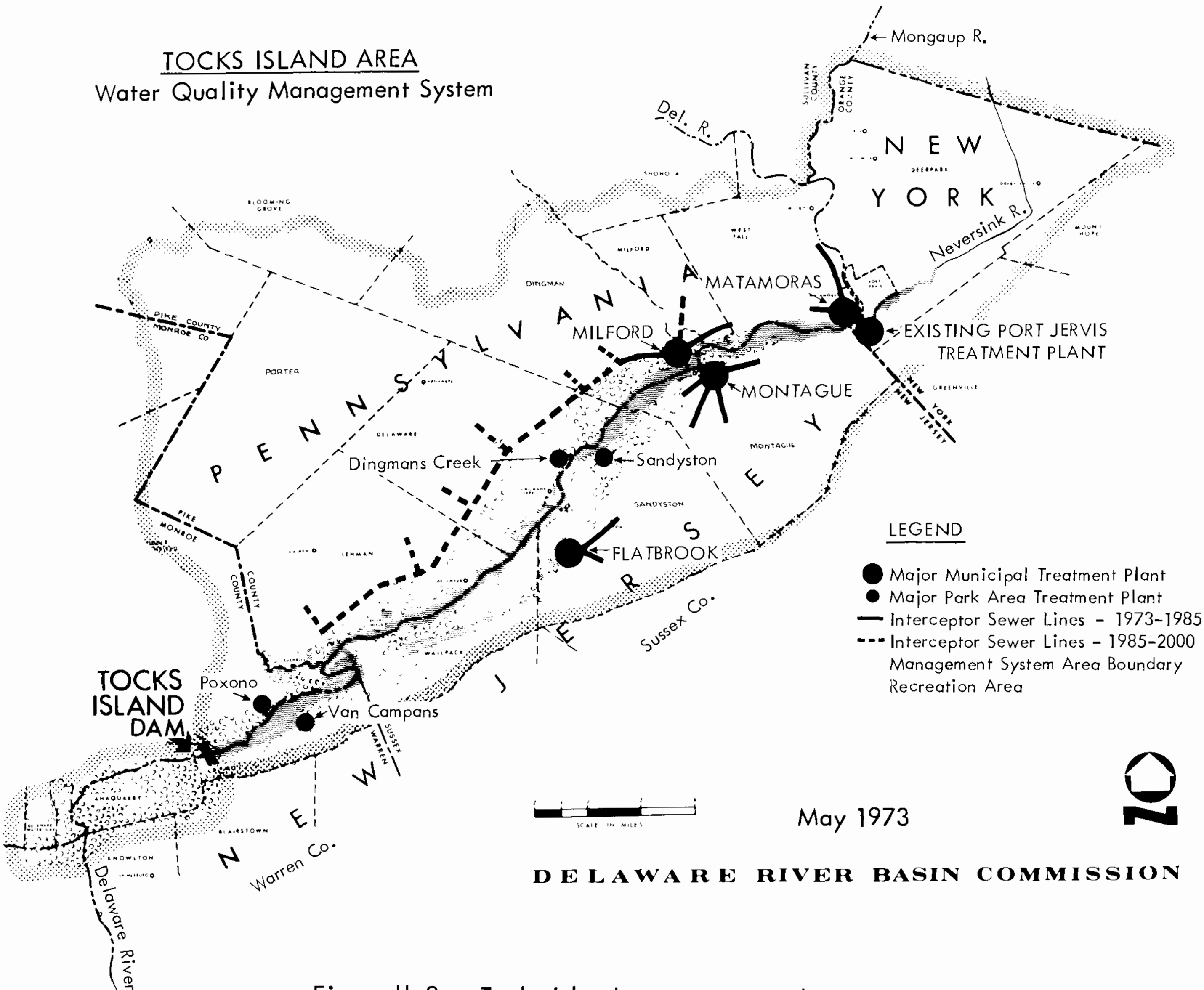


Figure II-8 -- Tocks Island area water quality management system consulting firm of Alexander Potter Associates, for the period to year 2000.

To the extent feasible, treated wastewater would be managed so as to minimize discharges to the reservoir or its tributary streams. Use of land application techniques for wastewater disposal would conform with established soil suitability data and criteria contained in a report entitled "Potential Use of Spray Irrigation in the Tocks Island Region," dated December 2, 1972, prepared for the Delaware River Basin Commission by William E. Sopper and Louis T. Kardos. All existing or proposed discharges to surface water would be treated including removal of not less that 95 percent of BOD and soluble phosphorus by July 1, 1983, or closure of Tocks Island dam, whichever is earlier. All discharges for land disposal of treated wastewater, to the extent authorized by the areawide wastewater treatment management plan, would include secondary treatment and disinfection before the wastewater is applied to the land. The use and and development of groundwaters, and the disposal of treated wastewaters into the ground, would be in accordance with Commission policy contained in Resolutions 64-8 and 72-14 dated September 23, 1964 and December 12, 1972, respectively.

The areawide wastewater treatment management plan requires construction of facilities in the respective States as follows:

New Jersey

A. Construction prior to closure of the Tocks Island dam of public wastewater facilities in Montague and Sandyston Townships as required to serve their population centers.

B. Construction of public wastewater treatment facilities at the Sandyston and Van Campens recreation use areas inside the Delaware Water Gap

National Recreation Area not later than the opening of each respective recreation use area.

C. Construction of on-site public sewerage facilities at authorized upland recreation use areas within the Delaware Water Gap National Recreation Area not later than the development of each area. Upland recreation use areas will be served by connection to the public wastewater treatment facilities where feasible.

Pennsylvania

A. Construction prior to closure of the Tocks Island dam of public wastewater treatment facilities as required to serve population centers, including but not limited to (a) public wastewater treatment facilities at Milford, and (b) public wastewater treatment facilities at Matamoras.

B. Staged development, as needed, of interceptor sewers and other wastewater collection and treatment facilities in accordance with TIRES Alternative III, except as hereinbefore noted, including interceptor sewers serving the region between Milford and Bushkill generally along the alignment of relocated Route 209.

C. Construction of public wastewater treatment facilities at the Poxono and Dingmans Creek recreation use areas inside the Delaware Water Gap National Recreation Area not later than the opening of the respective recreation use areas.

D. Construction of on-site wastewater sewerage facilities at authorized upland recreation use areas within the Delaware Water Gap National

Recreation Area not later than development of each area. Upland recreation use areas will be served by connection to the subregional plants where feasible.

New York

A. Upgrading of the Port Jervis wastewater treatment plant to comply with applicable standards relating to regional requirements.

B. Prior to 1995, in areas of Orange County outside the Port Jervis plant's service area, phased development as needed of small-scale wastewater treatment plants or, alternatively, on-site disposal units. These facilities will, as far as feasible, be designed so as not to preclude possible future incorporation within regional collection and treatment systems.

C. After 1995, further phased modification of the Port Jervis or other subregional wastewater treatment system into a regional facility to serve adjacent areas in Orange County or, alternatively, construction of two new subregional wastewater treatment systems in the Neversink sub-basin and on the Delaware River upstream from Port Jervis.

The areawide wastewater treatment management plan outlined above is subject to modification by the Commission to maximize the advantages of new technology, adjust to changed rates and patterns of growth in the area, or conform to new water quality standards.

The siting of wastewater collection and treatment facilities, and the selection among alternative techniques, will be based upon environmental and engineering studies and environmental impact reviews required by statute and the Commission's regulations.

Such determinations will be based upon the policy of maximum feasible preservation of the natural physical environment and the application of sound watershed management standards.

Management of non-point sources of water pollution in the area, and drainage areas tributary thereto, will be in accordance with EPA policy dated January 14, 1972, and with applicable regulations, including without limitation thereto, those relating to erosion and sediment control, efficient fertilizer use and land disposal of animal wastes.

The implementation of this areawide wastewater management plan would be consistent with land use policies and controls of the respective States. New land developments and uses which may have a major impact upon the plan or upon a critical environmental area, and which are reviewable under the Compact, will be subject to an environmental impact review under the Commission's Rules of Practice and Procedure.

WATER MANAGEMENT OF THE

DELAWARE RIVER BASIN

PART TWO

CHAPTER 4 - FLOOD CONTROL MANAGEMENT

General

The purpose of the planning and operating criteria and programs for flood management, as described in this chapter is to provide for the development of an optimum combination of structural and nonstructural measures necessary to protect human life and, to the extent justified by economic criteria, to prevent damages to public and private property. Specific objectives of flood control management are presented, as well as discussions of existing facilities and authorized future projects designed to contribute to attainment of those objectives. Also presented in this chapter are evaluations of the capabilities of those facilities and projects to meet the long-range needs of the Basin for reduction of flood losses. In addition, consideration is given to certain operating requirements designed to promote optimum use of all flood-control works, whether single-purpose or multiple-purpose in their nature, not only to reduce flood damages, but also to insure minimum interference with other objectives of sound water management. Finally, this chapter outlines flood-plain management and other programs designed to supplement and augment the structural measures for flood control and protection.

As noted in Part One, floods of major proportions have occurred repeatedly along the primary and secondary streams of the Delaware River Basin. The flood control facilities currently in existence would reduce damages that would occur with a repetition of historic floods on the Lackawaxen and Lehigh Rivers, but would only reduce the observed Delaware River stage at Trenton by 1.3 feet. As a result of development that has taken place along the lower Delaware River since August 1955, the date of the most severe flood of record, property damage with a repetition of that flood would no doubt be greater in the 1970's than it was in 1955. The Schuylkill River Basin found itself as vulnerable to flooding in 1972, when tropical storm Agnes occurred, as in 1869 when the highest flood stages were recorded at Philadelphia. No reservoir storage facilities are available as tools to help in controlling flood flows of the Musconetcong River in New Jersey, nor of Brandywine Creek in Pennsylvania and Delaware.

Objectives

Toward fulfillment of the broad goals of protecting human life from floods and preventing flood damages to public and private property, specific flood control management objectives have been adopted, as described in the following sub-sections.

Stage and flow objectives.-- Flood stages, the water levels at which flood damages begin to occur, together with corresponding stream flow discharges, have been officially adopted by the responsible resources agencies and the Delaware River Basin Commission for selected locations on Basin streams, as listed in Table II-3. If flood control works were provided to prevent water levels above these flood stages, virtually all flood damages would be eliminated. As a practical matter, however, such a high degree of control will rarely be economically attainable. Until economic evaluations can be performed, the flood stages presented in Table II-3 can serve as the objectives for operational control of existing flood-control structures. For planning additional flood control works, these flood stages also indicate the lower limits of reduced storm runoff that can be economically justified by potential reductions of flood damages.

Table II-3

Flood stages and flows for selected locations, Delaware River and tributaries

Stream and location	Stream mile	U.S.G.S. number	Flood stage and corresponding discharge: Stage, feet above local datum	Discharge, c.f.s.
(1)	(2)	(3)	(4)	(5)
East Branch Delaware River at Fishs Eddy, N.Y.	330.7-10.9	4210	11	10,500
West Branch Delaware River at Hale Eddy, N.Y.	330.71-9.5	4265	11	11,800
Delaware River near Barryville, N.Y.	279.3	4285	17	64,000
Lackawaxen River at Hawley, Pa.	277.7-16.4	4315	11	19,000
Delaware River at Port Jarvis, N.Y.	254.7	4340	18	138,000
Delaware River at Milford, Pa.-Montague, N.J.	246.3	4385	25	131,000
Delaware River at Riverton, Pa.-Belvidere, N.J.	197.84	4448	20	122,000
Delaware River at Easton, Pa.-Phillipsburg, N.J.	183.82	4470	22	76,500
Lehigh River at Lehighton, Pa.	183.66-43.0	4490	10	16,900
Lehigh River at Walnutport, Pa.	183.66-33.7	4510	8	18,900
Lehigh River at Allentown, Pa. (Hamilton St. Bridge)	183.66-17.00	a	12	Not rated
Lehigh River at Bethlehem, Pa. (New St. Bridge)	183.66-11.82	4530	16	38,000
Delaware River at Riegelsville, Pa. & N.J.	174.8	4575	22	116,000
Delaware River at Upper Black Eddy, Pa.-Milford, N.J.	167.7	4580	20	Not rated
Delaware River at Uhlerstown, Pa.-Frenchtown, N.J.	164.3	4585	16	Not rated
Delaware River at Center Bridge, Pa.-Stockton, N.J.	151.9	4615	18	Not rated
Delaware River at New Hope, Pa.-Lambertville, N.J.	148.7	4620	12	Not rated
Delaware River at Trenton, N.J.	134.43	4635	20[b]	138,000
Assunpink Creek at Trenton, N.J.	133.8-1.45	4640	6	945
Neshaminy Creek near Langhorne, Pa.	115.63-11.44	4655	9	7,650
Schuylkill River at Berne, Pa.	92.47-95.5	4705	12	17,000
Schuylkill River at Reading, Pa. (Metro-Edison Co., West Reading, Pa.)	92.47-75.7	4715	13	Not rated
Schuylkill River at Pottstown, Pa.	92.47-53.7	4720	13	27,800
Schuylkill River at Norristown, Pa.	92.47-24	4735	17	Not rated
Perkiomen Creek at Graterford (Wire-weight gage, RR bridge)	92.47-32.3-9.9	4730	11	14,200
Schuylkill River at Philadelphia (Fairmount Dam), Pa.	92.47-8.5	4745	11	50,000
Brandywine Creek at Chadds Ford, Pa.	70.73-1.5-14.62	4810	9	5,320
Brandywine Creek at Wilmington, Del.	70.73-1.5-4.4	4815	11	14,100

[a] National Weather Service Station (no number).
[b] Datum of gage changed from 7.77 ft. above mean sea level to mean sea level (0.00) as of Oct. 1, 1964.

Nonstructural objectives.-- The Delaware River Basin Commission recognized that structural measures cannot guarantee, at acceptable costs, that no flood damages will occur. For this reason, the Commission's objectives include the development of non-structural measures or programs of flood-loss reduction to complement the reservoirs and other structural measures of flood control. Such nonstructural measures include flood-plain zoning and other land-use controls, as well as flood forecasting and warning systems.

Because extensive development has already taken place in many flood plains in the Basin, neither structural nor nonstructural measures can be relied upon to wholly eliminate all flood losses. To decrease the risk to property owners in flood-prone areas, the Commission has established programs, in cooperation with the U. S. Dept. of Housing and Urban Development for developing the information on flood risks and other data to assist the municipalities in qualifying for flood insurance under the National Flood Insurance Program.

Existing facilities

Existing facilities that have been provided for flood protection and the reduction of flood damages in the Delaware River Basin include reservoir impoundments, channel improvements, and local protection works. These facilities and others that provide incidental flood control have been tabulated and complete listings are available at the Commission offices. Also, land-treatment measures have been undertaken on agricultural lands to retard runoff, and programs of flood-plain management, flood-warning and flood insurance are in effect.

Some of these existing facilities and their effects, either individually or collectively, are described in the following sections. Some of the on-going programs and non-structural measures are described also.

Major reservoirs.-- Table II-4 lists the existing large reservoirs with storage capacity allocated to the purpose of flood control. These large impoundments have a total flood-storage capacity of 59.0 billions of gallons (179,800 acre-feet).

Prompton Reservoir.-- Located on the West Branch Lackawaxen River just north of the Village of Prompton in Wayne County, Pennsylvania, the U. S. Army Corps of Engineers completed Prompton Reservoir in 1960. With a flood-runoff storage capacity of 6.6 billions of gallons (20,300 acre-feet), this reservoir is designed as a single-purpose facility to reduce flood stages on the Lackawaxen River at Prompton, Honesdale, and Hawley, all in Pennsylvania. The reservoir also provides limited reduction of flood stages on the Delaware River below the mouth of the Lackawaxen River. The dam was constructed originally with an uncontrolled outlet not subject to operational regulations. However, a temporary outlet structure was installed at Prompton Dam in 1966 to provide for emergency regulation for low-streamflow augmentation during severe droughts. An operational program designed particularly for the collection of observational data required for evaluation of the facility was established by the Corps of Engineers in 1961.

Jadwin Reservoir.-- The General Edgar Jadwin Reservoir is a single-purpose flood-control facility on Dyberry Creek, a tributary of the Lackawaxen River. Jadwin Dam is located 2.4 miles north of Honesdale in Wayne County, Pennsylvania. With a storage capacity of about 8.0 billions of gallons (24,500 acre-feet), this Corps of Engineers' reservoir is designed to reduce flood stages at Honesdale and Hawley, Pennsylvania. Like Prompton Dam, Jadwin Dam was constructed with an uncontrolled

Table II-4

Large reservoirs with storage capacity allocated to flood control in the Delaware River Basin

Name of facility	Location of dam, stream (river mile)	Flood-control storage capacity acre-feet	Flood-control storage capacity billions of gallons
Prompton Reservoir	West Branch Lackawaxen River, 0.3 mile north of Prompton, Pa. (277.7-27.11-4.9)	20,300	6.6
General Edgar Jadwin Reservoir	Dyberry Creek, 2.4 miles north of Honesdale, Pa. (277.7-27.1-2.7)	24,500	8.0
Francis E. Walter Reservoir	Lehigh River, near Bear Creek, Pa. (183.66-77.9)	108,000	35.4
Beltzville Reservoir	Pohopoco Creek, 4 miles east of Lehighton, Pa. (183.66-41.1-5.2)	27,000	8.8
	TOTAL	179,800	59.

outlet, and releases from the reservoir are not subject to operational regulation. In 1961 the Corps of Engineers established an operational program providing for observations of hydrologic data needed for evaluation of the facility's effects on downstream flood stages.

The proximity of the dam to Honesdale contributes to a high degree of flood protection for that community. Prompton and Jadwin Reservoirs together have 14.6 billions of gallons (44,800 acre-feet) of flood-storage capacity. The combined drainage area above the two dams is 125 square miles, or 76 percent of the 164 square miles in the total drainage area above Honesdale. Estimates of the combined effects that Prompton and Jadwin Reservoirs would have had on flood stages on the Lackawaxen River during several major floods of record are presented in Table II-5.

Francis E. Walter Reservoir.-- Located on the Lehigh River near Bear Creek in Carbon, Luzerne, and Monroe Counties, Pennsylvania, the Francis E. Walter Reservoir was completed in 1961. This Corps of Engineers facility, designed primarily for flood control with incidental use of recreation, has a flood-storage capacity of 35.4 billions of gallons (108,000 acre-feet). This capacity is operated during periods of heavy rainfall and runoff to reduce flood stages on the Lehigh River at Lehighton, Walnutport, Allentown, and Bethlehem, all in Pennsylvania. At Bethlehem, the worst flood of record occurred in August 1955, when the peak stage reached 23.4 feet above the local datum. Flood stage at this location is 16.0 feet, assuming local protection works on the right bank are intact. If Walter Reservoir had been in operation during the 1955 flood, the peak flood stage would have been reduced by about 1.5 feet.

Table II-5

Effects of Prompton and Jadwin Reservoirs on flood stages, Lackawaxen River, Pennsylvania [a]

Location	Date of flood	Peak stage, feet above local datum without reservoirs	with reservoirs
Honesdale at 4th Street	March 1936	17.7	b
Honesdale at 4th Street	May 1942	24.5	20.0
Honesdale at 4th Street	August 1955	----	b
Hawley below Wallenpaupack Creek	March 1936	13.9	9.4
Hawley below Wallenpaupack Creek	May 1942	20.1	16.6
Hawley below Wallenpaupack Creek	August 1955	20.6	17.1

[a] Source: Corps of Engineers (1961)
[b] Below damaging stage

Francis E. Walter Dam is equipped with gated outlets so that impounded flood waters can be released at controlled rates. An operational program designed to minimize flooding at downstream damage centers was established by the Corps of Engineers in 1963. Walter Reservoir is operated in conjunction with Beltzville Reservoir, also in the Lehigh River Valley.

Beltzville Reservoir.-- Beltzville Dam, a U. S. Army Corps of Engineers facility, is located on Pohopoco Creek, a tributary of the Lehigh River, near Lehighton in Carbon County, Pennsylvania. The Drainage area above the Dam is 96.3 square miles. With a total storage capacity of 22.2 billions of gallons (68,250 acre-feet), Beltzville Reservoir has an allocation of 8.8 billions of gallons (27,030 acre-feet) of storage capacity for flood control. This is equivalent to 5.28 inches of depth of runoff from the drainage area above the dam. Releases from the reservoir are controlled by gated outlets.

In 1964, the Corps of Engineers established an operation program for flood control along the Lehigh and Delaware Rivers. Control points for Beltzville Reservoir operation are located at Lehighton and Bethlehem on the Lehigh River and at Easton on the Delaware River.

Francis E. Walter Reservoir and Beltzville Reservoir are operated jointly for purposes of flood control. Estimates of the effects of these two facilities on flood stages equivalent to those accompanying major floods of record, as observed at Bethlehem, are presented in Table II-6.

Table II-6

Effects of Francis E. Walter and Beltzville Reservoirs on major floods on the Lehigh River at Bethlehem, Pennsylvania

Date of flood	Peak Discharge, cfs without reservoirs	Peak Discharge, cfs with reservoirs	Peak stage, feet above local datum without reservoirs	Peak stage, feet above local datum with reservoirs
August 1933	64,800	52,000	18.7	16.3
July 1935	63,700	52,600	18.5	16.4
March 1936	55,700	37,500	17.0	13.4
May 1942	92,000	69,000	23.5	19.5
November 1950	42,500	34,200	14.4	12.6
December 1950	46,900	34,500	15.3	12.7
August 1955	91,300	78,500	23.4	21.2

[a]Source: Corps of Engineers (1964)

Small reservoirs.-- There are numerous small flood-control reservoirs throughout the Delaware River Basin. A list of watersheds, with the number of small reservoirs in each watershed and the combined storage capacity allocated to flood control in each watershed, is given in Table II-7. The total combined storage capacity allocated to flood control in these small reservoirs is approximately 7.8 billions of gallons (24,000 acre-feet), more than a third of which is in the Little Schuylkill River watershed.

These small watershed facilities are designed as flood-retarding structures, with automatic release of water collected during periods of heavy runoff. Thus, they require no operation program, other than one of routine inspection and maintenance. Because of the relatively small capacities of the individual reservoirs, they provide flood protection to only limited reaches downstream of the dams. In time, however, existing and future additional small reservoirs in some watersheds would have enough aggregate capacity to provide significant reductions of flood flows in larger streams farther downstream.

Incidental flood control.-- Additional flood control, though incidental, is afforded by many existing reservoirs and lakes located throughout the Basin other than those constructed specifically for flood-damage reduction. These lakes and reservoirs may have empty storage capacity as a result of evaporation, or drawdown for their purposes of water supply, power generation, etc. Such empty capacity, when available during periods of heavy runoff, provides incidental flood-stage reduction in downstream reaches of streams.

