Special Report:

JK

USE ATTAINABILITY ANALYSIS
OF THE
NEW YORK HARBOR COMPLEX

JUNE 1985

New Jersey Department of Environmental Protection · Division of Water Resources

Acknowledgements

The Division of Water Resources gratefully acknowledges the contribution of the following individuals in the timely completion of this report:

Bureau of Systems Analysis and Wasteload Allocation Staff:

Shing-Fu Hsueh, Ph.D., P.E., Chief - overall project direction
Tzay-Rong (Tom) Jenq, Ph.D., P.E., Environmental Scientist II - principal investigat
John W. Kashner, Environmental Scientist I - coordination, review and editing
Harbhajan Hundal, Principal Environmental Engineer - technical assistance
Howard Litwack, Principal Environmental Engineer - technical assistance
Georgia Marino, Environmental Scientist III - technical assistance
Jeffrey Reading, Environmental Scientist III - technical assistance
Steven Lubow, Environmental Scientist I - legal process coordination
Luetta Hall, Principal Clerk Typist typing
Angela Starling, Secretarial Assistant III - typing
Hai-An Chen, Student Assistant - contributor
Ellen Gluck, Student Assistant - contributor
Frank M. Rugg, Student Assistant - contributor

Drafting Department: Allan Bell - graphical production

Other individuals and agencies involved in providing guidance and review, including:

Douglas M. Clark, P.E. - Assistant Director, Monitoring and Planning Element, Division of Water Resources, NJDEP

Staff of: U.S. Environmental Protection Agency - Headquarters, Washington and Region II, Interstate Sanitation Commission, and New York State Dept. of Environmental Conservation

EXECUTIVE SUMMARY

The major function of this use attainability study is the reappraisal of the New Jersey stream classification status of the waterbodies in the New York Harbor area. A thorough assessment of the current, as well as potential uses of waterways was made, based on existing water quality studies and/or data. Water quality, as well as socio-economic effects of various wastewater treatment alternatives were also analysed.

All municipal wastewater treatment plants in the study area will attain at least secondary treatment level in the near future. With this alternative, most waterbodies, with the possible exception of the Arthur Kill, Kill Van Kull, Newark Bay and tidal Passaic will be designated for fish propagation. However, other sources of pollution, especially combined sewer overflows (CSOs), as the major source of bacterial pollution, pose the main hinderance to substantial improvement in the water quality. CSO control, after implementation of the secondary treatment requirement, has been identified as the crucial factor in achieving the swimmable goals. According to the NYC 208 Report, the zero discharge alternative (meaning advanced or tertiary treatment) and a high level of CSO control (90%), will bring substantial improvements in water quality, rendering most of the harbor complex swimmable. However, the economic, as well as engineering, feasibility of this plan has not yet been demonstrated. For example, for the Hudson River basin, the cost of 90% CSO control, involving capture, primary treatment and disinfection, would be over 7 billion dollars. Even if implemented, the effectiveness of this plan to achieve the desired end results is still questionable, due to the simplications and assumptions made in the (NYC 208) modeling anaylsis.

Recognizing the scope and limitations of the analyses to date, further studies are underway and will be continued. It is possible that other treatment/abatement alternatives for CSOs, which were not evaluated in the New York City 208 planning process, could produce the desired result of attaining swimmable water quality. New Jersey is currently actively pursuing Marine CSO abatement funding under Section 201(n) for local communities. Additionally, New York State has required the City of New York to undertake a more detailed evaluation of CSO problems and abatement alternatives for the New York Harbor Complex. This study has just begun.

During the same time period as the CSO study, the North River and Red Hook Water Pollution Control Facilities will begin to treat and provide disinfection for flows which are currently discharged without treatment to the Hudson River and the lower East River.

Continued monitoring during the time period will help to evaluate the predicative capability of the New York City 208 model and provide an up-to-date data base in order to determine if the swimmable goal is attainable.

The conclusions on attainability in this report are required by Federal regulations to be reviewed every three years and the results of these further studies will be assessed at that time.

Based on the findings of this report, the following assessment, regarding the use classifications of the waterbodies in the study area, can be made. There are no documented major natural sources of pollution stressing the water quality in the metropolitan area. Therefore, in the absence of man-induced activities, the highest natural attainable use for all waterbodies in this area will be suitable for fish propogation and swimming (N.J. SE1 classification).

Hudson River

Heavy bacterial pollution in the Hudson River, especially below its confluence with the Harlem River, has been attributed to substantial flows of untreated and inadquately treated sewage from New York and New Jersey. For example, summer fecal coliform levels exceed 40,000 MPN/100 ml in parts of the river. Other sources of pollution, especially CSO and urban runoff, also play a significant role in the water quality degradation. Therefore, the restoration of higher uses will be contingent upon the control of all sources of bacterial pollution.

Completion of pollution abatement projects, in the New York and New Jersey areas, will enhance the water quality in the river. With all treatment plants at secondary level, as expected in the near future, the Hudson River section, between the state line and the Harlem River junction, has been projected to meet the criterion for a swimmable waterbody (fecal coliforms less than 200 MPN/100 ml) and, hence, is recommended to be upgraded to the N.J. SE1 stream classification.

However, for the Hudson River segment between the Harlem River junction and the Upper New York Bay, although the secondary treatment alternative will lower the bacterial levels below the existing standard (770 MPN/100 ml), the criterion for SE1 classification (200 MPN/100 ml) will still not be met. According to the NYC 208 Report, only the zero discharge alternative, with 90% CSO control, predicts sufficient coliform reductions to achieve the swimmable goals. However, the N.Y.C. 208 report concluded that, based on environmental, technical and institutional facts, this alternative was not feasible. Even if implemented, the projected improvements in the water quality may still not materialize, since the precision of the NYC 208 water quality model in predicting fecal coliform levels has not been demonstrated. Therefore, this portion of the river, i.e. between the Harlem River and New York Bay, should retain its existing SE2 classification and, thus, remain non-swimmable.

Arthur Kill

Currently, the water quality in the Arthur Kill is very poor, with severe DO and coliform problems. DO levels close to zero have been observed in parts of the Kill. Point sources containing BOD, bacterial and thermal emanations from primary and raw sewage and some industrial discharges contribute to the poor water quality. Other major sources of pollution are CSOs, urban runoff and benthic deposits (SOD).

Pollution abatement programs currently underway, and anticipated CSO controls, will have beneficial effects. Elimination of sewage flow from

Perth Amboy, Carteret and Sewaren plants (these facilities are to be phased out) will improve the DO levels signigicantly, however, the DO criterion for the SE2 classification, i.e. 4 mg/l, would still not be met due to other pollution souces, such as SOD, etc. A simplified coliform modeling analysis, by NJDEP, demonstrated that even with 80% control of CSOs from the New Jersey side, the remaining 20% will still be sufficient to contravene the fecal coliform criterion for the SE2 classification (770 MPN/100 ml). Only the zero discharge alternative, as spelled out in the NYC 208 Study, predicts substantial improvements, even to the extent of making the Kill swimmable. Removal of benthic deposits would also have significant effects. However, the feasability of such programs to completely attain upgraded water quality standards has not been established at the present time. Therefore, the existing SE3 classification (not suitable for fish propagation and swimming) should be retained for the Arthur Kill.

Kill Van Kull

Water quality in the Kill Van Kull is slightly better than that of the Newark Bay and Arthur Kill, probably due to the dilutional effects of the Upper New York Bay. Sources of pollution include a primary facility in Bayonne, New Jersey and CSO and urban runoff discharges from Staten Island and Bayonne. High levels of benthic deposits have also been observed in this waterway. In addition, heavily polluted Newark Bay and the Arthur Kill also contribute BOD and coliform loads to the Kill Van Kull.

According to the NYC 208 Report, with the secondary treatment alternative, the water quality in the Kill Van Kull is predicted to improve to above the criteria for SE2 classification (DO = 4 mg/l, FC = 770 MPN/100 ml). However, the extent of benthic oxygen demand has been underestimated in this report. According to the N.J. Northeast Water Quality Management Study, benthic deposits exert as much oxygen demand as do the point source BOD loads. It is, therefore, doubtful, whether after these improvements in treatment levels (secondary treatment), the water quality consistent with that of the SE2 classification would be attained. Since the water quality in the Kill Van Kull is closely tied to that of Newark Bay and the Arthur Kill, this waterbody is recommended to retain its SE3 classification.

Tidal Passaic and Newark Bay

Water quality problems in the tidal Passaic are mainly caused by non-point sources of pollution, and the existing levels of DO and fecal coliforms are in violation of the state standards. No significant improvement in the water quality is expected, unless corrective measures for the control of regional and local CSOs, urban runoff, and benthic pollution are undertaken. It has been estimated in the modeling analyses that, with advanced levels of treatment for dischargers in the freshwater Passaic, and with high levels of CSO control (assuming 100% control), the DO resources of the tidal Passaic will improve by about 2 mg/l. DO levels at the critical point may rise to about 4 mg/l with this improvement and will be, at best, marginal for the SE2 classification. The major problem in the tidal Passaic is the heavy accumulation of benthic deposits. As rectification of benthic pollution and the CSOs does not appear to be feasible at the present time, the existing SE2 and SE3

Classification should be retained for the tidal Passaic.

The same holds true for Newark Bay. Without effective control of CSOs and urban runoff and removal of heavy benthic deposits, the DO levels in Newark Bay are not likely to rise above 4 mg/l and fecal coliforms will not meet the criterion for SE2 classification (770 MPN/100 ml). Therefore it is recommended that, Newark Bay shall retain its existing SE3 classification (not suitable for fish propagation and swimming).

Tidal Hackensack

Acute DO problems, resulting from BOD and thermal discharges currently exist in the tidal Hackensack. However, with the rectification of the problem at the BCUA (Bergen County Utilities Authority) facility, the fecal coliform levels are believed to be significantly improved. As soon as BCUA and other sewage treatment plants attain treatment level 3 (90% removal of CBOD and NBOD), the minimum DO levels at the critical point are expected to rise above 4 mg/l. Therefore, the Hackensack River segment from Berry's Creek to Route 1 and 9 crossing, now classified as SE3, is recommended to be upgraded to SE2 classification. The Hackensack River segment from Overpeck Creek to Berry's Creek is currently classified as SE2. Coliform projections, based on the Teledyne Modeling Study (1973), have indicated that for all discharge and treatment alternatives, including 99.99% coliform removal at the BUCA (a major past coliform contributor), the fecal coliform levels in the Tidal Hackensack will stay above the criterion for the swimmable classification (200MPN/100). Therefore, this portion of the Hackensack River shall retain its current SE2 classification and thus remain non-swimmable.

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

TABLE OF CONTENTS CONTINUED

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

I. INTRODUCTION

A. Water Quality Standards Revision Requirements

The Federal Clean Water Act (PL 92-500) requires the State, from time to time, but at least once every three years, to hold public hearings to review the State Surface Water Quality Standards and to make appropriate modification to these standards. For all water bodies, for which the approved standards do not include all of the uses described in Section 101(a)(2) of the Act, the Water Quality Standards Regulation (40 CFR 131) requires the State to provide an analysis which demonstrates that the Section 101(a)(2) uses are unattainable. Section 101(a)(2) sets 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". A use attainability analysis meets this requirement of the Regulation and must be submitted to the US Environmental Protection Agency (EPA) by the State for all water bodies in which the State: "(a) is designating uses for the water body, such that the water body will not have all the uses which are included in Section 101(a)(2) of the Act, (b) maintaining uses for the water body which do not include all of the uses in Section 101(a)(2) of the Act, (c) removing a use included in Section 101(a)(2) of the Act or (d) modifying a use, included in Section 101(a)(2) of the Act, to require less stringent criteria" (48 FR 51401). A full use attainability study is required only once for each water body and designated uses. The State is required, as part of each subsequent triennial review of the Water Quality Standards, to reexamine the basis that was used to exclude specific uses, given in Section 101(a)(2) of the Act, and to consider any new information that is available which could indicate that a revision of the applicable standard is warranted.

The Water Quality Standards Regulation describes a use attainability analysis as a "multi-step scientific assessment of the physical, chemical, biological and economic factors affecting the attainment of the use. It includes a water body survey and assessment, a wasteload allocation, and an economic analysis, if appropriate" (48 FR 51401). The State may designate uses for a water, which do not reflect the Section 101(a)(2) goals, if the use attainability analysis demonstrates that the use is not attainable because of any of the following:

"(1) Naturally occurring pollutant concentrations prevent the attainment of the use; or

(2) Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for, by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements, to enable uses to be met; or

(3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

(4) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or

(5) Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or

(6) Controls more stringent than those required by Sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact."

The New Jersey Surface Water Quality Standards(16) incorporate designated uses for SE2 and SE3 waters that do not include all of the Section 101(a)(2) uses. SE2 waters are fishable, but are not swimmable; SE3 waters are neither swimmable or fishable. This use attainability analysis is supplied to demonstrate that fishable and swimmable uses are not attainable in most of the SE2 and SE3 waters studied and to upgrade two waterways in which a change is warranted.

The two parameters of major interest in the study area are coliform bacteria and dissolved oxygen. Bacterial concentrations restrict swimming and shellfishing uses, while low dissolved oxygen levels limit the aquatic biota. The New Jersey Surface Water Quality Standards give the following criteria for these two parameters, in SE1, SE2 and SE3 waters.

Parameter	Criteria	Classification
Fecal Coliform	Levels shall not exceed a geometric average of 200/100 ml nor should more than 10 percent of the total samples taken during any 30-day period exceed 400/100 ml.	SE1
	Levels shall not exceed a geometric average of 770/100 ml	SE2
	Levels shall not exceed a geometric average of 1500/100 ml	SE3
	For all classifications, samples shall be obtained at sufficient frequencies and at locations, during periods which will permit valid interpretation of laboratory analyses.	
Dissolved Oxygen	24 hour average not less than 5.0 mg/l but not less than 4.0 mg/l at any time. Supersaturated DO values shall be expressed as their corresponding 100 percent saturation values, for purposes of calculating 24 hour averages	SE1

Not less than 4.0 mg/l at any time SE2

Not less than 3.0 mg/l at any time SE3

These two parameters will be examined in detail in this report, because they are key water quality indicators routinely used to assess whether a water body can be used for swimming and fishing purposes. It should be noted that these are not the only factors that must be considered when conducting a use attainability study. However, if the DO and coliform concentrations in a water body do not meet the applicable water quality criteria, it indicates that the condition of the water body is already below the level necessary to support the 101(a)(2) uses.

Other parameters that should be considered include the toxics, including heavy metals. The effects of these other parameters, both singly and in combination, on the designated uses of the area's waters, need to be taken into account. It is also important to recognize the effect of these parameters on human health and the maintenance and propagation of aquatic biota. The last section of Chapter V will briefly assess the condition of the biological community in the Hudson-Raritan Estuary, based on a Tetra Tech Study done for the EPA.

The evaluations in this report can be used as a guide, to determine whether the standard for a water body should be retained, with current designated uses that do not include the 101(a)(2) uses, or whether the standard should be changed to include those uses.

B. Objectives

The objectives of this study are to:

1) Conduct a water quality assessment to determine whether the existing water quality supports the current designated uses;

2) Document, where appropriate, why the present uses do not include all designated uses; and

3) Assess the optimal uses for these water bodies, including consideration of the Section 101(a)(2) uses.

C. Tasks

In order to meet the above goals, the major tasks for this study include: review of background information, identification of pollution sources, quantification of pollutant loading, assessment of current water quality conditions, cause and effect analysis, and consideration of pollution abatement programs. In this study, a simplified, one dimensional, steady-state estuarine model has been employed to evaluate the impact of the individual CSO discharges on estuarine water quality.

II. Study Area Description

As shown in Figure II-1, the Use Attainability Study area encompasses a section of northeastern New Jersey centered on Jersey City and Newark. The northern border is the New York - New Jersey line; the southern border is the Raritan River. On the east the study area is bounded by the center lines of the Hudson River, Upper New York Bay, the Kill Van Kull and the Arthur Kill. The drainage area covered by this study is approximately 234 square miles.

In terms of political subdivisions, the study area includes all of Hudson County, the southern and eastern parts of Bergen County, the southeastern tip of Passaic County, the eastern half of Essex County, the eastern end of Union County and the northeast corner of Middlesex County.

The Use Attainability study area encompasses all or part of several river basin systems:

1. The lower Passaic River and the tidal portions of its tributaries from Dundee Dam to Newark Bay, including the last half mile of the Saddle River.

2. The Hackensack River and the saline portions of its tributaries from Overpeck Creek to Newark Bay, including Overpeck Creek and Berry's Creek.

3. The Rahway River mainstem, from the Pennsylvania Railroad bridge to the Arthur Kill, the Rahway River South Branch, from Hazelwood Avenue to the mainstem, and the Elizabeth River, from the Broad Street bridge to the Arthur Kill.

4. Newark Bay, from the confluence of the Hackensack and Passaic Rivers to the Arthur Kill and Kill Van Kull, and the Elizabeth Channel, from its source to Newark Bay.

5. The Arthur Kill, from Newark Bay to Raritan Bay, and its tributaries: Morse's Creek Smith Creek and Woodbridge Creek.

6. The Kill Van Kull, from Newark Bay to Upper New York Bay.

7. Upper New York Bay, from the mouth of the Hudson River to a point opposite the mouth of Kill Van Kull.

8. The Hudson River, from the New York - New Jersey line to Upper New York Bay.

All of these waterways are tributary to the Atlantic Ocean. Tides affect their salinity, their ability to disperse and flush pollutants, and their ability to support aquatic life.

Nearly two million people live in the study area, with an average density of about 8,300 per square mile. The land is about 75% developed. About half of the developed land is devoted to generally impervious uses. Much of the undeveloped land consists of tidal wetlands and other lowland areas, with unconsolidated soil. Approximate population figures and land use percentages, for each drainage basin within the study area, are shown in Tables II-1 and II-2. Population estimates are derived from census data and NJDEP projections. Land use percentages are based on data in the Northeast New Jersey 208 Water Quality Management Study(15).

Average annual precipitation in the region is about 42 inches. Seasonal variations are fairly small, on the average, but are often large in any one year. Topographically, the area is characterized by gently rolling terrain, with a gradual net slope toward the south-southeast. The northern reach of the study area drops off abruptly to the Hudson River.

In this study area, the Hudson River and Upper New York Bay have been designated as fishable waters (SE2). Therefore, there is no need to conduct a DO assessment to justify the water use for these waters.

