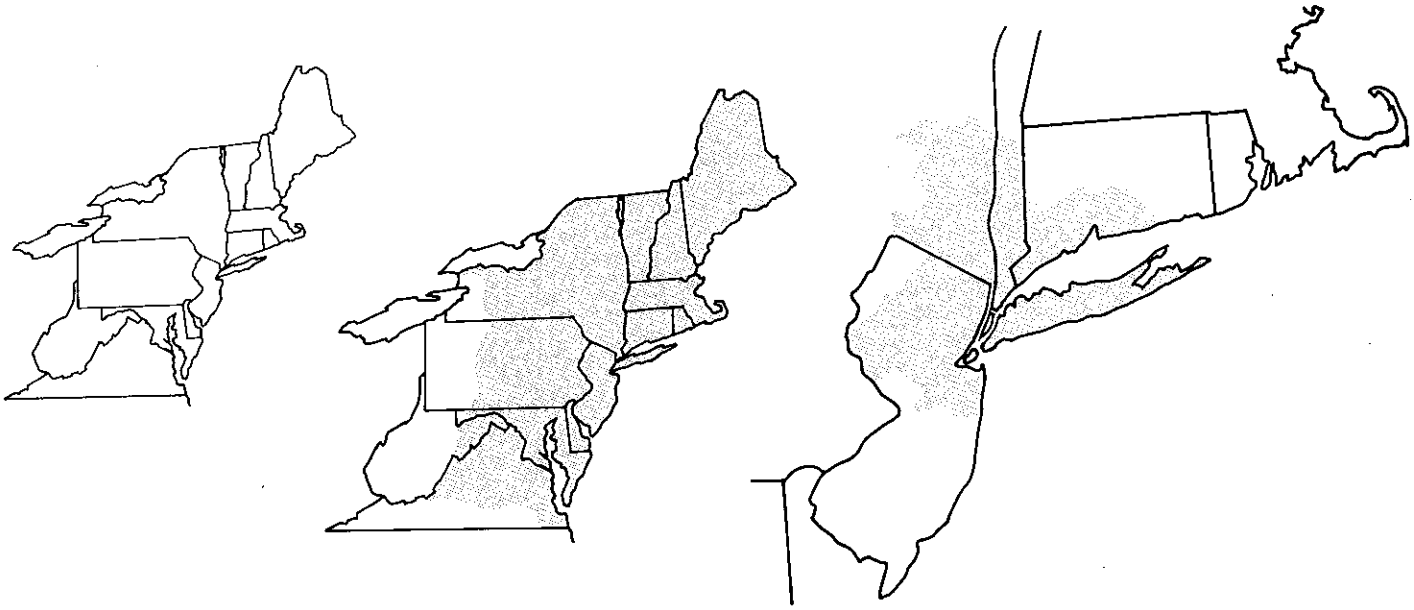
NORTHEASTERN UNITED STATES WATER SUPPLY STUDY

WATER SUPPLY: WASTEWATER MANAGEMENT ASPECTS FOR NORTHERN NEW JERSEY - NEW YORK CITY - WESTERN CONNECTICUT METROPOLITAN AREA



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NORTH ATLANTIC DIVISION, CORPS OF ENGINEERS
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NOTICE

This report is one in a series of studies to be undertaken in connection with the Northeastern United States Water Supply Study authorized under Public Law 89-298, and assigned to the Division Engineer, North Atlantic Division, U.S. Army Corps of Engineers, for accomplishment.

The report surveys wastewater legislation, reviews each state's wastewater management program, existing water quality and future water quality of potential potable water sources in the study area. It examines wastewater management programs in specific areas as a means of protecting water quality and enhancing water yield through water recovery, reuse, or proper management. The report evaluates the possibility of using treated wastewater as a supplemental water supply source. Preliminary cost estimates of selected wastewater management programs are developed. Finally, a review of wastewater technology as it applies to a management program is presented to include wastewater treatment, wastewater reuse, land orientated systems and problems caused by specific contaminants.

The wastewater programs and policies described in this report are being appropriately considered in the study of regional water supply for the northern New Jersey-New York City-western Connecticut metropolitan region.

DEPARTMENT OF THE ARMY
NORTH ATLANTIC DIVISION, CORPS OF ENGINEERS

WATER SUPPLY
WASTEWATER MANAGEMENT ASPECTS
FOR
NORTHERN NEW JERSEY NEW YORK CITY
WESTERN CONNECTICUT
METROPOLITAN AREA

CONTRACT NO. DACW 52-73-C-006

JUNE 1973

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June 29, 1973

Maj. Gen. R. H. Groves
Division Engineer
North Atlantic Division
Corps of Engineers
Department of the Army
90 Church Street
New York, New York 10007

Dear General Groves:

RE: Contract No. DACW 52-73-C-0006

In accordance with the terms and conditions of the referenced contract, we have conducted a survey of the existing legislation, programs, water quality and future water quality conditions of water supply sources of the study area and developed specific wastewater management programs to protect or enhance the quality of alternative water supply sources which may be utilized to meet the projected needs of the Northern New Jersey-New York City-Western Connecticut Metropolitan Area.

Development of the specific wastewater management programs is based mostly on existing published data and is presented at a low level of detail. We believe the results of this study will complement previously developed projects and programs, and can be considered along with the institutional and environmental factors and with studies currently underway, in the selection process to determine which programs merit further study in depth.

We would like to acknowledge the cooperation of the North Atlantic Division, Corps of Engineers staff during the execution of the project.

Respectfully submitted,

NEBOLSINE, TOTH, McPHEE ASSOCIATES

Arnold R. Smith

Arnold R. Smith

The earth also is defiled under the inhabitants thereof; because they have transgressed the laws, changed the ordinances, broken the everlasting covenant.

Isaiah 24:5

PREFACE

NORTHEASTERN UNITED STATES WATER SUPPLY STUDY (NEWS)

During the major drought in the northeastern part of the United States in the early 1960's, the Congress recognized that the Federal Government had a major role to play in the solution of water supply problems.

The 89th Congress enacted Public Law 89-298 on October 27, 1965. Title I thereof authorized the Secretary of the Army, acting through the Chief of the Army Corps of Engineers, to cooperate with the various Federal, state, and local agencies in the preparation of plans to meet the long-term water needs of the northeastern United States. (A copy of the Title I legislation is shown on page xii.)

Specific features of the legislation related to this study include the provision that the plans developed "may provide for the construction, operation and maintenance by the United States of a system of major reservoirs" and that "such plans shall provide for appropriate financial participation by the states, political subdivisions thereof, and other local interests."

Under authorization of this Act, the Corps of Engineers, North Atlantic Division, has established a NEWS Study Group, which has conducted a series of studies to determine the water supply needs of the area, to identify alternative water supply projects to meet these needs, and to identify institutional and cost-sharing options relative to Federal, state, and local efforts required for the implementation of the water supply projects.

The following report examines the wastewater management aspects of water supply pertaining to the New York-New Jersey-Connecticut part of the study area.

Public Law 89-298
89th Congress, S. 2300
October 27, 1965

An Act

Authorizing the construction, repair, and preservation of certain public works on rivers and harbors for navigation, flood control, and for other purposes.

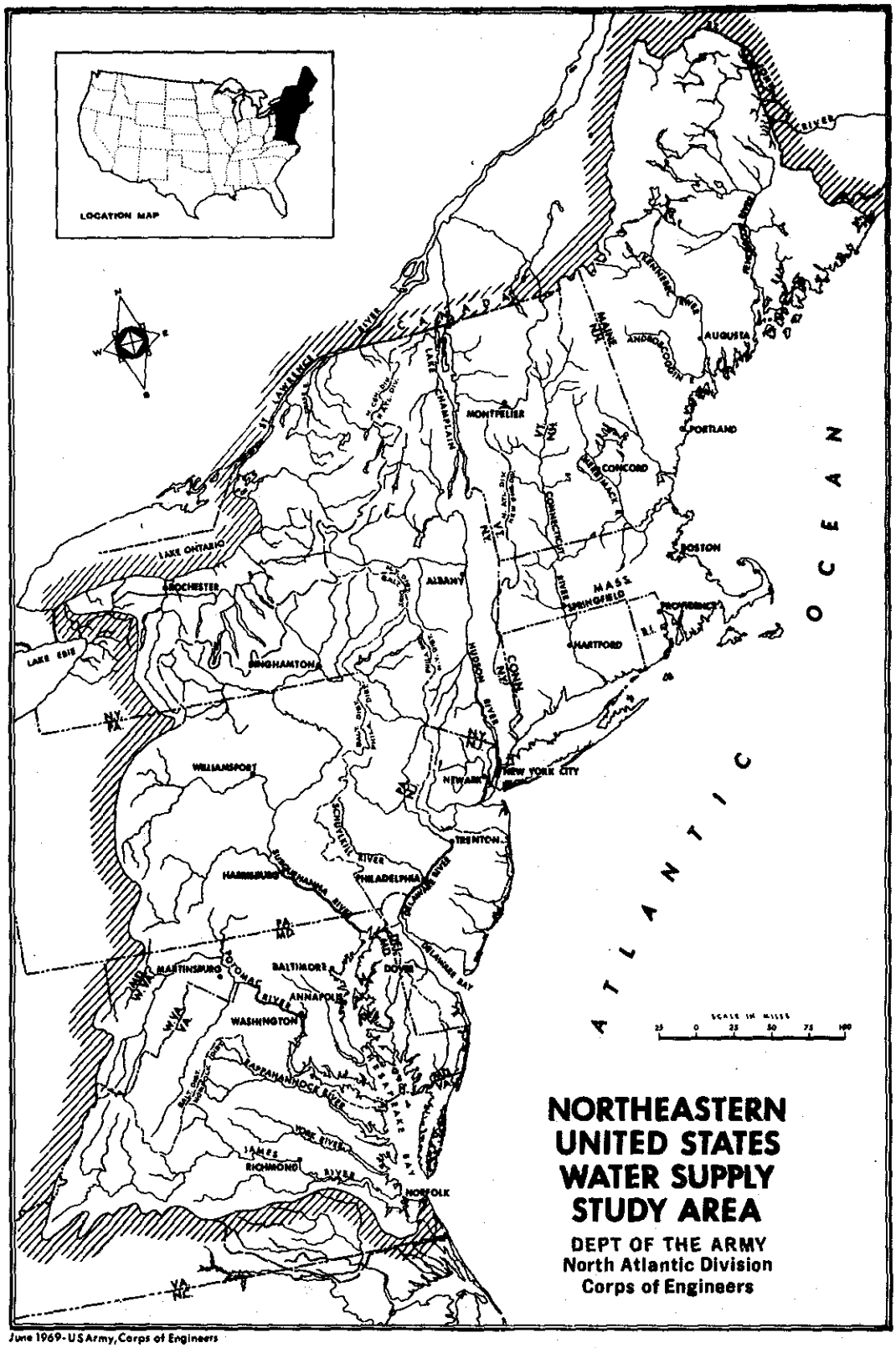
Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

TITLE I—NORTHEASTERN UNITED STATES WATER SUPPLY

SEC. 101. (a) Congress hereby recognizes that assuring adequate supplies of water for the great metropolitan centers of the United States has become a problem of such magnitude that the welfare and prosperity of this country require the Federal Government to assist in the solution of water supply problems. Therefore, the Secretary of the Army, acting through the Chief of Engineers, is authorized to cooperate with Federal, State, and local agencies in preparing plans in accordance with the Water Resources Planning Act (Public Law 89-80) to meet the long-range water needs of the northeastern United States. This plan may provide for the construction, operation, and maintenance by the United States of (1) a system of major reservoirs to be located within those river basins of the Northeastern United States which drain into the Chesapeake Bay, those that drain into the Atlantic Ocean north of the Chesapeake Bay, those that drain into Lake Ontario, and those that drain into the Saint Lawrence River, (2) major conveyance facilities by which water may be exchanged between these river basins to the extent found desirable in the national interest, and (3) major purification facilities. Such plans shall provide for appropriate financial participation by the States, political subdivisions thereof, and other local interests.

(b) The Secretary of the Army, acting through the Chief of Engineers, shall construct, operate, and maintain those reservoirs, conveyance facilities, and purification facilities, which are recommended in the plan prepared in accordance with subsection (a) of this section, and which are specifically authorized by law enacted after the date of enactment of this Act.

(c) Each reservoir included in the plan authorized by this section shall be considered as a component of a comprehensive plan for the optimum development of the river basin in which it is situated, as well as a component of the plan established in accordance with this section.



June 1969-US Army, Corps of Engineers

PURPOSE AND SCOPE

This report was prepared under contract with the North Atlantic Division, U. S. Army Corps of Engineers as part of the Northeastern United States Water Supply Study (NEWS). The report is a preliminary survey of legislation, programs, existing water quality and future water quality of potential potable water sources in the study area; and to examine wastewater management programs in specific areas as a means of protecting water quality and possibly enhancing water yield through wastewater recovery or reuse.

The results reflect the contractor's judgment and are presented by the Corps of Engineers for public information as a means of more fully exploring alternatives and judging potentials for the development of safe, adequate regional water supplies. The contents of the report are neither advocated or proposed in whole or in part by the Corps of Engineers.

The scope of the work includes the gathering of information relating to water quality, wastewater management and legislation in the New York, New Jersey, Connecticut Metropolitan area. Included in the scope, where applicable, is the determination of the type of wastewater management plan required to protect threatened water sources and the development of feasibility cost estimates for wastewater reuse.

Specifically, the scope of the report concentrates on the following areas:

1. Evaluation of the use of treated wastewater as a supplemental water supply source.

2. Evaluation of the relative benefits of small treatment plants vs. larger regional treatment plants.

3. Development of wastewater management programs for Long Island to enhance groundwater aquifer yields.

4. Determination of the type of wastewater management program needed to enhance the yield of the Passaic River, at Little Falls, New Jersey.

5. Evaluation of the possible effects of introducing treated Hudson River water and Long Island groundwater into New York City's Water Supply.

6. Determination of the effects of Hudson River high flow skimming and other water withdrawals on the salt water estuary and location of the salt water wedge.

7. Development of preliminary cost estimates for selected wastewater management programs. (ENR Index of 1400 is used to facilitate comparison to other "NEWS" studies.)

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I. INTRODUCTION

A. WASTEWATER AS A RESOURCE

There is a finite amount of water on the earth. The amount of potable water is relatively small in comparison to the fresh water stored in polar ice caps and to the vast quantities of relatively useless ocean water. Available water is constantly being replenished by precipitation which in turn is supported by water evaporated from the earth's surface or transpired by the flora and fauna.

In a smaller area, such as a river basin, there is also a finite amount of water. The actual amount of water varies annually and as stream flow and precipitation records extend back only 50 or 60 years in most cases, no one can say for certain what is the least amount of water that will be available, say in the next 100 years. The drought of 1961-1966 brought attention to the precious nature of water and to the fact that it is not limitless.

When large scale municipal water works were first constructed, they usually consisted of a large dam to impound water and a transmission line to convey it to the center of population. These water works were constructed to provide water for many years in the future and thus at the beginning, water was abundant and rates were set to encourage use - the more water used, the lower the charge per unit. Unfortunately, people were ingrained with the philosophy that water was cheap and was theirs for the asking. Perhaps it should have been sold by the pound. A rate of, say, 50¢ per thousand gallons means one is getting 8,340 pounds, or over four tons for half a dollar. It is truly a bargain.

But the situation has changed. Some highly developed areas don't have all the pure water they need now and many others will find shortages within the next few years. Water that coursed down a river may have been used once and then discarded, perhaps pumped out of the basin so the supply along the stream was always clean. But we can no longer afford to do this. The used water must be treated such that it can be discharged into the stream and safely reused by a municipality or industry downstream. Wastewater must be husbanded today in the same manner as pure water was previously.

In all the literature, there are many references to direct reuse of wastewater and no author recommends it. Most claim there are too many unknowns - virus and bacteria content, unknown industrial wastes, etc. Yet many people have been drinking renovated water and are not aware of it. In New Jersey, it is estimated that the Passaic Valley Water Commission has a raw water supply that is some 41% treated or partially treated sewage in dry years. If the tributary area is further developed, this percentage will undoubtedly increase, and without this water resource, the Commission would not have enough water. The same situation exists in other areas.

Thus wastewater is a resource in the New York Metropolitan area and it will have to be considered as such. If it is discharged into a stream, it will have to be treated so it can be used again downstream. The possibility also exists for pumping treated wastewater upstream for discharge and eventual reuse downstream. On the other hand, it may be used for non-potable uses, such as cooling and process water in some industries. This will have the effect of decreasing the potable water demand and in effect, increasing the supply for other uses.

With appropriate treatment, wastewater may be used to satisfy many industrial, agricultural and recreational water needs. Although at the present time it is not recommended to be used directly for potable water supplies, it may be used to indirectly enhance water supplies by providing salt water intrusion barriers in groundwater systems and recharging groundwater via surface basins or well recharge methods. The use of wastewater in agriculture and industry will conserve water of potable quality, which would otherwise be used for many lower quality requirement purposes. Many examples of industrial wastewater use are available including use as cooling water and process waters. Irrigation of agricultural land with reclaimed wastewater not only conserves water, but may have a fertilizer value due to the presence of nutrients in wastewater. Wastewater has already been reclaimed for recreational uses including water sports, fishing and aesthetically appealing purposes such as raising water levels in dried up streams and lakes. The waste sludge produced as a result of wastewater treatment has been used for landfills and construction materials.

Perhaps a more far-reaching effect of wastewater reuse is its potential to greatly affect land management,

population growth and industrialization. For example, reclamation of land with wastewater sludges can make land available for development. Moreover, the placement of wastewater treatment plants and the quality of effluent they produce will affect the development of population and industrial growth patterns in a given area; i.e., the placement of sewer interceptor mains will affect population growth along a given line. The availability of cheap process and cooling water and availability of industrial wastewater treatment facilities will greatly affect industrial growth. Formation of recreational lakes will make an area attractive to vacationers, while the use of reclaimed wastewater irrigation for agricultural lands will preclude the development of land for other purposes, for any decided period of time.

The combinations of any of the aforementioned options constitute a wastewater management program. In the area of study, the potential for wastewater reuse exists, and the optimum management of wastewater to protect and enhance present and potential pure water supplies is mandatory.

Historically most reports have covered either water supply or wastewater management in general, without regard to the effect of one or the other. This report is a beginning, an attempt to tie both together, relying heavily on existing reports and a limited amount of direct contact with involved officials.

B. STUDY AREA

The area of study for the report includes the following counties: (Figure I-1)

New Jersey: Bergen, Essex, Hudson, Hunterdon, Middlesex, Monmouth, Morris, Passaic, Somerset and Union Counties.

New York: Dutchess, Nassau, Orange, Putnam, Rockland, Suffolk, Ulster and Westchester Counties, and New York City.

Connecticut: Fairfield and New Haven Counties, and that part of Middlesex County west of the Connecticut River.

STUDY AREA

FIGURE I-1

C. STATEMENT OF THE PROBLEM

Within the study area there are water quality problems in existing water supply sources. The acuity of the problem is accentuated by the fact that the entire study area is expected to grow to the point where existing water supplies and the potential of presently developed water supplies will fall short of water demands. The potential sources needed to supply the future demands also have water quality problems.

An integrated wastewater-water management program is needed to best satisfy the demands now and in the future for water supply. The wastewater management part of the program is concerned with the following:

1. Protection of existing and potential water supplies.

2. Supplementing water supply through wastewater reuse.

3. Assuring the quality of the total water resource through all phases of use including its ultimate return to the environment.

In order to forumlate a wastewater management program, the water sources with present or potential problems must be identified, and the sources of pollution must be identified. Wastewater reuse must be evaluated from the standpoint of available technology, potential uses in the study area, and public health. In the development of a wastewater management program, the legal and institutional framework, federal, state and local, must be studied. Identification of management programs underway should be evaluated to determine the need for new programs.

In the study area, illustrative regional programs for water supply supplementation include the use of Hudson River water and Long Island ground water. The management of wastewater will be important in these areas as will be the effects of using these sources upon existing better quality sources.

D. THE NEED FOR INCREASED WATER SUPPLY

1. Population and Growth

The present and future population forecast of the study area is summarized in Table I-1. Population

TABLE I-1

PRESENT AND ESTIMATED FUTURE POPULATION OF THE STUDY AREA

	Population in Thousands			
	Present	1980	2000	2020
New Jersey	4,846.0	5,784.0	7,652.0	9,677.3
New York	11,945.0	13,365.4	15,604.2	18,293.0
Connecticut	1,522.0	1,897.0	2,555.0	3,085.0
Total	18,313.0	21,046.4	25,811.2	31,055.3

SOURCE: Metcalf & Eddy, Hazen & Sawyer, "Alternative Regional Water Supply Plans for Northern New Jersey - New York City - Western Connecticut Metropolitan Area", Nov. 1971

densities vary from 26,600 persons per square mile in New York City and 13,000 persons per square mile in Hudson County; to between 1,930 and 7,420 in the nearby suburban counties; and to only a few hundred persons per square mile in the more remote portions of New Jersey and New York.

2. Water Consumption

Water consumption at present, based on water utility data, is presented in Table I-2. At present, industry in the study area depends mostly on public water supply, with some 200 MGD provided by company-owned industrial supplies, mainly for cooling purposes. Estimated future demands, based on population and industrial growth are presented in Table I-3.

3. Water Supply

There are some 500 water supplies including municipal systems, water districts, and investor-owned water companies serving the study area. The largest supplier is the New York City water system, with an average water production of about 1400 MGD or over 65 percent of the total produced by the combined water system in the study area. Except on Long Island and in parts of New Jersey, the principal source of water supply is from rivers or from impounded streams.

The average output of present water supply systems in the study area is listed in Table I-4. Since most of the water supplies operated at capacity during the recent drought, the average production and the safe yield of the systems are much the same, and only a few systems have any capacity to spare. Local surface resources in much of the study area have either been appropriated or have been contaminated beyond use. Metcalf & Eddy, et al (Joint Venture Report) have estimated the quantity of water supply that can be obtained by economically expanding present sources (Table I-4). These figures are based on estimates by some of the larger water utilities in the study area.

It can be seen that by 1980 all three areas will have water demand surpassing the safe yield. This problem is well recognized and may be resolved either by regional project participation or by means of an undeveloped local water resource. Table I-5 presents the quantity of water supply

TABLE I-2

PRESENT WATER CONSUMPTION IN THE STUDY AREA

Total Consumption, MGD

Study Area	Non-Industrial	Industrial	Total
New Jersey	516	110	626
New York	1,141	342	1,483
Connecticut	149	63	212
Total Study Area	1,806	515	2,321

Per Capita Consumption, GPD

Study Area	Non-Industrial	Industrial
New Jersey	110	23
New York	98	29
Connecticut	108	46
Weighted Average - Study Area	102	29

SOURCE: Metcalf & Eddy and Hazen & Sawyer, "Alternative Regional Water Supply Plans for Northern New Jersey - New York City - Western Connecticut Metropolitan Area" Nov. 1971

TABLE I-3

ESTIMATED FUTURE WATER DEMANDS

Total Consumption, MGD

	1980	2000	2020
New Jersey	848	1,219	1,666
New York	2,019	2,445	2,996
Connecticut	286	417	546
Total	3,153	4,081	5,208

Per Capita Consumption, GPD

	1980	2000	2020
New Jersey	150	162	175
New York	154	160	167
Connecticut	165	176	187
Weighted Average Study Area	154	161	171

SOURCE: Metcalf & Eddy and Hazen & Sawyer, "Alternative Regional Water Supply Plans for Northern New Jersey - New York City - Western Connecticut Metropolitan Area" Nov. 1971

TABLE I-4

WATER SUPPLY AVAILABLE FROM DEVELOPED SITES

	Average Output of Present Water Supply Systems MGD	Safe Yield MGD	Potential Safe Yield MGD
New Jersey	626	767	893
New York	1,483	1,888	2,151
Connecticut	212	262	320
Total	2,321	2,917	3,364

SOURCE: Metcalf & Eddy, Hazen & Sawyer, "Alternative Regional Water Supply Plans for Northern New Jersey - New York City - Western Connecticut Metropolitan Area", Nov. 1971

estimated (Joint Venture Report) to be developed in regional systems to meet future demands, with the assumption that five counties would be served by local resources through the year 2020.

E. AVAILABLE INFORMATION

Most of the information for this report was gathered from existing reports and from limited interviews with persons involved in water supply and wastewater management in the area. There has been a tremendous interest in wastewater management in the last few years, including recharge, reuse, reclamation, etc. and a corresponding increase in research and the number of papers and reports written on the subject. The drought of 1961-1966 was the severest of record in the area and thus made obsolete many predictions and recommendations in the older reports. Thus the date of a report was important and many that were published before 1967 were of diminished value. For example, predictions of safe yield which were the basis of future water supply developments are now outdated. The need for developing regional supplies is now more apparent. Additionally, recent problems in water pollution have rendered potentially available water supplies unusable. The new legislation pertaining to wastewater requires a change in the handling of wastewater problems.

Some recognition had to be given to the sponsor of a referenced report. For example, competition among water purveyors in Northern New Jersey is very keen, whether the companies are private or quasi-governmental. Thus a report directed to several municipalities in the area was actually sponsored by a private water company, although the name of the water company was not mentioned as the one paying for the report. Thus it took some knowledge of the reason for writing reports to interpret them correctly.

An additional problem is that the availability of water quality records and the form and extent of data analysis varies from State to State.

F. ACKNOWLEDGEMENTS

Despite pressures from their regular work, all persons contacted for information were most cooperative. In particular, the following furnished much valuable information:

TABLE I-5

ESTIMATED REGIONAL WATER SUPPLY NEEDS*

	Water Need, MGD		
	1980	2000	2020
New Jersey	120	400	820
New York	150	450	840
Connecticut	40	100	240
Total	310	950	1900

SOURCE: Metcalf & Eddy, Hazen & Sawyer, "Alternative Regional Water Supply Plans for Northern New Jersey - New York City - Western Connecticut Metropolitan Area" Nov. 1971

* Five counties are assumed to be locally supplied through 2020:

1. Hunterdon County - could be supplied by wells and Raritan River.
2. Ulster County - supply from Hudson River or local streams.
3. Dutchess County - Hudson River and some additional upland sources.
4. Suffolk County - groundwater supply.
5. Middlesex County - from Connecticut River.

Mr. Robert Cyphers, DEP, New Jersey
Mr. John Gaston, DEP, New Jersey
Mr. Joseph Miller, DEP, New Jersey
Mr. Donald Kroeck, DEP, New Jersey
Mr. Peter Anderson, USGS, Trenton, New Jersey
Mr. Samuel Syrotinski, Department of Health, New York
Mr. Frank Flood, Nassau County, New York
Mr. John Vecchioli, USGS, Mineola, New York
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Mr. Francis M. McGowan, Supervisory Sanitary Engineer
Mr. Kyle Schilling, Project Manager
Mr. Raymond Boc, Engineer
Capt. Robert Lo Pinto, Engineer
Mr. Peter Shaw, Economist
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G. PROJECT STAFF

The project was under the direction of Arnold Smith and for various sections and at various times, the following contributed:

Mr. Walter McPhee
Mr. Irwin Rosenstein
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Mr. Harvey Moutal
Mr. Alan Simon

II. WASTEWATER MANAGEMENT

A. POLICIES

Wastewater management policies in the United States have recently undergone a change in direction. A general concern among the governmental, private and public sectors of the nation about the state of our rivers, lakes, and oceans, and the need for water pollution control has led to much study as to what can be done to reduce pollution. These studies and their attendant publicity have enlightened the public and responsible authorities to the realization that new policies were needed to efficiently meet water pollution problems. Morever, the need for a total environmental outlook was recognized, i.e. wastewater management, air pollution control, solid waste management and water supply are intimately related. Past efforts to control pollution and to develop water supply had been separate, promoting duplication of efforts in many cases, and negating many benefits that would otherwise be realized with more integrated efforts. It is the purpose, in part, of this report to examine the state of wastewater management with its specific relation to water supply, and examine new possible integrations of wastewater management and water supply in specific areas.

Nationwide policies for water pollution control are stated in the Federal Water Pollution Control Act Amendments of 1972.

The Federal legislation grew, in a large part, from a survey by the General Accounting Office (GAO) of the Federal Government which tried to assess the impact of federal monies on cleaning up the nation's waterways. The GAO found that the monies were being spent on an uncoordinated basis and there didn't seem to be adequate value received for the monies spent. On a river dividing two states, for example, one state may be concentrating on its side of the river while the other state may have concentrated on another stream far removed. Thus while something was being done, few streams were being cleaned up effectively.

This led the Federal Environmental Protection Agency (EPA) in January 1971, to require planning by river basins in contrast to the former county, or multi-county basis. The latter has been found wanting for broad planning, i.e. benefits that could be gained from natural hydrologically connected areas were not realized in politically bounded planning areas.

Subsequently, the efforts of the federal, state and local governments were integrated by virtue of the 1972 Amendments. These amendments are quite comprehensive and indicate the national priorities and goals, and state the roles of the federal government, state governments, local governments, other private and public organizations and the general public in implementing these priorities and goals.

B. FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972

1. Goals and Policy

The Amendments of 1972 have had a far reaching effect on wastewater management programs. The objective of the Amendments is expressed in Section 101a):

"The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In order to achieve this objective it is hereby declared that, consistent with the provisions of this Act-

"(1) it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985;

"(2) it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983;

"(3) it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited;

"(4) it is the national policy that Federal financial assistance be provided to construct publicly owned waste treatment works;

"(5) it is the national policy that areawide waste treatment management planning processes be developed and implemented to assure adequate control of sources of pollutants in each State; and

"(6) it is the national policy that a major research and demonstration effort be made to develop technology necessary to eliminate the discharge of pollutants into the navigable waters, waters of the contiguous zone, and the oceans."

It should be noted that the objectives set forth are goals.

Some have questioned the confidence of Congress in meeting these goals as Section 315 establishes a National Study Commission to make an investigation "of the technological aspects of achieving, and all aspects of achieving or not achieving the effluent limitations and goals set forth for 1983 . . ."

The Amendments further state that the primary responsibility shall be upon the states "to prevent, reduce, and eliminate pollution". The Federal Government will be responsible for encouraging pollution abatement programs by foreign countries and in international waters. The general public is encouraged to participate in the development of any plans and regulations.

The Act is to be administered by the Administrator of the Environmental Protection Agency (EPA).

2. Federal Role

The federal role in implementing the goals, policies, and specific items covered in the amendments are:

i. With the cooperation of state and local agencies, the Federal Government shall develop comprehensive programs to prevent, reduce, or eliminate pollution of navigable waters and ground waters. Due regard will be given to wildlife, aquatic life, recreation, etc. All planning by governmental agencies, such as the Corps of Engineers, shall give weight to storage of stream flow for stream regulation to provide additive water for treated waste discharges.

ii. EPA is authorized to establish research and surveillance programs in cooperation with the states and with other federal agencies. One research goal is to develop "Improved methods and procedures to identify and measure the effect of pollutants, including those pollutants created by new technological developments". This includes studies of thermal discharges.

iii. EPA will maintain field research laboratories in various sections of the nation. The Great Lakes are specifically mentioned as an area of concern.

iv. The Federal Government will cooperate with the states, financially, to develop pilot programs to train personnel for operation and maintenance of sewage treatment works.

v. EPA can enter into contracts for "the purpose of developing and demonstrating new and improved methods for the prevention, removal, reduction and elimination of pollution in lakes, including the undesirable effects of nutrients and vegetation". The Agency will also cooperate with the Coast Guard on studies to do with oil pollution and the removal of oil.

vi. EPA will investigate equipment to handle wastes from marine vessels, with emphasis on small recreational type vessels.

vii. EPA shall disseminate knowledge about pesticides, their effect and control on water, and study methods of release of pesticides into the environment. The Agency shall also investigate the disposal of waste oils.

viii. EPA will concentrate on studies of estuaries with respect to sedimentation, pollution, fish and wildlife, sport and commercial fishing, recreation, etc.

ix. EPA shall conduct research and investigations on the unnecessary consumption of water which in turn will reduce the amount of sewage to be treated.

x. EPA is charged with studying and researching the reduction of pollution from agricultural runoff. And in rural areas, the Agency is to investigate alternates to septic tank systems and central collection facilities where these do not work or are not feasible, respectively.

xi. EPA will make grants for research and development to investigate new methods for storm or combined sewer discharges, and advanced waste treatment for domestic sewage, and combined domestic and industrial wastes.

xii. EPA will investigate mine drainage and siltation from mining operations.

xiii. Training grants will be made to institutions of higher learning to train students for design, operation, and maintenance of sewage treatment works. Scholarships can be awarded to qualified students.

xiv. EPA shall encourage waste treatment management which results in integrating facilities for sewage treatment and recycling with facilities to treat, dispose of, or utilize other industrial and municipal wastes, including but not limited to solid waste and waste heat and thermal discharges.

xv. EPA is charged with setting industrial waste effluent limitations for point sources other than publicly owned treatment facilities. These will be based on classes of industry and take into account the best available technology and the normal effluent to be expected from a typical industrial plant.

xvi. EPA must establish standards for secondary treatment and for pretreatment for contributors to municipal sewage treatment plants.

xvii. EPA will have to issue permits to every discharger into navigable waters, although each state can administer its own permit program if its program for issuance is satisfactory to EPA.

xviii. EPA is charged with setting up guidelines for "ocean dumping" and with issuing permits for such acts.

3. States Role

The Water Pollution Control Act Amendments of 1972 imposes a wide range of planning requirements upon the States. The Amendments are quite complex in their regulations and the best definition of state roles appears in an EPA report entitled "Water Strategy Paper" of February 1973. The paper outlines the main thrust of EPA's implementation of the Amendments and is to serve as a guideline for State and Federal personnel involved with implementation of the Amendments. Mainly it is to insure that the States' regulations are consistent with each other and conform to a single strategy. The paper has been said to be the "bible" for implementation of the Amendments during the coming year, and will be revised annually to accommodate new realities and refocus the national program in light of legislative deadlines and the expanding role of the States.

The strategy is to have each of the 267 major river basins in the United States divided into hydrologically discreet segments. States will make a preliminary investigation for each segment. Within this preliminary

investigation there will be flexibility regarding the sequence of implementation steps required by the States, specifically, a dual approach of using water quality standards and effluent limitations in different cases. The workings of this dual approach are:

a) Where the application of best practicable technology (for industry) or secondary treatment (for municipal plants) will result in meeting 1977 water quality goals, the segment will be categorized as an effluent guideline segment. The States will only have to develop a management plan listing the discharges to that segment and the schedule of compliance for these discharges. Permits for discharge can then be issued in these segments as soon as there is a solid technical basis for the effluent limitation.

b) Where the technology base is insufficient and where the water quality standards themselves dictate the necessary level of effluent reduction, the segment will be classified as a water quality segment. The same type of information required in (a) will be required here, and in addition, the State plan must include maximum daily loads based on monitoring surveys and data for pollutants for that segment, and are required to prepare mathematical models of segments for this purpose, and finally to establish target effluent reductions for discharges. The waste load allocations and permit sequencing will be developed using this planning data and issurance of permits can follow immediately.

In addition to the two alternatives listed above, a third alternative exists where there is a significant doubt as to whether the technology base is sufficient. In this case a segment will be considered as a water quality limited segment subject to later reclassification as more data are generated.

Of the wide range of planning requirements imposed on the States in the Amendments, the EPA Strategy Paper provides a description of the three principal planning functions envisioned and their relationship to each other. These functions are:

a) Section 303 Plans: These are the most comprehensive of the three planning functions which require the development of water quality goals and plans for achievement. These are essentially basin-wide and consider, by segment, the effect of discharges on the condition of the receiving water. They provide a management

schedule for municipal and industrial point sources for attaining the desired improvement in water quality.

b) Section 201 plans are area-wide in scope and provide for the development of best practicable treatment technology as a condition of the Federal grant program, and their purpose is to determine cost effectiveness. This emphasis makes them more source orientated than the 303 plans, and provides for a reasoned choice from among alternative technologies for construction of municipal facilities.

c) Section 208 plans require the development of area-wide waste treatment management. These are more complex than the 201 plans, and affect the investment of both public and private resources over a longer period of time. These plans will be developed for metropolitan areas with critical water conditions. Pollution from such non-point sources as urban runoff is a major factor that must be considered, along with point source discharges, and control of land use, if necessary, for the control of water pollution.

EPA suggests that the States concentrate on those water quality segments in which they have adequate data to develop planning programs. Concentrations on industry and agriculture is suggested in segments where there are many discharge applicants. As there have been virtually no applications for permits for municipal treatment plant discharges, issuance of municipal permits will be essentially posponed until fiscal 1974.

4. Public Involvement

Public involvement is one of the priorities listed in the 1972 Federal Water Pollution Control Act Amendments:

"Public participation in the development, revision and enforcment of any regulation, standard, effluent limitation, plan or program established by the Administrator or any State under this Act shall be provided for, encouraged and assisted by the Administrator and the States. The Administrator, in cooperation with the

States, shall develop and publish regulations specifying minimum guidelines for public participation in such processes" (Section 101-e).

The guidelines are to be developed by the EPA (Administrator) in cooperation with the States, and are as yet unpublished. These guidelines will no doubt contain specific items on both federal and state levels enabling the public to attain information developed by provisions of the Amendments and providing for public hearings and forums in the implementation of Amendment provisions.

Specific items pertaining to public involvement contained in the Amendments include the following:

i. The provision for public hearings prior to the establishment of any effluent limitation. The purpose of these hearings is "to determine the relationship of the economic and social costs of achieving any such limitation or limitations, including any economic or social dislocation in the affected community or communities, to the social and economic benefits to be obtained (including the attainment of the objectives of this Act) and to determine whether or not such effluent limitations can be implemented with available technology or other alternative control strategies" (302-b1). If a person affected by the limitations (including the Amendment objectives) can prove there is no reasonable relationship between the economic and social costs and the benefits to be obtained, the limitation shall not become effective (302-b2).

Public hearings are also provided for prior to the adoption of: toxic substance effluent standards (307-a2), the issuance of permits for the discharge of dredged or fill materials into navigable waters (404-c), and the adoption of effluent standards developed by the Water Quality Information Advisory Committee, a committee of nine technical persons appointed by the Administrator of the EPA (established in the Amendments-515).

ii. The EPA is to establish national programs which shall, in cooperation with other Federal, State and local agencies, encourage, cooperate and render technical services to not only pollution control agencies but to other appropriate public or private agencies, institutions and organizations and individuals including the general public. Specifically, these programs will conduct and promote the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys and

studies relating to the causes, effects, extent, prevention, reduction and elimination of pollution (104-a).

iii. The Amendments specifically call for all permit applications and each permit issued to be available to the public upon request for reproduction (402-j).

iv. A "Water Pollution Control Advisory Board" is established in the Amendments (503-a). This board will consist of the Administrator of the EPA (or his designee) and nine other members appointed by the President of the United States. These members shall be selected from among representatives of various non-federal governmental agencies of public or private interests who contribute to, are affected by, or are concerned with pollution. Additionally, members may be chosen from other public and private agencies, organizations or groups demonstrating an active interest in the field of pollution prevention and control, as well as other individuals who are expert in this field. This Board will advise, consult with and make recommendations to the EPA on matters of policy relating to the activity and functions of the EPA under the Amendments.

v. The Amendments provide for the filing of suits by any citizen against any person (including the United States) or agency who is alleged to be in violation of effluent standards or limitations under the Amendments, or an order issued by the EPA or a State with respect to such a standard or limitation. Additionally, any citizen may sue the EPA for not performing any act or duty established in the Amendments which is not discretionary in nature.

5. Financial Aspects

EPA can make a grant to cover a maximum of 50% of the administrative expenses of a planning agency (not to exceed 3 years), if the planning agency is capable of developing an effective basin, or basin portion, comprehensive plan.

Construction grants to the extent of 75% of the cost of a sewerage system can be made. The Amendments call for the States to set up a construction priority system, and require that the proposed sewerage system be part of an

overall management plan. One significant change from previous rules is that industry will be required to pay back the share of Federal monies applicable to their share of the cost of the facilities. This has given second thoughts to some industries thinking of discharging to municipal systems, as they will become obligated for the life of the repayment period, with no assurance they will continue to operate in the same location for this period. The Amendments also obligate the grantee to set up equitable charges for all users.

6) Federal, State and Local Relationships

The 1972 Amendments state: "It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of State to prevent, reduce, and eliminate pollution. . . . ." However with 75% Federal financial participation in the construction of sewerage facilities, it is fairly obvious that the Federal Government will have a lot to say how the programs are managed. Yet there are roles for all participants - Federal, State and Local - and the relationship is summarized in Figure II-I which applies to New Jersey but is applicable to all states.

C. PAST, PRESENT AND PROPOSED WASTEWATER MANAGEMENT PROGRAMS OF THE STATES

Each of the three states - New York, New Jersey and Connecticut - went through virtually the same development of their wastewater management programs.

Up to the time of Federal aid for the construction of sewage treatment plants, each state tugged and pulled to get municipalities to build their own plants. Concentration was on areas of the greatest pollution, There was some regional development, especially in New Jersey, where many regional authorities were formed to handle sewage from two or more towns. These were generally along the coastal areas and for the cities immediately inland along the Arthur Kill and along the Hackensack Meadowlands.

When Federal aid of 50% of construction costs was authorized, much of the money was not appropriated so New York and Connecticut passed bond issues and prefinanced the Federal share that was not forthcoming. New Jersey did not; the Federal share amounted to some 30% of construction costs. The various State schemes changed during the years with

INSTITUTIONAL FRAMEWORK FOR WATER QUALITY MANAGEMENT

	Construction, Operation and Maintenance	Monitoring & Surveillance	Enforcement	Planning	Finance and Funding	Legislative & Administrative
Federal (EPA)	– Approve Construction Plans – Review O & M Programs – Support Research Capabilities	– Develop Demonstration Programs – Approve Water Quality Standards – Supervise interstate oil spills	– Approve Permit System – Conduct Enforcement Conferences – Coordinate Activities with State Program	– Support Comprehensive Basin Planning – Approve State Program – Review Basin, Areawide & Facilities Planning	– Maintain Major Funding – Approve cost recovery systems – Allocate resources to sludge management	– Implement Legislation – Oversee Water Quality Programs
State (DEP) (DCA)	– Serve as Federal agent for Construction – Issue Permits, Guidelines, Rules and Regulations – Develop Technical Assistance Programs – Administer O & M Aid – Supervise Construction	– Coordinate Multi-Agency Network System – Formulate Uniform Reporting System – Repository for M & S Data – Ensure Water Quality Standard	– Institute Permit System – Maintain Criteria for Interim Solutions – Issue Annual Reports – Develop Inter-Agency Approach	– Formulate Water Resources Planning – Develop Institutional Management Planning – Manage land use planning – Approve areawide and facilities planning – Maintain Information System	– Review costs, bonds and debt management – Monitor grant & loan monies – Institute O & M Program – Institute Cost Recovery System	– Establish administrative criteria to guide inter-agency relations – Draft State legislation – Annunciate priorities, formulate policies, and implement criteria.
Inter-State (DRBC) (ISC)	– Review Plans – Manage technical assistance programs in jurisdiction as state agent – Operate training laboratories	– Manage M & S in jurisdiction as State agent – Operate Water Quality Labs – Verify Water Quality Standards	– Institute Enforcement Actions – Maintain Technical Assistance – Supervise jurisdiction as State agent	– Review Concepts & Approaches – Process Information as State Agent – Approve regional plans	– Review priority system – Aid State in determining priority projects	– Develop Management Capabilities – Ensure inter state cooperation – Review service areas
Regional -County (Auth)	– Supervise O & M as agent of the State – Develop Educational Programs for Training – Certify Construction	– Operate Sampling Stations – Monitor Waterways – Manage M & S Operations	– Operate Permit System – Report to State DEP – Coordinate Agencies	– Coordinate Planning Process – Manage Treatment – Transmission Collection Planning – Analyze Environmental Impact Proposals – Supervise Planning Information	– Manage cost recovery system – Provide a flexible basis for meeting Federal-State requirements	– Develop intra and inter-agency communication systems – Employ management techniques
Local (Auth)	– Issue Performance Bonds – Conduct Daily Operations – Maintain adequate staff	– Catalogue Dischargers – Conduct Daily Testing – Maintain Effluent Data – Analyze infiltration – Supervise Collection Systems	– Protect all waters within jurisdiction – Inter-face with Health Dept – Supervise connections	– Ensure local representation – Supervise facilities planning – Inter-relate with all local levels – Maintain Information System	– Institute cost recovery procedures – Develop equitable charges – Maintain financial data	– Maintain administrative competence – Develop adequate Personnel System – Ensure accountability
Public	– Develop Oversight Capabilities – Pursue public forums	– Report all irregularities – Conduct portable testing	– Inform State DEP – Implement "right to sue"	– Participate in Area Wide & Facilities Planning – Review Planning Proposals	– Support sound WQ programs – Demand accountability	– Demand efficiency and effectiveness – Foster legislative review

Source: New Jersey Municipalities, May 1973

FIGURE II-1

Connecticut giving 15% grants over the Federal share and New York dividing the financing - 30% Federal, 30% State. New Jersey also gave State construction grants.

Money was originally distributed on a first-come, first-served basis. Later the States set up the beginnings of priority systems with New York and New Jersey requiring planning on a county or regional basis and Connecticut on a town or regional basis. The priorities were based on readiness to proceed, the extent of pollution, financial need, conformance with regional schemes, etc. Loans for planning were available from various Federal agencies.

A typical priority program is as follows:

Points		Item
20	1.	Severity of pollution problem
15	2.	Population affected by the project
10	3.	Need for preservation of high quality waters
5	4.	National priorities (priority basins)
15	5.	Projects needed to meet enforceable provisions of the law
10	6.	Projects desirable in terms of water quality improvement
5	7.	Projects which are not discharges
10	8.	Benefits to downstream uses of receiving streams: public health and health of aquatic ecosystem, recreation, industry, agriculture
10	9.	General water quality improvement expected due to the project
100		

At this writing (June 1973) all the State's programs will have to conform to the Federal Water Control Act Amendments of 1972 and all will be identical in concept, if not in details. Each State has set up a priority system and each is working on area-wide and basin planning. The States are presently reviewing rules and regulations issued by the Environmental Protection Agency (EPA) for the preparation of the overall planning schemes. The situation may be considered in a state of flux at this time with the States' reviewing plans and specifications, prepared in accordance with previous county, town and regional plans, for submission to EPA. New Jersey has proposed a plan to study the northeastern area of the State to define a wastewater management study (Section IV-B).

A summary of the provisions of the Amendments Act as they affect the States is found in Section II-B-3.

While the provisions of the Amendments Act will provide an orderly wastewater management strategy to take into account infiltration and inflows into sewers, combined sewer overflows, industrial wastes, etc. - the immediate effect is to slow down treatment plant construction. The States can no longer prefinance and be reimbursed, and many necessary tasks specified require further clarification.

Procedures

In general each State follows the same procedure to implement water pollution control measures.

First an order is issued against the offending industry or municipality.

"All orders are broken down into a sequence of steps to be taken by the polluter with dates set for compliance with each step. This procedure has greatly facilitated the enforcement of orders because failure to complete any step of an order by the date specified places the polluter in violation of the order whereupon he can be made subject to the penalties provided.

"A typical order to a private or industrial polluter might contain four (4) steps such as: Step A - Submission of an engineering report for approval, describing the cause and extent of the problem and the proposed method of solution; Step B - Submission for approval of plans and specifications for the proposed treatment facility or system; Step C - Start of construction of the approved facility; Step D - Placing of the facility in operation.

"A typical order to a municipality causing pollution usually contains up to three (3) additional steps. Steps A and B are generally the same as those in a private or industrial order. Steps C, D and E are usually designed as follows: Step C - Arrangmenet of municipal financing; Step D - Arranging for and acceptance of State and Federal grants; Step E - Advertising for construction bids. Steps F and G correspond to steps C and D of a private or industrial order.

"Some orders contain only one or two steps. An example may be the requiring of a simple connection to an available municipal sanitary sewer or the discontinuance of a discharge."

III. DEVELOPED AND POTENTIAL WATER SUPPLY SOURCES

A. STATE CLASSIFICATION SYSTEMS

The existing quality of a surface water is the direct result of its interaction with surrounding natural and cultural environments. Water for human consumption, swimming and shellfish must be of high quality, while water for navigational and waste disposal purposes may be of lower quality. Various water qualities between these extremes are acceptable for fishing, irrigation and industrial process use.

Classification systems are used to define various surface water qualities. The dual purpose of classification is to assign a best usage to each source and to define the quality of the water necessary to meet the best usage. A number of factors affect the quality of a given surface water, and no single standard is applicable to all streams or even parts of streams. Therefore, classifications are made in consideration of best usage and interest of the public in regard to the following:

a) The geography, flow patterns and temperatures of the waters.

b) The character and uses of the land bordering the waters.

c) The past, present and contemplated future uses of the waters.

Classification systems for surface waters are determined by individual states and while the systems in general are similar, each varies to some degree. Appendix 'B' presents the classification system for New York, New Jersey and Connecticut in Tables B-1a, B-2a and B-3a, respectively. Water quality criteria determine each classification and these criteria appear in Appendix 'B' as Tables B-1b, B-2b and B-3b for New York, New Jersey and Connecticut, respectively.

Each state distinguishes fresh waters from tidal and coastal waters. Fresh and tidal (marine water) supplies are generally classified, as the case may be, for potable water supply, bathing and recreational use,

recreational boating, fishing, selected industrial and agricultural use, and navigation, in descending order. A few of the variations between the three systems follow: New York State has two classifications (AA, A) for human consumptive use, with different minimum treatment requirements for each, as does Connecticut (A, B), while New Jersey (FW-2) has one classification for this use. New Jersey has a unique classification for waters designated as being set aside for posterity to preserve the natural aquatic environment and its associated biota (FW-1). Connecticut has a unique classification (E) for surface waters not suitable for any purpose. New Jersey has a separate classification for coastal waters as distinguished from tidal or marine waters. Table 4 in Appendix 'B' indicates the relationships of the three state classification systems in general terms.

B. NEW YORK STATE

1. Developed Water Supply Sources

a) General Quality

New York water supply sources for human consumption consists of surface and ground waters. In the area of study, most of the surface waters are derived from the Hudson River Basin. Nassau and Suffolk Counties, on Long Island, rely on ground water supplies for their potable water supplies. Two water supply systems in the Hudson River drainage basin provide water for New York City and some local needs north of New York City. They are the Croton System of 12 reservoirs, and the Catskill System of Ashoken and Schoharie Reservoirs. Additional supply is obtained by diverting the Delaware River through a system of reservoirs including the Roundout reservoir. Although the Roundout Reservoir is in the Hudson River drainage basin, all Delaware water diversions pass through the reservoir.

Surface waters in New York used for human consumption are limited to those with State classifications of A and AA. Currently, all major water sources in the study area are receiving treated or untreated industrial and non-industrial wastes. Ground water sources of Long Island are generally of good quality, often treated only by chlorination. Iron and salt concentrations vary with the aquifer.

Surface water quality has been tabulated, using the most recently available data and appears in Appendix 'A'.

Degradation is apparent in all surface waters near larger population and industrial centers. This has generally led to a reduction in the types of uses for these waters. Current stream reaches with water quality problems in the New York Study area include all of the Hudson River and parts of the Wallkill River and Wappinger Creek. Water supply from the Hudson River for potable use is in present danger, and industrial usage of some of these waters is also in danger. Continued land development in the northwest New York Study area can present a water quality problem. For example, second home developments on the Schoharie Creek near Hunter, New York could pose some danger since there is no central sewerage system in the Town. There is presently some discharge of untreated sewage into the Creek from failing septic tank systems.

New York State has, in many cases, not waited for Federal money to finance sewage treatment plant construction, but has prefinanced many plants with State bond money. Plans and specificiations have been prepared for virtually all major centers of population. Federal financial assistance, provided under the 1972 Federal Water Pollution Control Act Amendments, will stimulate construction as soon as EPA issues clarification of some of the sections. Once all these plants have been constructed, the Hudson River should be a good source of water along its entire length.

These plants are designed to meet the 1972 Amendments interim goal of water quality which provides for the protection of fish, shellfish and wildlife and provides for recreation in and on the water, by July 1, 1983. As directed by the EPA's policy in dealing with the implementation of the Amendments provisions, a priority list of construction facilities is being formulated. New York is considering the problems of storm and combined sewer overflow, non-point waste sources, and industrial waste discharges. The eventual goal stated in the 1972 Amendments of zero discharge of pollutants will enhance the potential of using Hudson River fresh water for water supply.

The Croton watershed in the New York City water supply system is threatened by continued development of the area. The City is aware of this and has studied several schemes to solve the problem. One plan is to intercept the sewage at the perimeter of the reservoir and treat it at a plant below the Croton Dam.

The Upper Croton Reservoir has a submerged dam that has kept a portion of the reservoir behind the dam in a stagnant condition and nutrient buildup in this section has resulted in the growth of weeds which harbor worms (larvae). These worms do occasionally show up in sections of the City distribution system. Planned reservoir drawdowns in winter periods allow winter frost to kill these weeds. Past experience with this method has been relatively successful and the program will continue in the future. Copper sulfate is used periodically for nutrient control in the Croton and Cannonsville Reservoirs.

Catskill Reservoir System water is naturally low in hardness and alkalinity (therefore low in buffering capacity) and pH adjustments are made periodically.

Potential future problems in the existing New York City Water Supply System include trace metals and pesticides. The 1972 Amendments, when fully interpreted and implemented, should eliminate trace metals and pesticides from point sources. Filtration of the Croton Water Supply System is currently being studied by New York City.

New York City water quality management consists of: 1) extensive sampling programs, 2) regulation of watershed land, and pesticide and herbicide use, 3) watershed and inspection programs, 4) operation of sewage treatment plants throughout the watersheds, 5) long water storage periods in reservoirs far from urban centers, 6) chlorination.

Wastewater management programs to protect developed surface water supply sources in the study area include: sewerage of rural areas; secondary treatment or its equivalent for municipal and industrial wastes and tertiary treatment or its equivalent for municipal and industrial wastes within Westchester County.

Ground water in Long Island is currently threatened. Local over-usage of some aquifers has caused

salt water intrusion. Septic tank systems have caused a nitrate problem in some areas, which is indicative of other contaminant problems including refractory organics, such as some detergents. The most prolific ground water source on Long Island is the Magothy aquifer. Even with past and current sewerage installations, nitrate buildup over the years from septic tank systems could make a large part of the water from this aquifer unusable for human consumption. Iron and salt problems are evident in the other two aquifers in the area, the Jameco and Lloyd aquifers.

Population increase is continuing in the Long Island area and it is expected that both short and long range water supply needs will exceed the developed water supply sources, particularly in Nassau County. Replacement of septic systems with sewer systems will minimize the future nitrate contamination problem of the ground water, however, the current practice of discharging treated sewage to the ocean permanently removes a water resource from the area.

There have been current experiments using ground water recharge of treated sewage to replenish the ground water supply and to provide a salt water barrier. Preliminary results indicate that further study will be needed to solve the problem of frequent well clogging, and to identify and evaluate the spread of contaminants in the aquifer.

2. Potential Water Supply Sources

a) General Quality

With the increase of population and industry in the New York Study area, new sources of water will have to be developed both on a regional and local basis. Regional sources of development lie both within the study area and north of the study area in the Hudson and Mohawk River basins. Generally good quality water sources are available in these regions, for a variety of uses.

Local potential sources for Ulster and Dutchess Counties are of good quality and are expected to remain so in the forseeable future with the continuation of present wastewater management policies.

Surface waters with less than an "A" classification may possibly be developed. These sources may be upgraded because of successful wastewater management programs. The use of these waters may be required in the future to meet increased demands, however, some treatment will be required. These sources included reaches of the Hudson, Hoosic, Mohawk and Wallkill Rivers. Other surface water sources expected to be used or further developed in the future include the East Canada, West Canada, Esopus and Roundout Creeks, and the Wallkill River. Surface water sources not predicted to be used for water supply in the future include the Schroon River, the Batten Kill, and the Wappinger, Kinderhook, Catskill and Kayaderosseras Creeks. ("North Atlantic Regional Water Resources Study", 1972).

On Long Island, further development of ground water may be enhanced by ground water recharge with treated sewage or other waters, and further use of the Jameco and Lloyd aquifers. Generally, good quality water exists over most of the Island and may be expected to be of good quality in the future with proper water resource management.

b) Problem Areas

Further Hudson River development for water supply by diverting water from the Hudson is attractive but has some restrictions. Specifically, the Hudson River is tidal up to Troy and a minimum flow in the River is necessary to prevent the salt front from advancing further up the River and degrading present water supply sources; the minimum flow is currently estimated as 3000 CFS at Green Island. It is reported that Indian Lake and Sacandaga Reservoir, at the headwaters of the Hudson, can maintain the necessary minimum flow in the River.

If ground water supply on Long Island is further developed via ground water recharge of treated sewage, nitrate contamination may require nitrogen removal in treatment plants. The discharges of wastewater from Long Island to the Atlantic Ocean and Long Island Sound is currently being done and currently being investigated further. Some investigators conclude that this is the only acceptable alternative for wastewater disposal until technology and feasibility studies for the other

alternatives (including ground water recharge, stream and pond augmentation, and spray irrigation) are concluded.

C. NEW JERSEY

1. Develolped Water Supply Sources

a) General Quality

New Jersey water supply for human consumption consists of fresh surface waters and ground waters, approximately 76% being surface waters. Interbasin transfer from the Delaware River contributes some water to the study area. Currently, the study area uses approximately 50% of the maximum 7.5 mgd available from this source. The two major river basins contributing to water supply in the New Jersey area of study are the Raritan and Passaic River basins. Two reservoirs in the Raritan River basin and intakes along the Raritan River supply water for potable use. Additionally, water is diverted from the Delaware River to the Raritan River via the Delaware and Raritan Canal. In the Passaic River basin, water for potable use is taken from the Passaic River and the Ramapo, Wanaque, Pequannock and Rockaway Rivers, tributaries of the Passaic River.

Surface waters in New Jersey used for human consumption are limited to those with a State classification of FW-2. Most of the surface waters of New Jersey are classified FW-2, with the eastern reaches of the Passaic, Hackensack and Raritan Rivers discharging to the New York City Harbor complex, classified less than FW-2. Surface waters are generally soft, the hardest occurring in the Passaic River at Little Falls, attributed to the presence of industrial waste discharges to this stream.

Surface water quality has been tabulated using the most recently available data. Appendix "A" includes surface water data for developed and potential water sources. Also included in Appendix "A" are water quality data of New Jersey water suppliers, reported by the Joint EPA-New Jersey Water Supply Monitoring and Survey Program.

Industrial and municipal treated wastes are discharged to all major streams in the New Jersey study area, including some existing potable supplies.

b) Problem Areas

Developed water supply sources are adequate to supply only current demands for water. Quality of water supply varies, generally decreasing downstream.

Treated municipal and industrial wastes are discharged into potable supply sources. In the Passaic River, 50 mgd of treated wastewater is discharged upstream of Little Falls, however, a water utility with intakes at Little Falls surprisingly produces water meeting United States Public Health Service (USPHS) standards for clean sources of water. Water utilities tapping the Wanaque and Pequannock Rivers have not consistently met USPHS standards and have been ordered to filter their raw mater supplies to reduce turbidity.

Water diverted from the Delaware River via the Delaware and Raritan canal has had a significant increase in iron concentration, possibly attributable to quarrying operations adjacent to the canal and industrial waste discharges in the Trenton area. Further waste treatment by industries contributing to the problem can help alleviate the situation.

Developed water supply sources are in danger of degradation in the future. Considering the requirement of secondary treatment or its equivalent for all municipal and industrial waste discharges, some developed sources may still be degraded beyond the requirements for a potable water source, notably the Passaic River. Wastewater management programs to be investigated to preserve the present quality in existing supplies are: a) Restriction of land use upstream of Little Falls in the Passaic River Basin; b) Enforcement of municipal and industrial requirements for BOD removal of greater than 90%.

2. Potential Water Supply Sources

a) General Quality

The State of New Jersey will have to develop new sources of water to meet demands of future population and industrial growth. Allowing for existing water supply systems and their potential expansion, estimates of water supply to be provided by regional developments are 120 mgd by the year 1980, 400 mgd by the year 2000 and 820 mgd by the year 2020. Industrial water needs

are expected to increase to the point where in the year 2020 municipal water supplies may be needed to supplement industrial demands.

Water quality in potential sources of the western region of New Jersey in the area of study is generally good, and classified as FW-2. Potential supply sources in the eastern and coastal regions of the New York Harbor Complex are generally less than FW-2 in classification. Impoundment in new reservoirs and upgrading of existing reservoirs in the eastern area seem the most plausible sources of development, as it is not expected that the downstream reaches of the Passaic, Raritan and Hackensack Rivers will become suitable for potable water supply in the future.

b) Problem Areas

As industry and population increase in the future, areas of potential water source development will be threatened, especially in the Passaic and Raritan River Basins. Reservoirs can impound water upstream and feed these rivers for intake further downstream, however, waste discharges between impoundment and intake will decrease the quality of the additional water supply.

Wastewater management for areas in the central and western regions is particularly important to insure good surface water quality for these areas. Better than secondary treatment will be required in some areas and the possibility exists of transfer of wastewater to areas downstream of potable water intake locations to insure good quality. Wastewater reclamation for direct consumptive use seems unlikely on aesthetic basis for the immediate future. Indirect reuse of wastewater for irrigation is too costly as an alternative since suitable agricultural lands are far from the wastewater sources and thus would require inordinate costs for transmission.

Wastewater reuse is possible by industry. Thus more water of good quality will be available for potable use. Further detailed discussion of this alternative for the Passaic River Basin appears in Section IV-C of this report.

D. CONNECTICUT

1. Developed Water Supply Sources

a) General Quality

Water supply sources for human consumption in Connecticut consist of fresh surface waters and ground water supplies, the greater percent being surface waters (76%). Surface water supplies are generally located in upstate regions and serve both upstate and the more highly populated western downstate areas. Ground water development is spread throughout the state, serving local communities. The largest ground water developments are in the Housatonic River area.

Surface waters in Connecticut used for human consumption are limited to those with state classifications of A and B. Upstate surface waters are generally in these classifications. On a mileage basis, 71% of the fresh water streams are of Class A, however, most of the larger streams in the State are classified less than A. The water is generally soft and has a low fluoride content. Ground water supplies throughout the State are generally of high quality but with higher fluoride contents than surface waters.

Surface water quality has been tabulated using the most recently available data. Appendix"A"includes surface water data for developed and potential potable water sources.

Existing surface water developments for potable use do not appear to be threatened at this time or in the near future. Municipal and industrial discharges to these supplies are prohibited by the State.

b) Problem Areas

A great many small water utilities exist, which are not integrated for future demands. Greater sources of potential development are located away from the areas of greatest need. Another problem is the inconsistent quality of water distributed by the various water utilities. Generally, surface waters are treated by disinfection for corrosion control and by fluoridation. In many cases, raw water is not filtered, resulting in taste, odor, color, sediment and living and dead worms, nematodes and fly larvae appearing in the product water.

Greater integration of water supply from various sources is needed to better serve the whole State. More consistent water quality should be maintained by requiring filtration of raw water where quality problems are evident.

Problems in ground water supply are those caused by exfiltration of wastes from old or leaky sewers, and overflow of combined sewer systems during storms. The problem is minimal, however, since sewer systems are generally removed from ground water development sites, and ownership of sufficient buffer zones by the utility companies is required by the State.

2. Potential Water Sources

a) General Quality

The State of Connecticut will have to develop new sources of water to meet demands of future population and industrial growth, both in the near future and in the long run. Allowing for existing water supply systems and their potential expansion, estimates of water supply to be provided by regional developments are 40 mgd by the year 1980, 100 mgd by the year 2000 and 240 mgd by the year 2020.

Potential water sources are numerous in the State and include ground and surface water sources. Ground water sources are generally of excellent quality throughout the State. Both further development of existing ground water sources and new sources can be accomplished to serve regional needs.

Surface water development potential exists in the upstate streams of water quality classes A and B. Additionally, water management programs already in existence should result in the upgrading of many surface waters to a Class of A and B. Surface water quality in many downstate areas is at the present time below class B.

b) Problem Areas

While a substantial potential for surface water development exists in Connecticut, it has been recommended that ground water supplies receive priority in development. This is because they are more easily

protected and of more constant quality. Many surface waters have had a significant degradation in quality. Numerous and difficult to control municipal and industrial discharges into downstate streams have rendered much of these supplies unusable for human consumption. Lower reaches of the Connecticut, Naugatuck and Housatonic rivers and their tributaries have severe pollution problems characterized by sedimentation, nutrient enrichment, high coliform content and low dissolved oxygen concentrations. Until 1965, 96% of municipal sewage received primary treatment only, while 53% of industrial discharges were receiving some form of treatment. Many municipal plants were then and are still overloaded due to continued population growth. There are combined sewers in older communities for sanitary and storm water which have overflows during storms.