Table II-7

Existing flood-control storage capacity in small watersheds of the Delaware River Basin

Watershed	Location, County(ies) and State(s)	Number of small reservoirs	Billions of gallons	Flood-storage capacity acre - feet
Lackawaxen tributaries Watershed	Wayne County, Pa.	7	0.4	1,112
Neshaminy Creek Watershed	Bucks & Montgomery Counties, Pa.	2	1.3	3,827
Green-Dreher Watershed	Wayne, Pike & Monroe Counties, Pa.	7	0.9	2,837
Paulins Kill Watershed	Warren & Sussex Counties, N. J.	3	0.05	168
Mauch Chunk Creek Watershed	Schuylkill and Carbon Counties, Pa.	1	0.4	1,094
Assunpink Creek Watershed	Monmouth & Mercer Counties, N.J.	4	0.4	1,350
Furnace Brook Watershed	Warren County, N.J.	1	0.2	487
Little Schuylkill River Watershed	Schuylkill, Carbon & Berks Counties, Pa.	5	2.7	8,281
Kaercher Creek Watershed	Berks County, Pa.	3	0.1	450
Saw Mill Run Watershed	Montgomery County, Pa.	1	0.1	400
Brandywine Creek Watershed	Lancaster, Chester & Delaware Counties, Pa. & New Castle County, Del.	2	1.3	4,098
	Totals	36	7.85	24,104

Channel improvements and local protection works. -- Channel improvements to alleviate flooding and local flood protection works are to be found at scattered locations throughout the Delaware River Basin. Communities protected by these facilities include Honesdale, White Mills, and Hawley, Pennsylvania, in the Lackawaxen River Basin; Stroudsburg and East Stroudsburg, Pennsylvania, in the Brodhead Creek Basin; areas on unnamed tributaries and along the main stem of Paulins Kill in Sussex County, New Jersey; an area along the Pequest River in Warren County, New Jersey; Weissport, Allentown, and Bethlehem, Pennsylvania, on the Lehigh River; Mount Holly, New Jersey, on Rancocas Creek; an area along Parkers Creek (a tributary of Rancocas Creek) in Burlington County, New Jersey; areas along the Chester River in Chester and Delaware Counties, Pennsylvania; areas in the Repaupo Creek watershed in Gloucester County, New Jersey; areas in Town Bank watershed in Salem County, New Jersey; areas along East Branch, West Branch, and the Salem River in the Middle Neck watershed in Salem County, New Jersey; areas along Alloway Creek and Silver Lake in the Silver Lake-Locust Island watershed in Salem County, New Jersey; along Mill and Mounce Creeks in the Pine Mount-Mill Creek watershed in Cumberland County, New Jersey; along the Maurice River, New England Creek, and Dickeys Ditch in the Maurice River Cover watershed of Cumberland County, New Jersey; and along Riggins Ditch in Cumberland County, New Jersey.

The channel improvements were constructed to enhance the flood-carrying capacity of the streams and to prevent flood waters from being backed up to damage-prone areas above the reaches improved. They have been incorporated in the Commission's Comprehensive Plan in order to promote their maintenance as a means of minimizing flood damage in these flood-prone areas. The local flood protection works, likewise a a part of the Comprehensive Plan, were constructed by various agencies as a means of protecting local communities that could not be protected at reasonable cost by other measures, such as upstream flood-control reservoirs.

Land Treatment.-- As part of the small watershed program, land treatment measures have been carried out in the Delaware River Basin by the U. S. Soil Conservation Service in cooperation with State and local agencies. Such measures are designed to improve hydraulic conditions for runoff from open land by providing cover, by decreasing the length of field slopes, and by decreasing the rates of overland flow, thereby decreasing sediment production by reducing sheet and gully erosion. Land-treatment measures have accompanied structural measures for flood retardation in the work plans of watersheds in all parts of the Basin. The land-treatment measures include strip cropping, establishing perennial grasses and legumes, planting trees on some open lands, and controlling erosion from skid trails and logging roads. These measures help reduce peak runoff from lands so treated, and thus augment the effects of flood-retarding reservoirs.

Flood-plain management.-- Structural and land-treatment measures cannot-- and are not intended to -- guarantee complete protection against every flood threat. In general the cost of reservoirs big enough and numerous enough to stop all floods is prohibitive. Therefore, water-resource agencies in the Delaware River Basin are attempting through flood-plain management to prevent uses of flood plains that are incompatible with their natural use of helping to carry flood-swollen streamflows to the sea.

The Commission has established the Flood Plain Regulation Advisory Committee to assist the Commission, the States and all municipalities in a coordinated flood-plain management program. The membership of this committee is composed of two representatives of each of the signatory parties.

Flood-plain studies. -- With a goal of inducing municipalities, which have the authority to control land use, to zone their flood plains for reduction of flood losses water agencies and organizations have prepared flood histories and maps for areas bordering more than 450 miles of streams in the Basin with a record of flooding. The maps delineate the boundaries of lands subject to flooding at various average recurrence intervals, say 5, 25, or 100 years. The Delaware River Basin Commission, U. S. Geological Survey, Corps of Engineers, Soil Conservation Service, State agencies, and volunteer watershed associations all have cooperated in this work.

Flood-plain zoning.-- More than a score of municipalities in the Basin have adopted flood-plain zoning ordinances, and others are preparing them. The Commission will continue to encourage the adoption of these local laws to prohibit damage-prone structures from being located in areas subject to flooding. The flood-plain information and mapping studies completed, in progress, or planned will provide much of the data needed for proper zoning of these lands.

Flood-warning system.-- A flood forecasting and warning system has been established in the Delaware River Basin for the advance notification of impending floods, to allow time for the evacuation of people from flood-prone areas and the protection of property, and to provide information needed for operation of flood-control reservoirs. Cooperating agencies include the U. S. National Weather Service, the U. S. Corps of Engineers, the U. S. Geological Survey, and water-resources agencies of the States of the Delaware Basin. The National Weather Service issues flood forecasts and warnings to the public. This service has contributed significantly to the overall flood-loss reduction program.

Flood insurance.-- All structural and non-structural measures for flood-damage reduction that have been accomplished to date fall far short of eliminating monetary losses from high waters. As recently as September 1971, property damages from overflowing streams in the Basin, resulting from tropical storm Heidi, exceeded $36 million in value. Partly to soften the effects of such losses, the National Flood Insurance Program was established by Federal law in 1968. This program provides for subsidized flood-loss insurance on private residential and commercial property, but only in municipalities that act to control future use of flood plains through zoning and other measures. The Federal law also requires that participating municipalities be in possession of local flood-history information. Thus, the previously mentioned flood-plain studies have taken on added importance since enactment of the Flood Insurance Act. The flood-plain information studies already completed have met this part of the insurance -eligibility requirements for many communities in the Basin. The Commission is directing studies for 119 communities within the Basin. These studies in cooperation with HUD, will enable these communities to meet the FIA requirements.

Future projects

Complete listings of authorized future projects that would serve the purpose of flood-loss reduction in the Delaware River Basin are available at the Commission Offices. These projects consist of major reservoirs, channel improvements, small watershed programs consisting of a small reservoir and land treatment measures, and various flood-plain management programs. Some of these projects are described in the following sections.

Major reservoir projects -- There are five large reservoir projects in the Commission's Comprehensive Plan that include storage capacity allocated to flood control. These reservoirs, authorized but not yet constructed, are listed in Table II-8.

Table II-8

Flood-control reservoir projects in the Delaware River Basin authorized for construction by the U. S. Army Corps of Engineers

Name of project	Location of dam, stream (stream mile)	Flood-control storage capacity: Billions of gallons	Flood-control storage capacity: acre-feet
Tocks Island Reservoir	Delaware River (217.2)	106	323,500
Aquashicola Reservoir	Aquashicola Creek (183.66-36.3-4.6)	6.5	20,000
Trexler Reservoir	Jordan Creek (183.66-16.4-0.41-0.3-17.5)	4.8	14,579
Maiden Creek Reservoir	Maiden Creek (92.47-86.7-9.6)	12.4	38,000
Blue Marsh Reservoir	Tulpehocken Creek (92.47-76.8-6.5	10.6	32,390
	Totals	140.3	428,469

Prompton Reservoir modification.-- Congress has authorized a modification of the existing Prompton Reservoir to make it a multiple purpose impoundment providing water supply and recreation benefits, in addition to its original function of flood control. A control tower with gates will be added to control releases of water from the reservoir and the spillway will be widened to 250 feet. The allocated flood-control storage capacity of 6.6 billions of gallons (20,300 acre-feet) after modification will be the same as now exists. However, the ability to control releases during and immediately after storms, the incidental additional flood protection to be available at times when the reservoir is drawn down for water-supply purposes, and the incremental increase in surcharge storage capacity resulting from the enlarged reservoir will all tend to increase the average annual flood-control benefits attributable to Prompton Reservoir.

After modification, Prompton Reservoir would be operated by the Corps of Engineers for flood control in accordance with the "Schedule of Regulation" set forth in Table II-9. The Prompton and General Edgar Jadwin Reservoirs would be operated as a unit to minimize flooding on the Lackawaxen River. The critical stages shown in the table have been established to protect the communities of Prompton and Honesdale from flood caused by streamflows in excess of 3,000 cfs and 10,000 cfs respectively. Because the outflow from Jadwin Reservoir is uncontrolled, it would be necessary to vary the discharge from Prompton Reservoir in order to limit the flow at Honesdale to 10,000 cfs. For times when the Dyberry or Honesdale gages might become inoperable due to damage or malfunction, a maximum release of 2,000 cfs from Prompton Reservoir has been established as an operational rule.

Table II-9

Schedule of regulation, Prompton Reservoir, for flood control and low-flow agumentation [a]

Schedule	Stage of Lackawaxen River at Honesdale, feet above local datum	Jadwin Reservoir pool elevation, feet above sea-level datum	Stage of Dyberry Creek near Honesdale, feet above local datum	Prompton Reservoir pool elevation feet above sea-level datum	Regulation
A	7.0 and below	982.0-1053.0+	0-7.3	1112.0*-1180.0**	Maintain top of water supply pool as closely as possible. To meet low flow objectives downstream, outflows are never less than 70 cfs.
B	7.0 and below	982.0-1053.0+	0-7.3	1180.0**-1205.0***	Release at rate not exceeding allowable values from maximum release table corresponding to a Dyberry Creek gage height and Honesdale gage height of 7.0 feet.
C	7.0 and above	982.0-1053.0+	0-7.3	1112.0*-1205.0***	Release at rate from maximum release table corresponding to a Dyberry Creek gage height and the gage height at Honesdale.
D	any elevation	982.0-1053.0+	0-7.3	1205.0*** and above	When reservoir pool reaches spillway crest, release inflow up to conduit capacity. If pool crests at this elevation, continue to release inflow until maximum release table can be used to empty reservoir flood control pool. If pool continues to rise with conduit gate fully open, maintain the gate setting until pool recedes to spillway crest.

* Top of sediment reserve
** Top of water supply pool
*** Spillway crest elevation

Maximum release table for Prompton Reservoir

Stage of Dyberry Creek, feet above local datum	Maximum allowable releases, cfs — Stage of Lackawaxen River at Honesdale, feet above local datum: 7.0	8.0	9.0	10.0
3.7 & below	3,000	1,850	200	70
3.7-4.7	2,500	1,350	70	70
4.7-5.5	2,000	850	70	70
5.5-6.1	1,500	350	70	70
6.1-7.3	950	70	70	70
7.3 & above	70	70	70	70

[a] Source: Corps of Engineers (1966)

Tocks Island Reservoir.-- The Tocks Island project calls for construction by the U. S. Army Corps of Engineers of a multipurpose reservoir on the Delaware River above the Delaware Water Gap. Storage capacity allocated to flood control would account for 106 billions of gallons (323,500 acre-feet) of the total volume of 275.5 billions of gallons (845,400 acre-feet) in this impoundment. This capacity would be operated to reduce flood peaks at downstream damage areas from Tocks Island to Burlington, New Jersey, including Easton, Riegelsville, New Hope, and Yardley, Pennsylvania; and Belvidere, Phillipsburg, Trenton, and Burlington, New Jersey. The flood-control storage would be sufficient to protect the downstream areas from a flood caused by a storm greater than the greatest flood of record. The peak river stage at Easton would be reduced as much as 12 feet by using the planned flood control storage capacity.

A schedule for operation of Tocks Island Reservoir was prepared by the Corps of Engineers in 1969 to serve the authorized project purposes. Flood-control releases from storage would be made within the range of the downstream channel capacity of 70,000 cfs during periods of encroachment in the flood-control pool caused by runoff events less severe than that of the August 1955 flood. Partially controlled flood releases would be made for very high runoff rates when the rate of change of increasing inflow exceeds that of the August 1955 flood. These releases would be made to prevent a flood wave downstream, which could occur if minimum releases were maintained until flood-storage capacity was exceeded and then the spillway gates were opened suddenly. Uncontrolled releases would occur when the flood-control and operational capacity is exceeded by runoff rates and the spillway gates are fully open.

Aquashicola Reservoir.-- The Aquashicola Reservoir project, proposed by the U. S. Army Corps of Engineers, is to be located on Aquashicola Creek near Palmerton, Pennsylvania, in the Lehigh River Basin. The drainage area above the damsite is 66 square miles. The multiple purpose impoundment with total storage capacity of 14.7 billions of gallons (45,000 acre-feet) would include 6.5 billions of gallons (20,000 acre-feet) of short term storage capacity for flood control. This capacity would contribute to flood-stage reductions at Palmerton, just downstream of the damsite, and at principal flood damage areas along the Lehigh River below the Lehigh Gap, including Walnutport, Northampton, Hokendauqua, Catasauqua, Allentown, Bethlehem, Freemansburg, and Easton, all in Pennsylvania.

Trexler Reservoir.-- The Trexler Reservoir project, proposed by the Corps of Engineers as a multipurpose impoundment, is to be located on Jordan Creek in Lehigh County, Pennsylvania. The damsite is in the Trexler Pennsylvania State Game Preserve about eight miles northwest of Allentown. The drainage area above the site is 51 square miles. The impoundment, total storage capacity of 18.1 billions of gallons (55,590 acre-feet), would include storage capacity of 4.8 billions of gallons (14,579 acre-feet) allocated to flood control. Temporary storage of stormwater runoff would contribute to flood-stage reductions at Allentown, Bethlehem, and Easton, Pennsylvania, in the Lehigh River Basin.

Combined operation of Beltzville, Aquashicola, and Trexler Reservoirs in the Lehigh River Basin would result in a peak stage reduction of two feet at Bethlehem for a flood equivalent to the one in August 1955. This reduction is in addition to the effects of the existing Francis E. Walter Reservoir. The Lehigh River Basin flood control reservoirs would also contribute to the control of floods on the Delaware River.

Maiden Creek Reservoir.-- Located on Maiden Creek about 12 miles north of Reading, Pennsylvania, the Maiden Creek Reservoir project, as proposed by the Corps of Engineers, would be a multipurpose impoundment for water supply, recreation and flood control. With a total storage capacity of 37.1 billions of gallons (114,000 acre-feet), this impoundment would include 12.4 billions of gallons (38,000 acre-feet) of short-term storage capacity for flood control. This capacity would contribute to flood-stage reductions at principal flood damage areas along the Schuylkill River, including Reading, Birdsboro, Pottstown, Norristown, Conshohocken, Manayunk, and Philadelphia, all in Pennsylvania.

Blue Marsh Reservoir.-- As proposed by the Corps of Engineers, the Blue Marsh Reservoir project will be a multipurpose impoundment for water supply, recreation and flood control. The dam is now under construction on Tulpehocken Creek, a tributary of the Schuylkill River, about six miles northwest of Reading, Pennsylvania. The drainage area above the damsite is 175 square miles. The reservoir, with total storage capacity of 16.3 billions of gallons (50,010 acre-feet), will include 10.6 billions of gallons (32,390 acre-feet) of short-term storage capacity for flood control.

The flood-control storage capacity in this project will help reduce flood stages on the Schuylkill River at the principal damage centers, including Reading, Birdsboro, Pottstown, Norristown, Conshohocken, Manayunk, and Philadelphia, Pennsylvania.

Combined operation of the storage capacity allocated to flood control in Maiden Creek and Blue Marsh Reservoirs would reduce the peak flood stage by about 4.5 feet at Reading and by about 3 feet at Pottstown for a flood similar to that of August 1955.

The Blue Marsh project is scheduled for completion of construction in 1979.

Small reservoir projects. -- A list of small watersheds in the Delaware River Basin showing the number of unconstructed reservoir projects and the allocated flood-control storage capacity for each watershed is presented in Table II-10. Currently, as of the end of 1974, there are 35 authorized small flood-control reservoirs in the Comprehensive Plan that have not been completed. These small impoundments would provide a combined storage capacity of 12.9 billions of gallons (39,749 acre-feet) for flood control.

Table II-10

Authorized flood-storage capacity in unconstructed small watershed projects of the Delaware River Basin

Watershed	Location, County(ies) & State(s)	Number of small reservoir projects	Flood-storage capacity Billions of gallons(approx)	acre-feet
Green-Dreher Watershed	Wayne, Pike, and Monroe Counties, Pa.	9	1.2	3,590
Brodhead Creek Watershed	Monroe and Pike Counties, Pa.	3	1.2	3,778
Assunpink Creek Watershed	Monmouth & Mercer Counties, NJ	7	2.4	7,410
Neshaminy Creek Watershed	Bucks & Montgomery Counties, Pa.	8	5.5	16,878
Brandywine Creek Watershed	Lancaster, Chester, and Delaware Counties, Pa. New Castle County, Del.	8	2.6	8,093
	Totals	35	12.9	39,749

Most of these small watershed reservoir projects are planned as flood-retarding structures with automatic release of water collected during periods of heavy runoff. No operation program is needed for such structures. Because of their small individual capacities, these reservoirs protect only areas along limited reaches downstream of the dams. However, the authorized aggregate storage capacity for flood control in some of the small watersheds is significant, and completion of all authorized small reservoir projects would help reduce flood peaks on the Delaware River and major tributaries below these small watersheds.

Incidental flood control.-- Most of the authorized water supply reservoirs that have not yet been constructed would also afford incidental control of floods, whether planned to serve that purpose or not, as would the storage capacity in multiple-purpose reservoir projects other than that specifically allocated to flood control. When the water-supply storage in such reservoirs is drawn down to meet water demands, the resulting empty capacity would become available until refilled to catch and hold back flood runoff. Though such empty capacity would reduce flood peaks downstream, it is undependable for purposes of flood control, because it may not be available when needed.

Channel improvements and local protection works.-- Future channel improvements and local protection works have been authorized for various scattered locations throughout the Basin, and are incorporated in the Commission's Comprehensive Plan. The projects are planned to protect life and property in flood-prone areas that cannot be protected adequately by upstream flood-control impoundments. Such planned improvements include projects for the Village of East Branch, New York; areas along Paulins Kill, Blairs Creek, and Furnace Brook in Warren County, New Jersey; areas along Parkers Creek in Burlington County, New Jersey; on North Branch Newton Creek at Woodlynne and Collingswood, Camden County, New Jersey; on the Little Schuylkill River in the vicinity of Reynolds, Schuylkill County, Pennsylvania; and on Wabash Creek at Tamaqua, Pennsylvania.

The channel improvements would increase the flood-carrying capacity of critical stream reaches to prevent flood waters from backing up and overflowing stream banks in damage-prone areas, and when completed, would materially reduce flood damages in those areas. The planned local protection works include levees and flood walls, stream diversion tunnels, tide barriers, and tide gates. These projects would protect communities that cannot be protected at reasonable cost by other flood control measures, such as upstream flood-storage reservoirs.

Land treatment.-- Most of the authorized future small watershed plans that have been incorporated in the Commission's Comprehensive Plan call for land-treatment measures. These measures, when carried out as planned by the U. S. Soil Conservation Service in cooperation with State and local agencies, would improve hydraulic conditions for runoff from open land by providing cover, by utilizing terraces, ditches, or strip cropping to break up sloping fields, and by decreasing the rates of overland flow, thereby decreasing sediment production by reducing sheet and gully erosion. Land-treatment measures would include strip cropping, establishing perennial grasses and legumes, planting trees on some open lands, and controlling erosion from skid trails and logging roads. These measures would help reduce peak runoff from lands so treated, and thus would supplement the flood-reducing effects of reservoirs. Land treatment would also reduce sedimentation of streams, thereby helping to maintain their flood-carrying capacity.

Flood-plain management.-- The Delaware River Basin Commission will continue to promote the proper management of flood plains by support of flood-plain mapping and information studies until all flood-prone areas are adequately delineated. In its review of projects pursuant to Section 3.8 of the Compact, the Commission will insure that projects proposed for development in the flood plains of the Delaware River and its tributaries will not conflict with standards of flood-plain use as approved by the Commission, to safeguard the public health, safety, and property. All projects that would encroach upon a stream or its 100-year-flood plain are subject to the Commission's review process.

The Commission will continue to promote the adoption of flood-plain zoning ordinances by local or State governments having zoning authority, and will use the Commission's reviewing authority under the Compact to insure that projects proposed for development in the 100-year-flood plain do not conflict with provisions of such ordinances.

WATER MANAGEMENT OF THE

DELAWARE RIVER BASIN

PART TWO

CHAPTER 5 - RECREATION, FISH, AND WILDLIFE MANAGEMENT

General

The Delaware River Basin, in general, offers excellent recreational opportunities and facilities. The Catskills of New York, the Poconos of Pennsylvania, and the highlands of northwest New Jersey, all located in the northern portion of the Basin are well-established mountain resort areas. The southern portions, particularly Cape May County, New Jersey, and Sussex County, Delaware, provide extremely good shore resorts. The Delaware is one of the nation's most beautiful rivers, and its scenic attractions, particularly from the Delaware Water Gap northward, draw millions of tourists annually. The Basin is rich in fish and wildlife resources. There is excellent sport fishery throughout the Basin, varying from trout in the cold streams in the mountains to salt water fishing in Delaware Bay. The forest habitat of the highlands supports large populations of deer, grouse, squirrels, turkeys, racoons, and a variety of other fur-bearing animals, including a few black bears in remoter areas. Farm-game habitats support good populations of ring-neck pheasants and cottontails. The coastal wetlands, particularly the marshlands surrounding Delaware Bay, provide some of the best waterfowl habitat in the nation. The coastal plains and their marshes form an important link in the Atlantic flyway followed by migratory birds in their seasonal pilgrimage.

Objectives

The purposes of the Commission's recreation, fish and wildlife management program are to provide for the coordinated development of water-related recreational facilities in a timely manner to insure the availability of facilities adequate to meet existing and projected demands, and to insure adequate quantity and quality of the waters of the Basin to preserve and enhance fish and water-related wildlife resources and habitats.