Table II-1

Study Area Population by Drainage Basin

		Population		Population Density (Persons/Sq. Mi)	
Receiving Water	Area Drained (Square Miles)	1980	Projected 2000	1980	Projected 2000
Hackensack River	66.1	384,000	423,000	5800	6400
Passaic River	62.3	616,000	563,000	9,900	9000
Arthur Kill	50.6	406,000	392,000	8,000	7700
Hudson river	20.3	251,000	248,000	12,400	12,200
Elizabeth Channel	18.6	98,000	83,000	5,300	4,500
New York Bay/Newark Bay/Kill Van Kull	11.2	166,000	153,000	14,800	13,700
Others	4.8	29,000	29,000	6,100	6,100
TOTALS	234.0	1,950,000	1,890,000	8,300	8,100

Table II-2

STUDY AREA LAND USE BY DRAINAGE BASIN

Receiving Water	Area Drained (Sq. Mi.)	Resid.	Streets	Indus.	Comm.	Public	Undevelop.
Hackensack River	66.1	27%	12%	15%	5%	5%	36%
Passaic River	62.3	46%	15%	17%	3%	6%	14%
Arthur Kill	50.6	34%	14%	16%	4%	5%	27%
Hudson River	20.3	28%	15%	16%	6%	5%	31%
Elizabeth Channel	18.6	11%	13%	48%	2%	16%	10%
New York Bay/ Newark Bay/ Kill Van Kull	11.2	23%	14%	30%	6%	9%	18%
Other	4.8	32%	14%	13%	3%	6%	32%
TOTAL AREA	234.0	32%	13%	19%	4%	6%	25%

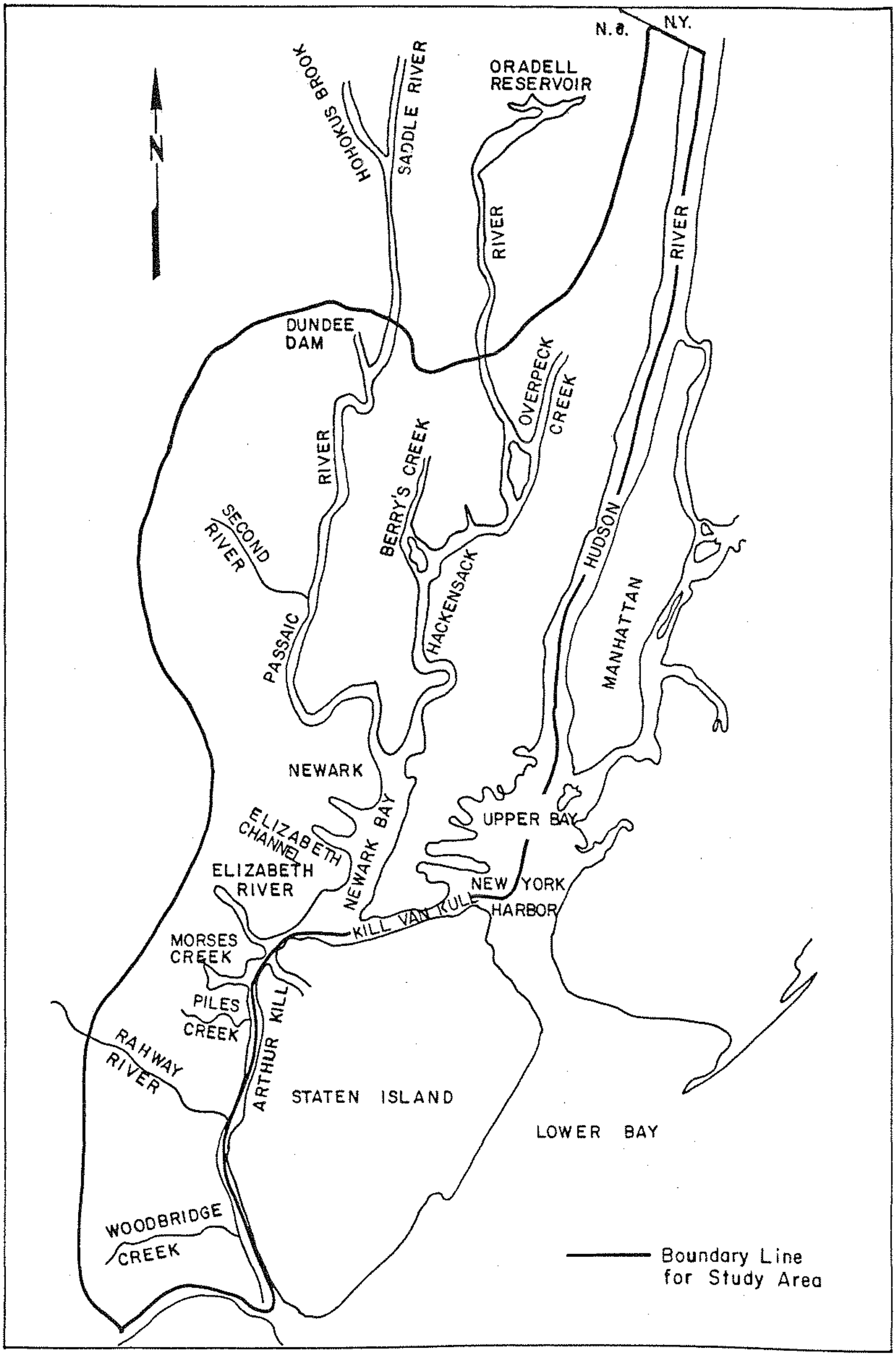


Figure II-1 : Study Area

III. Historicial Studies

A. Water Quality Management Plans (19) and 208 (15,21)

The 1972 and 1977 amendments to the Federal Water Pollution Control Act set long term goals for the nation, for the improvement and protection of water quality. The purpose of the 208 program was to develop a comprehensive strategy for the management of water quality problems within a particular geographic area. The northeast New Jersey 208 study examined all potential sources and types of pollution within the study area, measured levels and trends, and provided a data base to guide formulation and implementation of water quality management policies and actions. Consideration was given to identification of point and nonpoint source discharges and abatement of pollution from these sources, in order to meet the water quality standards. Population projections and economic and land use considerations are also factors which greatly influence present and future water quality. The 303(e) Urban Area Basin Plan, which is based on the Hydroscience model for New York Harbor, also presented a detailed analysis of water quality. The assessment in this report was based on summer low flow conditions in 1970, and included loading determinations, steady-state model calibration and verification, and projection of future water quality, with an emphasis on dissolved oxygen.

The northeast urban area encompasses the following basin systems: 1) The Passaic River and tributaries, 2) the Hackensack River and tributaries, 3) the Hudson River, 4) Kill Van Kull, 5) Arthur Kull (including the Elizabeth and Rahway Rivers) and 6) Newark Bay. The area is comprised of 175 municipalities, within the counties of Bergen, Essex, Hudson, Morris, Passaic, Union and Somerset. Water resources in the urban area consist mainly of saline waters, which are used primarily for transportation and cooling purposes.

The two general categories of pollution sources are point and nonpoint. The point source control plan, set forth in the 208 report, suggests locations of treatment plants and treatment levels necessary to meet water quality standards. The key to effective control of point sources was the National Pollutant Discharge Elimination System (NPDES) permits, which were issued to all point source dischargers. These permits included appropriate effluent limitations and wasteload allocations. This program has been subsequently delegated to New Jersey, and the permits are referred to as NJPDES permits.

Nonpoint sources are more difficult to identify. They can include combined sewer overflows (CSO), urban runoff, leachate, sediments, bank load and spills. Land use and precipitation intensity are important factors which influence the concentration of nonpoint source pollutants entering a watershed. Included in the 208 report are best management practices (BMP), for control of pollution from nonpoint sources. An assessment of surface water quality was also performed in this report. This task was accomplished by obtaining data from a variety of sources. Historical data was compared with the then current conditions to observe water quality trends. The pollutants of interest were biochemical oxygen demand

(BOD), fecal coliform, suspended solids, nutrients, pH, temperature and some toxics and heavy metals. In addition, dissolved oxygen (DO) concentrations were studied. Based on the 208 report(15) and the 303(e)(19) basin plan, the following review sections will summarize the water quality issues, and their causes and effects for each waterway of the study area. Specific attention will be focused on coliform and DO-BOD related pollutants, which are the key water quality indicators for the EPA water quality goals: swimmablity and fish propagation.

1. Lower Passaic River

The Passaic River is tidal below Dundee Dam. The lower Passaic River Basin is a highly urbanized area with large scale industrial development. According to the revised New Jersey Surface Water Quality Standards, the tidal portion of the river is classified as SE2 from Dundee Dam to the confluence of the Second River, where it becomes SE3 to its mouth at Newark Bay.

Intensive survey data from 1970 indicated that DO concentrations were in violation in all but the segment immediately below Dundee Dam, which reflected the aeration effect from the dam. The DO concentration here was approximately 7 mg/l. However, it fell below 5 mg/l by mile point 4, below the dam, before leveling off between mile points 4 and 6. By mile point 9, it had fallen below the SE2 standard (4 mg/l), and below the SE3 standard of 3 mg/l by mile point 10. The lowest point was at mile point 12, where DO was just over 2 mg/l. DO was found to increase slightly in the last 2 miles of the river, reaching 3 mg/l at the entrance to Newark Bay and remaining at that level throughout the length of the Bay. Large benthic deposits and significant BOD loading from the freshwater Passaic, above Dundee Dam, both contributed to a DO deficit in the tidal Passaic. Approximately 31% of inflow BOD is attributable to the combination of point and nonpoint discharges in the upstream freshwater Passaic River System, while "bank loads" are responsible for 69% of the BOD in the tidal Passaic. The low freshwater dilution (MA7CD10 was 23.1 cfs) from background flow was also considered as a main factor causing low DO concentrations in the lower Passaic River.

In the four miles below Dundee Dam, the fecal coliform level was near the SE2 standard of 770 MPN/100 ml. Between Mile point 4 and Newark Bay, the average count was between 1000 and 1500 MPN/100 ml (SE3 standard). However, in Newark Bay, fecal coliform concentrations increased. The dry weather overflow from CSO and other nonpoint pollution sources were responsible for the fecal coliform violations.

In summary, pollution problems in the tidal Passaic River Basin were determined to be the result of substantial loadings from upstream point and nonpoint sources, benthic deposits, upstream diversions and heavy nonpoint loadings. Benthic deposits were determined to be the largest consumers of DO in the lower Passaic River. Reduction of upstream point and nonpoint source pollution, especially CSO, to prevent runoff loads, was deemed necessary to reduce the benthic deposits and coliform contribution in the system.

2. Hackensack River

The Hackensack River becomes tidal below the Oradell Reservoir. It follows a southerly course to its mouth at Newark Bay. In this area, there is high residential density along with numerous commercial and industrial establishments. Residential development comprises 32% of the land use in the basin, commercial/industrial uses 14%, and 54% is generally undeveloped. There are approximately 35 facilities discharging 85.6 MGD of domestic or industrial wastewater in the basin. The largest discharger is the Bergen County Utilities Authority (BCUA), discharging about 63 MGD from its Little Ferry facility. Many of the municipalities in the downstream area are served by combined sewers. The lower reach of the river is encompassed by the Hackensack Meadowlands, where large scale development has taken place. The Hackensack Meadowlands Development Commission has jurisdiction over this area. The river is classified as SE2 from Overpeck Creek to Berry's Creek, and SE3 from Berry's Creek to Newark Bay. The lower portion of the river is utilized for industrial cooling or process water, along with boating, fishing and some secondary contact recreation.

A low DO profile was found to exist in all but the first four miles below Oradell Dam, where the concentration was nearly 8 mg/l. DO then fell rapidly to below the SE2 standard of 4 mg/l at mile point 5. By mile point 6, DO had fallen below the SE3 standard of 3 mg/l. The point of minimum DO was just below the Bergen County Utilities Authority (BCUA) discharge at mile point 8, where the concentration was only 1.2 mg/l. In the next 10 miles, extending to Newark Bay, DO gradually increased, reaching 3 mg/l between mile points 16 and 17, but never approaching 4 mg/l. 69% of the total BOD load was the result of continuous point sources, with most of it coming from the BCUA. The total BODu loading was given as 122,000 lbs/day. The large nonpoint runoff loads were mainly attributable to leachate from the solid waste dump sites within the Hackensack Meadowlands. There were also large benthic deposits exerting a DO demand of approximately 1.0 mg/l. Inflow of BOD from above the Oradell Dam was negligible and resulted in loads of less than 300 lbs/day. However, the low DO concentration water from Newark Bay has a very significant impact on the Lower Hackensack water.

Immediately below Oradell Dam, the fecal coliform concentration met the SE1 standard of 200 MPN/100 ml. Downstream from the dam, the concentration increased to 1,000 MPN/100 ml at mile point 3 and 2,000 MPN/100 ml at mile point 4. A maximum of about 7,000 MPN/100 ml was reached near the BCUA outfall at mile point 8. Beyond this point, the fecal coliform concentration declined steadily, falling below 1,500 MPN/100 ml by mile point 13 and remaining between 1,000 and 1,500 MPN/100 ml in the remaining 5 miles extending to Newark Bay.

Thus, the probable causes of water quality degradation in the Hackensack River were determined to be the BCUA, along with other point sources, substantial suspended solids loadings from NPS, and upstream water diversions when the river flow is low, the effluent flow from BCUA (50MGD) determines water quality. The 303(e) study also cites thermal loadings, from electric generating plants, as a factor in depressing DO levels. A considerable reduction in runoff loads and benthic deposits was predicted through the actions outlined in the Hackensack Meadowlands

Development Commission comprehensive plan (HMDC,1970) and the expansion and upgrading of sewage treatment plants. In addition, the upgrading of the BCUA facility to a higher level of treatment, which would result in an improvement in water quality, was discussed. With continuous point source dischargers, in the uppper and middle portions of the tidal Hackensack River, employing level 3 treatment, and dischargers in the lower portion employing level 1 treatment, water quality modeling predicted compliance with DO standards of SE2 and SE3 waters.

3. Rahway and Elizabeth Rivers

Both the Rahway and Elizabeth Rivers are tributaries of the Arthur Kill, and most of the wastewater from their drainage basins is discharged to the Arthur Kill. At the time of the 208 study, there were seven facilities discharging 4.3 MGD of domestic and industrial wastes. The water quality for these rivers was found to be fair to poor. The tidal sections are classified as SE2 and SE3. The SE3 classification begins at the Route 1-9 crossing on the Rahway River, and at the Broad Street Bridge in Elizabeth. The Elizabeth River watershed is predominantly developed, with 38% of the basin residential, 5% commercial, 16% industrial and 41% generally undeveloped. Residential and uses comprise 48% of the Rahway Basin, commercial/industrial 7%, and undeveloped lands 45%. These two rivers were not modeled as part of the 303(e) study.

Although the dissolved oxygen data for both rivers were sparse, average summer DO concentrations were estimated at 4.7 mg/l for the Elizabeth River and 8.4 mg/l for the Rahway River. Summarized historical data indicated a decrease in DO concentrations for the Elizabeth River and an increase in DO concentrations for the Rahway River. This increase was attributed to a possible increase in algal growth, which promoted super-saturated levels of DO. In addition, BOD concentration for the Elizabeth River was estimated at 8.5 mg/l and 3.8 mg/l for the Rahway River. However, the 208 draft report was unclear as to whether the BOD loadings were due to nonpoint or point sources, stressing each in different sections.

The data presented in the study indicated that the Rahway River met the SE2 standard for fecal coliforms (770 MPN/100 ml) in 1973 and 1974. In the Elizabeth River, fecal coliform concentrations were over 900 MPN/100 ml, in the summers of 1973 and 1974, and about 5,000 MPN/100 ml during those two winters. Fecal coliform and suspended solids discharged into the Elizabeth River were almost entirely due to nonpoint sources. In the residential sector, the majority of this loading occurred in areas served by combined sewers. The importance of CSO contributions to the City of Elizabeth will be described in a later section.

Since most of the water quality problems in these areas were attributed to nonpoint sources, the 208 report concluded that applying best management practices to this area would most likely result in improving the poor water quality. In addition, controls for combined sewer overflow were also recommended.

4. Newark Bay, Arthur Kill, Kill Van Kull, New York Bay and Hudson River

These estuarine water bodies are components of the New York Harbor complex and separate New Jersey from Staten Island and New York City.

The Passaic and Hackensack Rivers both empty into the northern part of Newark Bay, which is connected to the Arthur Kill and Kill Van Kull at the southern end. The Arthur Kill is joined to Raritan Bay and the Kill Van Kull to the Upper New York Bay. Extensive residential and industrial development has taken place in the areas that drain to the New York Harbor complex. There are numerous wastewater treatment facilities discharging into the New York Harbor complex. On the New Jersey side, the total wastewater discharged by these facilities is 483 MGD, of which approximtately 258 MGD is discharged by the Passaic Valley Sewerage Commissioners facility. The Hudson River is classified as SE2, the Newark Bay, Kill Van Kull and Arthur Kill as SE3. These waters are primarily used for transport, with the ports of Newark and Elizabeth being located on Newark Bay. In addition, there is a heavy concentration of petrochemical facilities, along with Newark Airport, bordering Newark Bay.

a. Newark Bay

The surrounding land uses of Newark Bay Basin are as follows: 53% are industrial lands, 2% are commercial, 14% are residential and 31% are generally undeveloped. Almost half the segment is served by combined sewers. The DO levels for Newark Bay were found to meet the state criteria for SE3 classification (3 mg/l) for all but the first mile of the system, from the confluence of the Passaic and Hackensack Rivers. Poor water quality in this portion was attributed to the poor water quality within the Hackensack and Passaic Rivers and the Jersey City West treatment plant discharge.

At the time of the 208 Study, more than 7 million pounds of BOD were discharged annually into Newark Bay by industries, compared to 1.3 million pounds from nonpoint sources. This difference was expected to increase with the construction of an additional PVSC outfall to Newark Bay to handle wet weather flows. Of the nonpoint BOD loads, 74% originates from industrial lands, especially in the area served by combined sewers, and from upstream and downstream boundary conditions.

In general, water quality problems in Newark Bay were attributed to heavy loadings from upstream and downstream sources, upstream freshwater diversions reducing the assimilative capacity, accumulated benthic deposits from point and nonpoint sources, nonpoint suspended solids loadings and combined sewer overflows. The 208 study suggestions for enhancing Newark Bay's water quality included upgrading the basin's treatment plants, correcting overflow problems and implementing pollution abatement measures for the Hackensack and Passaic Rivers tributary to the Bay. In addition, management practices for unrecorded suspended solids were recommended. However, bay sediments were found to be anaerobic, containing as much as 10% oil and grease. Therefore, even if the point and nonpoint source problems were solved, the benthic sources would persist, continuing the water pollution problem until dissipation of the sludge bed.

b. Arthur Kill

The 303(e) Basin Plan's statements about the Arthur Kill are based on the New Jersey Water Quality Inventory Section 305(b) Report (1975).

The average DO levels only met the SE3 standard of 3 mg/l during cold weather periods, dropping to less than 1.0 mg/l during summer low flow conditions. This was said to be the result of "the heavy concentration of both population and industry along certain narrow, combined waterways such as the Arthur Kill and Kill Van Kull". Based on the Hydroscience model, the 208 Report predicted fecal coliform levels in the Arthur Kill ranging from 1,000 MPN/100 ml, near Raritan Bay, to approximately 5,000 MPN/100 ml near Newark Bay. This profile was slightly lower than observed data.

The 208 study attributed water quality problems in the Arthur Kill to heavy point source loads of poorly treated effluents, intermittent point source loads and nonpoint sources related to storm events. Upgrading facilities to secondary treatment levels was expected to enhance water quality to meet the DO standard of 3 mg/l. However, at that time, the 303(e) Report concluded that "no practical treatment technology will improve the Arthur Kill, Kill Van Kull and Newark Bay...to 4 or 5 mg/l of dissolved oxygen." The three treatment plants in the Arthur Kill sub-basin, Joint Meeting of Essex and Union Counties, Linden-Roselle Sewerage Authority and Rahway Valley Sewerage Authority, were in the process of upgrading to secondary treatment at the time the plan was written.

c. Kill Van Kull

The 1973 Teledyne model indicated that DO in the Kill Van Kull met standards of 3.0 mg/l at the Newark Bay end and rose to about 3.6 mg/l at the Upper New York Bay, despite a 10 MGD discharge from the Bayonne STP. However, the 1975 Hydroscience model indicated DO concentrations of below 3.0 mg/l throughout most of the system, during low flow periods. Fecal coliform concentrations exceeded the SE3 standard throughout the Kill Van Kull. The count was about 5,000 MPN/100 ml at Newark Bay, falling to 1,600-1,700 MPN/100 ml at Upper New York Bay.

Water quality in the Kill Van Kull suffers from the combined effects of Newark Bay and Upper New York Bay. Heavy pollutant loads from both bays are intermixed throughout the system by strong tidal action. Therefore, water quality in the Kill Van Kull directly reflects the conditions in the other two systems. Total point source loading was estimated at 160,000 lbs/day BODu and nonpoint source loading at less than 21,000 lbs/day. A sensitivity analysis indicated that the oxygen demand from benthic deposits was almost as great as that from point sources.

The 208 study recommended upgrading of continuous point sources to secondary treatment. Intermittent and nonpoint source control was not deemed necessary to meet water quality standards at low flow conditions. Controls for transient nonpoint problems were also suggested. The Bayonne facility, which is the only treatment plant in the Kill Van Kull sub-basin, was planned to be upgraded to secondary treatment.

d. Upper New York Bay

The New Jersey side of the Upper New York Bay basin is among the most densely populated in the study area. The basin is comprised of 21%

residential, 44% commercial/industrial land, and 35% generally undeveloped lands. The Upper New York Bay basin (N.J. side) is entirely served by combined sewers under the jurisdiction of the Hudson County Sewerage Authority.

The DO concentrations were found to be below the 3.0 mg/l standard. Fecal coliform levels were in excess of standards. More than 300 million pounds of BOD were reported to be discharged annually into the bay from New Jersey, with 99% coming from the Passaic Valley Sewerage Commissioner's (PVSC) facility. At the time of the 208 report preparation, the PVSC was in the process of upgrading their treatment plant from primary to secondary. This point source improvement was expected to reduce 90% of the total BOD discharged to the system. Unrecorded BOD loadings were estimated to be 1.4 million lbs/year; 46% generated from industrial lands.

Poor quality water in Upper New York Bay was attributed primarily to heavy point source loadings from New Jersey and New York. The raw sewage discharges from New York City accounted for the major DO deficit and the coliform violations in this water body. The boundary condition and sediment oxygen demand, considered as a nonpoint source, were deemed to have a significant effect on the DO concentration in the Upper New York Bay area. Continuous point source and CSO controls, to correct water quality problems, were recommended.

e. Hudson River

The Hudson River Basin is the most densely populated in the study area. Multiple density, residential development comprises 22% of the total land area, commercial/industrial land uses make up 21% of the basin and undeveloped lands make up the remaining 57%. Combined sewers service 77% of this segment.

The dissolved oxygen concentration in the Hudson River was about 5.5 mg/l at the New York - New Jersey boundary. Continuing downstream, DO continued to decline, reaching 3 mg/l at mile point 10. The DO minimum, 2.8 mg/l, was reached at mile point 12, near the North Bergen outfall. DO climbed steadily, from mile point 14, reaching 3 mg/l at mile point 16. Point source BOD loading was estimated to be 40 times greater than annual non-point BOD loadings, with most of it coming from treatment plants in the basin. Of the unrecorded loading, 43% is generated by the residential sector, while 31% is supplied by industrial lands.