Requirement of secondary treatment for municipal and its equivalent for industrial treatment has been made. However, the State of Connecticut does not allow discharge into streams used for potable water supplies. This will limit the use of lower reaches of surface waters for potable supply, even if these reaches are upgraded to class B waters. Those reaches with no municipal or industrial discharges will require filtration of raw water.

It is suggested that ground water development on a local basis be developed to its full potential as a priority. Surface water development for long range needs is recommended, with priority given to the upper reaches of the Housatonic and Connecticut Rivers and their tributaries. Reuse of wastewater directly or indirectly does not appear to be necessary to maintain a safe yield in the forseeable future. Enough potential water resources are available for development which are less costly, more aesthetically appealing and safer sources of water for potable use. Treatment of wastewater to at least secondary, and in some cases, tertiary quality should be achieved to maintain or upgrade surface water quality for all uses other than for potable supplies. Storm and sanitary sewerage should be separate and replacement of old and leaky sewers should take place to insure against ground water contamination.

Greater integration of various water supply sources will be required to insure a workable system with optimum efficiency of water conservation and supply.

IV. WASTEWATER MANAGEMENT TO INCREASE AVAILABLE WATER SOURCES

A. GENERAL

Wastewater management is an important aspect of any water supply program. It is needed to both protect existing and potential supplies, and is in itself a valuable water resource.

In evaluating a program of wastewater management, consideration is given to the potential uses of the wastewater resource, and wastewater treatment techniques.

Wastewater management to increase available water sources may consist of reusing treated wastewater directly or indirectly. Reuse for potable supply, industrial, agricultural, or recreational purposes may be possible. The choice of a reuse scheme involves evaluation of available treatment techniques to produce a desired water quality, and the potential for reuse in any particular area. Careful engineering evaluation for any scheme must be cognizant of treatment reliability to reach the desired quality. While treatment methods exist to render water of good enough quality for many uses, the practicality, reliability and public acceptance of such reuse is not always favorable. Reuse of wastewater for potable supplies is not recommended until further reliability of treatment, and identification of trace elements and viral constituents are made. Reuse for indirectly supplying potable water includes application of reclaimed wastewater to land to protect or increase available ground water, and while practiced at various locations, the reliability and technical feasibility of this method must be proven in each application. Reuse for industrial, agricultural and recreational purposes has successfully been practiced and reuse in these ways increases the amount of good quality water available for potable use. Wastewater reuse may be accomplished by treating wastewater and discharging it to a stream, to be reused again downstream.

In any wastewater reuse evaluation, specific investigation into possible human contamination problems must be made. A wide variety of specific viral, bacterial and chemical constituents of treated wastewater have been found to cause undesirable effects on human beings. Much of the research needed to properly evaluate this aspect of wastewater reuse lies in the future.

Land orientated systems for renovated wastewater reuse is receiving much attention recently. Land systems have been used for waste treatment, ground water recharge, ground water protection, nutrient removal and irrigation purposes. In the study area, Long Island, New York is particularly being considered for land orientated systems. As with any reuse scheme, a careful evaluation must be made of the technical, practical and reliability aspects of these methods.

Management of wastewater is needed to protect existing and potential sources of water from contamination. For example, this may involve the sewering of a district where septic tanks are leaching contaminants into potable ground water sources. It may involve the upgrading of treatment for wastewater where its discharge into a water course will degrade the quality of that source of water, or it may involve the collection and management of non point sources as agricultural runoff and urban area storm water runoff.

The specific areas of wastewater management concern in the study area are Long Island, New York and the Passaic River Basin, New Jersey, which are the subject of this section. More detailed discussion of general aspects of wastewater management appear in the following appendices:

Appendix C - Wastewater Treatment
Appendix D - Wastewater Reuse
Appendix E - Land Orientated Systems for Renovated Wastewater Reuse
Appendix F - Specific Contaminant Problems in Treated Wastewater

B. LONG ISLAND

1. Introduction

Long Island is 120 miles in length, roughly the shape of a whale with a split tail, some 23 miles wide at the widest point. The head end is one border of Upper New York Bay while the tail runs easterly into the Atlantic Ocean. Long Island Sound, to the north, connects the Ocean and the Bay. The southern shore is washed by the Ocean.

The western end of the Island is part of New York City-Kings County (Borough of Brooklyn) and Queens County

(Borough of Queens). New York City water is available to these areas and the City handles all wastewater disposal for the two Counties.

The need for a comprehensive wastewater management program for Long Island is acute. The acuteness stems from the need to enhance the quantity of water supply and the need to protect the quality of the existing and potential water supplies. Although Suffolk County is not expected to surpass its available ground water supply by the year 2020, Nassau County is projected to surpass its available ground water supply by 1980. The quality of existing ground water aquifers in both counties are suffering from degradation of quality due to salt water encroachment, nitrate contamination and refractory organic material contamination. The latter two problems are attributed to the existence of septic tank systems throughout the Island. Proposed sewering will all but eliminate the sources of ground water pollution, however, the natural recharge of wastewater experienced in unsewered districts will contribute to the water supply problem. Additionally, the area expansion of impervious surfaces has and will continue to cause a storm water overflow problem. The Long Island area has been under intense study in recent years to answer the questions of water supply and wastewater management. Here, more than any other area in the report study area, the integration of wastewater management and water supply is obvious (but by no means simple), and this interrelationship has been realized and studied.

2. Socio-Economic Trends

Socio-economic trends are those trends which determine an area's projected development and thus its need for water supply, quantity of wastewater, availability of land for wastewater treatment and further water supply development. The two socio-economic trends most important to a water supply-wastewater disposal program are land use and population.

a) Nassau County

Land usage in Nassau County is reflected in Table IV-1, based on two study periods (1959, 1956). The significant trends are those of increased land use for residence, recreation and roadways. Agricultural and vacant land areas have decreased. Nassau County is continuing to experience a suburban growth period where

TABLE IV-1

NASSAU COUNTY, NEW YORK

LAND USE

Classification	1959(1) Acres	1959(1) %	1966(2) Acres	1966(2) %
Residential	82,477	46.66	89,701	50.87
Commercial	4,836	2.74	4,831	2.74
Industrial	5,291(5)(6)	3.00	4,593(5)	2.61
Recreational	11,808	6.70	16,464	9.34
Agricultural	(3)		2,056	1.17
Roadways	27,607	15.62	30,134	17.08
Vacant	31,373	17.80	15,281	8.66
Inland Water	1,646	0.93	1,831	1.04
Public	11,588	6.55	9,460	5.36
Transportation and Utilities	(4)		1,998	1.13
TOTALS	176,626(7)	100.00	176,349(7)	100.00

(1) A Compilation of Land Uses, Nassau County Planning Commission, 1959 as reported in the Greeley and Hansen report of 1963.

(2) Existing Land Use, Nassau-Suffolk Regional Planning Board, 1968. Data as of 1966.

(3) Included in Vacant Land.

(4) Included in Industrial.

(5) Includes abandoned gravel pits.

(6) Includes 841.26 acres of railroad right-of-way.

(7) Discrepancy in total is attributed to difference in accuracy in methods of measurement.

residential and recreational land use predominates over industrial, commercial and agricultural land use. By 2020, it is expected that agricultural land will be insignificant in Nassau County. Table IV-2 lists the expected trend in land use. Thus, the problems of a dense suburban community are present in Nassau County, including the need for sewering, and the unavailability of land for waste treatment.

Population projections for Nassau County (Joint Venture Report) are:

Present	1,397,000
1980	1,542,400
2000	1,779,200
2020	2,000,000

In the 1950's, a sharp increase in population was experienced due to the urban expansion of metropolitan New York City, however, the rate of increase has slowed since then and projections to 2020 reflect the slower rate. A number of construction projects which will affect the rate of population growth for the next 50 years are listed in Table IV-3. The town of Hempstead and Oyster Bay are thus expected to be the center of population growth.

b) Suffolk County

Similarly to Nassau County, Suffolk County experienced a rapid suburban growth following World War II. Residential, recreational and industrial land usages are expected to continue to increase, while agricultural land use is expected to decrease. Suffolk County is less densely populated than Nassau County and the problems of water supply and wastewater management are correspondingly less severe. The opportunity for land orientated wastewater treatment systems and agricultural irrigation with treated wastewater is greater in Suffolk County. Population projections (Joint Venture Report) for Suffolk County are:

Present	927,000
1980	1,499,000
2000	1,972,000
2020	2,495,000

TABLE IV-2

TREND IN LAND USE

NASSAU COUNTY, NEW YORK

Classification	Expected Change
Residential	Increase
Commercial	Slight increase
Industrial	Slight increase
Recreational	Increase
Agricultural	Decrease
Roadways	Slight increase
Vacant	Decrease
Inland Water	Slight increase
Public	Increase
Transportation and Utilities	Increase

SOURCE: "Existing Land Use" Nassau-Suffolk Regional Planning Board, 1968.

TABLE IV-3

TRENDS AND SPECIAL PROJECTS OR EVENTS AFFECTING POPULATION GROWTH IN NASSAU COUNTY 1965 - 1985

Item	Area of Maximum Impact	Period of Maximum Impact
1. Completion of Nassau Expressway	Southwestern Hempstead and the City of Long Beach	1970-75
2. Improvement of existing Rail Transportation-increased speeds, direct service to East Side and Downtown Manhattan, and the creation of "Park and Ride" centers.	Entire County	1970-75
3. Development of Mitchel Field	Town of Hempstead	1970-80
4. Expansion of Institutions of higher education with a shift toward the provision of dormitory facilities for an increasing proportion of the student body.		
a. Adelphi	Town of Hempstead	1965-75
b. Hofstra	Town of Hempstead	1965-70
c. C. W. Post	Town of Oyster Bay	1975-85
d. State University of New York (Old Westbury)	Town of Oyster Bay	1975-85
e. State University of New York (Center for International Studies)	Town of Oyster Bay	1975-85
f. New York Institute of Technology	Town of Oyster Bay	1970-75

SOURCE: CPWS-60 Report

Most of the growth is expected to be centered in the western towns, with a projected 70% of the total County population by 2020.

3. Geohydrology

The geohydrology of an area is important in considering the water supply and wastewater management. This is especially true in Long Island, where the total water supply is derived from ground water sources. Particular problems of wastewater management are related to the ground water supply; the contamination of water sources due to the use of septic systems, the lowering of ground water tables due to sewering, the proposed ground water recharge of treated wastewater, the current use of storm water runoff for ground water recharge. Perhaps more than any other area in the study area, the wastewater management program is intimately connected with geohydrology.

a) Geology

The geologic structure of Long Island consists of three major geological systems - Precambrian bedrock, Cretaceous sediments and Pleistocine deposits. The bedrock consists of granite gneisses and schists, sloping sharply to the south and southeast. Bedrock does outcrop in Astoria, Queens, in the extreme northwest corner of the island.

Atop the bedrock are cretaceous sediments, including the Magothy formation, the Raritan Clay and the Lloyd Sand members of the Raritan formation. The Lloyd Sand and Raritan Clay formations are roughly parallel to the bedrock surfaces. The Magothy formation is predominantly sandy materials with its upper surface nearly horitontal. The Magothy and Lloyd Sands are permeable sands which form important aquifers, while the Raritan Clays are relatively impermeable and limit the fresh water entering the underlying Lloyd aquifer.

During the Pleistocene period (Ice Age) at least two ice sheets terminated over the area, superimposing two terminal moraines, the Ronkonkoma and Habor Hills, providing a thin layer of outwash deposits. These deposits are mostly sand with the exception of Gardiner's Clay lenses in the North and South regions. These sands form the upper glacial aquifer.

A simplified geologic section, representing the principal Long Island aquifers, has been used in various reports since it first appeared in a USGS report issued about 1903. (Figure IV-1) The actual geology of the Island, however, is not so "ideal". There are lenses of clay in the sand and the demarcation of the various layers is not always sharply defined. It has been reported that there are pockets or valleys of highly permeable sand under the northern terminal morrain in Suffolk County.

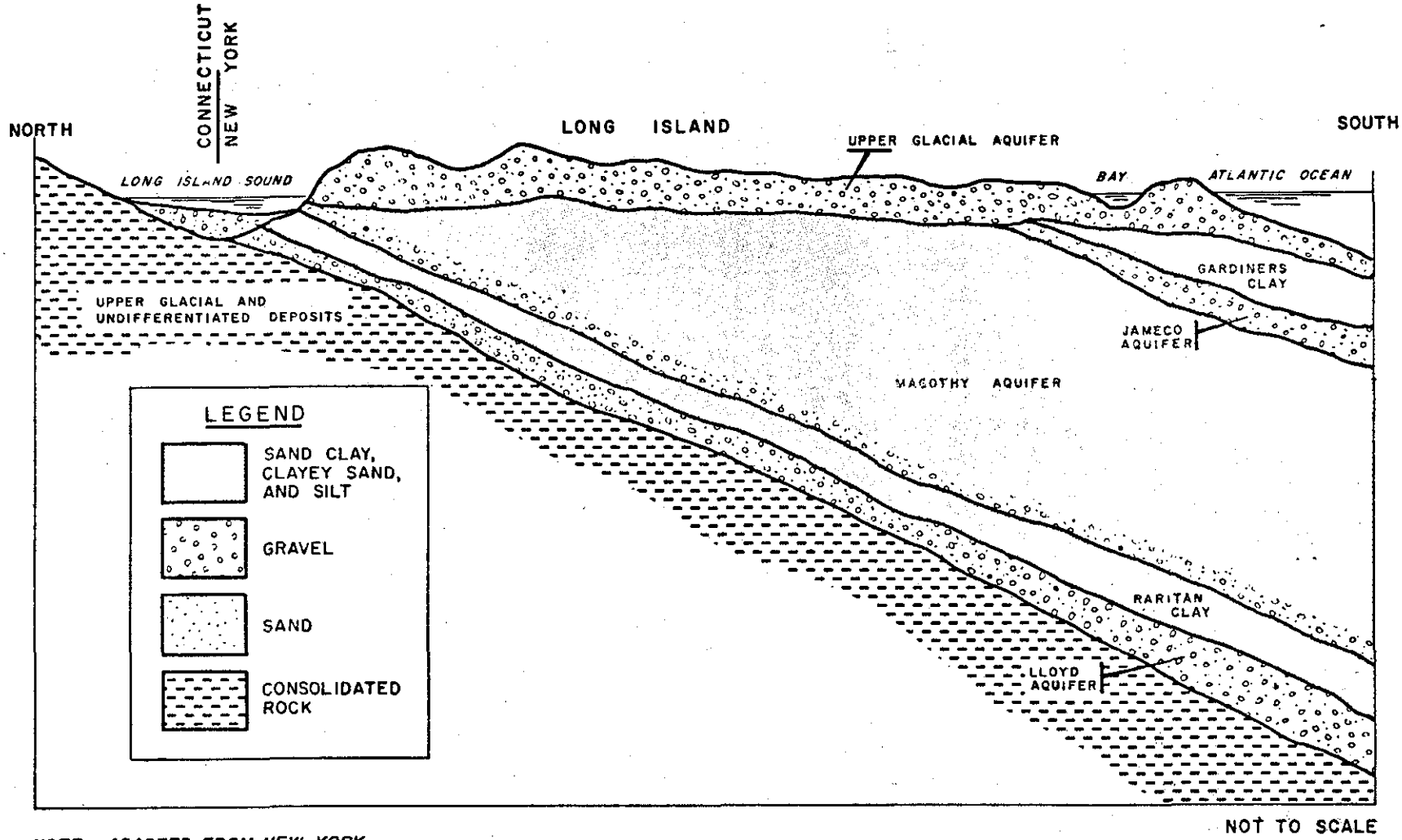
b) Hydrology

There is no fresh water source from outside the Island, the entire fresh water supply on the Island results from infiltration of local rainfall. The average rainfall in the area is 44 inches per year. It has been approximated that 22 inches go to evapotranspiration, one inch to stream flow, 4.5 inches to underflow and 16.5 inches to underground storage in the three principal aquifers.

The pattern of groundwater flow has been characterized by the USGS as it appears in Figure IV-2. It can be seen that vertical flow is steepest directly below the regional groundwater divide. This divide denotes the axis above which water will drain north to the Sound and below which water will drain south to the Atlantic Ocean and intermediate bays.

The uppermost aquifers, the Jameco gravel and the upper glacial aquifers have yields up to 1300 gpm for individual wells and water quality is characterized by a high natural iron content and is salty near the shore line. The Magothy aquifer has yields up to 2200 gpm per well under artesian pressure. This bed extends under virtually all of Long Island and is the Island's principal source of public water supply. These beds have a thickness of 200 feet on the north shore and become progressively thicker approaching the south. At Wantagh, they have a thickness of about 700 feet and at Jones Beach, 1000 feet. The Lloyd sand has yields of up to 2000 gpm to individual wells, under artesian pressure, and except for natural iron content, is of good quality.

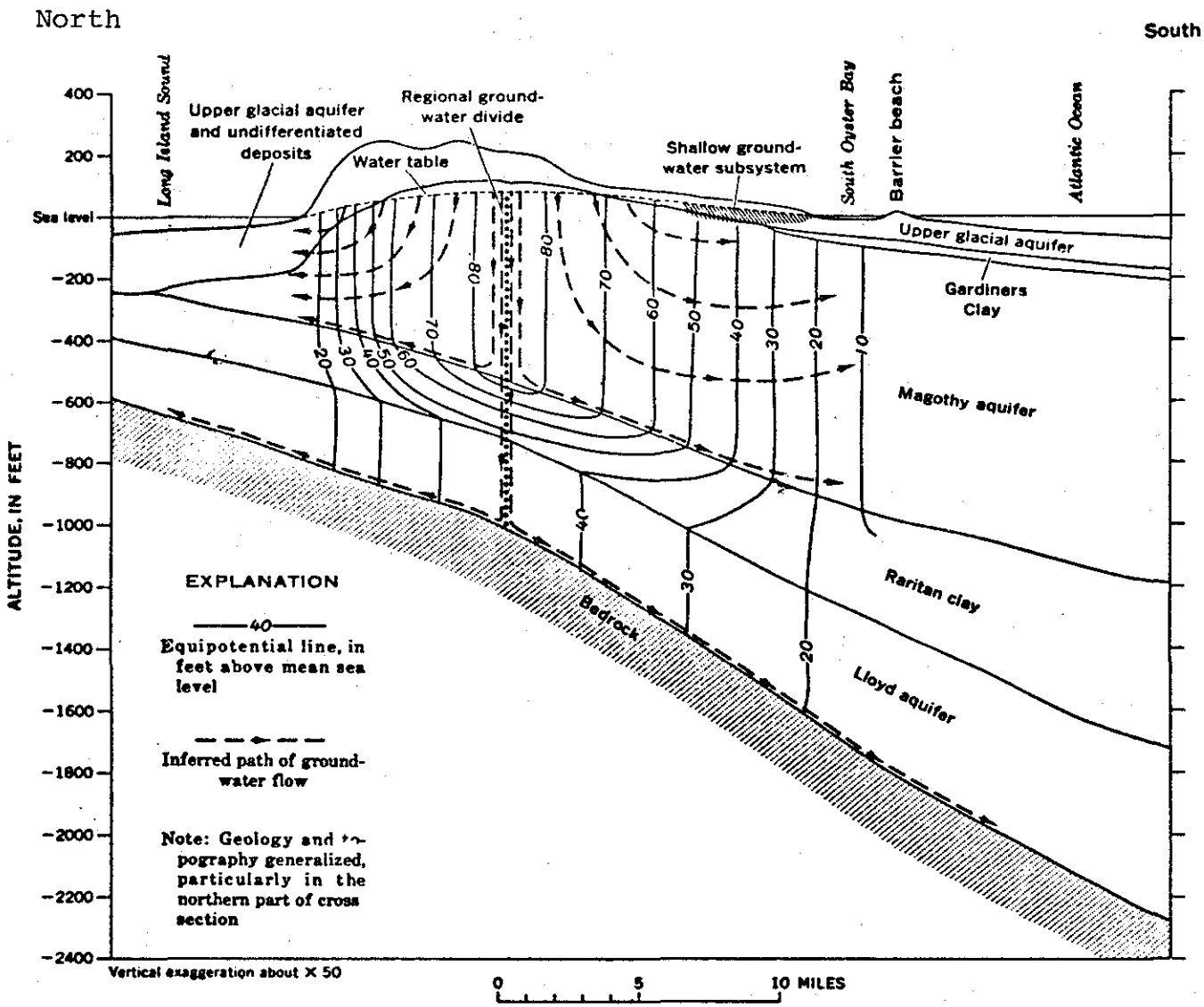
Most of the surface waters on the Island are simply the exposed water table in a depression and thus surface water and groundwater are intimately connected.



NOTE: ADAPTED FROM NEW YORK WATER RESOURCES COMMISSION BULLETIN No. 62, 1968

GEOLOGIC SECTION OF PRINCIPAL LONG ISLAND AQUIFERS

FIGURE IV-1



Generalized equipotential and flow lines in the ground-water system of Long Island, N.Y., under natural conditions.

SOURCE: USGS Prof. Paper 800-C

FIGURE IV-2

4. Groundwater

Since groundwater is the only source of potable water in Nassau and Suffolk Counties, the interrelated problems of wastewater management and water supply require a study of both the quality and extent of groundwater. The levels of groundwater, its relationship to precipitation, the evidence of salt water encroachment and other water quality problems are important aspects in determining the type of wastewater-water supply management program required.

a) Groundwater levels

Groundwater levels in Long Island have recently been dropping, contributing to the projected need for water supply. With the need for sewering due to increased population growth, and the areal expansion of impervious surfaces, natural recharge of the groundwater has been curtailed. An important factor of a wastewater recharge program will be the possible spread of contaminants in the aquifers, which is dependent, in part, upon groundwater levels. Moreover, the effect of sewering upon the groundwater levels may be studied by tracing the history of groundwater levels.

An indication of the degree of groundwater level decrease is given by Greeley & Hansen (CPWS-60) who report a maximum 15 feet decline in Nassau County in the period 1959-1967, which is almost equal to the total of the period 1903-1959. Holzmacher reports drops as much as 12 feet in some areas of Suffolk County during the period 1957-1965.

Several factors contributed to large scale lowering of the water table:

1. Increased withdrawals of the groundwater due to increase in population.

2. Increased use of water per capita.

3. Decreased natural recharge related to urban development.

4. Decreased artificial recharge as a result of county-wide sewering.

5. The drought (1961-1966) which decreased the rainfall available for recharge and subsequently increased water consumption for sprinkling and irrigation.

Figures IV-3 and IV-4 show a contour map of Nassau County groundwater levels and a groundwater level section respectively. The section represents the area (Hicksville) where the maximum lowering of the water table was experienced.

The present, prevalent method of disposing of wastewater in Suffolk County and parts of Nassau County, is through individual cesspools or septic tanks with leaching pits. This practice allows the effluent to be returned to the groundwater reservoir. Continuation of large scale installation of public sewerage systems will affect groundwater levels to a degree depending on where the treated effluent is discharged, i.e., discharging treated effluent into the sea or recycling it into the ground after undergoing further treatment.

USGS has recently published a study on the effects of sewering on groundwater levels in Nassau County. Suffolk County is expected to experience the same effects because of its similarity in terms of hydrology, geology, topography and urbanization. A double-mass curve technique was used to represent groundwater changes and is represented by Figure IV-5, indicating that the groundwater levels in the sewered area are dropping relative to the unsewered areas.

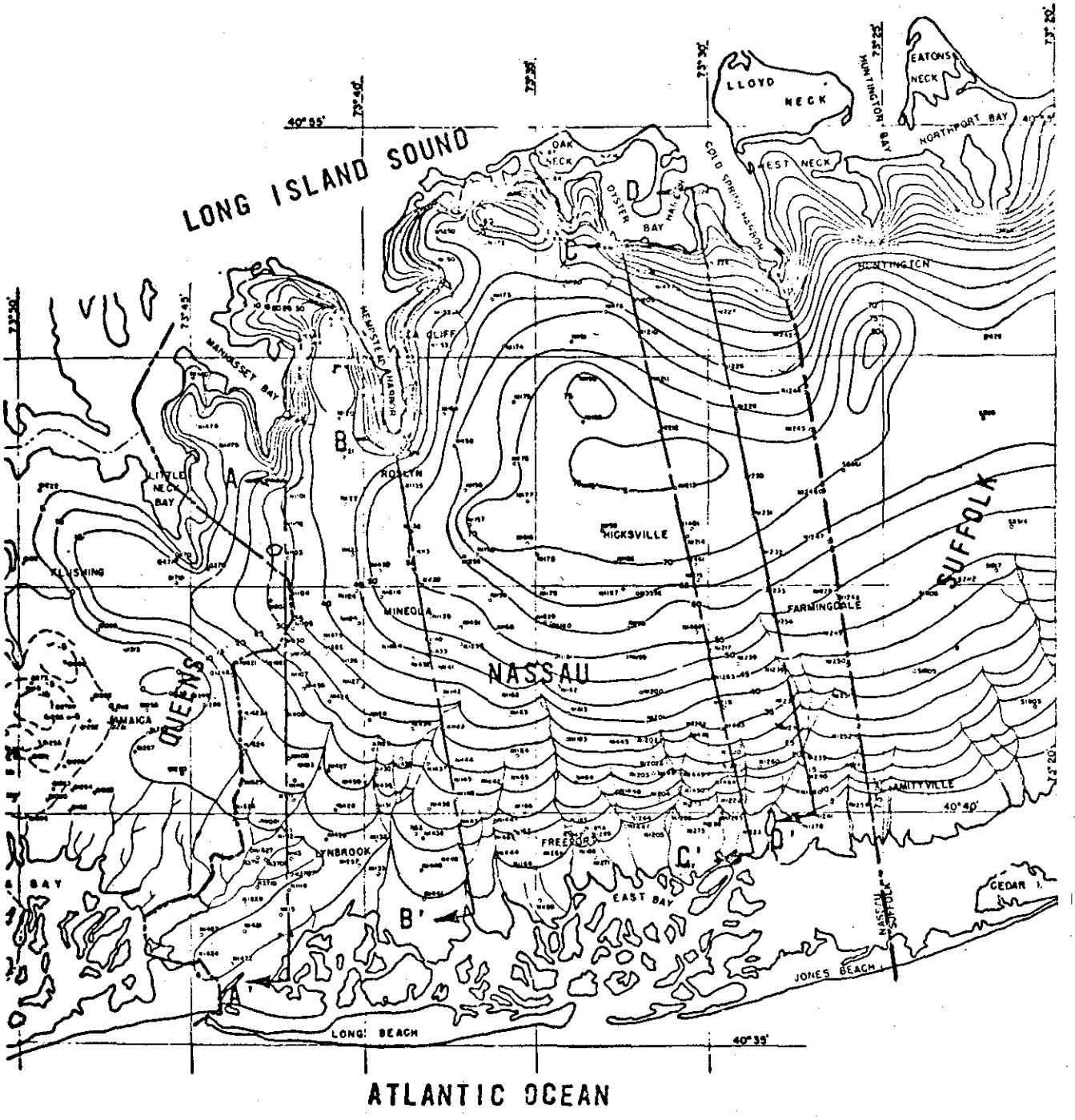
Very recent years of heavy precipitation have reversed the trend on a local basis and some areas have experienced groundwater level increases to levels near the maximum of record. Data for this period has not yet been correlated and published.

b) Correlation of Groundwater Levels and Precipitation

The drought that occurred during the period 1961-1966 was considered as the major contributing factor in the sharp decrease of Long Island groundwater in less than a decade (1959-1968). Since the sole source of fresh water which enters Long Island's groundwater is precipitation, it is therefore the most important parameter that has a direct bearing on the groundwater table levels.

Holzmacher related groundwater levels to precipitation (CPWS-24) as seen in Figure IV-6, and concluded that there is a distinct correlation between groundwater levels and precipitation, reflected in the sharp decline of the curves during the drought period.

FIGURE IV-3

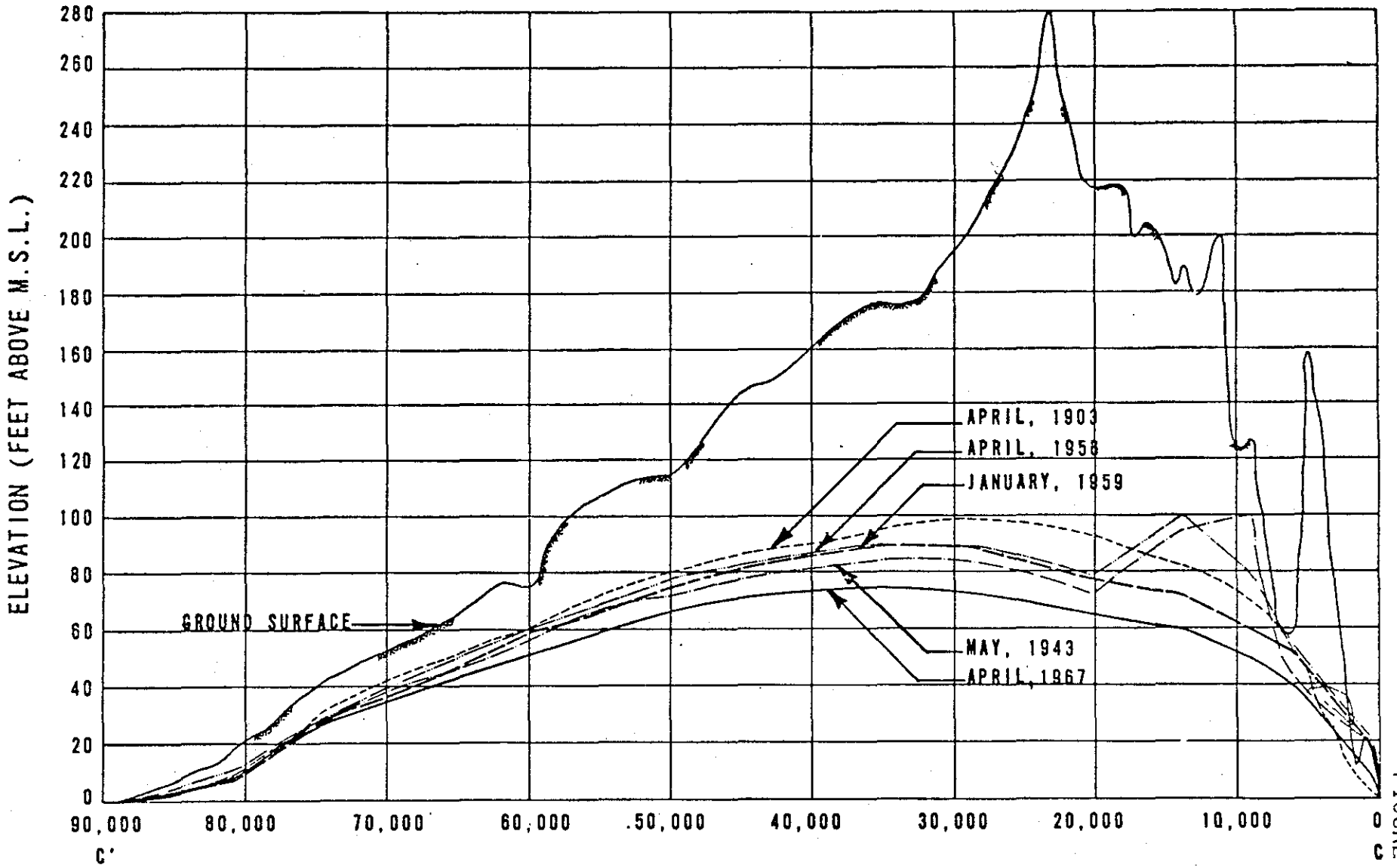


Nassau County Ground Water Levels, Plan View

LEGEND

County Boundaries
Section Lines

SOURCE: Greeley and Hansen, "Comprehensive Water Supply Study - Nassau County, N.Y.", June 1971

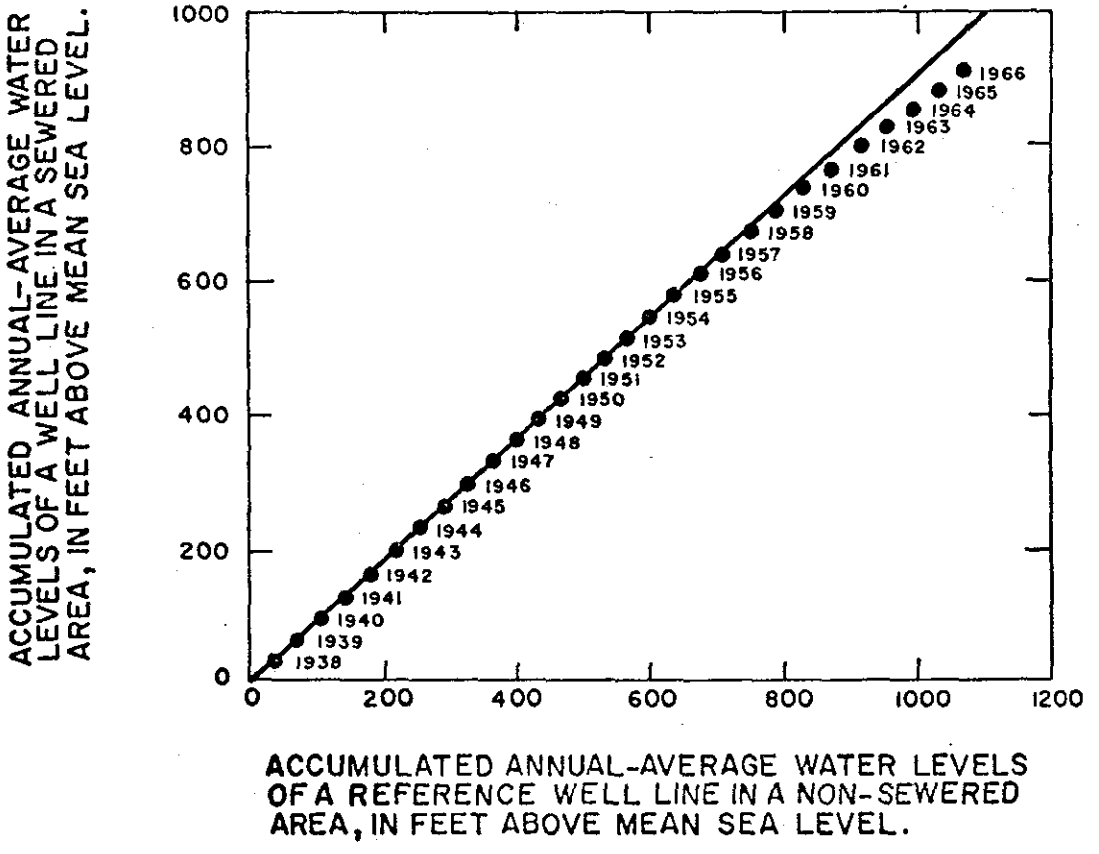


NASSAU COUNTY GROUND WATER LEVELS **SECTION C-C'**

NOTE: See Figure IV-6 for the location of this section.
SOURCE: Greeley and Hansen, "Comprehensive Water Supply Study - Nassau County, N.Y.", June 1971

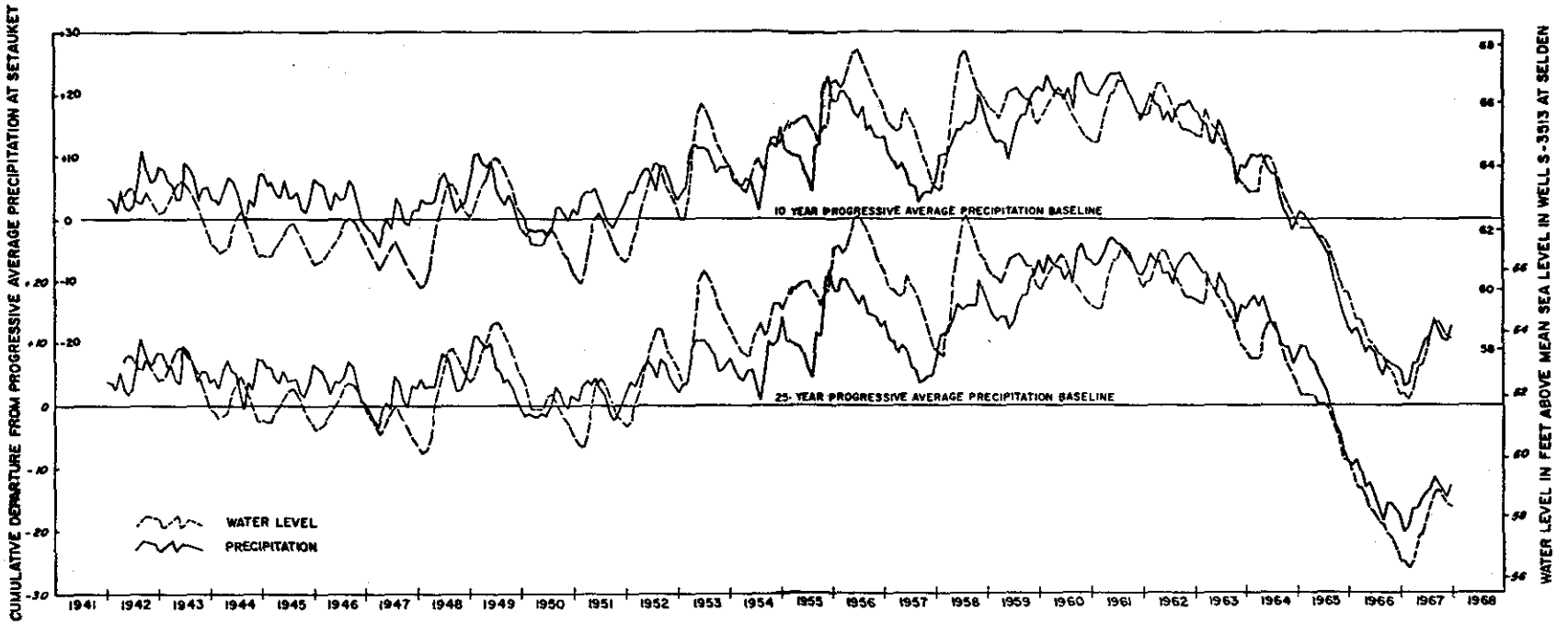
FIGURE IV-4

FIGURE IV-5



DOUBLE-MASS PLOT OF COMPOSITE ANNUAL-AVERAGE GROUND-WATER LEVELS SHOWING THE EFFECT OF SEWERING, NASSAU COUNTY

Source: Franke, O.L., 1968, "Double-Mass-Curve Analysis of the Effects of Sewering on Ground-Water Levels on Long Island, New York", U.S. Geol. Survey Prof. Paper 600-B, P.B208



CORRELATION OF PRECIPITATION AND GROUND WATER LEVEL

SOURCE: Holzmacher, McLendon & Murrell, "Comprehensive Public Water Supply Study - Suffolk County, N. Y." 1970

FIGURE IV-6

Precipitation increase in the last two years has led to an observed elevation of groundwater levels in both Nassau and Suffolk Counties. Groundwater levels in Nassau have approached the maximum of record on a local basis. Suffolk County has recently experienced flooding of basements on a local basis. The increase of groundwater levels may be a short term phenomena, however, study of the effect of precipitation upon the entire hydrological cycle on Long Island requires immediate and definitive study.

c) Salt Water Encroachment

Salt water encroachment refers to the phenomona of brackish water from the Ocean and Sound entering fresh groundwater supplies in coastal areas due to hydraulic pressures caused in part by low groundwater levels on the mainland.

Salt water encroachment in Long Island groundwater has been a matter of concern since the 1950's. The most serious problem exists in a small area on the southern Queens-Nassau County border. This area has been studied to predict the extent of the problem, investigate its causes and plan means for its prevention. Southwestern Nassau and southeastern Queens Counties have a parallel history of groundwater and general development and the remaining eastern areas in Nassau and Suffolk Counties are expected to develop similarly. Therefore studies at the Nassau-Queens border should have future implications for the whole Long Island area.

Four bodies of salty groundwater are found near and beneath parts of the southern Queens-Nassau border area:

1. A shallow body in the upper glacial aquifer.

2. An intermediate wedge that extends downward from the Gardiners clay through the Jameco aquifer and into the upper part of the Magothy aquifer.

3. A deep wedge in the Jameco aquifer but mainly in the lower and middle parts of the Magothy aquifer.

4. A wedge in the Lloyd aquifer.

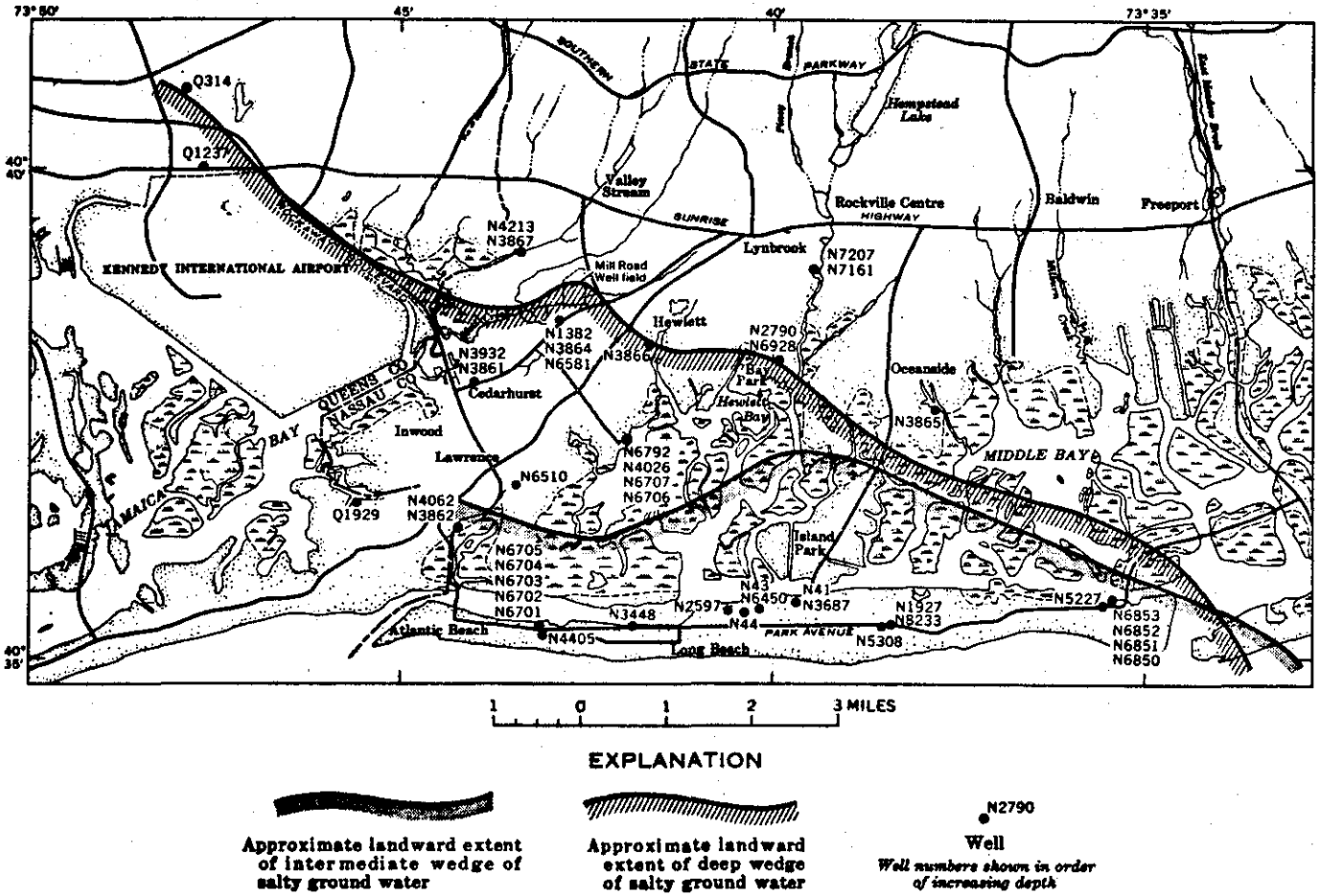
Shallow salty groundwater is associated with the salty bays and estuaries and with the Atlantic Ocean.

The intermediate and deep wedges thicken appreciably and ultimately merge in a seaward direction. Little is known about the wedge in the Lloyd aquifer, except that it is believed to be seaward of the coastal barrier beaches. The landward extent of the intermediate and deep wedges were mapped by Lusczynski and Swarzenski in 1961 (as presented in Cohen & Kimmel, USGS Prof. Paper 700-D, 1970) and is presented herein as Figure IV-7. Chloride contents in the salty-fresh water mix zone range from 10 to 40 mg/l on the fresh water side to about 18,000 mg/l on the salt water side. Fresh groundwater has a chloride content of about 10 mg/l (chlorine content of greater than 40 mg/l is generally assumed to indicate salt water contamination in Long Island).

It is believed that the positions of the wedges as depicted on Figure IV-7 have remained relatively constant, except for some small local exceptions. Furthermore, the present position, alignment, thickness and width of the salt water wedges are phenomena attributable mainly to natural conditions that prevailed long before groundwater development in the study area. In 1969, it was concluded (Cohen & Kimmel) that regional estimates of salt water wedge movement are as follows: deep wedge velocity of 10 feet per year; intermediate wedge velocity of less than 10 to 20 feet per year. Recent data indicates that salt water intrusion is apparently a local problem only in the aforementioned area and is not expected to be of serious concern for the remainder of the area for many years hence. Additionally, recent years of high precipitation have most probably slowed the estimated rates of salt water wedge movement.

d) Water Quality Problems

During recent years groundwater quality in Long Island has undergone considerable deterioration. The major problems are those of nitrate, detergent and iron contamination. Additionally, local problems of salt water intrusion and thermal and industrial waste pollution contribute to the overall quality deterioration. Salt water contamination has been discussed previously and its local nature makes it a problem of less serious nature. Nitrate and detergent contamination are a result of widespread usage of septic systems for wastewater disposal. Iron problems arise from naturally high iron content groundwater.



Location of the landward extent of the intermediate and deep wedges of salty ground water in southern Nassau and southeastern Queens Counties, Long Island,N.Y.

SOURCE: Cohen and Kimmel, USGS Prof. Paper 700-D, 1970.

FIGURE IV-7

High iron content water problems occur mostly in the southern portion of Nassau County, where the groundwater is naturally characterized by low dissolved oxygen content and high natural iron content. Natural iron is in the ferrous state and undergoes oxidation and precipitation within the distribution system, resulting in the deposit of iron bearing sediment. The immediate cause of rusty water conditions is local disturbances in the water mains which stir up iron sediments. Systematic main flushings, and chemical treatment for iron removal and application of sequestering agents and corrosion control chemicals have been used to combat the problem. Chemical treatment has met with limited success due to the inability to keep pH consistently within limits necessary for iron removal.

Synthetic detergents contain substances which can be non-biodegradable or may contain nutrients and other substances which cannot or are not easily removed in septic tank systems or conventional sewage treatment systems. Phosphates are nutrients and have been eliminated from detergents. ABS, (alkyl benzene sulfonate) a refractory organic substance is non-biodegradable and has been replaced in detergents by LAS (linear alkyl benzene sulfonate) a more biodegradable substance. Due to the use of septic tanks, these substances have entered groundwater aquifers especially in the upper glacial aquifers. MBAS (methylene blue active substances), a measure of refractory organics, persist in quantities and travel sufficient distances to endanger the adequacy and quality of the water supply sources on Long Island. The soap and detergent association states that although not aesthetically appealing, detergent residues do not constitute a health hazard and that no replacement of materials that will disappear after use with adequate sewage treatment appear on the research horizon. Sewage treatment will eliminate groundwater detergent pollution if the treated effluent does not eventually reach the groundwater. Suffolk County has banned the use of detergents for several years but test wells show no improvement in MBAS content.

Perhaps the greatest problem of groundwater contamination in Long Island is that of nitrates. The importance of nitrogen contamination is discussed in Appendix E of this report, as is the fate of nitrogen in a soil-ground water system. Increase of nitrate content in groundwater and streams mainly due to infiltration of sewage, leachate from chemical fertilizers and wastes from decayed crops, is a major water quality problem in Nassau

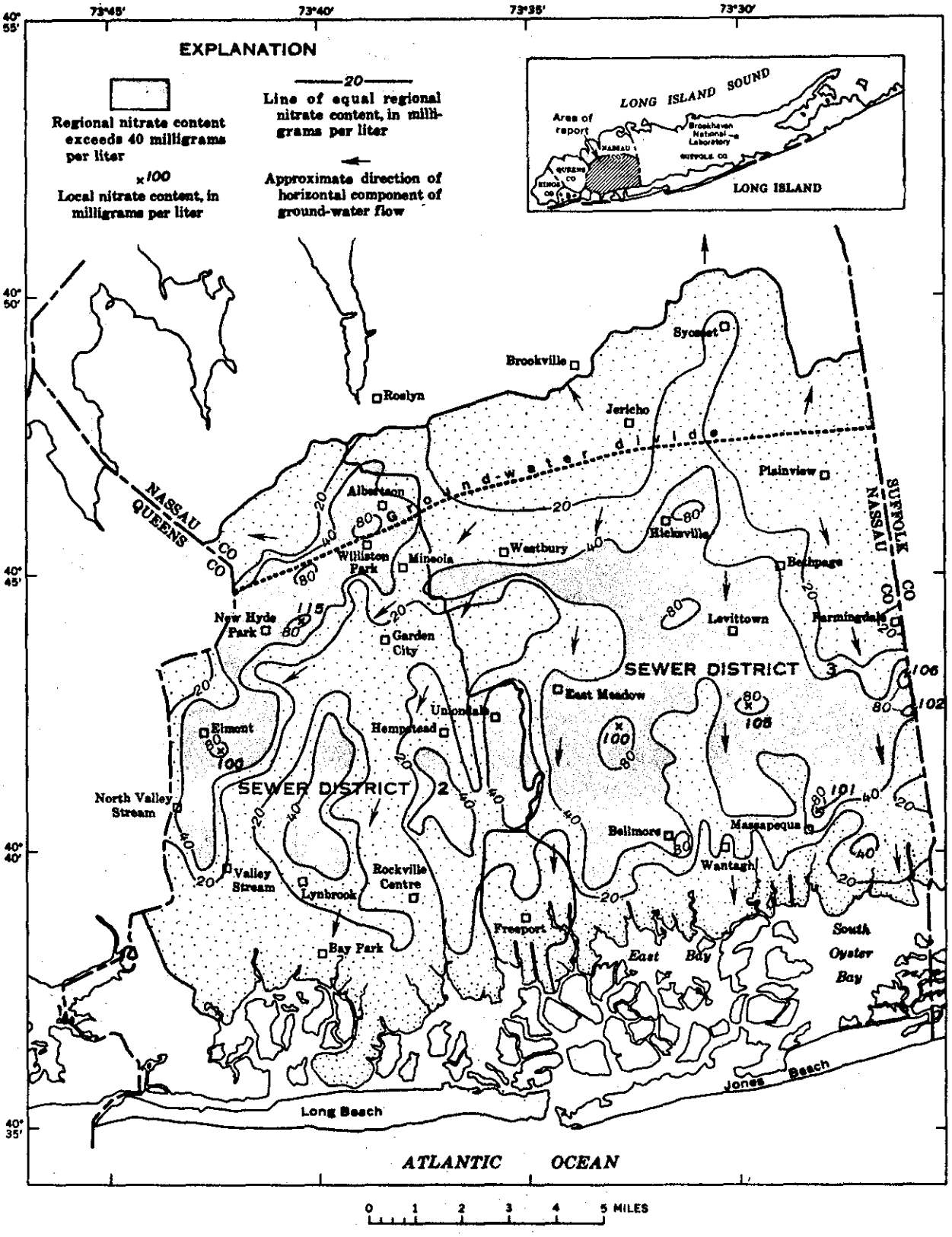
County studied by the USGS and the Nassau County Department of Public Works (NCDPW) since 1966. Although the problem is less severe in the more sparsely populated Suffolk County, parallel trends of development indicate that the nitrate contamination problems in Suffolk County will approach that of Nassau County in the future. Figure IV-8 indicates the regional nitrate content in the upper glacial aquifer in the USGS and NCDPW Study. The nitrate content in the upper glacial aquifer averaged 30 mg/l (as nitrate) and equalled or exceeded 100 mg/l (as nitrate) in seven locations. Nitrate content in groundwater fed streams averaged 11 and 25 mg/l in sewered and unsewered areas respectively. Nitrates in 234 public supply wells reaching into the Magothy aquifer averaged 10 mg/l but in 16 wells the nitrate content ranged from 45 to 94 mg/l. The estimated average natural nitrate content is 1 mg/l.

Nitrate movement within the aquifers has been traced and depends upon the following factors:

1. Population concentration.
2. Extent of sewerage.
3. Location with respect to groundwater divide and local soil conditions.
4. Groundwater levels.

Reference to Figure IV-5 indicates a generalized section of Long Island and groundwater flow within the major aquifers. It may be seen that the steepest gradients and thereby the quickest flow through the aquifer occurs under the groundwater divide, which is also relatively densely populated. The nitrate content in the Magothy aquifer was studied and can be seen as Figure IV-9 (areal distribution) and Figure IV-10 (vertical distributions). Movement of nitrate to the Magothy aquifer is partly due to pumping of deep wells and partly due to natural flow pattern. Study of the hydraulic control of nitrate movement has yielded estimates of vertical movement in the Magothy aquifer of 5 to 25 feet per year vertically and 130 feet per year horizontally. There is some evidence that ion exchange in the ground is responsible for chemical inhibition of the movement of nitrates.

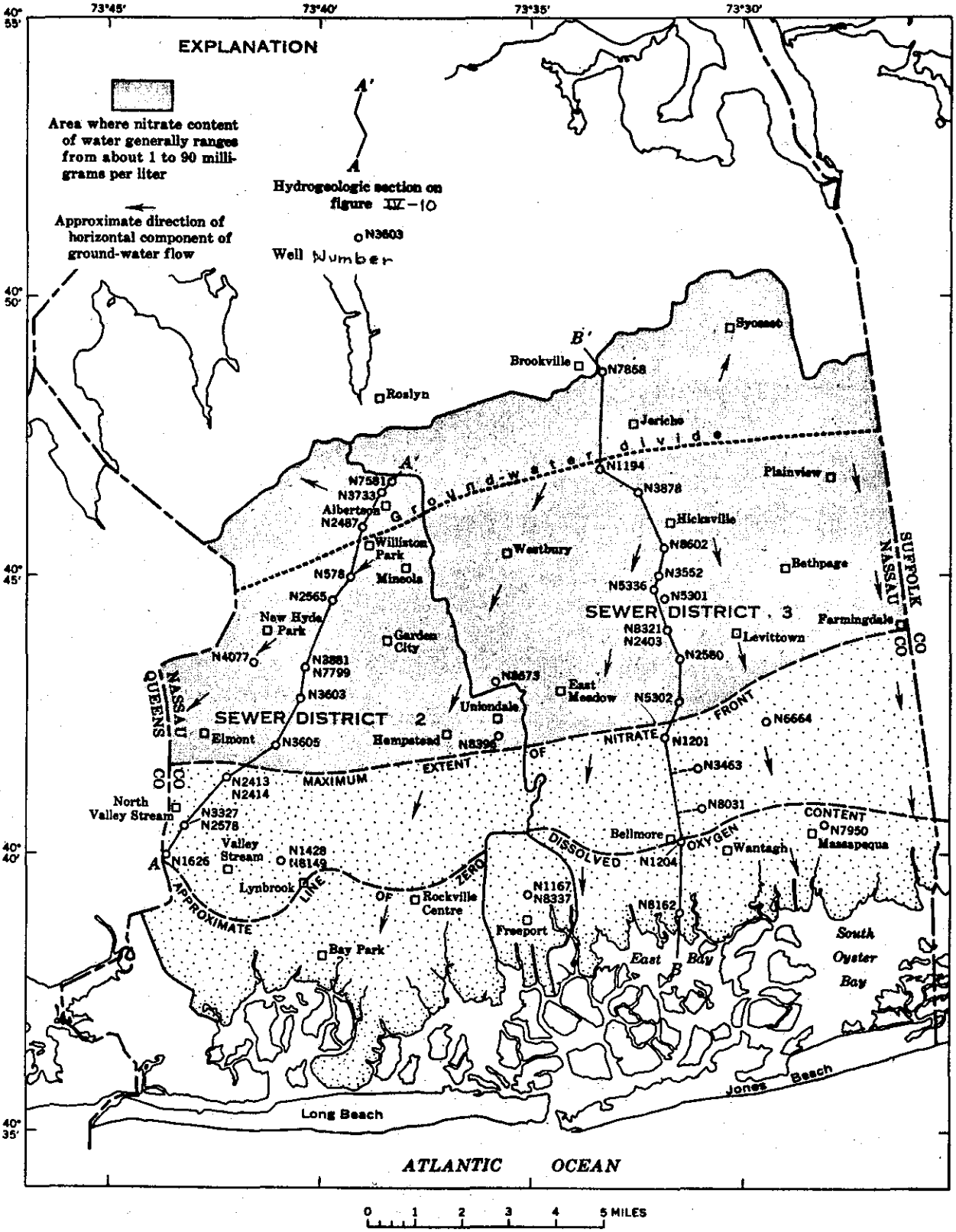
The level of the groundwater can greatly affect the movement of groundwater and thus nitrates through the aquifers. Local and regional depression of groundwater tables by pumping will increase the rate of nitrate flow to the lower Magothy aquifer. Conversely, increase of



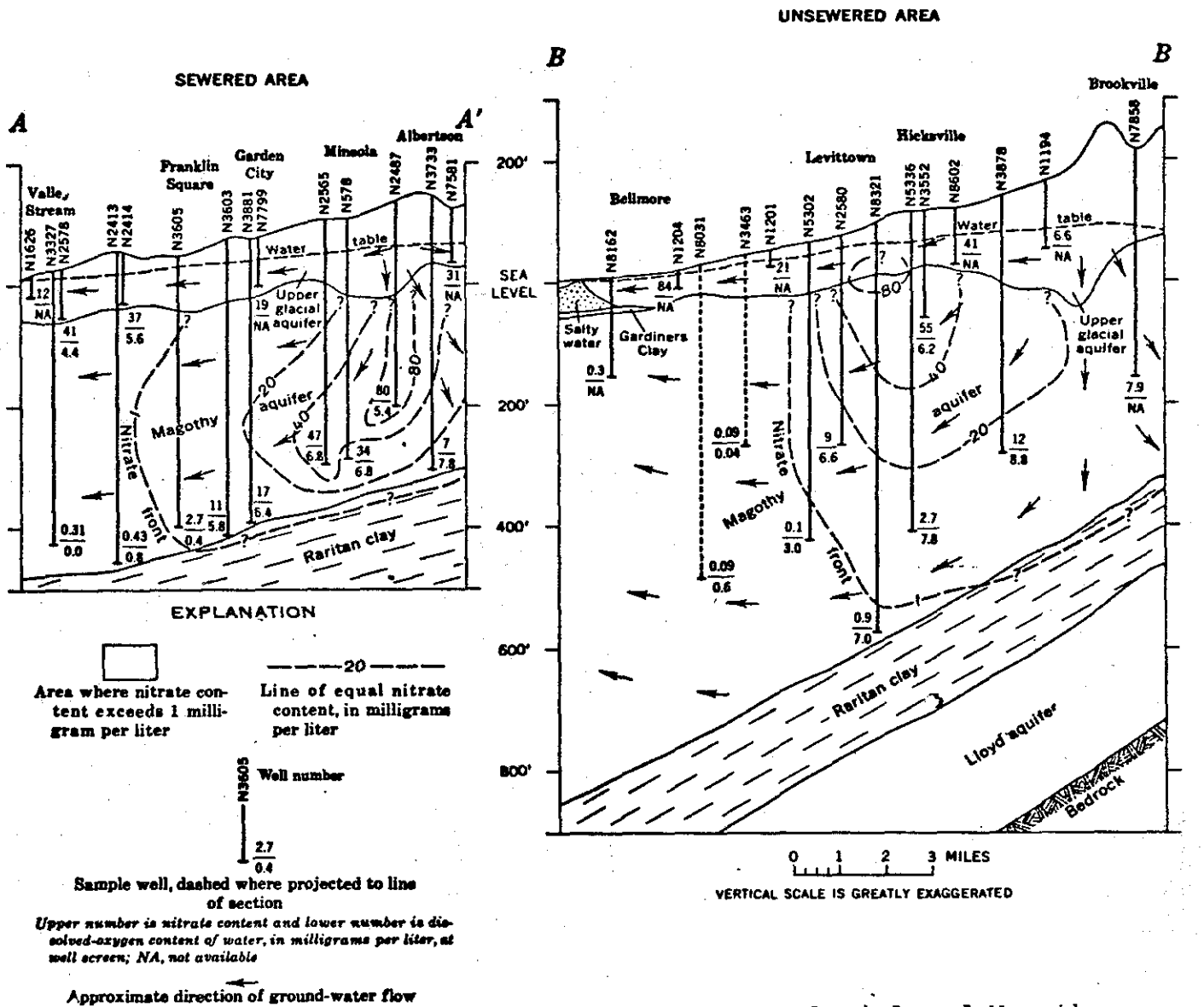
Regional nitrate content of water in upper glacial aquifer in report area (patterned), southern Nassau County, Long Island, N.Y. 1966-70.

SOURCE: USGS Prof. Paper 800-B (1972)

FIGURE IV-9



Approx. areal extent of main body of nitrate-enriched water, max. southern position of nitrate front, and approx. line of zero dissolved-oxygen content of water in Magothy aquifer, southern Nassau County, L.I., N.Y., 1969-70.
SOURCE: USGS Prof. Paper 800-B (1972)



Vertical distribution of nitrate in water in upper glacial and Magothy aquifers, southern Nassau County, Long Island, N.Y., 1968-70

NOTE: Lines of sections are shown on figure IV-9.

FIGURE IV-10

groundwater tables by heavy precipitation will slow the groundwater movement of nitrates. Additionally, the respective concentration-dilution effect of increased pumping and rainfall will affect nitrate concentrations. Sewered areas have lower concentrations of nitrate in the groundwater than unsewered areas, however, the water taken out of the aquifers is not returned and groundwater levels are lower.

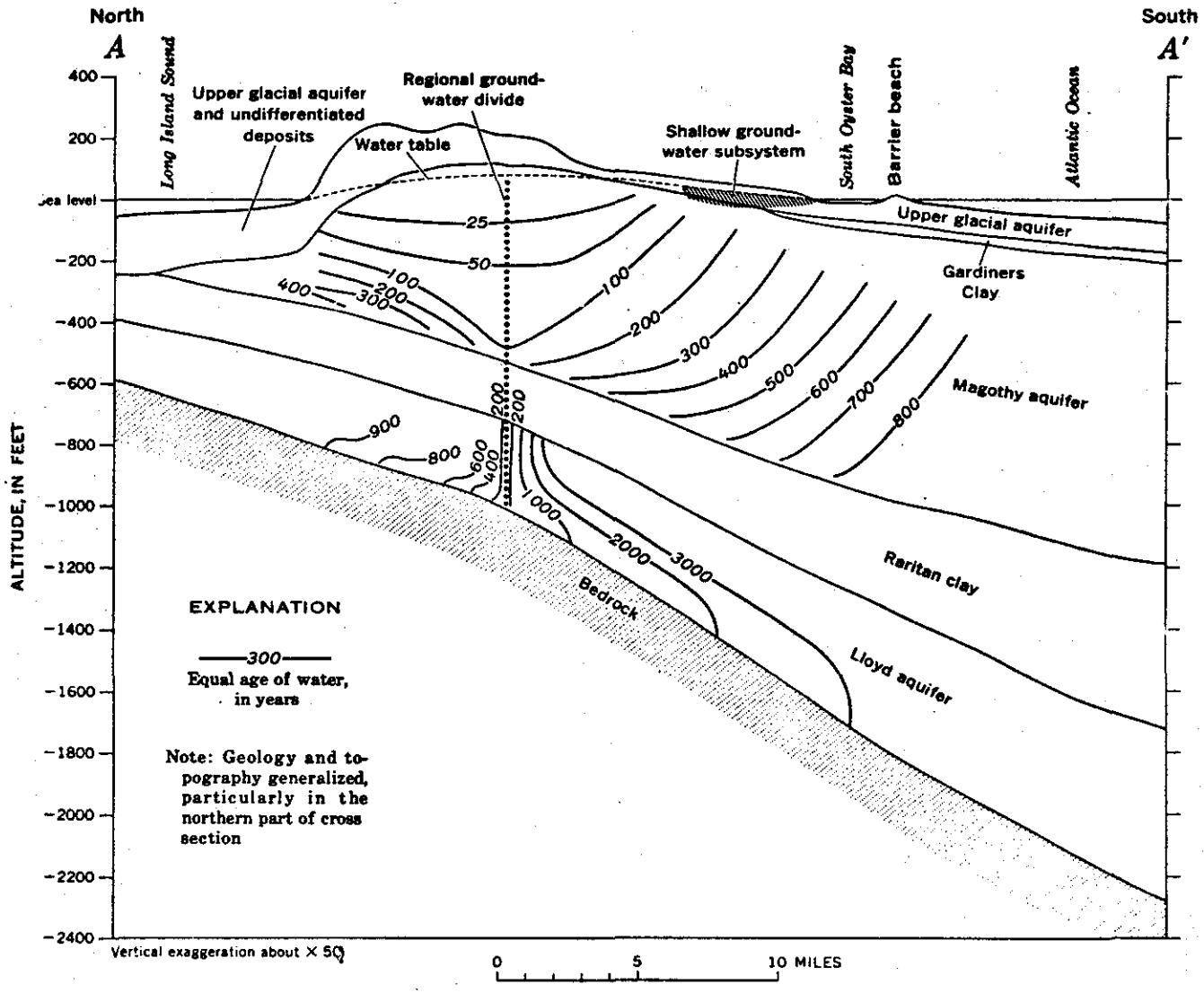
It can be seen that rates of groundwater movement are dependent upon location and groundwater levels. One study estimated the approximate time for water near the Nassau-Suffolk County border to move from the water table to points within the regional groundwater system and this is shown as Figure IV-11. These times may be roughly indicative of the time to flush out nitrates after a sewerage system is placed in a particular area.