Both the Compact and the needs of a complex society mandate that the Delaware's water resources be developed to accommodate recreation demands simultaneously with the development of the water resources for other uses. The protection and enhancement of recreational water uses, as well as sport and commercial fisheries, are required. Included in the Commission's program, therefore, is the identification of present and future recreation, fish, and wildlife resources needs by types and comparison with economic demands for other project purposes. Population densities and distribution of visitors to recreation areas are under continuing study to determine demand and supply. The establishment and maintenance of continuing inventories and classifications of existing recreational, fish, and wildlife resources and facilities are also included. Costs and benefits are considered through economic analyses of recreation, fish, and wildlife related values, facilities, and projects. These must be evaluated on subregional, regional, and basin-wide scales for total assessment of impact on the Basin's water resources.

The conservation, protection, and enhancement of the natural character of water-related resources is an important objective in the development of a basin-wide plan.

Approach and methodology

The Delaware River is a recreational service area for approximately 25,000,000 people. To a large extent, this entire population is expected to utilize Basin facilities to satisfy many of its demands for outdoor recreational opportunities. Most existing recreation facilities are sustaining maximum or near maximum use. Because of increasing population, income, liesure, and travel, the trend is toward still greater demands. The 1970 demands for water-associated recreation in the Basin was estimated to have totalled about 90,000,000 man-days per year. By the year 2020, this demand upon the Basin's water resources is expected to double, and possibly triple. In recent years, the growing competition for land and water has resulted in the need to acquire land and water areas to be managed specifically for hunting and fishing purposes, and to preserve open space for preservation of habitat essential for protection of all wildlife. Other recreational uses include boating, bathing, skindiving and sightseeing. Along with boating, there is a latent demand for water in presently water-scarce areas of the Basin for these other recreational activities. Delaware Bay and the tidal segment of the Delaware River offer tremendous capacity for increased use for boating and other water-related recreational activities. Here, the greatest need is for more facilities at points of access, and the remedial measures now being implemented to improve water quality.

Remedial measures-- The quality of the tidal Delaware River from Wilmington, Delaware to Trenton, New Jersey, is degraded, principally in terms of low dissolved osygen and high counts of coliform bacteria, which hinders movement of anadromous fish, prevents maintenance of all species of resident fish, and limits use of potential recreational areas for bathing and direct body-water contact sports. The procedures described in Chapter 3 pertaining to allocation of carbonaceous waste assimilative capacity of these waters and the implementation of minimum levels of treatment basin-wide are aimed at restoring waters of the entire reach to those levels required to sustain the specified uses.

Acidic drainage from the coal fields located in the upper Schuylkill and Lehigh River Basins effectively kills all forms of aquatic life for some distance downstream of the affected areas. The State of Pennsylvania is conducting a program involving direct addition of lime to waters of the Lehigh River and its tributaries to determine the effectiveness of the procedure in neutralizing excessive acidity. Natural deposits of limestone in some areas also aid in recovery of the river.

The mining region in the headwaters of the Schuylkill River presents a dual pollution problem with its heavy drainage of mine acids and discharges of raw or only primary-treated sewage from a concentration of small towns. The river down to Hamburg, as well as its West Branch and Little Schuylkill tributaries, is spoiled by mine acid for most recreation and fish use, but recovery occurs over the 10 miles from Hamburg downstream. The Commonwealth is engaged in a major effort to clean up the Schuylkill River Basin within the limits of its resources and curtailed grant funding.

The continued implementation of existing policies and programs in these blighted areas will provide substantial increments of available recreational opportunities in addition to that provided by existing facilities and authorized projects.

Protective measures-- The process of project review is particularly important in the protection of all aspects of water-related natural resources, from the general recreational environment to such specifics as maintenance of trout streams or insuring against any impairment of migratory wildfowl habitat.

As described in Chapter 3 (Part Two) the Basin Water Code makes "water uses" the paramount criteria for determining stream quality, and stipulates that "the quality of Basin waters shall be maintained in a safe and satisfactory condition for ..." wildlife, fish and other aquatic life, recreation, navigation," ...etc. There are no exceptions except those caused by conditions such as natural salinity, flooding, or other uncontrollable factors.

In the review of projects, therefore, all of the possible adverse effects are carefully weighed; not only the more obvious matters of degree of treatment required for safe effluent to streams, but physical protection as well. Intakes must be guarded with fish screens; design of the screens is checked to insure that losses to aquatic life are not excessive by reason of entrainment or impingement. The velocity of flow through screens and the physical location of intakes with respect to stream channels may be critical to the protection of resident fish.

Moreover, it is the policy of the Commission to maintain the quality of interstate waters wherever existing water quality is better than established stream quality objectives. No change will be considered which would be injurious to any designated present or future use. For example, the Water Code sets more stringent limits for dissolved oxygen in spawning areas whenever water temperatures are suitable for trout spawning, and wastewater effluents which would create more than a specified rise above background may not be discharged to natural trout propagation waters. The specified rise is variable depending on the temperature of the natural background.

Since the policies and standards which protect the specified water uses are incorporated into the Commission's Comprehensive Plan, existing facilities which may violate requirements, as well as new project applications, may be tested against the legal requirements, thus insuring the maintenance and enhancement of all water-associated recreational, fish and wildlife resources. In accordance with requirements, policies and procedures of the National Environmental Policy Act, review of projects must include a balanced assessment of their environmental and economic impacts and such projects must be in harmony with applicable specific standards of environmental quality legally established by the Commission or any signatory party.

Major projects

Major recreational features of recently completed facilities and proposed projects included in the Commission's Comprehensive Plan which are intended to meet the growing demand are described in the following section. Location and scheduling of authorized projects are given in the description of projects in Chapter 2. Some of the existing and proposed public, nonurban recreation areas, parks, forest preserves, wildlife refuges and historical sites are depicted in Figure II-9 and listed in Table II-11.

The Tocks Island reservoir area and Delaware Water Gap National Recreation Area together would provide recreation capacity to accommodate 4,000,000 visitors annually under existing authorizations (1972). Studies by the National Park Service demonstrate that recreation benefits at the project would be of widespread regional and national significance. Accordingly, project lands are being developed under P.L. 89-158 as the Delaware Water Gap National Recreation Area. The lands being acquired for recreation would retain the shore area in public ownership and would provide space for development of significant recreation areas. Outstanding scenic and recreation

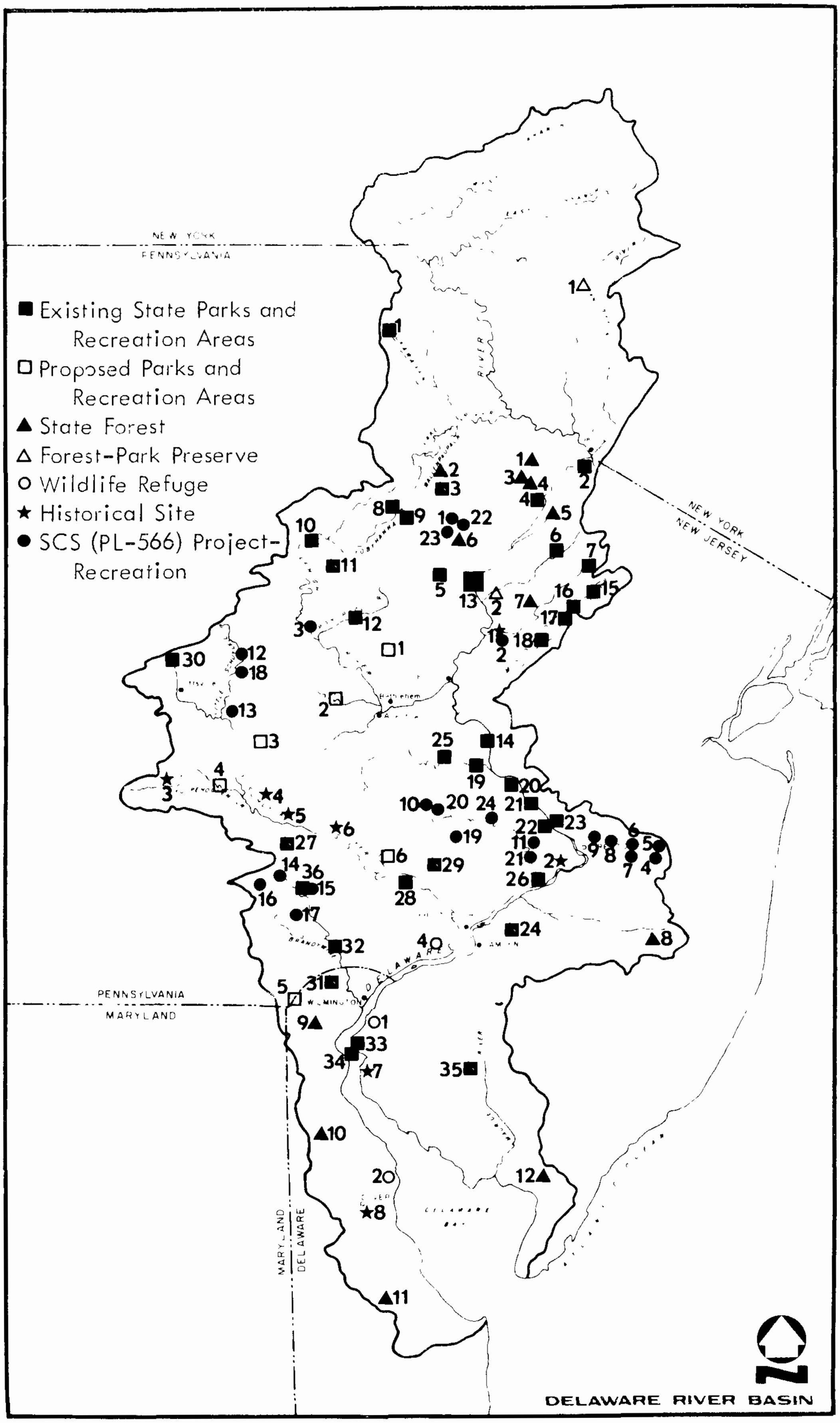


Figure II-9 --Recreation facilities and projects in the Delaware River Basin

Table 11-11--Recreation Facilities and projects in the Delaware River Basin

Legend

Existing State parks and recreation areas

1. Prompton Reservoir State Park
2. High Point State Park
3. Promised Land State Park
4. George W. Childs State Park
5. Big Pocono State Park
6. Swartswood State Park
7. Cranberry Lake State Park
8. Gouldsboro State Park
9. Tobyhanna State Park
10. Francis E. Walter Reservoir (incidental recreation)
11. Hickory Run State Park
12. Beltzville Reservoir
13. Delaware Water Gap National Recreation Area
14. Prahls Island Park (Bucks Co.)
15. Hopatcong State Park
16. Musconetcong Lake State Park
17. Hackettstown Project
18. Stephens State Park
19. Ralph Stover State Park
20. Theodore Roosevelt State Park (Easton to Bristol)
21. New Hope-Lambertville Recreation Pool
22. Washington Crossing State Park (Pa.)
23. Washington Crossing State Park (N. J.)
24. Mount Laurel State Park
25. Nockamixon State Park
26. Neshaminy State Park
27. French Creek State Park
28. Valley Forge State Park
29. Fort Washington State Park
30. Locust Lake State Park
31. Brandywine Springs State Park
32. Brandywine Battlefield State Park
33. Fort Mott State Park
34. Fort Delaware State Park
35. Parvin State Park
36. Marsh Creek State Park

Proposed parks and recreation areas

1. Aquashicola Project Site
2. Trexler Project Site
3. Maiden Creek Project Site
4. Blue Marsh Project Site
5. Newark Project Site
6. Evansburg State Park

State forests

1. Delaware State Forest
2. Bruce Lake State Forest (natural area)
3. Pecks Pond State Forest (picnic area)
4. Stillwater State Forest (natural area)
5. Stokes State Forest
6. Snow Hill State Forest (picnic area)
7. Jenny Jump State Forest
8. Lebanon State Forest
9. Red Lion State Forest
10. Blackbird State Forest
11. Appenzeller State Forest
12. Belleplain State Forest

Forest-park preserves

1. Catskill Forest Preserve
2. Worthington Tract

Wildlife refuges

1. Killcohook National Wildlife Refuge
2. Bombay Hook National Wildlife Refuge
3. Trexler State Game Preserve
4. Tinicum Preserve

Historical sites

1. Oxford Furnace State Historical Site
2. Pennsbury Manor State Historical Site
3. Conrad Weisler State Historical Site
4. Daniel Boone Homestead Site
5. Hopewell Village National Historical Site
6. Pottsgrove State Historical Site
7. Hancock House State Historical Site
8. John Dickenson Mansion State Historical Site

SCS-(PL-566) recreation projects

1. PA-463	9. 2010-20	17. PA-433
2. 2013-2	10. PA-617*	18. PA-426
3. PA-462	11. PA-620	19. PA-611
4. 2010-19	12. PA-423	20. PA-616
5. 2010-18	13. PA-478	21. PA-620
6. 2010-4	14. PA-431	22. PA-464
7. 2010-5	15. PA-437*	23. PA-466
8. 2010-6	16. PA-436	24. PA-614

*Complete

resources of the project would thus be preserved in public trust. Various facilities would provide for one-day outings as well as camping. Operation of the project would consider the fishing requirements of the impoundments and the flow requirements for the stream fisheries downstream from the dam. Facilities would be provided for moving anadromous fish above the dam and consideration would be given to augmenting flows when needed for the purpose of moving young fish populations through the zone of low dissolved oxygen in the Delaware Estuary. Hunting would be permitted during appropriate season and in accordance with reasonable regulation to assure public safety. A specific program for development of recreation use areas and facilities is delineated on a map entitled "Tocks Island Lake - Delaware Water Gap National Recreation Area" dated March 5, 1973, on file in the offices of the Delaware River Basin Commission.

The Prompton Reservoir modification would provide a total recreation capacity to accommodate a total of 156,300 visitors annually. Of these, 81,900 visitors annually are credited to the directly related recreation developments. Due to the lack of suitable terrain, recreation potential at this reservoir is limited. However, lands suitable for day-use recreation are included in the plan of improvement. Necessary roads, trails, sanitary and administrative facilities would be provided. Hunting would be permitted during appropriate season and under reasonable regulation to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impoundment for lake fisheries as a coordinated element for full realization of the recreational potential of the project.

The Francis E. Walter Reservoir would provide recreation capacity for 250,000 visitors annually, of which 101,200 are credited to the directly related recreation uses. The lands acquired for recreation would provide for public ownership of the desirable shore area and provide space for development of three recreation sites. Necessary facilities for one-day outings as well as camping would be provided. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impoundment for lake fisheries as a coordinated element for the full realization of the recreation potential of the project. Hunting would be permitted during appropriate season and in accordance with reasonable regulation to assure public safety. The Govenor of Pennsylvania has proposed the establishment of a Pocono Art Center at this site.

The recreation pool of the Mauch Chunk Creek Project (PA 462) contains 3,794 acre-feet to create a 330-acre lake with five miles of shoreline. Approximately 75 percent of the lake is between five to fifteen feet deep, an optimum depth for fishery-resource management. It will be stocked with warm-water fish species including game fish. The 1,600 acres of land acquired assures availability of public land for recreation. Facilities are designed to permit 120,000 recreation days of use annually. Recreation facilities permit swimming, boating, fishing, camping, picnicking, nature study, and hiking.

The Aquashicola Reservoir would provide a recreation capacity to accommodate 156,300 visitors annually, of which 100,500 are credited to directly related recreation uses. The lands to be acquired specifically for recreation development provide for public ownership of the principal part of the shoreline and space for the development of four recreation sites. Facilities would be provided for one-day outings and camping. Hunting will be permitted in appropriate season under reasonable regulation to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for the full realization of the recreation potential of the project.

The Trexler Reservoir would provide a recreation capacity to accommodate a total of 343,800 visitors annually of which 177,200 are credited to directly related recreation uses. The lands to be acquired specifically for recreation development would provide for public ownership of the shore area and space for the development of five recreation sites. Facilities would be provided for one-day outings as well as camping . Necessary roads, trails, sanitary and administrative facilities, and potable water also would be provided. Hunting would be permitted during appropriate season and under reasonable regulations to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for the full realization of the recreation potential of the project.

The Hackettstown project would provide a recreation capacity to accommodate 1,500,000 visitors annually during the initial stage of development and 2,500,000 visitors annually when fully developed. The total recreation resources available would provide outstanding nonurban recreation opportunities. The character of the area is such that facilities for every conceivable type of nonurban recreation could be included in the development plan.

It has been estimated that flow augmentation from the Nockamixon Project will not be required for the satisfaction of water needs in the immediate future. Accordingly, the Pennsylvania Department of Environmental Resources plans initial development of the site for recreation only. The original structure provides a storage pool for that purpose to approximately elevation 375 msl, but is built as to provide a storage pool to approximately elevation 388 msl when needed for water supply. The recreation area is primarily developed for day-use activities, and it is estimated that over one million visitors annually will be accommodated.

The Maiden Creek Reservoir would provide a recreation capacity to accommodate a total of 625,000 visitors annually, of which 267,400 are credited to the directly related recreation uses. The lands to be acquired specifically for recreation development would provide for public ownership of the shore area and space for development of five recreation sites. Facilities would be provided for one-day outings and camping. Necessary access, and sanitary and administrative facilities also would be provided. Hunting would be permitted in appropriate season and under reasonable regulation to assure public safety. Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for the full realization of the recreation potential of the project.

The Blue Marsh Reservoir now under construction, will provide a recreation capacity to accommodate a total of 437,500 visitors annually, of which 137,000 are credited to the directly related recreation uses. The lands acquired specifically for recreation development will provide public ownership of the shoreline and space for the development of six recreation sites. Facilities will be provided for one-day outings as well as camping. Necessary access, sanitary and administrative facilities also will be provided. Hunting will be permitted during appropriate season and under reasonable regulations to assure public safety. Operation of the project will consider downstream flow requirements for stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for the full realization of the recreational potential of the project.

The Evansburg Project would provide a recreation capacity to accommodate 936,000 visitors annually during the initial stage of development and 1,560,000 visitors annually when fully developed. The topography of the land surrounding the reservoir varies from steep, near the dam site, to rolling with an exceptional amount of usuable area. This area would be particularly adaptable for such activities as swimming, boating, fishing, picnicking, hiking, field sports, nature study, and group camping.

The Newark Project including the recreation element defined as the Mason-Dixon Interstate Park Area would provide recreation capacity of 937,500 visitors annually, of which 554,000 are credited to directly related recreation. The lands to be acquired specifically for recreation development would provide public ownership of the shore area and space for the development of six major recreation sites. Facilities also would be provided for one-day outings and camping. Required roads, trails, sanitary and administrative facilities, and potable water are included in the plan. Hunting would be permitted during appropriate season and under reasonable regulation to assure public safety.

Operation of the project would consider the downstream flow requirements for stream fisheries and the management of the impounded water for lake fisheries as a coordinated element for full realization of the recreation potential of the project.

The recreation pool of the Marsh Creek project contains 1,064 acre-feet to create a 100-acre pool. Of the 1,780 acres of land, 780 acres are inside the top of dam elevation; the remaining 1,000 acres are available for recreation purposes. The basic recreation facilities are designed primarily for summer outdoor use, consisting of picnicking, boating, hiking, fishing and nature study. The recreational development is expected to handle about 400,000 people annually. It is expected that the development will operate at 95 percent of capacity for the sixteen summer weekends and about 20 percent during the week. Operations during the spring and fall are expected to be 60 percent of capacity on weekends and 10 percent during the week. It is expected that a limited amount of fishing will take place during the winter months.

The Delaware River Basin Commission participated in a federal-interstate study task force established under the Wild and Scenic Rivers Act of 1968 which concluded that the upper Delaware River between Hancock, N. Y. and Matamoras, Pa. should be studied to determine if it should be included as part of the national scenic rivers system. By resolution adopted April 7, 1971 the Commission endorsed the proposal and urged early action. The Delaware River Basin Commission stated one of the reasons for endorsement was that the designation of the upper Delaware River would enhance the value of the Delaware Water Gap National Recreation Area and help maintain high water quality conditions in the Tocks Island Reservoir.

The 13 major recreation projects described above, when fully developed, would provide recreational opportunities for over 12,000,000 visitors annually. In addition, out of more than 150 authorized smaller projects, comprising reservoirs, watershed programs, flood control measures, and marinas, at least 40 are designed to include provisions for recreational, fish and wildlife, and boating uses. While these projects, in total, would provide substantial increased recreational opportunities, the capacity would fall short of projected long-range demands. The Commission, through its continuing programs, will identify the areas of greatest deficiency, and coordinate and encourage early planning and construction of those projects required to meet the heaviest demands on a timely basis.

WATER MANAGEMENT OF THE DELAWARE RIVER BASIN

PART TWO

CHAPTER 6 - SUMMARIES

This staff report of management and use of the water resources of the Delaware River Basin is designed to be sufficiently flexible to accommodate to changing times. It is built on the premises that surface waters of the Basin are to be maintained in a condition satisfactory for domestic, agricultural, recreational, fish and wildlife uses, except when natural water quality precludes such uses, and that underground water-bearing formations, their waters, storage capacity, recharge areas and abilities to convey water are to be preserved and protected. Policies set forth in the Water Code of the Basin provide guidelines for those wishing to use the water resources of the Basin, and at the same time preserve the principle of flexibility of approach to such uses.

To be accepted by the Delaware River Basin Commission for inclusion in its Comprehensive Plan, a project must, among other things, provide beneficial development of the water resources, be physically and financially feasible, and conform to accepted public policy. For a federal project to gain financial support by the Commission, it must be shown that the unit cost of additional water is not more than the unit cost of additional development of water supplies at established facilities in the same area. A project will not be approved by the Commission if, among other things, it would conflict with applicable standards of environmental quality legally established by the Commission or by any signatory party to the Compact, or if the project would have an unjustifiable impact upon the environment.

The more significant water-related facilities that have been approved by the Commission are discussed in Part Two. Public policy as regards water resources has been undergoing substantial changes in recent years, particularly in the environmental field, so that some of these existing facilities will not meet current tests for acceptance. For example, some existing waste treatment plants will not produce an effluent of quality level now specified in the Water Code. When conflicts of this type emerge, the current policy of the Commission, as set forth in the Water Code of the Basin, takes precedence and the facilities in question are subject to modification.

The approach to management, control and use of the water resources of the Basin is based upon the assumptions that historic extremes in stream flow will recur in the future, that present and future demands for use of water are to be met, and that protection is to be afforded against undue intrusion of ocean salinity into surface and underground fresh water courses. Further, it is premised that certain selected streams will serve as the dependable sources of raw water supply in the Basin, the flow in these streams to be augmented by releases of water from strategically located regulatory reservoirs as required, the reservoirs to be operated in conjunction with natural runoffs, and the reservoirs to be constructed when the demands for water supply, water quality, flood control and fish, wildlife and recreation justify. Responsible governmental agencies at all levels, and private entities are expected to plan for, construct and operate, on a timely basis, water treatment and distribution facilities needed to treat and convey water from the augmented streams or underground supplies to the ultimate consumer.