The fecal coliform concentration was very low at the state line and remained below the SE2 standard (770 MPN/100 ml) until about mile point 7. By mile point 8, the count exceeded the SE2 standard of 770 MPN/100 ml. Fecal coliforms continued to rise with downstream travel, reaching a high point of about 4,000 MPN/100 ml at mile point 13. At mile point 15, the concentration began to decrease but it did not fall far below 2,000 MPN/100 ml at any point in Upper New York Bay.

It was concluded that the principal reason for the decline in water quality from the state line to mile point 14 was municipal sewage discharges from both sides of the Hudson.

The 208 Study recommended upgrading the existing sewage treatment plants in New Jersey and New York City to improve water quality. At the time of the 208 Study, on the New Jersey side, the Hudson River sub-basin had 5 treatment plants, three of which were to remain in operation, but be expanded and upgraded to secondary treatment.

Overall, municipal dischargers were found to contribute the vast majority of the point source BOD and suspended solids loadings for the New Jersey North East 208 Study area. In segments with both municipal and industrial dischargers, the municipal loads were found to dominate those contributed by industries. Based on the analysis in the 208 report, it was determined that, for those industries discharging wastewater directly to a receiving stream, the minimum treatment requirements would be at the secondary level.

The majority of industries within the 208 study area discharge their wastes to municipal sewer systems. These industries must comply with the treatment plant authority, EPA and DEP requirements for industrial pretreatment. These requirements were in the process of being implemented when the DEP draft report was published. Therefore, no specific recommendations were made concerning pretreatment at the time the reports were prepared. Since the Hudson River and New York Harbor complex are also directly influenced by dischargers in New York City, it is necessary to consider the New York City 208 Report.

The goal of the New York City 208 Plan(21) was the same as the New Jersey 208 plan(15) - improvement of water quality. The area of concern in New York City's Plan is the New York Harbor complex. The largest source of pollution in the New York Harbor is continuous wastewater discharges. This includes flows from industrial point sources and leakage from regulators. The New York City 208 Study(21) surveyed seasonal, dry weather water quality in New York Harbor during the late summer (1975), late fall/winter (1976), and late spring/summer (1977).

In 1975, approximately 2.2 billion gallons/day of municipal wastewater, both treated and raw sewage, were discharged to the waters of New York Harbor. New York City was responsible for approximately 60% of this wastewater (1.9 billion gallons/day). Approximately 142 million gallons of this was raw. Another 150 MGD of untreated wastewater was discharged to the Hudson River because of the lack of treatment facilities in these areas. The planned North River and Red Hook plants were expected to alleviate this situation. After treatment and bypassing, the city discharged 927,000 lbs/day total BOD_5 and 888,000 lbs/day suspended solids into the Harbor. Without controlling the raw and untreated wastewater, New York City is considered to be the major coliform contribution source to the New York Harbor complex. Dry weather leakage from waterfront sewage regulators was estimated to contribute only about 2% of total municipal flow. This included about 30,000 lbs/day each of BOD and SS from New York and New Jersey. As other continuous sources are reduced, leakage was estimated to amount to about 5% of the total BOD and SS by year 2000. There are approximately 33 major, direct industrial discharges (> 50,000 gal/day) to New York Harbor, but their overall impact on the Harbor was considered to be insignificant when compared to the municipal point source discharges.

During and after storms, up to twice the dry weather flow rate may be conveyed by combined municipal sewer systems, although less than 1.5 times the dry weather flow is treated at the sewage plants. The balance is discharged without treatment. Based on New York City's 208 study(21), these CSO discharges increased New York City's annual discharge of BOD and SS by 20% and 35% respectively. Bathing and shellfishing standards for fecal coliform were frequently exceeded, during both wet and dry weather, in the Harbor.

The New York City 208 Plan(21) projected approximately 2.5 billion gallons per day of wastewater, from treated municipal sewage, to be released to the Harbor in the year 2000. The total BOD load after secondary treatment, would be about 530,000 lbs/day.

Water Pollution Control Plants would account for 67% of the future flow but only 28% of the BOD loading. These projections assume that 85% removal of BOD and SS will be achieved - or more if it is necessary to meet the 30 mg/l restriction.

B. 301(h) - ISC Study - Dissolved Oxygen Assimilative Capacity in the New York Harbor Complex(9)

Although the Federal Clean Water Act requires secondary treatment of municipal wastewater and equivalent treatment for industrial discharges, section 301(h) of the Act makes it possible for publically owned treatment works (POTWs) to apply for a waiver allowing lesser treatment, if they discharge into marine waters. To obtain such a waiver, a discharger must show that there will be no adverse effect on the environment.

Dissolved oxygen and biochemical oxygen demand are key factors in determining the assimilative capacity. The objective of this report was to determine if there was any unused assimilative capacity for DO in the New York Harbor Area, now and in 1990. Therefore, the evaluations are based solely on DO assimilative capacity and were intended to be used as a guide to determine whether applications for section 301(h) waivers warrant further consideration.

The model used in this report was the New York Harbor water quality model developed by Hydroscience. Different loading schemes were developed. Most attention was given to summer conditions. Model runs were done to determine the relative significance of the various components (POTW discharges, industrial discharges, CSOs, SOD, bypass, leakage) which exert an effect on the oxygen balance. Runs were also made to determine the sensitivity of the model.

Wastewater inputs from municipal and industrial sources for 1981 and 1990 conditions were determined by ISC. For 1990 several treatment conditions were considered for POTW's. Point source and bypass loads were used for 1981 conditions but not for 1990. Leakage loads for 1981 and 1990 were calculated using the NYC 208 methodology but updated with 1981 data. Oxygen deficit loadings were the same as used in the NYC 208 study. Industrial discharges were assumed to receive Best Practical Treatment. (BPT).

For CSOs and storm drainage, most model runs used estimates of BOD loading developed from the Rainfall/Runoff model(20) in the 208 Study. An average summer rainfall of 0.12 inches/day was used.

Forty one computer runs were done for 1990 conditions. Water quality projections, with respect to DO, were made for differnt seasons and different conditions.

The modeling results of this study showed that there is <u>no</u> available, unused, assimilative capacity for BOD during the summer months. Therefore, all POTWs should be required to employ secondary treatment during the warm weather season. If seasonal treatment is to be used, it can only be done at times when there is good assurance that DO levels would not drop below the standards. In conclusion, this study stated that, lessened treatment to any degree that would result in worthwhile cost reductions, it would also cause a violation of the water quality standard requirements most of the time.

C. CSO Studies

1. City of Elizabeth

The following section is a summary based on the City of Elizabeth CSO study (1981)(1), prepared by the consulting engineers - Clinton Bogert Associates.

Two interceptors, the Easterly and Westerly, convey sewage to the Trenton Avenue Pumping Station, which then delivers it to the Joint Meeting (Essex and Union Counties) sewage treatment plant. The tributaries to the city's interceptors drain 13 areas -7 discharging into the Easterly Interceptor and 6 to the Westerly Interceptor. The combined sewer area discharging to the Westerly Interceptor totals 1,776.3 acres. The combined sewer area discharging to the Easterly Interceptor totals about 1,114.6 acres. Of the 13 drainage areas, 8 discharge combined sewage to the Elizabeth River, two to the Great Ditch and 3 to the Arthur Kill. The combined sewer system contains 29 discharge points along the Elizabeth River, 2 points on the Great Ditch, one point on the Peripheral Ditch, one point on Newark Bay and 5 points on the Arthur Kill. About 18 of these discharge points are considered to be principal points of overflow.

The water quality in the Elizabeth River was found to be very poor, with dissolved oxygen concentrations often reduced to zero. This condition is due, in large part, to the following reasons:

- -high SOD from CSOs and urban runoff
- -discharge of raw sewage from CSOs
- -less freshwater flow for dilution due to upstream diversions
- -the Elizabeth River acts as a sink basin for pollutants from the Arthur Kill

In addition, mathematical models were developed to evaluate the expected performance of the sewer system under actual and hypothetical conditions, the amount of pollutants discharged during wet weather and alternatives which would provide abatement of pollution from combined sewer overflows. The Storm Water Management Model (SWMM) and the Storage, Treatment, Overflow, Runoff Model (STORM) were used, and modifications were made to meet specific criteria.

In the study, combined sewer overflows were found to occur about 70 times per year into the Elizabeth River, resulting in an average discharge of about 10,000 lbs of BOD per event (700,000 lbs/yr). Overflows to the Great Ditch and Arthur Kill occurred about 40 times per year, resulting in an average discharge of 13,700 lbs of BOD per event (548,000 lbs/yr). Overall, the Elizabeth CSOs discharge an average flow of 1.82 MGD into the Elizabeth River and Arthur Kill.

2. PVSC District (Passaic River and Newark Bay)

This section is based on the Overflow Analysis Report by Elson T. Killam Associates, Inc. - 1976(3).

The SWMM-3 Model has been used to estimate the CSO effluent characteristics due to the rainfall impact. The MIT-Dynamic Network Model (DNM) was also used to estimate the water quality impact in the lower Passaic River due to the Passaic Valley Sewerage Commissioners' CSO discharges.

Combined sewers are located in about 24% of the area served. 73 overflows are located within the PVSC district, providing an outlet for about 16 square miles of combined sewer area. During the study period (1974-1975), CSOs into the Passaic River from PVSC and other system overflow facilities were estimated to be in excess of 7.5 billion gallons per year (20.5 MGD). Total estimated overflow from all sources amounted to 11 BG/year (30.1 MGD). Average dry weather BOD loading from the major CSO's in Newark and Kearny was approximately 115,930 lbs/day. Average overflow BOD was approximately 135,490 lbs/day. Total coliform loading was approximately 319×10^{15} MPN/day. This was based on an estimated average of 1.23×10^{8} MPN/100 ml total coliform concentration for each CSO. It was also determined that CSO discharges have only slight impact on long-term DO concentrations in the lower Passaic River.

Although Paterson is not in our study area, its major CSOs were included, since they may have an impact on the lower Passaic River, in terms of bacteria contribution. The average dry weather BOD loading from major CSOs in Paterson is approximately 60,918 lbs/day and the average overflow BOD is approximately 64,135 lbs/day. Total coliform loading is approximately 203×10^{15} MPN/day.

3. Hudson County

Based on the Hudson County Utilities Authority's application(6) for a marine CSO Grant, August 10, 1984, seventy-three combined sewer overflows from Hudson County discharge into either the Hudson River or Newark Bay from the communities of Jersey City, Bayonne, Hoboken, Weehawken, West New York, Guttenberg and North Bergen. Approximately 70% of the discharges are into the Hudson River and 30% are into Newark Bay. There are about 18 miles of shoreline in Hudson County bordering the Hudson River, the Kill Van Kull and Newark Bay. Shoreline developments are planned for 8.5 miles. This development, which will include residences for about 60,000 people is expected to create a demand for shellfishing and body contact recreation.

About 55% of the shoreline CSOs are in the development area. The mathematical water quality model, developed as part of the NYC 208 study, showed that the main channel waters in the New York metropolitan area (including the New Jersey side), would be considerably improved in quality by reductions in CSOs. The CSOs have a great impact along the shoreline, which was illustrated in photographs. However, water quality changes at the shoreline could not be determined because the model was not sensitive enough.

The mean CSO flow was estimated to be 496 MGD per storm event (42.2 MGD daily average), while the dry weather flow is 122.4 MGD. Annual average overflow BOD loading is 6.5×10^{6} lbs/yr and fecal coliform loading is 28×10^{13} MPN/day.

D. Summary of Interstate Sanitation Commission District Waters - 1982 305(b) Report(17)

Interstate Sanitation Commission District waters showed some improvement in 1982, when compared to previous years. This was due, in part, to wastewater treatment projects being completed and less continuous by-passing of untreated sewage into district waters. However, further improvement was still deemed necessary to meet applicable regulations and uses.

The municipal primary level treatment plants in the district do not provide adequate pollutant removal and many of the biological treatment plants require upgrading. Water quality is continuously degraded by: (1) untreated municipal and industrial discharges entering Harbor waters daily, (2) combined sewers releasing raw sewage into the waterways during rainfall periods, and (3) large concentrations of both heavy meatals and oil entering the waters from inadequately treated municipal and industrial wastes. This constant influx of pollutants is especially pronounced during the summer months, causing low dissolved oxygen values. For example, the Commission's DO requirements were being met less than 40% of the time, during the summer, in the Arthur Kill.

Bacterial contamination has lessened, but further improvements must still be made to allow for the full intended uses of many of the waters. Thermal pollution is a problem in some areas, as is oil and grease and heavy metals.

The planning and continued construction of secondary treatment plants throughout the region and the univerisal application of Best Practical Treatment (BPT) technology to industrial discharges constitute a program capable of rendering the District waterways aesthetically appealing and viable for both public and commercial users. However, much of the effectiveness of both secondary treatment and BPT technology will be negated unless efforts are directed towards abating: (1) combined sewer overflows, (2) heavy metal inputs (3) toxic organic loading and (4) oily wastes. In addition, because of the heavy concentrations of both population and industry along the Arthur Kill and Kill Van Kull, apparently no practical amount of treatment technology will improve these bodies of water to the point at which dissolved oxygen will be appreciably greater than 3.0 mg/l.

E. Others

Steady State Water Quality Modeling of Conventional Pollutants in the Berry's Creek Estuary(18)

Berry's Creek is a large tidal tributary of the lower Hackensack River. It has a total length of about 7 miles and a drainage area of about 12 square miles. There are two major municipal sewage treatment plants in its drainage basin, the Woodridge STP and the Triboro (Joint Meeting - East Rutherford) STP. In addition, there are many industrial discharges in the basin.

Since the predominant form of transport in the Hackensack River is tidal, the water quality is Berry's Creek will be influenced by transport of pollutants from the Hackensack River. In addition, Berry's Creek contains mercury, which has been released to the environment over a 40 year period at the Ventron Corp. site in Woodridge.

During the months of September and October, 1982, an intensive water quality survey was conducted. Its purpose was to provide information necessary to develop a water quality model. The conventional pollutants in Berrys Creek, CBOD and NBOD, were found to cause a severe dissolved oxygen problem.

The most downstream sections of Berry's Creek show poor water quality and fail to meet the DO standard under all alternative treatment projections. This section is primarily influenced by the water quality in the Hackensack River and the only approach to solving DO problems in this section of Berrys Creek is to control sources of pollution along the Hackensack River.

It was recommended that the Triboro STP was required to meet treatment level 3. The alternatives of level 3 treatment and diversion to Bergen County MUA for the Woodbridge STP were recommended.

IV. Major Sources of Pollution

A. Existing Point Source Dischargers

This section includes an inventory of the major point source dischargers for the contribution of coliform and BOD pollutants within the New Jersey Study area and New York City. The point sources consist of municipal and industrial dischargers. Tables IV-1 to IV-4 present the existing municipal and industrial dischargers in New Jersey and New York City, along with their effluent BOD and coliform concentrations. Most of the existing effluent characteristics for the municipal dischargers were obtained from the Interstate Sanitation Commission's (ISC) 1983 annual report(8). The industrial dischargers listed in Tables IV-3 and IV-4 were compiled from the ISC 1983, 301(h) report(9). The proposal for municipal wastewater controls, shown in Tables IV-1 and IV-2, were taken from the recommendations made in the Northeast New Jersey 208 report (1979)(15) and the New York City 208 plan (1979)(21). The locations of municipal dischargers, identified in Tables IV-1 and IV-2, are indicated in Figure IV-1. The numbers in parentheses, next to the plant name, correspond to plant location on the map.

The New York City and Northeast New Jersey 208 study areas are both heavily populated and highly industrialized, resulting in poor water quality. The improvement in wastewater treatment over the past 10-15 years has begun to improve the quality of the region's waters. Many parts of the New York Harbor complex now meet applicable standards for increasing portions of the summer months. However, overall conditions still leave much to be desired. Actual treatment given by point source dischargers varies. All dischargers have been expected to upgrade to secondary treatment, but not all have responded rapidly and fully. A number of plants still provide primary treatment. Both the Red Hook plant, which now discharges 50 MGD raw sewage into the East River, and North River plant, which discharges 150 MGD raw sewage into the Hudson River, are nearing completion. The target date for the North River sewage treatment plant is December, 1985, at which time BOD removal will be 35%, using step aeration. This will be upgraded to 85% BOD removal by July, 1989. The Red Hook plant is scheduled to begin operating at the primary treatment level by August, 1987, and at secondary level by August, 1989. In addition to the 150 MGD of raw sewage discharged into the Hudson River, there are 3 other STPs in New York which discharge a total of 208 MGD. These 3 plants are at secondary treatment and contribute a combined BOD loading of approximately 34,000 lbs/day. The North River plant's reported loading is 125,100 lbs/day. On the New Jersey side of the Hudson River, there are 8 STPs discharging a total of 61.66 MGD. Six(6) of these are primary treatment plants and have a combined BOD loading of 50,008 lbs/day. There are two secondary STPs which contribute 90,338 lbs/day BOD loading. In the study area, the total loading into the Hudson River from New Jersey and New York is approximately 299,646 lbs/day, at a flow of 652.23 MGD. Three of the primary plants in New Jersey are scheduled to be upgraded and 3 are scheduled to be phased out.

There are 2 STPs which discharge into Newark Bay. These two(2) plants, which are scheduled to be phased out and their flows directed to PVSC, are primary treatment plants with a combined BOD loading of 22,918 lbs/day and a combined flow of 17.8 MGD.

Three primary and three secondary STPs discharge into the Arthur Kill. All are in New Jersey. All 3 primary plants are scheduled to be phased out and their flows sent to Middlesex County Utilities Authority. These 3 plants contribute a BOD loading of 23,500 lbs/day and a flow of 11 MGD. The 3 secondary plants contribute a total BOD loading of 17,616 lbs/day and a flow of 104 MGD. Therefore, the total BOD loading into the Arthur Kill is 41,114 lbs/day with a flow of 114 MGD.

The Kill Van Kull receives discharges from 2 STPs, one in New Jersey, which is primary, and one in New York, which is secondary. The Bayonne City STP is scheduled to be upgraded to a secondary STP. Presently, its reported BOD loading is 12,283 lbs/day with a flow of 12 MGD. The Port Richmond plant has a reported BOD loading of 4,278 lbs/day and a flow of 38 MGD. Therefore, the total loading into the Kill Van Kull from STPs is 16,561 lbs/day, with a flow of 370 MGD.

The Raritan River has 5 STPs discharging into it, with the MCUA being the only one at the secondary level. However, the other 4 are scheduled to be phased out to MCUA. These 4 plants now contribute a BOD load of 2,025 lbs/day and a total flow of 2.2 MGD. The MCUA has a reported loading of 27,084 lbs/day and a flow of 120 MGD. Therefore, the total BOD loading into the Raritan River is 29,109 lbs/day and the total flow is 93 MGD.

There are 3 secondary treatment plants and 4 primary treatment plants which discharge into the Hackensack River and its tributaries. The primary STPs contribute a BOD loading of 5,322 lbs/day and a total flow of 6.03 MGD. Of these plants, Bergen County-Little Ferry has been upgraded to secondary with the discharge to the Hackensack River. Woodbridge and North Arlington-Lyndhurst will be phased out to BCUA, and North Bergen Northern and North Bergen Central will be phased out to Jersey City East. The 2 secondary treatment plants contribute a BOD loading of 33,522 lbs/day and a flow of 86.3 MGD. The Secaucus plant is scheduled to be upgraded, with flows greater than 2.25 MGD to go to Jersey City East, and Tri-Borough Joint Meeting-Rutherford is scheduled to be phased out to BCUA.

The portion of the Passaic River in our study area has only one secondary sewage treatment plant, discharging a BOD load of 580 lbs/day and a flow of 1.55 MGD. This plant is scheduled to be phased out to PVSC.

In New York City, there are 5 secondary treatment plants which contribute a BOD Load of 134,331 lbs/day into the East River. This is in addition to the 55,253 lbs/day loading from the raw sewage from the Red Hook Plant. This amounts to a total BOD load of 189,584 lbs/day and a total flow of 1,050 MGD into the East River.

Overall, New Jersey has 30 sewage treatment facilities directly discharging to the study area. Eleven(11) of these STPs provide secondary treatment and 19 provide primary treatment. These 30 plants discharge a total of 626 MGD producing 285,194 lbs/day BOD_5. New York City, including Yonkers, has nine(9) secondary STPs, with 1,087 MGD of effluent flow and 203 MGD of raw sewage, discharging into the study area with resultant water quality effects in New Jersey. These nine(9) facilities, including the 203 MGD of raw sewage, discharge a total of 353,166 lbs/day of

BOD_5. Contributions from industrial discharges are relatively minor in the study area, amounting to less than 2% of the total. New Jersey industrial dischargers contribute a total BOD load of 5,261 lbs/day, compared to a total of 278,856 lbs/day from municipal dischargers. Significant industrial dischargers in New York contribute a total BOD loading of 1,391 lbs/day, while municipal wastewater treatment plants have a reported loading of 353,166 lbs/day.