5. Wastewater Management

Wastewater Management is a necessary and important consideration in the Long Island area, especially from the water supply point of view. To meet water supply demands in the future, wastewater recharge, direct or indirect wastewater reuse or importation of water will be necessary. Direct wastewater reuse is not recommended for potable use. Water importation schemes include development of Suffolk County groundwater to feed Nassau County and importation of water from New York City's supply. The latter schemes are discussed in detail in Section V-B of this report.

a) Need for Water Supply

Water supply demand is expected to surpass the safe yield of Nassau County within 10 to 20 years, while Suffolk County's supply is expected to be sufficient for at least the next 50 years. The safe yields of Nassau and Suffolk Counties are estimated at 159 and 513 mgd respectively. Safe yield refers to the long term average outflow of fresh water into Long Island Sound or the Atlantic Ocean through surface streams and underground aquifers, plus the discharge of spent water through sewers to the sea. The usable water supply in Long Island is substantially greater than the safe yield because much of the water pumped from wells returns to the ground as wastewater through septic tanks, cesspools and sewage fields. In Nassau County, approximately 69 mgd of water is returned via these methods. Recent sewering of areas has changed the situation since



Approximate time required for water to move from the water table to points within the regional ground-water system of Long Island, N.Y.
NOTE: Section located slightly east of Nassau-Suffolk County border.
SOURCE: USGS Prof. Paper 800-C (1972)

FIGURE IV-11

treated wastewaters are discharged directly to the ocean, and sewering is expected to continue for the rest of Nassau and Suffolk Counties.

The permissive sustained yield (PSY) is defined as the maximum rate at which water can be consumed perennially without bringing about some undesirable results. Estimates of the PSY places the figure at 151 mgd for Nassau County and 466 mgd for Suffolk County. The undesirable effects are defined as (1) the salt water interface moving one mile toward land; and (2) the ground water table going down about 30 feet. The PSY is based on a total average annual precipitation rate of 44 inches per year, of which 22 inches goes to evapotranspiration, 1 inch to stream flow and 4.5 inches to underflow, leaving 16.5 inches for the PSY. These assumptions are subject to a degree of error, especially the evapotranspiration value. Current increases in groundwater are laid to recent heavy rainfall above 44 inches per year. Assuming 50% of rainfall going to evapotranspiration, groundwater level increase is in excess of that expected. Moreover, further careful study of the factors affecting the PSY should be made to enable more accurate evaluation of water supply needs and therefore wastewater management needs.

b) Sewerage Facilities

Nassau County

The Nassau County sewerage system is divided into four separate disposal districts. Disposal District No. 1 and No. 2 are in operation. Disposal District No. 3 is under construction while Disposal District No. 4 is proposed.

District No. 1 is located in the southeastern region of the County and is served by the Inwood Sewage Treatment Plant.

District No. 2, which covers the western portion of the County, extends from Albertson and Williston in the north to Woodmere and Hewlett in the southwest, and Oceanside in the southeast. The sewage from this area is treated at the 70 MGD Bay Park Treatment Plant.

District No. 3 comprises the eastern half of Nassau County and facilities are presently under construction. A treatment plant located in Wantagh will provide similar

treatment to that of the Bay Park Treatment Plant. Completion of the sewerage facilities for this district is expected in 1975.

Preliminary studies have been already started for proposed District No. 4 which will serve areas draining north to Long Island Sound. It is expected that the Bay Park and Wantagh Sewage Treatment Plants will handle 70% of the total Nassau County wastewater flow.

Collection and disposal is directed by the Nassau County Department of Public Works. Cost of construction and operation of the sewerage plants are assessed to the areas being served through special service districts.

The present and future sewer districts for Nassau County are shown in Figure IV-12.

Suffolk County

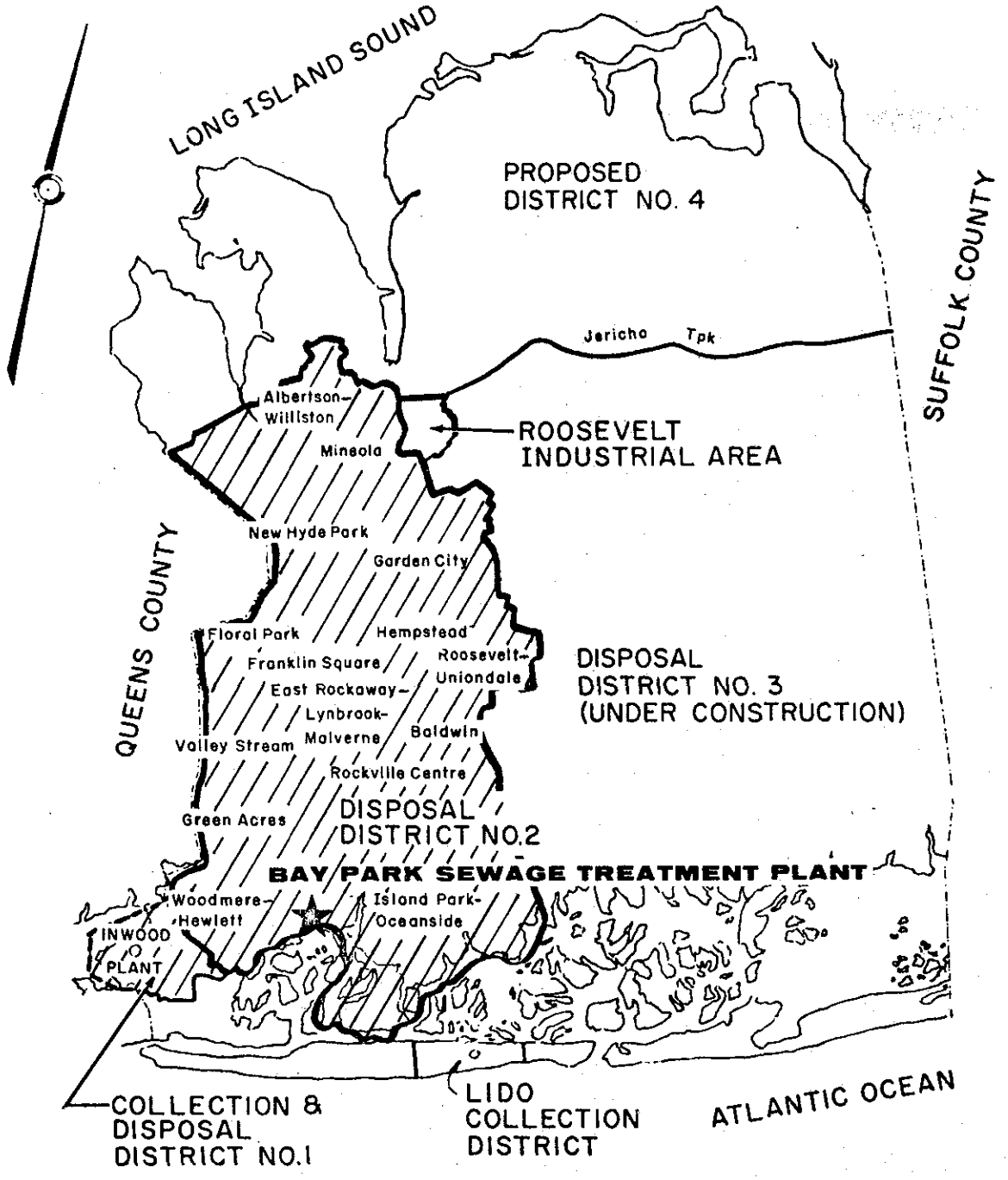
In Suffolk County, there are presently ten major sewage treatment plants serving less than 10% of the total population. Suffolk County is less densely populated than Nassau County and thus has not had the pressure to sewer as has Nassau County. Population predictions show a growth period for the future and expectedly sewerage programs are being proposed. The densest areas of population occur close to Nassau County in the western end of the County.

Comprehensive sewerage studies for the five western towns of Suffolk County, containing 80% of the County's total population led to the adoption of ten sewerage districts, each to have its own collection system and sewage treatment plant. The first of these is being constructed to serve approximately 25% of the total county population and includes a sewage treatment plant at Bergen Point with a design capacity of 30 MGD. Comprehensive sewerage studies have recently been completed for the five eastern towns of the County with the recommendation of seven additional collection and disposal districts to serve this area.

c) Recharge of Reclaimed Wastewater

Recharge of reclaimed wastewater may be used to conserve water supply by recharge to the aquifer directly via

FIGURE IV-12



PRESENTLY SEWERED AREAS

SEWER DISTRICTS — NASSAU COUNTY

SOURCE: Burns and Roe, Inc., "Final Report - Phase I - Water Renovation Project", County of Nassau, March 1967

wells, or indirectly via recharge basins. Additionally, direct recharge of treated wastewater may be successfully employed to form a hydraulic salt water intrusion barrier. The effects and suggested study outline for a land application system is further discussed in Appendix E of this report. The application of treated sewage effluent in Long Island is specifically discussed in this section.

Since recharge appears to have potential in Long Island, the New York State Department of Environmental Conservation (NYSDEC) has proposed the adoption of the following implementation procedures to conserve water resources (February 2, 1972, NYSDEC policy directive for groundwater replenishment on Long Island):

1. By 1980, recharge of 50% of the total volume of collected and treated wastes.

2. By 1990, recharge of the maximum volume which is technically feasible with respect to groundwater management and quality.

(i) Direct Recharge

Direct recharge refers to the pumping of treated sewage effluent directly into an aquifer. This is accomplished by injection of recharge liquor via deep and shallow wells. This method has been studied for the Long Island area, specifically Nassau County, and a pilot scale, 1-year study is soon to come to completion. The study is being conducted by the Nassau County Department of Public Works (NCDPW) and the United States Geological Survey (USGS) and consists of taking secondary treated effluent from the Bay Park Sewage Treatment Plant (BPSTP), adding tertiary treatment and injecting the final effluent into aquifers via wells. The purpose of the tests is to obtain scientific and economic data needed to evaluate the feasibility of injecting reclaimed water into wells, the major focus being to determine the degree and causes of injection-well clogging and the application of various treatments to remedy or to reduce clogging. The second involves changes in the quality of recharge water as it moves through the aquifer, including the gain or loss of dissolved or suspended matter resulting in either an improvement or degradation in the water quality.

Preliminary results indicate that clogging of the injection wells reduces well specific capacity such that frequent well redevelopment is required. The rate of clogging was determined as dependent upon the turbidity of the injection water. Suspended matter carried by the injection water is filtered out at or near the gravel pack aquifer interface of the injection well. The fine to medium grained character of the injection stratum renders it very effective in filtering particulate matter from the injected water, and accounts for the high sensitivity of the injection well to small amounts of suspended matter. Much of the clogging was found to be remedied by pumping the injection well to waste at rates up to 1000 gpm, however, a maximum of 40% of the specific capacity could be redeveloped in this manner. The remaining deposits inhibiting redevelopment are attributed to dissolved and suspended iron, aluminum and phosphate present in the injection water. Acid treatment of the well with hydrochloric acid restored nearly 50% more specific capacity, however, the practical application of this method may not be favorable.

Bacterial clogging was also evident, however, the maintenance of a total chlorine residual of at least 2 mg/l was found to make this an insignificant factor. Shock chlorination of injection wells with a chlorine solution containing 200 mg/l total chlorine residual was found to restore initial specific capacity to injection wells where bacterial clogging occurred.

The other problem evaluated in these tests was the change in water quality as the injection water moved through the aquifer. Apparently, cation exchange in the soil is responsible for an increase in dissolved solids concentrations of nitrate, sulfate and chloride ions. Iron concentrations in observation wells were found to be significantly higher than the native water from the Magothy Aquifer and small amounts of hydrogen sulfide were formed by native sulfate reducing bacteria.

The most recent conclusions of the study are as follows (Vecchioli, USGS, 1971):

"The Bay Park experiments have shown that the Magothy Aquifer can be recharged with reclaimed water through the use of injection wells, however, several

problems involving clogging of the injection well and changes in water quality have become apparent in this early work. Better definition of these problems is needed before the economic feasibility of recharging reclaimed sewage to Long Island's aquifers can be determined."

"Stringent quality requirements would have to be maintained on the injected water to minimize well clogging. For example, turbidity, iron, aluminum and phosphate contents of the injection water would have to be kept at near-zero levels, and the water would have to be chlorinated; otherwise, the rate of clogging would require frequent redevelopment of the well. Continued studies of the degree to which these parameters contribute to the overall clogging of the well and of the methods for reducing or remedying the clogging due to each would be useful."

"Preliminary results show objectionable amounts of iron and hydrogen sulfide are acquired by the injected water as it moves through the aquifer. Further investigation of the geo-chemical stability of the injected water would be necessary to predict the long-term character of the water."

Direct recharge of sewage may be practiced to form a hydraulic salt water barrier near the coast line. Water quality from the standpoint of eventual potable use would be less stringent, however, physical aspects of pumping will require high quality water.

The conclusions of the study in Nassau will provide data for preliminary feasibility information. This information could lead to a second stage study. In this study, approximately 5 MGD will be recharged in a 3 to 5 year period, and the questions of what wastewater treatment will be necessary, what type of injection well or basin to use, where to locate the injection facility and economic feasibility will hopefully be answered. At the present, it may be said that large scale recharge of treated sewage effluent is a possibility, and further study is required to determine its widespread feasibility.

In Suffolk County, in addition to cooperating with studies in Nassau County, a major study has been authorized under the auspices of the Suffolk County Department

of Environmental Conservation (SCDEC) to study recharge feasibility, and tests are currently being performed to study, among other items, the movement of contaminants in a groundwater system. A nitrogen removal system is under construction in Suffolk County. In a preliminary phase is a well monitoring study, a basin recharge study with secondary effluent, and a study to assess fertilizer effects on groundwater.

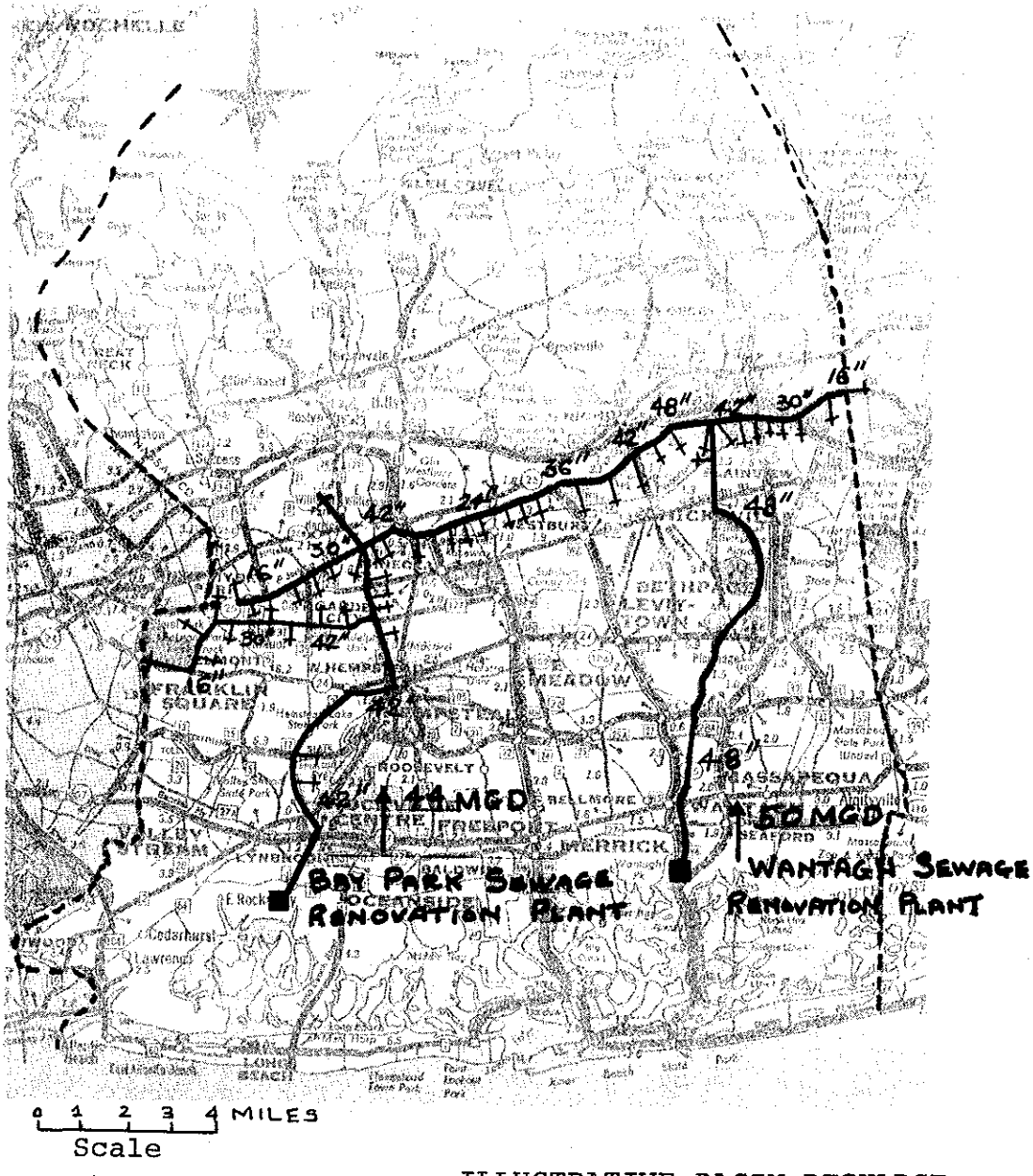
(ii) Basin Recharge

Basin recharge employs basins which hold wastewater effluents to allow recharge through percolation to the groundwater. This method requires more land area than well recharge, however, it will take advantage of the land's ability to provide a degree of treatment. Much study is required to determine the feasibility of this method for domestic wastewater on Long Island.

Basin recharge is currently being practiced in both Nassau and Suffolk Counties using storm water runoff and industrial cooling waters. Basins may take anywhere from less than one day to two weeks to drain, depending on the quantity of water to recharge and specific location of the basin among other factors. The quality of these waters may be equivalent to secondary or tertiary treated sewage on a solids content basis, indicating that basin recharge may be a feasible method to employ for reclaimed wastewaters. Potentially long drainage times, large basin areas, odoriferous conditions, and potential groundwater contamination are the major problems for this method.

Greeley and Hansen present a renovated wastewater basin recharge proposal for Nassau County. In this plan 94 MGD of treated wastewater from Bay Park and Wantagh Sewage Treatment Plants will be recharged in existing storm water basins at a design rate of 50 gpd/SF. This rate is considerably less than the average rate of storm water infiltration of 211 gpd/SF determined by the USGS for Long Island. Considering 100% spare capacity for maintenance and lost time during rainstorm runoff periods, only 80 acres of recharge basins would be needed. At present, storm water runoff recharge basins are in use only 5 to 10% of the time. Figure IV-13 depicts the Greeley and Hansen plan.

FIGURE IV-13



LEGEND

Transmission Main
Recharge Basin
Renovation Plant
County Boundary
16" Pipe Diameter

ILLUSTRATIVE BASIN RECHARGE PROJECT - NASSAU COUNTY

Source: Greeley and Hansen, "Comprehensive Water Supply Study, Nassau County, New York" (CPWS-60), 1971.

Holzmacher, in a report on the preliminary feasibility of recharging treated wastewater for Suffolk County, suggests the use of existing storm water basins for recharging reclaimed wastewater. The existence of enough basins of required capacity and appropriate infiltration rates for this scheme in Suffolk County is cited. During periods of storm water recharge, wastewater might necessarily be bypassed via ocean outfall because of the lack of storage and recharge capacity. Holzmacher suggests the possibility of recharging 12 MGD of renovated wastewater at 5 gpd/SF to storm water basins along the Long Island Expressway in the Babylon-Islip area.

Reclaimed wastewater would probably have to be of better quality than storm water to be acceptable, i.e., crystal clear, odor free and pathogen free. Further study is recommended to determine the feasibility of this method and the required quality standards for the reclaimed wastewater.

(iii) Spray Irrigation

Spray irrigation requires more land area than either basin or well recharge, but offers the advantages of the former and the water may provide some fertilizing value. Long term studies are required to design such a system. Soil and crop mechanisms have been cited as imparting various degrees of treatment upon the applied wastewater and determination of the extent of treatment specifically for Long Island is necessary to consider this as a viable wastewater management alternative in the Long Island area. A more detailed discussion of soil systems for wastewater treatment-crop irrigation is presented in Appendix 'E' of this report.

In Suffolk County more agricultural land is available than in Nassau County. Potato, cabbage and sod production are the major agricultural activities in Suffolk. Spray irrigation is not recommended for crops that are for human consumption. Sod has been found an effective agent in assimilating nitrogen from wastewater, however, two factors may preclude the use of reclaimed wastewater for irrigation of sod. Sod farms are very scattered and transporting wastewater would be uneconomical. Secondly, sod production is a high pressure industry, with much competition and the potential for clogging of machinery and irrigation rigs would be unacceptable.

d) Surface Water Augmentation

Holzmacher cited in his report to Suffolk County that reclaimed wastewater may be best utilized in Suffolk County by augmenting streams and ponds and that recharge for water supply purposes is not required for at least 50 years. However, it is estimated that some streams and ponds in Suffolk County will run dry in 15 years after completion of sewering due to the lowering of the groundwater levels. These surface waters must be maintained at present flows and levels for recreational, aesthetic and ecological reasons. Ecological reasons cited include: (1) continued unpolluted fresh water stream flow and underflow into certain bays is required in order to maintain the brackish conditions which are essential to the growth of many forms of marine life; (2) there may be possible adverse effects on inland plant and animal ecosystems by lowering water levels.

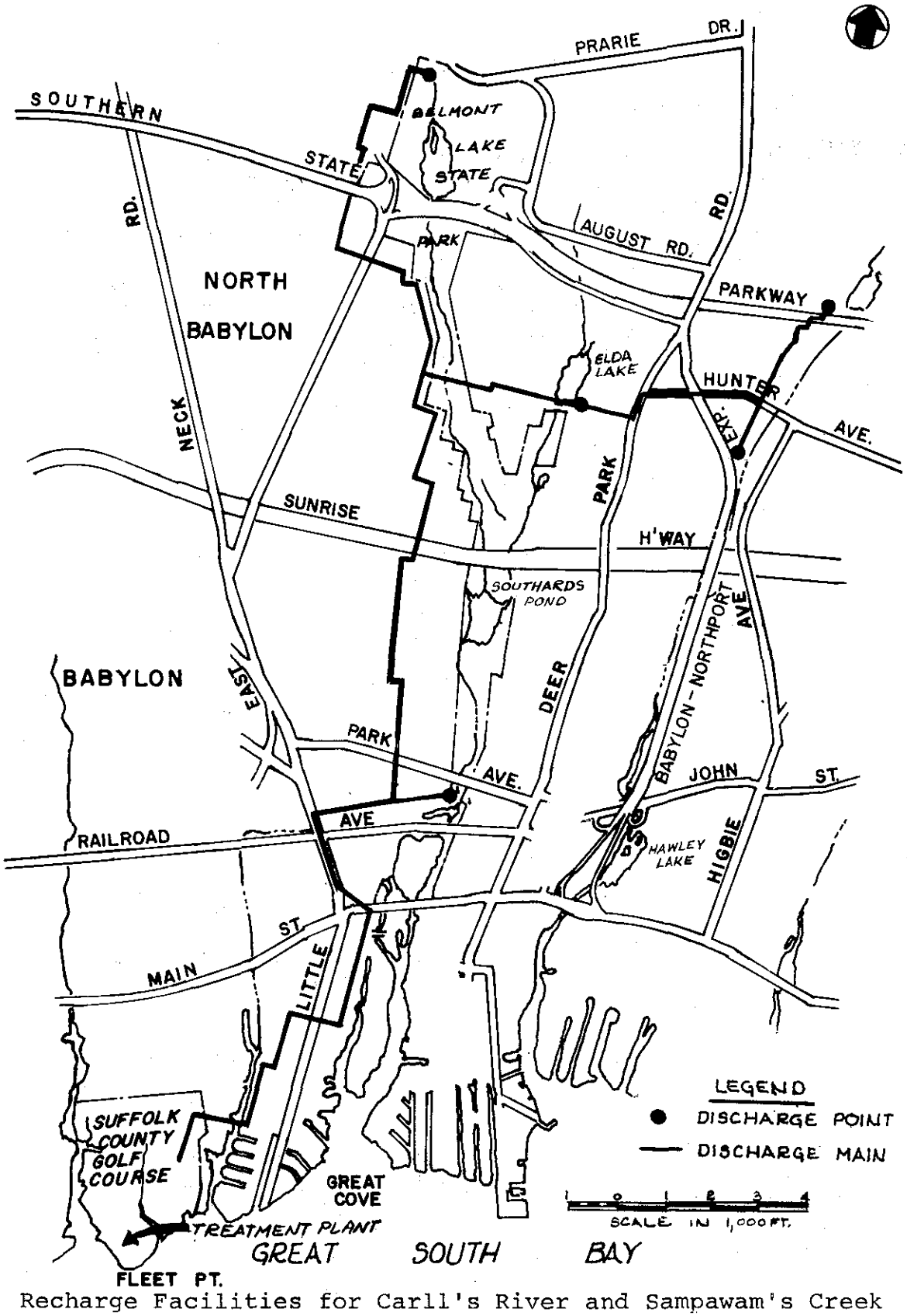
In Nassau County,Hemstead Lake might be augmented with reclaimed wastewater. This lake has been nearly dry for the last five years and is just recently beginning to rise due to the heavy precipitation in the last few years. In Suffolk County, Holzmacher proposed a preliminary feasibility study on the recharge of treated wastewater for Carl's River and Swampawam's Creek surface water systems. (Figure IV-14)

(iv) Renovated Wastewater Recharge Conclusions

The growth projected for Long Island, its corresponding need for increased water supplies and its particular geohydrologic and land use aspects may make renovated wastewater recharge the paramount feature in a wastewater management program. Much attention has been given to various methods of recharging renovated wastewater, including well injection, basin recharge and spray irrigation. Studies are currently underway on pilot plant scale for well injection, and studies are proposed for other methods of recharge. Further studies are planned to determine more exactly the technical, economic and social feasibility of recharge and to select recharge methods and sites.

Comprehensive study of all aspects of recharging renovated wastewater, both for the particular area of Long Island and more generally for the questions of possible human contamination, should be continued. Until technology is fully developed and the need for recharge is

FIGURE IV-14



Recharge Facilities for Carll's River and Sampawam's Creek Surface Water Systems, Suffolk County
SOURCE: "Preliminary Feasibility Study on the Recharge of Treated Wastewater" - Holzmacker, McClendon & Murrell (1972)

established for a particular area, ocean disposal is suggested. Some investigators state that recharge should be practiced only after permissive sustained yields are reached. In Suffolk County, this is not expected for 50 years, although the advantages of a spray irrigation system may be attractive for this area. Nassau County will need supplemental supplies by 1980, and continued research may lead to the feasibility of either a basin or well recharge system. Availability of agricultural lands close to sewage treatment plant locations is lacking in Nassau County.

Recharge of renovated wastewater to form a salt water barrier is currently being studied in Nassau County, however, the salt water encroachment problem is a localized phenomena, and recharge for this purpose is not seen as an encompassing answer to wastewater management and water supply for most of Long Island.

Perhaps a more probable use of renovated wastewater would be its use to augment surface water flows and raising of lake and pond levels for ecological and aesthetic reasons.

e) Management of Storm Water Runoff

The total amount of water available for groundwater recharge in an area is the difference between precipitation and the losses associated with direct runoff and evapotranspiration. The natural geohydrologic conditions on Long Island make losses to direct runoff very small. Most surface water streams are merly open surface exposures of the ground water. A USGS study in Suffolk County indicated that 2% of precipitation is lost to the Ocean and the Sound as direct runoff. Various studies have indicated that approximately 50% of precipitation is lost as evapotranspiration.

With the rapid urban and suburban development of the Long Island area in recent years, areal expansion of impervious surfaces, such as roads, highways, commercial centers and residences, has substantially increased the direct runoff in these areas. Storm water collected in such an area is discharged in two manners: to surface water streams which convey storm water to the Ocean or Sound, or to storm water recharge basins.

Two areas employing discharge of storm water to surface streams indicate the effect of land development on water losses. A USGS study of the East Meadow Brook and Mill Neck Creek drainage basins in Nassau County indicates that the volume of direct runoff from the sewered area is estimated to be roughly 20% of the precipitation.

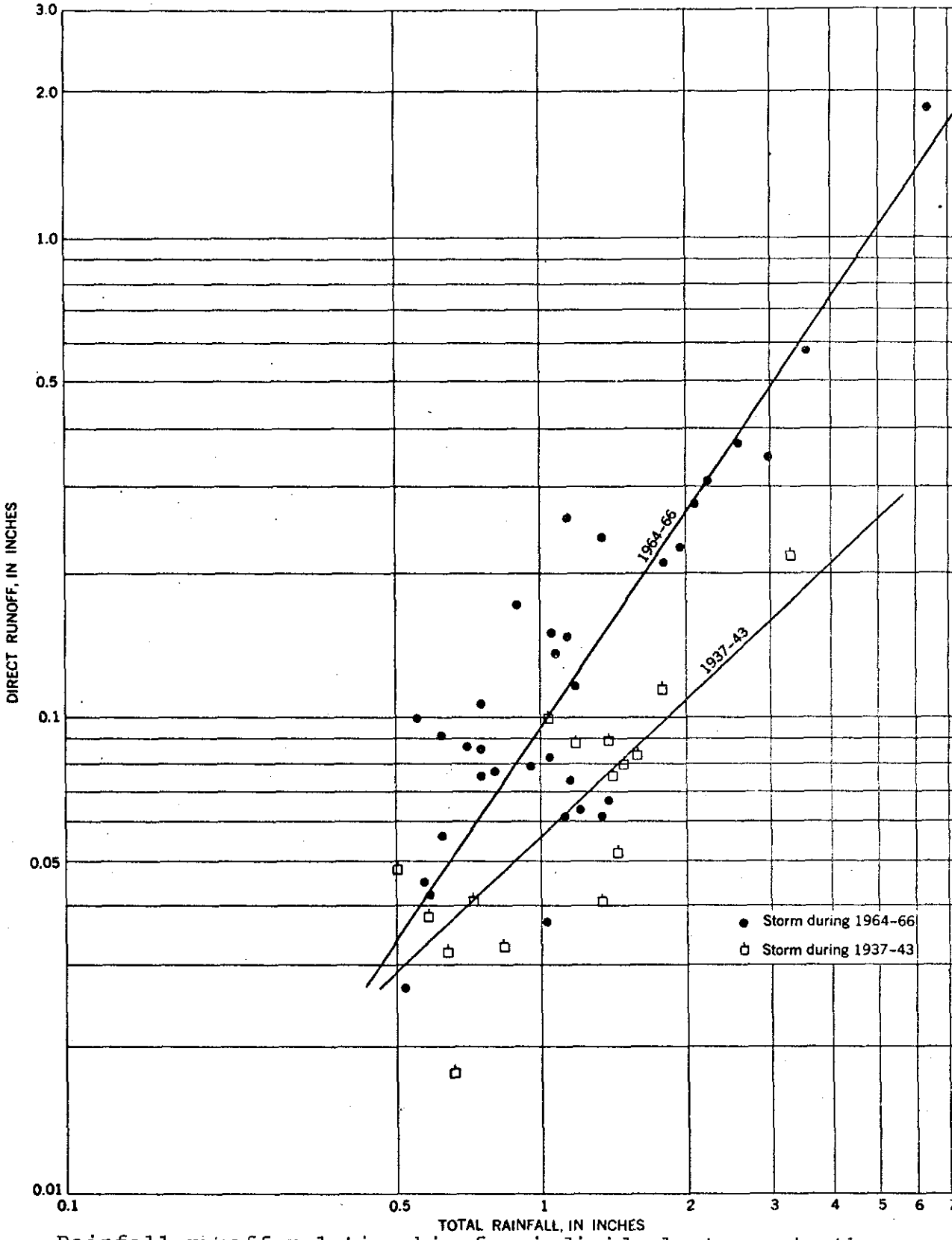
The effect of urban development on the rainfall-runoff relationship based on the above mentioned study is shown in Figure IV-15. It is evident from the graph that a given amount of precipitation during the urban period (1964-1966) resulted in a significantly greater amount of runoff than in the pre-urban period (1937-1943). Studies in Nassau County Sewer District No. 2 indicate that direct runoff, as a percent of total stream flow, has increased from a county average of 10% to 50%.

As early as 1930, Nassau County started the installation of open storm water recharge basins. It was recognized then that such a program would offset the escape of storm water runoff to the Atlantic Ocean and Long Island Sound.

In Nassau County storm water runoff is being recharged in 550 County and State owned basins. These basins range in area from 0.1 to 30 acres with an average of two acres each and an average depth of 10 feet.

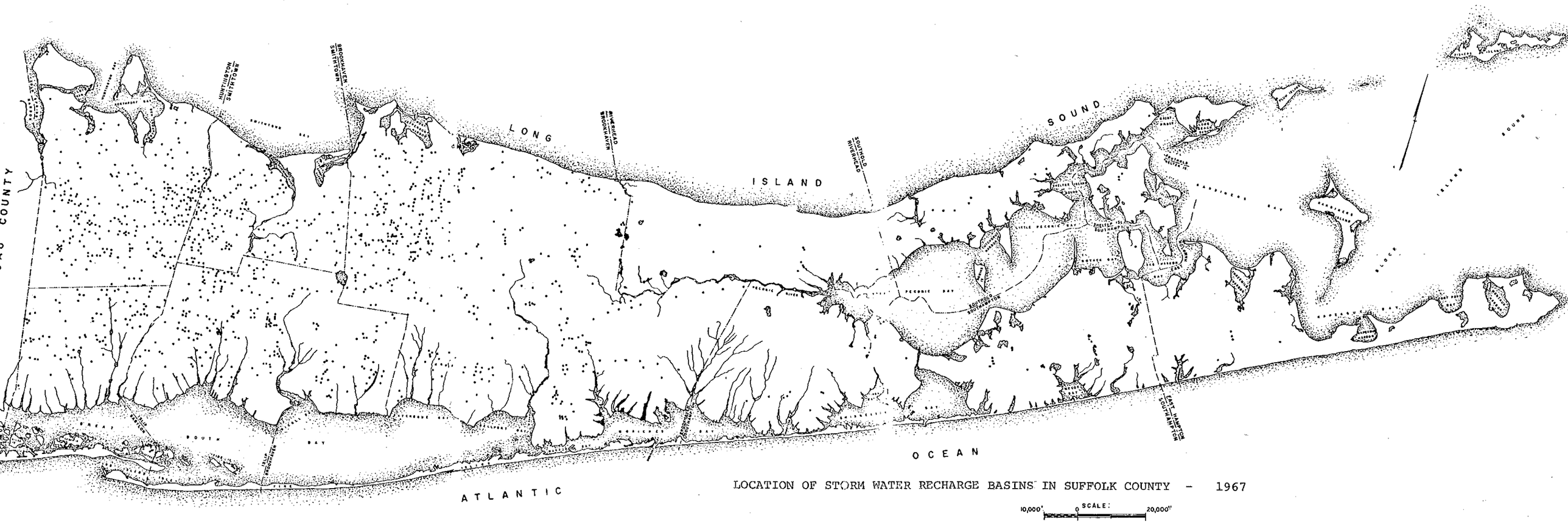
In Suffolk County, there are now over 1000 storm water recharge basins (Figure IV-16). Most of these are located in residential subdivisions, and range in size from approximately 0.3 acres upward to more than 102 acres.

The recharge of storm water in storm water recharge basins is an effective way of conserving the water resource. An estimate of the total effectiveness of this method is not readily available for the total Long Island area. However, based on the approximate figures of 50% evapotranspiration losses, and 2% losses due to natural direct runoff, a total of 48% of the average rainfall may be recharged. Of this total, some is naturally recharged in storm water basins derived from the runoff of developed (impervious surface) areas. From the USGS finding that the ratio of the storm water basin inflow to the rainfall in Long Island closely approximate the ratio of street area to total area, one can approximate the percent of total precipitation recharged in this manner. A survey of all systems which employ storm water basins would then define the effectiveness of water conservation.



Rainfall-runoff relationship for individual storms in the Hempstead subarea for urban (1964-66) and preurban (1937-43) conditions, Nassau County

SOURCE: Effects of Urban Development on Direct Runoff to East Meadow Brook, Nassau County - Geological Survey Professional Paper 627-B



LOCATION OF STORM WATER RECHARGE BASINS IN SUFFOLK COUNTY - 1967

Source: Holzmacher, McLendon & Murrell, Engineers
"Comprehensive Public Water Supply Study
Suffolk County, New York"

The other consideration in evaluating the effectiveness of the method is the efficiency and economy of its operation. In some areas, discharge to a basin is an obvious economic alternative to the installation of long trunk sewers to transport storm water to the nearest stream. In others, the amount of land needed to recharge will determine the economics, which in turn is based on the infiltration rate in the basin. On Long Island, recharge basins generally completely drain in about a week. Infiltration rates vary over a wide range, with reported values of 20 to 400 gpd/SF in Nassau County. Based on USGS studies, an infiltration rate of 211 gpd/SF is typical of a well operating basin in Long Island. Basins are generally designed to store 5" of precipitation for several days to prevent flooding.

As continued growth in Long Island is apparent, storm water runoff from urban areas will increase. The use of storm water recharge basins provide an effective means of conserving water resources, and should continue to be used in the future. Moreover, these basins may be used to recharge renovated wastewater as well as storm water.

A further study needed to develop the latter concept, and to determine the effect on groundwater quality of recharged storm water runoff, is to better characterize storm water quality. The effect of dissolved solids in storm water runoff on Long Island is not presently known. The management of storm water on Long Island should include the careful monitoring of quality parameters and infiltration rates. New basin locations should be chosen with the consideration of possible renovated wastewater recharge.

Storm water runoff may be considered for many of the same purposes as renovated wastewater. For example, with proper collection and possibly treatment, it may be used for irrigational purposes. This would, however, involve construction of collection and distribution systems, and seems an unlikely alternative in most areas. Combination of storm and sanitary sewerage is not recommended.

In conclusion, storm water management on Long Island should consist of the following items:

1. Continuation and expansion of present basin recharge methods.

2. Further study into the quality characterization of storm water runoff and its effect on groundwater quality.

3. Further study into the design factors for storm water recharge basins to minimize required land area.

4. Further study into the possible integration of renovated wastewater and storm water basin recharge systems.

5. Further study into the possibilities of using storm water runoff, either directly or after appropriate treatment, for industrial, agricultural or recreational purposes, on a local or regional basis.

f) Regional vs Local Treatment

Regional wastewater treatment offers the advantage of economy of scale in construction and operation. Federal grant incentives and guidelines promote the use of regional solutions for wastewater collection and disposal. Efficient treatment and qualified personnel are more easily found in regional systems, and better coordination of water supply resources and other environmental aspects of the area may be developed.

The extent of regionalization in a municipal facility will be dependent upon the individual municipalities in a given region cooperating; Federal and State level funding and direction; and physical and economic aspects of both the region and its individual municipalities.

In 1966, New York State funded statewide comprehensive sewerage studies on a county level, the first state to institute such a program. In New York State, the County is the largest unit of local government that can develop and implement areawide sewerage utility wastewater plans.

In accordance with this directive, both Nassau and Suffolk Counties have complete county-wide sewerage studies and have implemented these plans as discussed in Section IV-B-5b of this report. The existence of proposals of four disposal districts in Nassau County and 17 disposal districts in Suffolk County is based on county-wide planning studies directed by the Nassau County Department of Public Works in Nassau County and the Suffolk County Department of Environmental Control in Suffolk County. Plans for both counties are approved by the New York State Department of Environmental Conservation.

Regional plans developed are based in part on natural drainage areas independent of municipality borders and lend themselves to being served by a central facility and a minimal number of pumping stations and force mains. As the population increases and coordination of water supply and wastewater collection and treatment is ever more necessary, regional sewerage systems will become all the more important for this area. The problems of water resources discussed for this area is served best by regional systems, and perhaps inter-regional systems in the water supply-wastewater reclamation area.

If wastewater is to be reclaimed and used to recharge groundwater supplies, a high degree of treatment will probably be necessary, especially in well recharge systems. Collection of sewage from a large area to a central treatment plant will have the advantages of economy of size in construction costs and better treatment reliability. Operating and maintenance costs for larger plants will be smaller per gallon of sewage treated. Administration of a few large sewage treatment plants can proceed more efficiently than many smaller plants. Piping and pumping costs for transporting the renovated wastewater to recharge sites will be greater for regional systems, however, the reliability gained in these systems and the other cost savings should overshadow this fact.

6. Costs

Three projects were considered in making cost estimates for wastewater reuse in Long Island. The first project is a basin recharge scheme utilizing existing storm water basins, proposed by Greeley & Hansen, Engineers, (Figure IV-13) presented in Table IV-4. The second project is a well injection of treated wastewater to form a salt water barrier in Nassau County (Table IV-5). The third is a land application of treated wastewater via spray irrigation in Suffolk County (Table IV-6). The projects are based on wastewater flows of 94, 150 and 140 mgd, respectively. An ENR construction cost index of 1400 was used.

TABLE IV-4

COST ESTIMATE (ENR=1400)

RECHARGE OF TREATED WASTEWATER IN STORM WATER BASINS
NASSAU COUNTY, N.Y. (MILLION DOLLARS)

Project Yield(1) - 94 MGD

	Project Cost	Benefits	Benefits Minus Project Cost
Construction Costs	(2)	(3)	
Treatment Plant	$38.5	$35.0	$ 3.5
Pumping Station	3.3	-	3.3
Transmission Lines	15.1	-	15.1
Road Crossings	1.7	-	1.7
Sub Total	$58.6	$35.0	$23.6
Engineering Contingencies (at 30% of Sub Total)	17.6	10.5	7.1
Total Construction Costs	$76.2	$45.5	$30.7
Construction Cost per MGD Capacity	.81	-	.33
Fixed Annual Costs			
Interest and Amortization			
4-5/8%, 50 years	$ 3.933	$ 2.348	$ 1.585
5%, 50 years	4.174	2.492	1.682
10%, 50 years	7.686	4.589	3.097
Variable Annual Costs			
Maintenance and Repair	$ .924	-	$ .924
Treatment Plant Operation	6.837	-	6.837
Pumping Power	.793	-	.793
Administration	.259	-	.259
Labor and Supervision	.104	-	.104
Research and Development	.100	-	.100
Total Variable Annual Costs	$9.017		$ 9.017
Total Annual Costs			
4-5/8%, 50 years	12.950	2.348	10.612
5%, 50 years	13.191	2.492	10.699
10%, 50 years	16.703	4.589	12.114

(1) Project yield is at end of last stage of a 4 stage program which would develop yields of 25, 44, 74 and 94 mgd by the years 1975, 1980, 1985, 1990, respectively.
(2) Secondary Treatment
(3) Tertiary Treatment
(4) Project Costs (first column) Source: Greeley and Hansen Engineers, "Comprehensive Public Water Supply Study - Nassau County, N.Y.", (CPWS-60) 1971
(5) Project costs are adjusted to ENR=1400 from ENR=1700 reported in CPWS-60. Variable annual project costs are as reported in CPWS-60.

TABLE IV-5

SUMMARY OF ESTIMATED PROJECT COSTS (ENR 1400)
RENOVATED WASTEWATER INJECTION WELL SYSTEM
NASSAU COUNTY, N.Y. (MILLION DOLLARS)

Project Yield (MGD)	150
Construction Cost	
Wastewater Renovation Plant (1)	$ 48.4
Well Injection System	80.5
Transmission Pumping Stations	25.3
Transmission Pipeline	22.4
Sub Total	$167.3
Engineering and Contingencies (25% of Sub Total)	41.8
Land	3.0
Legal and Administrative	18.4
Total Construction Cost	$230.5
Construction Cost per MGD Capacity	$ 1.54
Fixed Annual Costs	
Interest and Amortization	
4-5/8%, 50 years	11.90
5%, 50 years	12.63
10%, 50 years	23.25
Variable Annual Costs	
Taxes	$ .33
Personnel	.58
Power ($0.014/KWH)	3.38
Chemicals and Supplies	6.06
Total Variable Annual Costs	$ 10.35
Total Annual Costs	
4-5/8%, 50 years	$ 22.25
5%, 50 years	22.98
10%, 50 years	33.60

(1) Tertiary Treatment

TABLE IV-6

SUMMARY OF ESTIMATED PROJECT COSTS (ENR 1400)
LAND APPLICATION OF SECONDARY EFFLUENT VIA SPRAY IRRIGATION
SUFFOLK COUNTY, N. Y.

Project Yield - 140 MGD

	Project Cost	Benefits	Project Costs Minus Benefits
Construction Cost			
Irrigation System (Overland Flow)	$ 23	-	$ 23
Storage (Interceptors and Chambers)	18	-	18
Flood Lagoons	63	-	63
Pipes (Collection and Distribution)	32	-	32
Tertiary Treatment (1)	-	$ 48	-48
Equipment Salvage (3)	-	2	- 2
Sub Total	$136	$ 50	$ 86
Engineering & Contingencies (25% of Sub Total)	34	13	21
Land (6)	3	-	3
Land Salvage (2)	-	6	- 6
Legal and Administrative	14	5	9
Total Construction Cost	$187	$ 74	$113
Construction Cost per MGD Capacity	$ 1.34	-	$ 0.81
Fixed Annual Costs			
Interest and Amortization			
4-5/8%, 50 years	$ 9.65	$ 3.82	$ 5.83
5%, 50 years	10.24	4.05	6.19
10%, 50 years	18.86	7.46	11.40
Variable Annual Costs			
Taxes	$ .29	-	$ .29
Personnel	.35	-	.35
Power (0.014/KWH)	3.50	-	3.50
Chemicals and Supplies	1.17	2.30	-1.13
Nutrient Value (5)	-	.25	- .25
Total Variable Annual Costs	$ 5.31	$ 2.55	$ 2.76
Total Annual Costs			
4-5/8%, 50 years	$14.96	$ 6.37	$ 8.59
5%, 50 years	15.55	6.60	8.95
10%, 50 years	24.17	10.01	14.16

Notes:
(1) Tertiary treatment otherwise needed in a non land disposal alternative.
(2) Includes irrigation and storage land. Salvage value is based on a doubling of land value after cessation of irrigation.

TABLE IV-6 (Continued)

(3) Salvage value assumed at 10% original costs.
(4) Benefits in variable annual costs for taxes, personnel and power are not considered due to the complex analysis such an estimate would require.
(5) Nutrient value of secondary sewage effluent as fertilizer assumed at $4 per million gallons applied.
(6) Land cost is based on the purchase of land totaling 2% of the total construction cost. However, based on an application rate of 2 inches per week/acre, 35,000 acres of privately owned land will be used for spray irrigation.

In the spray irrigation and basin recharge projects there are certain benefits to be realized when considering the probable alternative of eventually providing tertiary treatment to sewage for any other proposed eventual reuse project. The cost of tertiary treatment is saved in both these projects, while an injection well project will most probably require tertiary treatment. Additionally, in the spray irrigation project, benefits of the fertilizer value of sewage, and eventual land and equipment salvage may be realized.

The costs of ultimate disposal of wastewater solids was not considered, although, in the spray irrigation and basin recharge projects, there will be less solids to dispose of since tertiary treatment solids will not be generated and this may amount to a significant cost benefit.

In general, the design of these systems is complex, and detailed engineering information necessary to develop more exact costs is unavailable, thus the costs presented are "ballpark" estimates.

The choice of an alternative will involve further investigation of technical feasibility, followed by more exact economic analysis. Benefits will have to be further defined, and benefits of a non-dollar value nature (aesthetic values) will have to be considered. Certain trade-offs in benefits and costs will be made before finally instituting one of the alternatives.

C. PASSAIC RIVER BASIN

The Passaic River has probably been the source of more studies than any other river in the country. It serves a large area in northeastern New Jersey as a source of water and as a repository for municipal and industrial wastes, and also serves as a source of controversy because of periodic flooding. The Passaic has been called "the most polluted river in the United States" although the upper reaches are rural and pretty.

It would appear that with all the reports that have been written, it would be possible to write a definitive study of the Basin. However, there has almost been an explosion in residential, commercial and industrial building in the tributary area and it is difficult to update information to one point in time because things are changing so rapidly.

1. Topography and Hydrology

The total Passaic River Drainage Basin is some 950 square miles. Eighty-five percent, or 800 square miles, is in New Jersey with the remainder in New York State. The River rises in Mendham Township in south central Morris County, drains most of Passaic County and parts of Morris, Somerset, Union, Essex, Hudson and Bergen Counties in New Jersey and parts of Orange and Rockland Counties in New York (see Figure IV-17). Major tributary systems are:

Stream	Drainage Area Sq.Mi.
Rockaway River	136
Whippany River	69
Pompton River	24
Pequannock River	88
Wanaque River	111
Ramapo River	158
Saddle River	61

The River is tidal to Dundee Dam in Garfield, some 14 miles upstream from the mouth of the River at Newark Bay. About 12 miles above Garfield the River drops precipitously 63 feet at "The Great Falls" in Paterson. Water power potential was first recognized by Alexander Hamilton and this led to the emergence of Paterson as a major industrial city in the nineteenth century.

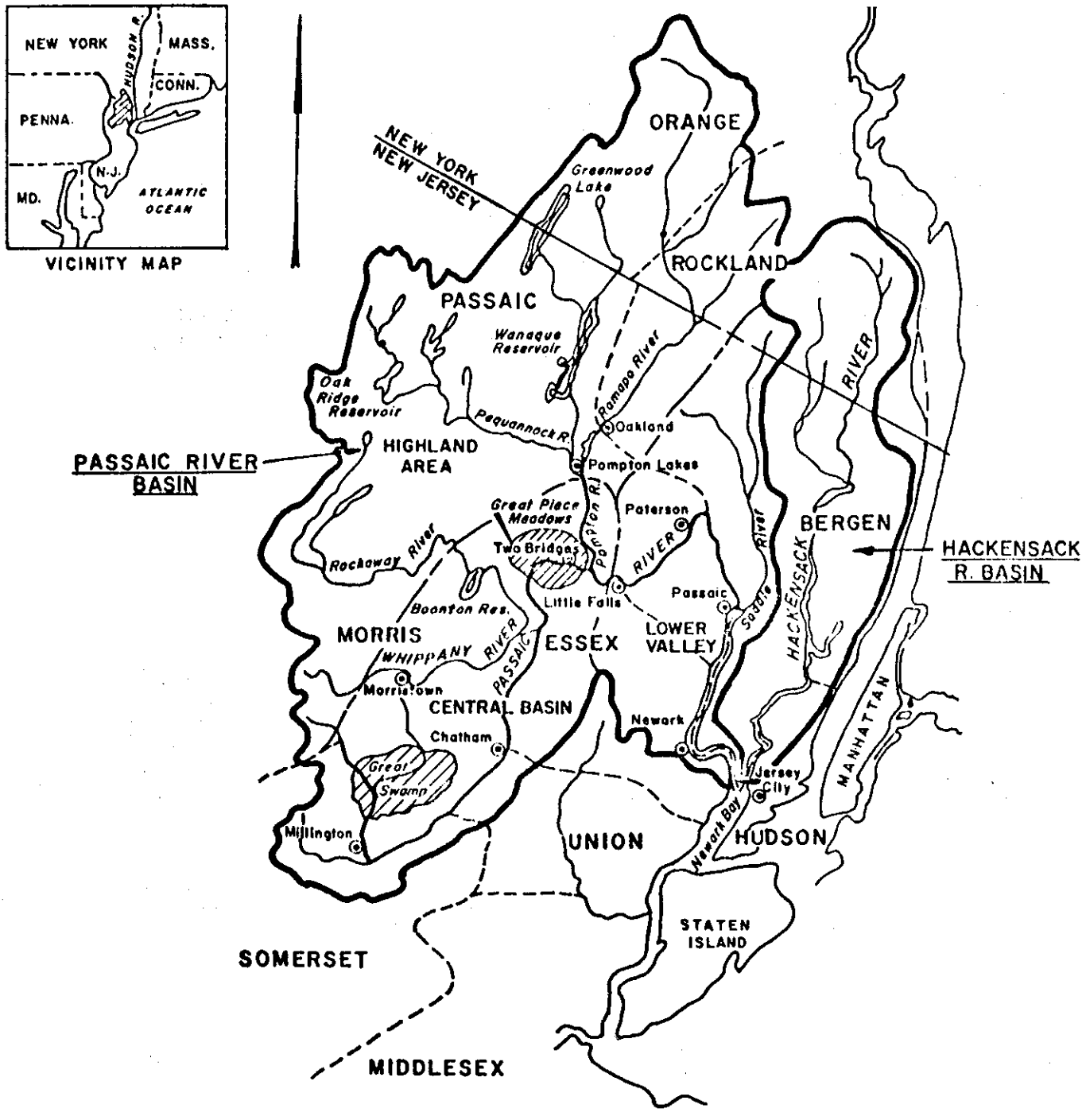
Water is abstracted from the River at Little Falls by the Passaic Valley Water Commission and it is the area above this point, some 762 square miles, that is of major interest.

Topography

The Basin may be divided into three general classifications (Figure IV-17):

a) Highland Area - This is a wooded, mountainous region, some 55% of the total watershed area, occupying the northwestern half of the Basin. In general, it is west of a line from Morristown north through Boonton to Riverdale. Population concentration is low and there are few industries in the area. There is evidence of residential

FIGURE IV-17



PASSAIC AND HACKENSACK RIVER BASINS

SCALE IN MILES
0 4 8

LEGEND

- RIVER BASIN BOUNDARY
- COUNTY BOUNDARIES
- AREA BOUNDARIES

Source: U.S. Dept. of the Interior, FWPCA, Northeast Region, "Water Supply and Water Quality Control Study: Passaic River Basin -New Jersey-New York", 1967

development along the area to the east and because of the precipitous rise in housing costs closer to New York City and because of the construction of the Interstate Highway system, there will be great future pressure to urbanize this land. This area contains the headwaters of the Passaic and there are many lakes in the area that have been developed as water supply sources. Maximum elevation of the peaks is about 1300 feet.

b) Central Basin - This is part of the Piedmont Province and is in the southeastern part of the Basin. The River actually rises in this section. The area is characterized by generally rounded hills with a few ridges and some isolated hills rising conspicuously above the Plain. Altitude ranges from 200 to 400 feet. There are several large swamps in the area - the Great Swamp and the Great Piece Meadows.

Very few rural areas remain, most development is for residential use and for smaller industrial facilities.

c) Lower Valley - This area is low and flat, a flood plain with abutting low rolling hills. It is probably as densely populated and developed as any land in the United States. There are many heavy industries in this area. It comprises the area east of a line north from Little Falls to the New York line east of Oakland.

Hydrology

The Passaic River Basin appears to lie at the confluence of several major storm systems - late summer storms from the Ocean to the south, fall hurricane storms, spring storms from the west and southwest and local thunderstorms. Thus flow can vary considerably over the year especially as the Highland Area is subject to fast runoff.

There is some variation in precipitation. It averages 51 inches in the Highlands Area and 44 inches in the Lower Valley near Newark.

The drought period, 1961-1966, made a shambles of previous data and trends. The previous lowest observed precipitation was 36.90 inches in 1930; a record low of 33.95 inches was observed in 1936 but this record was subsequently broken in 1965 when 30.54 inches was recorded.

Flows at Little Falls for the period 1945 to 1970 are shown on Figure IV-18.

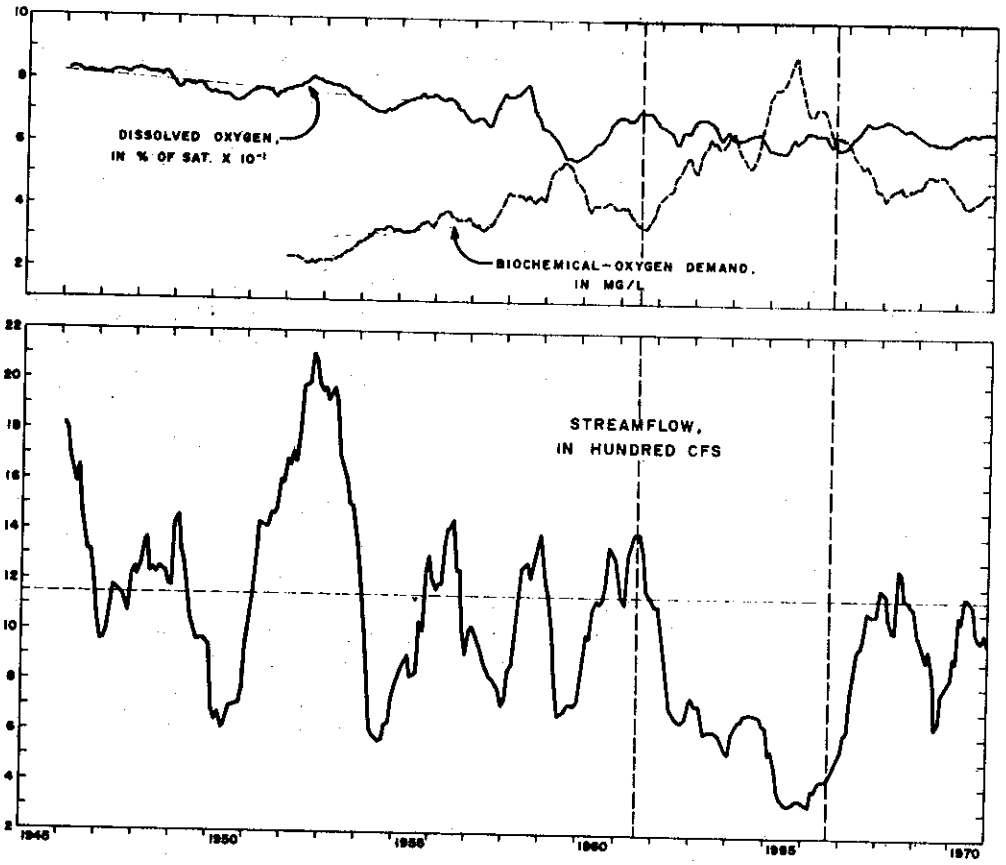
2. Quantity and Quality of Water

Quantity of Water - The Passaic River Basin contains several swampy areas - Great Piece Meadows south of Lincoln Park, Troy Meadows in Parsippany-Troy Hills, Hatfield Swamp near Caldwell and the Great Swamp National Wildlife Refuge south of Morristown. These in some measure act as storage basins, collecting water during high flows and releasing it during low flows. Thus any calculations of flows have to take into consideration these natural flow regulators.

It is estimated that the extreme low flows of the River at Little Falls, without regulation and without reservoirs would be 30 MGD. With existing reservoirs, the flow is some 260 MGD in a dry year and if all potential reservoir sites were developed, and there was no diversion out of the basin, the dry year flow would be some 385 MGD.

The Basin is underlain with several valleys containing sand and gravel which have been developed as groundwater sources. Most of the wells are concentrated along the Passaic River in the Florham Park area and along the Whippany River in East Hanover. There is also a concentration of wells in the Caldwell area. The location of these valleys is not known precisely so the general groundwater area has been described as a "bowl of spaghetti covered with chocolate pudding", referring to the valleys covered with some 60 feet of clay. In any event, some 50 MGD is drawn from the existing wells. It is reported that wells in Madison and Chatham were almost dry during the drought but have recovered somewhat during the last few years. However, they appear to be overpumped and with recharge being reduced as land is developed and paved, there is some question as to future large scale availability of groundwater.

Morris County has formed a Municipal Utilities Authority which proposes to construct several small reservoirs. Part of the water would be used to supplement surface supplies and part would be used, hopefully, to recharge underground aquifers. In a sense water would



TWELVE-MONTH MOVING AVERAGE OF DISSOLVED-OXYGEN SATURATION, BIOCHEMICAL-OXYGEN DEMAND, AND STREAMFLOW, PASSAIC RIVER AT LITTLE FALLS, 1945-70

Source: Based on chemical analyses by the Passaic Valley Water Commission and streamflow records of U.S. Geological Survey.

Note: Dashed lines represent apparent trend and boundaries of drought (1961-66).

be stored underground during wet years and utilized during dry periods.

Most of the well water is returned to the River as sewage. However, the Commonwealth Water Company, drawing some 5 MGD from Canoe Brook, a tributary of the Passaic River near Chatham, and some 11 MGD from wells in the area, serves Springfield, Millburn, Maplewood, Irvington and West Orange which have sewage disposal services out of the Passaic Basin. Summit is also served by Commonwealth and while within the Basin, sends it sewage to the Rahway Valley Plant, outside the Basin. Probably most of the 16 MGD is exported out of the Passaic River Basin.

Table IV-7 shows the withdrawals of the major water companies in the Basin and also the safe yield of various tributaries and of the Passaic River at Little Falls. The Passaic Valley Water Commission has the right to abstract 75 MGD at Little Falls, the safe yield, thus there can be no proposed water supply development below Little Falls under present conditions. Table IV-7 indicates that withdrawals are exceeding the safe yield under present development.

On an average day some 6% of the flow at Little Falls may be sewage treatment plant discharges. This may increase to 41% of the flow during dry periods.

This report has not considered the many plans to augment the Passaic River supply by diversions from the Tocks Island Project on the Delaware River, or the proposed Two Bridges Flood Control, Water Supply and Recreational Project of the Corps of Engineers and by the many projects proposed over the years for interconnecting various river basins and changing service districts.

The total water use in and from the Basin is estimated at about 800 MGD in 1970 and is expected to increase to 920 MGD in 1980, 1220 MGD in 2000 and 1500 MGD in 2020.