Under this staff recommendation, the Delaware, Lehigh, Musconetcong, Schuylkill and Christina Rivers will be regulated by reservoir storage to assure dependable sources of water supply to meet present and future Basin needs. These needs will also be met in part from underground water sources with their natural regulatory capabilities. The minimum level -of-flow objective in the Delaware River will be 1,750 cfs at Montague, 3,000 cfs at Trenton and 3,600 cfs immediately below the mouth of the Schuylkill River.

To overcome deficits in surface water flows that would occur with a repetition of the severest drought of record and 1972 levels of depletive use, new reservoir storage capacity is needed to augment the base flows of the Delaware, Lehigh, Musconetcong, Schuylkill and Christina rivers. The most economic storage capacity for meeting these present local and regional water needs would result from construction of the Tocks Island Project on the Delaware River, the Francis E. Walter Project on the Lehigh River, the Blue Marsh Project (already under construction) in the Schuylkill River Basin, the Hackettstown Project in the Musconetcong River Basin, and the Newark Project in the Christina River Basin. The Tocks Island Project is the only project which alone would yield sufficient water to overcome present water deficiencies for salinity protection in the Delaware River Estuary, provide a modest surplus to meet the ever-increasing depletive water demands of the Basin and allow for some additional exportation.

It is contemplated under this staff recommendation that the underground water resources of the Delaware River Basin will continue to be developed largely by private or public purveyors of water for domestic, municipal, industrial and agricultural uses. The development and use of underground aquifers will be controlled by appropriate state agencies and the Delaware River Basin Commission to assure the best use of the surface and underground resources. With respect to groundwater quality, the Commission will require the best water management determined to be practical. No quality change will be considered which, in the judgment of the Commission, may be injurious to any designated present or future ground or surface water use.

As set forth in the Water Code of the Basin, the Commission has established that the quality of ground water shall be maintained in a safe and satisfactory condition for use as domestic, agricultural, industrial and public water supplies and use as a source of surface water suitable for recreation, wildlife, fish and other aquatic life, except where such uses are precluded by natural quality. Similarly, the quality of surface water shall be maintained in a safe and satisfactory condition for agricultural, industrial, and public water supplies after reasonable levels of treatment, except where natural salinity precludes such uses; and for wildlife, fish and other aquatic life; for recreation; for navigation; and, for controlled and regulated waste assimilation to the extent that such use is compatible with other uses.

The protected water uses are the paramount criteria in judging the adequacy of the various elements of stream water quality, such as dissolved oxygen, alkalinity, acidity, salinity, etc., and these stream standards in turn are the basis for determining whether the amounts of certain degrading elements in the effluents are acceptable. Where water uses require greater protection than that afforded by either the stream or effluent standards, the assimilative capacity of the waterways affected will be allocated among current and future waste dischargers.

The quality of interstate waters will be maintained where existing quality is better than established stream quality objectives, unless it can be affirmatively demonstrated to the Commission that change is justifiable as a result of necessary economic or social development or to improve significantly another body of water. In implementing this policy, the highest degree of waste treatment determined to be practical will be required.

The quality of water in the streams tributary to the interstate streams shall be maintained at least equal to the clean and sanitary condition of the waters of the Delaware River immediately above the confluence of the tributary. Ocean salinity, as measured as chlorides, shall be controlled in the Delaware River at a maximum of 250 mg/l at the mouth of the Schuylkill River.

The Commission policy requires that planning for regional solutions to water pollution problems be explored fully and encouraged, and that regional water pollution control facilities providing optimum combinations of efficiency, reliability and service area be used to the maximum extent feasible.

Historic floods of major proportions have occurred along both the primary and the secondary streams of the Delaware River Basin. While a few flood control projects have been constructed in the Basin, a recurrence of recorded flood stages of the past would result in major destruction.

The flood management portion of this staff report provides for (1) the construction and operation by appropriate agencies of physical facilities to reduce flood stages, (2) the close scrutiny of any project proposed to be constructed on the 100-year flood plain and the limitation of such projects to those compatible with sound principles of flood plain use and with other functions of the plan, and (3) those non-structural measures of flood-loss reduction such as flood-plain zoning, land use controls, and flood forecasting and warning systems. The Commission, under contract with the Federal Insurance Agency of the Department of Housing and Urban Development, conducts flood plain mapping and information studies to assist municipalities in qualifying for flood insurance.

A total of five large reservoir projects,having storage capacity allocated to flood control,have been adopted by the Commission. When constructed,they will add 140 billions of gallons (428,000 acre-feet) of flood control storage capacity to that already in existence. The largest block of this storage would be included in the multipurpose Tocks Island Project, with 106 billions of gallons (324,000 acre-feet) dedicated to flood control. This project, the only major reservoir proposed for construction on the main stem of the Delaware River, would be capable of reducing historic flood stages at Trenton, New Jersey, by six feet. The proposed Blue Marsh and Maiden Creek Reservoirs will be the first projects to provide flood relief in the Schuylkill River Basin, and will be capable of reducing flood stages at Reading, Pennsylvania, by 4.5 feet.

There are 35 small flood control reservoir projects currently approved. When completed, these small impoundments would provide a combined storage capacity of about 13 billions of gallons (40,000 acre-feet). Nine of these projects would be located in the Brandywine Creek Watershed, and would offer the first meaningful tools to control floods in that region. Channel improvements and local flood protection works have also been authorized for various scattered locations throughout the Basin.

The Delaware River Basin offers excellent recreational opportunities and facilities, from the mountain resort areas in the highlands to the shore resorts on Delaware Bay. The Basin is rich in fish and wildlife resources, including trout streams and large game in the northern area, and an abundance of finfish, shellfish and waterfowl in the downstream reaches. Existing recreation facilities are for the most part sustaining maximum use, although Delaware Bay and the tidal segment of the Delaware River can accommodate greatly increased use for boating and many other water-related recreational activities.

The recreation, fish, and wildlife management portion of this staff report provides for the coordinated development and use of Basin waters to optimize recreational opportunities, to insure the availability of facilities adequate to meet existing and projected demands, and to insure adequate quantity and quality of the waters of the Basin to preserve and enhance the sport and commercial fisheries and water-related wildlife resources and habitats.

Presently authorized projects specifically relating to recreation, fish and wildlife, range from major multipurpose projects such as the Tocks Island Reservoir and the Delaware Water Gap National Recreation Area, which will accommodate 4,000,000 visitor days annually, to small watershed projects primarily of localized benefit. These, along with provisions in many other projects for increased supplies of water and scheduled pollution abatement and control, would, if implemented on a timely basis, provide adequate increased recreational opportunities to meet future demands based on present projections and estimates. If the upper Delaware River between Hancock, New York, and Matamoras, Pennsylvania, is designated as a wild and scenic river, this would not only keep the northernmost 76 miles of the River in its natural state as a recreation and scenic attraction, but would also complement and protect recreational uses and scheduled new development downstream.

The water quality features of the Water Code are expected to return the tidal portions of the Delaware River to conditions which will sustain resident populations of fish, make possible the unimpeded passage of anadromous fish, and greatly enhance the potential for boating and related water-body contact sports. This section of the River and the recreational opportunities it provides is directly accessible to millions of Basin residents.

The Delaware River Basin has been divided into 12 sub-basins which delineate more significant areas along the Delaware River or isolate major tributary drainage areas. These sub-basins are described briefly in Table 1-1, and presented graphically in Figure 1-3. In the following paragraphs the water supply, water quality, flood control and recreational aspects of the Water Management Plan are combined and summarized for each of the 12 sub-basins of the Delaware River Basin. In general, throughout the Delaware River Basin the relationship between depletive use of water and minimum stream flow serves to indicate the nature and extent of the over-all water supply problem as well as individual sub-basin problems.

Sub-basin 1--Upper Basin

As is shown in Table II-12, in Sub-basin I, that very large and water-rich upper portion of the Delaware River drainage area, the aggregate depletive use of water at this time is about 13 mgd (20 cfs), in the month of maximum demand, with only small increases forecast through the year 2020. When this is related to the minimum sustained outflow from the sub-basin in the Delaware River, required to be 1,130 mgd (1,750 cfs), it is apparent that water supply is not a significant present or future problem in this sub-basin.

Table II-12

Estimated maximum monthly depletive uses of
water in Sub-basin I -- Upper Basin, 1970-2020

(In million gallons per day)

Type of use	1970	1980	2000	2020
Rural-domestic	0.3	0.3	0.3	0.3
Municipal	1.1	1.1	1.1	1.1
Industrial	0.8	0.8	0.8	0.9
Steam-electric power	---	---	---	---
Irrigation	7.8	9.9	9.5	9.9
Livestock water	2.0	2.0	2.0	2.0
Exportation *	0.8	1.1	1.1	1.1
Total mgd	12.8	15.2	14.8	15.3
cfs	19.8	23.5	22.9	23.7

* Exportations other than those authorized to the City of New York by the U. S. Supreme Court in 1954.

It is contemplated under this staff recommendation that the very modest increase in depletive use of water forecast for Sub-basin 1 can be supported by selective development of the underground water resources and withdrawals from surface streams. Pursuant to the U. S. Supreme Court decree of 1954 (See Appendix B), the City of New York must sustain flows in the Delaware River of at least 1,130 mgd (1,750 cfs) at Montague, New Jersey, which lies immediately downstream of the sub-basin boundary. Hence, there appears to be little need for additional water supply storage to meet the needs of this sub-basin. It is expected, however, that Prompton Reservoir, on a tributary of the Lackawaxen River, would be modified at some future date to provide for depletive water uses downstream of Port Jervis. The sustained flows from this project would add to the dependability of the Lackawaxen and also offer improved recreational opportunities.

The generally excellent quality of surface and underground waters would be maintained in Sub-basin 1 by requiring the installation of fully adequate waste treatment facilities, as the need arises. Existing problems of degraded stream quality in localized areas would be remedied by strict enforcement of State, Delaware River Basin Commission and Federal effluent standards.

Protection against flooding along the Lackawaxen River is presently provided by the Prompton and Jadwin single purpose flood control reservoirs and six smaller reservoirs. The remaining areas in the sub-basin that are subject to local flooding problems are currently being investigated for flood control by the U. S. Army Corps of Engineers, the U S. Soil Conservation Service and the New York State Department of Environmental Conservation.

Many of the streams in this sub-basin are of suitable temperature and quality to be designated for trout habitat. Most of these are suitable for artificial stocking purposes, and a few for natural trout propagation. Under this staff recommendation all other perennial streams would be maintained at sufficiently high quality for warm-water fish species by requiring waste waters to be treated to appropriate levels.

In addition to the lands set aside by private, state and local agencies for recreational and game purposes, the Delaware River from Hancock, New York to Matamoras, Pennsylvania, has been potentially selected to be designated as a "Scenic and Recreational River" under Public Law 90-542, although final authorization is still pending. Current water-related recreational opportunities at Prompton Reservoir could be expanded when this facility is enlarged during the latter decades of the century

Sub-basin 2 -- Port Jervis-Reigelsville

As shown in Table II-13, total depletive uses of water within Sub-basin 2, that large mid-portion of the upper Delaware River drainage area between Port Jervis, New York, and Riegelsville, New Jersey, excluding the Lehigh River basin, are small at this time, totalling only about 21 mgd (33 cfs) in the month of maximum use. This relates to an estimated minimum sustained inflow to the sub-basin in the Delaware River of some 1,130 mgd (1,750 cfs), and indicates that present water supply problems are minimal and subject to ready solution. However, depletive uses of water within the sub-basin are expected to experience a somewhat rapid percentage increase during the next 50 years, most of this resulting from expansion of steam-electric power production, plus moderate increases in municipal and industrial needs. Even with a forecast maximum rate of depletive use of water of some 56 mgd (87 cfs) in the year 2020, the sub-basin should experience little difficulty in resolving its problems of water supply in view of its ample water resources.

Table II-13

Estimated maximum monthly depletive uses of water in Sub-basin 2--Port Jervis-Riegelsville, 1970-2020

(in million gallons per day)

Type of use	1970	1980	2000	2020
Rural-domestic	0.5	0.5	0.5	0.5
Municipal	2.2	3.3	5.5	7.7
Industrial	6.0	7.2	10.5	15.0
Steam-electric power	6.4	25.5	25.5	25.5
Irrigation	5.3	6.6	6.6	6.6
Livestock water	0.8	0.8	0.8	0.8
Exportation	--	--	--	--
Total mgd	21.2	43.9	49.4	56.1
cfs	32.8	67.9	76.4	86.8

Under this staff recommendation, it is concluded that the underground water resources of Sub-basin 2, and the secondary stream systems are capable of continuing to meet the water supply needs of rural areas and smaller villages and towns. The expected moderate increases in water supply demands of the larger communities and of industrial activities can be met by withdrawals from the Delaware River, as augmented by upstream storage, and by storage planned on the Musconetcong River.

Quality of the water of Sub-basin 2 would be maintained at its generally high present levels by requiring the installation of secondary or tertiary levels of treatment and by selective implementation of regional sewerage systems calling for collecting and treating wastes prior to discharge.

The Tocks Island Reservoir would be located on the Delaware River, centrally in this sub-basin. Protection against flooding along the main stem of the Delaware River within the sub-basin would be provided by Tocks Island Reservoir and by Soil Conservation Service and State projects on Brodhead Creek and its tributaries. As a part of non-structural flood-damage reduction measures, flood plain mapping studies have been completed for Martins Creek, for a portion of the Delaware River in this sub-basin, and for Bushkill Creek.

There are extensive opportunities for water-associated recreation in Sub-basin 2, on and around many natural and manmade lakes and trails, including the Delaware Water Gap National Recreation Area and Lake Hopatcong. The Tocks Island Project would include provisions for fish passage facilities, plus a fishery management plan. In addition to the many other state parks and recreation areas, the sub-basin includes the Oxford Furnace State Historical Site, and the Worthington Tract Forest-park Preserve.

Sub-basin 3 -- Lehigh Valley

As is shown in Table II-14, total depletive uses of water in Sub-basin 3, the relatively large and industrially developed Lehigh Valley, now total about 24 mgd (37 cfs) during the month of maximum demand and are expected to increase to 33 mgd (51 cfs) by the year 2020. About 30 percent of present depletive use of water is for industry, and this and most other use categories should experience only moderate growth or remain essentially static during the coming 50 years.

Table II-14

Estimated maximum monthly depletive uses of water in Sub-basin 3--Lehigh Valley, 1970-2020

(in million gallons per day)

Type of use	1970	1980	2000	2020
Rural-domestic	0.2	0.2	0.2	0.2
Municipal	6.6	6.6	7.7	8.8
Industrial	7.2	7.7	8.7	10.0
Steam-electric power	0.4	---	---	---
Irrigation	5.3	6.6	6.6	6.6
Livestock water	0.8	0.8	0.8	0.8
Exportation	3.4	6.6	6.6	6.6
Total mgd	23.9	28.5	30.6	33.0
cfs	37.0	44.1	47.4	51.1

The average observed discharge in the Lehigh River at Bethlehem is 2,225 cfs, and the minimum monthly observed flow during the critical drought month of record averaged 334 cfs. Relating these flows to present and future depletive uses of water, as shown in Table II-14, indicates that with the planned additional, strategically-located storage, the water resources of Sub-basin 3 should provide an adequate water supply into the foreseeable future.

To meet the estimated increases in depletive use of water within Sub-basin 3, this staff report anticipates that further demands will be placed upon the productive groundwater resources and upon the Lehigh River. Existing water supply storage in Beltzville Reservoir will need to be augmented by storage in an enlarged Francis E. Walter Reservoir, in Trexler Reservoir and in Aquashicola Reservoir. These projects are planned for construction when justified, based upon the economic demand for water supply throughout the Delaware River Basin, weighed with the benefits to be provided by their flood control and recreational functions. Together with the underground water sources, the projects are capable of replacing growing depletive uses of water within the sub-basin and also providing supplemental water to downstream users.

Quality of the Lehigh Valley's water is generally good, except for problems related to acid mine water which will be alleviated by State and Federal programs, and degradation by industrial and municipal wastes in the densely populated Allentown-Bethlehem area. The latter will be remedied by requiring a minimum of secondary treatment of wastes prior to discharge into streams.

Severe flooding has been frequent in the Lehigh River Valley. Since its completion in 1961, some protection has been provided by the operation of the Francis E. Walter Reservoir, with a flood control storage capacity of 35.4 billion gallons (108,000 acre feet), while Beltzville Reservoir, completed in 1971, provides additional flood control storage capacity of 8.8 billion gallons (27,030 acre feet). With this flood control regulation, the peak stage of 23.5 feet of the record May 1942 flood would have been reduced to 19.5 feet. Further flood stage reduction will be accomplished by operation of the Trexler and Aquashicola projects when they are constructed later in the century, and by modifications approved for the Francis E. Walter Reservoir. Additionally, flood protection is provided incidentally by numerous impoundments constructed for other purposes, by channel improvements and local protection works, by land treatment measures, and by flood forecasting and warning. Flood plain mapping studies are in progress on the Lehigh River in the vicinity of Allentown. Results of these studies are intended to be used by local agencies to enact flood-plain zoning ordinances, which, in turn, will provide one of the basic requirements for participation in the National Flood Insurance Program.

Substantial water-associated recreational opportunities now exist in Sub-basin 3 at Francis E. Walter and Beltzville Reservoirs. These would be expanded by recreational facilities planned to be installed at Trexler and Aquashicola when those reservoirs are constructed in the future. At some future date, the Lehigh River may be opened for anadromous fish by the installation of appropriate fish passage devices over low level dams at the mouth and along the main streamcourse. Goldsboro, Tobyhanna and Hickory Run State Parks are existing recreational facilities in Sub-basin 3.

Sub-basin 4--Riegelsville-Trenton

Total projected depletive uses of water through the year 2020 in Sub-basin 4 are rather modest with the exception of the "Exportation" category. As shown in Table II-15, the major increase in depletive use will be the result of the anticipated exportation to the State of New Jersey of 300 mgd (465 cfs) expected to materialize between the years 1980 and 2000. This is in addition to the present exportation to New Jersey via the Delaware-Raritan Canal which is predicted to reach the authorized 100 mgd by 1980.

Table II-15

Estimated maximum monthly depletive uses of water in Sub-basin 4--Riegelsville-Trenton, 1970-2020

(in million gallons per day)

Type of use		1970	1980	2000	2020
Rural-domestic		0.2	0.2	0.2	0.2
Municipal		1.1	1.1	1.1	2.2
Industrial		0.7	0.8	1.2	1.6
Steam-electric power		1.2	15.3	15.3	15.3
Irrigation		2.5	3.3	6.6	3.3
Livestock water		0.4	0.4	0.4	0.4
Exportation		74.0	113.6	452.7	452.7
Total	mgd	80.1	134.7	477.5	475.7
	cfs	123.9	208.4	738.8	736.0

An increase of this magnitude could only be met from the Delaware River if its base flows were enhanced by water storage in, and timely release from, the proposed Tocks Island project. However, when existing and anticipated or potential exportation figures are considered with other use-demand figures, the total --476 mgd (736 cfs) in 2020--dictate the necessity for prudent management and control of the total resource.

The proposed Tocks Island Reservoir would have to be operational in order to meet projected long-term water exportations. Operation of the reservoir would maintain Delaware River flow at Trenton at not less than 1,939 mgd (3,000 cfs) while accommodating the depletive uses identified.

In addition to the two New Jersey exportations, it is anticipated that the Point Pleasant diversion project will withdraw water from the Delaware River in this sub-basin and supplement natural supplies in Neshaminy Creek (Sub-basin 5), and in Perkiomen Creek (Sub-basin 6).

The quality of Delaware River water in Sub-basin 4 is not considered to be a major problem, however, attainment and maintenance of legally acceptable quality levels throughout the sub-basin will be a continuing managerial activity during the planning time horizon.

Flooding conditions in the stretch of Delaware River included in Sub-basin 4 have recurred regularly over the years of record. While there are no major flood control structures proposed for this sub-basin, this stretch of River can be expected to derive the greatest benefits from the flood abatement features of upstream projects designed for flood protection. The relative absence of major tributary streams that might cause flash flooding coupled with the controlled flows from flood control structures planned for the Delaware and Lehigh Rivers would result in this stretch of River enjoying the greatest relief from the historic dilemma of too much or too little water.

The generally rural, esthetically pleasing nature of the Delaware River in Sub-basin 4 coupled with the sub-basin's proximity to the more densely populated portion of the lower Basin result in proportionately heavy demands for water-associated outdoor recreational opportunities. In this stretch, however, such opportunities other than at Nockamixon Reservoir do not include major natural or impounded water bodies. Instead, numerous county and state parks, historic sites, including the Delaware Canal, and some River access areas offer a wide variety of recreational and fishing opportunities. The rehabilitated wing dams at New Hope-Lambertville re-established a major recreational pool on the main stem of the Delaware River.

Additional facilities for public access to the Delaware River are considered to be essential for full recreational utilization.

Sub-basin 5--Pennsylvania-Estuary

The projected depletive water uses during the month of maximum demand are presented for Sub-basin 5 in Table II-16.

Table II-16

Estimated maximum monthly depletive uses of water in Sub-basin 5--Pennsylvania-Estuary, 1970-2020

(in million gallons per day)

Type of use	1970	1980	2000	2020
Rural-domestic	0.3	0.3	0.3	0.3
Municipal	46.0	50.4	60.2	72.3
Industrial	41.3	45.2	56.0	70.4
Steam-electric power	23.6	35.4	35.4	35.4
Irrigation	2.5	3.3	6.6	3.3
Livestock water	0.3	0.3	0.3	0.3
Exportation	--	--	--	--
Total mgd	114.0	134.9	158.8	182.0
cfs	176.4	208.7	245.7	281.6

The increases in estimated depletive water uses in this sub-basin are large and must be met by releasing replacement water from upstream reservoirs. If those levels of depletive uses are not replaced, ocean salinity can be expected to penetrate beyond River Mile 92.47 of the Delaware River during years of drought. The primary sources of river water for meeting the demands of the sub-basin are the planned augmented flows of the Delaware River, development of Neshaminy Creek, and imported supplies from Octoraro Creek in the Susquehanna River Basin. Underground water resources, having limited yields, will support the less intensively populated areas.

The Point Pleasant diversion project, discussed in Chapter Two of Part Two of this staff report, would transport water from the Point Pleasant pumping station on the Delaware River in Sub-basin 4 to the North Branch of Neshaminy Creek and a storage reservoir in this sub-basin, and to the East Branch of Perkiomen Creek in Sub-basin 6. While the withdrawal from the Delaware River would be made above Trenton, this augmentation of natural flows of the Neshaminy Creek and Schuylkill River systems would return to the Delaware River--less depletive uses--upstream of River Mile 92.47. Thus, the total net yield of this fresh water diversion would be returned to the main stem above the point of salinity control, within the boundaries of Sub-basin 5.