B. Other Sources of Pollution

1. Combined Sewer Overflows (CSO)

Figures IV-2a (New Jersey) and IV-2b (New Ypork City) indicate the locations of the major combined sewer overflow (CSO) discharges which directly affect the waters of interest in the New York Harbor Complex. Also included are CSOs in Paterson, New Jersey. Although this area is not part of our study area, these discharges can have an impact on the lower Passaic River and are, therefore, included. The numbered CSO discharges (Figure IV-2) along the Passaic River, in the vicinity of the Cities of Newark and Paterson, correspond to the numbered locations on Table IV-5. The discharge points along the Elizabeth River and the western side of Newark Bay indicate locations of major CSO discharges. In addition, Tottenville, on Staten Island, is also indicated on the map. Tottenville discharges 2 MGD of raw sewage and has a significant impact on water quality in the Arthur Kill.

The following sections describe the CSO inventory which would have an impact on the study area.

The Hudson River CSOs are represented in Figure IV-2 as follows: NB, G, WNY3 = North Bergen, Guttenberg, West New York (3 CSOs); W5 = Weehawken (5 CSOs); H8 = Hoboken (8 CSOs), FL1 = Fort Lee CSOs and E1 = Edgewater CSOs. These CSOs have all been included in the north Hudson River inventory, and they are divided into 2 sections, FL-1 and E1 comprise one section and NB, G, WNY3, W5 and H8 comprise the other section. The southern Hudson River CSOs are represented by the arrows, with numbers indicating the number of CSOs. The Jersey City East and Bayonne systems are the major contributors to CSO discharges in the southern Hudson River.

There are 4 major CSO discharges in the Hackensack River Basin: Hackensack, Ridgefield, North Bergen and Jersey City. These CSOs contribute a total coliform loading of 12.7×10^{14} MPN/day, a BOD_5 loading of 5,426 lbs/day and a suspended solids loading of 7,355 lbs/day, at a flow rate of 5.6 MGD.

The Passaic River CSOs were divided into those from the Newark/Kearny area, which discharge into the lower Passaic and those in the Paterson area, which discharge into the freshwater Passaic. The Paterson CSOs were included in our inventory because of their potential impact on water quality in the lower Passaic. There are 6 significant CSO discharges in the Paterson area and their contributions are as follows: 73.69×10^{14} MPN/day of total coliform, 64,135 lbs/day BOD_5 loading and a flow rate of 32 MGD. The CSO discharges into the lower Passaic River, from the Newark/Kearny area, consist of: 117.4×10^{14} MPN/day total coliform loading, 57,469 lbs/day BOD_5 loading and a flow rate of 52 MGD.

There are 3 CSOs discharging into Newark Bay. Their loadings are as follows: 73.69 x 10^{14} MPN/day total coliform, 3,396 lbs/day BOD_5, 8,247 lbs/day suspended solids and a flow rate of 3.9 MGD.

There are 6 major CSO discharges into the Arthur Kill. Their total loadings are: 84.8 x 10^{14} MPN/100 ml total coliform, 6,935 lbs/day BOD_5 and a flow rate of 8.8 MGD.

The Hudson River was divided into a northern and southern section. In addition, the northern Hudson was sub-divided into 2 sections, as previously mentioned. This is also illustrated in the input data. The combined loadings to the northern Hudson River are: total coliform - 6.3 x 10^{14} MPN/day, BOD_5 - 2,096 lbs/day, suspended solids - 9,5 lbs/day and a flow rate of 2.8 MGD. Loadings into the southern Hudson River are: 14.66 x 10^{14} MPN/100 ml total coliform, BOD_5 - 7,844 lbs/day, suspended solids - 21,751 lbs/day and a flow rate of 6.6 MGD. Therefore, the total loadings into the Hudson River, from CSOs in both the northern and southern sections are: total coliform - 20.96 x 10^{14} MPN/day, BOD_5 - 9,940 lbs/day, suspended solids - 30,776 lbs/day and a total flow of 9.3 MGD.

CSO loadings into the Kill Van Kull are from Bayonne and the contributions are: total coliform - 1.21 x 10^{14} MPN/day, BOD_5 - 970 lbs/day, suspended solids = 7,540 lbs/day and a flow of .05 MGD.

Therefore, in summary, total CSO contributions to the study area are: total coliform-319.6 x 10^{14} MPN/day, BOD_5 - 148,271 lbs/day and a flow rate of 113 MGD. Also, note that total coliform loadings were based on a concentration of 6.0 x 10^6 MPN/100 ml (EPA data).

2. Urban Runoff

Estimated BOD_5 loadings from urban runoff, not included in CSO discharges, are shown in Table IV-6. The loadings listed are sums of two components. One component is an estimate of BOD_5 loading from separate storm sewers, derived from data in the Northeast New Jersey 208 Water Quality Management Plan. The data in the Management Plan was calculated from data in the Northeast New Jersey 303(e) Water Quality Management Study (1976), using the USEPA Storm Water Management model.

The second component of the loadings, listed in Table IV-6, is "background" runoff, which includes exfiltration from sanitary or combined sewers, overland flow, unidentified industrial discharges into ditches, groundwater discharges and leaking lagoons. As suggested in the Appendices to the 208 Management Study, background runoff is assumed to contribute 0.015 lb. BOD_5/person/day.

Per acre BOD_5 loadings from urban runoff are greater in areas where human activity is particularly intense, such as the Passaic, Hudson and Upper New York Bay basins. However, the Hackensack River receives more runoff in proportion to flow than the Passaic River.

3. Landfills

As shown in Table IV-7, the study area includes about 1,500 acres (2.3 square miles) of solid waste landfills. Based on the EPA Areawide

Assessment Manual (1975), the Northeast New Jersey 208 Water Quality Management Plan (1977) estimates that runoff from these landfills contributes about 13 million pounds of BOD_5 per year to the waterways of the study area. Almost 80% of this loading occurs in the Hackensack River Basin; the Hackensack Meadowlands are the primary landfilling area in northeastern New Jersey. Another 9% of the BOD loading from landfill runoff is received by the Passaic River just above Newark Bay.

Figure IV-3 shows the location of the landfills listed in Table IV-7.

C. Regionwide Point and Nonpoint Source Loading

Table IV-8 gives an overall summary of BOD_5 and coliform loadings into the New York Harbor complex from all sources in New York and New Jersey. BOD_5 and coliform are the pollutants of interest since they have a serious impact on water quality. The decrease in BOD_5 loading from point sources in 1981 is due, in large part, to the upgrading of the PVSC Plant from primary to secondary. Raw sewage, from the Red Hook and North River plants in New York, and runoff are responsible for the major pollutant loads.

TABLE IV-1

N.J. MUNICIPAL WASTEWATER TREATMENT PLANTS DISCHARGE INVENTORY

PLANT	TYPE of TREATMENT	RECEIVING WATERS	EXISTING EFFLUENT CHAR. DATA FLOW (MGD) DESIGN	REPORTED	BOD_5 (mg/l)	lbs/da.	TOTAL COLIFORM SUMMER COND. ($x10^{13}$ MPN/Day)	208 PROPOSAL (1979) DESIGN CAPACITY (MGD)	RECOMMENDATION
Carteret Borough (10)	P	Arthur Kill	3.0	3.02	545	13,720	0.05	--	Phase out to MCUA
Perth Amboy (13)	P	Raritan Bay	10.0	3.79	215	6,799	0.06	--	Phase out to MCUA
Rahway Valley Sewerage Auth (14)	S	Arthur Kill	35.0	29.09	16	3,791	0.4	35	Secondary; no action
Woodbridge Twp, Sewaren (18)	P	Arthur Kill	10.0	4.13	87	2,979	0.1	--	Phase out to MCUA
Joint Meeting of Essex & Union Co. (19)	S	Arthur Kill	75.0	64.41	23	12,420	0.9	75.0	Secondary; no action
Linden Roselle S.A. (2)	S	Arthur Kill	19.0	10.01	17	1,405	0.2	19.0	Secondary; no action
SUBTOTAL			152.0	114.45		41,114	1.6		
Bayonne City (2)	P	Kill Van Kull	20.0	11.93	123	12,283	0.2	10.1	Secondary; upgrade
Jersey City West (5)	P	Newark Bay	36.0	15.76	79	17,026	0.5	--	Phase out to PVSC
Kearn Town (6)	P	Newark Bay	4.0	2.0	353	5,892		--	Phase out to PVSC
SUBTOTAL			40.0	17.76		22,918	0.5		
Edgewater Boro. (1)	P	Hudson R.	4.4	3.03	96.0	2,427		3.3	Secondary; expand and upgrade
Hoboken City (3)	P	Hudson R.	20.8	12.45	125	13,009		21.1	Secondary; expand and upgrade
Jersey City East (4)	?	Hudson R.	46.6	36.0	91	27,397		56.3	Phase out to PVSC

Table IV-1 (Continued)

PLANT	TYPE OF TREATMENT	RECEIVING WATERS	EXISTING EFFLUENT CHAR. DATA FLOW (MGD) DESIGN	REPORTED	BOD_5 (mg/l)	(lbs./day	TOTAL COLIFORM SUMMER COND.	208 PROPOSAL (1979) DESIGN CAPACITY (MGD)	RECOMMENDATION
North Bergen Twp. Woodcliff (8)	P	Hudson R	3.3	1.84	101	1,552		3.34	Proposed to be abandoned to Hoboken STP pend. updated 201 plann appr
West NY MUA (9)	P	Hudson R	10.0	6.43	78	4,156		10.0	Upgrade to secondary
* North Bergen Guttenberg (29)	P	Hudson R	3.34	1.8	97.7	1,467			Phase out to Hoboken
Military Ocean Terminal-Bayonne (7)	S	Upper NY Bay	0.18	0.11	6	5			Secondary STP
Passaic Valley Sewage Comm. (21)	S	Upper NY Bav	300.0	232.93	47	90,333	3.6	300	Secondary, no action
SUBTOTAL			388.62	294.59		140,346	4.1		
* Bergen Co. U.A. Little Ferry (22)	S	Hackensack R	75.0	82.0	40.0	27,355		82.6	Secondary; discharge to Hudson R
* Wood-Ridge (23)	P	Berry's Creek	0.90	0.60	26.6	133.3			Phase out to BCUA
* Tri-Borough Joint mtg. Rutherford (24)	S	Berry's Creek	4.0	3.1	225	5,817			Phase out to BCUA
* North Arlington Lyndhurst (25)	P	Hackensack R	1.73	1.73	93.8	1,353			Phase out to BCUA

TABLE IV-1 (Continued)

PLANT	OF TREATMENT	RECEIVING WATERS	EXISTING EFFLUENT CHAR. DATA (FLOW (MGD) DESIGN	REPORTED	BOD_5 (mg/l)	(lbs/day	TOTAL COLIFORM SUMMER COND.	208 PROPOSAL (1979) DESIGN CAPACITY (MGD)	RECOMMENDATION
*N Bergen Northern(26)	P	Bellman's C	1.0	2.0	150.1	2,503			Phase out to Jersey City East
*N Bergen Central(27)	S	Cromakill Creek	2.0	1.7	9.40	1,333			
*Secaucus(28)	S	Mill Creek	2.25	1.2	35.0	350		2.25	upgrade to level 3
SUBTOTAL			86.88	92.33		38,844.3			Phase out to PVSC or upgrading & expansion
*W Paterson	S	Passaic R	0.8	1.55	46.4	580			
Middlesex Co. utilities Auth(11)	S	Raritan R	120.0	90.84	36.0	27,084			Outstanding interim & find outfall
Old Bridge Twp, MUA Lawrence Harb. (12)	P	Raritan Bay	1.4	1.05	92.0	803			to MCUA
Sayreville Boro Morgan (16)	P	Raritan Bay	0.30	0.23	88	169			to MCUA
Sayreville Boro Melrose (16)	P	Raritan R	.15	.07	67	39			to MCUA
S Amboy City (17)	P	Raritan Bay	0.8	0.83	147	1,014			to MCUA
SUBTOTAL			122.65	93.02		29,109			
TOTAL			810.95	625.63		285,194			

[1]NJ municipal wastewater treatment plants discharging into ISC district waters-1984 DEP-DWR data 1984

*data from NE NJ 208 report

Table IV-2 New York Municipal Wastewater Treatment Plants Discharger Inventory in Study Area

PLANT	Type Of Treatment	Receiving Waters	Existing Effluent Char, (1983 Data) Flow (MGD) Design	Reported	BOD_5 (mg/l)	(Lbs/day)	NYC 208 (1979) Design Flow (MGD)	Treatment
Hunts Point (32)	S	East River	200.0	112.5	16.5	15,481	200	Secondary
Newtown Creek (33)	S	East River	310.0	258.0	40.0	86,069	310	(M.A.) less than secondary
Red Hook (35)	Raw	East River	60.0	53.0	125.0	55,253	60	Secondary
Wards Island (37)	S	East River	250.0	285.5	6.5	15,477	250	Secondary
Bowery Bay (38)	S	East River	150.0	127.0	11.5	12,181	150	Secondary
Tallman Island (39)	S	East River	80.0	58.5	10.5	5,123	80.0	Secondary
Subtotal			1050.0	894.5		189,584		
Yonkers Joint Treatment (42)	S	Hudson River	92.0	110.1				
North River (36)	Raw	Hudson River	170.0	150.0	100.0	125,100	170	Secondary
Owl's Head (34)	S	Upper Bay	160.0	77.0	51.0	32,751	120	Secondary
Oakwood Beach (40)	S	Lower Bay	40.0	20.5	8.5	1,453	80	Secondary
Subtotal			462.0	357.6		159,304		
Port Richmond (41)	S	Kill Van Kull	60.0	38.0	13.5	4,278	60	Secondary
TOTAL			1572.0	1290		353,166		

TABLE IV-3

1981 NEW JERSEY SIGNIFICANT INDUSTRIAL DISCHARGERS

		1981 DATA		
FACILITY	RECEIVING WATERS	FLOW (MGD)	EFFLUENT BOD5 (mg/l)	LOADING (lbs/day)
Standard Tank Cleaning Corp		0.48	476.6	1908
Exxon-Bayonne pt. no.1	Arthur Kill	1.41	15.74	185.1
Exxon-Bayonne pt. no.2	Arthur Kill	1.39	16.33	189.3
Exxon-Bayonne pt. no.3	Arthur Kill	0.03	39.75	9.94
Capital City Products		0.09	466.9	350.4
Singer		.53	10.36	45.8
CPC Int'l Bayonne		0.01	114.75	9.6
Allied Chemical	Newark Bay	.26	6.75	14.6
Colgate		7.6	1.68	106.5
GAF	Arthur Kill	3.5	36.0	1050.8
Exxon-Linden	Rahway River	9.36	10.4	811.8
American Cyanamid	Rahway River	4.73	1.3	51.3
EI Dupont	Arthur Kill	2.21	4.75	87.5
FMC Corp	Arthur Kill	2.28	6.25	118.8
NL Industries		2.83	1.5	35.4
White Chemical Corp		0.41	5.4	18.5
American Cyanamid OOA	Rahway River	3.98	1.76	58.0
OOC	Rahway R.	13.85	1.1	127.1
OOD	Rahway R.	5.14	1.68	72.0
Subtotal		60.09		5250.4
Others		3.044		10.69
TOTAL		63.134		5261.09

FROM NEW YORK HARBOR WATER QUALITY STEERING COMMITTEE STEADY STATE MODEL LOADINGS

TABLE IV-4

1981 NEW YORK SIGNIFICANT INDUSTRIAL DISCHARGERS

FACILITY	1981 DATA			
	RECEIVING WATERS	FLOW (MGD)	EFFLUENT BOD5 (mg/l)	LOADING (lbs/day)
Kay Fries		0.3	40.0	100.1
Bush Terminal		0.2	83.0	138.4
Port Auth-JFK		.01	10.3	.86
Amstar		12.8	0.6	64.1
Conrail-Harmon		0.21	13.0	22.8
Clevepak		0.77	43.0	276.1
Greenwich		8.8	10.75	789.0
TOTAL		23.09		1391.4

From NY Harbor Water Quality steering committee-steady state model loadings

Table IV-5

CSO INVENTORY

Receiving Water	CSO's	Flowrate (MGD)	BOD_5 (lbs/day)	SS (lbs/day)	T.C.# MPN/dayx10^{14}
Hackensack River	Hackensack[14]	1.31	1223.6*	1576.5**	3.0
	Ridgefield[15]	0.541	514.6*	658.3**	1.3
	North Bergen[16]	0.877	717.8*	759.0**	2.0
	Jersey City[17]	2.83	2970.0*	4361.6**	6.4
	TOTAL	5.56	5426.0	7355.4	12.7
Passaic River	Verona Ave.	1.05	3660	-	2.35
	Herbert Ave.	1.12	1392	-	2.51
	Johnston Ave. (Kearny)	0.72	624.5	-	1.63
	Clay St.	14.6	40,791	-	32.67
	Sayfrook Pl.	1.46	1403	-	3.24
	City Dock	2.2	2605	-	4.92
	Ivy St. (Kearny)	3.25	6993.1	-	7.37
	Other	28.0	-	-	62.7
	TOTAL	52.4	57,469	-	117.39
Passaic River (Patterson Area)	Curtis Pl.[8]	7.4	12,467	-	16.56
	Northwest St[9]	2.0	1985	-	4.48
	Hudson St.[10]	3.95	-	-	3.84
	Montgomery[11]	1.87	2855	-	4.18
	10th & 33rd St.[12]	2.65	6903	-	5.93
	Market St.[13]	7.5	39,925	-	16.78
	Other	7.56	-	-	16.92
	TOTAL	32.93	64,135	-	73.69
Newark Bay	Jersey City[18] (West)	1.36	1540	2191.8	3.1
	Bayonne[19]	0.43	778	6054.8	0.1
	Newark Airport[20]	2.5	1078	-	5.7
	TOTAL	3.9	3396	8246.6	8.9
Arthur Kill	Elizabeth	1.82	378	-	34.4
	Linden-Roselle	0.44	411	-	8.33
	Rahway	0.71	663	-	13.33
	Carteret	1.15	1074	-	21.7
	Perth Amboy	4.48	4185	-	2.53
	Woodbridge	0.24	224	-	4.51
	TOTAL	8.84	6935	-	84.8

Table IV-5 Continued

CSO INVENTORY

Receiving Water	CSO's	Flowrate (MGD)	BOD_5 (lbs/day)	SS (lbs/day)	T.C.# MPN/day$\times 10^{14}$
N. Hudson River	Fort Lee-BCUA (F1-1)	.608	583.6	1882.2	1.4
	Edgewater BCUA (E-1)	.359	139.7	811.0	0.8
	Hoboken (H-8)	.663	605.5	2709.6	1.5
	Weehawken (W5)	.441	255.1	1326.0	1.0
	West New York	.510	397.3	1701.4	1.2
	Guttenberg	.088	49.9	276.7	0.2
	North Bergen	.107	65.2	317.8	0.3
	SUBTOTAL	2.79	2095.9	9024.6	6.3
S. Hudson River	Jersey City (East)	0.044	800	6235.6	.098
	Bayonne	3.44	3408.2	7389.0	7.70
	Jersey City (East)	3.07	3635.6	8126.0	6.87
	SUBTOTAL	6.55	7843.8	21.751	14.66
Hudson River	TOTAL	9.33	9939.7	30.776	20.96
Kill Van Kull	Bayonne	.054	970.0	7540	1.21
	TOTAL	113.0	148.271		319.6

* avg. conc. = 112 mg/l

** avg. conc. = 144.3 mg/l

\# T.C. conc.= 6×10^{6} MPN/100 ml

Table IV-6

URBAN RUNOFF (EXCLUDING CSO's)

Drainage Basin	Urban Runoff (BOD_5, lb/yr.)
Hackensack River	2,702,000
Passaic River	4,326,000
Arthur Kill	2,780,000
Hudson River	1,436,000
Elizabeth Channel	841,000
Upper New York Bay/Newark Bay/ Kill Van Kull	909,000

Table IV-7

Landfills in Study Area

Location No. & Landfill	Drainage Basin	Size (Acres)	Runoff Areal Loading (BOD5, lb./year)
1. 1947 Corporation	Hackensack River	59	505,000
2. Mall Landfill	Hackensack River	65	556,000
3. Kearny Site	Hackensack River	83	710,000
4. Kearny MSLA, Site I-C	Hackensack River	210	1,800,000
5. P&M Sanitation SWDA	Hackensack River	10	86,000
6. C. Egan & Sons Sanitary Landfill, Inc.	Hackensack River	80	684,000
7. Avon Landfill Corp.	Hackensack River	90	770,000
Kingsland Park Disposal Area	Hackensack River	400	3,420,000
Kingsland Pk. Landfill Extension	Hackensack River	60	513,000
Sawmill Park Landfill Extension	Hackensack River	27	231,000
8. Esposito Constr. SWDA, R&M Recloration	Hackensack River	9	77,000
9. Village of Ridgefield Park	Hackensack River	45	389,000
10. Bergen County SWDA	Hackensack River	45	389,000
SUBTOTAL FOR HACKENSACK BASIN		1183	10,130,000
11. V. Ottilio & Sons	Passaic River	3.5	30,000
12. Kearny MSLA, Site I-D	Passaic River	83	710,000
13. Kearny MSLA, Site I-A	Passaic River	57	488,000
SUBTOTAL FOR PASSAIC BASIN		143.5	1,228,000
14. City of Rahway	Arthur Kill (Rahway River)	10	86,000
15. City of Linden Sanitary Landfill	Arthur Kill (Rahway River)	14.8	127,000
16. American Cyanamid Corp.	Arthur Kill (Piles Creek)	—	—
23. Fresh Kill	Arthur Kill	—	—
SUBTOTAL FOR ARTHUR KILL BASIN (Available Data)		24.8	213,000
17. D&J Trucking & Waste Co.	Elizabeth Channel	13	11,000
18. T&J Landfill	Elizabeth Channel	10	86,000
19. R. Devino SWDA	Elizabeth Channel	--	--
SUBTOTAL FOR ELIZABETH CHANNEL (Available Data)		23	197,000

Table IV-7 Cont.