Figure IV-19 shows the total picture of the water situation for six streams in the northeast section of New Jersey, and also shows the amount of dilution water required to maintain 4.0 mg/l dissolved oxygen in the streams. The Figure is somewhat misleading as it assumes only one use of water. It would be useful to have such

TABLE IV-7

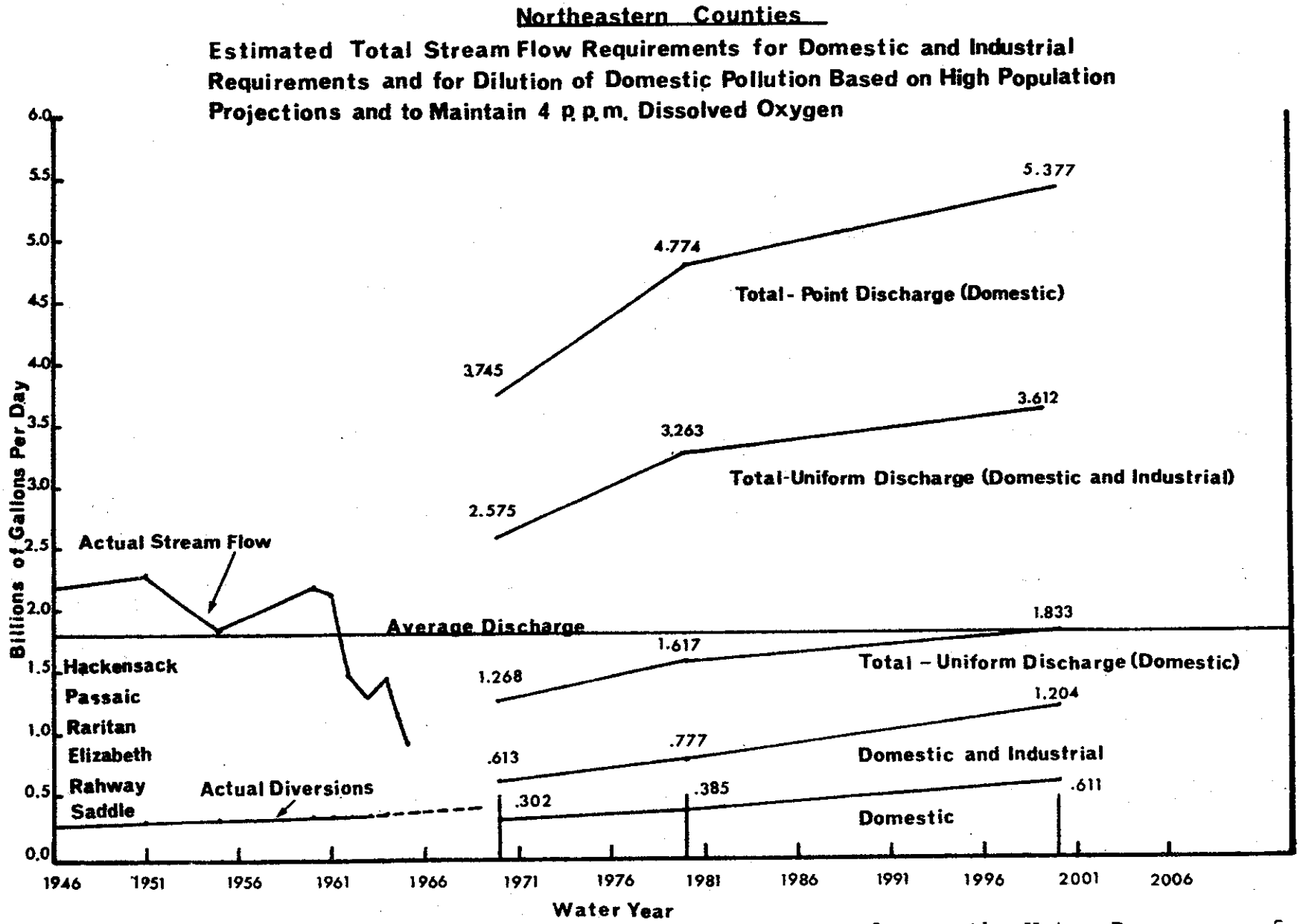
MAJOR WATER SYSTEMS IN THE PASSAIC RIVER BASIN

(Withdrawal MGD)

Water System	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	Safe Yield
Wanaque (NJDWSC)	109	110	94	93	93	103	109	110	109	112	94
Pequannock (Newark)	54	54	42	33	54	59	61	66	65	61	50
Rockaway (Jersey City)	55	57	55	56	53	59	58	75	66	71	65
Little Falls (PVWSC)	40	40	41	43	45	47	46	54	52	49	75
TOTAL	258	261	232	225	245	268	274	305	292	293	284

Source: New Jersey Department of Environmental Protection

Note: Safe yield is based upon drought of 1961-1966.



SOURCE: Faust, Samuel D."Future Quantity and Quality Demand Upon the Water Resources of New Jersey", Rutgers Public Policy Forum (1966)

FIGURE IV-19

a picture of the Passaic River and its tributaries if one has not already been made.

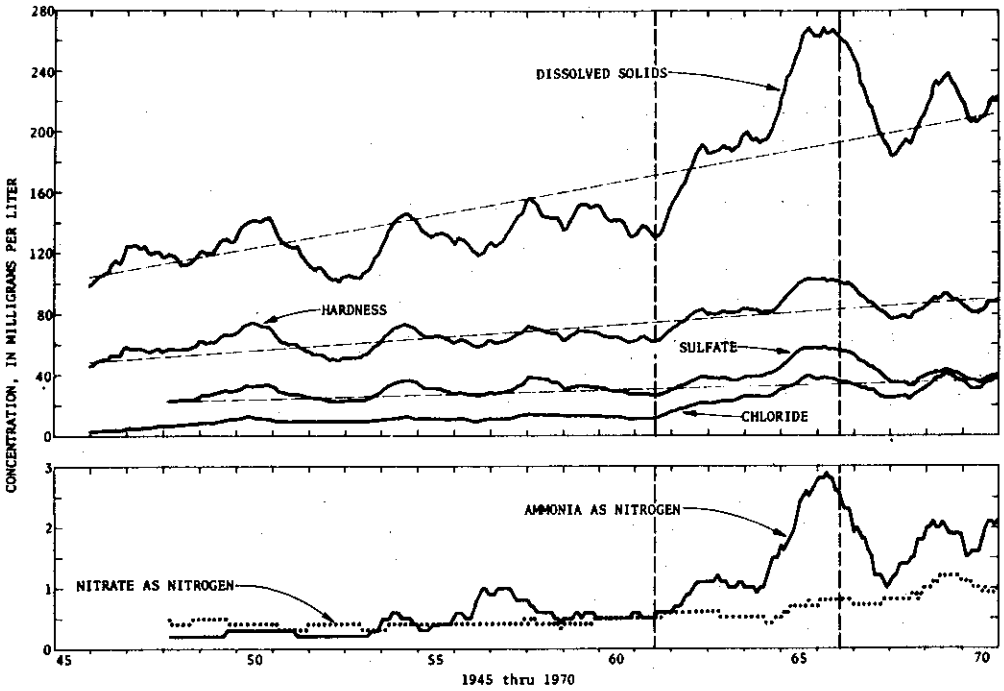
Quality of Water - Anderson and Faust have shown that the water quality of the Passaic River is deteriorating. Figure IV-20 illustrates several chemical-quality parameters, and also ammonia-nitrogen and nitrate-nitrogen. Even when considered with flow in the River, Figure IV-18, it is apparent that there is a definite upward trend in the chemical content of the water. Figure IV-21 shows the mean monthly stream-turbidity measurements. The upward trend is probably due to increased urganization of the Basin, from construction site runoff and storm water runoff from streets and paved areas.

The quality of the water above Little Falls is affected primarily by the discharge of sewage treatment plants and the discharge of industrial wastes into the River. Various reports state the number of sewage treatment plants and the number varies from 123 to 160 (Figure IV-22. Many are small "package" plants and as some are installed and others abandoned during any one year, it is difficult to keep track of the exact number at any point in time. In any event, the plants range in size from 2000 GPD to 13 MGD and have an average BOD removal of 77%. About 25% are overloaded or are reaching capacity so the State has had to declare a building moratorium in many areas until sewage plant construction or enlargement catches up to the growing load.

About 40% of the BOD in the River can be accounted for, the remainder is from surface runoff, overflow from sewage treatment plants and natural and accidental pollution. Increased urbanization means more streets and consequent runoff containing dog droppings, oil leaks, dirt, etc. One other hazard is oil spills. In 1969 there were 16 spills, of 1000 gallons or more in the basin due to accidents or broken or unattended loading lines from tanks.

It is estimated that each person in the watershed contributes organic matter equivalent to that from 1.5 acres of land.

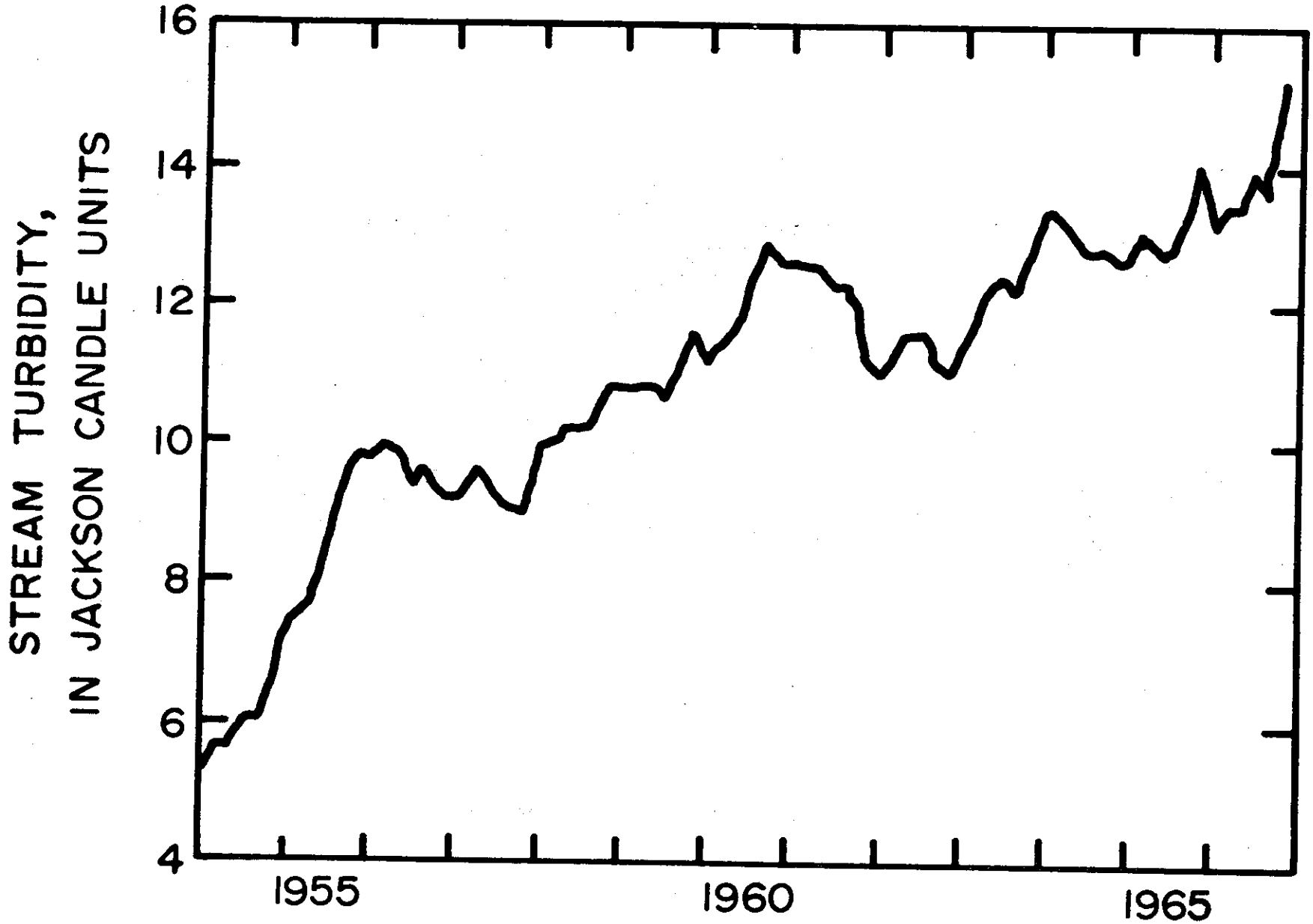
According to the Passaic Valley Water Commission, they can treat the raw water adequately if it contains only treated municipal sewage. Their big problem is with industrial wastes, especially spills of dissolved organic



TWELVE-MONTH MOVING AVERAGES OF THE CONCENTRATION OF SEVERAL CHEMICAL-QUALITY PARAMETERS, PASSAIC RIVER AT LITTLE FALLS, 1945-70

Source: Based on analyses by the Passaic Valley Water Commission.

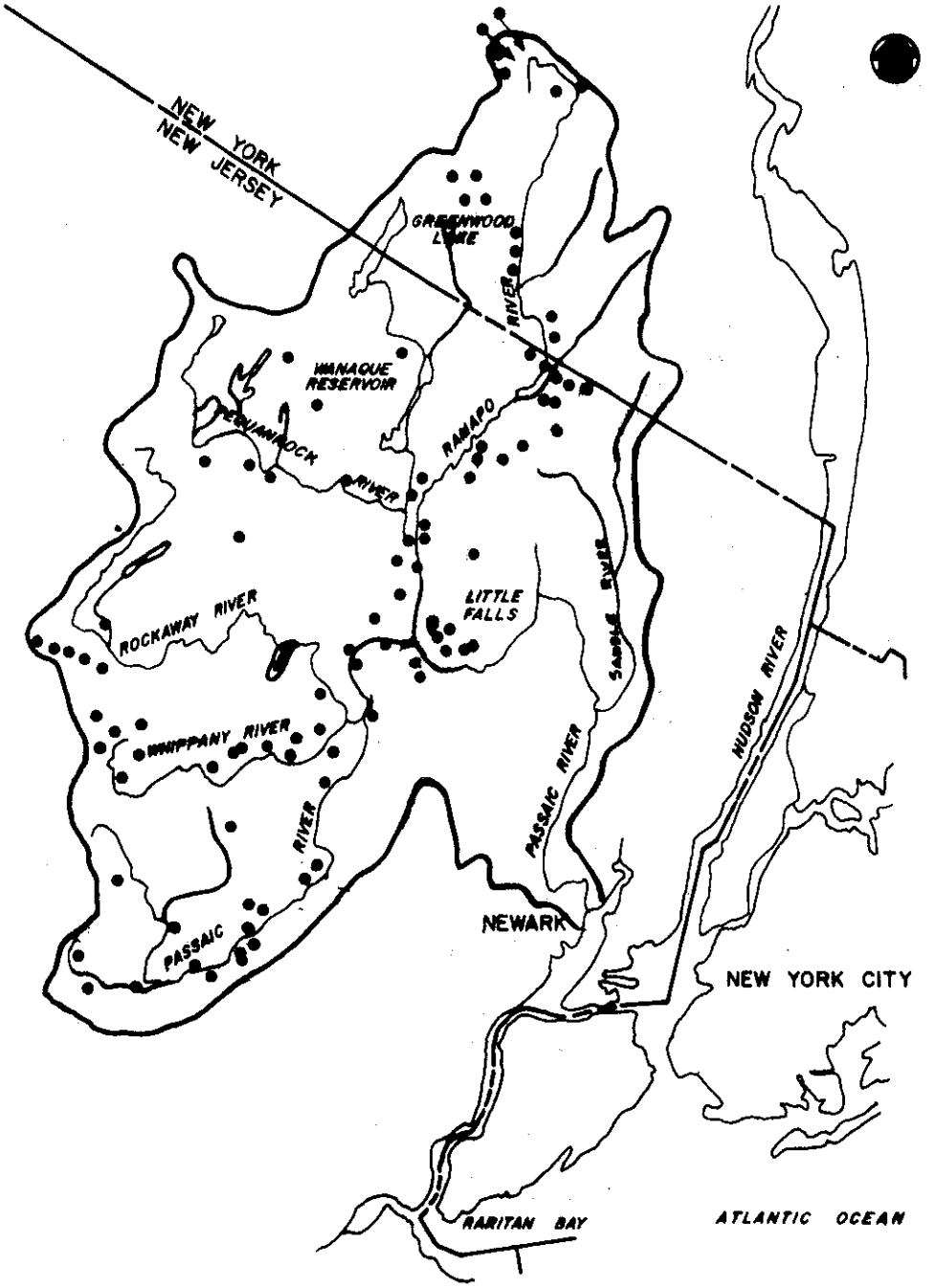
Note: Dashed line indicates apparent trend and boundaries of drought (1961-66).



Two-year moving average of monthly stream-turbidity values, Passaic River at Little Falls, New Jersey, 1953 to 1956 (data provided by Passaic Valley Water Commission)

FIGURE IV-21

FIGURE IV-22



5 0 5 10 15

SCALE IN MILES

LEGEND

River Basin Boundary

State Boundary

EXISTING SEWAGE TREATMENT PLANTS IN PASSAIC RIVER BASIN ABOVE LITTLE FALLS, NEW JERSEY

Source: Passaic Valley Water Commission

wastes. These pass through the plant relatively unchanged. The Commission, however, plans to add activated carbon during the treatment process which they believe will remove most of these organic chemicals. While activated carbon removes many organic chemicals, it is not a panacea and does not remove them all. Methanol, formic acid and sugars, for example are not easily removed. It does remove phenolics however which are probably the greatest cause of undesirable tastes and odors in water and thus the quality of the Commission's water should improve.

3. Wastewater Management

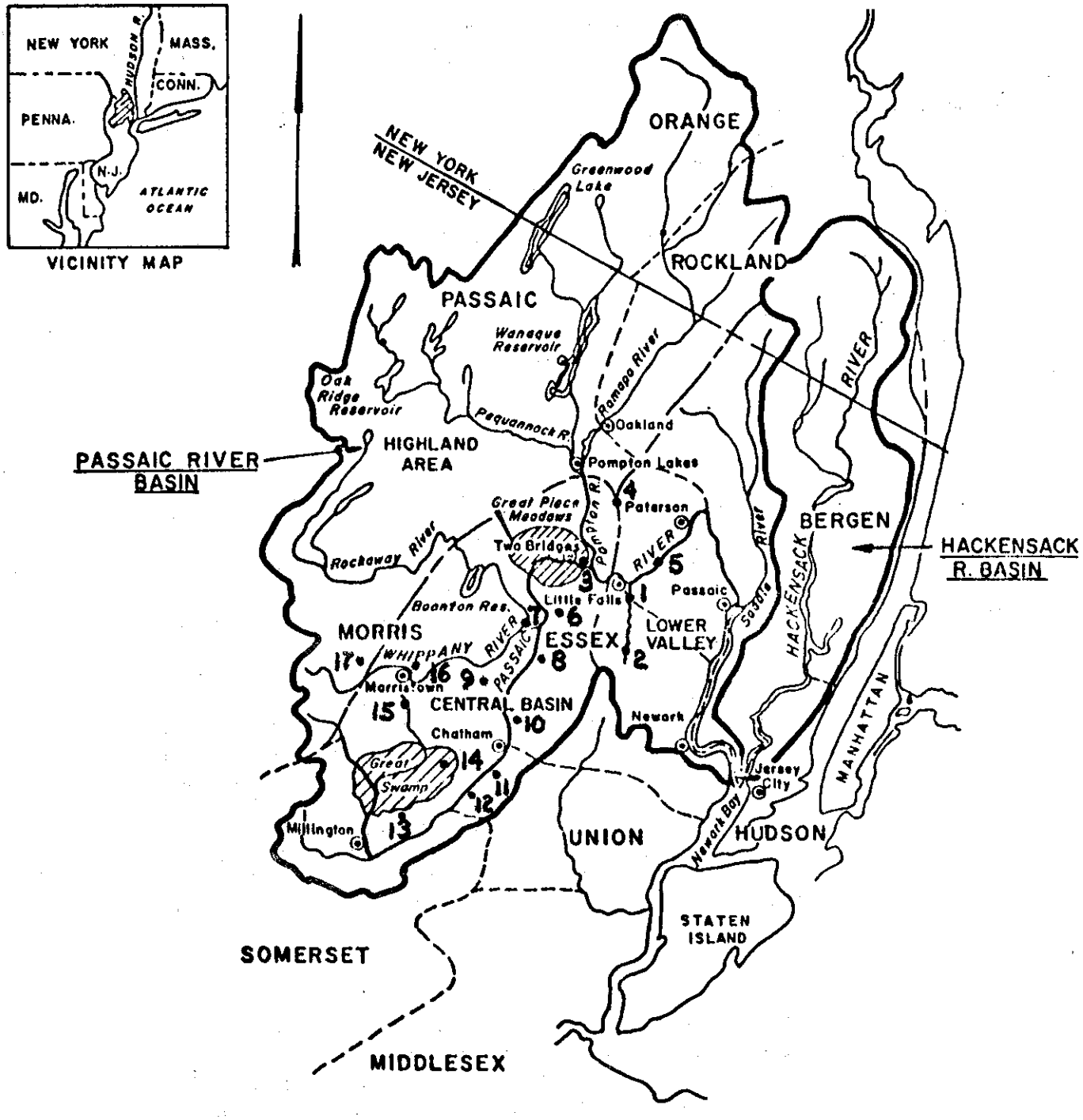
As shown previously in Table IV-7, water withdrawals from the River are exceeding the safe yield by almost 10 MGD. It is imperative that as much water be returned to the Basin as possible so that it may be reused.

Figure IV-23 and Table IV-8 show the proposed regional sewage treatment facilities to handle most of the sewage generated within the Basin in the more populated areas. All this water will be returned to the River above Little Falls. While many of these regional plants are in design or under construction, some of them are still in the talking stage but it is probable that the regional plan shown will be the final one. There was some consideration given to constructing one large plant just above Little Falls with the discharge being to the River at that point or with the discharge being piped downstream from the Passaic Valley water intake. In the first case, any malfunction of the plant would mean the Water Commission would be treating virtually all raw sewage under some conditions, while the second plan would have exported water out of the Basin. Other problems were recognized and the alternate plan of several regional plants above Little Falls was adopted.

State Study -

The State of New Jersey has proposed a study of northeastern New Jersey and parts of New York, with the objective of formulating a water quality management strategy. Included in the study area is part of the Passaic River Basin. The scope of work is broken down into five tasks:

FIGURE IV-23



PROPOSED REGIONAL TREATMENT FACILITIES,
PASSAIC RIVER BASIN

SCALE IN MILES

LEGEND

RIVER BASIN BOUNDARY

COUNTY BOUNDARIES

AREA BOUNDARIES

NOTE: To be used with TABLE IV-8

Source: New Jersey Department of Environmental Protection.

TABLE IV-8

PROPOSED REGIONAL PLANTS IN PASSAIC RIVER BASIN ABOVE LITTLE FALLS

No.	Plant	Present Avg.Daily Flow (mgd)	Present Design Capacity (mgd)	Future Design Capacity 1985 (mgd)
1	Little Falls Municipal	1.7	.8	
2	Verona Municipal	2.4	4.0	4.0
3	Two Bridges Regional	-	-	10.0
4	Wayne Township-Mountain View	4.2	4.0	9.0
5	Totowa Borough Riverview	1.4	1.1	
6	West Caldwell Municipal	3.0	4.0	6.0
7	Parsippany-Troy Hills Township Municipal	3.5	4.0	16.0
8	Livingston Municipal	2.8	2.25	4.2
9	Florham Park Sewerage Author.	.55	1.0	
10	Chatham-Madison Joint Meeting	2.4	3.0	
11	New Providence Municipal	1.35	2.25	2.25
12	Berkeley Heights Municipal	1.5	1.5	3.5
13	Passaic Township-Sterling Section	.35	.4	
14	Chatham Township Municipal	.6	.75	
15	Morris Township-Woodland	1.0	1.3	2.5
16	Morristown Municipal	2.5	3.0	3.45
17	Morris Township-Butterworth	.35	2.0	2.5

Source: New Jersey Department of Environmental Protection

NOTE: To be used with Figure IV-23

a) Water Quality Data Survey and Data Bank - To collect, compile and evaluate water quality data on surface and groundwater.

b) Existing Wastewater Collection, Treatment and Disposal System Survey and Data Bank - A survey of municipal treatment plants, industrial treatment systems, solid waste landfills, power plants, water supply diversion works, collection systems and combined sewage overflow points. The information will be stored in an information retrieval system.

c) Demographic and Social Data Surveys and Projections - To study population, land use, economic development and open space.

d) Water Quality Models - In the Passaic River Basin, models will be developed for the Tidal Passaic, Upper Passaic, Whippany, Rockaway and Ramapo Rivers.

e) Environmental Assessment Statement - This will be prepared in accordance with Federal Guidelines.

All the information will be used to determine the effects of wastewater and other discharges upon the waters of the Passaic and other Rivers. In a sense, the strategy is to plan land use to manage water pollution.

For the purposes of this study, the area has been divided into three regions - the Urban Area or Lower Basin Problem; Suburban Area or Middle Basin Problem, and the Rural Area or Upper Basin Problem. Although an outline of water related problems is given for each area, they are included for the total study area and are not specific for the Passaic River Basin. Among the items listed which are applicable to the Passaic are:

a) The problems associated with the Passaic Valley Sewerage Commission - inadequate treatment, many industrial discharges, combined sewer overflows, etc.

b) Combined sewer system overflows.

c) Suburban runoff (presumably storm water discharges) which contribute a varying amount of polluting matter.

d) Pollution from landfills.

e) Non-point sources of pollution.

f) Inadequate municipal sewage treatment.

g) Controlled development of the rural areas.

The technical aspects of the State's Study will be related to the governments concerned in four categories:

a) Jurisdictional Concerns - A determination of the jurisdiction, rights and responsibilities of all interested parties and an evaluation of areas of cooperation and support.

b) Financial Concerns - An investigation of means of financing regional sewerage systems, reporting procedures, and an equitable system of assessing capital costs.

c) Management - An analysis of operation and maintenance, monitoring and surveillance, planning and enforcement.

d) Legislative - An overall analysis of statutes as they relate to water and its management.

Passaic River Basin Schemes

The State's Study includes all the major elements of a wastewater management study - an inventory of all sources of pollution, a model of the waterways to determine assimilative capacity and the development of a strategy to improve water quality.

The Study should also include, if it doesn't now, the quantity of water available for use as a source of water supply. The area would be short of water now if there were a severe drought and even if the quality were upgraded, it is academic if the missing water was of good or bad quality. The Study must weigh the possibility of water being added to the Basin from the Tock's Island project on the Delaware River or by skimming the Hudson River. The State could cooperate with the Corps of Engineers on this section with the Corps furnishing the input on water supply.

As noted earlier, most of the water furnished to users in the Basin above Little Falls is returned to the Basin for reuse but there are at least two areas where

keeping water within the Basin may influence construction. The Towns of Oakland and Mahwah in Bergen County are in the Passaic River Basin but are within the service area of the Northwest Bergen Sewer Authority, whose plant is in Waldwick, Bergen County. Plant effluent finds its way to the Saddle River and thence to the Passaic River below Little Falls. The Towns could pump their sewage to the treatment plant at Pompton Lakes, which discharges into the Pompton River which flows into the Passaic above Little Falls. There are economic questions that must be decided and as the flow is relatively small, it is questionable if the reuse of the wastewater is going to be a deciding factor.

The second area is the drainage basin of the Peckman River. The River enters the Passaic below Little Falls. River is rather a noble title as the drainage area is only 12 square miles. There are no gaging stations on the Peckman although it is reported that the River never runs dry as it is fed from Verona Lake which in turn is fed by springs. About 6 mgd of sewage plant effluent is or will be discharged into the River. This amount, plus natural flow, could be lifted into the Passaic to a point upstream of Little Falls. The cost would be about $750,000.

However, the greatest loss of water from the Basin is the export of potable water by the largest purveyors, the North Jersey District Water Supply Commission, the Passaic Valley Water Commission, the Newark Water Department and the Jersey City Water Department. These waters are used and eventually treated at primary sewage treatment plants in Bayonne and Jersey City, by the Passaic Valley Sewerage Commission and in several smaller plants. The State has ordered that all these plants be upgraded to secondary treatment and eventually they all will be, individually or in combination.

Two Jersey City plants have a total flow of some 88 mgd, the Passaic Valley Sewerage Commission, 250 mgd, and Bayonne 8 mgd. If this wastewater could be salvaged, it would add to the available water resources in the Basin above Little Falls, either directly or indirectly.

The indirect benefit would come if the treated wastewater could be used by heavy industry in Hudson County to replace the use of potable water for cooling or process water.

It is reported there have been informal requests for 10 mgd, without solicitation, and there is undoubtedly a potential demand for much more. The State has proposed regionalizing sewage treatment in Hudson County by piping all county sewage to one secondary plant in Jersey City. A preliminary study will reveal if the potential demand for treated wastewater will make the regional concept less desirable. Several plants may be preferable if the water can be used at more than one location. Its only use may be to replace sea water as cooling water and while this won't save potable water, it could be a source of income.

In any event, every gallon of treated wastewater that replaces a gallon of potable water means another gallon available within the Passaic Basin.

The direct way to increase the quantity of water within the Basin is to pump treated wastewater from outside the Basin to some point within the Basin so the water can be reused. It seems rather futile to argue that treated wastewater shouldn't be used as a source of water supply when it is already done, particulary in dry years, by the Passaic Valley Water Commission.

The largest source of wastewater is the existing primary treatment plant of the Passaic Valley Sewage Commission, located near Newark Airport. Influent to the plant is a combination of domestic sewage and industrial wastewaters, with virtually every type of industry represented. The treatment plant will be upgraded to secondary treatment and with pretreatment of those industrial wastes that are not amenable to biological treatment, the effluent from the proposed plant could be used to supplement existing water sources in the Passaic River Basin. It may be necessary to provide tertiary treatment for that portion of the effluent to be returned to the Basin. This decision will have to be made after the plant is upgraded.

Returning the water to the Basin is somewhat of a problem because there are two low mountain ranges between the treatment plant and the Basin. However, there is a slight gap near Springfield and Millburn and a 14-mile pipeline could be run through it to the Passaic River near Chatham, downstream from the intakes of the Commonwealth Water Company. The drainage area of the Passaic River above this point is some 116 miles. This area will provide some dilution water even in the dry years. The scheme

is shown on Figure IV-24.

It should be emphasized that this scheme is for use in water-short years and it assumes that none of the proposed methods of supplementing Passaic Valley water with good quality water comes to fruition.

Establishing the quantity of water to be returned will require further study. The probable effluent quality from the treatment plant will have to be determined, as will its effect on the quality of the Passaic River at Chatham and further downstream. Assuming however that the quantity will be 200 mgd or less, preliminary cost figures have been calculated for four different quantities as shown in Table IV-9.

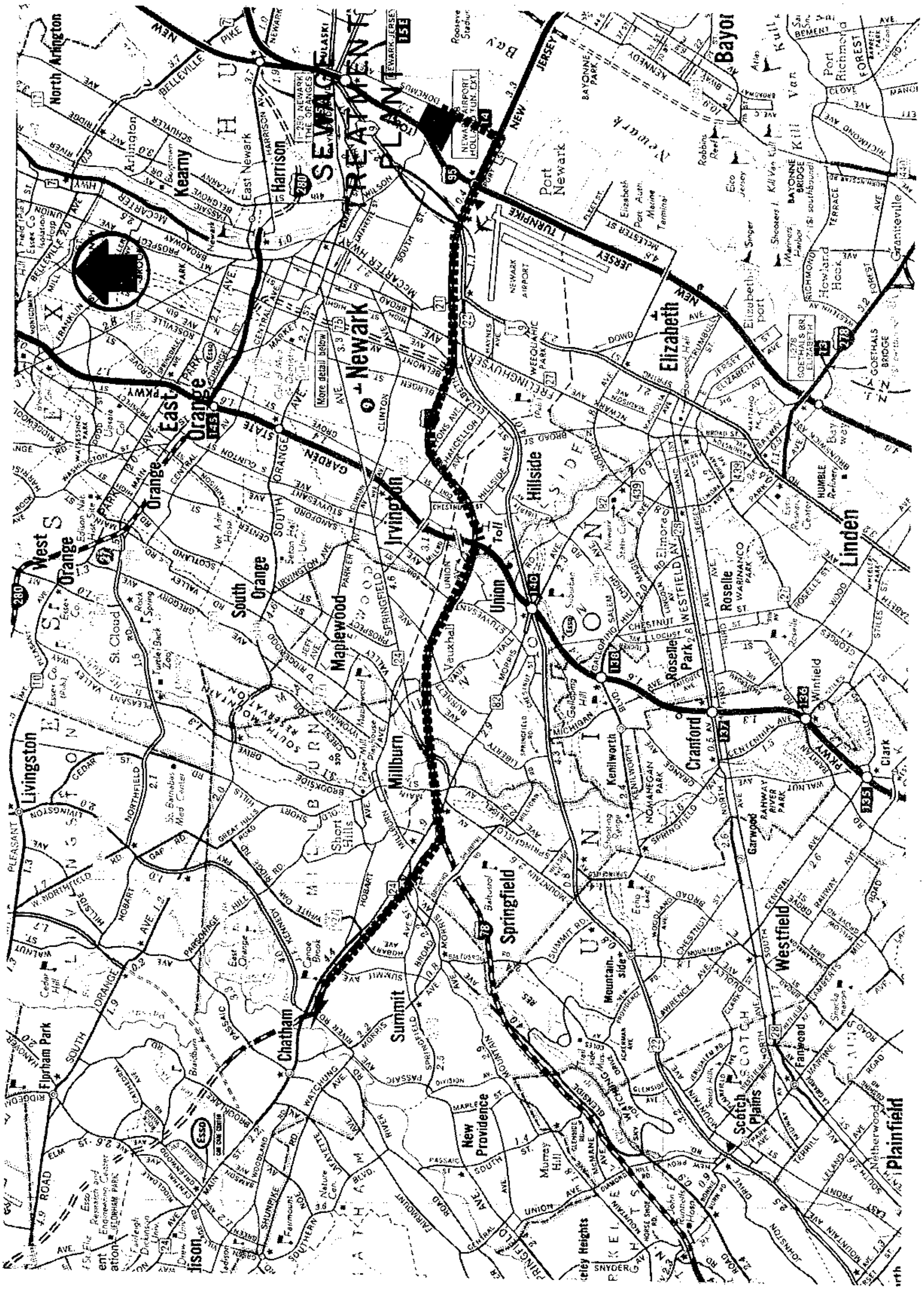
Cost calculations are based on curves in the Joint Venture Report (in part) at an ENR index of 1400.

4. Summary and Conclusions

There is a shortage of surface water in the Passaic River Basin for use as a source of water supply and while there may be untapped sources of groundwater, the developed groundwater sources appear to be in short supply during drought periods. Most of the water used within the Basin is returned to the Basin for reuse. However, the largest percentage of available surface water is exported from the Basin and not returned.

The exported water can be utilized in two ways to reduce the demand on the available water resources. It can be reused by industry in the consumption area for process or cooling water in place of potable water, or treated wastewater can be pumped back to the Passaic River at Chatham from the treatment plant of the Passaic Valley Sewerage Commission near Newark Airport.

The State of New Jersey has proposed a wastewater management study for the northeastern part of the State including the Passaic River Basin. While details are not available, a summary of the scope of work indicates that it covers all the elements of such a study. It does not appear, from the summary at least, that the State has considered the possible reuse of treated wastewater as an influence on wastewater management in Hudson County. This is, in effect, one way to tie together waste treatment and water supply and from this standpoint, it may be more economical to consider several sewage treatment plants in the County rather than one large plant.



SURFACE WATER RECHARGE IN THE PASSAIC RIVER AT CHATHAM, NEW JERSEY

TABLE IV-9

COST ESTIMATE: PUMPING SEWAGE TREATMENT PLANT EFFLUENT TO THE PASSAIC RIVER AT CHATHAM, NEW JERSEY
(MILLION DOLLARS)

A. WITHOUT TERTIARY TREATMENT

Project Capacity, MGD	50	100	150	200
Pipeline Diameter, inches	54	78	90	96
Construction Cost				
Pumping Stations	$ 1.4	$ 2.5	$ 3.6	$ 4.9
Transmission	4.4	8.5	10.7	12.2
Sub Total	$ 5.8	$11.0	$14.3	$17.1
Engineering & Contingencies (25% of Sub Total)	1.5	2.8	3.6	4.3
Legal & Administrative	.7	1.4	1.8	2.1
Total Capital Cost	$ 8.0	$15.2	$19.7	$23.5
Construction Cost per MGD Capacity	$ .160	$ .152	$ .131	$ .118
Fixed Annual Costs				
Interest and Amortization				
4-5/8%, 50 years	$ .413	$ .785	$1.017	$1.213
5%, 50 years	.438	.833	1.079	1.287
10%, 50 years	.807	1.533	1.987	2.370
Variable Annual Costs (1)	.5	.9	1.5	2.0
Total Annual Costs				
4-5/8%, 50 years	$ .91	$1.69	$2.52	$3.21
5%, 50 years	.94	1.73	2.58	3.29
10%, 50 years	1.31	2.43	3.49	4.37

B. WITH TERTIARY TREATMENT

Project Capacity, MGD	50	100	150	200
Pipeline Diameter, inches	54	78	90	96
Construction Cost				
Pumping Stations	$ 1.4	$ 2.5	$ 3.6	$ 4.9
Transmission	4.4	8.5	10.7	12.2
Tertiary Treatment	17.6	37.0	48.4	51.0
Sub Total	$23.4	$48.0	$62.7	$68.1
Engineering & Contingencies (25% of Sub Total)	5.9	12.0	15.7	17.0
Legal & Administrative	3.0	6.0	7.8	8.5
Total Capital Cost	$32.3	$66.0	$86.2	$93.6
Construction Cost per MGD Capacity	$ .646	$ .660	$ .575	$ .468

TABLE IV-9 (continued)

Fixed Annual Costs				
Interest and Amortization				
4-5/8%, 50 years	$ 1.67	$ 3.41	$ 4.45	$ 4.83
5%, 50 years	1.77	3.62	4.72	5.13
10%, 50 years	3.26	6.66	8.69	9.44
Variable Annual Costs (1)	5.1	9.5	13.5	17.5
Total Annual Costs				
4-5/8%, 50 years	$ 6.8	$12.9	$18.0	$22.3
5%, 50 years	6.9	13.1	18.2	22.6
10%, 50 years	8.4	16.2	22.2	26.9

Notes

(1) Costs include Power, Operation and Maintenance
(2) ENR=1400
(3) Operating costs will vary depending on how often effluent is pumped.

While there is no question that it is preferable to have a high quality water as a source of water supply, by necessity water purveyors, particularly the Passaic Valley Water Commission, have to treat water that is partially or wholly treated sewage. If it is possible to do so at this time, it would be informative to go through the health records of the Commission's service area during the drought years 1961-1966 to see if there was an increase in actual or presumptive water borne diseases. This was the period when the Commission was treating raw water that was almost 50% sewage.

D. COMBINED SEWER OVERFLOWS AND STORM SEWER FLOWS

1. General

Some municipalities in the study area have combined sewers which carry both sewage and storm water. Treatment plants are designed to handle two or three times the dry weather flow with the excess being discharged to a convenient waterway. Probably all the municipalities have some sort of separate storm water drainage system which also discharges into nearby waterways.

Thus, even if all the proposed sewage treatment plants are constructed, and they will be eventually, combined sewers and storm sewers will still contribute some polluting material to water courses. This fact has been recognized by EPA, which has funded many demonstration projects to study various methods of handling overflows from combined sewers. One such project has been built by the City of New York on a combined sewer discharge to Jamaica Bay. The scheme consists of a large retention basin to hold most of the smaller overflows and then bleed them back to a nearby sewage treatment plant. Flows from large storms will pass through the basin to capture most of the settleable material and the effluent will be chlorinated before discharge to the Bay. This basin in now in operation but it is too early to judge how effective it is.

Jamaica Bay has an area of 28 square miles, is virtually landlocked and has a great recreational potential. It is located in the southern part of the City. Four City sewage treatment plants discharge into the Bay but the effects of the combined sewers are such that the highest use of the water is boating. Coliform concentrations increase vastly after rains thus preventing water contact recreation.

2. Storm Sewer Flows

All storm water will become polluted to a certain extent, even in rural areas. Soil, animal droppings, leachate from rotting vegetation, etc. will all contribute something to the water. Urban development increases the potential for pollution and in most cases, it can probably be assumed that it does indeed increase pollution.

Two reports were studied to investigate the character of storm water pollution:

"Water Pollution Aspects of Urban Runoff", American Public Works Association, under Contract No. WA 66-23 with the Federal Water Pollution Control Administration, January 1969 and "Pollutional Effects of Stormwater and Overflows from Combined Sewer Systems" (A Preliminary Appraisal), by the Public Health Service, U.S. Department of Health, Education and Welfare, November 1964.

Both reports mention that the characteristics of storm water vary from location to location and that information gathered at one place is usually not applicable to another. Such things as precipitation patterns, character of the runoff area and capacity and design of the sewer system will determine the storm water characteristics.

A study done in Cincinnati on a 27 acre residential and light industrial drainage area with separate sewers illustrates that storm water does pollute. The following table gives some details:

Mean Concentrations of Constituents in Urban Land Runoff vs Time

Parameter	Time after start of runoff				
	0–15 minutes	15–30 minutes	30–60 minutes	60–120 minutes	120 minutes and over
	(mg/1)				
Suspended solids	390	280	190	200	160
Volatile suspended solids v	98	69	47	58	38
COD	170	130	110	97	72
BOD	28	26	23	20	12
Total Nitrogen—N	3.6	3.4	3.1	2.7	2.3
Phosphate PO_4 (total soluble as PO_4)	.99	.86	.92	.83	.63

Source: USPHS, "Pollutional Effects of Stormwater and Overflows from Combined Sewer Systems" (11,1964)

"Bacteriological examination of the stormwater revealed that coliform counts and fecal streptococci counts were rather high. Fifty percent of the coliform counts were in excess of 58,000/100 ml and 50 percent of the fecal strep counts were in excess of 20,500/100 ml. These results are of special significance in areas where the receiving water is to be used for swimming.

"A computation was made to compare stormwater to sanitary wastewater from the same area. In terms of the ratio of stormwater to sanitary wastewater the various components were as follows: suspended solids, 140 percent; volatile suspended solids, 44 percent; COD, 25 percent; BOD, 6 percent; phosphate, 9 percent; and total nitrate nitrogen, 11 percent."

3. Combined Sewer Overflows

There is a lot of data on the characteristics of combined sewer overflows, all of which indicates no pattern of pollution. One study concluded that "...any evaluation of the pollutional effect of combined sewage overflows based on volume alone may be grossly misleading because of the wide variations in constituent strengths."

Other studies show that the first big storm of a season was responsible for much higher coliform counts than subsequent storms, that sometimes "the first flush" contains more pollutional material than succeeding flow and sometimes the greatest amount of pollutional material comes some time during the storm. It was estimated that, in Chicago, an average of 8.4 million pounds of BOD per year are discharged in combined sewer overflows, compared to 46.9 million pounds of BOD in secondary treatment effluent.

Preliminary investigations by New York City, prior to construction of retention basin on Jamaica Bay, showed that in a 12-hour rain, the values for suspended solids, BOD and chlorine demand for the combined sewer overflow were 1060, 340 and 26 mg/l respectively, an hour after the overflow started. After an extended rain of some two days' duration, the lowest values found were suspended solids, 46 mg/l; BOD, 25 mg/l; and chlorine demand 2.4 mg/l.

4. Remarks

Many studies have been made on combined sewer overflows and relatively few studies on stormwater flows, but it is

apparent that each flow exerts a pollutional load on the receiving water. It doesn't appear that these loads have been considered seriously in evaluating the potential quality of a water source. Unfortunately, it doesn't seem feasible to apply information obtained in one area to another such as is done in assuming a domestic sewage contribution of 100 gallons/capita/day with a BOD of 200 mg/l and suspended solids of 200 mg/l. Each stream or water body has to be examined as an entity and the stormwater and combined sewer overflow contribution evaluated over some period of time.

In the study area, stormwater is piped to recharge basins on Long Island as a means of augmenting ground water supplies. An in-depth study should be made of the effect of the stormwater on the ground water, by means of shallow test wells around a recharge basin and at various distances from it to see how the water quality changes as it passes through the ground. Several sites would have to be selected - an all urban area, a residential area, and an agricultural area - to see how land use affects the characteristics of the stormwater.

An in-depth study of a stream in the study area, such as the Passaic River, should also be made to determine what effect stormwater flows have on water quality. If the river is divided into segments according to land use, it may be possible to use this data for other streams in the study area.

Section 105(a-1) of the 1972 Federal Water Pollution Act Amendments states that EPA can make grants to assist in the development of -

"Any project which will demonstrate a new or improved method of preventing, reducing, and eliminating the discharge in any waters of pollutants from sewers which carry stormwater as both stormwater and pollutants...". This Section gives recognition to the polluting nature of stormwater and it is hoped that money will be available to do further work on stormwater.

V. INTER-BASIN TRANSFER OF WATER

A. SKIMMING THE HUDSON RIVER

1. Background

The Hudson River drains a total area of 13,370 square miles (Figure V-1) which extends from the Mt. Marcy, New York area in the north to the Upper Bay of New York Harbor in the south. The eastern and western limits are approximately at the eastern boundary of New York State and the Rome-Utica area, respectively. This tremendous watershed area makes the Hudson River one of the best potential sources of water supply for New York City and the Metropolitan Area.

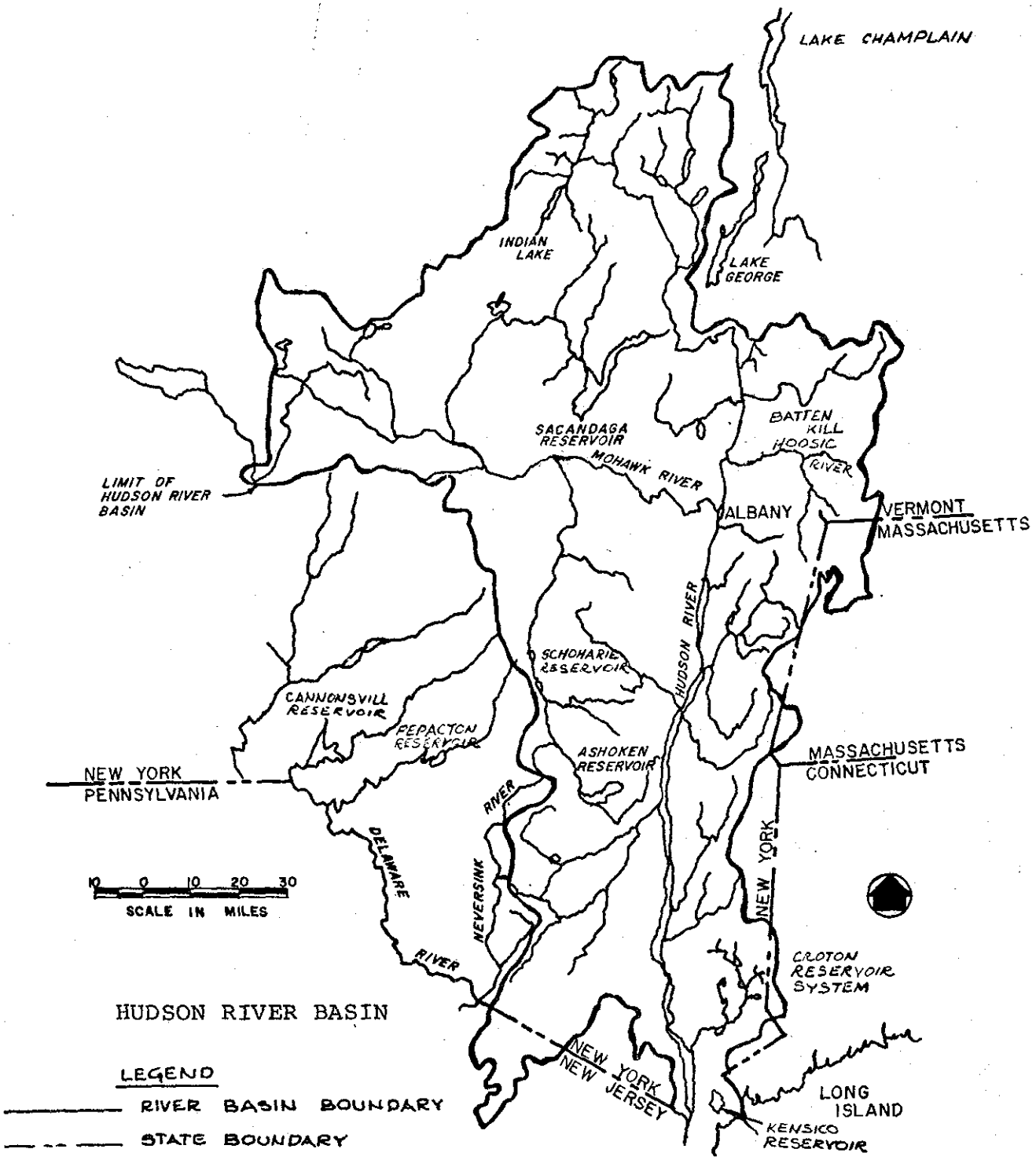
The feasibility of Hudson River as a source of water supply for New York City has received serious consideration even before the City embarked on the Catskill Water Supply System in 1905. It was in 1920 that the results of the studies were reviewed and in 1951 a 200 mgd auxiliary supply taken from the Hudson at Hyde Park was recommended as an alternate to building the Cannonsville Reservoir to impound Delaware River water for New York City supply.

2. Description of the Project

Hudson River High Flow Skimming is one of the projects used to develop the illustrative regional programs set forth in the Joint Venture Report. Specifically, one project termed HU-6, High Flow Skimming at West Park, is considered in this report. This project is only one alternative presented, and is not proposed or advocated at this time. It was envisioned to provide a flexible water supply system for the New York-New Jersey area. This particular project is chosen for discussion only since it represents the technical and water quality problems of many alternatives for using the Hudson River for water supply. The physical plan of the project is described below.

Approximately five miles north of Poughkeepsie a regional treatment plant will be built on the west side of the Hudson River at West Park. River water will be skimmed off nine to ten months a year during periods of high flow.

FIGURE V-1



SOURCE: Metcalf & Eddy and Hazen & Sawyer, (1971) "Alternative Regional Water Supply Plans for Northern New Jersey, New York City, Western Connecticut Metropolitan Area".

Water for New York Metropolitan Area would enter the Delaware and Catskill aqueducts at their intersection and would be carried to Hillview and Kensico Reservoirs in the New York City System. This scheme will provide an additional 180 mgd water supply for New York City on a continuous basis.

Project (HU-6b) is a two-stage development whereby the filtration plant will be constructed first to 800 and then to 1300 mgd capacity. A seventeen foot tunnel would transport water from the treatment plant to the intersection of the Delaware and Catskill Aqueducts. In the initial stage, a 62 mile long, 6-foot diameter pipe would deliver water to Great Notch, New Jersey. Water for New York would be transported through the existing Delaware and Catskill Aqueducts utilizing excess capacities in these facilities. In the second stage, an additional 38.5 mile, 16-foot diameter tunnel to Spring Valley would be built from this point. From Spring Valley a 19.8 mile, 12-foot diameter tunnel will continue down to Great Notch, New Jersey and an 11.3 mile, 14-foot diameter tunnel from Spring Valley will transport water to Kensico Reservoir. This scheme would provide an alternative way of conveying water to Kensico in the event of any damage to either the Delaware or Catskill aqueduct.

At a later date additional aqueducts could be constructed northward from the treatment plant to Ashokan Reservoir in the Catskill System or to Roundout Reservoir of the Delaware System, to provide additional necessary storage.

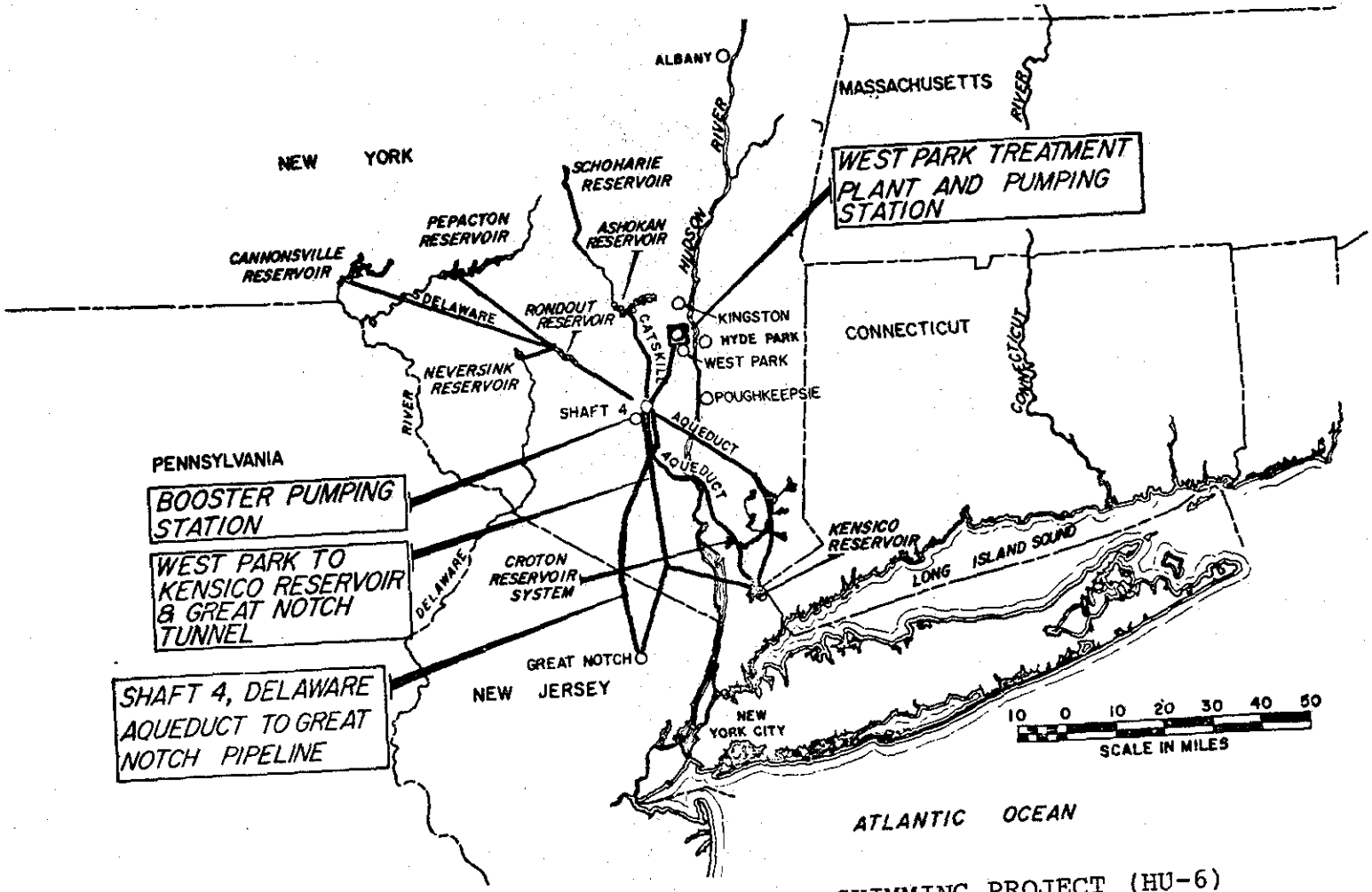
The first stage development would provide a total water supply of 480 mgd. In Stage 2, upstream storage would be constructed, to provide a continuous 1300 mgd supply.

Figure V-2 shows the approximate location of the Hudson High Flow Skimming Project.

Estimated project costs are presented in Table V-1.

3. Problems

Preliminary investigations on the Hudson River high flow skimming project revealed various water quality and environmental problems that must be resolved as soon as possible, if early endorsement of the project is contemplated. These problems may be summarized as two basic issues as presented below:



HUDSON RIVER SKIMMING PROJECT (HU-6)

SOURCE: Metcalf & Eddy and Hazen & Sawyer (1971), "Alternative Regional Water Supply Plans for Northern New Jersey, New York City, Western Connecticut Metropolitan Area".

FIGURE V-2

TABLE V-1
HUDSON RIVER HIGH FLOW SKIMMING AT WEST PARK, N. Y.
COST ESTIMATE (1) (MILLION DOLLARS)

Project Name	HU-6b(5) Phase 1 High Flow Skimming	HU-6b(6) Phase 2 High Flow Skimming plus storage
Yield, mgd	480	1,300
Tunnel Capacity, mgd	1,300	1,300(2)
Treatment Plant Capacity, mgd	800	1,300
Construction Cost		
Impoundments	$ -	$ 73.1
Raw-Water Pumping Stations(3)	10.6	20.6
Raw-Water Transmission(3)	18.6	20.0
Treatment Plant	81.0	133.7
Finished-Water Transmission	199.6	661.2
Sub Total	$209.8	$ 908.6
Engineering Contingencies (25% of Sub Total)	52.5	227.2
Land	1.4	15.4
Legal and Administrative	26.4	115.1
Total Construction Cost	$290.1	$1266.3
Construction Cost per MGD Capacity	$ 0.60	$ 0.97
Fixed Annual Cost		
Interest and Amortization		
4-5/8%, 50 years	$ 15.0	$ 65.4
5%, 50 years	15.9	69.4
10%, 50 years	29.3	127.7
Variable Annual Costs		
Taxes	$ 3.1	$ 8.4
Personnel	1.5	3.2
Power(4)	6.9	24.2
Chemicals and Supplies	3.6	8.8
Total Variable Annual Costs	$ 15.1	$ 44.6
Total Annual Costs		
4-5/8%, 50 years	$ 30.1	$ 110.0
5%, 50 years	31.0	114.0
10%, 50 years	44.4	172.3
Delivered to:	Kensico & Great Notch	Kensico & Great Notch

Notes:
(1) All data given are cumulative and include data for preceding stages.
(2) The capacities of various tunnels in Stage 2 are: West Park to Shaft 4, Delaware Aqueduct - 1,300 mgd; Shaft 4, Delaware Aqueduct to Bardonia - 1,200 mgd; Bardonia to Kensico Reservoir - 750 mgd; Bardonia to Great Notch - 350 mgd. Pipeline from Shaft 4, Delaware Aqueduct to Great Notch - 100 mgd. Local use - 100 mgd.
(3) Includes facilities for both diversion into the basin and raw-water intake to the treatment plant.

TABLE V-1 (continued)

(4) Demand and energy charges of $1.53 per kw per month and 0.92C per kwh, respectively.
(5) Intermittent operation.
(6) Continuous operation.
(7) Sub-total of Construction Cost for Project HU-6b seems to be in error. It has not been determined whether the sub-total is incorrect or one of the items above it is incorrect.

SOURCE: Metcalf & Eddy - Hazen & Sawyer, "Alternative Regional Water Plans for Northern New Jersey - New York City - Western Connecticut Metropolitan Area", Nov. 1971
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a) The quality of Hudson River water is regarded as poorer than the present clear mountain water flowing to the New York City water supply system. It is contended that treatment will improve the diverted Hudson River water supply to a degree equal to or better than New York City's present supply. A possible taste problem of the finished Hudson River water after undergoing chemical treatment may present an important aesthetic consideration.

Relative to the poorer quality of the Hudson River water, is the possible problem of the salt water front moving upstream. (The salt water front is generally defined as that point in the river with an average salinity of 100 ppm.) This is true for any Hudson River water supply scheme. Available figures suggest that there is considerable leeway in operating high flow skimming within safe limits as far as this problem is concerned. However, it must be recognized that since Sacandaga Reservoir was placed in service in 1930, the salt water front reached Poughkeepsie in that year, and in 1949, 1964, 1965 and 1966. Thus the possibility of the salt front moving upriver and causing unacceptable salinity levels as far as West Park cannot be dismissed. Further study is suggested to conclusively determine the effects of such projects.

b) The skimming operation might cause ecological disturbances in the area. The area above Poughkeepsie is a favored breeding ground for shad, striped bass, sturgeon and herring. A major concern is that water intakes may take in large numbers of spawn and young fish.

4. Water Quality in Hudson River

Water quality in the Hudson River is affected by industrial and municipal waste discharges and the movement of a salt water wedge from the Atlantic Ocean upstream.

In the area near Albany, where the River may be considered polluted, wastewater discharged into the River undergoes a considerable amount of oxidation as it flows downstream. By the time it reaches Poughkeepsie, from a point near Saugerties, water is considered to be of good quality.

The Hudson River is tidal to Troy, New York. The entire lower river, considered as an estuary, is subject to varying incursions of sea water.

The position of the salt water wedge in the Hudson River will determine the salt concentration at a particular point in the River. An important factor in determining its position is the flow in the River. The high flow skimming of the Hudson will lower flows and bring the salt water wedge further upstream, however, the extent will depend on the amount and schedule of high flow skimming.

A more detailed discussion of the salt water wedge and the effects of high flow skimming upon its position are discussed in Part 7 of this section.

Water is taken from the Hudson River at Poughkeepsie for potable water supplies. A comparison of the Hudson River water quality at Poughkeepsie and points along the Delaware River are presented in Table V-2.

5. Effect on New York City Water Supply Quality

Quality of New York City Water Supply - Kensico Reservoir

As shown on Table V-3, water at the Kensico Reservoir is of generally high quality. The same is true for the Delaware supply entering the Kensico reservoir, the maximum turbidity recorded at the Kensico entry being 3.5 JTU units.

Chlorine is being applied to the water entering the Catskill and Delaware aqueducts. The latest figures released by the New York City Bureau of Water Supply show that 0.5 ppm chlorine residual is being maintained.

Fluoridation is practiced for water entering Kensico Reservoir from the Delaware and Catskill aqueducts, maintaining 1.0 mg/l fluoride ion concentration.

The flow entering Kensico Reservoir from the Delaware Aqueduct is being treated continuously with copper sulfate at the rate of 0.18 mg/l to inhibit the growth of algae in the reservoir.

Normally, water supplied from the reservoir does not require any treatment except chlorination. Ashokan Reservoir water entering the Catskill Aqueduct receives chlorine to maintain a residual chlorine concentration of 0.24 ppm (1968 average). The quality of the effluent from the Ashokan and Roundout Reservoirs is presented in Table V-3.

TABLE V-2

HUDSON RIVER AND DELAWARE RIVER WATER QUALITY

	Delaware River				Hudson River
	Trenton, N. J.	Yardley, Pa.	Delaware Water Gap	Port Jervis, N. Y.[1]	Poughkeepsie N. Y.
Year sampled	1964-65	1957	1957	1958	1962-66
Color	4	-	-	21	35
Turbidity	-	12	3	5	25
pH	7.0	-	-	7.2	7.1
Hardness, $CaCO_3$	68	69	23	16	70
Alkalinity, $CaCO_3$	40	49	18	11	60
Chloride, Cl	10	-	-	1.0	10.0
CO_2	-	-	-	2.0	6.0
Dissolved oxygen	8.5	8.8	8.0	9.5	8.0
Percent saturation	>90	-	-	95	-
BOD_5	-	3.0	1.3	0.7	2.0
Iron, Fe	0.10	-	-	-	-
Nitrate, N	1.3	-	-	-	0.5
Coliforms, MPN per 100 ml.	2,400	-	230	1,000	2,400

1. Above Neversink River

SOURCE: Comprehensive Public Water Supply Study for the City of New York and County of Westchester, Metcalf & Eddy, Hazen & Sawyer, Malcolm Pirnie, Engineers (1967)

TABLE V-3

COMPARATIVE ANALYSIS OF HUDSON RIVER WATER,
NEW YORK CITY SUPPLY AND USPHS DRINKING WATER STANDARDS

HUDSON RIVER AT POUGHKEEPSIE

ITEM	1 Raw	2 Treated
	8/24/70	8/24/70
Mean Discharge, cfs		
Color, standard units	25	0
Turbidity, Jtu	65	Trace
Temperature, °C.	72	72
Dissolved Oxygen	12.4	3.3
DO Saturation, %		
Carbon Dioxide		
pH, units	7.2	7.6
Conductivity, micromhos	-	-
Chlorides (Cl)	13.7	22
Fluorides (F)	0.09	1.29
Total Hardness ($CaCO_3$)	100	120
Carbonate Alkalinity ($CaCO_3$)		
Bicarbonate Alkalinity ($CaCO_3$)		
Total Alkalinity ($CaCO_3$)	58	56
Calcium (Ca)		
Magnesium (Mg)		
Sodium (Na)	9.4	9.2
Potassium (K)	1.0	1.8
Iron (Fe)	1.8	< 0.02
Manganese (Mn)	0.12	0.006
Ammonia (N)	0.012	0.010
Organic Nitrogen (N)	0.288	0.088
Nitrites (N)	< 0.001	< 0.001
Nitrates (N)	0.9	1.0
Phosphates (PO_4)	0.3	< 0.05
Sulphates (SO_4)	29	40
MBAS	< 0.02	< 0.02
Phenols		
Residue on Evaporation at 180°C.		
Total Suspended Solids		
Total Dissolved Solids	166	200
COD		
BOD (5-day at 20°C.)		
Coliform (MPN), number/100 ml		

SOURCE: Poughkeepsie Water Works
NOTE: All values in mg/l unless noted otherwise.

TABLE V-3 (Continued)

COMPARATIVE ANALYSIS OF HUDSON RIVER WATER,
NEW YORK CITY SUPPLY AND USPHS DRINKING WATER STANDARDS

NEW YORK CITY WATER SUPPLY

ITEM	3 Catskill Water Ashokan Reservoir Effluent 1961-1965	4 Delaware Water Roundout Reservoir Effluent 1961-1965
Mean Discharge, cfs		
Color, standard units	10	8
Turbidity, Jtu	5	2
Temperature, °C.	48	47
Dissolved Oxygen	12	-
DO Saturation, %		
Carbon Dioxide		
pH, units	7.2	7.2
Conductivity, micromhos	50	52
Chlorides (Cl)	2.1	2.5
Fluorides (F)		
Total Hardness ($CaCO_3$)	17	20
Carbonate Alkalinity ($CaCO_3$)		
Bicarbonate Alkalinity ($CaCO_3$)		
Total Alkalinity ($CaCO_3$)	9	8
Calcium (Ca)		
Magnesium (Mg)		
Sodium (Na)		
Potassium (K)		
Iron (Fe)	0.17	0.08
Manganese (Mn)		
Ammonia (N)		
Organic Nitrogen (N)		
Nitrites (N)		
Nitrates (N)	0.10	0.22
Phosphates (PO_4)		
Sulphates (SO_4)		
MBAS		
Phenols		
Residue on Evaporation at 180°C.		
Total Suspended Solids		
Total Dissolved Solids	41	40
COD		
BOD (5-day at 20°C.)		
Coliform (MPN), number/100 ml	12.3	5

Source: Metcalf & Eddy, Hazen & Sawyer, "Alternative Regional Water Supply Plans for Northern New Jersey, New York City, Western Connecticut Metropolitan Area", 1971.