Essentially, the entire sub-basin has developed plans for regional waste systems capable of treating used water to levels commensurate with Commission standards. For the most part, these plans anticipate the discharge of treated wastes into the tidal Delaware River at points where allocations of the assimilative capacity of the stream are required. The treatment levels required prior to discharge to such waters are from high secondary levels to low tertiary levels at the present time and are espected to become even more restrictive in the future. The allocation of assimilative capacity technique requires that the amount of waste discharged not exceed that which the receiving water can absorb without impairing the quality needed to protect the waters for the uses specified.

Flood protection facilities to provide relief from flash runoffs along Neshaminy Creek are being constructed by Bucks County. Delaware County is also relying upon channelization to carry flood runoffs through the more populated areas. Flood plain mapping studies are completed for Neshaminy Creek and several active watershed associations within the sub-basin are striving for the dedication of flood plains to compatible uses and to land management practices which would impede the rate of flood water runoff while increasing the percolation to underground waters. As much of this sub-basin is either highly urbanized, or in the process of becoming so, the Commission supports these efforts through its planning consultation, technical services, and small watershed program.

The tidal Delaware River, lying between Sub-basins 5 and 7, is accessible to, and is used by, sizeable numbers of recreational boats. Docking facilities are found along both the Pennsylvania and New Jersey shore lines. The State of Pennsylvania has constructed a waterfront park, with boat launching facilities on the tidal portion of Neshaminy Creek. Pennsbury Manor State Historical Site is also a feature of the Water Management Plan. Similar facilities are to be found in Delaware County, near the mouth of Darby Creek. The City of Philadelphia is constructing a waterfront park on the Delaware River, which will also contain marina facilities.

Due to its closeness to large populations, the tidal River from Trenton, New Jersey to Marcus Hook, Pennsylvania, is called upon to provide a wide range of fishing opportunities. The wetlands provide habitat for migratory wildfowl and indigenous wildlife. Although badly degraded at the present time, rejuvenating the water quality to levels suitable for anadromous, brackish and fresh water fish and all other uses specified for this zone is part of this staff recommendation.

Sub-basin 6--Schuylkill Valley

The projected depletive water uses during the month of maximum demand are presented for Sub-basin 6 in Table II-17.

Table II-17

Estimated maximum monthly depletive uses of water in Sub-basin 6--Schuylkill Valley, 1970-2020

(in million gallons per day)

Type of use		1970	1980	2000	2020
Rural-domestic		1.8	1.8	1.8	1.8
Municipal		15.3	17.5	19.7	24.1
Industrial		8.1	8.8	10.7	13.4
Steam-electric power		9.0	27.8	60.8	60.8
Irrigation		5.3	9.9	13.2	6.6
Livestock water		1.7	1.7	1.7	1.7
Exportation		0.06	0.1	0.1	0.1
Total	mgd	41.3	67.6	108.0	108.5
	cfs	63.9	104.6	167.1	167.1

The low flows of the Schuylkill River are presently overallocated. To overcome this situation and provide for the growth of the sub-basin, storage will be required, and the natural waters will require augmentation. In some areas, wells into limestone formations yield large quantities of water although, in general, the yields are not sufficient to meet the demands of sizeable communities. The Blue Marsh Reservoir Project on Tulpehocken Creek, with a safe yield of 31 mgd (47 cfs), will be operated to provide water to Western Berks County Water Authority, and augment low flows of the Schuylkill River from Reading to its mouth. The Maiden Creek Project on Maiden Creek, with a safe yield of 87 mgd (134 cfs), approximately 12 miles upstream of Reading, could also supplement the base flows. The Evansburg Project, with a safe yield of 23 mgd (36 cfs), on the Skippack Creek, a tributary of Perkiomen Creek, could provide recreational opportunities initially and water supply later in this century.

As recently as July 1966, the minimum discharge month of record--see Table 1-3--the average discharge of the Schuylkill River at Philadelphia was 74 mgd (116 cfs) and the minimum 7-day flow of record was 16 mgd (24 cfs). With the estimated increase of depletive uses of 26 mgd (40 cfs) from 1970 to 1980, there would be a potential deficit of about 10 mgd (16 cfs) with a recurrence of the severest drought of record until the Blue Marsh Reservoir becomes operational. The additional potential deficit occurring by year 2000 will remain critical until either the Maiden Creek Reservoir or Evansburg Project is completed.

The waters of the Schuylkill River Valley are overallocated during periods of extreme low flows and the waters are being used, released, and then reused by downstream takers. This, coupled with acid mine water drainage, causes the mineral content to reach the highest level of any fresh water stream in the Basin. For these reasons, and because of the limited opportunities for storage within the Schuylkill River Basin, provisions have been made to transfer water from the Delaware River via the Point Pleasant Project into the Perkiomen Creek, to offset a portion of the projected increases in depletive water uses, and to improve water supply capabilities of Perkiomen Creek.

The quality of water in this sub-basin would be improved by: (1) requiring at least secondary levels of treatment of all waste prior to discharge, (2) dedication of portions of the storage to be provided by Blue Marsh and Maiden Creek Reservoirs for low flow quality improvement via dilution, (3) neutralization or some other method of curing the acid mine drainage problems, and (4) limiting the amount of Schuylkill River Basin water dedicated to depletives uses.

As with the Blue Marsh Reservoir, the Maiden Creek Project would contain major storage capacity dedicated to controlling flood flows. In addition to the substantial flood relief to be provided by the two reservoirs, the watershed management activities along Wabash Creek and Kaercher Creek will be helpful in reducing flash flooding along the Little Schuylkill River. Flood plain mapping programs have been completed on the Philadelphia-to-Pottstown reach of the Schuylkill River, Perkiomen Creek and its East Branch, and Wissahickon Creek. Mapping has been completed for Darby Creek, Ridley Creek, and Chester Creek. Local agencies are encouraged to use the results of these programs for non-structural measures to reduce flood damages to augment the flood control benefits of reservoirs.

Blue Marsh, Evansburg, and Maiden Creek Reservoirs would provide water-oriented recreation opportunities for an estimated 2,522,000 visitors annually. The State of Pennsylvania has acquired land along Tulpehocken Creek from the Blue Marsh damsite to the junction of the creek with the Schuylkill River, to take full advantage of the fishing and recreational enhancements of the augmented creek flows. Other water associated projects and features include the proposed Locust State Park north of Pottsville, Conrad Weisler State Historical Site on Tulpehocken Creek, the Daniel

Boone Homestead, Hopewell Village National Historical Site, Pottsgrove State Historical Site, Valley Forge State Park and Fort Washington State Park.

The Point Pleasant pumping project is designed to enhance the fishing, recreational and aesthetic values of Perkiomen Creek. The plan of operation requires the discharge of some 17 mgd (27 cfs) throughout the low flow season, regardless of ultimate downstream consumptive use. This would maintain a healthy stream at locations which presently have intermittent flows, thus supporting a substantially large fish population.

Sub-basin 7--New Jersey-Estuary

The projected depletive water uses during the month of maximum demand are presented for Sub-basin 7 in Table II-18.

Table II-18

Estimated maximum monthly depletive uses of water in Sub-basin 7--New Jersey-Estuary, 1970-2020

(in million gallons per day)

Type of use	1970	1980	2000	2020
Rural-domestic	1.1	1.1	1.1	1.1
Municipal	13.1	17.5	26.3	36.1
Industrial	21.1	26.1	40.0	62.5
Steam-electric power	10.6	8.3	8.3	8.3
Irrigation	35.7	46.4	52.6	42.7
Livestock water	0.2	0.2	0.2	0.2
Exportation	--	--	--	--
Total mgd	81.8	99.6	128.5	150.9
cfs	126.6	154.1	198.8	233.5

The land surface of Sub-basin 7 overlies the best defined and most productive underground water aquifers to be found in the Basin. Accordingly, due to the purification characteristics of ground-water strata, most of the fresh water needed for existing development in this area is taken from the ground, and it is projected that much of the water needed to supply future growth will also be taken from the ground.

The major source of replenishment of these producing aquifers is the deep percolation of precipitation on overlying land. Most of the underground aquifers contribute water to surface streams and this, in turn, constitutes a significant part of the stream flow most of the time. Extended periods of drought or heavy pumping will cause water to be drawn into the aquifers from the surface stream, thus decreasing its volume and flow.

Due to the periodic interchange of water between the tidal Delaware River and the underground aquifers, the quality of water in the River is extremely important to this Sub-basin. Foremost among the quality concerns is that related to seasonal intrusion of ocean salts into the River. While some interchange takes place at many locations along the River, the most important recharge areas are upstream of the Benjamin Franklin Bridge (River Mile 100.16). Recognizing the disastrous effects of permitting salt water to enter the principal aquifers, the planned storage reservoir upstream of Philadelphia would be operated to maintain a flow of not less than 1,939 mgd (3,000 cfs) at Trenton, New Jersey, and not less than 2,327 mgd (3,600 cfs) at Philadelphia, in order to hold the line of ocean salts (measured as 250 mg/l of chlorides) at or downstream of the junction of the Schuylkill River with the Delaware River (River Mile 92.47).

The underground aquifers beneath Sub-basin 7 extend, at some point beyond the Basin boundaries, into the Atlantic Ocean. Future withdrawals of ground water will be controlled so that the delicate balance of forces which counteract seawater intrusion will not be permanently disturbed.

As in the case of adjacent Sub-basin 5, discharges of treated waste waters will be into the tidal Delaware River where allocations of assimilative capacity of the stream are required. This technique requires that the amount of waste discharged not exceed that which the receiving water can absorb without impairing the quality needed to protect the water for uses specified.

A regional approach to waste treatment is well advanced in Gloucester County and steps are under way toward development of such a system in Camden County. This approach is encouraged, and in these two Counties regional systems will return waste water of a quality and at locations which will aid in the repulsion of ocean salts.

Flood protection along the relatively small but numerous streams of this sub-basin will be afforded by ten impoundments on the Assunpink Creek in Monmouth and Mercer Counties; two small channelization projects in the Parkers Creek Watershed in Burlington County; and several flood control works in the Newton Creek Watershed in Camden County. Flood plain mapping has been completed for Crosswicks Creek, Pompeston Creek, North and South Branches of Pennsauken Creek, and the major portion of Rancocas Creek. As flood plain information studies are completed, the data are made available to zoning authorities with recommendations for adoption of flood-plain zoning ordinances.

As previously mentioned in the summary for Sub-basin 5, this reach of the tidal Delaware River from Trenton to the vicinity of Marcus Hook is readily accessible to recreational boaters, with many public and private launching facilities and marinas available. Although presently degraded in terms of oxygen content during the summer, this portion of the river at various times of the year contains white and channel catfish, brown bullhead, white perch, several species of sunfish, walleye, sturgeons, large mouth bass, alewife, blueback herring, American shad, and striped bass. As the quality of these waters is improved, it is expected that these and other species of game fish will expand in numbers creating a much more attractive sport fishing area. The improvement also will attract increasing numbers of recreationists to swimming, water-skiing , sailing, and all forms of pleasure boating.

Lebanon State Forest and Mount Laurel State Park are features of the Comprehensive Plan, and most of the SCS projects on Assunpink Creek referred to above incorporate provisions for recreational and fish and wildlife uses.

Sub-basin 8--Brandywine Valley

The projected depletive water uses during the month of maximum demand are presented for Sub-basin 8 in Table II-19.

Table II-19

Estimated maximum monthly depletive uses of water in Sub-basin 8--Brandywine Valley, 1970-2020

(in million gallons per day)

Type of use		1970	1980	2000	2020
Rural-domestic		0.1	0.1	0.1	0.1
Municipal		5.5	6.6	8.8	13.1
Industrial		13.8	17.3	26.4	41.1
Steam-electric power		3.6	7.2	7.2	7.2
Irrigation		2.5	6.6	13.2	3.3
Livestock water		0.7	0.7	0.7	0.7
Exportation		--	--	--	--
Total	mgd	26.2	38.5	56.4	65.5
	cfs	40.5	59.6	87.3	101.3

The increasing levels of water consumed in this sub-basin, and the basic supplies required to meet withdrawal demands, will be supplied by storage on Marsh Creek, with a safe yield of 12 mgd (19 cfs), importation of up to 66 mgd (102 cfs) of water from Octoraro Creek and the Susquehanna River, use of underground supplies, construction and operation of features of the Brandywine Watershed Plan with a safe yield of 14 mgd (21 cfs), and the Newark Project, with a safe yield of 28 mgd (43 cfs).

The quality of the surface and underground waters will be protected by strict adherence to the Commission's waste treatment requirements. Wastes originating within the New Castle County, Delaware, portion of the sub-basin, will be treated in the New Castle County/Wilmington regional sewerage system. All waste flows to the tidal waters will be compelled to comply with waste load allocations, to guarantee attainment of quality levels, as prescribed. Elsewhere in the sub-basin, high levels of waste treatment will be enforced to sustain the quality of surface and underground waters at the levels required to permit the uses designated in the Water Code of the Basin.

Flood plain mapping of portions of Brandywine Creek and tributaries has been completed and the remainder is in progress. The Brandywine Watershed Plan includes 12 reservoirs, all of which include flood control as a purpose. Channel improvement and land treatment measures also would control runoff and increase percolation into the underground aquifers.

Water related recreational opportunities are to be provided with the Marsh Creek and Newark Projects. The Marsh Creek Project which became operational in 1973, contains basic recreational facilities for picnicking, boating, hiking, fishing, and nature study. It is expected that these facilities will provide 400,000 recreation-days annually. The Newark Project, to be constructed when economically justified, would provide 938,000 man-days of recreation.

Brandywine Springs State Park (Delaware) and Brandywine Battlefield State Park (Pennsylvania) are also included as recreational features.

Sub-basins 9, 10, 11 and 12--Salem, New Castle, New Jersey-Bayside, Delaware-Bayside

The projected depletive water uses during the month of maximum demand are presented for Sub-basins 9, 10, 11, and 12 in Table II-20. It should be noted that a portion of this fresh water depletive use results from evaporation of salt and brackish water (See Tables 1-13 and 1-14). The water listed for depletive use by once-through cooling of steam-electric power generation is fresh water evaporated from the surface of the receiving body of water. The loss of this fresh water will, to some extent, disturb the balance of forces which affect the point at which ocean salinity is controlled in the tidal Delaware River.

Table II-20

Estimated maximum monthly depletive uses of water in Sub-basins 9, 10, 11 and 12--Salem, New Castle, New Jersey-Bayside, Delaware-Bayside, 1970-2020

(in million gallons per day)

Type of use	1970	1980	2000	2020
Rural-domestic	0.9	0.9	0.9	0.9
Municipal	4.4	6.6	8.8	13.2
Industrial	23.6	29.3	44.4	71.6
Steam-electric power	4.4	14.5	37.5	37.5
Irrigation	124.9	173	197.6	154.4
Livestock water	0.8	0.8	0.8	0.8
Exportation	4.0	4.0	4.0	4.0
Total mgd	163.0	229.1	294.0	282.4
cfs	252.2	354.5	454.9	436.9

The water supplies needed to meet essentially all demands of these sub-basins, except self-supplied industry and steam electric generation, are presently taken from underground sources. Future supplies for these uses will also be drawn mostly from these same sources. The efforts of the States and the Delaware River Basin Commission will be directed toward protecting these resources from over-drafts which could cause sea water intrusion, or from quality degradation caused by improper disposal of municipal and industrial by-products. As the precise yields of the underground aquifers (many of which are confined) are not known, continuous observations will be made to determine the effects of increasing levels of withdrawal, and subsequent discharge of the treated used water upon the general quality of the underground waters.

Industrial installations in these sub-basins utilize both surface and underground sources of supply, the larger demands of cooling being taken from surface waters, sometimes brackish. The electric utilities take nearly all of their water from surface water courses. As most of the heavily used waters are tidal, there is no threat of depletion, except as noted above with regard to evaporating a fresh water component which, to some extent, must be replaced.

The significant increases in projected depletive water uses are in the industrial and steam-electric power categories: the industrial from 23.6 mgd (36.5 cfs) in 1970 to 71.6 mgd (110.8 cfs) in 2020, and the steam-electric power from 4.4 mgd (6.8 cfs) in 1970 to 37.5 mgd (58.0 cfs) in 2000, then remaining at the same level to 2020. Of the aggregate increase of about 81 mgd (125 cfs) for these categories, part is drawn from ground water supplies. To meet the remainder of the increase in depletive water uses, only a moderate augmentation of fresh-water inflow to Delaware Bay will be needed to balance these losses. This need would be met by sustaining the objective of a minimum flow of 2,327 mgd (3,600 cfs) in the Delaware River at the mouth of the Schuylkill River (River Mile 92.47).

To take full advantage of the recycling potential of fresh water of high quality extracted from the ground, every opportunity must be taken to reintroduce the used water back into the underground aquifers.

It is foreseen that regional waste systems may prove to be economically advantageous in Sub-basin 9 and portions of Sub-basin 12. Elsewhere, the water quality of receiving streams will be protected by rigid enforcement of the States, Delaware River Basin Commission and Federal water quality effluent standards. Waste water discharge in the transition area of the tidal river (from Liston Point to Marcus Hook) will be subject to limited specific amounts, based upon an allocation of the assimilative capacity of the receiving waters.

Three factors of quality are of particular significance to this reach of the tidal River and Delaware Bay: (1) the oxygen and toxicity levels in the brackish areas which serve as nursery grounds for many species of fin-fish, (2) salinity levels over the natural oyster spawning beds at time of potential predation by the oyster drill, and (3) coliform levels over the oyster, clam and crab production areas in Delaware Bay. The first category will be controlled by a pollution abatement program directed toward the dischargers of waste. The natural salinity over the oyster spawning beds would be maintained insofar as possible by passing through the Tocks Island Reservoir Project all inflows during the critical months of April, May, and June. All wastes containing pathogenic organisms would be disinfected prior to discharge

Extensive areas of marshlands border the tidal water of the sub-basins. Protection against flooding, caused by both surface runoff and storm tides, is provided by channelization and levee works. Much of these wetlands remain in their native condition, intermittently submerged and exposed by the tides. This phenomenon results in nutrients being made available to the food-chain which is of use to the bay fishes. The wetlands also provide food and resting areas for migratory waterfowl following the Atlantic flyway.

The 782-square mile surface of Delaware Bay, with its connection to the Chesapeake Bay via the Chesapeake and Delaware Canal, provides recreational opportunities for boating and fishing, plus a commercial fishery. In these waters are found over 130 species of fish, including Atlantic sturgeon, black drum, blue fish, flounder, northern king fish, sharks, striped bass, and weakfish. American shad, striped bass and white perch, plus hard shell clams, oysters and blue crabs are taken commercially. The water management needs of these activities are recognized and accommodated by both the manipulation of upstream facilities and imposition of legal controls.

The following recreation areas located in these sub-basins are features of the Comprehensive Plan:

<u>In Delaware</u>

Appenzeller State Forest
Blackbird State Forest
Red Lion State Forest
Fort Delaware State Park
Bombay Hook National Wildlife Refuge
John Dickenson Mansion State Historical Site

<u>In New Jersey</u>

Belleplain State Forest
Parvin State Park
Fort Mott State Park
Kilcohook National Wildlife Refuge
Hancock House State Historical Site

APPENDIX A

Water Code of the Basin *

The Delaware River Basin Compact (section 3.1) provides that:

> "The Commission shall develop and effectuate plans, policies and projects relating to the water resources of the basin. It shall adopt and promote uniform and coordinated policies for water conservation, control, use and management in the basin. It shall encourage the planning, development and financing of water resources projects according to such plans and policies."

The Basin principles that have been adopted to guide all agencies and individuals who plan to develop and use the water resources of the Delaware River Basin are set forth herein. Projects submitted to the Commission for approval pursuant to sections 3.1, 11.1, and 11.2 of the Delaware River Basin Compact will be tested, in part, against these policies.

* Resolutions incorporated through December 1974

WATER CODE

Article 1 - GENERAL DELAWARE RIVER BASIN COMMISSION POLICIES

1.1 Intergovernmental relations

1.1.1 Federal, State and Local projects (Compact, article 11). "The planning of all projects related to powers delegated to the /Delaware River Basin/ commission.... shall be undertaken in consultation with the commission..."

1.10 Criteria for screening projects

1.10.1 Comprehensive Plan Inclusion (Phase 1 - Comprehensive Plan). The criteria against which specific project and proposals will be judged for acceptance into the Comprehensive Plan are as follows:

A. The project must provide beneficial development of the water resources in a given locality or region.

B. It must be economically and physically feasible.

C. It must conform with accepted public policy.

D. It must not adversely influence the present or future use and development of the water resources of the basin.

1.10.2 Environmental impact of projects (Resolution No. 71-6). Project review under section 3.8 and article 11 of the Compact shall include a balanced assessment of the environmental and economic impact of the project, in accordance with the requirements, policies and procedures of the National Environmental Policy Act and the Commission's regulations thereunder. A project will not be approved by the Commission whenever:

A. It would conflict with applicable specific standards of environmental quality legally established by the Commission or any signatory party.

B. It would have a major unjustifiable impact upon the environment after due consideration of its benefits in violation of the National Environmental Policy Act.

Article 2 - CONSERVATION, DEVELOPMENT AND UTILIZATION OF DELAWARE RIVER BASIN WATER RESOURCES

2.1 Allocation of water resources

2.1.1 Allocation of water resources (Compact - section 3.3). "The commission shall... in accordance with the doctrine of equitable apportionment....allocate the waters of the basin to and among the states..."

2.10 Surface Waters

2.10.1 Storage and release of waters (Compact - section 4.2). "The commission shall have power to acquire, operate and control projects and facilities for the storage and release of waters, for the regulation of flows and supplies of surface and ground waters of the basin, for the protection of public health, stream quality control, economic development, improvement of fisheries, recreation, dilution and abatement of pollution, the prevention of undue salinity and other purposes.

"No signatory party shall permit any augmentation of flow to be diminished by the diversion of any water of the basin during any period in which waters are being released from storage under the direction of the commission for the purpose of augmenting such flow, except in cases where such diversion is duly authorized by this compact, or by the commission pursuant thereto, or by the judgment, order or decree of a court of competent jurisdiction."

2.10.2 Commission role in federal water-supply projects (Resolution No. 64-16A). The Commission, acting for and on behalf of the signatory parties, will acquire the right to use and to control water-supply facilities associated with Federal projects authorized in the Comprehensive Plan.

2.10.3 Project construction scheduling (Resolution No. 72-4). The Commission will consider new projects economically justified for consturction scheduling by the Commission when:

A. The unit cost of additional water supply at a new location is not more than the unit cost of additional development of water supply at established facilities in the same service area.