Landfills in Study Area, Cont.

Location No. & Landfill	Drainage Basin	Size (Acres)	Runoff Areal Loading (BOD_5, lb./yr.)
20. City of Bayonne Landfill	Upper New York Bay	62	530,000
21. Thomas Heagney SWDA	Hudson River	35	299,000
North Hudson Hospital Assn.	Hudson River	7.1	61,000
22. Edgewater Boro SWDA	Hudson River	--	--
SUBTOTAL FOR HUDSON RIVER BASIN (Available Data)		42.1	360,000
TOTAL FOR STUDY AREA		1478	12,658,000

Table IV-8

SUMMARY OF TOTAL LOADS - BOD_5 & COLIFORM LOADS IN NY HARBOR COMPLEX

Verification Period	TOTAL BOD_5 LOADS BY SOURCE (LBS/DAY)							FECAL COLIFORM [(MPN/DAY) x 10^{14}]						
	Point Source	By Pass[1]	Raw	Leakage	Misc	Runoff	TOTAL	Point Source	By Pass[1]	Raw	Leakage	Misc	Runoff	TOTAL
Summer 1965	$1.140x10^6$	-	428,345	107,135	262,760	174,800	$2.11x10^6$							
Summer 1970	$1.84x10^6$	-	428,345	107,135	262,760	194,900	$2.84x10^6$	330.5		408	116	1.95	58.6	916
Summer 1975	$1.539x10^6$	169,479	440,021	107,135	262,760	441,500	$2.96x10^6$	330.5	229	408	116	1.95	137	1220
September 1975	$1.479x10^6$	129,343	440,021	107,135	262,760	435,800	$2.85x10^6$	330.5	229	408	116	1.95	131	1220
Nov.-Dec. 1976	$1.746x10^6$	274,150	281,227	107,135	262,760	177,600	$2.85x10^6$	262.6	345	265	116	1.95	53.6	1050
July 1977	$1.44x10^6$	137,516	281,227	107,135	262,760	192,000	$2.42x10^6$	507	190	265	116	1.95	57.6	1140
1981	$6.45x10^5$	-	281.227	107,135	262,760	332,000	$1.63x10^6$	$4.73x10^6$*		265	116	1.95	482	865

(1) Construction bypass only occurred 1975-1977

* Note order of magnitude

Figure IV-1

LOCATION OF NEW JERSEY AND NEW YORK MUNICIPAL WASTEWATER TREATMENT PLANTS

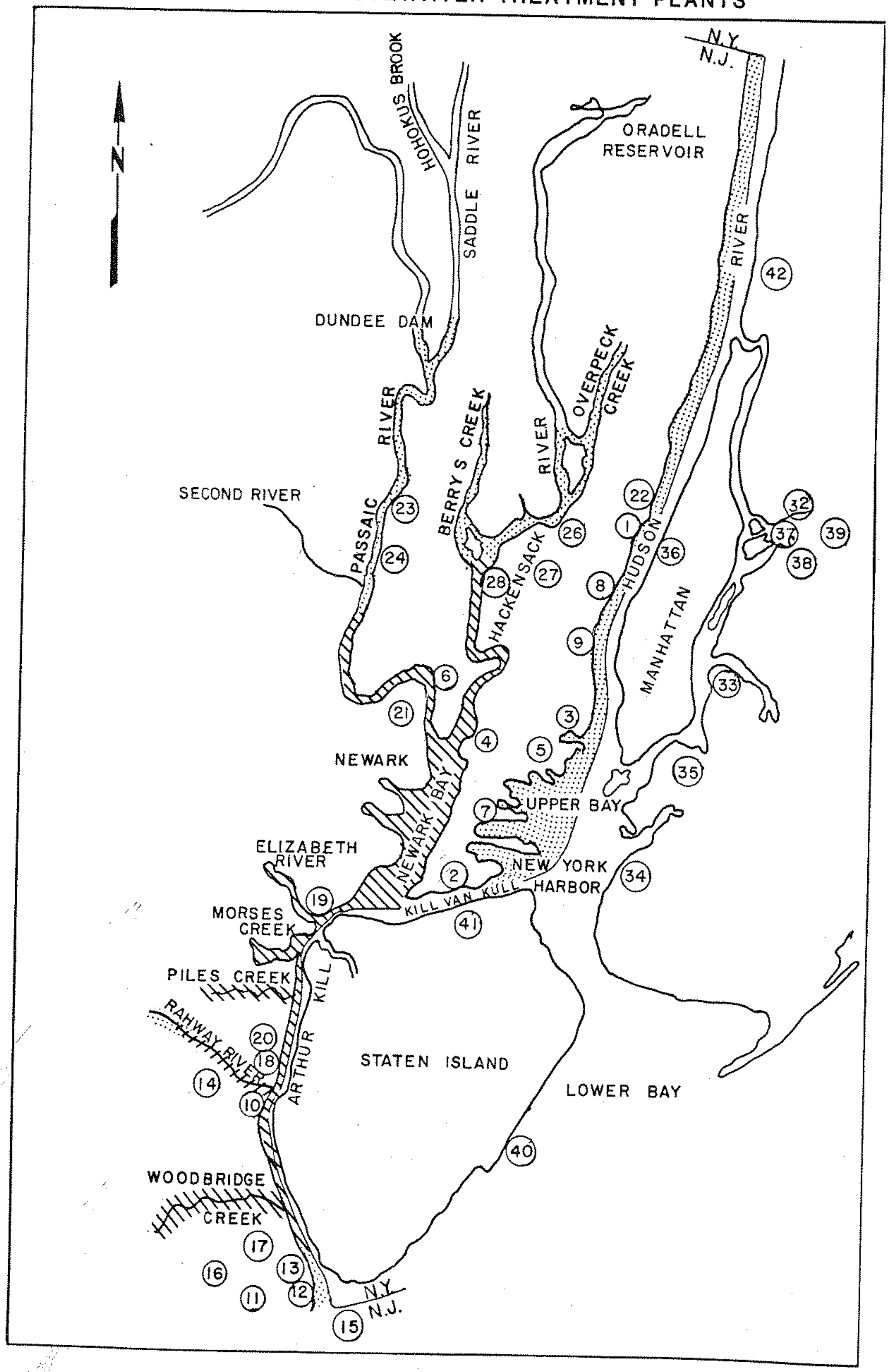


Figure IV :2a

LOCATION OF NEW JERSEY CSO'S

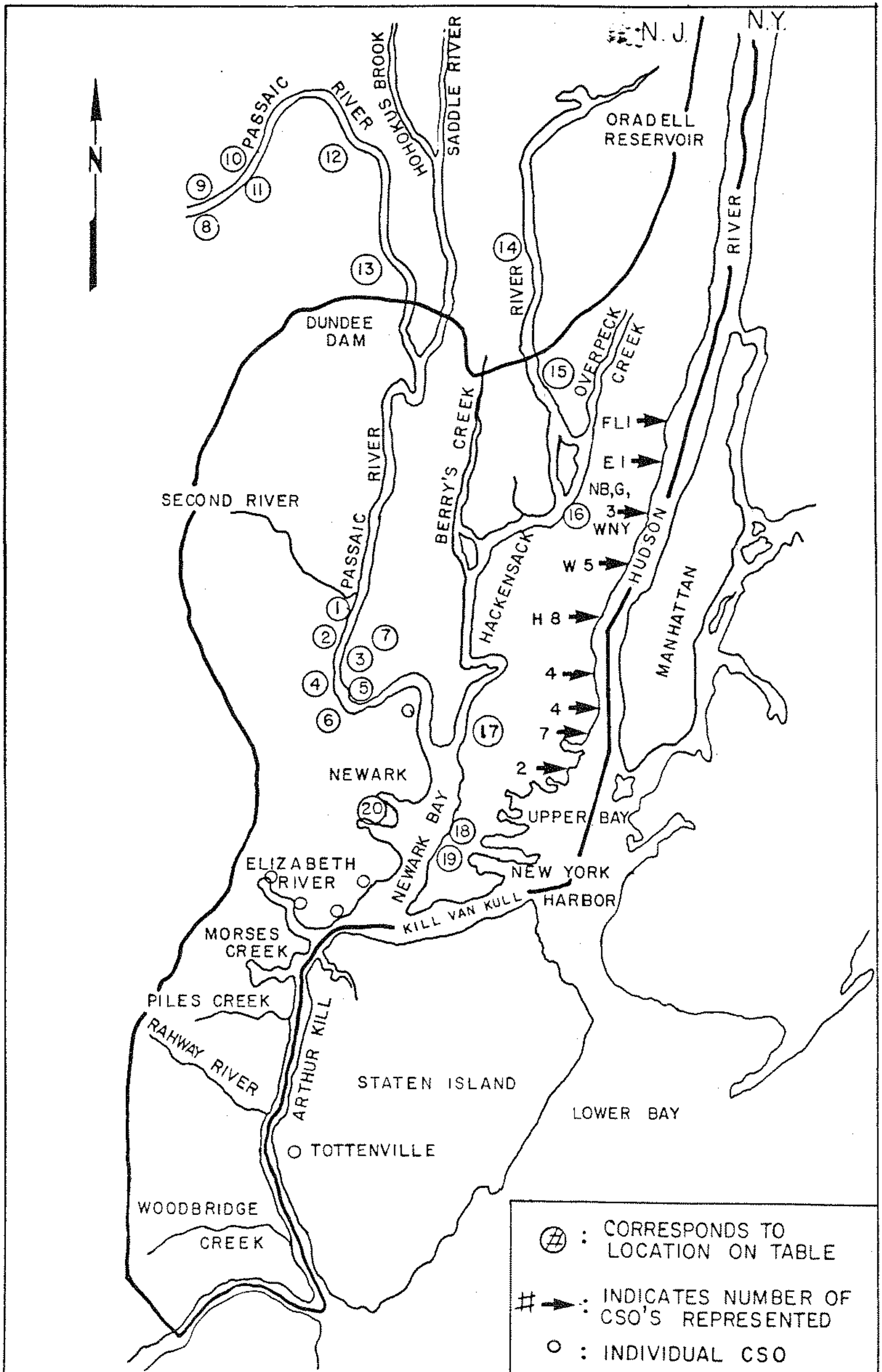


Figure IV-2b : LOCATION OF NEW YORK CSO's

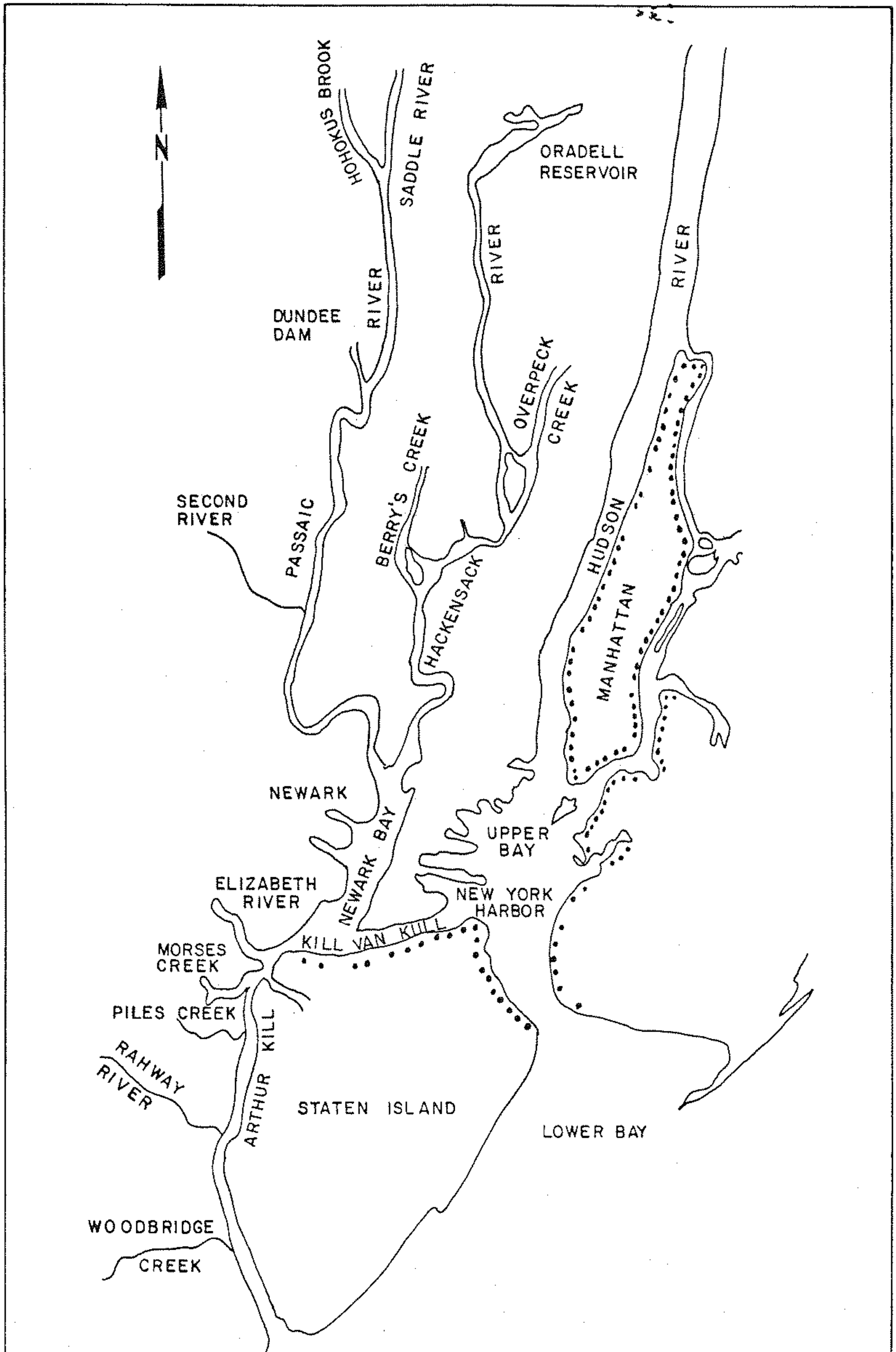
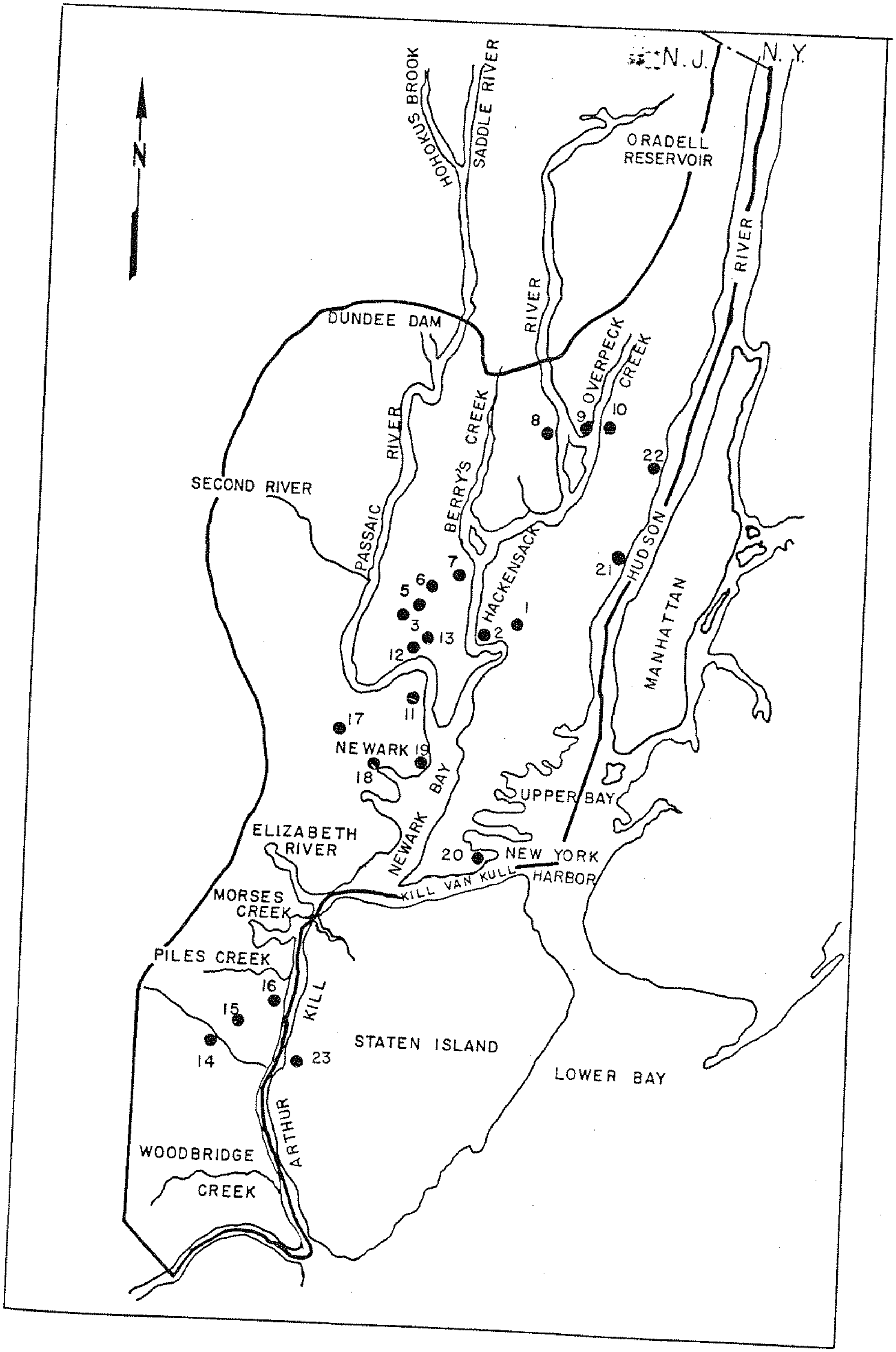


Figure IV-3 : LANDFILLS IN STUDY AREA



V. Current Water Quality Conditions and Trends

This section presents the water quality trends and current water quality conditions in the study area. The Interstate Sanitation Commission (ISC) has been conducting a regular sampling program in this area. The DO and fecal coliform data used in this study were taken from ISC files and the EPA STORET system, for the period 1974 - 1983. The sampling stations are shown in Figure V-1. Approximate minimum DO concentrations, at any given time, can be obtained by subtracting 1 mg/l from the average DO profiles, as presented in this section.

A. Water Quality Trends

The summer and winter average of DO and fecal coliform levels for the period are presented in Table V-1 and Figures V-2 to V-5 for the stations selected in this study (AK-07, NB-12, UH-11 and UH21). These stations represent the Arthur Kill, Newark Bay, Kill Van Kull and Upper New York Bay. By examining the water quality trends, as shown in Figures V-2 to V-5, the following conclusions are drawn:

1. The average summer and winter DO concentrations showed an increasing trend since 1979 in the Kill Van Kull (UH-11), the Upper Bay (UH-21) and Arthur Kill (AK-07). This DO improvement can be attributed to the upgrading of the Passaic Valley Sewerage Commissioners (PVSC) facility from a primary to a secondary treatment level.

2. Newark Bay showed a DO depression occurring in the summer of 1980. This was due to the PVSC sewage bypass to Newark Bay during the renovation of their outfall to New York Bay.

3. The winter DO average was always better than that of the summer, for all stations, and met the current DO criteria.

4. By subtracting 1 mg/l from the average DO values to obtain the minimum summer DO concentration at any given time, it is found that, except for the Kill Van Kull, the DO concentrations in the Arthur Kill, Newark Bay and Hudson River were at the margin or below the minimum DO criteria.

5. There was no sign of improvement of the coliform levels in the study area, during the summer as well as the winter conditions.

6. Both the summer and winter fecal coliform levels do not meet the current designated water quality criteria.

B. Current Water Quality Conditions

Based on the data recorded during 1979-1983, the spatial distributions of average summer DO and fecal coliform profiles are shown in Tables V-2 and V-3 and Figures V-6 and V-7. Insufficient water quality data were available to develop the water quality trend profiles for the Passaic and the Hackensack Rivers. Table V-4 shows the water quality conditions only at the upstream boundary of the Passaic and Hackensack Rivers. Based on the past six years, 1979 to 1984, of existing water quality records from the Interstate Sanitation Commission, the percentage of violations for the New York Harbor Complex, for summer dissolved oxygen and fecal coliform, are shown in the Table V-5. The sampling stations used for the frequency of violation analysis are shown in Figure V-1. By examining the water quality profiles, the following conclusions can be made:

1. By subtracting 1 mg/l from the average DO values, as shown in the DO profiles, it is found that the DO concentrations in the Arthur Kill still can not meet the SE3 criterion (3 mg/l).