NOTE: All values in mg/l unless noted otherwise.

TABLE V-3 (Continued)

COMPARATIVE ANALYSIS OF HUDSON RIVER WATER,
NEW YORK CITY SUPPLY AND USPHS DRINKING WATER STANDARDS

ITEM	5 Expected Quality of N.Y.C. Water	6 U.S.P.H.S. Drinking Water Standards (Recommended)
Mean Discharge, cfs		
Color, standard units	8	15
Turbidity, Jtu	2	5
Temperature, °C.	54	
Dissolved Oxygen	14	
DO Saturation, %		
Carbon Dioxide		
pH, units	7.3	
Conductivity, micromhos		
Chlorides (Cl)	8	250
Fluorides (F)		
Total Hardness ($CaCO_3$)	47	
Carbonate Alkalinity ($CaCO_3$)		
Bicarbonate Alkalinity ($CaCO_3$)		
Total Alkalinity ($CaCO_3$)	22	
Calcium (Ca)		
Magnesium (Mg)		
Sodium (Na)		
Potassium (K)		
Iron (Fe)	<0.09	
Manganese (Mn)		0.05
Ammonia (N)		
Organic Nitrogen (N)		
Nitrites (N)		
Nitrates (N)	0.4	45
Phosphates (PO_4)	<0.05	
Sulphates (SO_4)		
MBAS		
Phenols		
Residue on Evaporation at 180°C.		
Total Suspended Solids		
Total Dissolved Solids	9	500
COD		
BOD (5-day at 20°C.)		
Coliform (MPN), number/100 ml		

NOTE: All values in mg/l unless noted otherwise.

Resulting Quality

Since the withdrawal point of the Hudson River high flow skimming project will be in the vicinity of the Poughkeepsie Municipal Water Treatment Plant, it is assumed that treatment will be similar to that practiced at the Poughkeepsie plant. This includes aeration, chlorination, pH adjustment, phosphate sequestering of iron, fluoridation, coagulation and filtration.

Table V-3 shows a comparative typical analysis of Hudson River at Poughkeepsie, New York City water supplies, treated Poughkeepsie water and USPHS drinking water quality standards. It is very obvious from the table that the quality of New York City water supply is generally better than that of the Hudson River. However, it can be seen that after treatment, the Hudson River water compares favorably in quality with that of the New York City water supplies.

To determine the expected quality of water in the distrubution system as a result of integrating the treated Hudson River with the New York City water supply, a materials balance was made based on 480 MGD yield of the high flow skimming project and the respective normal flow from the two reservoirs (taken as 474 mgd from Catskill Aqueduct and 769 MGD from Delaware Aqueduct). As reflected in Table V-3, Column 5, the resultant water supply is equal or in some instances, better than the quality of New York City water supplies.

If there is a difference in taste between this "mixed water" (treated Hudson River, Ashokan and Roundout waters) and the present New York City water, at the point where they meet, there would probably be no detectable difference by the time the water is consumed due to enough mixing and dilution that would have occurred between the point of confluence and first New York water consumer outlet area.

6. Effect on Delaware River Flows

New York City impounds water from the Delaware River Basin in four reservoirs, Cannonsville, Pepacton, Neversink and Roundout. (Roundout, actually in the Hudson River basin, serves to collect water from the other three reservoirs). Separate tunnels deliver

water to Roundout reservoir from the other three reservoirs, and water is delivered from there to Kensico Reservoir via the Delaware Aqueduct.

While the Delaware system has an authorized delivery of 800 mgd, it produces about 600 mgd. The development of the Delaware system resulted in some problems because the Delaware is an interstate stream which flows from New York into and through Pennsylvania, New Jersey and Delaware. When the project was being planned, the taking of Delaware River water for New York water supply purposes was challenged by the downstream states since it involved the interbasin transfer of water and subsequent loss to downstream users. This resulted in the 1954 Supreme Court decree which requires that certain waters be released from the reservoirs downstream and certain minimum flows be maintained at Montague, New Jersey, a location just below the Pennsylvania-New York-New Jersey line. In addition to minimum flow requirements, there are certain excess flow requirements, which increases the amount of water that must be released. Consequently, the Delaware System provides water for delivery to the city for water supply purposes, and also for release downstream to comply with the Supreme Court decree. The decree was strengthened by the formation of the Delaware River Basin Compact, which is an interstate-federal agency consisting of New York, New Jersey, Pennsylvania, Delaware and the Federal Government. Part of the interstate compact was an agreement not to request changes in the Supreme Court decree for 100 years.

When the Hudson River skimming project feeds New York City, New York City water supply derived from the Delaware System will still be needed. No net effect would result on the Delaware River flow. However, with the diversion to New Jersey of Hudson River water, the prescribed contribution to the Delaware River flow from New York City's Delaware Supply System may be eased.

A unanimous agreement of the members of the Delaware River Basin Compact will allow petition to the Supreme Court, before 100 years, to change Delaware River flow augmentation requirements. The agreement of all parties is improbable, unless an inter-regional system and its effects make a change in the requirements amenable to all parties. If the Hudson River High Flow Skimming provides New Jersey with water in excess of its requirements from the Delaware River, they may agree to a relaxation of New York City's releases to the Delaware River.

7. Effects Upon the Salt Water Wedge

a) Salt Water Wedge in the Hudson River

Hudson River flows in excess of 3000 cfs at Green Island are required to maintain the salt front below West Park.

These flows are available except for two or three months of the most severe drought years. It has been proposed to skim excess flows at varying rates in each month to provide high annual yields.

Discharges at Green Island and downstream are critical in resisting the inflow of salt water through New York Harbor. The extent of the inflow termed the "salt front" is a function of fresh-water discharge to the Hudson, tides, wind and other factors. When the river discharges are high, the salt water front may lie between Tarrytown and Peekskill. High discharges are usually prevalent in the winter and spring. During the dry summer months, the salt water may extend to Newburgh and during severe drought has reached the waterworks intake at Poughkeepsie. In the 1880's prior to the operation of the Sacandaga Reservoir, during a severe drought, the salt front reached Kingston. The chlorides exceeded 200 mg/l for a short time in 1964 without any noticeable effects.

In the August 1967 report titled "Comprehensive Public Water Supply Study for the City of New York and the County of Westchester", (CPWS-27) there were several conclusions applicable to these investigations as follows:

1. River flows should be regulated to assure an average chloride concentration of less than 100 mg/l at the end of a protracted drought at intakes located in the vicinity of Poughkeepsie and Hyde Park.

2. Flows at Green Island should always exceed 3000 cfs, plus the quantity of water to be withdrawn at Hyde Park for water supply.

3. Existing storage in Indian Lake and Sacandaga Reservoir is sufficient to provide 3000 cfs minimum low-flow needed for salt front control.

Figure V-3 illustrates the chloride profiles of the Hudson River. The variations of chlorides with milepoint and fresh water flow are noted. From these curves the effects of reducing the fresh water flow can be estimated.

b) Effects on the Salt Water Wedge

The fresh water enters the estuary at the upstream end and flows downstream through the estuary to the ocean. Concurrently, heavier salt water intrudes upstream through the ocean entrance and flows beneath the lighter fresh water.

Due to tidal motion in the ocean, turbulent eddies mix the lighter fresh water downward, and the heavier salt water upward, causing an increase in the potential energy of the water. This type of action tends to dilute the landward flowing salt water and increase the density of the seaward flowing fresh water, resulting in an increase of the water volume of the seaward flowing layer.

In addition to the magnitude of fresh water flow and the tidal currents, the mixing processes and circulation pattern described above are also controlled by the physical characteristics of the river channel and the effect of the earth's rotation represented by the Coriolis force.

The hydrodynamic and kinematic characteristics of an estuary are governed, in a complex manner, by the fresh water influx, physical characteristics of the river channel and strength of the tidal currents. The factors affecting these variables will influence the degree of vertical stratification and therefore circulation patterns. The ratio of the tidal flow to the fresh water flow combines the important variables into a single factor. This factor provides an overall picture of the relative state of mixing and circulation in an estuary. When the tidal currents are relatively strong compared to the fresh water flow, turbulence increases and causes an upward advertion of salt water as well as a downward movement of fresh water into the lower layer. This type of circulation occurs in the Hudson River, which is referred to as a partially stratified estuary.

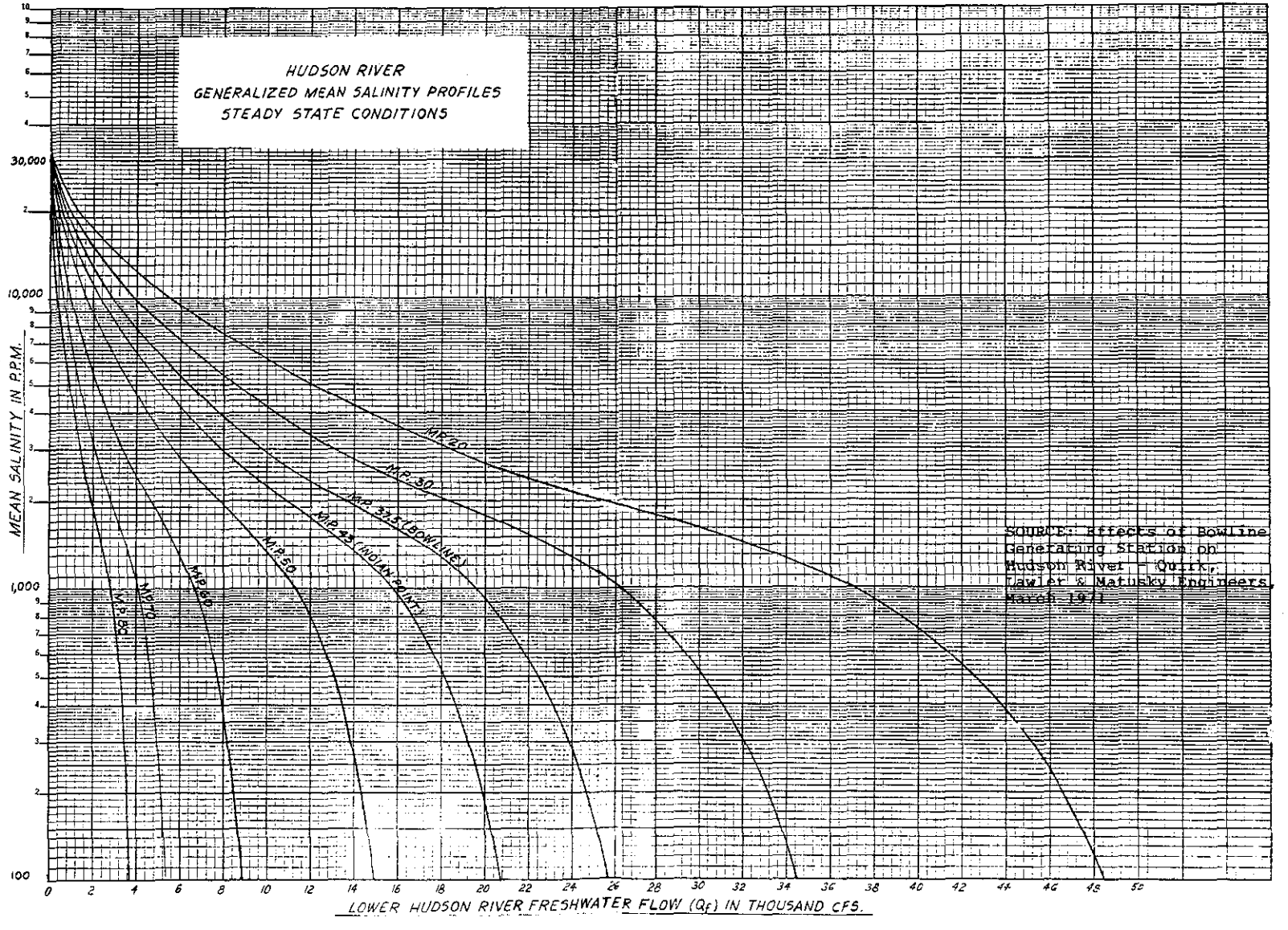

HUDSON RIVER
GENERALIZED MEAN SALINITY PROFILES
STEADY STATE CONDITIONS
MEAN SALINITY IN P.P.M.
30,000
10,000
1,000
100
M.P. 20
M.P. 30
M.P. 33.5 (BOWLINE)
M.P. 43 (INDIAN POINT)
M.P. 50
M.P. 60
M.P. 70
M.P. 80
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50
LOWER HUDSON RIVER FRESHWATER FLOW (Q_f) IN THOUSAND CFS.
SOURCE: Effects of Bowline Generating Station on Hudson River - Quirk, Lawler & Matusky Engineers, March 1971

FIGURE V-3

In the Hudson River, the mean tidal flow decreases from a maximum of 425,000 cfs at the Battery to some 140,000 cfs at Indian Point and approaches zero at the Federal Dam at Troy.

In the upper reaches of the estuary, the flood currents disappear with increasing run-off. For example, during extreme high flow the River lacks the usual tidal oscillations. Near the mouth of the River, the fresh water flow effect is relatively small, but becomes more important as one advances upstream and reaches a maximum at the upstream reaches. The fresh water flow influences both the magnitude of the tidal velocities and the duration of the tidal phases. Effects on the duration are usually greater than on the velocity magnitudes. Small effects on the velocity may result in significant changes in the circulation pattern.

Large scale skimming operations could result in substantial changes in the estuary characteristics as follows:

(i) River fresh water flow as a function of time and space.

(ii) Mixing or dispersion coefficients.

(iii) River channel characteristics.

These are areas which should be investigated in greater detail prior to a detailed program evaluation. Also a re-evaluation of the large power company intakes and discharges should be conducted in the light of lower than normal flows resulting from skimming. The river channel geometry, fresh water velocities, dispersion coefficients and the thermal stratification factors would change with a new flow regimen.

8. Effects on Flora and Fauna

Early fish life stages are commonly observed between Croton Point and Coxsackie.

Factors which influence the fish population in the Hudson River are:

(i) Seasonal and annual changes in runoff.

(ii) Commercial and sports fishing.

(iii) Municipal, agricultural and industrial waste discharges.

(iv) Withdrawals of municipal water for supply and other purposes.

(v) Other activities of man.

The influence of these factors will vary in significance although all will affect the aquatic ecosystem and the distribution of the various life stages on the river.

The potential of large scale skimming withdrawals to affect a river's fish population depends on many factors, several of which are listed below.

(i) Fish life cycle characteristics.

(ii) Location of the intake on the river with respect to the distribution of early fish stages.

(iii) The design of the intake, particularly with respect to entrainment of fish.

The effects on physical-chemical parameters in the river has logically initially centered on the changes in salinity profiles. In general sustained changes in salinity during critical times of the year can be expected to decrease available spawning area for those resident and migratory species that seek fresh water for spawning, reduce nursery areas now utilized by salt intolerant forms by causing the salt wedge to move up river and occupy those portions of the river which have wide shallow expanses, and result in changes in local population structure to more salt tolerant forms.

The latter point might not in itself appear to be a potential problem; however, an example may describe a set of circumstances where the withdrawal process seriously affects the impact of a downstream industry. For most of the year at mile point 43 the predominate macroinvertebrate species withdrawn is the amphipod

Gammarus sp. This species has been shown to be relatively resistant to power plant entrainment, suffering little mortality. During those periods of time when the salinity increases at mile point 43 Gammarus is replaced by Neomysis as the predominate entrained form. Neomysis does not withstand entrainment nearly as well as Gammarus. Increasing the salinity at mile point 43 with its concurrent increase in the period of time Neomysis is in residence will change the impact of Indian Point on the macroinvertebrate populations of the river. This example could be cited for other species and Indian Point or other industries along the river.

The changes in salinity profiles considered are based on mean values, while the biological components in the system do not recognize mean values but rather respond to conditions that exist during the withdrawal periods. For example, April 1973 presented a set of circumstances during which salinity values at mile point 43 exceeded 7,000 mg/l. This set of circumstances and the relationships between the spawning of striped bass and salinity may have delayed the onset of spawning or pushed it further up river than normal. These extremes occurring at critical times in the life history of important species coupled with man induced changes must be carefully considered and evaluated.

The potential biological problems associated with withdrawal of water from the river are dependent in part on the design of the structure used for removal. Two areas of obvious concern are impingement and entrainment. Impingement, a term coined to describe the process of drawing organisms against a screen during the withdrawal of water, is a recognized problem at power plants along the river.

Entrainment, defined as the withdrawal of non-screenable organisms is also a recognized problem at power plants along the river. Unlike entrainment at power plants the removal of organisms during withdrawal at this project would result in a complete loss to the system regardless of their condition after withdrawal.

Potential impacts due to such processes as impingement and entrainment could to an extent be minimized by design features of the withdrawal intake

system. Impacts due to changing the temporal and spatial location of the salt wedge and to reduced dilution probably cannot be ameliorated significantly by design or operational measures.

The Hudson River serves as spawning grounds and nursery areas for several anadromous species of fish important in commercial fisheries, as well as spawning grounds for resident non-migratory species. The impact of man's activities along the Hudson River on these species and their supporting flora and fauna is being seriously questioned and there is no doubt that new activities will undergo careful scrutiny prior to receiving approval.

The direct and hidden costs associated with all of the potential adverse effects could be prodigious. The proposers of such a plan to skim water from the Hudson should expect very adamant and effective opposition from many conservation groups.

9. Other Effects

Detailed analysis are also warranted to determine the response of the skimmed river to both thermal discharges and organic contaminants.

Normally estuarine vertical mixing, which tends to be relatively intense in the Hudson, overcomes tendencies for waste discharges to stratify - and the wastes become well mixed in depth.

A portion of the wastes, after introduction into the upper layer, will be transported to the lower layer and move upstream from the source - by this same mechanism of vertical mixing, some of this lower layer waste containing flow will be introduced into the upper layer above the source and eventually will flow down past the source.

A portion of this mixing capacity will be reduced by large upstream withdrawals.

Withdrawal of large volumes of water from the river with no return can also be expected to increase the residency time of pollutants within the basin, reduce circulation and mixing which in turn could affect

the assimilative capacity of the system, increase the potential for eutrophication, reduce the capacity of the system to disperse and mix thermal loading and alter suspended solid loads.

Adverse effects on biota sought commercially or by sport fishermen would have both financial and recreational impacts, which also have associated aesthetic ramifications.

Any eutrophication or other adverse effects on water quality that might result from reduction of dilution, increased transport time of pollutants out of the estuary, or relocation of the salt front could adversely affect the appearance of the estuary and reduce its capacity to assimilate present and future waste heat and other discharges.

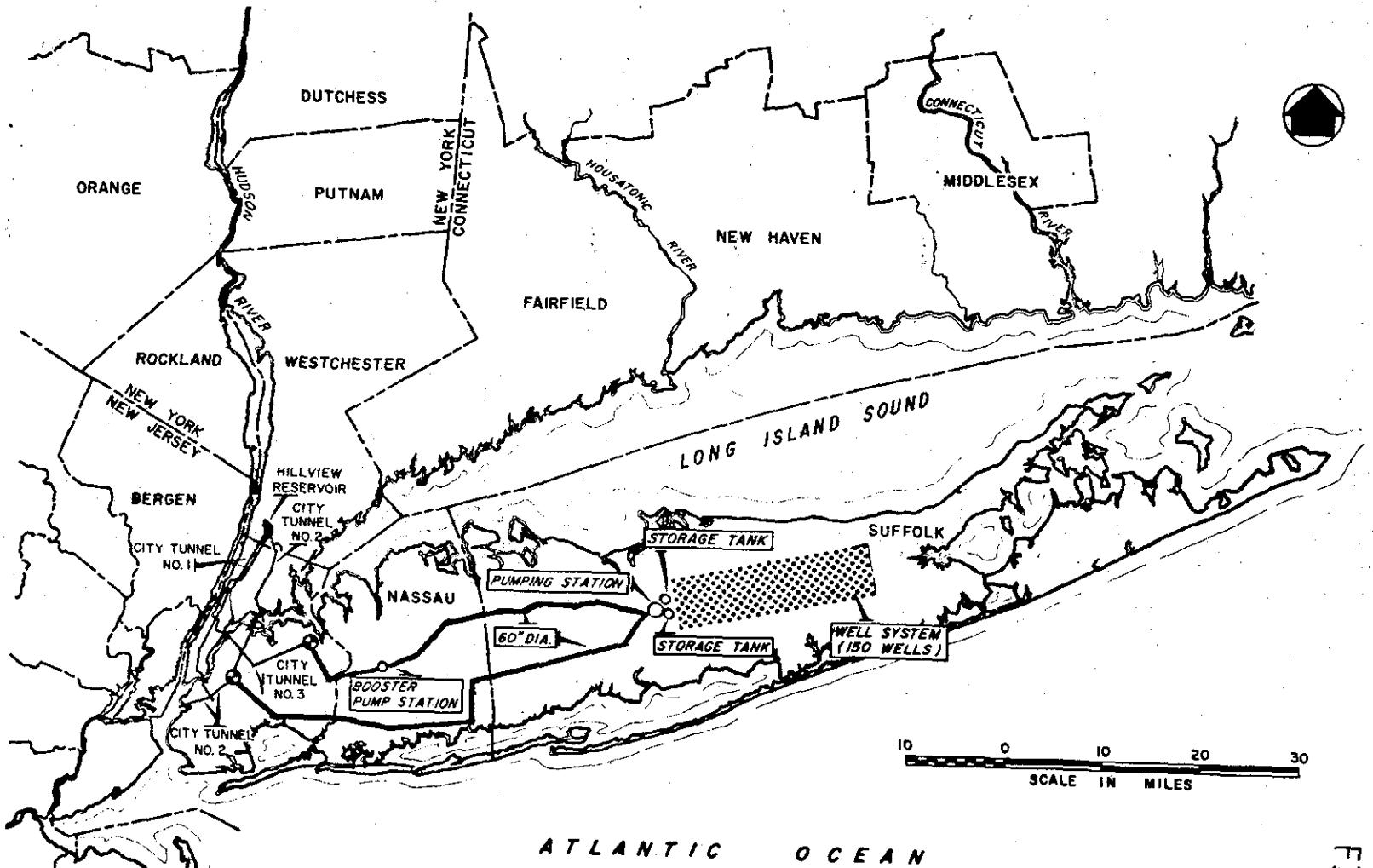
B. INTRODUCING LONG ISLAND GROUNDWATER INTO NEW YORK CITY'S WATER SUPPLY AND TRANSFER OF NEW YORK CITY WATER TO LONG ISLAND

1. General

The supplemental water requirements of Long Island, specifically Nassau County, were discussed in the Joint Venture Report. Supplemental sources of water supply considered would involve husbanding the New York City and Long Island water supplies for their mutual benefit. This arrangement would augment Long Island's water supply by drawing in water from New York City during wet periods. In return, the Long Island groundwater system would help in meeting the water needs of New York City during prolonged drought periods. A common transmission system would be provided to transport water in either direction. A schematic representation of this project is shown on Figure V-4.

2. Relative Quality of Waters

The quality of New York City water supplies is exceptionally good. Long Island groundwater supply is generally a good quality water, however, its quality is not as good as New York City's. The differences in the chemical character of the two sources may be further increased in the immediate and in the foreseeable future



TRANSFER OF SUFFOLK COUNTY GROUND WATER TO NEW YORK CITY
SOURCE: Metcalf & Eddy and Hazen & Sawyer (1971), "Alternative Regional Water Supply Plans for Northern New Jersey, New York City, Western Connecticut Metropolitan Area".

FIGURE V-4

because of the continuous degradation of Long Island groundwater resources. There are major and minor areas of concern with Long Island groundwater supplies: three major areas of concern are detergent contamination, increase of NO_3 concentration, and iron in groundwater. Three minor areas are thermal, industrial and salt contamination. (These problems are discussed in Section IV-B of this report.) These problems are nearly nonexistent in New York City water and the present quality would probably be maintained as a result of the continuous and vigilant water management programs presently practiced and those being planned.

With a knowledge of the present problems prevailing on Long Island, and to preserve a good water supply (New York City's) against possible contamination, it is extremely important to investigate the overall consequences of adopting the Long Island-New York City water supply interconnection.

3. Effect of Water Quality of One Source on Another

From a standpoint of mathematical models of water quality, there are three broad classes of pollutional substances significantly involved. These may be categorized into:

a) conservative or non-reactive substances such as chlorides or dissolved salts;

b) reactive substances, typified by BOD, coliform, radioactive material and temperature;

c) substances influenced by sequential reaction phenomena, such as dissolved oxygen, nitrogen and other nutrients.

The effect of water quality of Long Island-New York City water supply integration can be answered in detail by actual experimentation and employing mathematical models derived from the above mentioned categories. Due to the lack of available data on this subject, in-depth analysis and the exact answer to the particular situation cannot be given in this report. However, a generalized conclusion may be derived from various investigations on wastewater treatment and practices. These effects on water quality are discussed below and are classified into three categories.

Dilution and Dispersing Action

This is perhaps the major contributory factor in effecting a change in water quality. The quality of Long Island groundwater would undoubtedly be improved because of the dilution effect brought about by the better quality water from the New York City supply. This is particularly true with the conservative or non-reactive substances such as chlorides. A reverse effect would be experienced by the New York City supply.

Recent information released by U.S.G.S. reveals that salt water intrusion was observed on the shores of Nassau County. This phenomena is attributed to the lowering of the groundwater table caused by overpumping and also contamination from leaching of cesspools. Chloride content of water from selected production wells on Long Island reveal concentrations up to 1300 mg/l at the Atlantic Ocean border of Nassau and Queens Counties, and as low as 3.2 mg/l at the eastern end of Long Beach on Nassau County's southern shore. The wide range of chloride concentrations in the area is a clear indication that some wells are already showing contamination. Location of groundwater sources for New York City export is therefore an important consideration in carrying out the project.

Similarly other substances like heavy metals will exert a dispersing effect on the quality of New York City water supplies. Among the major metals which are imposing local problems in some parts of the island is iron. Iron present in the trivalent state will exert dispersion action and eventually will build up to an unacceptable degree.

Sulfate concentration in Long Island groundwater supply is sufficiently less than the present allowable PHS drinking water standards of 250 mg/l. However, buildup of this contaminant cannot be ruled out. The presence of sulfates in water supplies increases the corrosiveness of the water. This is of particular importance when considering a long concrete transmission line between Long Island and New York City water supply source where it is possible for the sulfates to be changed to sulfuric acid.

Sequential Reaction Effect

Dissolved oxygen, nitrogen and other nutrients are the major parameters influenced by this effect. During

the transportation of Long Island groundwater, some substances will undergo sequential reaction due to physical and chemical forces.

Free ammonia may oxidize during the transportation process, yielding nitrates resulting in an increase of nitrate concentration at the confluence.

Groundwater supply drawn out from certain areas, particularly the southern part of Nassau where its dissolved oxygen concentration is practically zero, will affect the stability of the ferrous iron in both supplies.

Reactive Substances

Reactive substances present in the Long Island groundwater supply may include coliform or pathogenic material and would require disinfection prior to mixing with the New York City supply. Both supplies, however, are routinely chlorinated. BOD and radioactive contents of both supplies are relatively low and should not constitute a water quality problem. Other reactive pollutants should not pose a water quality problem.

4. Plan for Transfer

A plan for transfer of water to New York is presented in the Joint Venture Report. A well field sized for 150 mgd would be built east of Lake Ronkonkoma in Suffolk County. Additionally, collector mains, two storage reservoirs, pumping station and chlorinator would be built. Two transmission mains extending through Nassau County to connections with the New York City distribution system in Queens would be built. The use of two transmission mains would provide greater distribution flexibility than a single main. Initial development would supply New York City and later could supply Nassau County.

Water could be transferred in the opposite direction if Long Island communities husband their groundwater reservoirs during wet years by drawing surplus water from New York's upland systems, so as to preserve quality and quantity of the water for use during prolonged droughts. The same transmission system between Suffolk County and New York City would serve to deliver water in either direction. This plan is being studied on a feasibility level.

5. Possible Treatment Requirements

As previously discussed, the groundwater quality in Long Island is relatively good, but somewhat lower than that of New York City's water supply. Nitrates, iron, detergents and salt water are the major contaminant problems. In addition to normal treatment requirements practiced on Long Island, further treatment for removal of the above contaminants may be required to be compatible with quality standards of New York City's water supply. Additional treatment requirements will depend upon the following:

a) Amount of contaminants in specific area.

b) Amount of Long Island water mixed with New York City waters.

c) Future quality of Long Island groundwater.

All these factors are affected by an overall water-wastewater management scheme for the Long Island area. Additionally, an aesthetic value must be placed on New York City's receiving its customary excellent quality water. At this point of development and in the context of the scope of this report, it is only possible to point out possible treatment requirements.

New York City water supplies are not filtered and receive chlorination and fluoridation. Small parts of the supply receive additional treatment for mineral removal and nutrient control. The standard treatment of Long Island groundwater may consist of chlorination, aeration, pH adjustment, phosphate sequestering of iron and fluoridation. These treatments require the simple injection of chemicals. Coagulation and filtration and iron removal are practiced on only one small supply source.

To bring Long Island groundwater quality to the level of New York City water the following treatment methods may be necessary now or in the future.

Iron Removal: It may be necessary to precipitate and filtrate iron rather than stabilization with polyphosphates.

Detergent Removal: Detergent removal (refractory organics) may be accomplished by activated carbon adsorption.

Salt Removal: Distillation or ion exchange may be used for salt removal.

Nitrate Removal: Ion exchange or biological denitrification may be used for nitrate removal.

6. Wastewater-Water Management to Minimize Adverse Effects

Wastewater management may reduce the incidence of polluted or low quality groundwater and proper water management may negate the necessity for the above mentioned extra treatment. Taking of water from better groundwater source and proper dilution techniques will help insure that the best quality water is delivered. A wastewater-water management program may include the following specific items:

a) Protection of groundwater sources: this includes the continuing of sewering of groundwater quality threatened areas and control of agricultural fertilizer and pesticide use, and those items listed in b).

b) Conservation of water supply quality and quantity: recharge of reclaimed wastewater, either directly or as a salt water intrusion barrier should be carried out so as to both increase usable supplies and maintain or improve present groundwater quality.

c) Water quality monitoring: studies of potential pollutants such as refractory organics and phosphates should be undertaken. Monitoring of these and other pollutants now monitored should be expanded and correlated.

d) Control of storm water runoff. This may include collection and discharge into selected storm water recharge basins or collection and treatment with municipal sewage. Research into the effects of current storm water recharge basin operation and characterization of storm water quality should be continued.

e) Advanced research on better technology to treat various pollutants associated with wastewater should be continued.

f) Wells found polluted and those showing signs of increasing quality deterioration should be shut down.

g) Deepening and replacement of wells in some areas.

h) Coordination of water supply, wastewater collection and treatment, and water quality monitoring should be achieved on a regional and/or inter-regional basis. Mixture of supplies should be physically regulated to minimize adverse effects and treatment requirements.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. GENERAL

After reading the many reports prepared for various regions within the study area, both on water and sewerage, and after talking to state, municipal and private persons directly involved in water and sewerage, one gets the impression that the "water" men do not talk to the "sewer" men. Lip service to water supply is paid in sewerage reports with statements that the type of treatment proposed must consider water quality. Fish and recreation appear to be more important than the possible downstream abstraction of water for treatment to produce potable water. Wastewater as a water resource doesn't seem to be considered. Water quality is stressed but there seems to be an unnatural reluctance to consider wastewater as a source of water supply, even though it is being done presently in such places as the Passaic Valley, for example. The Passaic River is almost 50% sewage plant effluent during dry years.

It should be stated again that this is an impression and there may well be communication between personnel that is not evident.

B. NEW YORK

As would be expected, sources of water supply are under pressure of degradation in heavily populated areas. In New York City's system, the Croton watershed has been under study because water quality is declining and it is probable that the Catskill system will begin to show some signs of degradation due to the building of second home developments and an increase in recreational areas in the basin. Most potential sources of water appear to be in good condition at this time but there must be well administered wastewater management programs to insure that water quality is maintained. Combined sewer overflows and storm water runoff will continue to be a problem until more emphasis is placed on controlling these sources of pollution.

The situation on Long Island is a little confusing. Nitrates are beginning to show up in several wells in concentrations that make the water unfit for potable use. The USGS has reported that the nitrate front is moving north and south from the water divide. Even if the entire Island were sewered, it is estimated that it would take some 50

years to flush out all the nitrates presently underground. Because the movement of nitrates is affected by local geology, the concentration of pumping, and the amount of precipitation, it is difficult to delineate specific areas where nitrate concentration will become a serious problem.

Nitrate leaching can be reduced substantially by sewering the entire Island and discharging treated sewage effluent to the Atlantic Ocean and Long Island Sound. This would solve the nitrate problem in the future, but it also reduces the amount of recharge. In effect, it is a trade off between quality and quantity.

In general, wastewater treatment on Long Island can take one of two forms: a) either recharge treated sewage via direct recharge, or by basins, and if the abstracted water continues to degrade, treat the water; or, b) treat the sewage until it approaches potable quality and then recharge it. In any event, treated effluent can be used in Nassau and Suffolk Counties to fill up existing lakes and ponds that generally contain exposed ground water but which will probably dry up when the surrounding area is sewered.

The following items should be studied in greater depth:

1. Is ground water on Long Island irreversibly ruined? If so, how can it be treated successfully and if ion exchange is feasible, how to dispose of regenerant water?

2. How can sewage be treated to make it suitable for recharge? And how should it be recharged?

3. The bacterial and viral constituents of treated sewage must be better understood and monitoring programs developed.

4. The exchange of water with the New York City supply should be studied in greater detail and such a study is presently underway on a feasibility level.

C. NEW JERSEY

Again, all fresh water in highly populated areas is in generally poor condition. The Delaware and Raritan Canal is showing signs of degradation due to industrial wastes. Most

of the upland sources of water are in fair condition, requiring only filtration to bring them to good quality. Once the State's plan for regional sewage treatment is implemented, water quality should improve. Water purveyors fear industrial waste discharges more than municipal sewage, principally because they are more unpredictable in nature and quantity. Increased monitoring and surveillance should ameliorate this problem.

While water quality will improve, the quantity of available water remains the same, pending construction of new storage facilities or pending inter-basin transfer of water. Thus wastewater management schemes will have to recognize the shortage of water and consider wastewater as a resource.

In the Passaic River Basin, most of the water used is returned to the basin. However, there is a great deal of water that is exported, used outside of the basin, and then discharged into saline waters. With respect to the Passaic, it is recommended that the following items be studied in greater depth:

1. Most water is exported for use in Hudson and Essex Counties, both heavily industrialized. The wastewater from this area is treated in four major treatment plants - two in Jersey City, one in Bayonne and the regional facility of the of the Passaic Valley Sewerage Commission near Newark Airport. All effluent discharges are to saline water. Study the feasibility of utilizing the treated wastewater for industrial use, determining the quality and quantity required. Possible uses include boiler make-up, cooling and process water. The study would have to consider the financial and institutional aspects of the water purveyors. It would have to consider the regional aspects of sewage treatment as it may be better, if the water can be reused, to provide more than one treatment plant proposed in Jersey City for Hudson County.

This reuse scheme would of course make more water available for use within the Basin where water is being abstracted at more than the safe yield.

2. Study in more detail the possibility of pumping treated effluent from the Passaic Valley Sewerage Commission Sewage Treatment Plant near Newark Airport, to the Passaic River near Chatham. The quantity to be pumped will depend

on the quality of the effluent after the plant is upgraded to secondary treatment. It may be necessary to provide tertiary treatment for the pumped effluent to meet water quality criteria in the Passaic River. The route to Chatham was selected because it passes through a gap in the mountains separating the upper and middle Passaic River Basin from the area to the east.

At an ENR Cost Index of 1400, costs for various flows are broken down into construction costs for a pump station and transmission main and construction costs for tertiary treatment:

Capacity MGD	50	100	150	200
Cost, in million dollars	8.0	15.2	19.7	23.5
Cost, tertiary treatment	17.7	37.0	48.4	51.0

Operating costs will depend on how often the effluent is treated and pumped. The illustrative scheme would operate only when flow in the Passaic River was low.

3. Explore the possibility of pumping the Peckman River to a point in the Passaic above Little Falls so the water could be made available to the Passaic Valley Water Commission. At least 6 MGD of sewage plant effluent, plus an unknown amount of fresh water could be made available.

D. CONNECTICUT

The upland water sources of Connecticut are good because the State forbids municipal and industrial waste discharges into the watersheds. Future water demands can be met by developing ground water sources and potential reservoir sites. Connecticut has a unique problem in wastewater management because of heavy concentrations of metal working industries. Pretreatment will be required and this will essentially change the problem into one of sludge disposal.

E. WASTEWATER TECHNOLOGY

Technology exists today to produce potable water from wastewater, from a physical and chemical standpoint. The greatest concern is the viral content. Certainly more work must be done on viricides - chlorine, ozone, ultraviolet, etc.

If possible, it would be worthwhile to make a study of the Passaic Valley Water Commission treated water during a period of low flow when the raw water is almost 50% treated and untreated sewage. It is rather pointless to say, "No, we can't reuse wastewater as a water resource", when, in fact, it is being done in the study area. Such studies have been done in other parts of the country but apparently at places where the quality of the water delivered was so bad that few people drank it. The Passaic Valley Water Commission delivered good water even during dry periods. An epidemiological study could be made of the service area to see if there is any increase in water borne diseases during dry years.

Answers to the following questions would be one step toward overcoming objections to direct or indirect reuse of wastewater:

1. Is there a greater incidence of so-called "24-hour viruses" or other transitory intestional infections in the Passaic Valley Water Commission service area than in other areas?

2. Are there any significant bacteria and viruses in the treated water?

3. What steps in the treatment processes account for most bacteria and virus kills?

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Key to Bibliography Abbreviations

ASCE, JSED	-	American Society of Civil Engineers, Journal of the Sanitary Engineering Division
C.E.	-	Civil Engineering, American Society of Civil Engineers
COE,NAD	-	Corps of Engineers, North Atlantic Division
CPWS	-	Comprehensive Public Water Supply Study (New York State Dept. of Health)
EPA	-	Environmental Protection Agency (Federal)
FWPCA	-	Federal Water Pollution Control Association
FWQA	-	Federal Water Quality Administration
JAWWA	-	Journal of the American Water Works Association
JWPCF	-	Journal of the Water Pollution Control Federation
N.J.D.E.P.	-	New Jersey Department of Environmental Protection
N.Y.S.D.E.C.	-	New York State Department of Environmental Conservation
S. & I.W.	-	Sewage and Industrial Wastes
USGS	-	United States Geological Survey
W. & S.W.	-	Water and Sewage Works
W. & W.E.	-	Water and Wastes Engineering

APPENDIX A

WATER QUALITY OF POTENTIAL AND DEVELOPED WATER SUPPLY SOURCES

APPENDIX A - WATER QUALITY OF POTENTIAL AND DEVELOPED WATER SUPPLY SOURCES

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Sources

(1) USGS, Annual Water Resources Data for New Jersey, New York and Connecticut
(2) Passaic Valley Water Commission
(3) N.Y.S.D.E.C., Annual Data

ADDITIONAL WATER QUALITY DATA REPORTED BY THE JOINT EPA-NEW JERSEY WATER SUPPLY MONITORING AND SURVEY PROGRAM

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TABLE A-1

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Black River

SOURCE: Black River near Greig, N. Y.

ITEM	YEAR(S): 1967-70
Mean Discharge, cfs	2350.
Color, standard units	29
Turbidity, Jtu	4.1
Temperature, °C.	11.2
Dissolved Oxygen	10.1
DO Saturation, %	88
Carbon Dioxide	4.3
pH, units	7.3
Conductivity, micromhos	74
Chlorides (Cl)	1.5
Fluorides (F)	-
Total Hardness ($CaCO_3$)	39
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	24
Total Alkalinity ($CaCO_3$)	24
Calcium (Ca)	10.
Magnesium (Mg)	2.9
Sodium (Na)	3.5
Potassium (K)	0.80
Iron (Fe)	0.43
Manganese (Mn)	0.04
Ammonia (N)	0.18
Organic Nitrogen (N)	0.38
Nitrites (N)	0.005
Nitrates (N)	0.21
Phosphates (PO_4)	0.12
Sulphates (SO_4)	6.8
MBAS	0.05
Phenols	-
Residue on Evaporation at 180°C.	122
Total Suspended Solids	13
Total Dissolved Solids	109
COD	18.2
BOD (5-day at 20°C.)	2.0
Coliform (MPN), number/100 ml	4300.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly Sampling

STREAM CLASSIFICATION: C

TABLE A-2a

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Mohawk River

SOURCE: Scoharie Creek near Auriesville, N. Y.

ITEM	YEAR(S): 1967-70
Mean Discharge, cfs	610.
Color, standard units	14
Turbidity, Jtu	16
Temperature, °C.	7.7
Dissolved Oxygen	11.4
DO Saturation, %	93
Carbon Dioxide	-
pH, units	7.9
Conductivity, micromhos	214
Chlorides (Cl)	9.4
Fluorides (F)	0.08
Total Hardness ($CaCO_3$)	96
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	74
Total Alkalinity ($CaCO_3$)	74
Calcium (Ca)	32
Magnesium (Mg)	3.5
Sodium (Na)	6.1
Potassium (K)	1.3
Iron (Fe)	0.72
Manganese (Mn)	0.02
Ammonia (N)	0.23
Organic Nitrogen (N)	0.33
Nitrites (N)	0.008
Nitrates (N)	0.19
Phosphates (PO_4)	0.15
Sulphates (SO_4)	43
MBAS	0.03
Phenols	-
Residue on Evaporation at 180°C.	210.
Total Suspended Solids	40.
Total Dissolved Solids	170.
COD	7.6
BOD (5-day at 20°C.)	1.9
Coliform (MPN), number/100 ml	400.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Sampling every 2 months

STREAM CLASSIFICATION: C

TABLE A-2b

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Mohawk River

SOURCE: West Canada Creek at Herkimer, N. Y.

ITEM	YEAR(S): 1968-70
Mean Discharge, cfs	1190.
Color, standard units	19
Turbidity, Jtu	6
Temperature, °C.	14.6
Dissolved Oxygen	10.9
DO Saturation, %	>100
Carbon Dioxide	2.8
pH, units	8.0
Conductivity, micromhos	125
Chlorides (Cl)	1.8
Fluorides (F)	-
Total Hardness ($CaCO_3$)	69
Carbonate Alkalinity ($CaCO_3$)	3.0
Bicarbonate Alkalinity ($CaCO_3$)	50.
Total Alkalinity ($CaCO_3$)	53
Calcium (Ca)	21
Magnesium (Mg)	4.1
Sodium (Na)	2.8
Potassium (K)	0.8
Iron (Fe)	0.49
Manganese (Mn)	0.03
Ammonia (N)	0.14
Organic Nitrogen (N)	0.31
Nitrites (N)	0.004
Nitrates (N)	0.25
Phosphates (PO_4)	0.11
Sulphates (SO_4)	8.5
MBAS	0.05
Phenols	-
Residue on Evaporation at 180°C.	121
Total Suspended Solids	18
Total Dissolved Solids	103
COD	11.5
BOD (5-day at 20°C.)	1.2
Coliform (MPN), number/100 ml	6600.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly Sampling

STREAM CLASSIFICATION: C

TABLE A-3a.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Upper Hudson River

SOURCE: Hoosic River at Schaghticoke, N. Y.

ITEM	YEAR(S): 1964-66
Mean Discharge, cfs	-
Color, standard units	23
Turbidity, Jtu	8
Temperature, °C.	11.0
Dissolved Oxygen	10.6
DO Saturation, %	96
Carbon Dioxide	-
pH, units	7.8
Conductivity, micromhos	184
Chlorides (Cl)	9.8
Fluorides (F)	-
Total Hardness ($CaCO_3$)	102
Carbonate Alkalinity ($CaCO_3$)	2.0
Bicarbonate Alkalinity ($CaCO_3$)	31
Total Alkalinity ($CaCO_3$)	33
Calcium (Ca)	24
Magnesium (Mg)	5.9
Sodium (Na)	20.
Potassium (K)	1.6
Iron (Fe)	0.26
Manganese (Mn)	0.06
Ammonia (N)	0.19
Organic Nitrogen (N)	0.55
Nitrites (N)	0.013
Nitrates (N)	0.32
Phosphates (PO_4)	0.41
Sulphates (SO_4)	18.5
MBAS	0.01
Phenols	-
Residue on Evaporation at 180°C.	143
Total Suspended Solids	31
Total Dissolved Solids	112
COD	16.3
BOD (5-day at 20°C.)	3.1
Coliform (MPN), number/100 ml	1800

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Bi-monthly sampling

STREAM CLASSIFICATION: B

TABLE A-3b

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Upper Hudson River

SOURCE: East Branch Sacandaga River at Griffin, N. Y.

ITEM	YEAR(S): 1967-70
Mean Discharge, cfs	193
Color, standard units	-
Turbidity, Jtu	-
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	6.6
Conductivity, micromhos	46
Chlorides (Cl)	2.3
Fluorides (F)	0.06
Total Hardness ($CaCO_3$)	18
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	8.0
Total Alkalinity ($CaCO_3$)	8.0
Calcium (Ca)	5.4
Magnesium (Mg)	1.1
Sodium (Na)	1.7
Potassium (K)	0.2
Iron (Fe)	0.14
Manganese (Mn)	0.01
Ammonia (N)	0.12
Organic Nitrogen (N)	0.17
Nitrites (N)	0.005
Nitrates (N)	0.22
Phosphates (PO_4)	0.02
Sulphates (SO_4)	10.
MBAS	0.03
Phenols	-
Residue on Evaporation at 180°C.	45
Total Suspended Solids	8
Total Dissolved Solids	36
COD	9.4
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly sampling

STREAM CLASSIFICATION: C

TABLE A-3c.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Upper Hudson River

SOURCE: Battenkill Creek at Greenwich, N. Y.

ITEM	YEAR(S): 1967-70
Mean Discharge, cfs	306
Color, standard units	17
Turbidity, Jtu	4
Temperature, °C.	9.6
Dissolved Oxygen	10.6
DO Saturation, %	89
Carbon Dioxide	-
pH, units	7.7
Conductivity, micromhos	184
Chlorides (Cl)	5.6
Fluorides (F)	0.06
Total Hardness ($CaCO_3$)	85
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	75
Total Alkalinity ($CaCO_3$)	75
Calcium (Ca)	25
Magnesium (Mg)	5.7
Sodium (Na)	3.5
Potassium (K)	0.8
Iron (Fe)	0.07
Manganese (Mn)	0.01
Ammonia (N)	0.29
Organic Nitrogen (N)	0.22
Nitrites (N)	0.010
Nitrates (N)	0.39
Phosphates (PO_4)	0.10
Sulphates (SO_4)	12
MBAS	0.03
Phenols	-
Residue on Evaporation at 180°C.	146
Total Suspended Solids	14
Total Dissolved Solids	134
COD	5.2
BOD (5-day at 20°C.)	1.6
Coliform (MPN), number/100 ml	2300.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly sampling

STREAM CLASSIFICATION: C

TABLE ~~A-4a~~.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Hackensack River

SOURCE: Hackensack River at River Vale, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	80.
Color, standard units	9
Turbidity, Jtu	-
Temperature, °C.	9.5
Dissolved Oxygen	9.3
DO Saturation, %	81
Carbon Dioxide	-
pH, units	7.1
Conductivity, micromhos	374
Chlorides (Cl)	48
Fluorides (F)	0.05
Total Hardness ($CaCO_3$)	106
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	68
Total Alkalinity ($CaCO_3$)	68
Calcium (Ca)	32
Magnesium (Mg)	6.6
Sodium (Na)	26
Potassium (K)	2.8
Iron (Fe)	0.06
Manganese (Mn)	0.12
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	1.3
Phosphates (PO_4)	0.55
Sulphates (SO_4)	31
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	222
COD	-
BOD (5-day at 20°C.)	2.4
Coliform (MPN), number/100 ml	1900.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly Sampling

STREAM CLASSIFICATION: FW-2

TABLE A-4b

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Hackensack River

SOURCE: Hackensack River at Orangeburg, N. Y.

ITEM	YEAR(S): 1967-70
Mean Discharge, cfs	-
Color, standard units	39
Turbidity, Jtu	47
Temperature, °C.	13.3
Dissolved Oxygen	10.0
DO Saturation, %	93
Carbon Dioxide	-
pH, units	7.5
Conductivity, micromhos	344
Chlorides (Cl)	42
Fluorides (F)	0.16
Total Hardness ($CaCO_3$)	108
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	72
Total Alkalinity ($CaCO_3$)	72
Calcium (Ca)	34
Magnesium (Mg)	6.0
Sodium (Na)	23
Potassium (K)	2.5
Iron (Fe)	0.68
Manganese (Mn)	0.10
Ammonia (N)	0.73
Organic Nitrogen (N)	0.60
Nitrites (N)	0.084
Nitrates (N)	0.57
Phosphates (PO_4)	0.32
Sulphates (SO_4)	30.
MBAS	0.06
Phenols	-
Residue on Evaporation at 180°C.	281
Total Suspended Solids	53
Total Dissolved Solids	231
COD	14.1
BOD (5-day at 20°C.)	3.5
Coliform (MPN), number/100 ml	90,500

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly Sampling

STREAM CLASSIFICATION: A

TABLE A-5a.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Passaic River at Little Falls, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	590.
Color, standard units	21
Turbidity, Jtu	-
Temperature, °C.	12.3
Dissolved Oxygen	7.8
DO Saturation, %	72
Carbon Dioxide	-
pH, units	7.0
Conductivity, micromhos	325
Chlorides (Cl)	48
Fluorides (F)	0.15
Total Hardness ($CaCO_3$)	90.
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	49
Total Alkalinity ($CaCO_3$)	49
Calcium (Ca)	24
Magnesium (Mg)	7.5
Sodium (Na)	24
Potassium (K)	4.5
Iron (Fe)	0.67
Manganese (Mn)	0.38
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	2.2
Phosphates (PO_4)	2.7
Sulphates (SO_4)	40.
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	164
COD	-
BOD (5-day at 20°C.)	4.6
Coliform (MPN), number/100 ml	9000.

NOTE: All values in mg/1 unless noted otherwise.

REMARKS: Quarterly Sampling

STREAM CLASSIFICATION: FW-2

TABLE A-5b

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Passaic River at Two Bridges, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	-
Color, standard units	20.
Turbidity, Jtu	-
Temperature, °C.	13.8
Dissolved Oxygen	4.8
DO Saturation, %	46
Carbon Dioxide	-
pH, units	7.0
Conductivity, micromhos	373
Chlorides (Cl)	43
Fluorides (F)	0.3
Total Hardness ($CaCO_3$)	91
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	50.
Total Alkalinity ($CaCO_3$)	50.
Calcium (Ca)	24
Magnesium (Mg)	7.7
Sodium (Na)	33
Potassium (K)	4.4
Iron (Fe)	0.28
Manganese (Mn)	0.099
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	4.1
Phosphates (PO_4)	3.8
Sulphates (SO_4)	45
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	234
COD	-
BOD (5-day at 20°C.)	5.2
Coliform (MPN), number/100 ml	3100

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly Sampling

STREAM CLASSIFICATION: FW-2

TABLE ~~A-5c~~.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Passaic River near Chatham, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	132
Color, standard units	48
Turbidity, Jtu	-
Temperature, °C.	-
Dissolved Oxygen	4.0
DO Saturation, %	40.
Carbon Dioxide	-
pH, units	7.2
Conductivity, micromhos	516
Chlorides (Cl)	99
Fluorides (F)	0.2
Total Hardness ($CaCO_3$)	88
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	56
Total Alkalinity ($CaCO_3$)	56
Calcium (Ca)	21
Magnesium (Mg)	8.6
Sodium (Na)	73
Potassium (K)	2.3
Iron (Fe)	0.6
Manganese (Mn)	0.21
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	2.12
Phosphates (PO_4)	3.2
Sulphates (SO_4)	45
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	179
COD	-
BOD (5-day at 20°C.)	4.2
Coliform (MPN), number/100 ml	4600

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly sampling

STREAM CLASSIFICATION: FW-2

TABLE A-5d

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Passaic River near Millington, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	67
Color, standard units	62
Turbidity, Jtu	-
Temperature, °C.	-
Dissolved Oxygen	5.4
DO Saturation, %	52
Carbon Dioxide	-
pH, units	7.0
Conductivity, micromhos	190.
Chlorides (Cl)	17
Fluorides (F)	0.5
Total Hardness ($CaCO_3$)	62
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	42
Total Alkalinity ($CaCO_3$)	42
Calcium (Ca)	15
Magnesium (Mg)	6.0
Sodium (Na)	11
Potassium (K)	2.6
Iron (Fe)	0.86
Manganese (Mn)	0.096
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	0.36
Phosphates (PO_4)	0.16
Sulphates (SO_4)	22
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	128
COD	-
BOD (5-day at 20°C.)	2.1
Coliform (MPN), number/100 ml	600.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly Sampling

STREAM CLASSIFICATION: FW-2

TABLE A-5e.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Whippany River at Morristown, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	36
Color, standard units	4
Turbidity, Jtu	-
Temperature, °C.	-
Dissolved Oxygen	10.0
DO Saturation, %	100.
Carbon Dioxide	-
pH, units	7.1
Conductivity, micromhos	272
Chlorides (Cl)	20.
Fluorides (F)	0.2
Total Hardness ($CaCO_3$)	78
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	51
Total Alkalinity ($CaCO_3$)	51
Calcium (Ca)	20.
Magnesium (Mg)	7.2
Sodium (Na)	20.
Potassium (K)	2.3
Iron (Fe)	0.11
Manganese (Mn)	0.072
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	1.6
Phosphates (PO_4)	0.78
Sulphates (SO_4)	36
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	152
COD	-
BOD (5-day at 20°C.)	3.0
Coliform (MPN), number/100 ml	<63,000

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly sampling

STREAM CLASSIFICATION: FW-2

TABLE A-5f.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Wanaque River at Wanaque, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	34.5
Color, standard units	15
Turbidity, Jtu	-
Temperature, °C.	13.0
Dissolved Oxygen	9.8
DO Saturation, %	92
Carbon Dioxide	-
pH, units	7.2
Conductivity, micromhos	108
Chlorides (Cl)	7.7
Fluorides (F)	0.05
Total Hardness ($CaCO_3$)	36
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	19
Total Alkalinity ($CaCO_3$)	19
Calcium (Ca)	9.6
Magnesium (Mg)	2.8
Sodium (Na)	5.3
Potassium (K)	1.3
Iron (Fe)	-
Manganese (Mn)	0.11
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	1.2
Phosphates (PO_4)	0.02
Sulphates (SO_4)	18
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	76
COD	-
BOD (5-day at 20°C.)	0.9
Coliform (MPN), number/100 ml	800.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly Sampling

STREAM CLASSIFICATION: FW-2

TABLE A-5g.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Passaic River near Mahwah, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	87
Color, standard units	5
Turbidity, Jtu	7
Temperature, °C.	13.9
Dissolved Oxygen	9.8
DO Saturation, %	94
Carbon Dioxide	-
pH, units	7.4
Conductivity, micromhos	349
Chlorides (Cl)	45
Fluorides (F)	0.4
Total Hardness ($CaCO_3$)	99
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	63
Total Alkalinity ($CaCO_3$)	63
Calcium (Ca)	27
Magnesium (Mg)	8.2
Sodium (Na)	24
Potassium (K)	1.6
Iron (Fe)	0.10
Manganese (Mn)	0.13
Ammonia (N)	0.13
Organic Nitrogen (N)	0.58
Nitrites (N)	-
Nitrates (N)	0.90
Phosphates (PO_4)	1.1
Sulphates (SO_4)	31
MBAS	0.02
Phenols	0.008
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	209
COD	-
BOD (5-day at 20°C.)	2.2
Coliform (MPN), number/100 ml	40

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly Sampling

STREAM CLASSIFICATION: FW-2

TABLE A-5h.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Pompton River at Two Bridges, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	-
Color, standard units	5
Turbidity, Jtu	-
Temperature, °C.	13.7
Dissolved Oxygen	9.2
DO Saturation, %	88
Carbon Dioxide	-
pH, units	7.1
Conductivity, micromhos	245
Chlorides (Cl)	21
Fluorides (F)	0.2
Total Hardness ($CaCO_3$)	69
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	38
Total Alkalinity ($CaCO_3$)	38
Calcium (Ca)	18
Magnesium (Mg)	5.6
Sodium (Na)	18
Potassium (K)	2.1
Iron (Fe)	0.26
Manganese (Mn)	0.076
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	1.1
Phosphates (PO_4)	0.80
Sulphates (SO_4)	34
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	164
COD	-
BOD (5-day at 20°C.)	2.7
Coliform (MPN), number/100 ml	1500.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly Sampling

STREAM CLASSIFICATION: FW-2

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Rockaway River above reservoir at Boonton, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	160.
Color, standard units	9
Turbidity, Jtu	-
Temperature, °C.	-
Dissolved Oxygen	8.9
DO Saturation, %	87
Carbon Dioxide	-
pH, units	7.4
Conductivity, micromhos	201
Chlorides (Cl)	20
Fluorides (F)	0.1
Total Hardness ($CaCO_3$)	71
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	43
Total Alkalinity ($CaCO_3$)	43
Calcium (Ca)	18
Magnesium (Mg)	6.5
Sodium (Na)	10.
Potassium (K)	1.3
Iron (Fe)	0.32
Manganese (Mn)	0.058
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	0.44
Phosphates (PO_4)	0.08
Sulphates (SO_4)	20.
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	120
COD	-
BOD (5-day at 20°C.)	1.2
Coliform (MPN), number/100 ml	1300.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly Sampling

STREAM CLASSIFICATION: FW-2

TABLE A-5j

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Wanaque River at River Vale, N. J.

ITEM	YEAR(S): 1962 - 1972
Mean Discharge, cfs	-
Color, standard units	23
Turbidity, Jtu	4.1
Temperature, °C.	12
Dissolved Oxygen	9.8
DO Saturation, %	88
Carbon Dioxide	4.2
pH, units	7.1
Conductivity, micromhos	-
Chlorides (Cl)	9.6
Fluorides (F)	-
Total Hardness ($CaCO_3$)	52
Carbonate Alkalinity ($CaCO_3$)	-
Bicarbonate Alkalinity ($CaCO_3$)	-
Total Alkalinity ($CaCO_3$)	34
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	-
Manganese (Mn)	-
Ammonia (N)	0.17
Organic Nitrogen (N)	-
Nitrites (N)	0.013
Nitrates (N)	0.72
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	2.7
Coliform (MPN), number/100 ml	3260

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly Sampling 1967 to 1972, previously bi-monthly sampling.

STREAM CLASSIFICATION: FW-2

TABLE A-5k

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Pequannock River at River Vale, N. J.

ITEM	YEAR(S): 1962 - 1972
Mean Discharge, cfs	-
Color, standard units	36
Turbidity, Jtu	25
Temperature, °C.	12
Dissolved Oxygen	10.5
DO Saturation, %	94
Carbon Dioxide	4
pH, units	7.3
Conductivity, micromhos	-
Chlorides (Cl)	25
Fluorides (F)	-
Total Hardness ($CaCO_3$)	63.10
Carbonate Alkalinity ($CaCO_3$)	-
Bicarbonate Alkalinity ($CaCO_3$)	-
Total Alkalinity ($CaCO_3$)	38.0
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	-
Manganese (Mn)	-
Ammonia (N)	0.61
Organic Nitrogen (N)	-
Nitrites (N)	0.013
Nitrates (N)	0.64
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	4.0
Coliform (MPN), number/100 ml	8160

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly Sampling 1967 to 1972, previously bi-monthly sampling.

STREAM CLASSIFICATION: FW-2

TABLE A-51

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Ramapo River at Pompton Lakes, N.J.

ITEM	YEAR(S): 1962 - 1972
Mean Discharge, cfs	256
Color, standard units	25
Turbidity, Jtu	4.3
Temperature, °C.	13
Dissolved Oxygen	10.6
DO Saturation, %	96
Carbon Dioxide	2
pH, units	7.8
Conductivity, micromhos	-
Chlorides (Cl)	20.0
Fluorides (F)	-
Total Hardness ($CaCO_3$)	75.0
Carbonate Alkalinity ($CaCO_3$)	-
Bicarbonate Alkalinity ($CaCO_3$)	-
Total Alkalinity ($CaCO_3$)	51.0
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	-
Manganese (Mn)	-
Ammonia (N)	0.13
Organic Nitrogen (N)	-
Nitrites (N)	0.014
Nitrates (N)	0.54
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	3.1
Coliform (MPN), number/100 ml	1694

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Mean discharge is for 1970; Monthly sampling 1967 to 1972, previously bi-monthly sampling.

STREAM CLASSIFICATION: FW-2

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Passaic River

SOURCE: Ramapo River at Oakland, N.J.

ITEM	YEAR(S): 1957 - 1972
Mean Discharge, cfs	
Color, standard units	22
Turbidity, Jtu	4
Temperature, °C.	12
Dissolved Oxygen	10.2
DO Saturation, %	89
Carbon Dioxide	3
pH, units	7.4
Conductivity, micromhos	-
Chlorides (Cl)	8.2
Fluorides (F)	-
Total Hardness ($CaCO_3$)	78.0
Carbonate Alkalinity ($CaCO_3$)	-
Bicarbonate Alkalinity ($CaCO_3$)	-
Total Alkalinity ($CaCO_3$)	41
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	-
Manganese (Mn)	-
Ammonia (N)	0.12
Organic Nitrogen (N)	-
Nitrites (N)	0.014
Nitrates (N)	0.72
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	2.2
Coliform (MPN), number/100 ml	1055

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly sampling 1967 to 1972, previously bi-monthly sampling.

STREAM CLASSIFICATION: FW-2

TABLE A-6a

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Raritan River

SOURCE: South River at Old Bridge, N. J.

ITEM	YEAR(S): 1969-70
Mean Discharge, cfs	100.
Color, standard units	5
Turbidity, Jtu	-
Temperature, °C.	-
Dissolved Oxygen	8.0
DO Saturation, %	81
Carbon Dioxide	-
pH, units	5.0
Conductivity, micromhos	235
Chlorides (Cl)	35
Fluorides (F)	0.1
Total Hardness ($CaCO_3$)	47
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	1
Total Alkalinity ($CaCO_3$)	1
Calcium (Ca)	11
Magnesium (Mg)	8.2
Sodium (Na)	17
Potassium (K)	6.5
Iron (Fe)	0.58
Manganese (Mn)	0.11
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	2.1
Phosphates (PO_4)	0.05
Sulphates (SO_4)	40.
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	165
COD	-
BOD (5-day at 20°C.)	2.2
Coliform (MPN), number/100 ml	1500

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Sampling every 4 months

STREAM CLASSIFICATION:

TABLE A-6b.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Raritan River

SOURCE: Raritan River near Manville, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	704
Color, standard units	7
Turbidity, Jtu	-
Temperature, °C.	13.4
Dissolved Oxygen	10.2
DO Saturation, %	97
Carbon Dioxide	-
pH, units	7.3
Conductivity, micromhos	230.
Chlorides (Cl)	15
Fluorides (F)	0.1
Total Hardness ($CaCO_3$)	82
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	46
Total Alkalinity ($CaCO_3$)	46
Calcium (Ca)	21
Magnesium (Mg)	7.0
Sodium (Na)	9.9
Potassium (K)	2.1
Iron (Fe)	0.11
Manganese (Mn)	0.024
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	1.2
Phosphates (PO_4)	0.21
Sulphates (SO_4)	36
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	143
COD	-
BOD (5-day at 20°C.)	2.2
Coliform (MPN), number/100 ml	1100.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly sampling

STREAM CLASSIFICATION:

TABLE A-6c.