B. The annual benefits from all project purposes equal or exceed their total annual cost.

2.10.4 Commission repayment obligations (Resolution No. 64-16A). Subject to appropriate authorization by the signatory parties, the Commission will assume the obligation to repay the nonfederal share of the federal investment cost of such water-supply facilities, and will meet future annual repayment obligations out of revenues provided from sale of water or other products and services, or from an apportionment of costs through the capital section of the Commission's annual budgets to the States in which benefits of the projects accrue, or both. The Commission will make the appropriate reductions in the share of the cost of water to States as revenues are received from direct sale of water or other products and services, and from various fees.

2.10.5 Cost apportionment to states (Resolution No. 64-16A). The Commission will determine the States within which the general benefits of such water-supply facilities will accrue. It will apportion to such States their fair share of the nonfederal cost of such facilities in proportion to the potential use thereof.

2.10.6 Payment for Use of Surface Water

A. Contracts (Resolution No. 71-4). The Commission will require contracts, which may be negotiated at any time, for the use, withdrawal, or diversion of any surface waters of the basin taken after the effective date of the rates and charges required by this article. Each of such contracts shall include:

1. An undertaking by the contracting party to pay for water used, withdrawn, or diverted, in accordance with the rates and charges established by the Commission pursuant to this article.

2. Provision for a minimum annual payment under the contract, in accordance with an estimated annual demand schedule, regardless of use, withdrawal, or diversion.

3. Such other and different terms and conditions with respect to the availability of the supply, its quantity and quality, its management and control, and the powers and duties and obligations of the parties, as may be negotiated.

B. Rates and charges (Resolution No. 71-4). Rates and charges for water supplied will include all costs associated with making the Basin water supply available and maintaining its continued availability in adequate quantity and quality over time. Rates will be determined as follows:

1. The Commission will use the weighted-average unit cost of all water stored by or on behalf of the Commission. The unit cost of water will be determined by dividing all of the Commission's annual project cost by the net yield of the water supply in federal reservoirs authorized in the Commission's Comprehensive Plan. Costs, rates

and charges will be recomputed whenever new or additional storage is provided and as often as necessary to reflect relevant changes in any cost components associated with sustaining specified base flows.

2. The Commission will collect sufficient annual revenue to meet all of its annual project costs, including debt service, operation, maintenance, replacement, reserves, and associated administrative costs. The minimum charge to specific users will be for the amount of water specified in an estimated demand schedule according to a contractural agreement. The maximum charge to these users will be for the amount of water they actually use, withdraw, or divert. Revenue not collected from specific users of water supply will be collected from the states in which general benefits of water supply occur.

3. The Commission will compute an annual adjusted rate in the form of a rebate to each contracting party of a pro rata distribution of the net annual revenues of the Commission in excess of the amounts required under paragraph /_1_/, provided that no such rebate will be made with respect to revenues received by the Commission on account of consumptive uses and exportations out of the basin, and provided further that no rebates will be made until there are no further annual costs allocated to the signatory states as general beneficiaries.

4. The Commission may make reasonable estimates of the components of combined withdrawals where separate water accounting is not feasible, such as for combinations of exportations and in-basin use and consumptive and non-consumptive uses, and for municipal systems.

5. The Commission may exempt or classify such non-consumptive uses of surface flows as it may determine to have no substantial effect on the water resources of the basin. It may also provide for a reduced rate structure with respect to water used for cooling purposes which is returned to a stream otherwise unimpaired in quantity and quality. The Commission may also classify rates and charges for consumptive uses and out of basin exportations of surface waters so as to include a surcharge to reflect any costs or adverse effects of such uses which are greater in kind or degree than those associated with other water uses.

6. The rates and charges for increased in-stream evaporative losses resulting from heated discharges will be the same as those for a consumptive use.

C. Special projects (Resolution No. 71-4). Charges for water supply from projects constructed pursuant to contractual arrangements between the Commission and local public agencies in advance of the time when the project is scheduled by the Commission in accordance with /_section 2.10.3_/ will be at rates sufficient to provide the total annual debt service and other obligations incurred by the Commission for such project, until such time as the project qualifies for Commission scheduling under the provisions of /_ section 2.10.3_/

D. Sanctions for unauthorized use of water (Resolution No. 71-4). The Commission will provide by regulation for the imposition of sanctions for any unauthorized use, withdrawal, or diversion of surface waters of the basin and for the assessment and collection of the value thereof.

E. Effective date of rates and charges (Resolution No. 71-4). Rates and charges required by [section 2.10.6B] shall apply to all surface waters of the basin used, withdrawn, or diverted by any person, corporation or other entity, public or private, on and after the date of the first impoundment of water for water supply purposes at the Beltzville Reservoir, except that there shall be no charge to a person, corporation or other entity for water used, withdrawn, or diverted at a monthly volume which is not greater than the average monthly volume taken or legally entitled to be taken by such person, corporation, or other entity during the twelve completed calendar months next preceding the effective date of this article. [The effective date of charges was established by Resolution No. 74-6 adopted May 22, 1974]

F. Legal entitlement (Resolution No. 71-4). "Legally entitled to be taken" refers to water taken under the following conditions:

1. A valid and sugsisting permit, issued under the authority of one of the signatory parties.
2. Physical facilities in being and operable as required for such taking.
3. A beneficial use throughout the year for the waters taken.
4. That such takings are within the limits of the total allowable flow without augmentation.

2.20 Underground Waters

2.20.1 Equitable apportionment (Resolution No. 64-11). Underground waters of the Basin shall be subject to the doctrine of equitable apportionment as provided by section 3.3 of the Compact.

2.20.2 Preservation (Resolution No. 64-11). The underground water-bearing formations of the Basin, their waters, storage capacity, recharge areas, and ability to convey water shall be preserved and protected.

2.20.3 Safeguard public interest (Resolution No. 64-11). Projects that withdraw underground waters shall be planned and operated in such manner as will reasonably safeguard the present and future public interest in the affected water resources.

2.20.4 Withdrawal limits (Resolution No. 64-11). Except as may be otherwise determined by the Commission to be in the public interest, withdrawals from the underground waters of the Basin shall be limited to their safe yields.

2.20.5 Protection of recharge areas (Resolution No. 64-11). The principal natural recharge areas through which the underground waters of the Basin are replenished shall be protected from unreasonable interference with their recharge function. No underground waters, or surface waters which are or may be the sources of replenishment thereof, shall be polluted in violation of water quality standards duly promulgated by the Commission or any of the signatory parties.

2.20.6 Activities subject to review (Resolution No. 64-11). The underground water resources of the Basin shall be used, conserved, developed, managed, and controlled in view of the needs of present and future generations, and in view of the resources available to them. To that end, interference, impairment, penetration, or artificial recharge shall be subject to review and evaluation under the Compact.

2.50 Water metering

2.50.1 Water metering (Resolution No. 73-1). All new public and private water supply systems, and extensions of existing water supply systems, using waters of the basin, that are designed to serve more than 250 connections or distribute water supplies in excess of 100,000 gallons per day, shall be required to install water meters incident to the provision of such service at the retail level. Meters shall be installed so as to record water use by each individual household, commercial, industrial, or other user. Apartment houses and other multiple dwelling units shall not be required to meter each dwelling unit separately.

2.100 Flood-damage reduction

2.100.1 Flood plain encroachment (Resolution No. 71-12). Any project substantially encroaching upon the 100-year flood plain of the Delaware River or its tributaries shall not conflict with standards of flood plain use as approved by the Commission to safeguard the public health, safety, and property or standards of water quality. Neither shall such project conflict with applicable flood plain zoning ordinances of other land use regulations duly established by state or local government agencies.

2.150 Watershed Management

2.150.1 Sound practices (Compact, section 7.1). "The commission shall promote sound practices of watershed management in the basin..."

2.150.2 Soil erosion (Resolution No. 71-13). Any project within the jurisdiction of the Commission which involves a significant disturbance of ground cover shall include sound practices of excavation, sediment retention, backfill, and reseeding to minimize soil erosion and deposition of sediment in streams.

2.200 Fish and Wildlife

2.200.1 Fish and Wildlife (Resolution No. 67-7). The quality of Basin waters shall be maintained in a safe and satisfactory condition for ...wildlife, fish and other aquatic life.

2.250 Recreation

2.250.1 Water-related recreation (Compact, article 8). "The commission shall provide for the development of water-related public sports and recreational facilities."

2.300 Hydroelectric Power

2.300.1 Hydroelectric Power (Compact, section 9.1). "The waters of the Delaware River and its tributaries may be impounded and used by or under authority of the commission for the generation of hydroelectric power and hydroelectric energy."

Article 3 - WATER QUALITY STANDARDS FOR THE DELAWARE RIVER BASIN

3.1 General

3.1.1 Policy and standards (Compact, section 5.2). "The commission may assume jurisdiction to control future pollution and abate existing pollution in the waters of the basin, whenever it determines after investigation and public hearing upon due notice that the effectuation of the comprehensive plan so requires. The standard of such control shall be that pollution by sewage or industrial or other waste originating within a signatory state shall not injuriously affect waters of the basin as contemplated by the comprehensive plan. The commission, after such public hearing may classify the waters of the basin and establish standards of treatment of sewage, industrial or other waste, according to such classes including allowance for the variable factors of surface and ground waters, such as size of the stream, flow, movement, location, character, self-purification, and usage of the waters affected. After such investigation, notice and hearing the commission may adopt and from time to time amend and repeal rules, regulations and standards to control such future pollution and abate existing pollution, and to require such treatment of sewage, industrial or other waste within a time reasonable for the construction of the necessary works, as may be required to protect the public health or to preserve the waters of the basin for uses in accordance with the comprehensive plan."

3.10 Basinwide Surface Water Quality Standards

3.10.1 Application (Resolution No. 67-7). The following sections shall apply to all surface waters of the Delaware River Basin.

3.10.2 Water Uses

A. Uses paramount (Resolution No. 67-7). Water uses shall be paramount in determining stream quality objectives which, in turn, shall be the basis for determining effluent quality requirements.

B. Uses to be protected. (Resolution No. 67-7). The quality of Basin waters shall be maintained in a safe and satisfactory condition for the following uses:

1. agricultural, industrial, and public water supplies after reasonable treatment, except where natural salinity precludes such uses;
2. wildlife, fish and other aquatic life;
3. recreation;
4. navigation;
5. controlled and regulated waste assimilation to the extent that such use is compatible with other uses;
6. such other uses as may be provided by the Comprehensive Plan.

3.10.3 Stream Quality Objectives

A. Limits

1. (Resolution No. 74-1) The waters of the Basin shall not contain substances attributable to municipal, industrial, or other discharges in concentrations or amounts sufficient to preclude the specified water uses to be protected. Within this requirement:
   a. the waters shall be substantially free from unsightly or malodorous nuisances due to floating solids, sludge deposits, debris, oil, scum, substances in concentrations which are toxic or harmful to huma, animal, plant, or aquatic life, or that produce color, taste, odor of the water, or taint fish or shellfish flesh;

b. the concentration of total dissolved solids shall not exceed 133 percent of background.

2. (Resolution No. 67-7). In no case shall concentrations of substances exceed those values given for rejection of water supplies in the United States Public Health Service Drinking Water Standards.

B. Nondegradation of Interstate Waters. (Resolution No. 70-3). It is the policy of the Commission to maintain the quality of interstate waters, where existing quality is better than the established stream quality objectives, unless it can be affirmatively demonstrated to the Commission that such change is justifiable as a result of necessary economic or social development or to improve significantly another body of water. In implementing this policy, the Commission will require the highest degree of waste treatment determined to be practicable. No change will be considered which would be injurious to any designated present or future use.

C. Tributaries (Resolution No. 62-14). Sewage, industrial waste, or other artificial polluting matter discharged into, or permitted to flow into, or be placed in any intrastate tributary of the...... Delaware River shall be treated to that degree, if any, necessary to maintain the waters of such intrastate tributary immediately above its confluence with the .....Delaware River in a condition at least equal to the clean and sanitary condition of the waters of the Delaware River immediately above the confluence of such tributary.

3.10.4 Effluent Quality Requirements

A. Minimum treatment (Resolution No. 67-7). All wastes shall receive a minimum of secondary treatment, regardless of the stated stream quality objective.

B. Disinfection (Resolution 67-7). Wastes (exclusive of storm-water by-pass) containing human excreta or disease producing organisms shall be effectively disinfected before being discharged into surface bodies of water.

C. Public Safety (Resolution 67-7). Effluents shall not create a menace to public health or safety at the point of discharge.

D. Limits (Resolution 67-7). Discharges shall not contain more than negligible amounts of debris, oil, scum, or other floating materials, suspended matter which will settle to form sludge, toxic substances, or substances or organisms that produce color, taste, odor of the water, or taint fish or shellfish flesh.

E. Allocation of capacity. (Resolution 67-7). Where necessary to meet the stream quality objectives, the waste assimilative capacity of the receiving waters shall be allocated in accordance with the doctrine of equitable apportionment.

3.10.5 Other Considerations

A. Combined sewers (Resolution 67-7). Any new facility or project combining sanitary or industrial waste with storm-water drainage which would have a substantial effect on the quality of waters of the Basin shall not be permitted, whether or not any such project or facility discharges into an existing combined system.

B. Access and reports

1. (Resolution 67-7). The Commission, or its duly authorized representatives, shall have access, at reasonable hours, to observe and inspect waste treatment facilities and to collect samples for analyses.

2. (Resolution 67-7). Upon written request, waste treatment facility operation reports shall be submitted to the Commission.

C. Zones (Resolution No. 67-7). The Delaware River and Bay and their tributaries may be divided into zones which will facilitate the management of surface and underground water quality.

D. Streamflow (Resolution No. 67-7). Numerical stream quality objectives are based on a minimum consecutive 7-day flow with a 10 year recurrence interval.

3.10.6 Definitions

A. Biochemical oxygen demand (Resolution No. 67-7). Biochemical oxygen demand as determined under standard laboratory procedures for 5 days at 20° C.

B. Carbonaceous oxygen demand (Resolution No. 67-7). That part of the ultimate oxygen demand associated with biochemical oxidation of carbonaceous, as distinct from nitrogenous, material.

C. Effective disinfection (Resolution No. 67-7). The destruction of pathogenic organisms in such manner and under such controls as shall be prescribed by Commission regulations.

D. Secondary treatment (Resolution 70-3)

1. The removal of practically all suspended solids at all times;

2. The reduction of the biochemical oxygen demand by at least 85 percent.

3. May include the in-plant control of industrial wastes as prescribed by the Commission.

E. River Mile. (Resolution No. 67-7). The distance, in statute miles, of a location or item measured from "mile zero".

1. Delaware Bay and River
   a. Mile zero is located at the intersection of the centerline of the navigation channel and a line between the Cape May Light and the Tip of Cape Henlopen.

   b. Distances from mile zero are measured essentially along the centerline of the navigation channel up to the Trenton-Morrisville Toll Bridge (R.M. 133.4) and above that point along the State boundary line as shown on published quadrangle maps of the United States Geological Survey.

2. Tributaries
   a. Mile zero is located at the intersection of the centerline of the tributary and a line joining the opposite banks at its mouth.

   b. Distances from mile zero are measured along the centerline of the tributary.

3.20 Interstate Streams - Nontidal - Standards

3.20.1 Application (Resolution 67-7). This Article shall apply to the interstate nontidal streams of the Delaware River Basin. The interstate nontidal streams of the Delaware River Basin are those rivers, lakes, and other waters that flow across or form a part of state boundaries.

3.20.2 Zone 1A

A. Description (Resolution 74- 1). Zone 1A is that part of the Delaware River extending from the confluence of the East and West Branches of the Delaware River at Hancock, New York, R.M. (River Mile)330.7, to the Route 652 bridge at Narrowsburg, New York, R. M. 289.9.

B. Water uses to be protected. (Resolution No. 67-7). The quality of Zone 1A waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. maintenance and propagation of trout,
   c. spawning and nursery habitat for anadromous fish,
   d. wildlife;

3. a. recreation

C. Stream quality objectives. The stream quality objectives of Zone 1A waters shall be those specified as follows:

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 5.0 mg/l at any time;
   b. minimum 24-hour average of 6.0 mg/l;
   c. not less than 7.0 mg/l in spawning areas whenever temperatures are suitable for trout spawning.

2. Temperature (Resolution No. 74-1) Except in designated heat dissipation areas.
   a. not to exceed 5^{o}F (2.8^{o} C) rise above ambient temperature until stream temperature reaches 50^{o} F (10.0^{o} C),
   b. not to exceed 2^{o} F (1.1^{o} C) rise above ambient temperature when stream temperature is between 50^{o} (10.0^{o} C) and 58^{o} F (14.4^{o} C),
   c. natural temperature will prevail above 58^{o} F (14.4^{o} C).

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60° C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. Alpha emitters - not to exceed 3 pc/l (picocuries per liter);
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1)
   a. Not to exceed 133 percent of background, or
   b. 500 mg/l, whichever is less.

10. Turbidity (Resolution No. 74-1). Unless exceeded due to natural conditions
   a. maximum 30-day average 10 units,
   b. maximum 150 units.

D. Effluent quality requirements (Resolution No. 62-14 and 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass shall not exceed that assigned by the Commission to maintain stream quality objectives.

3. No discharge shall exceed a biochemical oxygen demand of 50 mg/l.

4. The discharge of an effluent, after dispersion in the water of the river, shall not cause a reduction of the dissolved oxygen content of such water of more than five percent.

3.20.3 Zone 1B

A. Description (Resolution 74-1). Zone 1B is that part of the Delaware River extending from the Route 652 bridge at Narrowsburg, New York, R. M. 289.9, to the U. S. Routes 6 and 209 bridge at Port Jervis, New York, R. M. 254.74.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone 1B waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. spawning and nursery habitat for anadromous fish,
   c. passage of anadromous fish,
   d. wildlife;

3. a. recreation

C. Stream quality objectives.

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 4.0 mg/l at any time;
   b. minimum 24 hour average of 5.0 mg/l.

2. Temperature (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6° C),
   b. natural temperature will prevail above 87°F (30.6°C).

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60° C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. Alpha emitters - not to exceed 3pc/l (picocuries per liter);
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less

10. Turbidity (Resolution No. 74-1). Unless exceeded due to natural conditions
    a. maximum 30-day average 10 units,
    b. maximum 150 units.

D. Effluent quality requirements (Resolution No. 62-14 and 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3. No discharge shall exceed a biochemical oxygen demand of 50mg/l.

4. The discharge of an effluent, after dispersion in the water of the river, shall not cause a reduction of the dissolved oxygen content of such water of more than five percent.

3.20.4 Zone 1C

A. Description (Resolution 67-7). Zone 1C is that part of the Delaware River extending from the U. S. Routes 6 and 209 bridge at Port Jervis, N. Y., R. M. 254.75, to Tocks Island Dam, R.M. 217.0 (proposed axis of dam).

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone 1C waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment
   b. industrial water supplies after reasonable treatment
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic live,
   b. spawning and nursery habitat for anadromous fish,
   c. passage of anadromous fish,
   d. wildlife;

3. a. recreation

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 4.0 mg/l at any time
   b. minimum 24 hour average of 5.0 mg/l.

2. Temperature (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6°C),
   b. natural temperature will prevail above 87°F(30.6°C).

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60° C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters - not to exceed 3 pc/l (picocuries per liter);
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed
   a. 133 percent of background or
   b. 500 mg/l, whichever is less.

10. Turbidity (Resolution No. 74-1). Unless exceeded due to natural conditions
    a. maximum 30 day average 20 units,
    b. maximum 150 units

D. Effluent quality requirements (Resolution No. 62-14 and 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3. No discharge shall exceed a biochemical oxygen demand of 50 mg/l.

4. The discharge of an effluent, after dispersion in the water of the river, shall not cause a reduction of the dissolved oxygen content of such water of more than five percent.

3.20.5 Zone 1D

A. Description (Resolution 74-1). Zone 1D is that part of the Delaware River extending from Tocks Island Dam, R.M.217.0 (proposed axis of dam), to the mouth of the Lehigh River of Easton, Pennsylvania, R.M. 183.66.

B. Water uses to be protected.(Resolution No. 67-7). The quality of Zone 1D waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. spawning and nursery habitat for anadromous fish,
   c. passage of anadromous fish,
   d. wildlife,

3. a. recreation

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1).
   a. not less than 4.0 mg/l at any time
   b. minimum 24 hour average of 5.0 mg/l.

2. Temperature (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6°C),
   b. natural temperature will prevail above 87°F (30.6°C).

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60°C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 67-7). not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7).
   a. Alpha emitters - not to exceed 3pc/l (picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less

10. Turbidity (Resolution No. 74-1). Unless exceeded due to natural conditions
    a. maximum 30 day average 20 units,
    b. maximum 150 units.

D. Effluent quality requirements (Resolution No.62-14 and 67-7).

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3. No discharge shall exceed a biochemical oxygen demand of 50 mg/l.

4. The discharge of an effluent, after dispersion in the water of the river, shall not cause a reduction of the dissolved oxygen content of such water of more than five percent.

3.20.6 Zone 1E

A. Description (Resolution No. 74-1). Zone 1E is that part of the Delaware River extending from the mouth of the Lehigh River at Easton, Pennsylvania, R. M. 183.66, to the head of tidewater at Trenton, New Jersey, R.M. 133.4 (Trenton - Morrisville Toll Bridge).

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone 1E waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. spawning and nursery habitat for anadromous fish,
   c. passage of anadromous fish,
   d. wildlife;

3. a. recreation

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1).
   a. not less than 4.0 mg/l at any time
   b. minimum 24 hour average of 5.0 mg/l.

2. Temperature (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6°C).
   b. natural temperature will prevail above 87°F (30.6°C).

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60° C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters - not to exceed 3 pc/l (picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed
   a. 133 percent of background, or
   b. 150 mg/l, whichever is less.

10. Turbidity (Resolution No. 74-1). Unless exceeded due to natural conditions
   a. maximum 30 day average 30 units,
   b. maximum 150 units.

11. Alkalinity (Resolution No. 67-7). Not less than 20 mg/l.

D. Effluent quality requirements (Resolution No. 62-14 and 67-7).

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3. No discharge shall exceed a biochemical oxygen demand of 50 mg/l.

4. The discharge of an effluent, after dispersion in the water of the river, shall not cause a reduction of the dissolved oxygen content of such water of more than five percent.

3.20.7 Zone E

A. Description (Resolution No. 67-7). Zone E is East Branch Delaware River extending from its source in the Town of Roxbury, Delaware County, N. Y., to its mouth at Hancock, N. Y., at R. M. 330.7 on the Delaware River.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone E waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. maintenance and propagation of trout,
   c. wildlife;

3. a. recreation

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 5.0 mg/l at any time;
   b. minimum 24 hour average of 6.0 mg/l;
   c. not less than 7.0 mg/l in spawning areas whenever temperatures are suitable for trout spawning.