2. Newark Bay had a severe DO depression in 1980, due to the PVSC sewage bypass flow. However, the DO concentration met the SE3 criterion in the summers of 1982 and 1983.

3. In the Hudson River, the peak coliform level occurred around the Upper New York Bay, which is consistent with the historical data.

4. The fecal coliform levels fail to meet the SE2 and SE3 criteria in the Arthur Kill, Newark Bay and Hudson River.

5. Almost 98% of the fecal coliform record violated the swimmable goal, 200 MPN/100 ml; 24% of the overall dissolved oxygen record violated the fish propagation goal of 4 mg/l.

C. Biological Assessment

In a 1984 report entitled "Stressed Water Evaluation for the Hudson-Raritan Estuary (TC-3348)"(25), Tetra Tech, under contract to the USEPA, compiled the available information on the biological community in the Hudson-Raritan Estuary and made an assessment of it's condition, as part of a section 301(h) evaluation of those waters. Based on a review of biological and water quality information, the report concluded that "The Hudson-Raritan Estuary should be classified as stressed in the context of the 301(h) regulations." Those regulations (47 FR 53666; November 26, 1982) define "stressed waters" as waters characterized by "the absence of a balanced, indigenous population... caused solely by human perturbations."

The report concluded that benthic fauna were the best indicators of stressed conditions, and specifically characterized the benthos of the Hudson River, Raritan Bay, Upper New York Bay and the Newark Bay/Arthur Kill complex as stressed. This assessment was based on reductions in species richness, dominance by opportunistic/pollution-tolerant species, and a high numerical abundance of dominant species.

Fish communities were generally found not to exhibit alterations in community structure indicative of pollutant stress, however, substantial reductions in many commercially important species have occurred in the area. Unfortunately, an insufficient data base exists to evaluate the population dynamics of most species, in order to determine the causative factors (i.e. pollution, habitat alterations, overfishing). However, limited information on the occurrence of certain fish diseases does suggest that fish communities in certain areas, including Raritan Bay, may be subjected to pollutional stresses.

Another strong indicator of pollutant stress is the available information on bioaccumulation. In particular, PCB contamination of the edible tissues of species of recreational and commercial importance was found in a large portion of the estuary, including the Hudson River, Raritan Bay, and the Newark Bay/Arthur Kill complex.

The report supports its biological assessment with a review of available data on dissolved oxygen and ammonia concentrations in the estuary and concentrations of toxics, including selected heavy metals, pesticides and PCB's, in water and sediments. The report concludes that an "Evaluation of dissolved oxygen concentrations and concentrations of contaminants in water and sediments indicates that all of the subareas (of the estuary) are potentially stressful to estuarine biota."

Table V-1

WATER QUALITY TREND#

SAMPLING PERIOD	AK-07		NB-12		UH-11		UH-2	
	D.O.* (mg/l)	F.C.** (MPN/100ml)	D.O.* (mg/l)	F.C.** (MPN/100ml)	D.O.* (mg/l)	F.C.** (MPN/100ml)	D.O.* (mg/l)	F.C.** (MPN/100ml)
'74 S. AVG.	1.8	2739	2.94	8351	-	-	4.81	3401
'74 W. AVG.	6.59	2195	8.4	305	-	-	9.26	1672
'75 S. AVG.	3.6	16438	5.23	3882	6.83	3189	4.17	5685
'75 W. AVG.	7.4	3550	8.4	775	7.8	867	8.73	18166
'76 S. AVG.	3.14	20508	3.76	1254	4.26	4632	4.43	4866
'76 W. AVG.	7.0	3606	8.3	1265	9.1	1900	9.67	-
'77 S. AVG.	3.08	1020	3.68	3670	4.65	4468	5.27	1430
'77 W. AVG.	7.37	3479	7.4	1720	8.6	15000	10.15	6747
'78 S. AVG.	3.3	7071	4.66	11063	4.91	991	5.34	5900
'78 W. AVG.	6.35	3274	7.18	3000	8.1	1400	8.2	1530
'79 S. AVG.	4.84	9292	5.23	954	4.8	2623	4.57	621
'79 W. AVG.	5.8	4755	5.33	20174	8.5	3900	7.4	-
'80 S. AVG.	3.79	5141	3.24	17587	5.76	3203	-	-
'80 W. AVG.	8.47	785	8.05	363	9.3	1649	-	-
'81 S. AVG.	3.35	2863	4.37	1137	4.81	4908	-	-
'81 W. AVG.	7.9	477	9.1	710	9.98	2835	-	-
'82 S. AVG.	4.75	1113	5.75	2953	6.94	1811	7.2	3100
'82 W. AVG.	-	330	-	1300	-	1700	-	5400
'83 S. AVG.	4.6	2142	4.0	3447	5.5	2161	5.87	2357
'83 W. AVG.	12.0	1100	-	-	11.0	1700	12.0	330

\# Data calculated from I.S.C.

* D.O. average = arithmetic mean

* F.C. average = geometric mean

Table V-2

CURRENT WATER QUALITY CONDITION
ARTHUR KILL & NEWARK BAY #

	'79 S. AVG.		'80 S. AVG.		'82 S. AVG.		'83 S. AVG.	
STATION	D.O.* (mg/l)	F.C.** (MPN/100 ml)	D.O.* (mg/l)	F.C.** (MPN/100 ml)	D.O.* (mg/l)	F.C.** (MPN/100 ml)	D.O.* (mg/l)	F.C.** (MPN/100 ml)
AK-18	5.25	220	4.54	1802	6.28	922	4.63	1279
AK-13	5.03	3344	4.11	7692	5.75	11745	3.8	4215
AK-07	4.84	9292	3.79	5141	4.75	1113	4.6	2142
AK-03	4.95	1700	3.11	13468	5.7	3707	5.01	2219
NB-03	5.26	1022	1.96	14637	8.0	3200	6.07	908
NB-12	5.23	954	3.24	17587	5.75	2953	4.0	3447

Data calculated from ISC

* D.O. average = arithmetic mean

** F.C. average = geometric mean

Table V-3

CURRENT WATER QUALITY CONDITION
HUDSON RIVER & NEW YORK BAY #

	'79 S. AVG.		'80 S. AVG.		'82 S. AVG.		'83 S. AVG.	
STATION	D.O. (mg/l)	F.C. (MPN/100 ml)	D.O. (mg/l)	F.C. (MPN/100ml)	D.O. (mg/l)	F.C. (MPN/100 ml)	D.O. (mg/l)	F.C. (MPN/100 ml)
HR-07	-	-	-	-	7.2	-	5.96	-
HR-04	6.65	2289	5.9	655	7.8	434	5.3	562
HR-03	5.73	5000	6.01	2086	7.3	280	4.73	1609
HR-02	6.2	4000	5.27	1300	7.6	3896	5.0	1555
HR-01	4.96	3110	6.01	3647	7.3	1887	4.83	3500
UH-21	4.13	3782	6.24	2766	8.0	2574	4.9	4830
UH-03	4.69	3633	5.82	24662	8.17	695	5.93	3359

Data calculated from ISC
* D.O. average = arithmetic mean
** F.C. average = geometric mean

Table V-4

WATER QUALITY CONDITION OF PASSAIC RIVER BELOW DUNDEE DAM (PR-01) AND HACKENSACK RIVER BELOW ORADELL DAM (HR-01) #

SAMPLING PERIOD	PR-01 D.O.* (mg/l)	PR-01 F.C.** (MPN/100 ml)	HR-01 D.O.* (mg/l)	HR-01 F.C.** (MPN/100 ml)
'74 S. AVG.	8.77	1191	8.7	-
'74 W. AVG.	11.19	436	12.13	-
'75 S. AVG.	8.39	2303	8.53	8
'75 W. AVG.	12.21	483	10.57	71
'76 S. AVG.	5.8	1200	7.68	4
'76 W. AVG.	11.7	832	11.33	6
'77 S. AVG.	7.05	2674	7.22	5
'77 W. AVG.	13.1	478	11.7	5
'78 S. AVG.	7.97	2303	8.18	158
'78 W. AVG.	11.64	802	11.35	20
'79 S. AVG.	7.86	327	7.1	165
'79 W. AVG.	12.5	1075	10.83	25
'80 S. AVG.	7.78	1437	7.03	25
'80 W. AVG.	9.0	3500	11.03	23
'81 S. AVG.	8.4	3647	7.6	63
'81 W. AVG.	-	1049	11.6	98
'82 S. AVG.	7.23	5708	8.72	32
'82 W. AVG.	11.2	3500	9.98	259
'83 S. AVG.	-	-	8.4	490
'83 W. AVG.	-	-	-	-

Data calculated from STORET

* D.O. average = arithmetic mean

** F.C. average = geometric mean

Table V-5

VIOLATION FREQUENCY OF NEW YORK HARBOR COMPLEX (1) (2)

		DISSOLVED OXYGEN (3)			FECAL COLIFORM (4)		
		Total No. of Data	Violation Frequency of D.O. Goal		Total No. of Data	Violation Frequency of F.C. Goal	
RECEIVING WATERWAY	SAMPLING STATION		Total No.	% of Viol.		Total No.	% of Viol.
Hudson River	HR-01	38	9	23.7	17	17	100
"	HR-02	18	1	5.6	10	10	100
"	HR-03	17	1	5.9	11	11	100
"	HR-04	18	1	5.6	17	15	88.2
Upper Bay	UH-03	25	3	12.0	15	14	93.3
"	UH-21	26	6	23.1	13	13	100
"	UH-22	48	12	25.0	29	29	100
Kill Van Kull	UH-11	29	4	13.8	17	17	100
Newark Bay	NB-12	36	15	41.7	18	18	100
"	NB-03	14	4	28.6	9	9	100
Arthur Kill	AK-03	27	9	33.3	18	18	100
"	AK-07	28	12	42.9	27	27	97.6
"	AK-13	29	10	34.5	17	17	100
"	AK-18	29	5	17.2	16	15	93.8

(1) Data provided by ISC.
(2) Sample periods were from 1979 to 1984 of each summer season.
(3) D.O. fishable goal is 4 mg/l.
(4) F.C. goal is 200 MPN/100 ml.