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Raritan River

SOURCE: North Branch Raritan River near Far Hills, N. J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	42
Color, standard units	4
Turbidity, Jtu	-
Temperature, °C.	13.6
Dissolved Oxygen	10.7
DO Saturation, %	100.
Carbon Dioxide	-
pH, units	7.1
Conductivity, micromhos	157
Chlorides (Cl)	12
Fluorides (F)	0.6
Total Hardness ($CaCO_3$)	51
Carbonate Alkalinity ($CaCO_3$)	0.
Bicarbonate Alkalinity ($CaCO_3$)	32
Total Alkalinity ($CaCO_3$)	32
Calcium (Ca)	12
Magnesium (Mg)	5.0
Sodium (Na)	7.8
Potassium (K)	1.6
Iron (Fe)	0.17
Manganese (Mn)	0.076
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	0.67
Phosphates (PO_4)	0.17
Sulphates (SO_4)	18
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	102
COD	-
BOD (5-day at 20°C.)	1.8
Coliform (MPN), number/100 ml	200.

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly sampling

STREAM CLASSIFICATION:

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Raritan River

SOURCE: North Branch, Raritan River near Raritan, N.J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	250.
Color, standard units	7
Turbidity, Jtu	-
Temperature, °C.	-
Dissolved Oxygen	9.6
DO Saturation, %	92
Carbon Dioxide	-
pH, units	7.3
Conductivity, micromhos	205
Chlorides (Cl)	14
Fluorides (F)	0.4
Total Hardness ($CaCO_3$)	69
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	48
Total Alkalinity ($CaCO_3$)	48
Calcium (Ca)	18
Magnesium (Mg)	6.5
Sodium (Na)	11
Potassium (K)	2.5
Iron (Fe)	0.18
Manganese (Mn)	0.035
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	0.66
Phosphates (PO_4)	0.21
Sulphates (SO_4)	28
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	122
COD	-
BOD (5-day at 20°C.)	1.1
Coliform (MPN), number/100 ml	3200

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly Sampling

STREAM CLASSIFICATION:

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Raritan River

SOURCE: South Branch Raritan River near High Bridge, N.J.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	112
Color, standard units	6
Turbidity, Jtu	-
Temperature, °C.	12.8
Dissolved Oxygen	11.0
DO Saturation, %	100
Carbon Dioxide	-
pH, units	7.4
Conductivity, micromhos	184
Chlorides (Cl)	9.3
Fluorides (F)	0.5
Total Hardness ($CaCO_3$)	70
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	57
Total Alkalinity ($CaCO_3$)	57
Calcium (Ca)	16
Magnesium (Mg)	7.6
Sodium (Na)	5.4
Potassium (K)	3.0
Iron (Fe)	0.14
Manganese (Mn)	0.014
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	1.1
Phosphates (PO_4)	0.19
Sulphates (SO_4)	14
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	114
COD	-
BOD (5-day at 20°C.)	0.77
Coliform (MPN), number/100 ml	9200

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly sampling

STREAM CLASSIFICATION:

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Raritan River

SOURCE: Spruce Run at Clinton, New Jersey

ITEM	YEAR(S): 1971
Mean Discharge, cfs	98
Color, standard units	5
Turbidity, Jtu	-
Temperature, °C.	13.4
Dissolved Oxygen	11.2
DO Saturation, %	100
Carbon Dioxide	-
pH, units	7.3
Conductivity, micromhos	164
Chlorides (Cl)	10
Fluorides (F)	0.3
Total Hardness ($CaCO_3$)	60
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	38
Total Alkalinity ($CaCO_3$)	38
Calcium (Ca)	15
Magnesium (Mg)	5.5
Sodium (Na)	5.7
Potassium (K)	2.4
Iron (Fe)	0.24
Manganese (Mn)	0.27
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	0.57
Phosphates (PO_4)	0.01
Sulphates (SO_4)	21
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	94
COD	-
BOD (5-day at 20°C.)	1.4
Coliform (MPN), number/100 ml	2000

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Quarterly sampling

STREAM CLASSIFICATION:

TABLE A-7

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Toms River

SOURCE: Toms River at Toms River, New Jersey

ITEM	YEAR(S): 1970
Mean Discharge, cfs	-
Color, standard units	45
Turbidity, Jtu	56
Temperature, °C.	11.2
Dissolved Oxygen	8.9
DO Saturation, %	80
Carbon Dioxide	-
pH, units	5.0
Conductivity, micromhos	112
Chlorides (Cl)	7.6
Fluorides (F)	0.05
Total Hardness ($CaCO_3$)	10
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	1
Total Alkalinity ($CaCO_3$)	1
Calcium (Ca)	2.3
Magnesium (Mg)	1.1
Sodium (Na)	5.0
Potassium (K)	1.0
Iron (Fe)	0.47
Manganese (Mn)	0.10
Ammonia (N)	0.16
Organic Nitrogen (N)	0.40
Nitrites (N)	-
Nitrates (N)	0.42
Phosphates (PO_4)	0.33
Sulphates (SO_4)	11
MBAS	0.01
Phenols	0.007
Residue on Evaporation at 180°C.	-
Total Suspended Solids	13
Total Dissolved Solids	56
COD	-
BOD (5-day at 20°C.)	0.71
Coliform (MPN), number/100 ml	800

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly sampling

STREAM CLASSIFICATION: FW-2

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Housatonic River

SOURCE: Housatonic River at Stevenson, Conn.

ITEM	YEAR(S): 1971
Mean Discharge, cfs	2690
Color, standard units	-
Turbidity, Jtu	2
Temperature, °C.	13.0
Dissolved Oxygen	8.2
DO Saturation, %	73
Carbon Dioxide	-
pH, units	7.6
Conductivity, micromhos	233
Chlorides (Cl)	14
Fluorides (F)	0.1
Total Hardness ($CaCO_3$)	99
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	75
Total Alkalinity ($CaCO_3$)	75
Calcium (Ca)	27
Magnesium (Mg)	7.6
Sodium (Na)	8.3
Potassium (K)	1.8
Iron (Fe)	-
Manganese (Mn)	-
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	0.35
Phosphates (PO_4)	0.34
Sulphates (SO_4)	19
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	127
COD	7
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	3200

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly Sampling

STREAM CLASSIFICATION: B

TABLE A-8b

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Housatonic River

SOURCE: Fountain Lake at Ansonia, Connecticut

ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	13
Turbidity, Jtu	1
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	6.6
Conductivity, micromhos	-
Chlorides (Cl)	9.0
Fluorides (F)	0
Total Hardness ($CaCO_3$)	33
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	7.5
Total Alkalinity ($CaCO_3$)	7.5
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	0.2
Manganese (Mn)	-
Ammonia (N)	0.016
Organic Nitrogen (N)	0.102
Nitrites (N)	0
Nitrates (N)	0.07
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by Ansonia Water Company

STREAM CLASSIFICATION: A

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Housatonic River

SOURCE: Wigwam Reservoir at Watertown, Connecticut

ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	16
Turbidity, Jtu	2
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	7.1
Conductivity, micromhos	-
Chlorides (Cl)	11.8
Fluorides (F)	0.87
Total Hardness ($CaCO_3$)	45
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	16
Total Alkalinity ($CaCO_3$)	16
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	0.3
Manganese (Mn)	0.04
Ammonia (N)	0.01
Organic Nitrogen (N)	0.079
Nitrites (N)	0
Nitrates (N)	0.27
Phosphates (PO_4)	-
Sulphates (SO_4)	0
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by Waterbury Water Department

STREAM CLASSIFICATION: A

TABLE A-8d

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Housatonic River

SOURCE: West Lake Reservoir near Danbury, Connecticut

ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	3
Turbidity, Jtu	1
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	7.1
Conductivity, micromhos	-
Chlorides (Cl)	10.4
Fluorides (F)	0.93
Total Hardness ($CaCO_3$)	56
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	25
Total Alkalinity ($CaCO_3$)	25
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	0.1
Manganese (Mn)	-
Ammonia (N)	0.025
Organic Nitrogen (N)	0.065
Nitrites (N)	0
Nitrates (N)	0.08
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by Danbury Water Department

STREAM CLASSIFICATION: A

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Housatonic River

SOURCE: Tenmile River at Dover, New York

ITEM	YEAR(S): 1967-70
Mean Discharge, cfs	640
Color, standard units	-
Turbidity, Jtu	-
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	-
Conductivity, micromhos	312
Chlorides (Cl)	11
Fluorides (F)	0.08
Total Hardness ($CaCO_3$)	147
Carbonate Alkalinity ($CaCO_3$)	1
Bicarbonate Alkalinity ($CaCO_3$)	124
Total Alkalinity ($CaCO_3$)	125
Calcium (Ca)	39
Magnesium (Mg)	12
Sodium (Na)	5.7
Potassium (K)	1.8
Iron (Fe)	0.05
Manganese (Mn)	0.03
Ammonia (N)	0.19
Organic Nitrogen (N)	0.30
Nitrites (N)	0.05
Nitrates (N)	1.08
Phosphates (PO_4)	0.29
Sulphates (SO_4)	21.7
MBAS	0.04
Phenols	-
Residue on Evaporation at 180°C.	240
Total Suspended Solids	35
Total Dissolved Solids	205
COD	8.1
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	12,200

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly sampling

STREAM CLASSIFICATION: B (trout waters)

TABLE A-9a

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Connecticut River

SOURCE: Connecticut River near Middle Haddam, Connecticut

ITEM	YEAR(S): 1971
Mean Discharge, cfs	-
Color, standard units	16
Turbidity, Jtu	4
Temperature, °C.	13.6
Dissolved Oxygen	7.1
DO Saturation, %	65
Carbon Dioxide	-
pH, units	6.9
Conductivity, micromhos	152
Chlorides (Cl)	16
Fluorides (F)	0.14
Total Hardness ($CaCO_3$)	43
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	27
Total Alkalinity ($CaCO_3$)	27
Calcium (Ca)	14
Magnesium (Mg)	2.2
Sodium (Na)	10
Potassium (K)	1.5
Iron (Fe)	0.15
Manganese (Mn)	0.042
Ammonia (N)	-
Organic Nitrogen (N)	-
Nitrites (N)	-
Nitrates (N)	0.79
Phosphates (PO_4)	0.55
Sulphates (SO_4)	15
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	95
COD	13
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	113,000

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Monthly sampling

STREAM CLASSIFICATION: SD (upgrading to SC proposed)

TABLE A-9b

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Connecticut River

SOURCE: Mt. Higby Reservoir near Middletown, Connecticut

ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	7
Turbidity, Jtu	2
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	6.6
Conductivity, micromhos	-
Chlorides (Cl)	18.6
Fluorides (F)	1.0
Total Hardness ($CaCO_3$)	42
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	7.9
Total Alkalinity ($CaCO_3$)	7.9
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	0.2
Manganese (Mn)	0.07
Ammonia (N)	0.009
Organic Nitrogen (N)	0.106
Nitrites (N)	0
Nitrates (N)	0.04
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by Middletown Water Department

STREAM CLASSIFICATION: A

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Western Connecticut Coastal

SOURCE: Putnam Lake at Greenwich, Connecticut

ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	2
Turbidity, Jtu	1
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	7.4
Conductivity, micromhos	-
Chlorides (Cl)	12.4
Fluorides (F)	0.86
Total Hardness ($CaCO_3$)	70
Carbonate Alkalinity ($CaCO_3$)	2.8
Bicarbonate Alkalinity ($CaCO_3$)	25
Total Alkalinity ($CaCO_3$)	28
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	0.1
Manganese (Mn)	0.01
Ammonia (N)	0.008
Organic Nitrogen (N)	0.053
Nitrites (N)	0.001
Nitrates (N)	0.08
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by Greenwich Water Company

STREAM CLASSIFICATION: A

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Western Connecticut Coastal

SOURCE: Grupes Reservoir near New Canaan, Connecticut

ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	17
Turbidity, Jtu	2
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	6.9
Conductivity, micromhos	-
Chlorides (Cl)	12.3
Fluorides (F)	0.9
Total Hardness ($CaCO_3$)	43
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	14
Total Alkalinity ($CaCO_3$)	14
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	0.3
Manganese (Mn)	0.09
Ammonia (N)	0.019
Organic Nitrogen (N)	0.111
Nitrites (N)	0
Nitrates (N)	0.12
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by Norwalk First Taxing District

STREAM CLASSIFICATION: A

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Western Connecticut Coastal

SOURCE: Laurel Reservoir at New Canaan, Connecticut

ITEM	YEAR(S): 1966-67
Mean Discharge, cfs	-
Color, standard units	13
Turbidity, Jtu	2
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	7.1
Conductivity, micromhos	-
Chlorides (Cl)	15.3
Fluorides (F)	0.93
Total Hardness ($CaCO_3$)	65
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	28
Total Alkalinity ($CaCO_3$)	28
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	0.2
Manganese (Mn)	0.09
Ammonia (N)	0.006
Organic Nitrogen (N)	0.086
Nitrites (N)	0
Nitrates (N)	0.09
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by Stamford Water Company

STREAM CLASSIFICATION: A

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Western Connecticut Coastal

SOURCE: Wilton Reservoir at Wilton, Connecticut

ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	10
Turbidity, Jtu	1
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	7.4
Conductivity, micromhos	-
Chlorides (Cl)	14.3
Fluorides (F)	0.94
Total Hardness ($CaCO_3$)	59
Carbonate Alkalinity ($CaCO_3$)	1.8
Bicarbonate Alkalinity ($CaCO_3$)	23
Total Alkalinity ($CaCO_3$)	25
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	11
Potassium (K)	-
Iron (Fe)	0.1
Manganese (Mn)	-
Ammonia (N)	0.013
Organic Nitrogen (N)	0.067
Nitrites (N)	0
Nitrates (N)	0.16
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by Norwalk Second Taxing District

STREAM CLASSIFICATION: A

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Western Connecticut Coastal

SOURCE: Brookside Well in Fairfield, Connecticut

ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	0
Turbidity, Jtu	0
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	6.5
Conductivity, micromhos	-
Chlorides (Cl)	11.0
Fluorides (F)	0.10
Total Hardness ($CaCO_3$)	46
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	12
Total Alkalinity ($CaCO_3$)	12
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	6.0
Potassium (K)	-
Iron (Fe)	0
Manganese (Mn)	0
Ammonia (N)	0.16
Organic Nitrogen (N)	0.008
Nitrites (N)	0
Nitrates (N)	1.5
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	0.10
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by Bridgeport Hydraulic Company

STREAM CLASSIFICATION: A

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Western Connecticut Coastal

SOURCE: Trap Falls Reservoir near Huntington, Connecticut

ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	16
Turbidity, Jtu	2
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	7.2
Conductivity, micromhos	-
Chlorides (Cl)	15.3
Fluorides (F)	0.86
Total Hardness ($CaCO_3$)	67
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	29
Total Alkalinity ($CaCO_3$)	29
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	0.2
Manganese (Mn)	-
Ammonia (N)	0.009
Organic Nitrogen (N)	0.094
Nitrites (N)	0
Nitrates (N)	0.26
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by Bridgeport Hydraulic Company

STREAM CLASSIFICATION: A

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Central Connecticut Coastal

SOURCE: Lake Saltonstall at East Haven, Connecticut

ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	10
Turbidity, Jtu	2
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	7.5
Conductivity, micromhos	-
Chlorides (Cl)	16.9
Fluorides (F)	0.94
Total Hardness ($CaCO_3$)	93
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	50
Total Alkalinity ($CaCO_3$)	50
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	0.1
Manganese (Mn)	0.05
Ammonia (N)	0.015
Organic Nitrogen (N)	0.13
Nitrites (N)	0
Nitrates (N)	0.25
Phosphates (PO_4)	-
Sulphates (SO_4)	0
MBAS	0
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by New Haven Water Company

STREAM CLASSIFICATION: A

RAW WATER ANALYSES
AVERAGE VALUES

BASIN: Central Connecticut Coastal

SOURCE: Lake Gaillard at North Branford, Connecticut

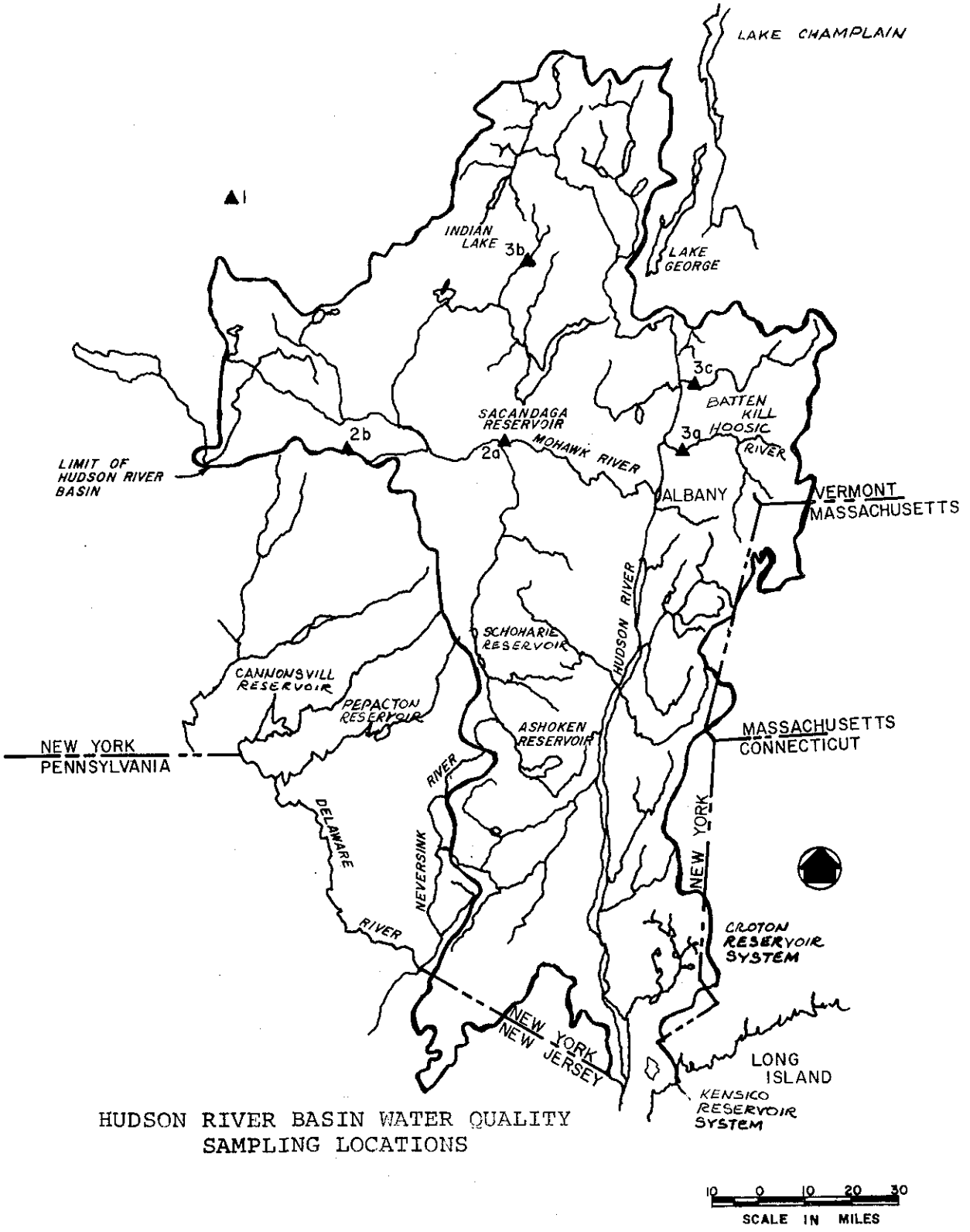
ITEM	YEAR(S): 1966-70
Mean Discharge, cfs	-
Color, standard units	10
Turbidity, Jtu	1
Temperature, °C.	-
Dissolved Oxygen	-
DO Saturation, %	-
Carbon Dioxide	-
pH, units	6.7
Conductivity, micromhos	-
Chlorides (Cl)	6.7
Fluorides (F)	0.97
Total Hardness ($CaCO_3$)	43
Carbonate Alkalinity ($CaCO_3$)	0
Bicarbonate Alkalinity ($CaCO_3$)	10
Total Alkalinity ($CaCO_3$)	10
Calcium (Ca)	-
Magnesium (Mg)	-
Sodium (Na)	-
Potassium (K)	-
Iron (Fe)	0.1
Manganese (Mn)	-
Ammonia (N)	0.006
Organic Nitrogen (N)	0.077
Nitrites (N)	0
Nitrates (N)	0.09
Phosphates (PO_4)	-
Sulphates (SO_4)	-
MBAS	-
Phenols	-
Residue on Evaporation at 180°C.	-
Total Suspended Solids	-
Total Dissolved Solids	-
COD	-
BOD (5-day at 20°C.)	-
Coliform (MPN), number/100 ml	-

NOTE: All values in mg/l unless noted otherwise.

REMARKS: Operated by New Haven Water Company

STREAM CLASSIFICATION: A

FIGURE A-1



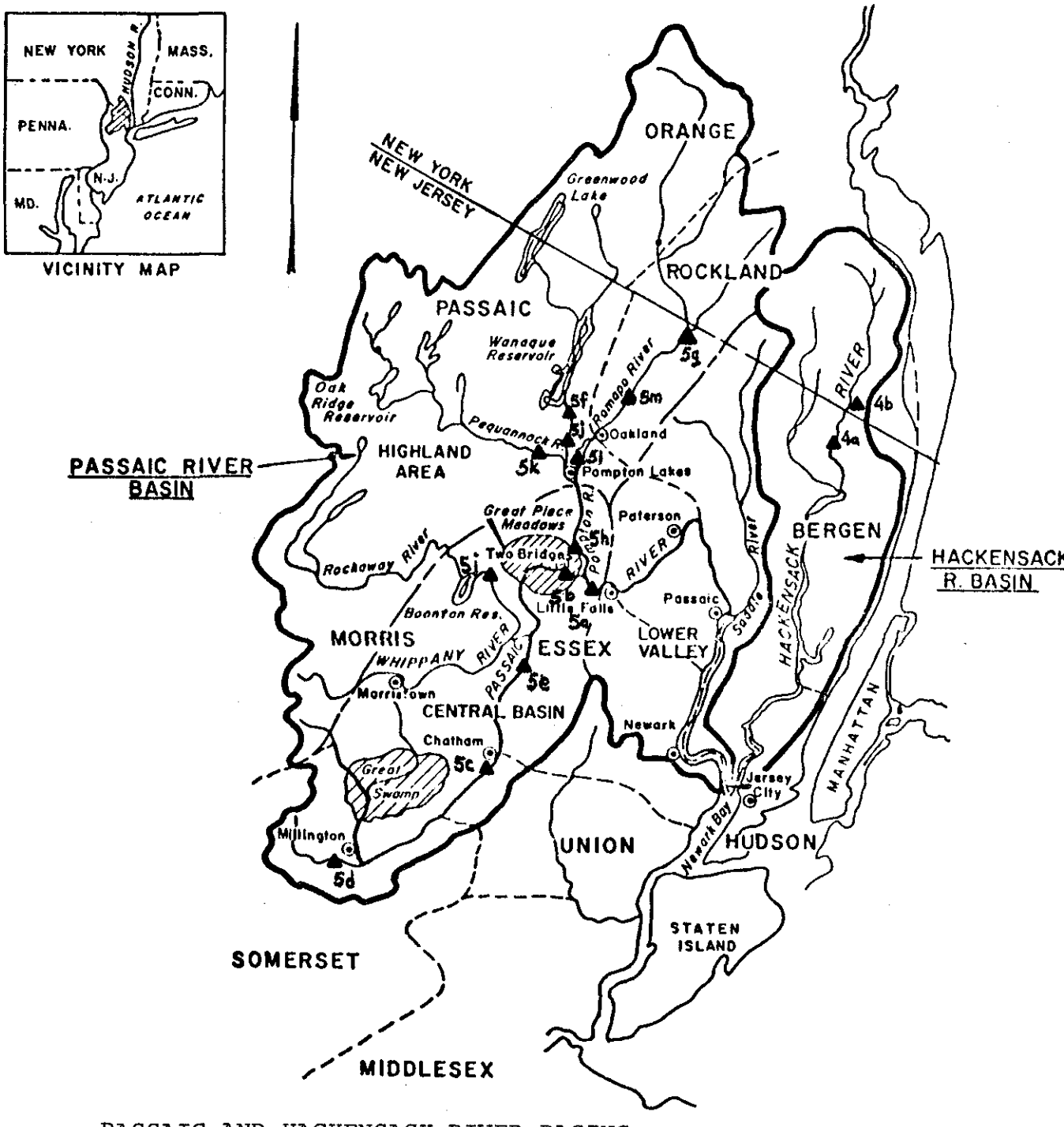
HUDSON RIVER BASIN WATER QUALITY
SAMPLING LOCATIONS

LEGEND

——— RIVER BASIN BOUNDARY

— - - — STATE BOUNDARY

FIGURE A-2



PASSAIC AND HACKENSACK RIVER BASINS
WATER QUALITY SAMPLING LOCATIONS

SCALE IN MILES
0 4 8

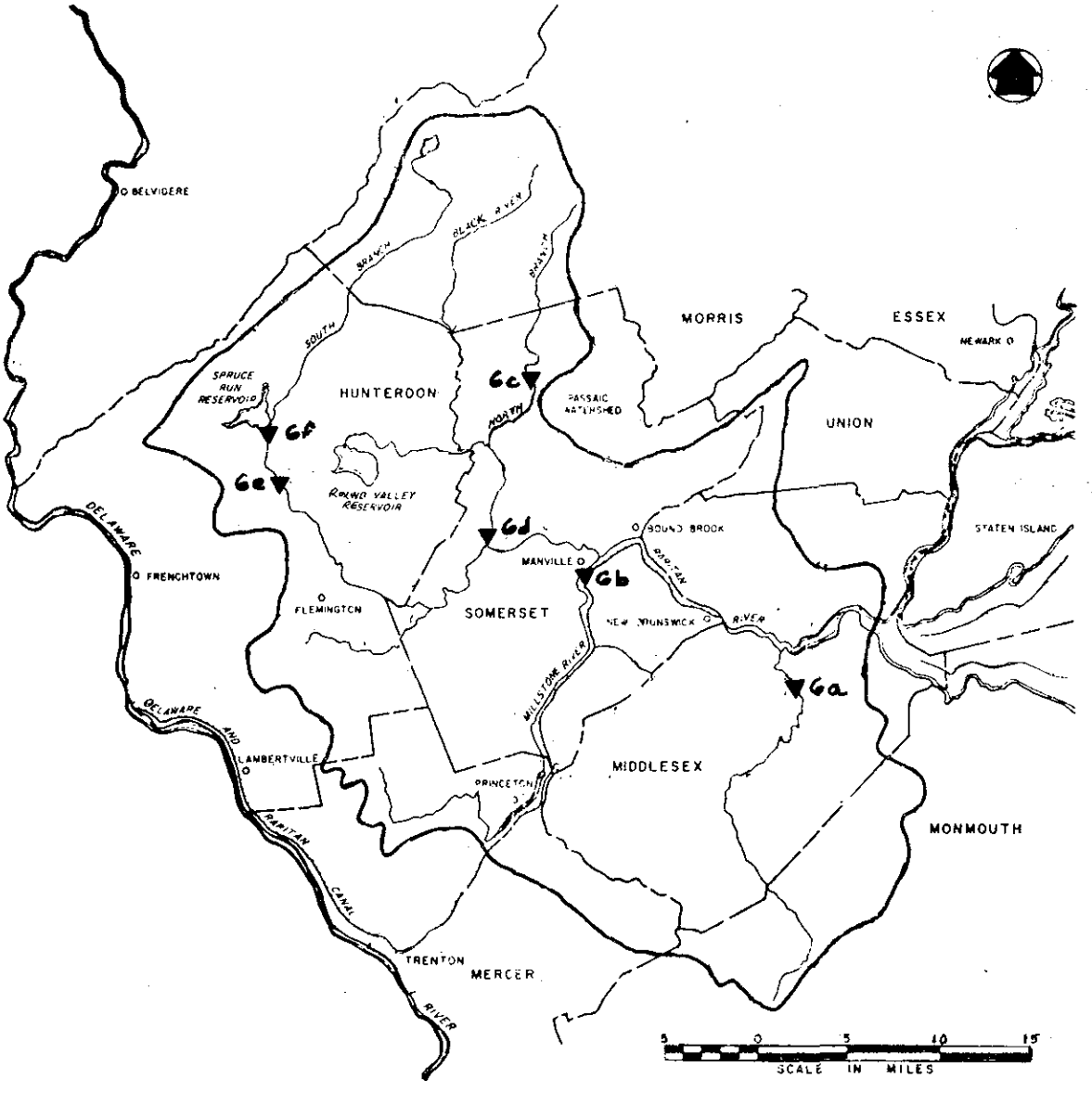
LEGEND

RIVER BASIN BOUNDARY

COUNTY BOUNDARIES

AREA BOUNDARIES

FIGURE A-3

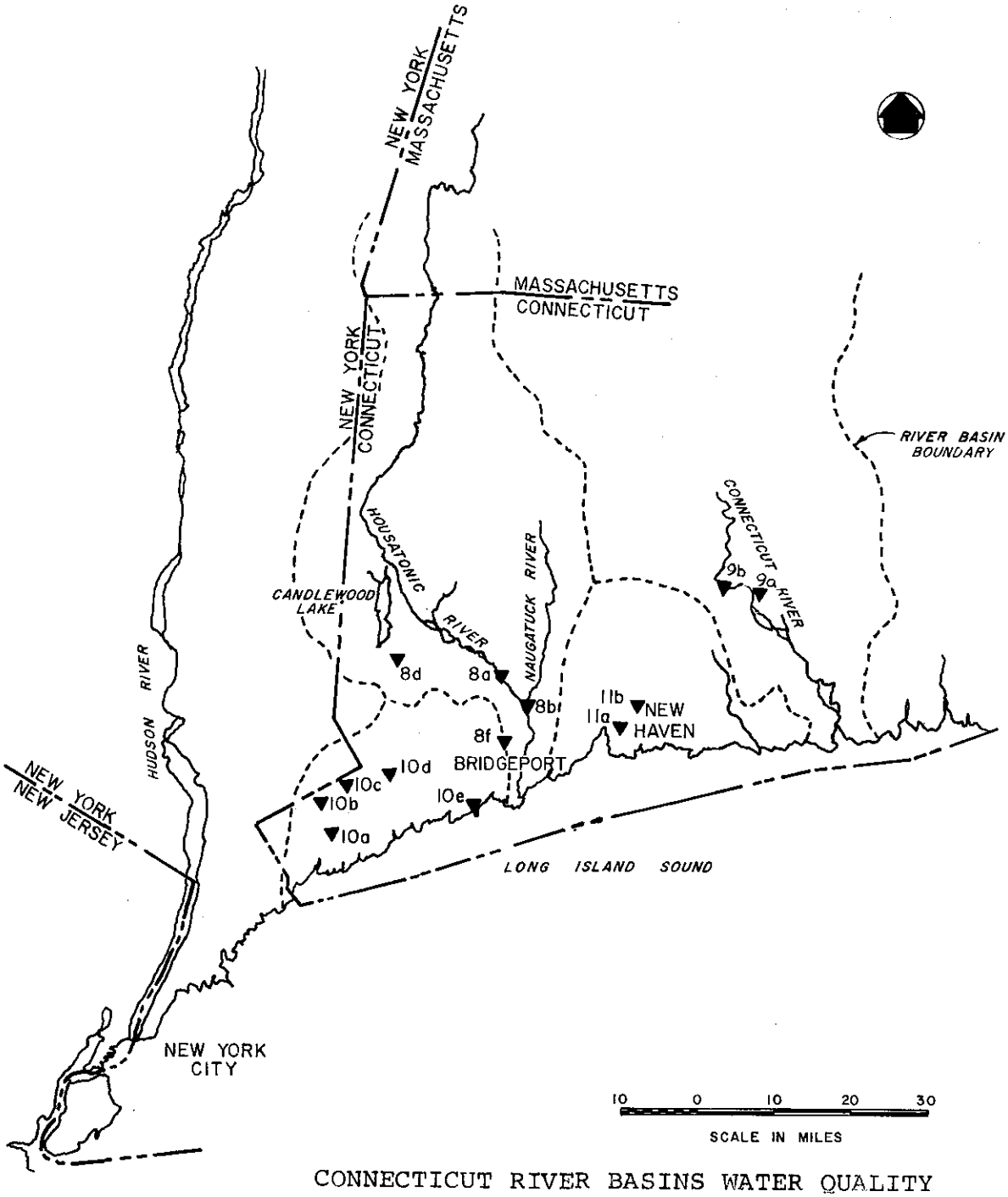


RARITAN RIVER BASIN WATER QUALITY SAMPLING LOCATIONS

LEGEND

_____ River Basin Boundary

\- - - - - - - - - - County Boundary



CONNECTICUT RIVER BASINS WATER QUALITY SAMPLING LOCATIONS

LEGEND

STATE BOUNDARY

RIVER BASIN BOUNDARY

ADDITIONAL WATER QUALITY DATA REPORTED BY THE JOINT EPA-NEW JERSEY WATER SUPPLY MONITORING AND SURVEY PROGRAM

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TABLE 1

NEW JERSEY RAW WATER ANALYSIS				
SUPPLIER: Hackensack Water Co. SOURCE: Hackensack River				
LATITUDE: 40° 57' 22"		LONGITUDE: 74° 1' 45"		
	SAMPLING DATES			
CONSTITUENT	6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.24	0.18	0.17	0.17
Nitrate Nitrogen	0.92	0.34	0.76	1.32
Total Phosphorus	0.10	0.14	0.09	0.14
Mercury	0.003	< 0.00025	< 0.00025	0.00037
Arsenic	0.0025	< 0.0025	0.0028	0.0025
Copper	0.6	0.095	0.036	0.01
Lead	< 0.1	0.031	0.017	0.014
Selenium	ID	0.005	0.005	< 0.002
Sodium	10	20	12.8	25
Zinc	0.025	0.07	0.046	0.026
MF-TOTAL COLIFORM PER 100 mL	7000	2300	25,000	2000
MF-FECAL COLIFORM PER 100 mL	ID	< 4	1300	32
TOTAL PLATE COUNT PER 100 mL	>300,000	1,900,000	73,000	81,000
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	<10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

TABLE 2

NEW JERSEY RAW WATER ANALYSIS

SUPPLIER: Elizabethtown Water Co. SOURCE: Raritan River

LATITUDE: 40° 32' 35" LONGITUDE: 74° 34' 20"

SAMPLING DATES

CONSTITUENT	6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.06	< 0.05	0.08	0.05
Nitrate Nitrogen	1.36	0.59	1.68	0.9
Total Phosphorus	0.11	0.08	0.17	0.07
Mercury	ID	< 0.00025	0.0005	< 0.00025
Arsenic	< 0.0025	< 0.0025	0.0035	< 0.0025
Copper	0.02	0.008	0.26	0.013
Lead	< 0.1	0.025	0.041	0.008
Selenium	< .005	< 0.0025	0.0045	< 0.002
Sodium	9.3	12	8.8	10
Zinc	0.04	0.046	0.059	0.012
MF-TOTAL COLIFORM PER 100 ML	-	-	-	-
MF-FECAL COLIFORM PER 100 ML	-	-	-	-
TOTAL PLATE COUNT PER 100 ML	-	-	-	-
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	< 10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

TABLE 3

NEW JERSEY RAW WATER ANALYSIS				
SUPPLIER: Elizabethtown Water Co.		SOURCE: Delaware-Raritan Canal		
LATITUDE: 40° 32' 32"		LONGITUDE: 74° 34' 18"		
	SAMPLING DATES			
CONSTITUENT	6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.17	< 0.05	< 0.05	0.08
Nitrate Nitrogen	1.34	1.08	2.64	2.0
Total Phosphorus	0.14	0.09	0.16	0.08
Mercury	ID	< 0.00025	< 0.00025	0.00032
Arsenic	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Copper	ID	0.011	0.095	0.009
Lead	ID	0.025	0.013	0.014
Selenium	0.0025	< 0.0025	0.0045	< 0.002
Sodium	ID	11	7.1	12
Zinc	ID	0.042	0.062	0.072
MF-TOTAL COLIFORM PER 100 ML	-	-	-	-
MF-FECAL COLIFORM PER 100 ML	-	-	-	-
TOTAL PLATE COUNT PER 100 ML	-	-	-	-
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	<10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

TABLE 4

NEW JERSEY RAW WATER ANALYSIS				
SUPPLIER: Jersey City		SOURCE: Rockaway River		
LATITUDE: 40° 53' 39"		LONGITUDE: 74° 23' 48"		
	SAMPLING DATES			
CONSTITUENT	6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.03	< 0.05	< 0.05	< 0.05
Nitrate Nitrogen	0.31	1.02	0.25	0.64
Total Phosphorus	0.05	< 0.05	< 0.05	< 0.05
Mercury	ID	< 0.00025	< 0.00025	< 0.00025
Arsenic	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Copper	ID	0.007	0.012	0.014
Lead	ID	< 0.025	0.034	0.008
Selenium	< 0.005	< 0.0025	0.0035	< 0.002
Sodium	ID	16	6.8	16
Zinc	ID	0.02	0.051	0.020
MF-TOTAL COLIFORM PER 100 ML	-	-	-	-
MF-FECAL COLIFORM PER 100 ML	-	-	-	-
TOTAL PLATE COUNT PER 100 ML	-	-	-	-
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	< 10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

NEW JERSEY RAW WATER ANALYSIS

SUPPLIER: Jersey City SOURCE: Reservoir

LATITUDE: 40° 53' 39" LONGITUDE: 74° 23' 52"

CONSTITUENT	SAMPLING DATES 6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.02	0.08	< 0.05	< 0.05
Nitrate Nitrogen	0.38	0.29	0.27	0.52
Total Phosphorus	0.05	< 0.05	< 0.05	0.06
Mercury	0.001	< 0.00025	< 0.00025	< 0.00025
Arsenic	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Copper	0.055	0.042	0.052	0.039
Lead	< 0.1	0.029	0.01	0.008
Selenium	< 0.005	< 0.0025	< 0.0025	< 0.002
Sodium	9.3	12	9.8	13
Zinc	0.18	0.138	0.074	0.05
MF-TOTAL COLIFORM PER 100 ML	-	-	-	-
MF-FECAL COLIFORM PER 100 ML	-	-	-	-
TOTAL PLATE COUNT PER 100 ML	-	-	-	-
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	-

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

TABLE 6

NEW JERSEY RAW WATER ANALYSIS				
SUPPLIER: North Jersey District Water Supply		SOURCE: Reservoir		
LATITUDE: 41° 02' 33"		LONGITUDE: 74° 17' 36"		
	SAMPLING DATES			
CONSTITUENT	6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.02	< 0.05	0.08	< 0.05
Nitrate Nitrogen	< 0.1	0.05	0.1	0.11
Total Phosphorus	< 0.05	< 0.05	< 0.05	0.05
Mercury	0.0021	< 0.00025	< 0.00025	< 0.00025
Arsenic	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Copper	0.057	0.06	0.055	0.028
Lead	< 0.1	< 0.025	0.008	0.02
Selenium	< 0.005	< 0.01	0.0045	0.002
Sodium	58	4.7	6.0	4.0
Zinc	0.025	0.03	0.045	0.031
MF-TOTAL COLIFORM PER 100 ML	140	20	170	16
MF-FECAL COLIFORM PER 100 ML	ID	< 4	< 4	12
TOTAL PLATE COUNT PER 100 ML	5,000	51,000	8,500	>30,000
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	<10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

TABLE 7

NEW JERSEY RAW WATER ANALYSIS

SUPPLIER: North Jersey District Water Supply

SOURCE: Ramapo River

LATITUDE: 40° 59' 33"

LONGITUDE: 74° 16' 44"

CONSTITUENT	SAMPLING DATES 6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.09	0.05	0.11	0.09
Nitrate Nitrogen	0.31	0.2	0.48	0.81
Total Phosphorus	0.08	0.13	0.08	0.08
Mercury	< 0.0024	< 0.00025	< 0.00025	< 0.00025
Arsenic	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Copper	0.016	0.013	0.05	0.008
Lead	< 0.1	< 0.025	0.013	0.01
Selenium	< 0.0015	< 0.01	0.0025	0.002
Sodium	9	15	15.2	17
Zinc	0.025	0.09	0.048	0.02
MF-TOTAL COLIFORM PER 100 ML	16,000	2,300	4,800	11,000
MF-FECAL COLIFORM PER 100 ML	210	< 4	280	< 4
TOTAL PLATE COUNT PER 100 ML	240,000	240,000	150,000	330,000
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	< 10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

NEW JERSEY RAW WATER ANALYSIS

SUPPLIER: Commonwealth Water Co. SOURCE: Passaic River

LATITUDE: 40° 44' 39" LONGITUDE: 74° 21' 16"

CONSTITUENT	SAMPLING DATES 6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.13	0.46	0.1	0.52
Nitrate Nitrogen	0.42	2.5	0.28	0.92
Total Phosphorus	0.18	1.2	0.14	0.38
Mercury	0.0010	< 0.00025	< 0.00025	< 0.00025
Arsenic	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Copper	0.02	0.012	0.017	0.009
Lead	< 0.1	< 0.025	0.013	< 0.01
Selenium	< 0.005	< 0.01	0.0025	< 0.002
Sodium	12	92	8.2	22
Zinc	0.06	0.083	0.057	0.27
MF-TOTAL COLIFORM PER 100 ML	-	-	-	-
MF-FECAL COLIFORM PER 100 ML	-	-	-	-
TOTAL PLATE COUNT PER 100 ML	-	-	-	-
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	<10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

NEW JERSEY RAW WATER ANALYSIS

SUPPLIER: Commonwealth Water Co.	SOURCE: Reservoir Outlet
LATITUDE: 40° 44' 39"	LONGITUDE: 74° 21' 16"

	SAMPLING DATES			
CONSTITUENT	6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.13	< 0.05	0.31	< 0.05
Nitrate Nitrogen	0.13	0.09	0.27	0.39
Total Phosphorus	0.08	0.2	0.07	0.09
Mercury	0.0027	< 0.00025	< 0.00025	< 0.00025
Arsenic	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Copper	0.05	0.034	0.018	0.015
Lead	< 0.1	< 0.025	0.017	0.01
Selenium	0.003	< 0.01	0.0035	< 0.002
Sodium	18	21	14.7	16
Zinc	0.053	0.05	0.04	0.017
MF-TOTAL COLIFORM PER 100 ML	-	-	-	-
MF-FECAL COLIFORM PER 100 ML	-	-	-	-
TOTAL PLATE COUNT PER 100 ML	-	-	-	-
POLYCHLORINATED BIPHENYLS MG/L	-	-	-	<10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

TABLE 10

NEW JERSEY RAW WATER ANALYSIS				
SUPPLIER: Monmouth Consolidated		SOURCE: Shark River		
LATITUDE: 40° 12' 13"		LONGITUDE: 74° 3' 57"		
	SAMPLING DATES			
CONSTITUENT	6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.1	0.06	0.11	0.27
Nitrate Nitrogen	0.27	2.6	0.32	0.3
Total Phosphorus	< 0.05	< 0.05	< 0.05	< 0.05
Mercury	0.0016	< 0.00025	< 0.00025	< 0.00025
Arsenic	< 0.0025	0.0025	< 0.0025	< 0.0025
Copper	0.03	0.014	0.05	0.022
Lead	< 0.1	< 0.025	0.01	< 0.005
Selenium	ID	< 0.01	< 0.0025	< 0.002
Sodium	9.5	10	8.6	10
Zinc	0.05	0.028	0.07	0.031
MF-TOTAL COLIFORM PER 100 ML	-	-	-	-
MF-FECAL COLIFORM PER 100 ML	-	-	-	-
TOTAL PLATE COUNT PER 100 ML	-		-	-
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	< 10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

NEW JERSEY RAW WATER ANALYSIS

SUPPLIER: Monmouth Consolidated SOURCE: Swimming River

LATITUDE: 40° 20' 7" LONGITUDE: 74° 5' 26"

CONSTITUENT	SAMPLING DATES 6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.11	0.2	0.14	0.08
Nitrate Nitrogen	0.99	0.29	0.6	1.56
Total Phosphorus	0.05	< 0.05	0.05	0.1
Mercury	ID	< 0.00025	< 0.00025	ID
Arsenic	< 0.0025	< 0.0025	< 0.0025	0.0045
Copper	ID	0.025	0.011	0.009
Lead	ID	< 0.025	0.009	0.008
Selenium	< 0.0015	< 0.01	0.0075	< 0.002
Sodium	ID	9.4	8.2	32
Zinc	ID	0.078	0.036	0.012
MF-TOTAL COLIFORM PER 100 ML	-	-	-	-
MF-FECAL COLIFORM PER 100 ML	-	-	-	-
TOTAL PLATE COUNT PER 100 ML	-	-	-	-
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	<10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

TABLE 12

NEW JERSEY RAW WATER ANALYSIS				
SUPPLIER: Passaic Valley		SOURCE: Passaic River		
LATITUDE: 40° 53' 4"		LONGITUDE: 74° 13' 56"		
	SAMPLING DATES			
CONSTITUENT	6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.11	2.64	0.2	0.49
Nitrate Nitrogen	0.33	1.4	0.56	0.72
Total Phosphorus	0.14	1.48	0.11	0.35
Mercury	ID	< 0.00025	< 0.00025	< 0.00025
Arsenic	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Copper	0.031	0.01	0.011	0.014
Lead	< 0.1	0.035	0.012	0.008
Selenium	ID	< 0.01	0.003	< 0.002
Sodium	9.9	47	9.5	20
Zinc	0.1	0.053	0.051	0.025
MF-TOTAL COLIFORM PER 100 ML	12,000	3,900	10,000	300
MF-FECAL COLIFORM PER 100 ML	ID	240	160	12
TOTAL PLATE COUNT PER 100 ML	>300,000	>3,000,000	270,000	17,000
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	< 10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

NEW JERSEY RAW WATER ANALYSIS

SUPPLIER: Newark Water Dept. SOURCE: Pequannock River

LATITUDE: 41° 01' 11" LONGITUDE: 74° 24' 11"

CONSTITUENT	SAMPLING DATES 6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	< 0.01	< 0.05	0.06	ID
Nitrate Nitrogen	0.16	0.09	0.07	ID
Total Phosphorus	< 0.05	< 0.05	< 0.05	ID
Mercury	0.0016	ID	< 0.00025	< 0.005
Arsenic	< 0.0025	ID	< 0.0025	< 0.0025
Copper	0.3	ID	0.011	0.005
Lead	< 0.1	ID	0.009	< 0.005
Selenium	< 0.0015	ID	< 0.0025	< 0.002
Sodium	5.9	ID	4.4	5.0
Zinc	0.034	ID	0.038	0.016
MF-TOTAL COLIFORM PER 100 ML	660	< 4	4,000	84
MF-FECAL COLIFORM PER 100 ML	ID	< 4	32	4
TOTAL PLATE COUNT PER 100 ML	8,800	2,700	58,000	7,900
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	< 10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

TABLE 14

NEW JERSEY RAW WATER ANALYSIS				
SUPPLIER: Rahway Water Dept.		SOURCE: Rahway River		
LATITUDE: 40° 37' 5"		LONGITUDE: 74° 17' 28"		
	SAMPLING DATES			
CONSTITUENT	6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.14	< 0.05	< 0.05	0.08
Nitrate Nitrogen	1.02	0.91	1.2	2.2
Total Phosphorus	0.15	0.09	0.09	0.06
Mercury	ID	< 0.00025	< 0.00025	< 0.00025
Arsenic	0.05	0.0025	0.004	< 0.0025
Copper	ID	0.009	0.033	0.012
Lead	ID	0.04	0.039	0.016
Selenium	0.0015	< 0.01	0.003	< 0.002
Sodium	ID	23	14.8	8.2
Zinc	ID	0.043	0.15	0.057
MF-TOTAL COLIFORM PER 100 ML	17,000	14,000	33,000	1,500
MF-FECAL COLIFORM PER 100 ML	500	200	1,100	45
TOTAL PLATE COUNT PER 100 ML	>300,000	500,000	270,000	60,000
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	< 10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

NEW JERSEY RAW WATER ANALYSIS

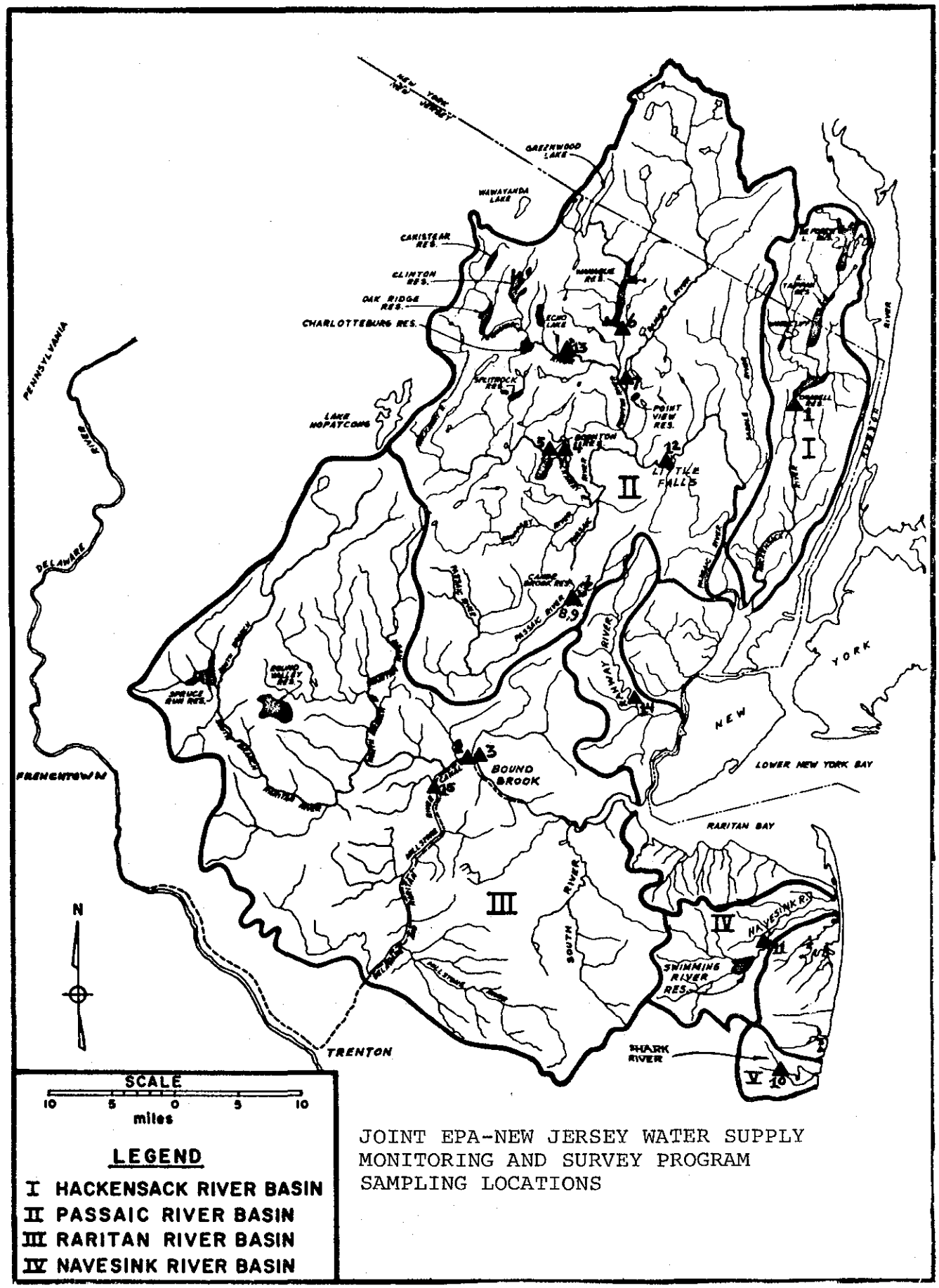
SUPPLIER: Middlesex Water Co. SOURCE: Delaware-Raritan Canal

LATITUDE: 40° 30' 6" LONGITUDE: 70° 26' 42"

CONSTITUENT	SAMPLING DATES 6/6/72	9/12/72	11/14/72	2/14/73
Ammonia Nitrogen	0.1	< 0.05	0.1	0.13
Nitrate Nitrogen	1.2	0.86	1.68	1.92
Total Phosphorus	0.11	0.05	0.11	0.16
Mercury	ID	< 0.00025	< 0.00025	< 0.00025
Arsenic	< 0.0025	< 0.0025	< 0.0025	< 0.0025
Copper	0.043	0.018	0.031	0.041
Lead	< 0.1	0.035	0.014	0.013
Selenium	ID	0.0075	0.009	< 0.002
Sodium	10	12	8.8	11
Zinc	0.1	0.033	0.68	0.066
MF-TOTAL COLIFORM PER 100 ML	11,000	280	2,200	640
MF-FECAL COLIFORM PER 100 ML	200	44	180	40
TOTAL PLATE COUNT PER 100 ML	230,000	91,000	100,000	43,000
POLYCHLORINATED BIPHENYLS µG/L	-	-	-	< 10

Note: All parameters expressed as mg/l unless otherwise indicated. ID=Insufficient Data. MF=Membrane Filter.

FIGURE A-5



JOINT EPA-NEW JERSEY WATER SUPPLY MONITORING AND SURVEY PROGRAM SAMPLING LOCATIONS

APPENDIX B

STATE SURFACE WATER CLASSIFICATIONS

APPENDIX B - STATE SURFACE WATER CLASSIFICATIONS

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TABLE B-1a

STATE OF NEW YORK SURFACE WATER CLASSIFICATION

Water Type	Water Class	Best Usage of Waters
Fresh	AA	Source of water supply for drinking, culinary or food processing purposes and any other usages. (Chlorination only)
	A	Source of water supply for drinking, culinary or food processing purposes and any other usages. (Sedimentation, filtration and chlorination)
	B	Bathing and any other usages except as a source of water supply for drinking, culinary or food processing purposes.
	C	Fishing and any other usages except for bathing or as a source of water supply for drinking, culinary or food processing purposes.
	D	Agricultural or source of industrial cooling or process water supply and any other usage except for fishing, bathing or as a source of water supply for drinking, culinary or food processing purposes.
Tidal and Coastal	SA	Shell fishing for market purposes and any other usages.
	SB	Bathing and any other usages except shell fishing for market purposes.
	SC	Fishing and any other usages except bathing or shell fishing for market purposes.
	SD	Any usages except fishing, bathing or shell fishing for market purposes.

TABLE B-1b

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
AA	1. Floating solids; settleable solids, oil, sludge deposits, tastes or odor producing substances.	None attributable to sewage, industrial wastes or other wastes.
	2. Sewage or wastes effluents.	None which are not effectively disinfected.
	3. pH	Range between 6.5 and 8.5.
	4. Dissolved oxygen.	For trout waters, not less than 5.0 parts per million; for non-trout waters, not less than 4.0 parts per million.
	5. Toxic wastes, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to fish life, make the waters unsafe or unsuitable as a source of water supply for drinking, culinary or food processing purposes or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

NOTE NO. 1: In determining the safety or suitability of waters in this class for use as a source of water supply for drinking, culinary or food processing purposes after approved treatment, the Water Pollution Control Board will be guided by the standards specified in the latest edition of "Public Health Service Drinking Water Standards", published by the United States Public Health Service.

TABLE B-1b (continued)

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA Conditions	Allowable Limits
	NOTE NO. 2: With reference to certain toxic substances as affecting fish life, the establishment of any single numerical standard for waters of New York State would be too restrictive. There are many waters which because of poor buffering capacity and composition will require special study to determine safe concentrations of toxic substances. However, based on non-trout waters of approximately median alkalinity (80 ppm) or above for the state, in which groups most of the waters near industrial areas in this state will fall, and without considering increased or decreased toxicity from possible combinations, the following may be considered as safe stream concentrations for certain substances to comply with the above standard for this type of water. Waters of lower alkalinity must be specially considered since the toxic effect of most pollutants will be greatly increased.	
	Ammonia or Ammonium Compounds	Not greater than 2.0 parts per million (NH_3) at pH of 8.0 or above.
	Cyanide	Not greater than 0.1 parts per million (CN)
	Ferro- or Ferricyanide	Not greater than 0.4 parts per million ($Fe(CN)_6$)
	Copper	Not greater than 012 parts per million (Cu)
	Zinc	Not greater than 0.3 parts per million (Zn)
	Cadmium	Not greater than 0.3 parts per million (Cd)

TABLE B-1b (continued)

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
A	1. Floating Solids, settleable solids, sludge deposits	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
	2. Sewage or waste effluents.	None which are not effectively disinfected.
	3. Odor producing substances contained in sewage, industrial wastes or other wastes.	The waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto shall not have an increased threshold odor number greater than 8, due to such added wastes.
	4. Phenolic compounds.	Not greater than 5 parts per billion (Phenol).
	5. pH	Range between 6.5 and 8.5.
	6. Dissolved Oxygen	For trout waters, not less than 5.0 parts per million; for non-trout waters, not less than 4.0 parts per million.

TABLE B-1b (continued)

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

CRITERIA

Water Classification	Conditions	Allowable Limits
A	7. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to fish, life, make the waters unsafe or unsuitable as a source of water supply for drinking, culinary or food processing purposes or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
	NOTE: Refer to Notes 1 and 2 under Class AA, which are also applicable to Class A standards.	
B	1. Floating solids, settleable solids, sludge deposits	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the waste discharged thereto.
	2. Sewage or waste effluents.	None which are not effectively disinfected.

TABLE B-1b (continued)

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
B	3. pH	Range between 6.5 and 8.5.
	4. Dissolved oxygen	For trout waters, not less than 5.0 parts per million; for non-trout waters, not less than 4.0 parts per million.
	5. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to fish life, make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
	NOTE: Refer to No. 2 under Class AA, which is also applicable to Class B standards.	
C	1. Floating solids, settleable solids, sludge deposits.	None which are readily attributable to sewage, industrial wastes or other amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
	2. pH	Range between 6.5 and 8.5.

TABLE B-1b (continued)

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
C	3. Dissolved oxygen	For trout waters, not less than 5.0 parts per million; for non-trout waters, not less than 4.0 parts per million.
	4. Toxic wastes, oil, deleterious subatances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to fish life or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
	NOTE: Refer to Note No. 2 under Class AA, which is also applicable to Class C standards.	
D	1. Floating solids, settleable solids; sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amount of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
	2. pH	Range between 6.0 and 9.5.

TABLE B-1b (continued

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

Water Classifications	CRITERIA	
	Conditions	Allowable Limits
D	3. Dissolved oxygen	Not less than 3.0 parts per million.
	4. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to prevent fish survival or impair the waters for agricultural purposes or any other best usage as determined for the specific waters which are assigned to this class.
	NOTE: Refer to Note No. 2 under Class AA, which is also applicable to Class D standards.	
SA	1. Floating solids, settleable solids, oil, sludge deposits.	None attributable to sewage, industrial wastes or other wastes.
	2. Garbage, cinders, ashes, oils, sludge or other refuse.	None in any waters of the Marine District as defined by State Conservation Law.
	3. Sewage or waste effluents.	None which are not effectively disinfected.
	4. Dissolved Oxygen	Not less than 5.0 parts per million.

TABLE B-1b (continued)

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowble Limits
SA	5. Toxic wastes, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor or sanitary condition thereof or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
	6. Organisms of Coliform group	The median MPN value in any series of samples representative of waters in the shellfish growing area shall not be in excess of 70 per 100 milliliters.
SB	1. Floating solids, settleable solids, oil, sludge deposits.	None attributable to sewage, industrial wastes or other wastes.
	2. Garbage, cinders, ashes, oils, sludge or other refuse.	None in any waters of the Marine District as defined by State Conservation Law.
	3. Sewage or waste effluents.	None which are not effectively disinfected.

TABLE B-1b (continued)

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
SB	4. Dissolved Oxygen	Not less than 5.0 parts per million.
	5. Toxic wastes, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor or sanitary condition thereof; and otherwise none in sufficient amounts to make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
SC	1. Floating solids, settleable solids, sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.

TABLE B-1b (continued)

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
SC	2. Garbage, cinder, ashes, oils, sludge or other refuse.	None in any waters of the Marine District as defined by State Conservation Law.
	3. Dissolved Oxygen	Not less than 5.0 parts per million.
	4. Toxic wastes, oil, deleterious substances, colored or other wastes or heated liquids.	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor or sanitary condition thereof or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
SD	1. Floating solids, settleable solids, sludge deposits.	None which are readily visible and attributable to sewage, industrial wastes or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.

TABLE B-1b (continued)

STATE OF NEW YORK SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
SD	2. Garbage, cinders, ashes, oils, sludge or other refuse.	None in any waters of the Marine District as defined by State Conservation Law.
	3. Dissolved oxygen.	Not less than 3.0 parts per million.
	4. Toxic wastes, oil, deleterious substances, colored or other wastes.	None alone or in combination with other substances or wastes in sufficient amounts to prevent survival of fish life or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

TABLE B-2a

STATE OF NEW JERSEY SURFACE WATER CLASSIFICATION

Water Type	Water Class	Definition
Fresh	FW-1	Fresh surface waters designated by authorized State Agencies as being set aside for posterity to represent the natural aquatic environment and its associated biota.
	FW-2	Fresh surface waters approved as sources of public potable water supply. These waters are to be suitable for public potable water supply after such treatment as shall be required by the State Department of Health. These waters shall also be suitable for all recreational purposes including fishing, the propagation of native fish species desired for angling and other fish and aquatic life necessary thereto as well as any other reasonable uses.
	FW-3	Fresh surface waters suitable for all purposes provided for under Class FW-2 except public potable water supply.
	FW-4	Fresh surface waters except as provided for under Classes FW-1, FW-2, and FW-3. These waters are to have limited recreational value and ordinarily not be acceptable for bathing or fishing but shall be able to maintain some fish life even though they may not be suitable for the propagation of fish. These waters shall not be an odor nuisance and shall not cause damage to pleasure craft having occasion to traverse the waters.
Tidal	TW-1	Tidal surface waters suitable for all recreational purposes, as a source of public potable water supply where permitted, and, where shellfishing is permitted, to be suitable for such purposes.
	TW-2	Tidal surface waters having limited recreational value and ordinarily not acceptable for bathing or fishing but suitable for fish survival although perhaps not suitable for fish propagation. These waters shall not be an odor nuisance and

TABLE B-2a (continued)

STATE OF NEW JERSEY SURFACE WATER CLASSIFICATION

Water Type	Water Class	Definition
		shall not cause damage to pleasure craft having occasion to traverse the waters.
	TW-3	Tidal surface waters used primarily for navigation, not recreation. These waters, although not expected to be used for fishing, shall provide for fish survival. These waters shall not be an odor nuisance and shall not cause damage to pleasure craft traversing them.
Coastal	CW-1	Ocean surf waters expected to be suitable for recreational use.

TABLE B-2b

STATE OF NEW JERSEY SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
FW-1	These waters shall be maintained, as to quality, in their natural state.	
	Conditions	Allowable Limits
FW-2	1. Floating solids, settleable solids, oil, grease, artificial coloring matter and turbidity	None of which are noticeable in the water or are deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota.
	2. Toxic or deleterious substances (including mineral acids, caustic alkali, cyanides, heavy metals, carbon dioxide, ammonia or ammonium compounds, chlorine, etc.)	None which would affect humans or be detrimental to the natural aquatic biota.
	3. Odor and taste producing substances.	None which are offensive to humans, detrimental to the aquatic biota or capable of producing offensive tastes and/or odors in water supplies and fauna used for human consumption.
	4. pH.	Between 6.5 and 8.5 unless naturally outside thereof.
	5. Dissolved oxygen.	Not less than 5.0 p.p.m. for trout waters; otherwise 4.0 p.p.m.
	6. Thermal discharges.	None which detrimentally affect the natural aquatic biota, or reasonably anticipated reuse of the waters.

TABLE B-2b (continued)

STATE OF NEW JERSEY SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
FW-3	1. Floating solids, settleable solids, oil, grease and turbidity.	None which are noticeable in the water or are deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota.
	2. Toxic or deleterious substances (including mineral acids, caustic alkali, cyanides, heavy metals, carbon dioxide, ammonia or ammonium compounds, chlorine, etc.)	None which would affect humans or be detrimental to the natural aquatic biota.
	3. Color, odor and taste producing substances.	None which are offensive to humans, detrimental to the aquatic biota or capable of producing offensive tastes and/or odors in fauna used for human consumption.
	4. pH.	Between 6.5 and 8.5 unless naturally outside thereof.
	5. Dissolved oxygen.	Not less than 5.0 p.p.m. for trout waters; otherwise 4.0 p.p.m.
	6. Thermal discharges.	None which detrimentally affect the natural aquatic biota, or reasonably anticipated reuse of the waters.