2. Temperature (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5° F (2.8°C) rise above ambient temperature until stream temperature reaches 50°F (10.0°C),
   b. not to exceed 2° F (1.0° C) rise above ambient temperature when stream temperature is between 50°F (10.0°C and 58° F (14.4° C),
   c. natural temperature will prevail above 58°F (14.4°C).

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60° C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters - not to exceed 3 pc/l (picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No.74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation .

9. Total dissolved solids (Resolution No.74-1). Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

D. Effluent quality requirements (Resolution No. 67- 7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.8 Zone W1

A. Description (Resolution No. 67-7). Zone W1 is West Branch Delaware River extending from its source in the town of Jefferson, Schoharie County, New York, to its mouth at Hancock, New York, at R.M. 330.71 on the Delaware River.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone W1 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment
   c. agricultural water supplies;

2. a maintenance and propagation of resident game fish and other aquatic life,
   b. maintenance and propagation of trout
   c. wildlife;

3. a. recreation

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 5.0 mg/l at any time
   b. minimum 24 hour average of 6.0 mg/l
   c. not less than 7.0 mg/l in spawning areas whenever temperatures are suitable for trout spawning

2. Temperature (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 50°F (10.0°C).
   b. not to exceed 2°F (1.1°C) rise above ambient temperature when stream temperature is between 50° F (10.0°C) and 58°F (14.4°C),
   c. natural temperature will prevail above 58°F(14.4°C).

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60°C.

6. <u>Synthetic detergents</u> (Resolution No. 67-7) (M.B.A.S.) Not to exceed 0.5 mg/l.

7. <u>Radioactivity</u> (Resolution No. 67-7).
   a. alpha emitters - not to exceed 3 pc/l (picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. <u>Fecal coliform</u> (Resolution No. 74-1) Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. <u>Total dissolved solids</u> (Resolution No. 74-1). Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

D. <u>Effluent quality requirements</u> (Resolution No. 62-14 and 67-7).

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3. In that part of the West Branch Delaware River extending from the New York-Pennsylvania boundary at R.M. 10.0 to its mouth at Hancock, New York, at R. M. 330.71 on the Delaware River:
   a. no discharge shall exceed a biochemical oxygen demand of 50 mg/l.
   b. the discharge of an effluent, after dispersion in the water of the river, shall not cause a reduction of the dissolved oxygen content of such water of more than five percent.

3.20.9 Zone W2

A. Description (Resolution No. 67-7). Zone W2 is:

1. Sand Pond Creek extending from R.M.1.8 at the confluence of Sherman Creek and Starboard Creek in Pennsylvania to its mouth in New York at R.M.10.1 on the West Branch Delaware River;

2. Cat Hollow Brook extending from its source in New York to its mouth in Pennsylvania at R.M. 1.05 on Sand Pond Creek;

3. Sherman Creek in Pennsylvania extending from its source to its mouth at R.M.1.8 on Sand Pond Creek;

4. An unnamed tributary of Sherman Creek extending from its source in New York to its mouth in Pennsylvania at R.M.1.6 on Sherman Creek;

5. Starboard Creek extending from its source in Lake Oquaga in New York to its mouth in Pennsylvania at R.M. 1.81 on Sand Pond Creek.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone W2 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. maintenance and propagation of trout,
   c. wildlife;

3. a. recreation.

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 5.0 mg/l at any time;
   b. minimum 24 hour average of 6.0 mg/l.
   c. not less than 7.0 mg/l in spawning areas whenever temperatures are suitable for trout spawning.

2. <u>Temperature</u> (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 50°F (10.0°C),
   b. not to exceed 2°F (1.1°C) rise above ambient temperature when stream temperature is between 50°F (10.0°C) and 50°F (14.4° C),
   c. natural temperature will prevail above 58°F(14.4°C).

3. <u>ph</u>(Resolution No. 67-7). Between 6.0 and 8.5.

4. <u>Phenols</u> (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. <u>Threshold odor number</u> (Resolution No.67-7). Not to exceed 24 at 60°C.

6. <u>Synthetic Detergents</u> (M.B.A.S.)(Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. <u>Radioactivity</u> (Resolution No. 67-7)
   a. alpha emitters - not to exceed 3 pc/l (picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. <u>Fecal coliform</u> (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. <u>Total dissolved solids.</u> (Resolution No. 74-1). Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

D. <u>Effluent quality requirements</u> (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.10 Zone N1

A. Description (Resolution No. 67-7). Zone N1 is that part of the Neversink River extending from R.M. 0.5 at its confluence with Clove Brook to its mouth on the Delaware River at R.M.253.64.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone N1 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. wildlife;

3. a. recreation.

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1).
   a. not less than 4.0 mg/l at any time;
   b. minimum 24 hour average of 5.0 mg/l.

2. Temperature (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6°C),
   b. natural temperature will prevail above 87°F(30.6°C).

3. pH (Resolution No. 67-7). Between 6.5 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60° C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters - not to exceed 3pc/l(picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.11 Zone N2

A. Description (Resolution No. 67-7). Zone N2 is

1. Clove Brook extending from its source in Steeny Kill Lake in New Jersey to its mouth in New York at R.M. 0.5 on the Neversink River;

2. an unnamed tributary of Clove Brook extending from its source in New York to its mouth in New Jersey at R.M. 1.0 on Clove Brook;

3. an unnamed tributary to the above unnamed tributary of Clove Brook extending from its source in New York to its mouth in New Jersey at R.M. 0.7 on the unnamed tributary of Clove Brook;

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone N2 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. maintenance and propagation of trout,
   c. wildlife;

3. a. recreation.

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 5.0 mg/l at any time;
   b. minimum 24 hour average of 6.0 mg/l
   c. not less than 7.0 mg/l in spawning areas whenever temperatures are suitable for trout spawning.

2. Temperature (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 50°F (10.0°C)

b. not to exceed $2^{o}F$ ($1.1^{o}C$) rise above ambient temperature when stream temperature is between $50^{o}F$ ($10.0^{o}C$) and $58^{o}F$ ($14.4^{o}C$).

c. natural temperature will prevail above 58^{o} F ($14.4^{o}C$).

3. pH (Resolution No. 67-7). Betwen 6.5 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at $60^{o}C$.

6. Synthetic detergents (M.B.A.S.)(Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters - not to exceed 3 pc/l(picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.12 Zone C1

A. Description (Resolution No. 67-7). Zone C1 is that part of the Christina River extending from its source in Pennsylvania to the head of tide water at R.M. 16.3 at the outlet of Smalley's Pond in Delaware.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone C1 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. wildlife;

3. a. recreation.

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 4.0 mg/l at any time,
   b. minimum 24 hour average of 5.0 mg/l.

2. Temperature (Resolution No. 74-1) Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6°C).
   b. natural temperature will prevail above 87°F(30.6°C).

3. pH (Resolution No.67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60°C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7).
   a. alpha emitters - not to exceed 3pc/l(picocuries per liter)
   b. beta emitters-not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1) Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

10. Turbidity
    a. Not to exceed
       1). the natural background by 10 units, or
       2). a maximum of 25 units, whichever is less.
    b. Increases not to be attributable to industrial waste discharges.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.13 Zone C2

A. Description (Resolution No. 67-7). Zone C2 is:

1. West Branch Christina River extending from its source in Maryland to its mouth on the Christina River in Delaware at R. M. 25.7;

2. Persimmon Run extending from its source in Maryland to its mouth on the West Branch Christina River in Delaware at R.M. 0.8;

3. East Branch Christina River extending from its source in Pennsylvania to its mouth on the Christina River at R.M.30.2.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone C2 waters shall be maintained in a safe and satisfactory condition for the following uses;

1. a. public water supplies after reasonable treatment
   b. industrial water supplies after reasonable treatment
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. wildlife;

3. a. recreation.

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 4.0 mg/l at any time;
   b. minimum 24 hour average of 5.0 mg/l.

2. Temperature (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6°C),
   b. natural temperature will prevail above 87°F (30.6°C.)

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60°C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters - not to exceed 3pc/l(picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-l) Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

10. Turbidity (Resolution No. 74-1)
    a. Not to exceed
       1). the natural background by 10 units, or
       2). a maximum of 25 units, whichever is less.
    b. Increases not to be attributable to industrial waste discharges.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.14 Zone C3

A. Description (Resolution No. 67-7). Zone C3 is that part of White Clay Creek extending from its source in Pennsylvania to R.M. 14.7 at the Pennsylvania-Delaware State line.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone C3 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. maintenance and propagation of trout,
   c. wildlife;

3. a. recreation.

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 5.0 mg/l at any time
   b. minimum 24 hour average of 6.0 mg/l;
   c. not less than 7.0 mg/l in spawning areas whenever temperatures are suitable for trout spawning.

2. Temperature (Resolution No. 74-1). Except in designated heat dissipation areas
   a. not to exceed 5°F (2.8°C) rise above ambient temperature until stream temperature reaches 50°F (10.0°C).
   b. not to exceed 2°F (1.1°C) rise above ambient temperature when stream temperature is between 50°F(10.0°C) and 58°F (14.4°C),
   c. natural temperature will prevail above 58°F (14.4°C)

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60°C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 67-7)
Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters - not to exceed 3pc/l(picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

10. Turbidity (Resolution No. 74-1)
   a. not to exceed
      1). the natural background by 10 units, or
      2). a maximum of 25 units, whichever is less.
   b. increases not to be attributable to industrial waste discharges.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.15 Zone C4

A. Description (Resolution No. 67-7). Zone C4 is that part of White Clay Creek extending from R.M. 14.7 at the Pennsylvania-Delaware State line to its mouth on the Christina River in Delaware at R.M. 10.0.

B. Water uses to be protected. (Resolution No. 67-7). The quality of Zone C4 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. wildlife

3. a. recreation

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 4.0 mg/l at any time,
   b. minimum 24 hour average of 5.0 mg/l

2. Temperature (Resolution No. 74-1) Except in designated heat dissipation areas
   a. not to exceed $5^{\circ}F(2.8^{\circ}C)$ rise above ambient temperature until stream temperature reaches $87^{\circ}F$ $(30.6^{\circ}C)$
   b. natural temperature will prevail above $87^{\circ}F(30.6^{\circ}C)$.

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No.67-7). Not to exceed 24 at $60^{\circ}C$.

6. Synthetic degergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters -not to exceed 3pc/l(picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1) Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

10. Turbidity (Resolution No. 74-1).
   a. Not to exceed
      1). the natural background by 10 units, or
      2). a maximum of 25 units, whichever is less,
   b. Increases not to be attributable to industrial waste discharges.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.16 Zone C5

A. Description (Resolution No. 67-7). Zone C5 is:

1. that part of Red Clay Creek extending from the confluence of East and West branches of Red Clay Creek in Pennsylvania at R.M.13.4 to R.M.12.6, at the Pennsylvania -Delaware State Line;

2. West Branch Red Clay Creek extending from its source to its mouth on Red Clay Creek at R.M.13.4.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone C5 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. maintenance and propagation of trout,
   c. wildlife,

3. a. recreation.

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 4.0 mg/l at any time,
   b. minimum 24 hour average of 5.0 mg/l

2. Temperature (Resolution No. 74-1) Except in designated heat dissipation areas
   a. not to exceed 5°F(2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6°C)
   b. natural temperature will prevail above 87°F(30.6°C).

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No.67-7). Not to exceed 24 at 60°C.

6. Synthetic degergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters --not to exceed 3pc/l(picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1) Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

10. Turbidity (Resolution No. 74-1).
    a. Not to exceed
       1). the natural background by 10 units, or
       2). a maximum of 25 units, whichever is less,
    b. Increases not to be attributable to industrial waste discharges.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.17 Zone C6

A. Description (Resolution No. 67-7). Zone C6 is that part of the Red Clay Creek extending from R.M. 12.6 at the Pennsylvania-Delaware State line to its mouth on White Clay Creek in Delaware at R.M. 2.6

B. Water uses to be protected. (Resolution No. 67-7). The quality of Zone C4 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. wildlife

3. a. recreation

D. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 4.0 mg/l at any time,
   b. minimum 24 hour average of 5.0 mg/l

2. Temperature (Resolution No. 74-1) Except in designated heat dissipation areas
   a. not to exceed 5°F(2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6°C)
   b. natural temperature will prevail above 87°F(30.6°C).

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No.67-7). Not to exceed 24 at 60°C.

6. Synthetic degergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters -not to exceed 3pc/l(picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1) Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

10. Turbidity (Resolution No. 74-1).
    a. Not to exceed
       1). the natural background by 10 units, or
       2). a maximum of 25 units, whichever is less,
    b. Increases not to be attributable to industrial waste discharges.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.18 Zone C7

A. Description (Resolution No. 67-7). Zone C7 is:

1. Brandywine Creek extending from the confluence of the East and West Branches of Brandywine Creek in Pennsylvania at R.M. 20.0 to the head of tidewater at R.M. 2.0 at the Market Street Bridge in Wilmington, Delaware;

2. West Branch Brandywine Creek extending from its source to its mouth on Brandywine Creek at R.M. 20.0.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone C7 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. spawning and nursery habitat for anadromous fish,
   c. passage of anadromous fish,
   d. wildlife;

3. a. recreation.

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 4.0 mg/l at any time,
   b. minimum 24 hour average of 5.0 mg/l

2. Temperature (Resolution No. 74-1) Except in designated heat dissipation areas
   a. not to exceed 5°F(2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6°C)
   b. natural temperature will prevail above 87°F(30.6°C).

3. pH (Resolution No. 67-7). Between 6.5 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No.67-7). Not to exceed 24 at 60°C.

6. Synthetic degergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters --not to exceed 3pc/l(picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1) Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

10. Turbidity (Resolution No. 74-1).
    a. Not to exceed
       1). the natural background by 10 units, or
       2). a maximum of 25 units, whichever is less,
    b. Increases not to be attributable to industrial waste discharges.

11. Fluorides (Resolution No. 67-7) Not to exceed 1.0 mg/l.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.20.19 Zone C8

A. Description (Resolution No. 67-7). Zone C8 is Naaman Creek extending from its source in Pennsylvania to the head of tidewater to Delaware.

B. Water uses to be protected. (Resolution No. 67-7). The quality of Zone C4 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment,
   b. industrial water supplies after reasonable treatment,
   c. agricultural water supplies;

2. a. maintenance and propagation of resident game fish and other aquatic life,
   b. wildlife

3. a. recreation

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. not less than 4.0 mg/l at any time,
   b. minimum 24 hour average of 5.0 mg/l

2. Temperature (Resolution No. 74-1) Except in designated heat dissipation areas
   a. not to exceed 5°F(2.8°C) rise above ambient temperature until stream temperature reaches 87°F (30.6°C)
   b. natural temperature will prevail above 87°F(30.6°C).

3. pH (Resolution No. 67-7). Between 6.0 and 8.5.

4. Phenols (Resolution No. 74-1). Not to exceed 0.005 mg/l, unless due to natural conditions.

5. Threshold odor number (Resolution No.67-7). Not to exceed 24 at 60°C.

6. Synthetic degergents (M.B.A.S.) (Resolution No. 67-7) Not to exceed 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters --not to exceed 3pc/l(picocuries per liter)
   b. beta emitters - not to exceed 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Not to exceed 200 per 100 milliliters as a geometric average; samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1) Not to exceed
   a. 133 percent of background, or
   b. 500 mg/l, whichever is less.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water by-pass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.30 Interstate Streams -- Tidal

3.30.1 Application (Resolution No. 67-7). This Article shall apply to the Delaware River Estuary and Bay, including the tidal portions of the tributaries thereof.

3.30.2 Zone 2

A. Description (Resolution No. 67-7). Zone 2 is that part of the Delaware River extending from the head of tidewater at Trenton New Jersey, R.M. (River Mile) 133.4 (Trenton-Morrisville Toll Bridge) to R. M. 108.4 below the mouth of Pennypack Creek, including the tidal portions of the tributaries thereof.

B. Water uses to be protected (Resolution No. 74-1). The quality of Zone 2 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment
   b. industrial water supplies after reasonable treatment
   c. agricultural water supplies;

2. a. maintenance and propagation of resident fish and other aquatic life,
   b. passage of anadromous fish,
   c. wildlife;

3. a. recreation from R. M. 133.4 to R. M. 117.81.
   b. recreation-secondary contact from R.M.117.81 to R.M. 108.4;

4. a. navigation.

C. Stream quality objectives. The stream quality objectives of Zone 2 waters shall be those specified as follows:

1. Dissolved oxygen (Resolution No. 74-1)
   a. 24 hour average concentration shall not be less than 5.0 mg/l.
   b. During the periods from April 1 to June 15, and September 16 to December 31, the dissolved oxygen shall not have a seasonal average less than 6.5 mg/l.

3.30.2 Zone 2 (Cont'd)

2. Temperature (Resolution No. 74-1). Shall not exceed
   a. 5° F (2.8° C) above the average 24 hour temperature gradient displayed during the 1961-66 period or
   b. a maximum of 86° F (30.0° C), whichever is less.

3. pH (Resolution No. 67-7). Between 6.5 and 8.5.

4. Phenols (Resolution No. 74-1). Maximum 0.005 mg/l, unless exceeded due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60° C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 74-1) Maximum 30-day average 0.5 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters - maximum 3;c/l (picocuries per liter);
   b. beta emitters - maximum 1,000 pc/l.

8. Fecal coliform (Resolution 74-1). Maximum geometric average
   a. 200 per 100 milliliters above R.M. 117.81.
   b. 770 per 100 milliliters below R.M. 117.81.

   Samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed
   a. 133 percent of background or,
   b. 500 mg/l, whichever is less

10. Turbidity (Resolution No. 74-1) . Unless exceeded due to natural conditions
    a. maximum 30-day average 40 units
    b. maximum 150 units;
    c. except above R.M. 117.81 during the period May 30 to September 15 when the turbidity shall not exceed 30 units.

11. Alkalinity (Resolution No. 67-7). Between 20 and 100 mg/l.

12. Chlorides (Resolution No. 74-1). Maximum 15 day average 50 mg/l.

13. Hardness (Resolution No. 74-1). Maximum 30-day average 95 mg/l.

D. Effluent quality requirements (Resolutions 62-14 and 67-7).

1. All discharges shall meet the effluent quality requirements of Section 3.10.

2. The carbonaceous oxygen demand from all outfalls in the zone (exclusive of storm-water by-pass) shall not exceed that assigned by Commission regulations.

3. No discharge shall exceed a biochemical oxygen demand of 100 mg/l.

3.30.3 Zone 3

A. Description (Resolution No. 67-7). Zone 3 is that part of the Delaware River extending from R. M. 108.4 to R.M. 95.0 below the mouth of Big Timber Creek, including the tidal portions of the tributaries thereof.

B. Water uses to be protected (Resolution No. 74-1). The quality of Zone 3 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. public water supplies after reasonable treatment
   b. industrial water supplies after reasonable treatment
   c. agricultural water supplies;

2. a. maintenance of resident fish and other aquatic life,
   b. passage of anadromous fish,
   c. wildlife;

3. a. recreation - secondary contact;

4. a. navigation.

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1)
   a. 24 hour average concentration shall not be less than 3.5 mg/l.
   b. During the periods from April 1 to June 15, and September 16 to December 31, the dissolved oxygen shall not have a seasonal average less than 6.5 mg/l.

2. Temperature (Resolution No. 74-1). Shall not exceed
   a. 5° F (2.8° C) above the average 24 hour temperature gradient displayed during the 1961-66 period or
   b. a maximum of 86° F (30.0° C), whichever is less.

3. pH (Resolution No. 67-7). Between 6.5 and 8.5.

4. Phenols (Resolution No. 74-1). Maximum 0.005 mg/l, unless exceeded due to natural conditions.

5. Threshold odor number. (Resolution No. 67-7). Not to exceed 24 at 60° C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 74-1) Maximum 30 day average 1.0 mg/l.

7. Radioactivity (Resolution No. 67-7)
   a. alpha emitters - maximum 3pc/l (picocuries per liter)
   b. beta emitters - maximum 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Maximum geometric average 770 per 100 milliliters. Samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed
   a. 133 percent of background, or
   b. 5o0 mg/l, whichever is less

10. Turbidity, (Resolution No. 74-1) Unless exceeded due to natural conditions.
    a. maximum 30 day average 40 units
    b. maximum 150 units

11. Alkalinity (Resolution No. 67-7). Between 20 and 120 mg/l.

12. Chlorides. (Resolution No. 74-1). Maximum 200 mg/l.

13. Hardness (Resolution No. 74-1). Maximum 30 day average 150 mg/l.

D. Effluent quality requirements (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.
2. The carbonaceous oxygen demand from all outfalls in the zone (exclusive of storm-water by-pass) shall not exceed that assigned by Commission regulations.

3.30.4 Zone 4

A. Description (Resolution No. 67-7). Zone 4 is that part of the Delaware River extending from R.M. 95.0 to R.M. 78.8, the Pennsylvania-Delaware boundary line, including the tidal portions of the tributaries thereof.

B. Water uses to be protected(Resolution No. 74-1). The quality of Zone 4 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. industrial water supplies after reasonable treatment

2. a. maintenance of resident fish and othrer aquatic life.
   b. passage of anadromous fish,
   c. wildlife

3. a. recreation - secondary contact

4. a. navigation

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-1).
   a. 24 hour average concentration shall not be less than 3.5 mg/l.
   b. During the periods from April 1 to June 15, and September 16 to December 31, the dissolved oxygen shall not have a seasonal average of less than 6.5 mg/l.

2. Temperature (Resolution No. 74-1) Shall not exceed
   a. 5° F (2.8° C) above the average 24 hour temperature gradient displayed during the 1961-66 period, or
   b. a maximum of 86° F (30.0° C)

3. pH (Resolution No. 74-1). Between 6.5 and 8.5.

4. Phenols (Resolution No. 74-1) Maximum 0.02 mg/l, unless exceeded dur to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60° C.

6. Synthetic detergents (M.B.A.S.) (Resolution No. 74-1) Maximum 30 day average 1.0 mg/l.

7. Radioactivity (Resolution No. 67-7).
   a. alpha emitters - macimum 3pc/l (picocuries per liter)
   b. beta emitters - maximum 1,000 pc/l

8. Fecal coliform (Resolution No. 74-1) Maximum geometric average 770 per 100 milliliters. Samples shall be taken at such frequency and location as to permit valid interpretation.

9. Total dissolved solids (Resolution No. 74-1). Not to exceed 133 percent of background.

10. Turbidity (Resolution No. 74-1). Unless exceeded due to natural conditions
   a. maximum 30 day average 40 units,
   b. maximum 150 units

11. Alkalinity. (Resolution No. 67-7). Between 20 and 120 mg/l.

12. Chlorides (Resolution No. 74-1). Maximum 250 mg/l at R.M. 92.47.

D. Effluent quality requirements (Resolution No. 67-7)

1. all discharges shall meet the effluent quality requirements of Section 3.10.
2. The carbonaceous oxygen demand from all outfalls in the zone (exclusive of storm-water by-pass) shall not exceed that assigned by Commission regulations.