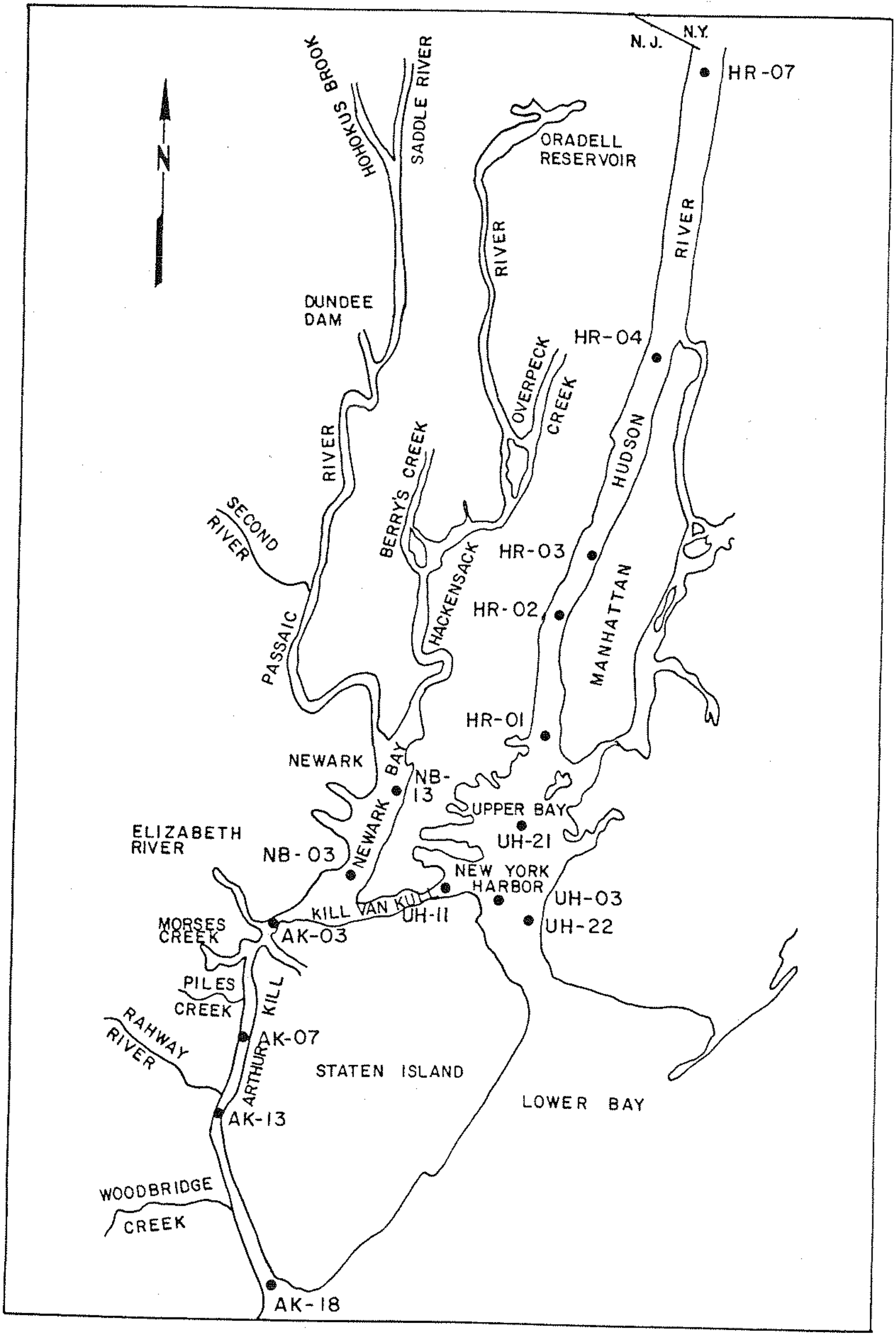


Figure V-1 : Location of I.S.C. Sampling Station

Figure V-2

TEN YEAR D.O. TREND

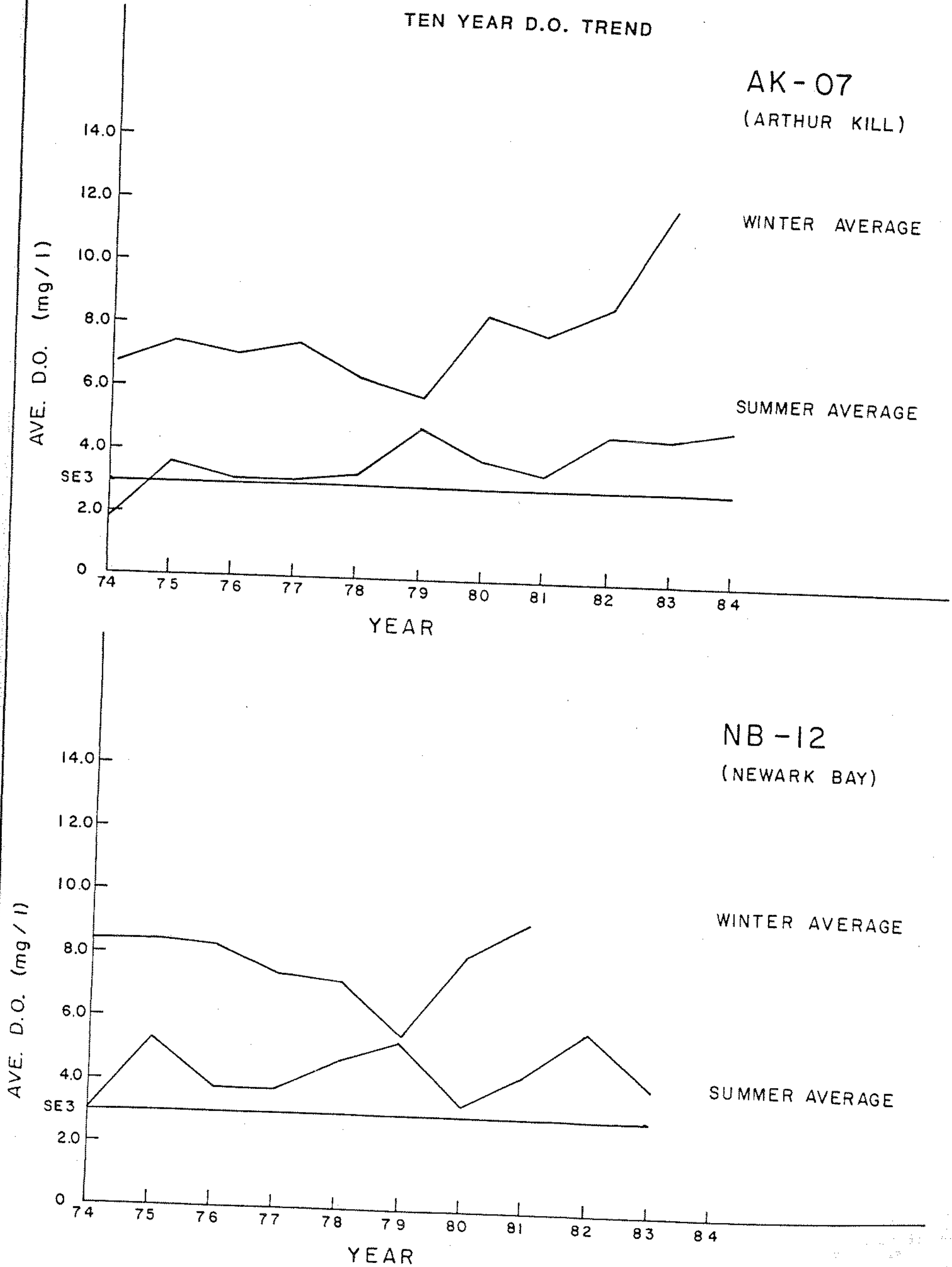
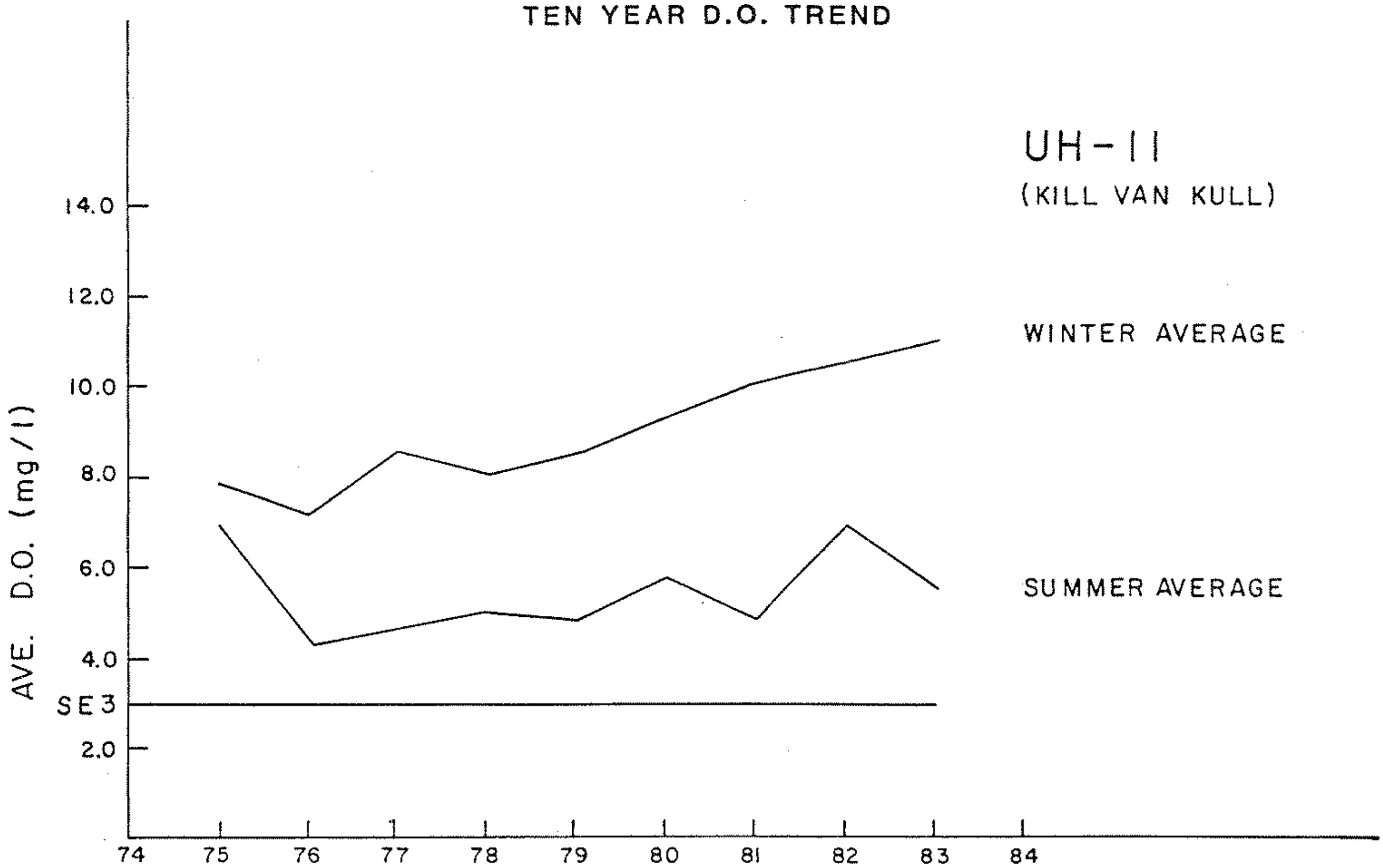
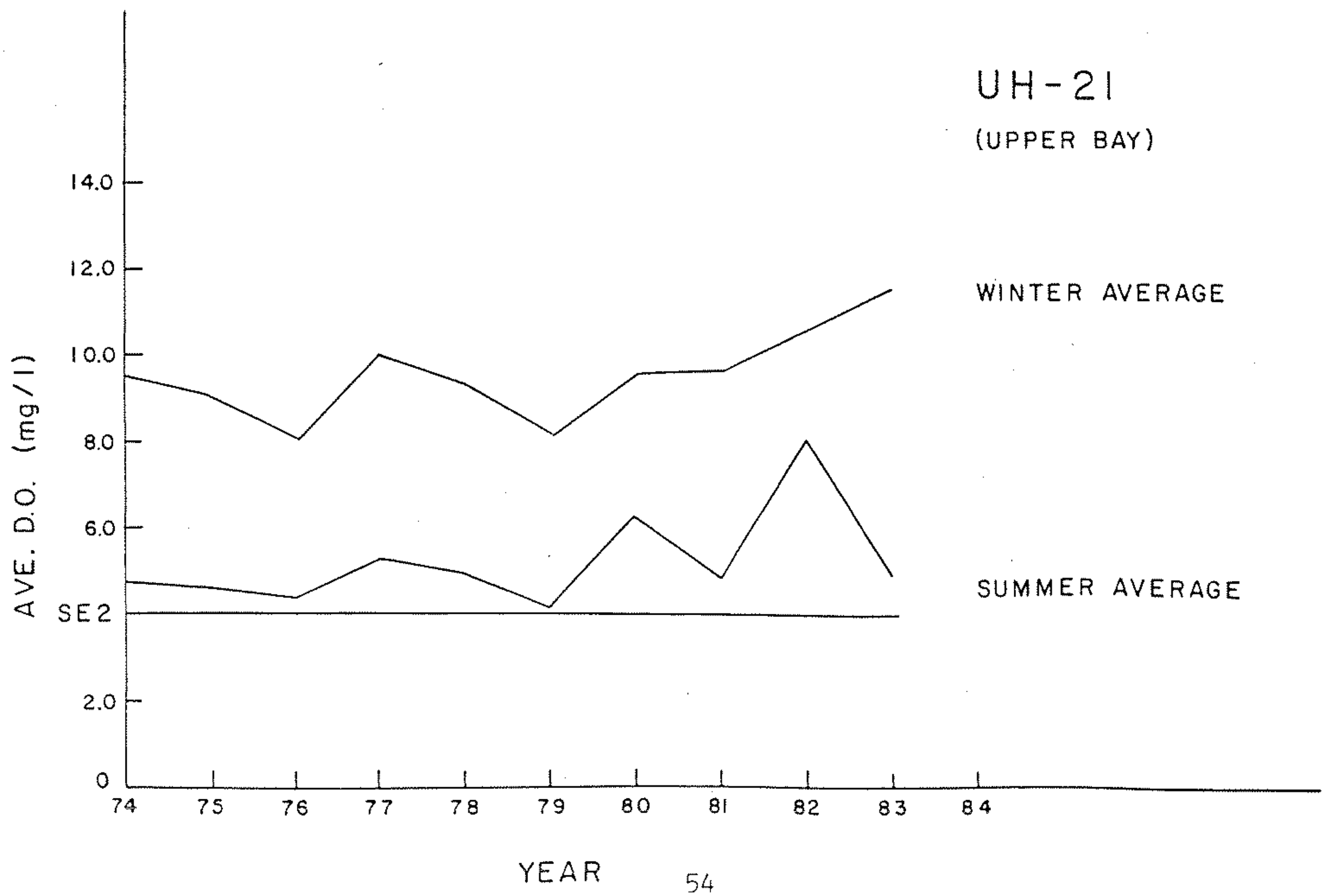
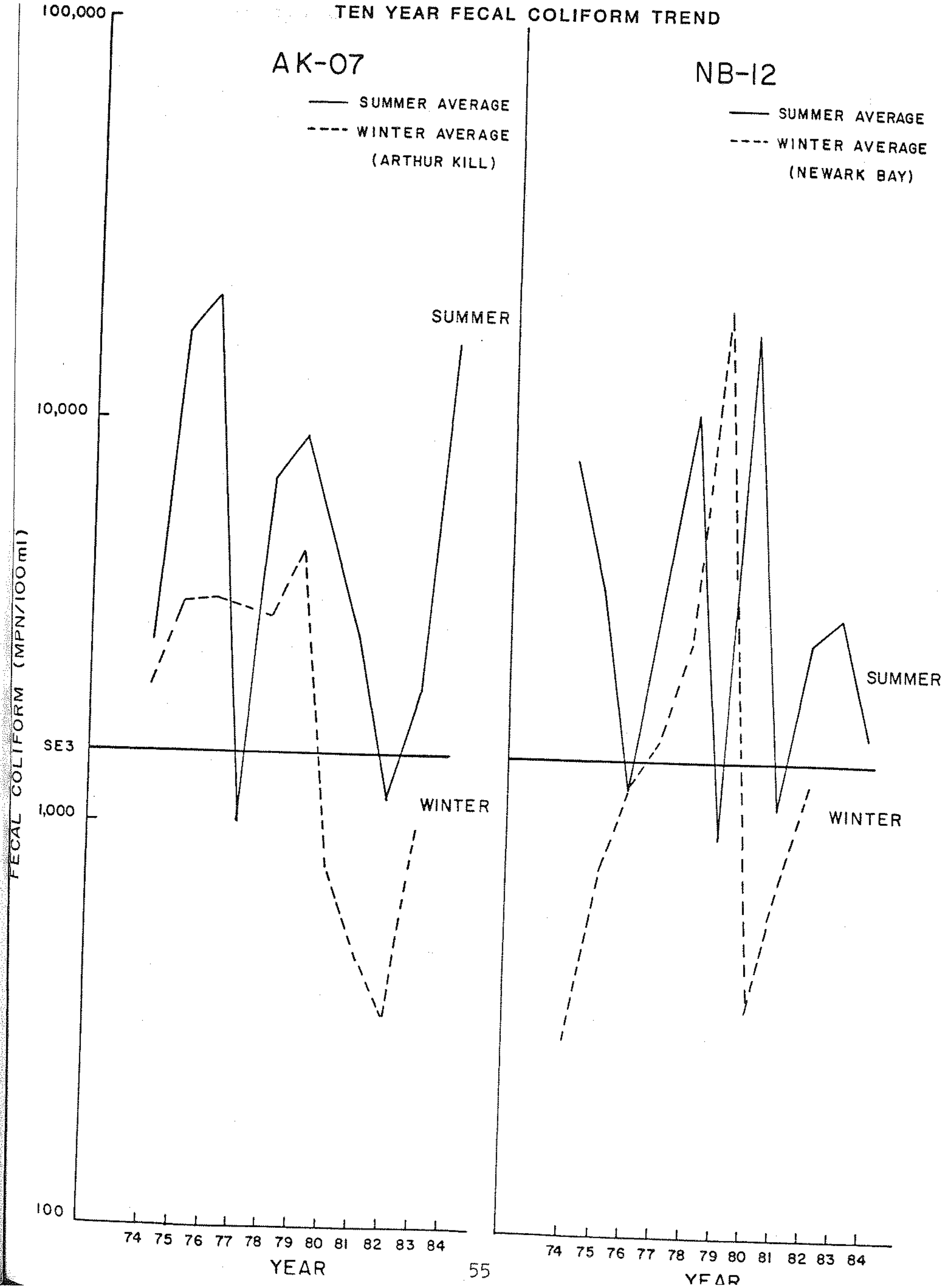


Figure V-3

TEN YEAR D.O. TREND







TEN YEAR FECAL COLIFORM TREND
AK-07
SUMMER AVERAGE
WINTER AVERAGE
(ARTHUR KILL)
NB-12
SUMMER AVERAGE
WINTER AVERAGE
(NEWARK BAY)
100,000
10,000
SE3
1,000
100
FECAL COLIFORM (MPN/100ml)
SUMMER
WINTER
SUMMER
WINTER
74 75 76 77 78 79 80 81 82 83 84
YEAR
74 75 76 77 78 79 80 81 82 83 84
YEAR

Figure V-3

TEN YEAR FECAL COLIFORM TREND

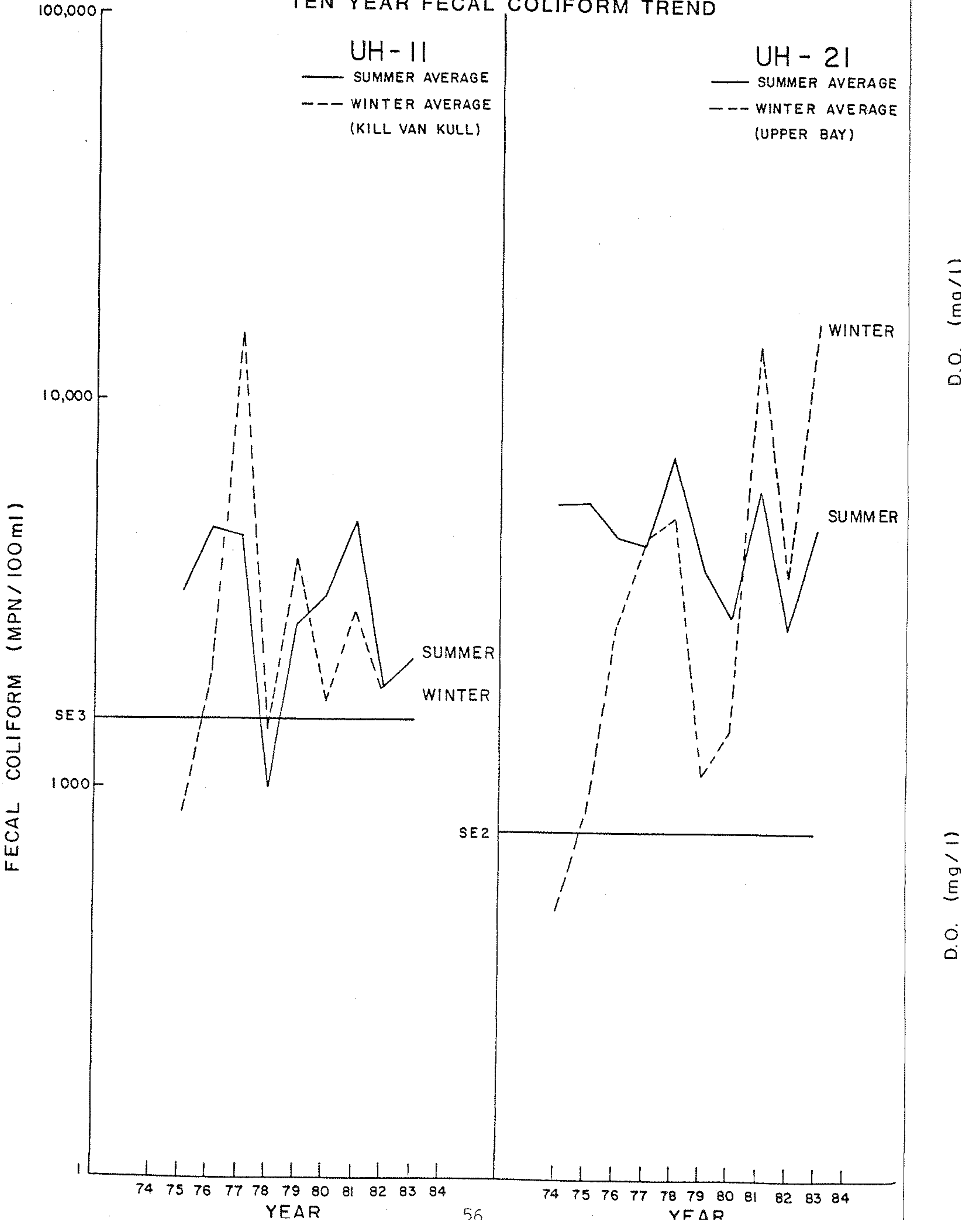


Figure V-6
D.O. CONCENTRATION, SUMMER AVERAGE

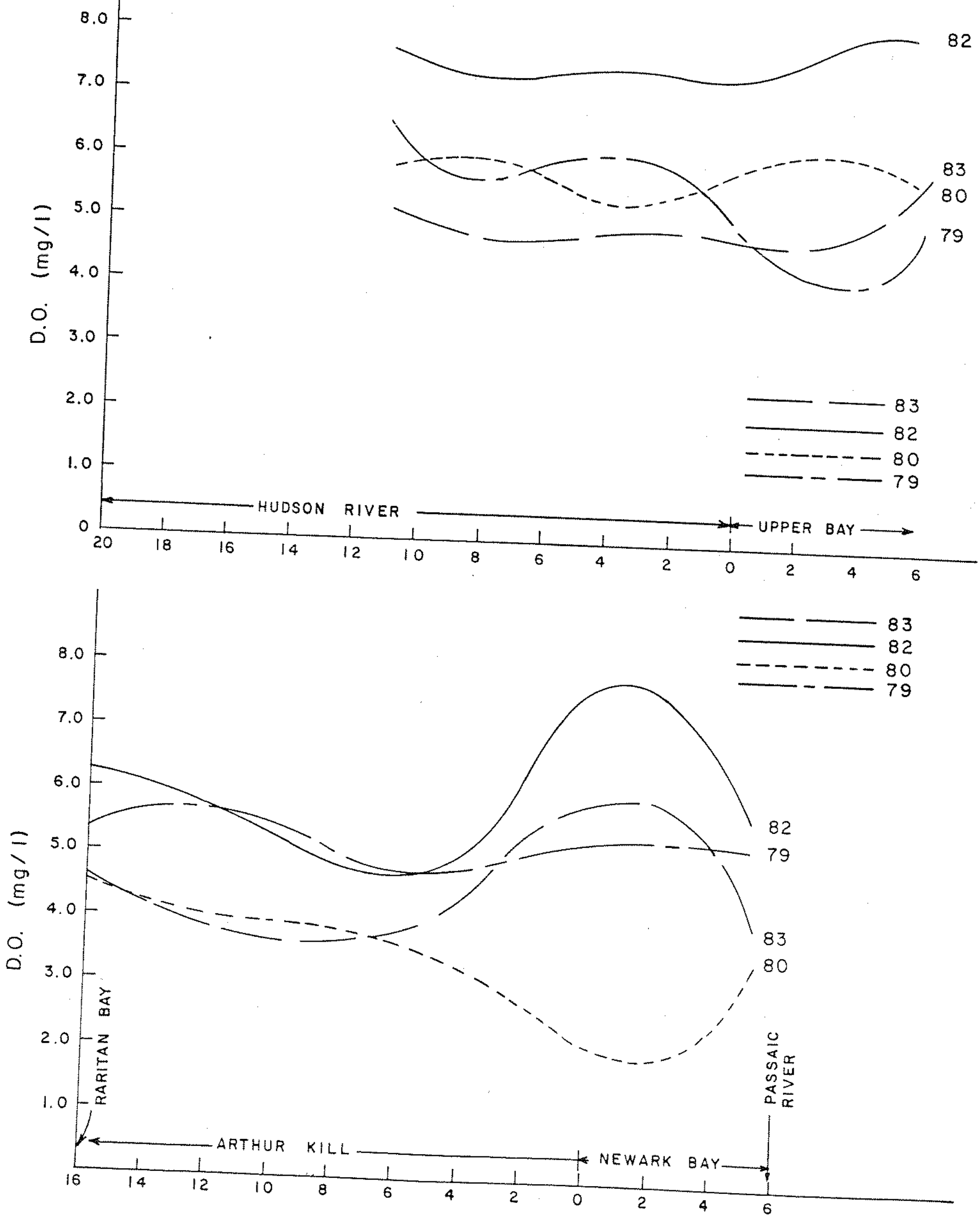
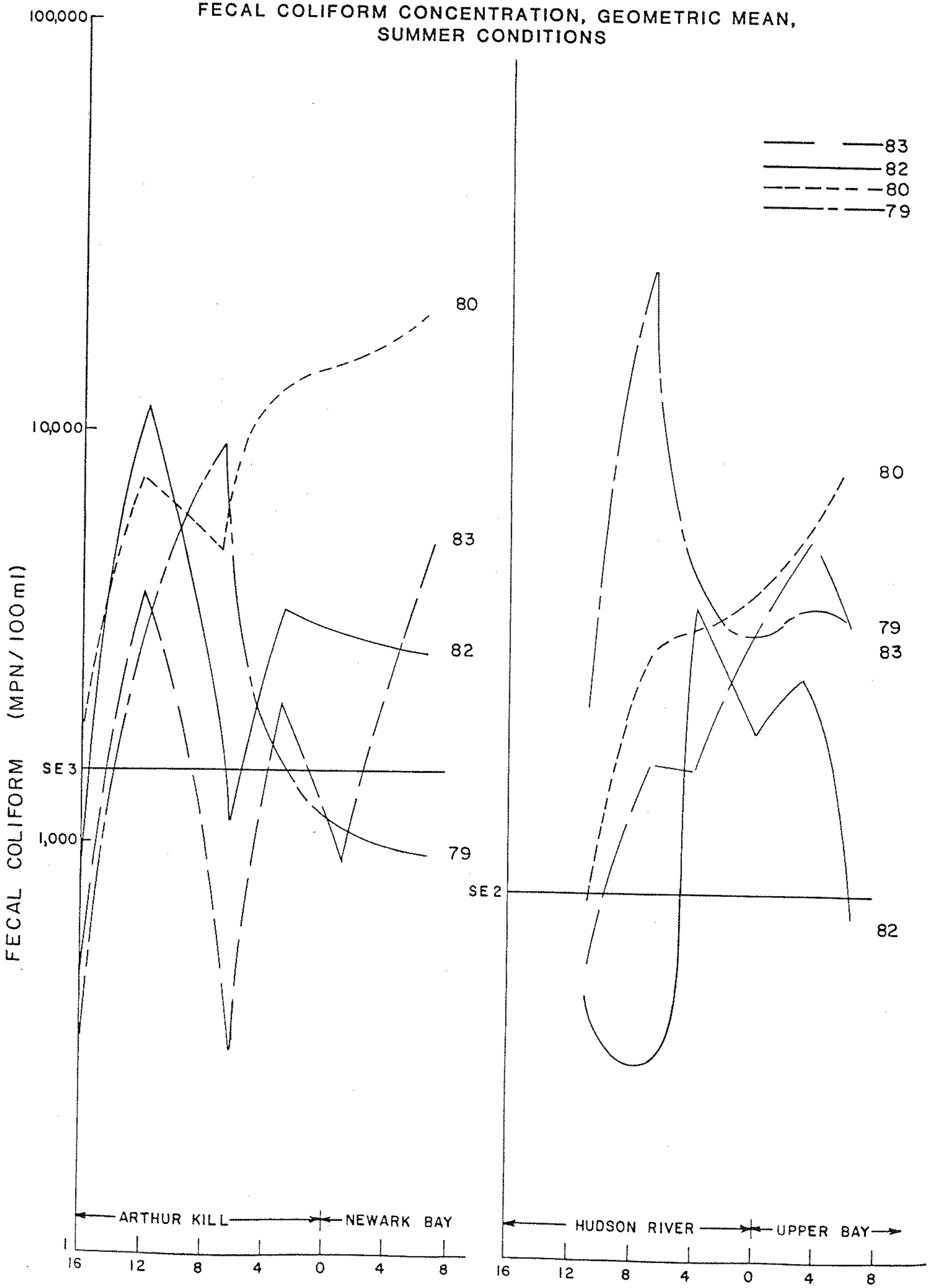


Figure V-7

FECAL COLIFORM CONCENTRATION, GEOMETRIC MEAN, SUMMER CONDITIONS



VI. Water Quality Impact Analysis

A. Physical and Hydrodynamic Characteristics (6)

Estuarine waters bordering or within the use attainability area include: portions of the Upper Bay of New York Harbor, the Hudson River, Newark Bay, lower Passaic River, lower Hackensack River, Kill Van Kull and Arthur Kill and their saline tributaries. These estuarine waters interact with one another within the Harbor system. The hydrodynamic characteristics in any segment of the New York Harbor area are dependent upon processes and conditions which occur throughout the harbor. Consequently, in this section, the physical and hydrodynamic processes occurring throughout the entire harbor complex will be considered, rather than attempting to confine the waters within the study area.

The major objective of this section is to describe the influence of the esturine features in the New York Harbor on the water quality and its uses. The physical processes which affect the dissolved oxygen and bacteria concentrations within these waters include: the freshwater inflow, tidal currents, net circulation with turbulent mixing processes, salinity distribution and flushing rate. In addition, the general bathymetry of the harbor will be discussed. The information described in the following sections was taken from the Hudson County Utilities Authority 201 Wastewater Facilities Planning Areas I, II, and III (1979)(6).