TABLE B-2b (continued)

STATE OF NEW JERSEY SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
FW-4	1. Floating solids, settleable solids, oil and grease.	None which are noticeable in the water or contribute to the formation of sludge deposits along the shores.
	2. Toxic and deleterious substances.	None in such concentrations as to cause fish mortality or inhibit their natural migration.
	3. Taste and odor producing substances.	None which shall be offensive or that would detrimentally affect finfish, shellfish or other aquatic life in higher quality receiving waters. Neither shall it inhibit the natural migration of fish.
	4. Dissolved oxygen.	Not less than 50% saturation.

TABLE B-2b (continued)

STATE OF NEW JERSEY SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
TW-1	1. Floating solids, settleable solids, oil, grease, scum and turbidity.	None which are noticeable in the water or are deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota.
	2. Toxic or deleterious substances (including mineral acids, caustic alkali, cyanides, heavy metals, carbon dioxide, ammonia or ammonium compounds, chlorine, etc.)	None which would affect humans or be detrimental to the natural aquatic biota.
	3. Color, odor and taste producing substances.	None which are offensive to humans, detrimental to the aquatic biota or capable of producing offensive tastes and/or odors in water supplies and fauna used for human consumption.
	4. pH.	Between 6.5 and 8.5 unless naturally outside thereof.
	5. Dissolved oxygen.	Not less than 50% of saturation.
	6. Thermal discharges.	None which detrimentally affect the natural aquatic biota, or reasonably anticipated reuse of the waters.
	7. Coliform bacteria.	The median MPN value in shellfish growing areas shall not be in excess of 700 per 100 milliliters.

TABLE B-2b (continued)

STATE OF NEW JERSEY SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
TW-2	1. Floating solids, oil and grease.	None which are noticeable in the water or contribute to the formation of sludge deposits along the shores.
	2. Toxic and deleterious substances.	None in such concentrations as to cause fish mortality or inhibit their natural migration.
	3. Taste and odor producing substances.	None which shall be offensive or that would detrimentally affect finfish, shellfish or other aquatic life in higher quality receiving waters.
	4. pH.	Between 6.5 and 8.5 unless naturally outside thereof.
	5. Dissolved oxygen.	Not less than 50% saturation.
	6. Thermal discharges.	None which detrimentally affect reasonably anticipated reuse of the waters.

TABLE B-2b (continued)

STATE OF NEW JERSEY SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
TW-3	1. Floating solids, settleable solids, oil and grease.	None which are noticeable in the water or contribute to the formation of sludge deposits along the shores.
	2. Toxic and deleterious substances.	None in such concentrations as to cause fish mortality or inhibit their natural migration.
	3. Taste and odor producing substances.	None which shall be offensive or that would detrimentally affect finfish, shellfish or other aquatic life in higher quality waters.
	4. pH.	Between 6.5 and 8.5 unless naturally outside thereof.
	5. Dissolved oxygen.	Not less than 30% of saturation or 3.0 p.p.m., whichever is less.

TABLE B-2b (continued)

STATE OF NEW JERSEY SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
CW-1	1. Floating solids, settleable solids, oil, grease and turbidity.	None of which are noticeable in the water or contribute to the formation of sludge deposits along the shores.
	2. Toxic and deleterious substances.	None which would affect humans or be detrimental to the natural aquatic biota.
	3. Color, taste and odor producing substances.	None which are offensive to humans, detrimental to aquatic biota or capable of producing offensive tastes and/or odors in fauna used for human consumption.

TABLE B-3a

STATE OF CONNECTICUT SURFACE WATER CLASSIFICATION

Water Type	Water Class	Water Uses
Inland	A	All water uses including potable supply with appropriate treatment
	B	Bathing, other recreation, agriculture, industrial cooling, fish and wildlife habitat, potable supply with appropriate treatment.
	C	Recreational boating, selected industrial, cooling, fish and wildlife habitat.
	D	Navigation, power, selected industrial, cooling, fish migration.
	E	Waters not suitable for any purpose.
Coastal and Marine	SA	Water contact sports, shellfish harvesting.
	SB	Water contact sports, cooling, fish and wildlife habitat.
	SC	Aquatic wildlife habitat, boating, cooling.
	SD	Navigation, power, selected cooling, fish migration.

TABLE B-3b

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	Criteria	
	Conditions	Allowable Limits
A	1. Dissolved oxygen	75% saturation, 16 hours/day; 5 mg/l at any time.
	2. Sludge deposits - solid refuse - floating solids, oils, and grease - scum	None allowable
	3. Color and turbidity	None other than of natural origin
	4. Coliform bacteria per 100 ml	Not to exceed a median of 100 nor more than 500 in more than 10% of samples collected
	5. Tase and odor	None other than of natural origin
	6. pH	As naturally occurs
	7. Allowable temperature increase	None other than natural origin
	8. Chemical constituents	(See note 4)

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	Criteria: Conditions	Criteria: Allowable Limits
B	1. Dissolved oxygen	75% saturation, 16 hours/day; 5 mg/l at any time
	2. Sludge deposits - solid refuse - floating solids, oils, and grease - scum	None (See note 6)
	3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this Class
	4. Coliform bacteria per 100 ml	Not to exceed a median of 1000 nor more than 2400 in more than 20% of samples collected
	5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this Class nor cause taste and odor in edible fish
	6. pH	6.5 - 8.0
	7. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 85° F, or in any case raise the normal temperature of the receiving water more than 4° F.
	8. Chemical constituents	(See note 4)

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	Criteria	
	Conditions	Allowable Limits
C	1. Dissolved oxygen	Not less than 5 mg/l for more than 6 hours during any 24-hour period, at no time less than 4 mg/l. For cold water fishery, Cc, not less than 5 mg/l at any time.
	2. Sludge deposits - solid refuse - floating solids, oils, and grease - scum	None (See note 6)
	3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this Class.
	4. Coliform bacteria per 100 ml	Not to exceed an average in any 30-day period of 5000 nor exceed this value in more than 20% of the samples collected during the period.
	5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this Class nor cause taste and odor in edible fish.
	6. pH	6.0 - 8.5
	7. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 85° F or in any case raise the normal temperature of the receiving water more than 4° F.
	8. Chemical Constituents	(See note 4)

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	Criteria	
	Conditions	Allowable Limits
D	1. Dissolved oxygen	A minimum of 2 mg/l at any time
	2. Sludge deposits - solid refuse - floating solids, oils, and grease - scum	None (See note 6)
	3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned in this Class
	4. Coliform bacteria per 100 ml	None in such concentrations that would impair any usages specifically assigned in this Class
	5. Taste and odor	None in such concentrations that would impair any usages specifically assigned in this Class
	6. pH	6.0 - 9.0
	7. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 85° F or in any case raise the normal temperature of the receiving water more than 4° F
	8. Chemical constituents	(See note 4)

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
SA	1. Dissolved oxygen	Not less than 6.0 mg/l at any time.
	2. Sludge deposits - solids refuse - floating solids, oils and grease - scum.	None allowable.
	3. Color and turbidity	None in such concentrations that will impair any usages specifically assigned to this Class.
	4. Coliform bacteria per 100 ml	Not to exceed a median MPN of 70 and not more than 10% of the samples shall ordinarily exceed an MPN of 230 for a 5-tube decimal dilution of 330 for a 3-tube decimal dilution. (See note S.5)
	5. Odor	None allowable
	6. pH	6.8 - 8.5
	7. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 85°F or in any case raise the normal temperature of the receiving water more than 4°F.

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
SA	8. Chemical constituents	None in concentrations or combinations which would be harmful to human, animal or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, impair the palatability of same, or impair the waters for any other uses.
	9. Radioactivity	(See note S.6)
SB	1. Dissolved oxygen	Not less than 5.0 mg/l at any time.
	2. Sludge deposits - solid refuse - floating solids, oils and grease - scum	None except that amount that may result from the discharge of a waste treatment facility providing appropriate treatment.
	3. Color and turbidity	None in such concentration that would impair any usages specifically assigned to this Class.
	4. Coliform bacteria per 100 ml	Not to exceed a median value of 700 and not more than 2300 more than 10% of the samples. (See note S.5)

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
SB	5. Taste and odor	None in such concentration that would impair any usages specifically assigned to this Class and none that would cause taste and odor in edible fish or shellfish.
	6. pH	6.8 - 8.5
	7. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 85°F or in any case raise the normal temperature of the receiving water more than 4°F.
	8. Chemical constituents	None in concentrations or combinations which would be harmful to human, animal, or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, or impair the water for any other usage assigned to this Class.
	9. Radioactivity	(See note S.6)

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
SC	1. Dissolved oxygen	Not less than 5 mg/l for more than 6 hours during any 24-hour period and at no time less than 4 mg/l. For cold water fishery, Scc, not less than 5 mg/l at any time.
	2. Sludge deposits - solid refuse - floating solids, oils and grease - scum	None except that amount that may result from the discharge from a waste treatment facility providing appropriate treatment.
	3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this Class.
	4. Coliform bacteria per 100 ml	Not to exceed an average in any 30-day period of 5000 nor exceed this value in more than 20% of the samples collected during the period.
	5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this Class and none that would cause taste and odor in edible fish or shellfish.

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
SC	6. pH	6.5 - 8.5
	7. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water use and in no case exceed 85°F or in any case raise the normal temperature of the receiving water more than 4°F.
	8. Chemical constituents	None in concentrations or combinations which would be harmful to human, animal or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propagation, or impair the water for any other usage assigned to this Class.
	9. Radioactivity	(See note S.6)
SD	1. Dissolved oxygen	Not less than 2 mg/l at any time.
	2. Sludge deposits - solid refuse - floating solids, oils and grease - scum	None except that amount that may result from the discharge from a waste treatment facility providing appropriate treatment.

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
SD	3. Color and turbidity	None in such concentrations that would impair any usages specifically assigned to this Class.
	4. Coliform bacteria	None in such concentrations that would impair any usages specifically assigned in this Class.
	5. Taste and odor	None in such concentrations that would impair any usages specifically assigned to this Class and none that would cause taste and odor in edible fish or shellfish.
	6. pH	6.5 - 8.5
	7. Allowable temperature increase	None except where the increase will not exceed the recommended limit on the most sensitive receiving water and in no case exceed 85°F or in any case raise the normal temperature of the receiving water more than 4°F.

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

Water Classification	CRITERIA	
	Conditions	Allowable Limits
SD	8. Chemical constituents	None in concentrations or combinations which would be harmful to human, animal or aquatic life or which would make the waters unsafe or unsuitable for fish or shellfish or their propogation, impair the palatability of same, or impair the water for any other usage.
	9. Radioactivity	(See note S.6)

NOTES: Water Class A, B, C and D

1. These criteria do not apply to conditions brought about by natural causes.

2. Class D waters will be assigned only where a higher water use Class cannot be attained after all appropriate waste treatment methods are utilized.

3. All sewage treatment plant effluents shall receive disinfection before discharge to the watercourse. The degree of treatment and disinfection shall be as required by the State.

4. Waters shall be free from chemical constituents in concentrations or combinations which would be harmful to human, animal or aquatic life for the appropriate, most sensitive and governing water class use. In areas where fisheries are the governing considerations and approved limits have not been established, bioassays shall be performed as required by the appropriate agencies. For public drinking water supplies the raw water sources must be of such a quality that

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

NOTES (continued)

United States Public Health Service limits, or state limits, if more stringent, for finished water can be met after conventional water treatment.

5. Radioactivity limits to be approved by the appropriate state agency with consideration of possible adverse effects in downstream waters from discharge of radioactive wastes; limits in a particular watershed to be resolved when necessary after consultation between appropriate state and federal agencies. In no case shall the Alpha emitters exceed a concentration of 3 picocuries per liter or the Gross Beta emitters exceed a concentration of 1000 picocuries per liter.

6. Sludge deposits, floating solids, oils, grease and scum shall not be allowed except for such small amounts that may result from the discharge of appropriately treated sewage or industrial waste effluents.

7. The minimum average daily flow for seven consecutive days that can be expected to occur once in ten years shall be the minimum flow to which the standards apply.

8. Class B and C waters shall be substantially free of pollutants that a) unduly affect the composition of bottom fauna; b) unduly affect the physical or chemical nature of the bottom; c) interfere with the propogation of fish.

9. Class A waters reserved for water supply may be subject to restricted use by state and local regulation.

10. All interstate Class A waters and all interstate Class B waters, except Shetucket River from confluence of Willimantic and Natchaug Rivers to Greenville Dam, Norwich, are considered to be suitable for cold water fish spawning and growth.

11. The criteria for dissolved oxygen and allowable temperature increase or interstate Class B and C waters are applicable to waters used only for fish passage. When such class waters are suitable for cold water fish spawning and growth, these criteria shall be the same as those specified for Class A waters.

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

NOTES (continued)

12. In the case of interstate Class B and C waters where parts of such waters are not suitable for spawning and growth, the requirements for fish passage shall be considered with other sensitive uses in defining allowable temperature increases.

NOTES: SA, SB, SC and SD

S.1 All sewage treatment plant effluents shall receive disinfection before discharge to coastal and marine waters. The degree of treatment and disinfection shall be as required by the State.

S.2 These criteria do not apply to conditions brought about by natural causes.

S.3 The waters shall be substantially free of pollutants that will a) unduly affect the composition of bottom fauna; b) unduly affect the physical or chemical nature of the bottom; c) interfere with the propogation of fish.

S.4 These criteria shall apply at all times in coastal and marine waters.

S.5 Surveys to determine coliform concentrations shall include those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions.

S.6 The discharge of radioactive materials in concentrations or combinations which would be harmful to human, animal or aquatic life shall not be allowed. In no case shall the Alpha emitters exceed a concentration of 3 picocuries per liter or the Gross Beta emitters exceed a concentration of 1000 picocuries per liter.

S.7 All interstate Class SA waters and all interstate Class SB waters, except Housatonic River from Derby Dam to mouth, Connecticut River from Hurd State Park in East Hampton to mouth, the Shetucket and Thames Rivers from Greenville Dam, Norwich to mouth are considered to be suitable for cold water fish spawning and growth.

TABLE B-3b (continued)

STATE OF CONNECTICUT SURFACE WATER QUALITY CRITERIA

NOTES (continued)

S.8 The criteria for dissolved oxygen and allowable temperature increase for interstate Class SB and SC waters are applicable to waters used only for fish passage. When such waters are suitable for cold water fish spawning and growth, these criteria shall be the same as those specified for Class SA waters.

S.9 In the case of interstate Class SB and SC waters where parts of such waters are not suitable for spawning and growth, the requirements for fish passage shall be considered with other sensitive uses in defining allowable temperature increases.

S.10 Coastal and marine waters are those generally subject to the rise and fall of the tide.

TABLE B-4

SURFACE WATER CLASSIFICATION SYSTEM

COMPARISON FOR NEW YORK, NEW JERSEY AND CONNECTICUT

Water Type	State: New York	State: New Jersey	State: Connecticut	General Water Uses[1]
Fresh Water		FW-1		Posterity
	AA	FW-2	A	Drinking
	A		B	
	B	FW-3		Bathing
	C		C	Fishing
	D	FW-4	D	Limited Recreat-ional and/or Industrial
			E	No use
Tidal and Coastal[2] Waters				Drinking
	SA	TW-1	SA	Shellfish
	SB		SB	Bathing
	SC	TW-2	SC	Fishing
	SD	TW-3	SD	Limited Recreat-ional and Industrial
Coastal Waters[2]		CW-1		Recreational

Notes: 1. Water use may be that listed or any of lower classification.
2. New Jersey distinguishes between tidal and coastal waters.

APPENDIX C

WASTEWATER TREATMENT

APPENDIX C - WASTEWATER TREATMENT

Wastewater may require various degrees of treatment to allow its incorporation into a particular wastewater management program to protect or enhance water supply. The treatment required may be as simple as a solids removing technique (primary) or as complex as current technical limits will allow. For example, for wastewater to be used as a potable supply, and for some high quality specialized industrial water requirements an advanced wastewater process or combination of processes will be required. Land application of wastewater may only require primary treated wastewater. The upper limits of quality which may be achieved are dependent on the available technology and on the economic practicality of producing the water quality necessary for a particular wastewater management scheme. The following paragraphs will present a general discussion of the state of the art of wastewater treatment.

A. WASTEWATER CHARACTERIZATION

Wastewater is characterized by its chemical, physical, bacteriological and viral constituents. The degree of treatment required to render wastewater amenable to a particular use will depend on the quality requirements for that use as measured in terms of these constituents. Table C-1 lists the most important physical, chemical and biological characteristics of wastewater. The typical composition of domestic sewage is summarized in Table C-2.

B. CONVENTIONAL WASTEWATER TREATMENT

Conventional domestic wastewater treatment is usually considered as two stages or levels of treatment, primary and secondary. Primary treatment is a solids removal process, usually consisting of a gravity settling operation, referred to as clarification. Clarification removes the waste contaminants associated only with the suspended and settleable solids in the waste. This is considered a physical process, that is, there is little if any biological treatment. Removal of solids in a primary sedimentation process may range from 35 to 75% while removal of the organic degradable portion associated with these solids, as measured by its biochemical oxygen demand (BOD) ranges from 25 to 40%. The removal efficiency will depend on the strength, age and type of sewage along with the operational characteristics of the clarifier.

TABLE C-1

PHYSICAL, CHEMICAL AND BIOLOGICAL

CHARACTERISTICS OF WASTEWATER

Parameter	Source
Physical	
Solids	Carriage water,* domestic and industrial wastes
Temperature	Domestic and industrial wastes
Color	Domestic and industrial wastes
Odor	Decomposing sewage, industrial wastes
Chemical	
Organic:	
Proteins	Domestic and commercial wastes
Carbohydrates	Domestic and commercial wastes
Fats, oils, and grease	Domestic, commercial, and industrial wastes
Surfactants	Domestic and industrial wastes
Phenols	Industrial wastes
Pesticides	Agricultural wastes
Inorganic:	
pH	Industrial wastes
Chlorides	Carriage water, domestic wastes, ground water infiltration
Alkalinity	Domestic wastes, carriage water, ground water infiltration
Nitrogen	Domestic and agricultural wastes
Phosphorus	Domestic and industrial wastes, natural runoff
Sulfur	Carriage water and industrial wastes
Toxic compounds	Industrial wastes, ground water infiltration
Heavy metals	Industrial wastes
Gases:	
Oxygen	Carriage water, surface water infiltration
Hydrogen sulfide	Decomposition of domestic wastes
Methane	Decomposition of domestic wastes
Biological	
Protista	Domestic wastes, treatment plants
Viruses	Domestic wastes
Plants	Open watercourses and treatment plants
Animals	Open watercourses and treatment plants

* Carriage water refers to domestic water supply.

SOURCE: Wastewater Engineering, Metcalf & Eddy, (1972)

TABLE C-2

TYPICAL COMPOSITION OF

DOMESTIC SEWAGE

All values except settleable solids expressed as mg/l

Constituent	Concentration		
	Strong	Medium	Weak
Solids, total	1,200	700	350
Dissolved, total	850	500	250
Fixed	525	300	145
Volatile	325	200	105
Suspended, total	350	200	100
Fixed	75	50	30
Volatile	275	150	70
Settleable solids, (ml/liter)	20	10	5
Biochemical oxygen demand, 5-day, 20°C (BOD_5-20°)	300	200	100
Total organic carbon (TOC)	300	200	100
Chemical oxygen demand (COD)	1,000	500	250
Nitrogen, (total as N)	85	40	20
Organic	35	15	8
Free ammonia	50	25	12
Nitrites	0	0	0
Nitrates	0	0	0
Phosphorus (total as P)	20	10	6
Organic	5	3	2
Inorganic	15	7	4
Chlorides*	100	50	30
Alkalinity (as $CaCO_3$)*	200	100	50
Grease	150	100	50

* Values should be increased by amount in carriage water.

SOURCE: Wastewater Engineering, Metcalf & Eddy, Inc. (1972)

Secondary treatment usually refers to a biological treatment process. Biological treatment processes conventionally used in domestic sewage treatment plants are the activated sludge process and the trickling filtrater process. Activated sludge treatment consists of the production of an activated mass of micro-organisms capable of aerobically stabilizing a waste. The process is carried out in a mixed, aerated reactor where the micro-organisms and the waste come in contact. The resulting biological mass is separated from the liquid in a settling tank. Trickling filters are fixed film biological reactors, so called since a microbial population is contained in a slime, forming on rocks or on an artificial surface, over which waste is sprinkled and allowed to trickle through. Each process has variations, based on the operation of the process, the type of preliminary treatment and the type of waste and strength of waste constituents. Typical removal efficiency in a secondary treatment process ranges from 60 to 95% BOD removed. Other biological treatment processes which achieve secondary treatment efficiencies include aerated lagoons and stabilization ponds. Secondary treatment efficiencies may be approached or surpassed by using physical-chemical (P-C) process exclusively or in conjunction with biological processes. Chemical coagulation and sedimentation may be used to achieve better than primary treatment efficiency, or used following a biological treatment process to improve on secondary treatment efficiency. Many P-C processes fall into the realm of advanced waste treatment (AWT) processes.

C. ADVANCED WASTEWATER TREATMENT

Advanced wastewater treatment refers to those treatment processes, or combinations of processes, which achieve better than secondary treatment efficiencies or replace conventional treatment processes. Generally, these processes are physical-chemical in nature. They may replace or be added to a conventional, secondary treatment plant to provide a tertiary level of treatment.

There are a great many physical chemical processes, each with varying degrees of treatment capabilities, existing technical development and proven full scale application. The more common processes used and those in early stages of development for application to domestic waste treatment are discussed in the following paragraphs.

Chemical treatment involves the addition of chemical agents to remove or aid in the removal of suspended solids

and specific waste contaminants. Lime, ferric chloride, alum and organic polymers have been used to improve suspended solids removal. Lime, ferric chloride and alum and various other chemicals have been found useful in phosphorus removal. Chemical aids in solids removal have been used in many full scale plants with good results. Phosphorus removal enacted by chemical precipitation has found varying degrees of success depending upon operational factors such as what chemicals are used and there they are added.

Nitrogen removal has been practiced on a large scale (3.75 mgd) using an ammonia stripping tower at the South Lake Tahoe Sewage Treatment Plant. Ammonia is air stripped from wastewater by passing the water into a tower with counter-current wastewater-air flow. Since approximately 90% of nitrogen in conventional secondary effluents exists as ammonia, ammonia removals of 80 to 98% achieved by ammonia stripping represents a sizable amount of overall nitrogen removal. The process requires a pH adjustment and is temperature dependent, (i.e. higher temperatures make the process more efficient). Nitrogen removal via modifications to the activated sludge process has recently received attention and is being developed on a full scale basis. Nitrogen is removed by first aerobically nitrifying ammonia and organic nitrogen and then removing nitrogen as elemental nitrogen gas by anaerobically denitrifying the nitrates. Further discussion of nitrogen removal is presented in Appendix E, "Land Orientated Systems for Renovated Wastewater Reuse".

Filtration has been used in various tertiary treatment plants to polish effluents. Secondary treatment processes remove from 70 to 98% of the suspended solids present in sewage. The remaining fraction of solids and associated biological constituents can be removed by a physical filtration device. Various filtration processes may be used for tertiary treatment of domestic wastes including microstraining, diatamaceous earth filtration, rapid sand filtration and multi-media filtration. Microstraining has been used in prototype treatment plants with a wide range of success, the major drawback to the process being its sensitivity to variations in solids loading. Suspended solids removals of 60 to 80% and BOD removals of 40 to 70% may be anticipated. Rapid sand and diatamaceous earth filters have been investigated for use as tertiary treatment, but have yet to be developed as a practical application. Multimedia filtration has been

TABLE C-3

STATUS OF PROCESS DEVELOPMENT

Fullscale Operation

Activated Sludge (modifications)
Granular Activated Carbon Adsorption
Ammonia Stripping
Biological Nitrification-Denitrification
Biological Phosphate Removal
Inorganic Coagulation and Phosphate Removal
Organic Polyelectrolytic Coagulation
Rapid Sand and Multimedia Filtration
Flotation
Wet Oxidation
Ozone oxidation

Pilot Plant Operation

Fluidized Bed Activated Carbon Adsorption
Powdered Activated Carbon Adsorption
Adsorption on Inorganics
Distillation
Coal Filtration
Plastic Media Filtration
Foam Separation
Ion Exchange for Ammonia Removal and Organics
Reverse Osmosis
Rotating Fixed Film Biological Contactor
Ultrafiltration

Laboratory Study

Adsorption on Coal
Adsorption on Polymers
Chemical Denitrification
Electrochemical Coagulation
Electrodialysis
Electrolysis
Electrooxidation of Ammonia
Ion Exchange for Phosphorus, ~~and~~ Nitrate and Organics Removal
Low Pressure Ultrafiltration
Catalytic Autooxidation
Light Catalyzed Chlorine Oxidation
Photochemical Oxidation
Plasma Arc Processing

Source: Stephan, D.G. & Schaffer, R.B., "Wastewater Treatment & Renovation Status of Process Development", JWPCF, 42, 3, 401 (1970).

used with success on a prototype basis. Suspended solids removal from secondary effluent of 100% was achieved at the South Lake Tahoe Sewage Treatment Plant's (7.5 mgd) multi-media filter. Total phosphorus removal of 70 to 95% and BOD removal of 40 to 70% was also experienced.

Granular activated carbon has been used to remove organic matter from secondary effluents by adsorption. Conventional treatment processes may remove nearly all of the organic material as measured by BOD, however, secondary effluents may contain 50 to 120 mg/l of organic materials including tannins, lignins, ethers, proteinaceous substances and other color and odor producing substances as well as MBAS (methylene blue active substances), herbicides and pesticides and refractory organics. Granular activated carbon has produced effluents with less than 1 mg/l BOD, 12 mg/l chemical oxygen demand (COD) and .13 mg/l MBAS. The efficiency of the process and the quality of the effluent will depend upon the degree of prior treatment and the operational variables of the process.

Many other processes have been proposed for advanced waste treatment of sewage and are in various stages of technical and practical development. Table C-3 lists some of these processes and their status of development. Additionally, new processes are being investigated to treat and dispose of sludge that will result from advanced or tertiary treatment processes, including pressure sludge oxidation with chlorine, by-product recovery, and electro-osmotic sludge dewatering.

Table C-4 represents the expected effluent quality from a sewage treatment plant employing a conventional primary or secondary treatment followed by some of the more common AWT processes, which represent those which are most economically and technically practical.

D. COSTS OF WASTEWATER RENOVATION PLANTS

Process Description

A typical wastewater reclamation plant at this time would probably be similar to the treatment processes at South Lake Tahoe, California. A schematic representation of this plant is shown in Figure C-1. Initially, the effluent from the secondary treatment plant undergoes

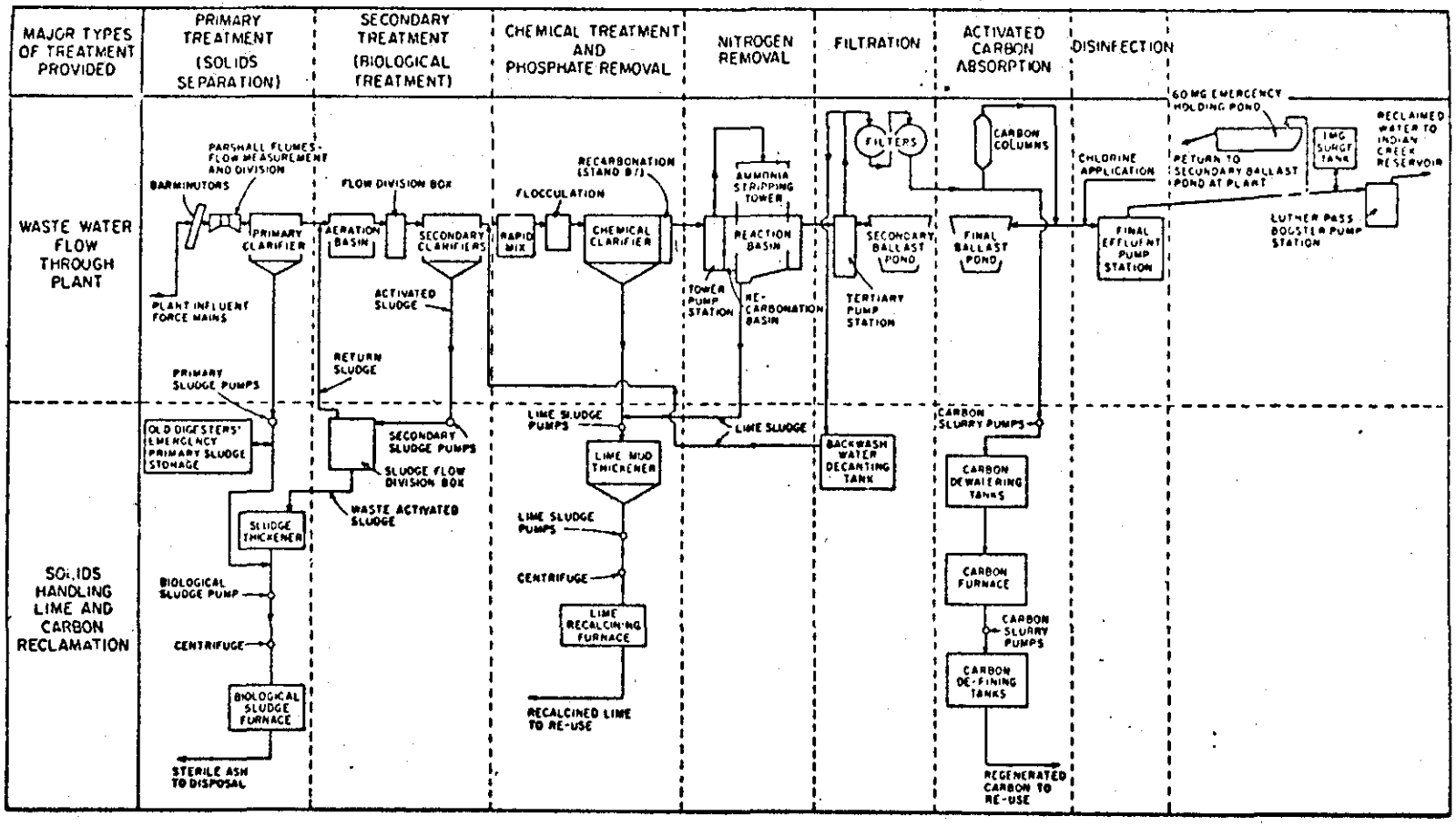
TABLE C-4

ANTICIPATED PERFORMANCE OF VARIOUS UNIT PROCESS COMBINATIONS *

AWT pretreatment	AWT process[a]	ESTIMATED AWT PROCESS EFFLUENT QUALITY BOD (mg/l)	COD (mg/l)	Turb. (JU)	PO_4 (mg/l)	S.S. (mg/l)	Color (units)	NH_3-N (mg/l)
Preliminary[1]	C,S	50–100	80–180	5–20	2–4	10–30	30–60	20–30
	C,S,F	30–70	50–150	1–2	0.5–2	2–4	30–60	20–30
	C,S,F,AC	5–10	25–45	1–2	0.5–2	2–4	5–20	20–30
	C,S,NS,F,AC	5–10	25–45	1–2	0.5–2	2–4	5–20	1–10
Primary	C,S	50–100	80–180	5–15	2–4	10–25	30–60	20–30
	C,S,F	30–70	50–150	1–2	0.5–2	2–4	30–60	20–30
	C,S,F,AC	5–10	25–45	1–2	0.5–2	2–4	5–20	20–30
	C,S,NS,F,AC	5–10	25–45	1–2	0.5–2	2–4	5–20	1–10
High rate Trickling Filter	F	10–20	35–60	6–15	20–30	10–20	30–45	20–30
	C,S	10–15	35–55	2–9	1–3	4–12	25–40	20–30
	C,S,F	7–12	30–50	0.1–1	0.1–1	0–1	25–40	20–30
	C,S,F,AC	1–2	10–25	0.1–1	0.1–1	0–1	0–15	20–30
	C,S,NS,F,AC	1–2	10–25	0.1–1	0.1–1	0–1	0–15	1–10
Conventional Activated Sludge	F	3–7	30–50	2–8	20–30	3–12	25–50	20–30
	C,S	3–7	30–50	2–7	1–3	3–10	20–40	20–30
	C,S,F	1–2	25–45	0.1–1	0.1–1	0–1	20–40	20–30
	C,S,F,AC	0–1	5–15	0.1–1	0.1–1	0–1	0–15	20–30
	C,S,NS,F,AC	0–1	5–15	0.1–1	0.1–1	0–1	0–15	1–10

[1]Preliminary treatment—grit removal, screen chamber, Parshall flume, overflow.
[a]C,S—coagulation and sedimentation; F—mixed-media filtration; AC—activated carbon adsorption; NS—ammonia stripping. Lower effluent NH_3 value at 18°C; upper value at 13°C.

*SOURCE: Advanced Wastewater Treatment, Culp, R. L. and Culp, G.L. (1971)



Schematic flow and process diagram, South Lake Tahoe, Calif.

SOURCE: Evans, D.R. & Wilson, J.C., "Capital and Operating Costs-AWT", Journal WPCF, Jan. 1972

FIGURE C-1

coagulation and clarification steps where phosphorus removal, utilizing lime, is undertaken. Spent lime mud is thickened in a gravity thickener, dewatered by centrifugation and then recalcined in a multiple-hearth furnace for reuse. The phosphorus-rich lime is concentrated in the centrifuge and some wasted to the organic sludge system.

The effluent from the lime clarifier flows through an air stripping tower for ammonia removal. This step involves the cascading of treated sewage in thin layers over a media effecting transfer of ammonium ions to gaseous ammonia. Air flows countercurrent to the wastewater flow. The ammonia stripped effluent flows to a two-stage recarbonation system where stack gases from the lime recalcining and sludge incineration furnaces are utilized to adjust the high pH ammonia stripping tower effluent.

The secondary recarbonation effluent is pumped to the mixed media filters. Alum is fed to the filter influent to control the effluent turbidity. Polyelectrolyte may be added also in conjunction with alum to act as a filter aid in controlling floc breakthrough.

Spent carbon is regenerated in a multiple-hearth furnace for reuse.

The carbon column effluent is dosed with 2 mg/l of chlorine as it is pumped to the main export pump station and finally to the Indian Creek Reservoir.

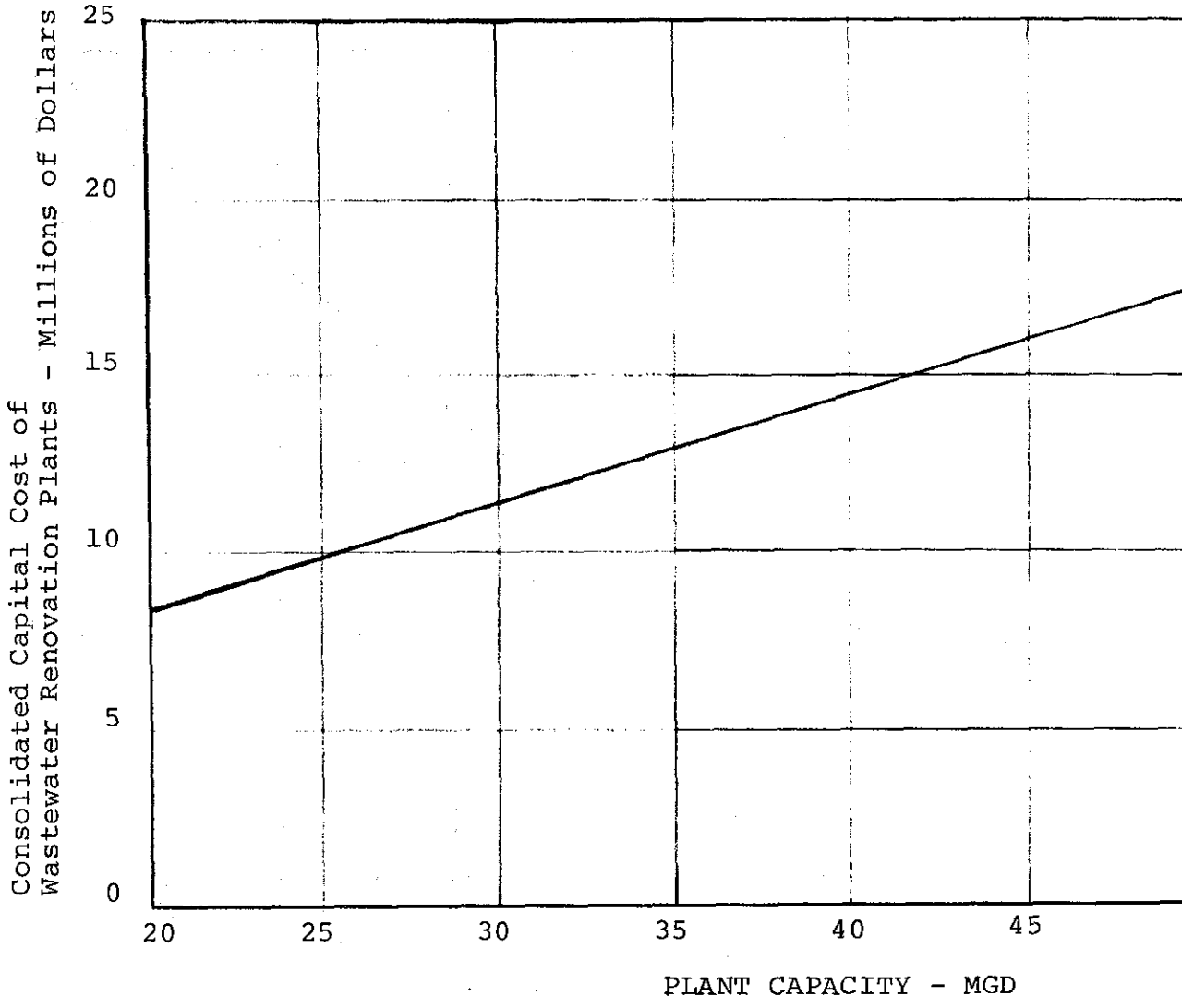
Costs for wastewater renovation plants, utilizing treatment processes, similar to the Lake Tahoe project, were presented in the Greeley and Hansen Report - Comprehensive Public Water Supply Study for Nassau County. These are shown in Figures C-2 and C-3.

The following information was used in arriving at these cost figures:

1. Capital costs were estimated, using data reported in the Federal Water Research Report No. TWRC-9 and adjusted to ENR-1400.

2. Engineering and contingencies which are included in the total capital costs are estimated as 30% of construction costs.

FIGURE C-2



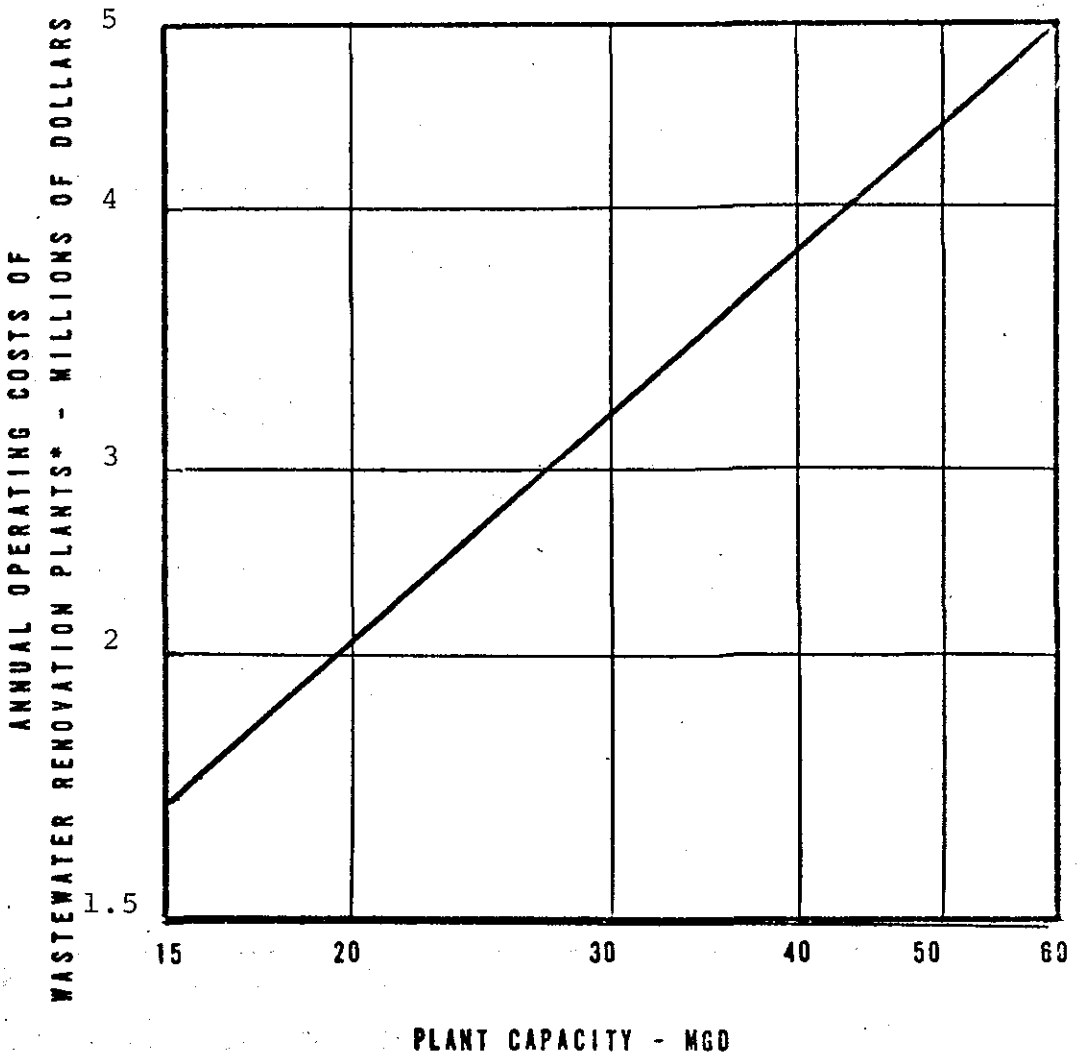
COSTS OF WASTEWATER RENOVATION PLANTS

(ENR=1400)

Source: Greeley and Hansen, "Comprehensive Water Supply Study - Nassau County, N.Y." CPWS-60, 1971. Data Adjusted to ENR=2400.

Note: Renovation process consists of precipitating phosphorus with lime, lime recalcination, dual-media filtration, carbon adsorption, ammonia stripping, chlorination and pumping.

FIGURE C-3



* Renovation process consists of precipitating phosphorus with lime, lime recalcination, dual-media filtration, carbon adsorption, ammonia stripping, chlorination and pumping.

COSTS OF WASTEWATER RENOVATION PLANTS

SOURCE: Greeley and Hansen, "Comprehensive Water Supply Study - Nassau County, N. Y.", June 1971

3. Amortization costs are based on 40-year bond durations at 6% interest rate.

4. Maintenance and repair was estimated as 1% of the total capital costs.

5. Power was estimated at $0.14 per KWH.

APPENDIX D

WASTEWATER REUSE

APPENDIX D - WASTEWATER REUSE

A. INTRODUCTION

Wastewater renovation is gaining recognition in the United States. Renovated wastewater may be used for a wide variety of purposes including industrial, agricultural, recreational and potable supplies. Examples of each exist, and when making a choice of possible reuses, each individual case should be examined to determine feasibilities and make the best choice.

Conservation of potable water supplies and water pollution control are currently of great concern. This may be affected by treating wastewater for direct reuse for industry, and agriculture and potable supplies or indirect reuse for potable supplies such as buffering ground water supplies against salt water intrusion.

B. RENOVATED WASTEWATER FOR POTABLE SUPPLIES

1. Methods

The treatment of wastewater for the purpose of reuse as a potable supply has been given much consideration recently, and future needs might dictate potable reuse of wastewater.

To attain a water of drinking quality, advanced wastewater treatment schemes, that is tertiary treatment, must be employed. Tertiary treatment is practiced at many treatment plants in the United States, and various degrees of effluent qualities are achieved. When considering reuse for potable supplies, standards of treatment must be rigorously met and the best methods of treatment schemes should be employed.

Advanced waste treatment and the water quality achieved in various process combinations can be seen in Table C-4, Appendix C. Reclaimed wastewater for potable use would have to meet the USPHS drinking water standards. Additionally, characteristics not listed in the USPHS standards should be within the limits of presently available public water supplies. Table D-1 lists the USPHS limits for drinking water along with the American Water Works Association's (AWWA) recommended potable water quality goals and the potable water quality standards of the World Health Organization (WHO). Comparison of these standards with the quality expected from

TABLE D-1

DRINKING WATER STANDARDS

Source: FWPCA, Water Quality Criteria, 1968

NOTE: All substances in mg/l unless otherwise noted.

SUBSTANCE	USPHS Conc.-should not be exceeded	USPHS Conc.-Rejection for Supply	AWWA Recommended Goals	WHO Drinking Water Max. Accept.	WHO Drinking Water Max. Allow.	WHO Water Source Max. Allowable
Turbidity (Units)	5		< 0.1	5	25	
Color (Units)	15		< 3	5	50	
Odor (Threshold Odor No.)	3		no odor	Unobject.		
Taste			none object.	Unobject.		
Alkyl Benzene Sulfonate (ABS)	0.5		< 0.2	0.5	1.0	0.5
Aluminum (Al)			< 0.05			
Arsenic (As)	0.01	0.05	0.01		0.05	0.05
Barium (Ba)		1.0	1.0		1.0	
Chloride (Cl)	250			200	600	
Cadmium (Cd)		0.01	0.01		0.01	0.01
Chromium (Cr^{+6})		0.05	0.05		0.05	0.05
Copper (Cu)	1.0		< 0.2	1.0	1.5	1.5
Carbon Chloroform Extract (CCE)	0.2		< 0.04	0.2	0.5	0.5
Cyanide (Cn)	0.01	0.2	0.01		0.2	0.2
Iron (Fe)	0.3		< 0.05	0.3	1.0	50
Lead (Pb)		0.05	0.05		0.05	0.05
Manganese (Mn)	0.05		< 0.01	0.1	0.5	5
Nitrate (NO_3)	45		45		45	45
Phenols (C_6H_5OH)	0.001		0.001	0.001	0.002	0.002
Selenium (Se)		0.01	0.01		0.01	0.01
Silver (Ag)		0.05	0.05			
Sulfate ($SO_4^{=}$)	250			200	400	
Total Dissolved Solids (TDS)	500		200			
Zinc (Zn)	5		< 1.0	5.0	15	1.5
Fluoride (F)	1.3	2.6	1.3		1.0-1.5	1.5
Silica (SiO_2)						
Hardness (As $CaCO_3$)			80-100			
Suspended Solids (S.S.)			1.0			
Phosphate ($PO_4^{=}$)			none			
Bicarbonate (HCO_3)						
COD						10
BOD_5						6
Calcium (Ca)				75	200	
Magnesium (Mg)				50	150	1000
Ammonia (NH_3)						0.5
Total Alkalinity (As $CaCO_3$)						
Hydrogen Sulfide (H_2S)						
pH (Value)				7-8.5	6.5-9.2	
Acidity (As $CaCO_3$)						
Methelene Blue Active Substances (MBAS)	0.5		0.2			
Carbon Alcohol Extract (CAE)			0.15			
Carbon Tetrachloride Extract (CTE)						

advanced waste treatment will indicate, in part, the treatment requirements to produce a potable quality.

Perhaps the major problem in using reclaimed wastewater for potable use, from a public health standpoint, is the possibility of pathogenic contamination. In the period during 1961-1971, a good part of some 128 known outbreaks of disease or poisoning resulting in many cases of illness which were attributed to water chlorination failures. Several species of pathogenic viruses found in domestic wastes have survived for long periods of time after normal disinfection procedures. The relatively small number of viruses needed to cause infection, and the shortcomings of present practical disinfection technology contribute to the seriousness of the virus problem.

The presence of trace materials, not considered in potable water quality criteria because they are insignificant in natural potable supplies, can also lead to health problems. Industrial waste contamination of domestic water supplies is well documented and the presence of trace toxic materials in a reclaimed water may be expected. Among the trace materials causing ill effects on humans are mercury, and benzpyrene based materials. Unfortunately, the human incurred toxilogic and pathogenic effects of many trace materials present in collected domestic wastes are not presently known and further research seems appropriate before direct reuse of water for potable use is considered. Specific contaminant problems in treated wastewater is discussed in more detail in Appendix F.

2. Policies

Treatment of wastewater for direct reuse as a potable supply has not historically been a popular nor a recommended practice. Indeed, only one such example exists to the present in South Africa. Technical, psychological, political and other factors have led many authorities to recommend against this practice.

Since drinking water must meet strict water quality criteria, assurance must be made that these standards will be met at all times. This assurance may be lacking since direct reuse of wastewater is limited as follows: 1) the potential for toxic substances in reclaimed water is high and variable, 2) fail safe monitoring has not yet been developed and, 3) the devices for detecting low levels of toxic substances are not adequate for quality control.

The Public Health Service Drinking Water Standards should not apply to reclaimed wastewater since specific organic chemical limits are not included, and BOD limits are unspecified. Additionally, the PHS drinking water standards state that "the water supply should be obtained from the most desirable source which is feasible, and effort should be made to prevent or control pollution of the source." Direct reuse of wastewater does not appear to be the most desirable method of obtaining potable water in the present or near future. Indeed, proper water and wastewater management may preclude the need for water reclamation for direct potable use in the long range.

It is the opinion of the AWWA that the current state of technology has not advanced sufficiently to permit direct reuse of wastewater for a public water supply source. While encouraging reuse for industrial, agricultural and recreational purposes, it advises that direct reuse for public consumption should be deferred until research and development demonstrates that such use will not be determinental to the health of the public. Ground water recharge, within the limits of historical practice, is considered a beneficial method for increasing the potable water supplies. Land use in wastewater-water supply management is discussed in detail in Appendix E, "Land Orientated Systems for Renovated Wastewater Reuse".

3. Information Required

An overall analysis of the problems associated with the direct reuse of treated wastewater indicates that there is much work to be done before such projects could be safely implemented. The background problems suggest that a very careful plan should be initiated directed toward research and development of all technical problems, upgrading water treatment management and the education of everyone on the need for reuse of wastewater. At this point it would be wise to delay the implementation of such projects until such time that the effect of renovated water on man and his activities is fully defined and guaranteed safe from any health hazards and other related problems resulting from altering nature's normal cycle.

Areas where additional information are required are as follows:

a) Additional studies must be done on the virological aspect of drinking water and similarly it must be started on renovated wastewater. These studies include development of improved viral detection and enumeration methodology; transmission of viruses via aquatic environment must be expounded; definition of the impact of viruses on man through associated epidemiological studies; and development of technology for the positive inactivation and removal of viruses.

The recent NEWS study on "The Consideration of Viruses on Potomac Estuary Water Supply" concluded that no definite pattern can be derived at this time to categorize the relative resistance of all existing types of enteric viruses. It is suggested that in order to get full assurance on the effectiveness of chlorination process, an examination of all known types and strains of human enteric viruses relative to chlorination must be expanded.

In the virus removal technique by phosphate precipitation, studies must be initiated on the resultant sludge containing the viruses. What actually happened to the viruses, its effect, and the best way to handle this virus-filled sludge must be carefully studied.

b) The potential problem of bacteria and other micro-organisms in reclamation systems must be investigated.

c) Identify and define the potential health effects of organic and other chemicals not removed by reclamation plants and subject to buildup and develop techniques to identify and measure readily the concentration of such chemicals.

d) Develop a systematic program to educate the public on the need of reusing treated wastewater. It may be worthwhile to mention that the establishment of recreational reservoirs such as Indian Creek at the Tahoe project and Santee Lakes at the Santee project (California) have helped favorable public reaction to water reuse immeasurably.

C. RENOVATED WASTEWATER FOR INDUSTRIAL, AGRICULTURAL AND RECREATIONAL USE

The potential of reclaimed wastewater for industrial use is great, and as yet has not been fully realized. Industrial water and irrigation needs in the

United States are estimated at 290 bgd for 1980. Domestic use for this projection is at 20 bgd. Therefore, the need for water in industry far exceeds the domestic needs, and if high quality water for potable supplies are to be conserved, greater use of reclaimed wastewater for industrial uses must be more widely practiced.

Industrial and agricultural water quality needs are, in most cases, far less demanding than potable water quality criteria. There are many examples of industrial, agricultural and recreational uses of reclaimed wastewater. A few pertinent examples follow.

Reclaimed wastewater from the South Lake Tahoe Treatment Plant is used for multiple purposes. A 165-acre lake in Alpine County, California, storing over one billion gallons of reclaimed wastewater, has been formed from Lake Tahoe's effluent. The lake affords a great recreational area and water released to Indian Creek is used for irrigation on a seasonal basis.

At Coachella Valley, California, over 3/4 of its 4.8 mgd domestic wastewater is reclaimed. In addition to ground recharge, secondary effluent is used for irrigation of alfalfa, cotton, sugar beets, and shrubbery and for a golf course lake.

At Amarillo, Texas, cooling water and boiler-makeup water for the Texas Company's refinery is treated secondary effluent. Chemical phosphate removal is accomplished at the refinery, and it was indicated that a well operated activated sludge plant should produce effluents that are of sufficient quality for industrial use.

Synthetic fibre, paper, power and steel processing industries use reclaimed wastewater in Monterrey, Mexico. Bethlehem Steel has been using reclaimed wastewater in Baltimore for over 20 years. Domestic uses, including household watering, cleansing and toilet flushing may also be feasible.

Tables D-2 and D-3 present water quality data for various industrial and agricultural uses. It is possible to produce waters of this quality with existing wastewater treatment technology.

TABLE D-2

RECOMMENDED LIMITING CONCENTRATIONS FOR INDUSTRIAL PROCESS WATERS

Source: FWPCA, Water Quality Criteria, 1968

SUBSTANCE	Air Conditioning	Baking	Boiler Feed (<250 psi)	Brewing	Carbonated Beverage	Confectionary
Turbidity (Units)		10		0-10	1-2	
Color (Units)		10		0-10	5-10	
Odor (Threshold Odor No.)	Low	None-Low		None-Low	None-Low	Low
Taste	Low	None-Low		None-Low	None-Low	Low
Alkyl Benzene Sulfonate (ABS)						
Aluminum (Al)						
Arsenic (As)						
Barium (Ba)						
Chloride (Cl)				60-100	250	
Cadmium (Cd)						
Chromium (Cr^{+6})						
Copper (Cu)						
Carbon Chloroform Extract (CCE)						
Cyanide (Cn)						
Iron (Fe)	0.5	0.2		0.1	0.1-0.2	0.2
Lead (Pb)						
Manganese (Mn)	0.5	0.2		0.1	0.2	0.2
Nitrate (NO_3)						
Phenols (C_6H_5OH)						
Selenium (Se)						
Silver (Ag)						
Sulfate ($SO_4^{=}$)					250	
Total Dissolved Solids (TDS)			3000-5000	500-1500	850	50-100
Zinc (Zn)						
Fluoride (F)				1.0	0.2-1.0	
Silica (SiO_2)			100-133			
Hardness (As $CaCO_3$)			0		200-250	Soft
Suspended Solids (S.S.)			300-600			
Phosphate ($PO_4^{=}$)			40-80			
Bicarbonate (HCO_3)						
COD					1.5	
BOD_5						
Calcium (Ca)						
Magnesium (Mg)						
Ammonia (NH_3)						
Total Alkalinity (As $CaCO_3$)				75-80	50-130	
Hydrogen Sulfide (H_2S)		0.2		0.2	0-0.2	0.2
pH (Value)			9.5	6.5-7.0		> 7.0
Acidity (As $CaCO_3$)						

TABLE D-2 (cont.)

RECOMMENDED LIMITING CONCENTRATIONS FOR INDUSTRIAL PROCESS WATERS

SUBSTANCE	Cooling	Dairy	Food Canning & Freezing	Food Equipment Washing	Food Processing-General	Ice
Turbidity (Units)	50		1-10	1	1-10	5
Color (Units)		None	5	5-20	5-10	5
Odor (Threshold Odor No.)		None	None-Low	None	Low	Low
Taste		None	None-Low	None	Low	Low
Alkyl Benzene Sulfonate (ABS)						
Aluminum (Al)						
Arsenic (As)						
Barium (Ba)						
Chloride (Cl)		30	250	250		
Cadmium (Cd)						
Chromium (Cr^{+6})						
Copper (Cu)						
Carbon Chloroform Extract (CCE)						
Cyanide (Cn)						
Iron (Fe)	0.5	0.1-0.3	0.2		0.2	0.2
Lead (Pb)						
Manganese (Mn)	0.5	0.03-0.1	0.2		0.2	0.2
Nitrate (NO_3)		24.2	10			
Phenols (C_6H_5OH)			0			
Selenium (Se)						
Silver (Ag)						
Sulfate ($SO_4^{=}$)		60	250			
Total Dissolved Solids (TDS)	2000		500-850	850	850	170-1300
Zinc (Zn)						
Fluoride (F)			1.0	1.0	1.0	
Silica (SiO_2)			50			10
Hardness (As $CaCO_3$)	Low	180	25-400	10	10-250	
Suspended Solids (S.S.)			10			
Phosphate ($PO_4^{=}$)						
Bicarbonate (HCO_3)						
COD						
BOD_5						
Calcium (Ca)			100			
Magnesium (Mg)						
Ammonia (NH_3)		Trace	0.5			
Total Alkalinity (As $CaCO_3$)	Low		30-250		30-250	
Hydrogen Sulfide (H_2S)	5		1.0			
pH (Value)		6.8-8.5	6.5-8.5			
Acidity (As $CaCO_3$)			0			
Methelene Blue Active Substances (MBAS)						
Carbon Alcohol Extract (CAE)						
Carbon Tetrachloride Extract (CTE)			0.2			
Total Solids (T.S.)		500				
Nitrite (NO_2)		0	0			

TABLE D-2 (cont.)

RECOMMENDED LIMITING CONCENTRATIONS FOR INDUSTRIAL PROCESS WATERS

SUBSTANCE	Laundering	Paper and Pulp-fine	Paper, Ground Wood	Paper, Kraft Bleached	Paper, Kraft Unbleached	Paper, Soda & Sulfate Pulps
Turbidity (Units)		10	50	40	100	25
Color (Units)		5	30	10-25	30-100	5
Odor (Threshold Odor No.)						
Taste						
Alkyl Benzene Sulfonate (ABS)						
Aluminum (Al)						
Arsenic (As)						
Barium (Ba)						
Chloride (Cl)			75	200	200	75
Cadmium (Cd)						
Chromium (Cr^{+6})						
Copper (Cu)						
Carbon Chloroform Extract (CCE)						
Cyanide (Cn)						
Iron (Fe)	0.2-1.0	0.1	0.3	0.1-0.2	1.0	0.1
Lead (Pb)						
Manganese (Mn)	0.2	0.05	0.1	0.05-0.1	0.5	0.05
Nitrate (NO_3)						
Phenols (C_6H_5OH)						
Selenium (Se)						
Silver (Ag)						
Sulfate (SO_4)						
Total Dissolved Solids (TDS)		200	500	300	500	250
Zinc (Zn)						
Fluoride (F)						
Silica (SiO_2)		20	50	50	100	20
Hardness (As $CaCO_3$)	0-50	100	200	100	200	100
Suspended Solids (S.S.)				10	10	
Phosphate ($PO_4^{=}$)						
Bicarbonate (HCO_3)						
COD						
BOD_5						
Calcium (Ca)				20	20	
Magnesium (Mg)				12	12	
Ammonia (NH_3)						
Total Alkalinity (As $CaCO_3$)	60	75	150	75	150	75
Hydrogen Sulfide (H_2S)						
Ph (Value)	6.0-6.8			6-10	6-10	
Acidity (As $CaCO_3$)						

TABLE D-2 (cont.)

RECOMMENDED LIMITING CONCENTRATIONS FOR INDUSTRIAL PROCESS WATERS

SUBSTANCE	Rayon & Acetate Fiber	Rayon	Sugar	Tanning	Textile	Plastics & resins
Turbidity (Units)	5	0.3		20	0.3-25	2
Color (Units)	5			5-100	0-70	2
Odor (Threshold Odor No.)						
Taste						
Alkyl Benzene Sulfonate (ABS)						
Aluminum (Al)						
Arsenic (As)						
Barium (Ba)						
Chloride (Cl)			20	250	100	0
Cadmium (Cd)					None	
Chromium (Cr^{+6})					None	
Copper (Cu)	5				None	
Carbon Chloroform Extract (CCE)						
Cyanide (Cn)						
Iron (Fe)	0.05	0	0.1	0.1-.5	0.1-1.0	0.005-0.2
Lead (Pb)					None	
Manganese (Mn)	0.02	0		0.1-0.2	0.05-1.0	0.005-0.02
Nitrate (NO_3)						0
Phenols (C_6H_5OH)						
Selenium (Se)						
Silver (Ag)						
Sulfate ($SO_4^{=}$)			20	250	100	0-200
Total Dissolved Solids (TDS)			Low		100	1.0
Zinc (Zn)					None	
Fluoride (F)						
Silica (SiO_2)						0.02
Hardness (As $CaCO_3$)	8	55	Low	50-500	0-50	0
Suspended Solids (S.S.)					5.0	2.0
Phosphate ($PO_4^{=}$)						
Bicarbonate (HCO_3)			100	Low	122	0.1
COD					8	
BOD_5						
Calcium (Ca)			20	60	10	0
Magnesium (Mg)			100		5	0
Total Alkalinity (As $CaCO_3$)	50-75			130		1.0
Hydrogen Sulfide (H_2S)						
Ph (Value)		7.8-8.3		6.0-8.0	2.0-10.5	7.5-8.5
Acidity (As $CaCO_3$)						
Methelene Blue Active Substances (MBAS)						
Carbon Alcohol Extract (CAE)						
Carbon Tetrachloride Extract (CTE)						
Total Solids (T.S.)	100					200

TABLE D-2 (cont.)

RECOMMENDED LIMITING CONCENTRATIONS FOR INDUSTRIAL PROCESS WATERS

SUBSTANCE	Farmstead	Livestock	Irrigation Long - Term	Irrigation Short - Term	Hydraulic Cement	
Turbidity (Units)	Sub. Free					
Color (Units)	15					
Odor (Threshold Odor No.)	Sub. Free					
Taste	Sub. Free					
Alkyl Benzene Sulfonate (ABS)						
Aluminum (Al)			1.0	20.0		
Arsenic (As)	0.05	<0.05	1.0	10.0		
Barium (Ba)	1.00		5.0	20.0		
Chloride (Cl)			355-780	355-780	250	
Cadmium (Cd)	0.01	<0.01	0.005	0.05		
Chromium (Cr^{+6})	0.05	<0.05	5.0	20.0		
Copper (Cu)	1.0		0.2	5.0		
Carbon Chloroform Extract (CCE)						
Cyanide (Cn)	0.2					
Iron (Fe)	0.3				25	
Lead (Pb)	0.05	<0.05	5.0	20.0		
Manganese (Mn)	0.05		2.0	20.0	0.2-0.5	
Nitrate (NO_3) as N	45.0					
Phenols (C_6H_5OH)						
Selenium (Se)	0.01	<0.01	0.05	0.05		
Silver (Ag)	0.05					
Sulfate ($SO_4^{=}$)					250	
Total Dissolved Solids (TDS)		<10,000			600	
Zinc (Zn)	5.0		5.0	10.0		
Fluoride (F)	0.7-1.2	<2.4				
Silica (SiO_2)					35	
Hardness (As $CaCO_3$)					400-500	
Suspended Solids (S.S.)					500	
Phosphate ($PO_4^{=}$)						
Bicarbonate (HCO_3)						
COD						
BOD_5						
Calcium (Ca)						
Magnesium (Mg)						
Ammonia (NH_3)						
Total Alkalinity (As $CaCO_3$)					400	
Hydrogen Sulfide (H_2S)						
pH (Value)	6.0-8.5		4.5-9.0		6.5-8.5	
Acidity (As $CaCO_3$)						
Methelene Blue Active Substance (MBAS)						
Carbon Alcohol Extract (CAE)						
Carbon Tetrachloride Extract (CTE)					1.0	

TABLE D-2 (cont.)