3.30.5 Zone 5

A. Description (Resolution No. 67-7). Zone 5 is that part of the Delaware River extending from R. M. 78-8 to R. M. 48.2, Liston Point, including the tidal portions of the tributaries thereof.

B. Water uses to be protected (Resolution No. 74-1). The quality of waters in Zone 5 shall be maintained in a safe and satisfactory condition for the following uses:

1. a. industrial water supplies after easonable treatment

2. a. Maintenance of resident fish and other aquatic life,
   b. propagation of resident fish from R.M.70.0 to R.M.48.2
   c. passage of anadromous fish
   d. wildlife;

3. a. recreation-secondary contact from R.M.78.8 to R.M.59.5,
   b. recreation from R.M.59.5 to R.M. 48.2;

4. a. navigation

C. Stream quality objectives

1. Dissolved oxygen (Resolution No. 74-l)
   a. 24 hour average concentration shall not be less than
      l). 3.5 mg/l at R.M. 78.8
      2). 4.5 mg/l at R.M. 70.0
      3). 6.0 mg/l at R.M. 59.5
   b. During the periods from April l to June l5, and September l6 to December 3l, the dissolved oxygen shall not have a seasonal average less than 6.5 mg/l in the entire zone.

2. Temperature (Resolution No. 74-l)
   a. Shall not be raised above ambient by more than
      l). 4° F (2.2° C)during September through May, or
      2). 1.5° F (0.8° C) during June through August
   b. nor shall maximum temperatures exceed 86° F (30.0° C).

3. pH (Resolution No. 67-7). Between 6.5 and 8.5.

4. Phenols (Resolution No. 74-1). Maximum 0.01 mg/l, unless exceeded due to natural conditions.

5. <u>Threshold odor number</u> (Resolution No. 67-7). Not to exceed 24 at 60° C.

6. <u>Synthetic detergents</u> (M.B.A.S.) (Resolution No. 74-1). Maximum 30-day average 1.0 mg/l.

7. <u>Radioactivity</u> (Resolution No. 67-7)
   a. alpha emitters - maximum 3pc/l (picocuries per liter)
   b. beta emitters - maximum 1,000 pc/l.

8. <u>Fecal coliform</u>(Resolution No. 74-1). Maximum geometric average
   a. 770 per 100 milliliters from R. M. 78.8 to 59.5
   b. 200 per 100 milliliters from R.M. 59.5 to 48.2

9. <u>Turbidity</u> (Resolution No. 74-1) Unless exceeded due to natural conditions
   a. maximum 30-day average 40 units,
   b. maximum 150 units.

10. <u>Alkalinity</u> (Resolutions No. 67-7). Between 20 and 120 mg/l.

D. <u>Effluent quality requirements</u> (Resolution No. 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.
2. The carbonaceous oxygen demand from all outfalls in the zone (exclusive of storm-water by-pass) shall not exceed that assigned by Commission regulations.

3.30.6 Zone 6

A. Description (Resolution No. 67-7). Zone 6 is Delaware Bay extending from R.M. 48.2 to R.M. 0.0, the Atlantic Ocean, including the tidal portions of the tributaries thereof.

B. Water uses to be protected (Resolution No. 67-7). The quality of Zone 6 waters shall be maintained in a safe and satisfactory condition for the following uses:

1. a. industrial water supplies after reasonable treatment;

2. a. maintenance and propagation of resident fish and other aquatic life,
   b. maintenance and propagation of shellfish,
   c. passage of anadromous fish,
   d. wildlife;

3. a. recreation;

4. a. navigation.

C. Stream quality objectives.

1. Dissolved oxygen (Resolution No. 74-1)
   a. 24-hour average concentration shall not be less than 6.0 mg/l;
   b. not less than 5.0 mg/l at any time unless due to natural conditions.

2. Temperature (Resolution No. 74-1).
   a. Shall not be raised above ambient by more than
      1). 4°F (2.2°C) during September through May, or
      2). 1.5°F (0.8°C) during June through August;
   b. nor shall maximum temperatures exceed 85°F (29.4°C).

3. pH (Resolution 67-7). Between 6.5 and 8.5.

4. Phenols (Resolution No. 74-1). Maximum 0.01 mg/l, unless exceeded due to natural conditions.

5. Threshold odor number (Resolution No. 67-7). Not to exceed 24 at 60°C.

6. Synthetic detergents (M.B.A.S.). (Resolution No. 74-1). Maximum 30-day average 1.0 mg/l.

7. Radioactivity (Resolution No. 67-7).
   a. alpha emitters - maximum 3 lc/l (picocuries per liter);
   b. beta emiters - maximum 1,000 pc/l.

8. Fecal coliform (Resolution No. 74-1). Maximum geometric average 200 per 100 milliliters. Samples shall be taken at such frequency and location as to permit valid interpretation.

9. Coliform. MPN (most probable number) not to exceed U.S. Public Health Service's shellfish standards in designated shellfish areas.

10. Turbidity (Resolution No. 74-1). Unless exceeded due to natural conditions
    a. maximum 30-day average 40 units,
    b. maximum 150 units.

11. Alkalinity (Resolution No. 67-7). Between 20 and 120 mg/l.

D. Effluent quality requirements.(Resolution 67-7)

1. All discharges shall meet the effluent quality requirements of Section 3.10.
2. The carbonaceous oxygen demand from an outfall (exclusive of storm-water bypass) shall not exceed that assigned by the Commission to maintain stream quality objectives.

3.40 Groundwater--Basinwide

3.40.1 Application (Resolution No. 72-14). This Article shall apply to the groundwater of the Delaware River Basin.

3.40.2 Description (Resolution No. 72-14). Groundwater shall include all water beneath the surface of the ground.

3.40.3 Water Uses (Resolution No. 72-14).

A. The quality of groundwater shall be maintained in a safe and satisfactory condition, except where such uses are precluded by natural quality, for use as:

1. domestic, agricultural, industrial, and public water supplies;

2. a source of surface water suitable for recreation, wildlife, fish and other aquatic life.

B. Other uses may be designated by the Commission.

3.40.4 Groundwater Quality Objectives.

A. Limits (Resolution No. 72-14). The groundwaters of the basin shall not contain substances or properties attributable to the activities of man in concentrations or amounts sufficient to endanger or preclude the water uses to be protected.

1. within this requirement, the groundwaters shall be free from substances or properties in concentrations or combinations which are toxic or harmful to human, animal, plant, or aquatic life, or that produce color, taste, or odor of the waters.

2. concentrations at any point shall not be degraded by the activities of man to exceed values specified by current U. S. Public Health Service Drinking Water Standards.

B. Nondegradation of groundwaters (Resolution No. 72-14). It is the policy of the Commission to prevent degradation of groundwater quality. In implementing this policy, the Commission will require the best water management determined to be practicable. No quality change will be considered which, in the judgment of the Commission, may be injurious to any designated present or future ground or surface water use.

3.40.5 Groundwater Quality Control

A. Controls (Resolution No. 72-14). The processing, handling, transportation, disposal, storage, excavation or removal of any solid, liquid, or gaseous material on or beneath the ground surface of the Basin shall be conducted in such manner and with such facilities, in accordance with such regulations and requirements as the Commission may prescribe, as to prevent any of the criteria or requirements of this Article from being violated.

B. Limitations (Resolution No. 72-14).

1. no substances or properties which are in harmful or toxic concentrations or that produce color, taste, or odor of the water shall be permitted or induced by the activities of man to become groundwater.

2. heat discharges which may adversely affect groundwater shall be regulated by the Commission.

3. notwithstanding any other criteria or requirements of this Article, the Commission may establish requirements, conditions, or prohibitions which, in its judgment, are necessary to protect groundwater quality.

4. certain activities otherwise prohibited by paragraph (A) of this section, such as approved solid or liquid waste disposal systems or fertilizer applications for farming practices, may be permitted subject to such requirements as may be prescribed.

3.50 Regional requirements (Resolution No. 68-6). It shall be the policy of the Commission to promote and encourage planning for regional solutions to water pollution problems. The use of regional water pollution control facilities providing optimum combinations of efficiency, reliability and service area will be required throughout the Delaware River Basin to the maximum extent feasible. The Commission will cooperate with industries and state, county and municipal agencies seeking a regional solution to water pollution problems. The Commission may provide planning, and, when necessary, constructing, financing and operating services required for regional solutions to water pollution problems where other appropriate agencies do not provide such services.

APPENDIX B

UNITED STATES SUPREME COURT DECREE

NEW JERSEY v. NEW YORK

347 U.S. 995 (1954)

Approved By The United States Supreme Court

June 7, 1954

United States Supreme Court Decree
New Jersey v. New York
347 U.S. 995 (1954)

Approved by the United States Supreme Court
June 7, 1954

The Court, having considered the amended petition of the City of New York, joined by the State of New York, to which is appended the consent of the State of New Jersey, the answer filed by the State of New Jersey seeking affirmative relief and the answers filed by the Commonwealth of Pennsylvania and the State of Delaware, the evidence and exhibits adduced by the parties, and the report of Kurt F. Pantzer, Esquire, Special Master, and being fully advised in the premises, now enters the following order:

I. REPORT OF SPECIAL MASTER APPROVED. The "Report of the Special Master Recommending Amended Decree", filed May 27, 1954, is in all respects approved and confirmed.

II. 1931 DECREE SUPERSEDED. The decree of this Court entered May 25, 1931 (283 U. S. 805) is modified and amended as hereinafter provided and, upon the entry of this amended decree, the provisions of the decree of May 25, 1931, shall be of no further force and effect.

III. DIVERSIONS BY THE CITY OF NEW YORK ENJOINED EXCEPT AS HEREIN AUTHORIZED. The State and City of New York are enjoined from diverting water from the Delaware River or its tributaries except to the extent herein authorized and upon the terms and conditions herein provided.

A. Authorized Diversions.

1. 440 M.G.D. The City of New York may divert from the Delaware River watershed to its water supply system the equivalent of 440 million gallons daily (m.g.d.) until the City completes and places in operation its reservoir presently under construction on the East Branch of the Delaware River.

2. 490 M.G.D. After the completion and commencement of operation of the East Branch reservoir, the City may divert the equivalent of 490 m.g.d. until the completion of its proposed dam and reservoir at Cannonsville on the West Branch of the Delaware River, provided, however, that in the event of an abnormal or unforeseeable interruption of its facilities, the City may divert in excess of the equivalent of 490 m.g.d. to meet its emergency requirements, but in no event shall such diversion impair the obligation of the City to make the releases hereinafter specified.

3. 800 M.G.D. After the completion of the Cannonsville reservoir, the City may divert the equivalent of 800 m.g.d.

4. Computation of Diversion. At no time during any twelve-month period, commencing June 1, shall the aggregate total quantity diverted, divided by the number of days elapsed since the preceding May 31, exceed the applicable permitted rate of diversion.

B. Conditions and Obligations Imposed in Connection With Diversions and Releases by City. The diversions and releases by the City of New York from the Delaware River shall be made under the supervision and direction of the River Master, hereinafter appointed, and shall be subject to the following conditions and obligations:

1. Compensating Releases—The Montague Formula. The City shall release water from its reservoirs as follows:

(a) Until the East Branch reservoir is completed and placed in operation, on the day following each day in which the average flow in the Delaware River falls short of 0.50 cubic foot per second per square mile (c.s.m.), either at Montague, New Jersey (below the mouth of the Neversink River), or at Trenton, New Jersey (0.50 c.s.m. being equivalent to a flow of 1740 cubic feet per second (c.f.s.) at Montague and 3400 c.f.s. at Trenton), the City shall release water from the Neversink reservoir at an average of 0.66 c.s.m. or 61.38 c.f.s.

(b) Upon the completion and placing in operation of the Neversink and East Branch reservoirs, the City shall release water from one or more of its storage reservoirs in the upper Delaware watershed. Such releases shall be in quantities designed to maintain a minimum basic rate of flow at the gaging station of the United States Geological Survey (U.S.G.S.) at Montague of 1525 c.f.s. (985.6 m.g.d.) until the Cannonsville project is completed and its reservoir first filled to the extent that 50 billion gallons above the lowest outlet are available for diversion and release, and of 1750 c.f.s. (1131.1 m.g.d.) thereafter. Compliance by the City with directions of the River Master with respect to such releases shall be considered full compliance with the requirements of this subsection (b).

(c) At the commencement of the calendar year following the completion and placing in operation of the Neversink and East Branch reservoirs and of each calendar year thereafter, the City of New York shall estimate and report to the River Master the anticipated consumption of water during such year to be provided for by the City from all its sources of supply. The City shall, as hereinafter provided, release in the aggregate from all its storage reservoirs in the upper Delaware watershed, in addition to the quantity of water required to be released for the purpose of maintaining the then applicable minimum basic rate of flow as hereinabove provided, a quantity of water equal to 83 per cent of the amount by which the estimated consumption during such year is less than the City's estimate of the continuous safe yield during such year of all its sources obtainable without pumping. In any such year the

City's estimate of anticipated consumption shall not exceed by more than $7\frac{1}{4}$ billion gallons the actual consumption in any previous calendar year; and its safe yield in any such year, obtainable without pumping, shall be estimated at not less than 1355 m.g.d. after the Neversink and East Branch reservoirs are put into operation; and at not less than 1665 m.g.d. after the Cannonsville reservoir is put into operation. If, at any time after the completion of the Cannonsville reservoir and prior to the year 1993, the continuous net safe yield for water supply of all of the City's sources of water supply, obtainable without pumping, is increased by the development of additional sources, such greater safe yield shall be used in determining the excess releases.

(d) The City of New York shall release the excess quantity provided for in subsection (c) at rates designed to release the entire quantity in 120 days. Commencing with the fifteenth day of June each year, the excess releases shall continue for as long a period, but not later than the following March 15, as such additional quantity will permit. Such period is hereinafter referred to as the "seasonal period". The excess quantity required to be released in any seasonal period shall in no event exceed 70 billion gallons. In releasing the excess quantity specified for any seasonal period, the City shall not be required to maintain a flow at Montague greater than the applicable minimum basic rate plus the excess quantity divided by 120 days, or in any event greater than 2650 c.f.s., nor to release at rates exceeding the capacity of its release works. The City shall in each seasonal period continue its excess releases until March 15 or until the aggregate quantity of the flow at Montague in excess of the basic rate or in excess of such higher rates as are not the result of the City's prior releases, is equal to the total specified excess quantity.

(e) The terms and conditions provided in subsections (b), (c) and (d) hereof shall continue to be applicable in all respects in the event that the U.S.G.S. gaging station at Montague shall be relocated at a point below the confluence of the Neversink River with the Delaware River.

2. Minimum Capacity of Release Works at Reservoirs of City. In constructing the Cannonsville reservoir, the City shall install release works of such capacity as will provide a minimum aggregate release capacity from all its reservoirs in the Delaware River watershed of not less than 1600 c.f.s. under conditions of maximum reservoir depletion.

3. Releases to be Continued in Spite of Interference. In the event that any works hereafter constructed by public or private interests in the watershed of the Delaware River outside of the State of New York shall prevent the proper operation of the U.S.G.S. gaging station at Montague or interfere with the effective operation of the above release requirements by diverting water past the station or by intercepting the natural flow and storing it in reservoirs with an aggregate storage capacity in excess of 25 billion gallons, the City of New York shall continue to make the releases above specified which would be required in the absence of such interference, and appropriate gaging stations shall be established for that purpose.

4. Inspection Permitted. The States of New Jersey and Delaware and the Commonwealth of Pennsylvania, through accredited representatives, and the River Master, shall at all reasonable times have the right to inspect the dams, reservoirs and other works constructed by the City of New York, to inspect the diversion areas and the inflow, outflow and diverted flow of such areas, to inspect the meters and other apparatus installed by the City of New York and to inspect all records pertaining to inflow, outflow and diverted flow.

IV. TREATMENT OF PORT JERVIS SEWAGE. The effluent from the sewage treatment plant at the City of Port Jervis, New York, shall be treated so as to effect a reduction of 85 per cent in the organic impurities and shall be treated with a chemical germicide, or otherwise, so that the B. coli originally present in the sewage shall be reduced by 90 per cent. Untreated industrial waste from plants in the City of Port Jervis shall not be allowed to enter the Delaware and Neversink Rivers. The treatment of such industrial wastes shall be such as to render the effluent practically free from suspended matter and nonputrescent. The treatment of both sewage and industrial waste shall be maintained so long as any diversion is made from the Delaware River or its tributaries.

V. DIVERSIONS BY NEW JERSEY AUTHORIZED UNDER SPECIFIED CONDITIONS.

A. Authorized Diversions. The State of New Jersey may divert outside the Delaware River watershed, from the Delaware River or its tributaries in New Jersey, without compensating releases, the equivalent of 100 m.g.d., if the State shall not, prior to July 1, 1955, repeal Chapter 443 of the New Jersey Laws of 1953, and if, when the Commonwealth of Pennsylvania accepts the conditions as specified in Section 19 of that Chapter, the State of New Jersey shall join with the Commonwealth of Pennsylvania in requesting the consent of Congress to the agreement embodied in Chapter 443 of the New Jersey Laws of 1953 and an Act of the Commonwealth of Pennsylvania accepting the conditions of such New Jersey Act.

B. Conditions and Obligations Imposed in Connection with Diversions by New Jersey. The diversions by New Jersey from the Delaware River shall be made under the supervision of the River Master and shall be subject to the following conditions and obligations:

1. Until the State of New Jersey builds and utilizes one or more reservoirs to store waters of the Delaware River or its tributaries for the purpose of diverting the same to another watershed, the State may divert not to exceed 100 m.g.d. as a monthly average, with the diversion on any day not to exceed 120 million gallons.

2. If and when the State of New Jersey has built and is utilizing one or more reservoirs to store waters of the Delaware River or its tributaries for the purpose of diversion to another watershed, it may withdraw water from the Delaware River or its tributaries into such impounding reservoirs without limitation except during the months of July, August, September and October of any year, when not more than 100 m.g.d. as a monthly average and not more than 120 million gallons in any day shall be withdrawn.

3. Regardless of whether the State of New Jersey builds and utilizes storage reservoirs for diversion, its total diversion for use outside of the Delaware River watershed without compensating releases shall not exceed an average of 100 m.g.d. during any calendar year.

VI. EXISTING USES NOT AFFECTED BY AMENDED DECREE. The parties to this proceeding shall have the right to continue all existing uses of the waters of the Delaware River and its tributaries, not involving a diversion outside the Delaware River watershed, in the manner and at the locations presently exercised by municipalities or other governmental agencies, industries or persons in the Delaware River watershed in the States of New York, New Jersey and Delaware and the Commonwealth of Pennsylvania.

VII. RIVER MASTER.

A. Designation. Subject to the concurrence of the Director of the U. S. Geological Survey, the Chief Hydraulic Engineer of the U. S. Geological Survey, or such other engineer of the U. S. Geological Survey as shall at any time be designated by the Chief Hydraulic Engineer, is hereby designated as River Master.

B. Duties. The River Master shall either in person or through his assistants possess, exercise and perform the following duties and functions:

1. General Duties.

(a) Administer the provisions of this decree relating to yields, diversions and releases so as to have the provisions of this decree carried out with the greatest possible accuracy;

(b) Conserve the waters in the river, its tributaries and in any reservoirs maintained in the Delaware River watershed by the City of New York or any which may hereafter be developed by any of the other parties hereto;

(c) Compile and correlate all available data on the water needs of the parties hereto;

(d) Check and correlate the pertinent stream flow gagings on the Delaware River and its tributaries;

(e) Observe, record and study the effect of developments on the Delaware River and its tributaries upon water supply and other necessary, proper and desirable uses; and

(f) Make periodic reports to this Court, not less frequently than annually, and send copies thereof to the Governors of Delaware, New Jersey, New York and Pennsylvania and to the Mayor of the City of New York.

2. Specific Duties with Respect to the Montague Release Formula. In connection with the releases of water which the City of New York is required to make under Par. III-B-1(b) of this decree, the River Master, in co-operation with the City of New York, shall, by appropriate observation and estimates, perform the following duties:

(a) Determine the average times of transit of the flow between the release works of the several reservoirs of the City and Montague and between the release works of other storage reservoirs in the watershed and Montague;

(b) Make a daily computation of what the average flow observed on the previous day at Montague would have been, except for that portion previously contributed by releases of the City or as affected by the contributing or withholding of water at other storage reservoirs, for the purpose of computing the volume of water that would have had to be released in order to have maintained precisely the basic rate on that day;

(c) Take account of all changes that can be anticipated in the flow from that portion of the watershed above Montague not under the City's control and allow for the same by making an appropriate adjustment in the computed volume of the daily release; and

(d) After taking into consideration (a), (b) and (c), direct the making of adjusted daily releases designed to maintain the flow at Montague at the applicable minimum basic rate.

C. Distribution of Costs. The compensation of, and the costs and expenses incurred by, the River Master shall be borne equally by the State of Delaware, State of New Jersey, Commonwealth of Pennsylvania, and the City of New York.

D. Replacement. In the event that for any reason the Chief Hydraulic Engineer of the U.S.G.S. or his designee cannot act as River Master, this Court will, on motion of any party, appoint a River Master and fix his compensation.

VIII. NO PRIOR APPROPRIATION NOR APPORTIONMENT. No diversion herein allowed shall constitute a prior appropriation of the waters of the Delaware River or confer any superiority of right upon any party hereto in respect of the use of those waters. Nothing contained in this decree shall be deemed to constitute an apportionment of the waters of the Delaware River among the parties hereto.

IX. DECREE WITHOUT PREJUDICE TO THE UNITED STATES. This decree is without prejudice to the United States. It is subject to the paramount authority of Congress in respect to commerce on navigable waters of the United States; and it is subject to the powers of the Secretary of the Army and Chief of Engineers of the United States Army in respect to commerce on navigable waters of the United States.

X. RETENTION OF JURISDICTION; NO ESTOPPEL. Any of the parties hereto, complainant, defendants or intervenors, may apply at the foot of this decree for other or further action or relief, and this Court retains jurisdiction of the suit for the purpose of any order or direction or modification of this decree, or any supplemental decree that it may deem at any time to be proper in relation to the subject matter in controversy. The fact that a party to this cause has not filed exceptions to the report of the Special Master or to the provisions of this decree shall not estop such party at any time in the future from applying for a modification of the provisions of this decree, notwithstanding any action taken by any party under the terms of this decree.

XI. COSTS OF THIS PROCEEDING. The costs of this proceeding shall be paid by the parties in the following proportions: State of New Jersey 26 2/3 per cent, City of New York, 26 2/3 per cent, State of New York, 10 per cent, Commonwealth of Pennsylvania, 26 2/3 per cent, and State of Delaware, 10 per cent.

Respectfully submitted,

Kurt F. Pantzer,
Special Master,