RECOMMENDED LIMITING CONCENTRATIONS FOR INDUSTRIAL PROCESS WATERS

SUBSTANCE	Farmstead	Livestock	Irrigation Long - Term	Irrigation Short - Term	Hydraulic Cement	
Turbidity (Units)	Sub. Free					
Color (Units)	15					
Odor (Threshold Odor No.)	Sub. Free					
Taste	Sub. Free					
Alkyl Benzene Sulfonate (ABS)						
Aluminum (Al)			1.0	20.0		
Arsenic (As)	0.05	<0.05	1.0	10.0		
Barium (Ba)	1.00		5.0	20.0		
Chloride (Cl)			355-780	355-780	250	
Cadmium (Cd)	0.01	<0.01	0.005	0.05		
Chromium (Cr^{+6})	0.05	<0.05	5.0	20.0		
Copper (Cu)	1.0		0.2	5.0		
Carbon Chloroform Extract (CCE)						
Cyanide (Cn)	0.2					
Iron (Fe)	0.3				25	
Lead (Pb)	0.05	<0.05	5.0	20.0		
Manganese (Mn)	0.05		2.0	20.0	0.2-0.5	
Nitrate (NO_3) as N	45.0					
Phenols (C_6H_5OH)						
Selenium (Se)	0.01	<0.01	0.05	0.05		
Silver (Ag)	0.05					
Sulfate ($SO_4^=$)					250	
Total Dissolved Solids (TDS)		<10000			600	
Zinc (Zn)	5.0		5.0	10.0		
Fluoride (F)	0.7-1.2	<2.4				
Silica (SiO_2)					35	
Hardness (As $CaCO_3$)					400-500	
Suspended Solids (S.S.)					500	
Phosphate ($PO_4^{\equiv}$)						
Bicarbonate (HCO_3)						
COD						
BOD_5						
Calcium (Ca)						
Magnesium (Mg)						
Ammonia (NH_3)						
Total Alkalinity (As $CaCO_3$)					400	
Hydrogen Sulfide (H_2S)						
pH (Value)	6.0-8.5		4.5-9.0		6.5-8.5	
Acidity (As $CaCO_3$)						
Methelene Blue Active Substance (MBAS)						
Carbon Alcohol Extract (CAE)						
Carbon Tetrachloride Extract (CTE)					1.0	

TABLE D-3
SPECIFIC QUALITY CHARACTERISTICS OF SURFACE WATERS THAT HAVE BEEN USED AS SOURCES FOR INDUSTRIAL WATER SUPPLY

SUBSTANCE	Boiler Makeup Industrial 0-1500 psig	Boiler Makeup Utility 700-5000 psig	Cooling Fresh Once-Through	Cooling Fresh Recycle	Cooling Brackish Once-Through	Cooling Brackish Recycle
Turbidity (Units)						
Color (Units)	1200	1200		1200		
Odor (Threshold Odor No.)						
Taste						
Alkyl Benzene Sulfonate (ABS)						
Aluminum (Al)	3	3	3	3		
Arsenic (As)						
Barium (Ba)						
Chloride (Cl)	19000	19000	600	500	22000	22000
Cadmium (Cd)						
Chromium (Cr^{+6})						
Copper (Cu)						
Carbon Chloroform Extract (CCE)						
Cyanide (Cn)						
Iron (Fe)	80	80	14	80	1.0	1.0
Lead (Pb)						
Manganese (Mn)	10	10	2.5	10	0.02	0.02
Nitrate (NO_3)			30	30		
Phenols (C_6H_5OH)						
Selenium (Se)						
Silver (Ag)						
Sulfate ($SO_4^=$)	1400	1400	680	680	2700	2700
Total Dissolved Solids (TDS)	35000	35000	1000	1000	35000	35000
Zinc (Zn)						
Fluoride (F)						
Silica (SiO_2)	150	150	50	150	25	25
Hardness (As $CaCO_3$)	5000	5000	850	850	7000	7000
Suspended Solids (S.S.)	15000	15000	5000	15000	250	250
Phosphate ($PO_4^{\equiv}$)		50	4	4	5	5
Bicarbonate (HCO_3)	600	600	600	600	180	180
COD	100	500		100		200
BOD_5						
Calcium (Ca)			500	500	1200	1200
Magnesium (Mg)						
Ammonia (NH_3)						
Total Alkalinity (As $CaCO_3$)	500	500	500	500	150	150
Hydrogen Sulfide (H_2S)					4	4
pH (Value)			5.0-8.9	3.5-9.1	5.0-8.4	5.0-8.4
Acidity (As $CaCO_3$)	1000	1000	0	200	0	0
Methelene Blue Active Substance (MBAS)	2	10	1.3	1.3		1.3
Carbon Alcohol Extract (CAE)						
Carbon Tetrachloride Extract (CTE)	100	100		100		100

Source: FWPCA, Water Quality Criteria, 1968.

TABLE D-3 (cont)
SPECIFIC QUALITY CHARACTERISTICS OF SURFACE WATERS THAT HAVE BEEN USED AS SOURCES FOR INDUSTRIAL WATER SUPPLY

SUBSTANCE	Textile	Lumber	Paper	Chemical	Petroleum	Metal
Turbidity (Units)						
Color (Units)			360	500	25	
Odor (Threshold Odor No.)						
Taste						
Alkyl Benzene Sulfonate (ABS)						
Aluminum (Al)						
Barium (Ba)						
Arsenic (As)						
Chloride (Cl)			200	500	1600	500
Cadmium (Cd)						
Chromium (Cr^{+6})						
Copper (Cu)	0.5					
Carbon Chloroform Extract (CCE)						
Cyanide (Cn)						
Iron (Fe)	0.3		2.6	5	15	
Manganese (Mn)	1.0			2		
Nitrate (NO_3)					8	
Phenols (C_6H_5OH)						
Selenium (Se)						
Silver (Ag)						
Sulfate ($SO_4^{=}$)				850	570	
Total Dissolved Solids (TDS)	150		1080	2500	3500	1500
Zinc (Zn)						
Fluoride (F)					1.2	
Silica (SiO_2)			50		50	
Hardness (As $CaCO_3$)	120		475	1000	900	1000
Suspended Solids (S.S.)	1000			10000	5000	3000
Phosphate ($PO_4^{\equiv}$)						
Bicarbonate (HCO_3)				600	480	
COD						
BOD_5						
Calcium (Ca)				200	220	
Magnesium (Mg)				100	85	
Ammonia (NH_3)						
Total Alkalinity (As $CaCO_3$)				500		200
Hydrogen Sulfide (H_2S)						
pH (Value)	6.0-8.0	5.0-9.0	4.6-9.4	5.5-9.0	6.0-9.0	3.0-9.0
Acidity (As $CaCO_3$)						75
Methelene Blue Active Substance (MBAS)						
Carbon Acetate Extract (CAE)						
Carbon Tetrachloride Extract (CTE)						30

APPENDIX E

LAND ORIENTATED SYSTEMS FOR RENOVATED WASTEWATER

APPENDIX E - LAND ORIENTATED SYSTEMS FOR RENOVATED WASTEWATER

Land application of raw and treated wastewater has been practiced for waste treatment, ground water recharge, ground water protection, nutrient removal and irrigational purposes. A variety of methods are used for these purposes including spray irrigation, ridge and furrow irrigation, seapage ponds, septic tanks and well injection.

A. INDIRECT REUSE OF WASTEWATER BY GROUND WATER RECHARGE

Indirect reuse of wastewater via the ground water recharge route is an established practice for some time. There are at least 26 states which practice artificial ground water recharge in the United States, although surface discharge of wastewater effluents to natural water courses is still the most popular means of disposal.

Ground water basins provide a natural reservoir large enough to hold several years of water supply and thus enable compensation throughout wet and dry periods. Evaporation losses are little if any in the ground water basin. Development or enhancement can be carried out in stages correlating with population development and available capital.

The State of California provides an excellent example of widespread artificial ground water recharge. As of 1958, 276 separate recharge sites were existing, distributing 630,000 acre-feet of water in 63 recharge projects, which amounts to a recharge rate of 563 mgd. Purposes of ground water recharge are multiple, and include water conservation by preventing sea water intrusion and direct increase of ground water capacity, improvement of water quality, improvement of ground water retrieval efficiency and solving of other specific problems.

Implementation of ground water recharge is accomplished through a variety of methods including: 1) flooding basins, 2) pits, 3) ditches, 4) furrows, 5) modified stream beds and 6) injection wells.

The feasibility of ground water recharge for a particular location must be studied in all cases. Positive conclusions to basic questions are necessary

to finally recommend ground water recharge for wastewater renovation. The first question to investigate is whether or not there is an historical basis for artificial recharge in the locality. Community acceptance of recharge depends upon the extent of previous practice. Health aspects are paramount when considering wastewater reuse, (be this direct or indirect) and community acceptance is more likely where precedence exists.

The second basic question to answer deals with the necessity of increased water supply. Increased population, industrialization and increasing per capita usage present new demands on a diminishing resource. Urbanization, salt water intrusion and new sewers which discharge wastes to the ocean which otherwise would have recharged the ground water supply, all contribute to the dimunition of existing water resources.

Technical feasibility of recharge is the third question to consider. Geological considerations in the area determine the technological feasibility.

The fourth question to consider is the reliability of meeting potable water standards where public supply wells tap the recharge or connected aquifer. Perhaps the most important aspect of ground water recharge with reclaimed wastewater is the nitrate problem in systems where nitrates will reach potable water supplies and surface waters.

B. CONSIDERATIONS TO BE INVESTIGATED IN LAND APPLICATION OF WASTEWATER

1. Geohydrological Considerations

Geohydrologic aspects of land application of domestic wastewaters are investigated for the following reasons:

a) To determine need for wastewater renovation, wastewater disposal and/or water pollution prevention.

b) To determine best method of land application.

c) To determine a design basis for an application system to optimize cost and minimize undesirable effects.

Investigations of geohydrologic aspects should be comprehensive and encompass a wide variety of information. The types of investigations necessary are:

Hydrologic Studies: Hydrologic studies determine the need for water in a particular area. Analysis of all aspects of the natural water cycle would be considered. Need for water can be then correlated with other aspects of a land application study to determine the type and operation of a land disposal system.

Geological Studies: These studies are basic to determine the type and operation of a land application of domestic waste. Specifically, the general areas to be considered are: Regional topographic characteristics and soil characteristics (chemical, biological and mineralogical).

2. Wastewater Characteristics

Wastewater characteristics will help determine what application method can be used; what degree of pretreatment is necessary, and what location is compatible to each method of application. The most important parameters are: pH, nitrogen (ammonia, nitrates), other pollutants, specific ion concentrations, waste variation.

Nutrients in the waste may be beneficial to the land's ability to support crops and in direct nutrient uptake by crops from the waste. However, a limited amount is used for these purposes and saturation with nutrients may cause the nutrients to pass through the soil into the ground water or collection system. An evaluation of secondary domestic sewage effluent as a fertilizer may be made.

3) Agricultural

Agricultural considerations include: type of crop, nutrient uptake, harvesting rate, crop value. Cover crops may serve the following purposes:

a) Provide a protective habitat for organisms.
b) Keep surface aerobic.
c) Increase infiltration rate.
d) Adsorb nutrients.
e) Protect soil from erosion.

4. Infiltration Rates - Application Rates

Infiltration rates are directly dependent upon soil conditions, wastewater characteristics and application method (type and schedule). Infiltration rates for spray irrigation are an order of magnitude less than those for spreading. Soil pretreatment with vegetation, organic residues or chemicals can increase infiltration rates.

Application rates are generally expressed as inches or feet of waste applied per period of time. Application rates will depend primarily on infiltration rates and the type of application used. However, rest periods are necessary and organic, nutrient, metal, sodium and salinity waste content may further limit application rates.

5) Economics

Costs of spreading is most directly associated with infiltration rates of the land. The costs are ultimately based upon the amount of land needed to dispose of the waste, i.e., the amount of collection piping or ditches, excavation, spray distribution systems, etc. Land costs have been found to exert only a small influence on spreading costs.

6) Environmental Evaluation Considerations

A detailed environmental evaluation will be necessary for each land application scheme. Environmental effects should be considered on ecological, hygienic, aesthetic and social levels.

C. IMPORTANCE OF NITROGEN

Nitrogen is present in raw sewage mainly as proteinaceous material and urea. It may be in organic form, or inorganically, as ammonia nitrates or nitrites. Typically raw sewage has an average concentration of 25 mg/l ammonia nitrogen,* 15 mg/l organic nitrogen* and small amounts of nitrate or nitrite nitrogen. In various locations, concentrations may be up to twice as high or as low as one-half the above amounts.

In aerobic biological treatment some ammonia is oxidized to nitrate and nitrite, however, nitrite is unstable and is rapidly oxidized to nitrate. Aerobic biological treatment effluents may have anywhere from 0 to 40 mg/l ammonia and 0 to 10 mg/l nitrate.

*as Nitrogen

Ammonia in secondary effluents will increase chlorine demands in disinfection and may be toxic to fish. Nitrate-nitrogen is a nutrient for aquatic growth including algae, and has been found responsible in part for algal blooms in concentrations over 0.3 mg/l (in quiescent lakes, however, phosphorus is the limiting nutrient in algal growth). The most important nitrate-nitrogen effect is that it can produce metheglobinemia in infants (blue babies) and therefore the United State Public Health Service limits its concentration to less than 10 mg/l in drinking water.

In considering wastewater management, nitrate-nitrogen must be limited so as not to contaminate potable supplies. On Long Island, various schemes of wastewater management have been considered, some of which offer the potential of nitrate contamination of ground water supplies. Moreover, nitrate contamination is presently evident in some locations on Long Island, attributable to domestic waste disposal in septic tanks. The nitrate problem specific to Long Island is discussed in Section IV-B of this report.

Considering wastewater as a water resource, and the proposals for Long Island to eliminate the loss of the resource, nitrate-nitrogen may well be the most important factor in choosing a wastewater management scheme. If, for example, wastewater is recharged into an aquifer, nitrate contamination must be avoided. There are two options to consider to prevent the use of nitrate contaminated water; remove nitrates before they reach the ground water; remove nitrates from ground water before its distribution for human consumption. The first option may be accomplished in the sewage treatment plant, or through proper design and operation of land application or recharge methods, and the second may be accomplished in the water treatment plant. A discussion of various treatment and disposal methods for nitrate removal is recorded in the following paragraphs. A detailed examination of the state of the art of nitrogen removal is beyond the scope of this study, and thus the discussion is of a general nature. However, it will be possible to point out the most promising methods, as they relate to a wastewater management-water supply development plan.

At the current stage of development, wastewater treatment for the removal of nitrogen requires a biological process in most instances. Air stripping of ammonia

may be impractical because of its cost and scaling problems, and possible biological nitrification of ammonia-nitrogen to nitrate-nitrogen. Additionally, climate limitations and readsorption of ammonia gas in surrounding waters may make air stripping locally impractical. Ion exchange may be feasible in small plants, however, resin fouling, resin slugging, and regeneration liquid disposal make this process undesirable for wastewater treatment. Electrodialysis, reverse osmosis and distillation provide satisfactory nitrogen removal, however, they are too costly for wastewaters to be discharged to surface waters and may only find interest in wastewater that is to be reused.

D. SOIL MECHANISMS RESPONSIBLE FOR NITROGEN REMOVAL IN LAND APPLICATION OF DOMESTIC SEWAGE TREATMENT PLANT EFFLUENT

1. Filtration: Filtration of secondary treated wastewater through soil has been found to remove as much as 90% of the nitrogen compounds applied to the soil, in addition to most biodegradable material and fecal coliforms. Nitrogen removed by land application is either stored in the soil, removed by diffusion to the atmosphere or removed as cell tissue in harvested cover crops. Nitrogen not removed in land applications can reach ground water as either ammonia-nitrogen or nitrate-nitrogen (depending on availability of oxygen).

2. Biological nitrification and denitrification: Nitrification is the process of oxidizing ammonia-nitrogen to nitrate-nitrogen, and occurs in aerobic soil systems (uppermost soil layers). Denitrification is the process of converting nitrate-nitrogen to elemental nitrogen anaerobically, where the source of oxygen is the nitrate-nitrogen. The conversion of nitrogen compounds to elemental nitrogen eliminates the problem of ground water contamination and surface water nitrification. The three basic conditions that are needed in establishing a denitrification system in secondary effluents are oxidation of ammonia to nitrate; passage through an anaerobic zone after oxidation to nitrate; and provision of an adequate energy source in the anaerobic zone for the denitrifying bacteria. Since about 90% of nitrogen present in the secondary effluent is ammonia nitrogen, nitrification must be effective to realize significant total nitrogen removal. Residence time

in an anaerobic zone must be provided for denitrification and soils with high infiltration rates, typically used in ground water recharge systems, will not provide enough time for the conversion of nitrates. Most of the carbon in the secondary effluent is utilized by the nitrifying bacteria before the waste reaches the anaerobic zone, and an additional carbon source for denitrification metabolism may be required. Both nitrification and denitrification have been sustained in the same soil profile in irrigated crop lands because of the presence of anaerobic pockets in essentially aerobic soils, however, denitrification has not been proven in a ground water recharge system.

3. Volatilization of Ammonia: Volatilization of ammonia requires a pH greater than 7 and considerable air water contact. It is estimated that less than 10% of the ammonia present can be volatilized at pH = 7.5-8.5 in a soil system, and thus may be considered insignificant.

4. Ammonia Adsorption: Ammonia is adsorbed by negatively charged clay and organic colloids present in soil, the amount of which is dependent on the cation exchange capacity of the soil (CEC). The CEC varies tremendously from soil to soil and is generally low in highly permeable sandy soils typical of ground water recharge systems. Additionally, calcium and magnesium present in the waste compete for exchange sites. Soils with irrigated crops have generally high CEC values, and may remove a significant amount of nitrogen as ammonia. However, due to intermittent dosing, nitrate nitrogen may be produced during the dry period and flushed out during the next dosing and travel to ground water sources.

5. Ammonia Fixation by Organics in Soil: Complex organic nitrogen compounds may be formed by fixation of ammonia by organics present in soil and have been found to be resistant to leaching and decomposition. This mechanism may account for a significant amount of ammonia removal, although ground water recharge systems would saturate this capacity within a few years. Irrigation systems have generally lower dosage rates and higher carbon content soils, both of which contribute to a much longer period before saturation is realized.

6. Nitrogen Conversion to Microbial Cell Tissue: Ammonia may be converted to microbial cell tissue since

most microbes easily assimilate nitrogen. Since the carbon to nitrogen ratio in microbial cell tissue is high and assuming a wastewater nitrogen concentration of 25 mg/l, a maximum of 5 to 10% of the ammonia present would be expected to be removed in this manner.

7. Removal of Nitrogen by Vegetation: Vegetation incorporates nitrogen into its tissue and this mechanism can be effective in nitrogen removal since nitrogen is completely removed from the system when the crop is harvested. Wastewater is normally applied in quantities adequate for crop production and water in excess of that consumed by crops will be added to the ground water, and therefore nitrogen compounds may find their way to the ground water. In one study, irrigation of wheat with secondary treatment effluent wastewater at 1 and 2 in./week removed 92 and 60% of the nitrogen respectively. Crop irrigation is usually limited by the amounts of nutrients the crop can take up, and the limiting nutrient in wastewater irrigation is usually nitrogen.

The best crop for this application is a perennial grass that has a long growing season and tolerates floods. Crops that have been used effectively include Bermuda grass, hay and Reed Canary grass. The optimum amount of wastewater applied without contamination of ground water will depend on the crop, the schedule of dosing, the climate and geohydrologic considerations. In one application about 82% of the nitrogen applied as fertilizer was recovered in a hay crop, corresponding to an application rate of slightly less than 15,000 gal./acre of secondary effluent (25 mg/l total nitrogen). In a well drained soil, 20 to 30% less volume applied may be required to achieve similar results and with a coastal Bermuda grass/small grain crop in an optimum location, 20 to 30% more may be applied with similar results. In comparison with a high rate ground water recharge system, crop irrigation requires an order of magnitude more land. For example, 1 mgd of secondary wastewater may require 80 acres for crop irrigation, while only four acres may be required for a high rate ground water recharge application.

The effectiveness of this method as a nitrogen removal technique must be studied in the actual location of application, where the nitrogen removal of other soil mechanisms can be measured concurrently to determine the total nitrogen removal efficiency. There is

some evidence that plants stimulate soil denitrification capacity, which would contribute to overall nitrogen removals.

E. LAND APPLICATION CONCLUSIONS

Natural chemical and biological processes occurring in soil offer a substantial potential for municipal wastewater reclamation when proper management and design are developed and maintained. Various groups within the consulting, governmental and research communities concerned with water pollution control have proposed the land disposal method as a primary technique to reach "zero discharge" by 1985. Of course, this method is not a new one and in all applications there have been and are critical technical problems to be answered. Questions to be answered deal with the universality of the concept's application, soil characteristics, soil capabilities, build up of salts, nutrients and heavy metals, odor problems, land availability and cost, capital costs, operating and maintenance costs and the ultimate effects on ground and surface water quality. These questions require detailed study for each proposed land application. More detailed engineering and operating experience must reach the engineering community so that they can better evaluate land disposal feasibility.

APPENDIX F

SPECIFIC CONTAMINANT PROBLEMS IN TREATED WASTEWATER

APPENDIX F - SPECIFIC CONTAMINANT PROBLEMS IN TREATED WASTEWATER

A. VIRUSES

The recognized groups of human viruses that are discharged in large numbers in feces and have a long survival in the water environment include: the enteroviruses, having the subgroups of polioviruses, coxsackieviruses and echoviruses; the viruses of infectious hepatitis; the adenoviruses; and reoviruses. A summary of these human enteric viruses is presented in Table F-1. As indicated in this table, the latter agents have not been positively isolated or identified by any laboratory procedure to date. There have been 53 outbreaks of infectious hepatitis and eight outbreaks of poliomyelitis reported traced as waterborne in the literature. The following summarizes the major factors responsible for the endemic threat from viruses:

1. Low infectious dose of viruses - A very small number of virus particles constitute an infective dose for a susceptible host, as illustrated in Table F-2. Using poliovirus type 3 strain for premature infants, one plague forming unit (PFU) taken orally would infect 30 percent of the experimental group. A water supply contaminated even with only a low concentration of virus could result in widespread sporadic cases in a community.

2. Ratio of clinical to subclinical cases is very low. Clinical illness is observed in only a small fraction of those who become infected. For example, one of 100 - 1000 infections of a coxsackievirus or echovirus is actually ill. There is the danger therefore of an unrecognized major epidemic should the viral infection be predominantly subclinical in nature.

3. Immediate and Delayed Effects Caused by Some Viruses - A partial list of serious diseases associated with some viruses have been identified over the years and is listed in Table F-3.

Coxsackie viruses are recognized as teratogenic (capable of being produced in abnormally high numbers) agents and the affinity of these viruses to heart tissue is increasingly being recognized. Heart damage caused by these viruses may impair the patient's activity for many years and finally claim their lives.

TABLE F-1

HUMAN ENTERIC VIRUSES WHICH CAN BE WATERBORNE

Group	Subgroup	# of types or subtypes	Type of nucleic acid	Size (diameter)	Reaction to	
					Ether	pH 3.0
Enterovirus	Poliovirus	3	RNA	28 mμ	Resistant	Stable
	Echovirus	31	"	"	"	"
	Coxsackievirus					
	A	24	"	"	"	"
	B	6	"	"	"	"
Reovirus		6	"	70 - 77 mμ	"	"
Adenovirus		31	DNA	60 - 85 mμ	"	"
Hepatitis		>1	?		"	"
Unknown		?				
Total		>102				

SOURCE: News Study - Potomac Estuary Water Supply: The Consideration of Viruses (1971)

TABLE F-2

MINIMAL INFECTIVE DOSES OF ATTENUATED POLIOVIRUS

FOR HUMAN HOSTS BY ORAL ROUTE

Hosts	Virus	Dose (PFU's)	Carrier rate	% infected
Adults	Poliovirus type 1 (SM strain)	200	4/4*	100
		20	4/4	100
		2	2/3	67
		0.2	0/2	0
Premature infants	Poliovirus type 3 (Fox strain)	10	2/3	67
		2.5	3/9	33
		1	3/10	30

* Number of persons developed into carrier for the virus/Number of persons who had taken the virus orally.

SOURCE: News Study - Potomac Water Supply: The Consideration of Viruses

TABLE F-3
RECENT REPORTS ON CLINICAL ILLNESSES ASSOCIATED WITH HUMAN ENTERIC VIRUSES

	Disease	Virus	Patients	Locale	References
(1)	Otitis conjunctivitis fatal pneumonia	Adeno 1,3, 6,7	16 infants	Moscow, U.S.S.R.	Oganasyan, O.T. Vop. Virus 12:582.
(2)	Acute appendicitis	Cox B and adeno	400+ cases all ages	Kyoto, Japan	Tobe, T. Lancet 1:1343, 1965.
(3)	Intussusception	Adeno	5-7 children	Formosa	Clark, Phillips & Alexander J.A.M.A. 208: 1671, 1969.
(4)	Subacute thyroiditis	Cox, Echo, adeno (Mumps, Infl.)	32 adults	Toronto, Canada	Volpe, R., et al J. Cl. End. 27: 1275, 1967.
(5)	Pericarditis myocarditis	Cox A9 Cox A9	3 young adults 9 young adults	Munich, Germany	Zollner, N., et al, Deutsch Med.
(6)	Interstitial myocarditis	Cox B	17 hearts from autopsy (to 30 years)	New Orleans, Louisiana	Burch, G.E., et al Am. J. Heart Dis. 75:13, 1967.
(7)	Valvulitis	Cox B	3 cases	?	?
(8)	Spontaneous abortion	Cox B	348 over normal average/month	Borinholm, Hungary	Czeizel, A. J.A.M.A. 201:142 1967.
(9)	Pericarditis	Cox B	12 adults 2 infants	Melbourne, Australia	Bennet, N.M., et al Am. H.J., 1967.
(10)	Meningitis	Mostly echo A9	132 cases	Vienna and lower Austria	Rahl, H. Munchen Med. Wschr. 109:1900, 1967.
(11)	Insulin-dependent diabetes	Cox B4	100 young adults	England	Gamble & Taylor B.M.J. 3:631, 1969.
(12)	Congenital heart anomalies	Cox B3 & 4	26 infants	U.S.A.	Brown & Evans, J.A.M.A. 199: 183, 1967.
(13)	Acute myocarditis (fatal)	Echo 9	34 yr. old dentist	New York, New York	Monit, G.R.G., et al, New Eng. J. Med. 277: 1353, 1967.
(14)	Acute myocarditis (fatal)	Echo 22	14 yr. old boy with agamma globulinemia	Los Angeles, California	Maller, H.M., et al J. Pediat. 71: 204, 1967.
(15)	Paralytic poliomyelitis	Vaccine poliovirus	29 yr. old male	Seattle, Washington	Swanson, et al J.A.M.A. 201:771, 1967.
(16)	Paralytic poliomyelitis	Vaccine strains	87 cases	U.S.A.	Henderson, et al J.A.M.A. 190:41-48, 1964.
(17)	Paralytic poliomyelitis (both lower ext.)	Vaccine poliovirus type 2	43 yr. old female	Worcester, Massachusetts	Morse, L.J., et al, J.A.M.A. 197: 1034, 1966.

SOURCE: News Study (Mar.1973) Potomac Estuary Water Supply: The Consideration of Viruses

Coxsackievirus infection has been associated with the insulin-dependent diabetics and children.

It has been reported that there is a high incidence of congenital heart anomalies (heart defects in newborns) associated with the infection of pregnant women with Type B coxsackievirus during early pregnancy. About half of the infected cases are of subclinical nature and could only be detected by serological examination.

An immediate serious effect of notable concern is the acute interstitial myocarditis (inflammation of the heart's muscular tissue), which is associated with infection from echoviruses, and where death may result in a matter of days.

4. Uncertain Behaviour Exhibited by Some Viruses - One strain of coxsackievirus may produce meningitis in one person, myocarditis in another and diarrhea in the third. The widely different incubation periods and clinical manifestations of some viruses is one of the difficult problems associated with the epidemiological identification of a water-borne viral infection.

5. Differing Resistance of Viruses to Disinfection by Chlorination - Human enteric viruses differ in their reaction to free chlorine and their mortality rate is generally much slower than bacteria. The killing effect of free chlorine on some bacteria and on nine viruses is summarized in Table F-4. As indicated, Adenovirus Type 3 is the least resistant virus while Poliovirus Type 1 and Coxsackievirus Type B5 appear to be the most resistant viruses among those tested. The data indicates the high resistance of infectious hepatitis. These results were obtained from limited studies using human volunteers. To date, laboratory procedures for the detection of this virus is not yet advanced and a direct comparison of their resistance to chlorine at this time is at best an approximation.

B. BACTERIA

One known health hazard associated with enteric bacteria is demonstrated by the flavobacteria type which appears to be resistant to chlorination and capable of multipyling greatly, given the proper time and environment. This bacteria has been involved in four cases of septicemia (blood poisoning) following heart surgery.

TABLE F-4

GERMICIDAL EFFECT OF FREE CHLORINE IN WATER REPORTED IN LITERATURE

	Microorganism	Temp. °C.	Final pH	Free Cl mg/liter	Destruction %/min.
1.	S. typhi in DFW	20-25	7.0	0.06	>99.99/5
		20-25	8.5	0.06	>99.99/5
2.	E. coli in DFW	20-25	7.0	0.04	>99.99/5
		20-25	8.5	0.07	>99.99/5
3.	A. aerogenes in DFW	20-25	7.0	0.05	>99.99/5
4.	Sh. dysenteriae in DFW	20-25	7.0	0.05	>99.99/5
5.	Infectious hepatitis	25	6.4-6.9	0.40	0.0/30
	Treated H_2O)	25		1.08	No disease/30
	Untreated H_2O)	25		15.23	Attenuated/30
6.	Purified polio 1	0	7.0	0.53	99.6/4.5
	(Mahoney) in DFW	0	8.5	5.0	99.6/3
		25-28	7.0	0.21-0.30	99.9/3
		25-28	9.0	0.21-0.30	99.99/8
	(MK500) in DFW	1-5	7.0	0.30	99/16
7.	Purified polio 2	1-5	7.0	0.23	99.9/16
	(MEF_1) in DFW	25-28	7.0	0.11-0.20	99.9/2
8.	Purified polio 3 (Saukett) in DFW	1-5	7.0	0.11-0.20	99.9/30
9.	Purified coxsackie	3-6	6.8-7.1	1.9-2.2	99.6/4
	A2 in DFW	3-6	8.8-9.0	7.4-8.3	99.6/5
		27-29	6.9-7.1	0.1-0.18	99.6/4
		27-29	8.8-9.0	0.92-1.0	99.6/3
10.	Purified coxsackie B1 (49683) in DFW	25-28	7.0	0.21-0.30	99.9/8
11.	Purified coxsackie	1-5	7.0	0.30	99.9/16
	B5 (EA80) in DFW	25-28	7.0	0.21-0.30	99.9/1
		25-28	9.0	0.21-0.30	99.9/8
12.	Purified adeno	25	6.9-7.1	0.20	99.8/8-16"
	type 3 in DFW	25	8.8-9.0	0.20	99.8/40-50"

SOURCE: NEWS Study (Mar. 1973) Potomac Estuary Supply: The Consideration of Viruses

Some potential elements of advanced wastewater treatment which would be an integral part of purifying wastewater for direct reuse may result in undesirable effects. For instance, it is well known that bacterial growth occurs on dialysis and osmosis membranes, ion-exchange media and activated carbon media. Chlorine is normally employed to control bacterial growth, however, these growths may include the chlorine-resisting strains which upon continued recycling would result in concentration of these infectious agents.

C. OTHER INTERFERING ORGANISMS

Some organisms present in wastewaters have shown harmful health effects and have likewise interfered with man's activities as well as his environment. These include the following:

1. Some chlorine-resistant protozoans have been implicated in throat paralyzation in children and also in cases of cerebromeningitis (inflammation of the membrane enveloping the brain). Nematodes have been found in municipal water supplies and can serve as carriers for enteroviruses, salmonellae, and shigellae. Helminth infections as well as ascaris, trichuris and hookworm may be spread by the practice of utilizing wastewaters for the watering of gardens and lawns. During the post World War II years, several European countries, particularly Munich, Germany, experienced extensive infection of ascaris and trichuris resulting from the use of sewage effluent for irrigation purposes. Similarly, irrigation of pastures have been shown to infect cattle with beef tapeworm, which may consequently infect man.

2. Algae have been known to cause fish kills, both directly and indirectly. A fatal disease affecting the respiration of fish resulting from infected gills, has been traced to a few aquatic algae. There are many recorded events of acute and fatal poisoning of livestock and other animals who had been drinking from ponds containing algae blooms. Epidemics of gastrointestinal disturbances have been reported in the United States, possibly attributable to water supplies having extensive algae blooms at the time of the outbreaks. The algae implicated as toxic or toxic producing agents are all blue-green algae such as Anabena and Anacystis.

3. Objectionable Tastes and Odors - This is probably one of the major interfering characteristics which may cause immediate concern and complaints from the general public. Synura algae, in small numbers, produce an odor resembling that of a ripe cucumber and imparts a bitter taste to the water. In large numbers, this and other pigmented flagellates such as Dinobryon, impart a fishy odor.

4. Clogging of Sand Filters and Screens in Water Treatment Plants - Organisms causing this problem are blue-green algae and various diatoms and pigmented flagellates.

5. Water Flow Inhibition and Unsightly Surface Mats - Large amounts of algae growing on reservoir walls, concrete structures and submerged rocks and logs may reduce water flows in canals and increase surface friction. These growths may break away to form unsightly surface mats, and produce offensive odors. Among algae causing such problems are the filamentous green algae and some diatoms.

6. Some smaller algae may produce continuous, slimy, slippery layers on concrete and other surfaces that is undesirable or dangerous.

7. Corrosion of Concrete and Metal Tanks - Some algae may contribute to the corrosiveness of the water by changing its character through physical and chemical means. Green and blue algae growing on submerged concrete have caused the concrete to become pitted and friable.

8. Algae may interfere with the proper control of a water treatment plant. They can cause changes in pH, alkalinity, total hardness and dissolved oxygen of the raw water. Upon death they increase the organic content of the water. For instance, proper control of chlorine dosage is difficult since varying amounts of algae can be expected to be present at any one time. Coagulation requires a narrow pH range which is difficult to maintain due to algae presence.

D. CHEMICALS

The presence of chemicals in public water supply may cause serious or chronic effects on humans. Contamination from man's activities is an ever increasing

problem, concomitant with the growing popluation and the increasing utilization of water in all aspects of human endeavor.

Everything man produces must eventually be disposed of and, in most cases, the final recipient of by-product wastes are the waterways. A great deal of these wastes are either toxic or resist the natural degrading power of nature and present water and wastewater treatment practices.

The availability of a wide variety of toxic chemicals should give serious concern about the possibility of accidental discharge to public water supplies. As an example, it is reported that since 1969 the Ohio River received over a million gallons of exotic chemicals, such as vinyl cyanide, phenols, 2-4 di-isocyanate. It is estimated that only 20% of the toxic spills are being reported. Furthermore, the time to report these accidental spills may range from one day to one month.

On March 24, 1970 the Canadian government imposed a ban on the use of Lake St. Clair for both sport and commercial fishing. Mercury residues were found in fish taken from the lake, traced to the effluents from Chlor-alkali plants using the mercury cell process. This incident triggered nationwide investigations in the United States and it was found that mercury contamination is widespread. It was found that rivers and lakes had been receiving mercury for years in runoff from agricultural lands where mercury-containing compounds have been used as fungicides and from various industrial wastes discharges.

Through June 1971, the United States Division of Water Hygiene (DWH) has analyzed 698 samples of raw and finished waters collected from 273 communities, recreational areas and Federal installation water supplies in 31 states, the Virgin Islands and Puerto Rico. Of the 273 sources examined, 261 showed either no detectable mercury present or concentrations of less than 0.001 ppm, eleven showed concentrations ranged from 0.001 to 0.0048, while only one source showed a mercury concentration in excess of 0.005, which is the proposed allowable level of mercury in drinking water by the Division of Water Hygiene. Although the above findings indicate no serious health hazard, the presence of mercury in even one community water supply in excess of the proposed standard indicates a potential public health problem and emphasizes the need for continuing surveillance.

Scientists in Russia found that a combined concentration of arsenic and lead in excess of 0.1 mg/l would produce a significant interference in the activity of sulfhydryl groups (mercury, arsenic, lead, cadmium and silver) in the body and adversely affect the nervous system response.

Among other chemicals requiring further attention are such organic compounds as those containing a benzpyrene base and known to be carcinogenic. In addition, potential sex hormone effects resulting from the increasing use of birth control pills and their residue or byproducts may be returned to sewer systems.

These are only a few of the problems that require careful attention. More may come to attention as a result of further research and technology. To date, most of the detailed studies concerning the chronic health effects due to the various chemicals currently found in the United States waters have yet to be undertaken, and more importantly, it should be known that there is practically no information available relating to the health hazards of chemicals found in renovated water.

Studies on the characterization and toxicity of organics recovered by the carbon adsorption process, as well as the development of methods to recover organics not removed by this process, should be an important program in line with the direct reuse of renovated wastewater.

The significance of trace elements and compounds in United States water supplies and in finished drinking water is summarized in Tables F-5 and F-6 respectively.

TABLE F-5

HEALTH AND AESTHETIC SIGNIFICANCE OF TRACE ELEMENTS AND COMPOUNDS AND THEIR OCCURRENCE IN U.S. WATER SUPPLIES

Trace Element or Compound	Health or Aesthetic Effect	1962 USPHS Drinking-Water Standards Limit *mg/l*	Occurrence in US Water Supplies 2,595 Distribution Samples (1969) *mg/l*	
			Average	Range
Alkyl benzine sulfonate (ABS)	USPHS limit gives a safety factor of 15,000; not highly toxic	0.5*	0.05	0–0.41
Arsenic (As)	Serious systemic poison—100 mg usually causes severe poisoning, is cumulative, and may cause chronic effects. Late evidence indicates tiny amounts may be beneficial.	0.01* 0.05†	0.0001	<0.03–0.10
Chloride (Cl^-)	Limit set for taste reasons.	250.*	27.6	<1.0–1,950
Copper (Cu)	Body needs copper at level of about a mg/day for adults; not a health hazard except when large amounts are ingested.	1.*	0.13	0–8.35
Carbon chloroform Extract (CCE)	At limit stated, organics in water are not considered a health hazard.	0.2*	0.11	0.008–0.56
Cyanide (CN^{-4})	Rapid fatal poison, but limit set provides safety factor of about 100.	0.01* 0.2†	0.00009	<0.1–0.008
Fluoride (F^-)	Beneficial in small amounts; above 2,250 mg, dose can cause death.	0.7–1.2* 1.4–2.4†	0.32	<0.2–4.40
Nitrate (NO_3)	Excessive amounts can cause methemoglobinemia (blue baby) in infants.	45*	6.3	<0.1–127
Sulfate (SO_4)	Above 750 mg/l, usually has laxative effects.	250*	46	<1.0–770
Zinc (Zn)	Zinc is beneficial in that a child needs 0.3 mg/kg/day; 675–2,280 mg/l may be an emetic.	5*	0.19	0–13.0
Barium (Ba)	Fatal dose is 550–600 mg as the chloride; it is a muscle (including heart) stimulant.	1.0†	0.034	0–1.55
Cadmium (Cd)	13–15 ppm in food has caused illness.	0.01†	0.003	<0.2–3.94
Chromium (Cr^{+6})	Limit provides a safety factor. Carcinogenic when inhaled.	0.05†	0.0023	0–0.079
Lead (Pb)	Serious, cumulative, body poison.	0.05*	0.013	0–0.64
Selenium (Se)	Toxic to both humans and animals in large amounts. Late research suggests small amounts may be beneficial.	0.01†	0.003	0–0.07
Silver (Ag)	Can produce irreversible, adverse cosmetic changes.	0.05†	0.008	0–0.03
Radium (Ra-226)	A bone-seeking, internal alpha emitter that can destroy bone marrow.	3 pc/l‡	2.2 pc/l	0–135.9 pc/l
Strontium (SR-90)	A bone-seeking, internal beta emitter.	10 pc/l‡	<1.0 pc/l	0–2.0 pc/l

* Not to be exceeded where other more suitable supplies are, or can be made, available.
† Excess constitutes grounds for rejection of the supply.
‡ Consult 1962 "USPHS Drinking Water Standards" for interpretation.

SOURCE: F. B. Taylor: "Trace Elements & Compounds in Waters", Jour. AWWA, Nov.1971

TABLE F-6
HEALTH AND AESTHETIC SIGNIFICANCE OF TRACE ELEMENTS AND COMPOUNDS IN FINISHED DRINKING WATER

Name of Ingredient	Health or Aesthetic Effect	Unofficial Limit *mg/l*	Occurrence in US Water Supplies *mg/l*	
			Average	Range
Substance				
Antimony (Sb)	Similar to arsenic but less acute. Recommended limit not to exceed 0.1 mg/l; routinely below 0.05 mg/l; over long-time periods below 0.01 mg/l.	0.05		
Beryllium (Be)	Poisonous in some of its salts in occupational exposure.	None		
Bismuth (Bi)	A heavy metal in the arsenic family—avoid in water supplies.	None		
Boron (B)	Ingestion of large amounts can affect central nervous system, and protracted ingestion may cause borism.	1.0	0.069	0–3.28†
Cobalt (Co)	Beneficial in small amounts; about 7 μg/day.	None	0.002	0.0–0.019*
Molybdenum (Mo)	Necessary for plants and ruminants. Excessive intakes may be toxic to higher animals; acute or chronic effects not well-known.	None		
Mercury (Hg)	Continued ingestion or large amounts can damage brain and central nervous system.	0.005	0.000	0.000–0.039†
Nickel (Ni)	May cause dermatitis in sensitive people; doses of 30–73 mg of $NiSO_4 \cdot 6H_2O$ have produced toxic effects.	None	0.005	0.0–0.072*
Sodium (Na)	A beneficial and needed body element, but can be harmful to people with certain diseases.	20‡	40 per cent above 20 mg/l	0.4–1,900§
Tin (Sn)	Long used in food containers without known harmful effects.	None		
Uryanyl ion (UO_2)	May cause damage to kidneys.	5.0		
Vanadium (V)	Some evidence that vanadium may be beneficial with respect to heart disease.	None		
Pesticides				
Aldrin	One or all of these complex organic compounds have severe, acute, adverse health effects when ingested in large amounts. Small amounts accumulate, and long-range effects are generally unknown.	0.017**	160 samples in NCWWS showed lower values than the limits.	
Chlordane		0.003**		
DDT		0.042**		
Dieldrin		0.017**		
Endrin		0.001**		
Heptachlor		0.018**		
Heptachlor epoxide		0.018**		
Lindane		0.056**		
Methoxychlor		0.035**		
Toxaphene		0.005**		
Organic phosphorous plus carbamates, such as Parathion, Malathion, Carbaryl, and others	The organic phosphorous and carbamate pesticides are severe acute poisons affecting the central nervous system; ingestion of small amounts over time can harm the central nervous system.	0.1††	Same as for pesticides	
Herbicides				
Algicide	A group having toxic properties of a generally lower order than the above pesticides. However, they should not be used without great care and should not be found in drinking water.	1.0		
Copper key-El		1.0 (Cu)		
Cuprose		1.0 (Cu)		
Cutrine		1.0 (Cu)		
Diquot		0.2		
Dalapon		0.1		
2,4-D		1.0		
2,4,5-T should not be used.				
Micro-gard PR		0		
Mogul algicide AG-470		1.0		
Radapon		0.1		
Silvex (2,4,5-TP)		0.2		
Tordon 10K & 101		0		
Twink		0.2		
Ureabor		1.0 (as B)		

* National Community Water Supply Study. 2500 samples.
† Late data from BWH, USPHS.
‡ The amount at, and above, which people on strict (500 mgd) sodium-restricted diets must include in their daily sodium-intake calculations.
§ Survey of over 2,000 US municipalities by USPHS in 1963–66.
** Report of the Com. on Water Quality Criteria, FWPCA, US Dept. of the Interior.
†† As parathion equivalent in cholinesterase inhibition.

SOURCE: F. B. Taylor: "Trace Elements & Compounds in Waters", Jour. AWWA, Nov. 1971

APPENDIX G

SEWERAGE CONSTRUCTION PRIORITY LIST

NEW YORK, NEW JERSEY AND CONNECTICUT

SEWERAGE CONSTRUCTION
PRIORITY LIST

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NEW YORK

Project Description is Defined as Follows:

STP	-	Sewage Treatment Plant
STP ADD	-	Sewage Treatment Plant Addition
STP UP	-	Upgrading Existing Sewage Treatment Plant from Primary to Secondary
MOD	-	Modification
PS	-	Pump Station
FM	-	Force Main
OS	-	Outfall Sewer
INT	-	Interceptor

SEWERAGE CONSTRUCTION
PRIORITY LIST

—

NEW YORK

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
1	Tonawanda (T) Erie	STP UP;INT;OS
2	Oswego (C) (Westside) Oswego	STP UP;INT;OS
3	Westchester County New Rochelle SD Westchester	STP;INT;PS;FM
4	Oakwood Beach Phase II New York City	STP;UP;INT;PS;FM
5	Rochester (C) Phase I Monroe	INT;PS;FM Holding Stations
6	Red Hook Phase II New York City	STP; INT; FM
7	Sag Harbor (V) Suffolk	STP
8	Newfane (T) Niagara	STP;INT;PS;FM;OS
9	Saratoga Co. SD #1 Saratoga	STP;INT;PS;FM;OS
10	Amherst (T) Erie	STP;INT;PS;FM;OS
11	Rome (C) Oneida	STP;UP;INT;PS;FM

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
12	Colonie (T) Hudson Watershed Albany	STP;INT;PS
13	Glen Cove (C) Nassau	STP ADD;OS
14	Brockport (V) Monroe	INT
15	Sackets Harbor (V) Jefferson	STP;INT;PS;FM
16	Ocean Beach (V) Suffolk	STP UP;ADD
17	Ontario (T) Wayne	STP;INT;PS;FM;OS
18	EFC Walton (V) Delaware	STP;INT;PS;FM;OS
19	Erie (Co) SD #2 Erie	STP UP;INT;PS;FM
20	Erie Co. SD #4 Erie	INT;PS;FM
21	Cortland (C) Homer (T) Cortland	STP UP; INT
22	Woodridge (V) Sullivan	STP;INT;PS;FM;OS
23	Sodus Point (V) Wayne	STP;INT;PS;FM;OS
24	N. Tonawanda (C) Niagara	STP UP;INT;PS;FM

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
25	Watervliet (C) Albany	INT;PS;FM
26	Clayton (V) Jefferson	STP;PS;FM;OS
27	Colonie (T) Mohawk View STP Albany	STP;INT;PS
28	Webster (T) Monroe	STP ADD;INT;PS;FM
29	Onondaga (Co.) Syracuse Metro STP Onondaga	STP UP
30	Tonawanda (C) Erie	INT;PS;FM
31	Cobleskill (V) Schoharie	STP UP;INT
32	Greenport (V) Suffolk	STP UP
33	Castleton (V) Rensselaer	STP;INT;OS
34	Plattsburgh (T) Champlain Park SD Clinton	STP UP
35	Porter (T) Niagara	INT;PS;FM
36	Westchester Co. Irvington Ext. Westchester	INT;PS;FM

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
37	Elmira (C) Chemung	STP UP; ADD
38	Orange Co. SD #1 Orange	STP;PS;FM;INT;OS
39	Guilderland (T) Normanskill Drainage Basin Albany	2-STP's;INT;FM;OS
40	Lewistown (T) Niagara	STP;INT;PS;FM
41	Saugerties (V) Phase I Ulster	STP UP;INT;PS;FM
42	Madison County SD Madison	STP;INT;OS
43	LeRoy (V) Genesee	STP UP;INT
44	Onondaga Co Onondaga SD Onondaga	INT;PS;FM
45	EFC Chautauqua Co. South Chautauqua Lake SD Chautauqua	STP;INT;PS;FM
46	Owls Head New York City	STP UP;INT;PS;FM
47	Coney Island New York City	STP UP;PS
48	Nassau (Co) Plandome - Sands Point Nassau	INT

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
49	Long Beach (C) Nassau	STP ADD
50	Adams (V) Jefferson	STP;INT;PS;FM;OS
51	Wayland (V) Steuben	STP;INT;OS
52	Green Island (V) Albany	INT;PS;FM
53	Grand Island (T) SD #1 and #2 ERie	STP UP;INT;PS;FM
54	Rensselaer (C) Rensselaer	INT
55	Cheektowaga (T) SD #5 Erie	STP UP
56	Thompson (T) Kiamesha Lake SD Sullivan	STP ADD
57	Onondaga Co. Clay SD Onondaga	STP;INT;PS;FM;OS
58	Newtown Creek New York City	STP - Improvement
59	Niagara Co. SD #1 Wheatfield (T) Niagara	STP;INT;PS;FM;OS

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
60	Westchester Co Ossining SD Westchester	STP;INT;PS;FM
61	Poughkeepsie (C) Dutchess	STP;INT
62	Cuba (V) Allegany	STP ADD
63	Whitehall (V) Washington	STP;INT;PS;FM;OS
64	Bloomingdale (EFC) Essex	STP;INT;PS;FM;OS
65	Port Washington SD Nassau	STP ADD
66	Oneida (C) Madison	STP UP;INT
67	Farmington (T) Ontario	INT
68	Northwest Quadrant PWD #1 Monroe	INT
69	Groton (V) Tompkins	STP UP
70	Scotia (V) (EFC) Schenectady	PS;FM;INT
71	Broome Co. SD #1 Broome	INT;PS;FM
72	Chester (V) Orange	STP;INT;PS;FM;OS

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
73	Mexico (V) Oswego	STP;INT;PS
74	Philmont (V) Columbia	STP;OS;INT
75	Manchester - Shortsville Joint Sewage Disposal System Ontario	STP;INT;OS
76	Waverly (V) Tioga	STP;INT;OS
77	Hammond (V) St. Lawrence	STP;INT;OS
78	Cattaraugus (V) Cattaraugus	STP;INT
79	Watkins Glen (V) Schuyler	STP UP;ADD
80	Valatie (V) Columbia	STP;INT;PS;OS
81	Hobart (V) Delaware	STP;PS;FM;INT;OS
82	EFC Oriskany Falls (V) Oneida	STP;INT;OS
83	Massena (V) St. Lawrence	STP UP
84	Utica (C) Oneida	INT
85	Westfield (V) Chautauqua	STP;INT;PS;FM
86	Orangetown (T) Rockland	INT;PS;FM

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
87	Gouverneur (V) St. Lawrence County	STP;INT;PS;FM;OS
88	Franklinville (V) Cattaraugus	STP UP;INT
89	Gowanda (V) Erie	STP-UP; INT;PS;FM
90	Highland Falls (V) Orange	STP-UP;PS
91	Goshen (T) Hambletonian Park SD Orange	PS;FM
92	Canadaigua (C) Ontario	STP UP;ADD;INT PS;FM
93	Montgomery Co. SD #1 Montgomery	STP;INT;PS;FM;OS
94	Shawangunk (T) Wallkill SD Ulster County	STP;PS;FM;INT;OS
95	Black River (V) Jefferson County	STP;INT;OS
96	Middleville (V) Herkimer County	STP;INT;OS
97	Croghan (V) Lewis County	STP;OS
98	Milford (V) Otsego County	STP;INT;OS
99	Onondaga (T) Southwood SD Onondaga	INT

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
100	Middletown (C) Orange	OS
101	Niagara (T) Niagara	INT
102	East Greenbush (T) Rensselaer	STP UP
103	Warsaw (V) Wyoming	STP UP;INT
104	East Oneida Lake SD Oneida	STP;INT;PS;FM;OS
105	Westchester Co. Peekskill SD Westchester	STP UP;INT;PS;FM;OS
106	Clinton (V) Kirland (T) Oneida	STP UP;INT
107	Ticonderoga (V) Essex	STP;INT;OS
108	Wellsville (V) Allegany	STP;INT;OS
109	Williamson (T) Wayne	STP;INT;OS
110	North Greenbush (T) Snyders Lake SD Rensselaer	INT;PS;FM
111	Rockland Co. SD #1 - Phase III Rockland	STP ADD;INT

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
112	Schuylerville (V)	STP UP
113	State Agricultural & Industrial School, Rush (T) Monroe County	STP
114	Antwerp (V) Jefferson	STP;INT;PS;FM;OS
115	Binghamton (C) Broome	INT;PS;FM
116	Marcy (T) Oneida County	INT
117	Dannemora (V) & Prison Clinton	STP UP;INT
118	EFC Herkimer Co. SD Herkimer	STP;INT;PS;FM;OS
119	Lloyd (T) Highland SD Ulster	STP UP
120	Fair Haven (V) Fair Haven (T) Cayuga	STP;INT;OS
121	Phoenix (V) Oswego	STP UP
122	Unadilla (V) Otsego	STP;PS;FM;INT;OS
123	Nassau (Co) Kings Point-Manhasset-Great Neck Nassau	INT
124	Dansville (V) Livingston	STP UP

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
125	Oakfield (V) Genesee	STP
126	Lyndonville (V) Orleans	STP;INT;OS
127	Sherrill (C) Oneida	STP UP;INT
128	Patchogue (V) Suffolk	STP UP;INT
129	Minetto (T) Minetto Sewer District Oswego	STP;INT;PS;FM;OS
130	Rockland (T) Roscoe SD Sullivan	PS;FM;STP
131	Brasher (T) Helena (H) St. Lawrence	STP;INT;OS
132	Hudson (C) Columbia	STP UP
133	Canajoharie (V) Montgomery	STP UP;INT
134	Greenport (T) Columbia	STP;PS;FM;INT
135	Watertown (C) Jefferson	STP UP;PS;FM;INT
136	Ogdensburg (C) St. Lawrence	STP UP
137	Schuyler (T) Herkimer	INT;PS;FM

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
138	Germantown (T) Columbia	STP;FM;PS;INT;OS
139	Nunda (V) Livingston	STP;INT
140	Chittenango (V) Madison	STP UP
141	EFC Chautauqua (Co) Center Chautauqua Lake SD Chautauqua	INT;PS;FM
142	E Syracuse (V) Onondaga	INT;PS
143	Poughkeepsie (T) Southgate SD Dutchess	INT;PS;FM
144	Union (T) Choconut Center Broome	INT;PS;FM
145	Mechanicville (C) Saratoga	PS;FM
146	Schuyler Falls (T) Plattsburgh (T) Morrisville SD Clinton	STP;INT;PS;FM;OS
147	Elicottville (T) Cattaraugus	INT
148	Altamont (V) Albany	STP UP

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
149	Marion (T) Wayne	STP;INT;OS
150	Andover (V) Allegany	STP;INT;OS
151	Little Valley (V) Cattaraugus	STP;INT;OS
152	Owego (V) Tioga	STP UP;INT
153	Jordan (V) EFC Onondaga	STP;OS;INT;PS;FM
154	Randolph (V) Cattaraugus	STP;INT;PS;FM;OS
155	Batavia SD #2 Genesee	INT;PS;FM
156	LaGrange (T) Titusville SD Dutchess	STP ADD
157	EFC - Savannah (V) Wayne	STP;INT;PS;FM;OS
158	Corfu (V) Genesee	STP;INT;PS;FM;OS
159	Owasco (T) SD #2 Cayuga	INT;PS;FM
160	Malone (V) Franklin	STP UP;INT
161	Dept. of Mental Hygiene Rockland State Hospital Rockland	PS;FM

RANK	LOCATION (COUNTY)	PROJECT DESCRIPTION
162	Seneca Nation (N) Cattaraugus	STP;INT;PS;FM;OS
163	Herman (V) St. Lawrence	STP;INT;OS
164	Limestone (V) Cattaraugus	STP;INT;OS
165	Theresa (V) Jefferson	STP;OS;PS;FM
166	Copenhagen (V) Lewis	STP;INT;PS;FM;OS
167	Nassau Co. (Belgrave) Kings Point - Manhasset Nassau	INT
168	Whitney Point (V) Broome	STP;INT;PS;FM;OS
169	Harrisville (V) Lewis	STP;INT;PS;FM
170	Norfolk (T) SD #2 Raymondville (H) St. Lawrence	STP;PS;OS;FM
171	Brasher (T) Brasher Falls (H) St. Lawrence	STP ADD
*	Verona SD Oneida County	STP;OS;INT

*Insufficient Data to be ranked

SEWERAGE CONSTRUCTION
PRIORITY LIST

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NEW JERSEY

SEWERAGE CONSTRUCTION
PRIORITY LIST

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NEW JERSEY

RANK	SEWERAGE SYSTEM
1	Atlantic Co. S.A.
2	Ocean Co. S.A.
3	Par-Troy Hills (expansion plus advanced)
4	Stony Brook Regional S.A.
5	Pequannock, Lincoln Park and Fairfield S.A.
6	Edison
7	Joint Meeting (Essex and Union)
8	Pemberton Township S.A.
9	Hamilton Township (Mercer County)
10	South Brunswick - Cranbury
11	Sayreville - South Amboy
12	Bridgeton City
13	Mount Holly S.A.
14	North Plainfield
15	East Windsor MUA
16	Passaic Valley Water Commission
17	Pleasantville
18	Rivervale

RANK	SEWERAGE SYSTEM
19	Morristown
20	Bergen County S.A.
21	Wayne Township
22	South Monmouth Regional S.A.
23	Musconetcong S.A.
24	Hanover S.A.
25	Livingston
26	Hopewell Township MUS (Stony Brook)
27	Lumberton MUA
28	Englishtown
29	Linden-Rosell S.A.
30	Atlantic Highlands - Highlands
31	Long Branch S.A.
32	Somerville
33	Berkeley Heights
34	Bayshore Regional S.A.
35	Northfield
36	Denville
37	Beverly S.A.
38	Branchburg
39	Wayne Township
40	West Caldwell

RANK	SEWERAGE SYSTEM
41	Washington Township
42	Mt. Laurel Township MUA
43	Deal
44	Secaucus

NOTE Priority List not available for future fiscal years.

SEWERAGE CONSTRUCTION
PRIORITY LIST

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CONNECTICUT

SEWERAGE CONSTRUCTION
PRIORITY LIST

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CONNECTICUT

RANK	TOWN (AREA)	PROJECT DESCRIPTION
1	E. Hampton Lake Pocotopaug E. Hampton Center	STP; outfall sewer and interceptors
2	Darien Central and S.W. Area	New Interceptors to Stamford STP
3	Plymouth Lake Plymouth, Town of Plymouth	Interceptors
4	Brooklyn East Brooklyn Village	Interceptor
5	Branford Short Beach and Indian Neck	Sewer Extension
6	Colchester Colchester Borough and possibly fringe areas	Interceptors to convey sewage to E. Hampton
7	Windsor Locks Airport Area	Upgrade STP to secondary and expand sewerage
8	Norwalk Norwalk River, Five Mile Post Road	New interceptors PS, force mains, replace siphons, expand STP
9	Wilton Wilton Center to Norwalk System	Interceptors
10	Glastonbury S Glastonbury	Interceptors, PS, Force Mains

RANK	TOWN (AREA)	PROJECT DESCRIPTION
11	Waterford Center of City, Quaker Hill Cohanzie, Smith's Cove	Local sewers and interceptors
12	New London	Upgrade Trumbull St. STP from PC to PAC
13	Bristol Eastern area of town	Lower Mine Brook
14	New Haven	East St. STP, Maintain P, Convey to Blvd. Plant East Shore STP, upgrade PC to PAC Blvd.STP, upgrade PC to PAC
15	New Britain South and east side of City	Interceptors
16	Suffield (2) Northern area	Upgrade STP to secondary Sewers, Interceptors
17	Berlin Kensington F.D. Worthington F.D.	Interceptors, connections to Matt. trunk interceptor
18	East Hartford	Construction of flood control dike, relocation at STP
19	Stratford	Hurricane Barriers for Stratford STP
20	Somers Villages of Somerville & Somers	New STP, interceptors, collectors

RANK	TOWN (AREA)	PROJECT DESCRIPTION
21	Brookfield Candlewood Area	Interceptors, PS
22	Shelton Route 8, Laurel Heights Area	Upgrade STP to secondary, PS, Route 8 sewers
23	Ansonia	Sludge handling facilities at STP
24	Berlin Center of City	Interceptors
25	Brookfield Southwest Area	Interceptors, PS
26	New Milford (2) Southern Area of Town	Expand and upgrade STP to secondary Interceptors
27	Avon Roaring and Nod Brook Areas	Interceptors and appurtenances
28	Mansfield Mansfield Training School, University of Connecticut	Interceptors to Coventry System
29	Milford Beaver Brook & Meadowside Road Area	Gravity and Force Mains, PS
30	Cromwell	Upgrade Mattabassett STP
31	Meriden	Upgrade and expand STP to tertiary
32	Deep River	New STP

RANK	TOWN (AREA)	PROJECT DESCRIPTION
33	Chester Center of City	Interceptor to Deep River STP
34	Guilford Whole town served	New STP
35	New Haven (CS) Whole City	Separation and elimination of overflows
36	Vernon	Tertiary added to STP
37	Meriden Rasted Lane Area	PS, Relief sewers
38	Sterling City of Sterling to go to Plainfield	Interceptors, PS Force Mains
39	Burlington Northeast area of Town	Interceptor
40	E. Windsor Broad Brook area to eliminate a STP	Broad Brook Intercep.
41	Orange Post Road Area	Interceptors to Milford STP
42	Enfield Green Manorville, East area of town	PS, Interceptor
43	Newtown Newtown Center	Interceptor, new STP
44	Griswold Glasgo Village	Sewer service, new Glasgo STP, septic tank, sand beds, chl.

RANK	TOWN (AREA)	PROJECT DESCRIPTION
45	Southington	Add tertiary to STP
46	Plainville	Tertiary treatment added to STP
47	Plymouth Southeast area	Fall Mountain Lake Interceptor
48	Bristol (3)	Tertiary treatment added to Forrestville and Plant St. STP's
49	Cheshire (2) Ten Mile River Area	Ten Mile River Industrial. Add advanced treatment to STP
50	Danbury	Add tertiary treatment to STP
51	Hartford (CS)- Entire City	Separation
52	North Haven	Add tertiary to STP Interceptor to North Branford
53	Wallingford	Add tertiary to STP
54	Bridgeport - Entire City	Separation
55	North Branford Whole Town	Total sewer system interceptors, PS
56	Norwalk (CS)	Separation/Collection system
57	East Hartford Burnside Avenue Area	Burnside Ave. Relief Sewer/PS

RANK	TOWN (AREA)	PROJECT DESCRIPTION
58	Ellington - Southeast area of Town	Interceptors
59	Plymouth	Add tertiary to STP
60	Waterbury (CS) - Center of City	Separation
61	Meriden (CS) - Center of City	Inflow-infiltration Study
62	Middletown (CS) - Center of City	Separation
63	Norwich - West Side, East Side, Chelsea, Mohegan Park, Greenville	Separation
64	Canton	Expand Collinsville STP
65	Greenwich Byram Shore Area	Byram Shore Interceptor
66	Enfield - Thompsonville Area	Separation
67	Ledyard - Gale's Ferry and Vicinity	Sewer Service and possible new STP
68	New Britain (CS) Willow and Piper Brook Area	Separation/eliminate overflows
69	Portland (CS) - Center of City	Separation
70	Shelton - Center of City, Huntington Area	Separation/excessive infiltration Far Mill River Int.
71	Woodstock - Roseland Lake Area	Interceptor to Putnam STP
72	Windsor Locks - Whole town	Sewer Inflow Study
73	Essex - Center of City of Essex	Sewers

RANK	TOWN (AREA)	PROJECT DESCRIPTION
74	Madison - Sewer Service south of Route 95	STP or interceptor to regional system
75	Naugatuck (2) Center of City, N.E. Naugatuck	North Main Interceptor, Prospect Interceptor
75	Torrington (CS) - Center of City	Stormwater separation
76	West Hartford (CS) East Ridge Area	Local sewers, inflow study
77	Westport - Central business district of Westport	Separation
78	Clinton Sewer Service south of Route 95	STP, possibly regiona
79	East Lyme Niantic Area	STP or interceptor to regional STP
80	Mansfield - South area of Town	Route 195 interceptor
81	Torrington - Northeast area of Burville	Northeast interceptor
82	Griswold (CS) - Center of Jewett City and Borough	Separation
83	Old Saybrook - Old Saybrook Center and shoreline communities	Sewer service and STP
84	N. Stonington (?)	Local sewers with interceptor to Pawcatuck STP. If service planned, N.Stonington Center and Industrial area at intersection of Rt. 2 and 1-95 would be served.

RANK	TOWN (AREA)	PROJECT DESCRIPTION
85	Litchfield (CS) - Center of City	Separation
86	New Hartford	Expand STP
87	Old Lyme - Old Lyme Center Rogers Lake and Shoreline Communities	Sewer Service and possible STP or interceptor to regional
88	Suffield - Northeast area	North River Interceptor
89	Torrington - Northwest area	N.W. Interceptor
90	Westbrook - South of Route 95	Sewer Service
91	Danbury - Beaver Brook Area	Beaver Brook Interceptor
92	E. Haddam E. Haddam Center and Moodus	Sewer Service and and new STP
93	Danbury - Central Area	Clapboard interceptor
94	New Canaan	New secondary STP
95	Wolcott (2) - Central Area	Old Tannery Brook Interceptor Woodtick Interceptor Extension
96	Vernon - Northwest area of town	Lake St. Interceptor

(CS) Combined sewer project