1. Bathymetry

In the Lower New York and Raritan Bays, the channels, including Ambrose, Sandy Hook, Chapell Hill and Raritan Bay reaches, were dredged to depths of 35 feet to 45 feet and widths of 1000 feet to 2000 feet. With the exception of these channels, the water depths in Lower New York and Raritan Bays are generally less than 20 feet and there are substantial areas where water depths are less than 10 feet. However, a deep, wide natural channel, with water depths ranging from 50 to 100 feet, is found in the vicinity of the Narrows Bridge.

In the Upper New York Bay, except for the dredged channels, with a width of approximately 2000 feet and depths of about 35 feet, the most western portion of Upper Bay included in the study area, the waters are generally in the shoal region, with a depth of less than 5 feet. The average water depths, from Upper New York Bay to the New Jersey and New York State border, range approximately from 35 to 45 feet.

The Kill Van Kull is a relatively narrow waterway about 4 miles long, ranging from 1000 to 2000 feet wide, with a dredged water depth of 35 feet. The Arthur Kill, which extends 12 miles from its mouth at Perth Amboy to Newark Bay, has a similar bathymetry to that of the Kill Van Kull, in that the predominant feature is the 35-foot deep, 500 foot-wide, dredged channel which runs from Perth Amboy to the Kill Van Kull. Along some reaches of the Arthur Kill, however, there are relatively broad shoal areas with widths as great as 1,500 feet and depths of less than 5 feet.

Newark Bay is about 5 1/2 miles long and varies in width from 0.5 to one mile. Except for the dredged channel along the axis of the bay and the dredged berthing channels along the western shore, the bay is shallow, with depths less than 10 feet prevailing over large portions of its total area.

The Passaic River and Hackensack River join Newark Bay at Kearny Point. The bathymetry, in the relatively narrow Passaic River, is dominated by a dredged, 300 foot-wide channel, which extends over twelve miles upstream from Kearny Point. The channel depths decrease from 30 feet near the mouth of the Passaic River to less than 10 feet at the northern limit of the dredged channel.

The Hackensack River is, in general, wider and deeper than the Passaic River. A dredged channel, 300-400 feet wide and 30 feet deep, extends upriver at least three miles from Kearny Point. The water depths in the bordering natural channel are greater than 15 feet.

2. Freshwater Movement in the New York Harbor Complex

The freshwater flow is one of the major mechanisms to transport the pollutants out of the estuarine system. The freshwater mixing with the ocean water in the estuary, produces a dispersion-type of mechanism to transport the pollutants. The physical connections of water bodies in the New York Harbor Estuary are shown in Figure VI-1. The movement of waters between these various bodies governs the probable paths of flow of pollutants that are discharged from various point and nonpoint sources. Figure VI-1 shows the net movement of flow through the estuary system, as prescribed in the development of a steady state model, in 1975, for the Interstate Sanitation Commission, by Hydroscience. The model was later used in the New York City 208 study(21).

Net flow through the estuary system has three components: freshwater, point source wastewater, combined sewer overflow and surface runoff. The major fresh water input originates in the Hudson River Basin, which discharges through Upper New York Bay, at the Narrows, into Lower Bay and continues on to the New Jersey seashore and the Atlantic Ocean. A portion of the discharge through the Narrows moves southwesterly along Staten Island into the easterly area of Raritan Bay. In 1951, Ayers, of Cornell University, calculated that a net discharge of 6.0 billion cubic feet of fresh water moved through the Narrows into Lower Bay on each tide. Because of the high flushing rate and short detention time, high coliform counts, from New York City's raw sewage discharged into the Hudson River and East River, and those from Hudson County's combined sewer system, are transported into the eastern part of Raritan Bay and Sandy Hook Bay. Since Newark Bay waters and part of the Arthur Kill waters discharge to Lower Bay via the Kill Van Kull and the Narrows, during ebb tide, some of the pollutants, discharged from combined sewer systems in Newark Bay, Elizabeth, Carteret, and the Passaic Valley Sewerage Commissioners' area, could also potentially reach the Sandy Hook Bay area. However, coliform bacteria discharged from these systems would probably die off significantly before reaching the shellfish waters because of the long travel time involved.

Water quality in the western part of the Raritan Bay is mainly affected by significant freshwater flow from the Raritan River (about 1600 cfs) and the Arthur Kill waters, through tidal exchange. In addition to tidal action, which cause waters in the Arthur Kill to oscellate, the water movement is complicated by its connection with Newark Bay to the north and Raritan Bay to the south. During ebb tide, the water flows from the Newark Bay, Elizabeth River, and Rahway River southerly to the Raritan Bay and the pollution load moves southward. During flood tide, the direction of flow is reversed. The Arthur Kill water enters the Elizabeth River and Rahway River and the polluted waters move northward.

3. Tides and Tidal Currents

The tides throughout the New York Harbor waterways are of a semidiural type, with approximately 12 hours-25 minutes duration for a complete tidal cycle. The mean tidal range (the difference between the elevation of high water and the next low water cycle in the harbor) is approximately 4.6 feet. The net tidal ranges are occasionally less than 3 feet. There are two primary tidal stations in New York Harbor: one is at Sandy Hook and the other at the Battery. The occurrence of high water at the Battery is about 3/4 of an hour after high water at Sandy Hook. In general, in Lower Bay, Upper Bay and the lower reach of the Hudson River, the tide has the characteristics of a progressive wave; while in the Kill Van Kull and Newark Bay waters, the tide appears to be closely associated with a standing wave.

The characteristics of the tides in the waters bordering the study area are summarized in Table VI-1. The elevations of high and low water at selected locations in these waters, relative to those for the Battery, are tabulated, together with the ratios of the maximum ebb and flood velocities, relative to their values at the entrance to the Kill Van Kull. Based on this table, general conclusions about the tidal features in the study area can be reached, as follows:

a. The tide appears to propagate from the harbor entrance to the Battery with little change in amplitude. As the tide progresses up the lower portion of the Hudson River, the elevation at high water decreases with distance upriver.

b. In Newark Bay, and the Hackensack and Passaic Rivers, there is an increase in elevation of high water with distance from Bergen Point. The Hackensack River has the most significant increase in water elevation during high water, when the tide progresses upriver.

c. The Kill Van Kull displays the strongest tidal current in the study area. The order of magnitude of tidal velocities are as follows: Kill Van Kull, Newark Bay, the mouth of the Arthur Kill, Hackensack and Passaic Rivers.

4. Net Circulation and Salinity Distribution

Overall, the New York Harbor complex can be considered a partially mixed estuary. The freshwater inflow and the tidal motion are the key factors affecting the degree of mixing. As a general rule, the intensity of vertical stratification in the estuary will be increased when either the freshwater discharge decreases or the mixing due to tidal action is diminished. The distribution of salinity throughout New York Harbor is typical of partially mixed estuaries, in which there is a net outflow of lower salinity surface waters and an inflow of higher salinity waters along the bottom. Consequently, in the New York Harbor, there is a close connection between the net circulation patterns and the characteristic distribution of salinity.

The net circulation consists essentially of an outflow of water in the surface layers of the estuary and an inflow along the bottom. According to studies by Duedall et al (1977) and Kao (1975), there is a net outflow at the harbor entrance. Based on the tidal current observation charts, it was found that the net outflow in the surface layer is several times larger than the freshwater discharge throughout the Hudson basin. The effect of this net circulation pattern will cause the discharged wastewater to be transported seaward by the net outflow in the surface layers, then transported upriver by the net inflow in the lower layer. This two layer, net circulation system will cause a critical DO condition to occur in the lower layer due to lack of sufficient mixing. Due to the tidal mixing and freshwater dilution processes, the typical salinity values throughout the New York Harbor decrease with distance from the ocean to the harbor. The degree of vertical stratification at an upstream location can, during periods of decreased freshwater flow and neap tides, be significantly greater than that observed at the harbor.

The variation of horizontal and vertical salinity distributions in the harbor complex are largely dependent on the freshwater discharge throughout most of the Hudson system. In general, the following phenomina have been observed.

a. Generally, the surface layers of the Upper Bay waters are more rapidly diluted by increased freshwater discharge in the Hudson River than the surface waters within Newark Bay.

b. In the Passaic, Hackensack and lower Hudson Rivers, the variation of salinity over a tidal cycle appears to follow an expected variation, in which salinities decrease monotonously, during the ebb, to a minimum value at low water slack and then increase during the flood to a maximum value at higher water slack. The Kills and the Newark Bay system do not have such a clear salinity pattern.

c. The distribution of salinity throughout New York Harbor is, in general, typical of partially mixed esturaries, in which there is a net outflow of lower salinity surface waters and an inflow of higher salinity waters along the bottom.

d. The behavior of salinity variations during the flood stage, at the entrance to Newark Bay, most likely reflects the initial predominance of the Kill Van Kull as the source of flooding waters to Newark Bay and then the effect of the subsequent inflow of waters from the Arthur Kill.

5. Flushing Rate

As described in previous sections, the two layer net circulation pattern in the harbor/bay system provides the estuary with a far greater flushing rate than would be the case if the net circulation were solely a seaward transport due to the freshwater discharge.

Inspection of the tidal current charts for New York Harbor, within average tidal ranges, indicates that, in the lower Hudson and Upper Bay, the near surface waters are transported about 7 miles upstream by the flood currents and about 10 miles downstream on the ebb tide. Therefore, a net displacement of these near surface waters, of about three (3) miles, results during each complete tidal cycle (12.5 hrs). This implies that it would require about three complete tidal cycles to transport near surface waters from the vicinity of Hoboken, on the Hudson River, to the Narrows Bridge. Below the Narrows Bridge, due to the influence of a counterclockwise gyre in the Lower New York Bay, resulting in a longer residence time, it takes about two days for the surface waters to be transported from the vicinity of the Narrows Bridge to the harbor entrance. Thus, a contaminant discharged into the Hudson River, near Hoboken, and confined to the near surface waters, would clear the harbor within 3-4 days, providing that it did not become entrained in the sluggish gyre in Lower New York Bay. Stewart (1952) estimated that it takes about 10 days for waters 60 miles north of the Battery to reach the harbor region, and an additional 3-4 days would suffice for these waters to reach the harbor entrance, approximately 15 miles below the Battery.

The waters in Newark Bay appear to respond rapidly to changes in freshwater inflow and to changes in water conditions in the Upper Bay. The flushing time in Newark Bay could range from 2 to 7 days depending on the upstream freshwater inflow. The Passaic River also appears to respond rapidly to a varying freshwater discharge rate. In contrast to the Passaic River, the Hackensack River response is more sluggish, due to the combination of low freshwater discharge and the physical configuration. It was estimated that the downstream displacement for one complete tidal cycle is only about 2 miles.

B. Existing Model Descriptions

1. Theoretical Background

There are two officially recognized 208 models which can provide information regarding these areas. One is the Northeast 208 (NE208) model done by Teledyne Isotopes, Inc. and M. Disko Associates, in 1973. The other is the New York City 208 (NYC 208) model done by Hydroqual, Inc., revised most recently in 1979. While there are some differences in the computational techniques used in both models, most of the theoretical basis for these models is the same. These are both 1 to 2 dimentional, steady-state models.

The concept of a steady state, estuary model is basicly a simplification of the complex natural situation. In an actual estuary, transport and circulation processes are the sum of many interacting effects including tides, wind shear, freshwater inflow (momentum and buoyancy), topographic frictional resistance, Coriolis effects, vertical mixing and horizontal mixing. Steady-state, estuary models resolve these effects into basic advective and dispersive forcing functions. The assumption of steady-state allows for the use of tidally averaged imputs to represent dynamic tidal effects. As many parts of New York Harbor are quite deep (20 ft - 40 ft) versus the tidal range (2-3 ft average range), this approach may be reasonable. However, this type of model is unable to predict the diurnal and tidal peak water quality concentrations. The NYC 208 model(21) handles this problem by assigning a diurnal correction factor of 1 mg/l to the dissolved oxygen results.

The methodology for evaluating the advective forces in such a model primarily depends on the freshwater inflows. Normally, the freshwater inflow is routed through the volume of the model segments. This determines the net non-tidal velocity which is used in advective calculations. When flow is routed in two dimensions, actual flow or velocity measurements are usually used to make the flow division. The dispersive forces are then calibrated versus the salinity data. Because of this, the dispersive forces represent the steady state sum of tidal and many other forces rather than just normal dispersive forces. The equation which represents the advective and dispersive transport of salinity (as a conservative substance) is as follows:

$$0 = E \frac{\partial^2 C}{\partial x^2} + E \frac{\partial^2 C}{\partial y^2} - \frac{Qx}{Ax} \frac{\partial c}{\partial x} - \frac{Qy}{Ay} \frac{\partial c}{\partial y} + S$$

where:

E = dispersion coefficent
Q = total freshwater flow
A = cross-sectional area
C = salinity concentration
S = salinity source

Many water quality parameters, such as BOD, NBOD, and coliforms, are normally modelled as first order decays. The coefficent of decay is initally based on literature reference, long term BOD measurements or other calculational procedures. Its final value is determined by calibration versus field data. The steady-state equation for first order decay is as follows:

$$0 = E_x \frac{\partial^2 L}{\partial x^2} + E_y \frac{\partial^2 L}{\partial y^2} + \frac{Qx}{Ax} \frac{\partial L}{\partial x} + \frac{Qy}{Ay} \frac{\partial L}{\partial y} + S - KL$$

where:

L = BOD (or other parameter) concentration
K = calibrated decay coefficent
Other variables are as previously described.

The NYC 208 model additionally includes terms for settling of BOD, adsorbtion of coliforms, 2 stage nitrification and algal ammonia release. In the NYC 208 model, the decay coefficent, for both total and fecal coliform, was calculated according to the following equation:

$$K_r = (0.8 + 0.0174 \times \text{salinity}) \times 1.07^{T-20}$$

where K_r is a function of salinity and temperature.

Dissolved oxygen is calculated by a set of coupled reactions incorporated into the transport equation. Terms are included to represent BOD decay, nitrification, reaeration, benthal demand and net algal photosynthesis. This equation is shown below:

$$0 = E_x \frac{\partial^2 D}{\partial x^2} + E_y \frac{\partial^2 D}{\partial y^2} + \frac{Qx}{Ax} \frac{\partial D}{\partial x} + \frac{Qy}{Ay} \frac{\partial D}{\partial y} + K_d L + K_n N - K_2 D + B - (P-R) + S$$

where:

D = dissolved oxygen deficit
K_d = deoxygenation rate
K_n = nitrification rate
K_2 = reaeration rate
P-R= net algal photosynthesis
L = BOD
N = NBOD
B = benthic demand

The dissolved oxygen concentration is calcualted from the deficit as a function of temperature and salinity.

2. Segmentation and Boundary Conditions

The establishment of the scope and boundary limits for an estuary model is a significant factor in determining the final results. The boundary limits should be located far enough from the impacted areas so that they can be considered unimpacted. Since impacts in estuaries can disperse in all directions, the boundary limits are usually located, if possible, upstream of the tidal areas. This is the case for the Passaic, Hackensack, and Raritan Rivers, where the boundary limits are located at dams above the head of tide. However, on the Hudson River, it is located near Bear Mountain which is well within the tidal area. This makes the value of this boundary condition more difficult to determine. The values chosen for the upstream boundary conditions are crucial in determining the water quality in the downstream segments. The downstream boundary limits for the model are located in Long Island Sound, near the Connecticut border, and in the Atlantic Ocean past Jamaica Bay. This is beyond the most outlying STP under study.

The NE 208 model has a more limited scope of study. Its southern boundary is at the north end of the Arthur Kill and at the "Narrows". The boundary conditions at these points, particularly for the Arthur Kill, are extremely impacted. Such boundary conditions can have a dominating effect on model output and are insensitive to changes in conditions for projection purposes. This markedly reduces the reliability of this model.

These models are segmented so as to account for available morphological data and provide a sufficient degree of resolution. All riverine segments consist of one segment horizontally. The model is segmented two dimensionally in the horizontal direction in the Hudson River downstream of the Battery, in Raritan Bay and Long Island Sound. In addition, the model is segmented vertically in the Hudson River above the Battery.

3. Calibration and Verification

The NYC 208 model was initially calibrated and verified with respect to the transport block alone. The flows were calibrated, based on recorded freshwater inputs and measured flow velocities. The freshwater inputs are: tributary flows at the boundaries, waste treatment plant effluents, leakage and bypasses in sewer lines, raw discharges and runoff. The runoff flows were developed as a time averaged input, based on the output of the NYC 208 rainfall runoff model(20). The dispersion coefficents were calibrated, based on the available salinity data. Calibration and verification were done versus a total of six data sets, which were collected over the period from 1965 - 1977. Results showed that the calibration was only for a limited range of flows. Outside of this range, a different calibration must be used.

The verification and validation of water quality parameters were based on the same six data collection periods. The periods and their average flows are shown in Table VI-2. Verification was done along transects through major water bodies. It should be noted that markedly less data were obtained along the transects in the New Jersey rivers.

4. Evaluation of NYC 208 Model

The NYC 208 model has advantages and disadvantages. Its chief asset is its overall comprehensiveness. The model extends the boundary conditions far enough that they should not have an inordinate effect on the inner harbor. The inventory of point impacts to the harbor is most complete. The use of vertical segmentation on the Hudson River, increases the reliability of the transport simulation.

The chief disadvantages of this model stem from its being a steady-state model. The data base for each survey consists of several data points per station, collected over a period of a few weeks. Such a data set could include some non-steady-state events. The inclusion of runoff (CSO) terms is of limited value. Such transient terms should not be included in a steady-state model. In areas where there is a major impact from runoff (such as the Passaic River), the results should be considered to have limited applicability. The overall effect of these problems cause this model to have principle usefulness as a farfield model.

C. Conservative Estimates of the CSO Impact

Combined sewer overflow (CSO), municipal raw sewage discharge, leakage, bypass and urban runoff are identified as the major pollution sources contributing bacteria to the study area. Based on the ISC's 301(h) report (1983) and the New York City (208) Water Quality Model Report (1978), it was estimated that the total CSO discharge, from both the New Jersey and New York sides of the Hudson River, in the Upper New York Bay area, amounts to approximately 500 MGD. The NYC modeling study also estimated that over 90 percent of this flow, plus the approximate 208 MGD of raw sewage discharged from the New York City North River and Red Hook drainage areas, will have a direct impact on the New York Harbor complex. However, due to the hydrodynamic characteristics of the harbor and the mortality rate of the bacteria, the impact of this Hudson River flow on the Newark Bay complex, which includes the lower Passaic and Hackensack Rivers, Kill Van Kull and Arthur Kill system, will be limited. The major impact on the Newark Bay complex will be due to the local CSO discharges.

An individual impact assessment will be performed, in the following sections, using a simplified model. The model will be assumed to be a steady-state, one dimensional model, with complete mixing of the receiving water at the discharge point. The model projections will use the most conservative assumption, that there is no background contribution when estimating the net impact from the individual discharge points to the receiving waters. In this study, due to the importance of shellfish production in the Raritan Bay, a simplified dynamic model will be applied in the Arthur Kill to estimate the net increase from CSOs from the Cities of Perth Amboy, Elizabeth and Carteret, on the lower section of the Arthur Kill, under a sequence of tidal cycles. The purpose of these modeling efforts is to examine whether the current designated water uses in the study area can be met, or whether these waters may be reclassified due to the control of CSO discharges.

1. Model Description

In order to assess the impact under natural hydrological conditions, a steady-state model has been used to estimate the net impact for the study area, except for the Hudson River (19a). Furthermore, due to the importance of shellfish production in Raritan Bay, a simplified dynamic model will also be used to estimate the net impact for the CSO discharges into the Arthur Kill.

a. Steady State

To be consistent with the NYC 208 model, the one dimensional, steady-state coliform model(25a), including advective and dispersive transport, with the assumption of first order decay, was used in this analysis and is shown as follows:

$$S = S_o \text{ Exp } (J_1 X) \text{ for } x < 0 \text{ (upstream)}$$
$$= S_o \text{ Exp } (J_2 X) \text{ for } x > 0 \text{ (downstream)}$$

Where:
$$J_1 = \frac{u}{2E}\left(1 + \sqrt{1 + \frac{4\ KE}{U^2}}\right)$$

$$J_2 = \frac{u}{2E}\left(1 - \sqrt{1 + \frac{4\ KE}{U^2}}\right), \quad So = \frac{W}{Q\sqrt{1 + \frac{4\ KE}{U^2}}}$$

Where: S = Coliform concentration at x

X = Distance from discharge point
S_o = Initial concentration at the immediate mixing point
W = Coliform loading input = Cw X Qw
Q = Net freshwater flow
Qw = CSO discharge (an average)
E = Dispersion coefficient
U = Net freshwater velocity
K = Coliform die-off rate
Cw = Total Coliform level from CSO discharge

b. Dynamic

Since, during ebb tide, discharges from Elizabeth and Carteret move southerly and can reach Raritan Bay within six hours, i.e., at the end of ebb tide, it is pertinent to estimate the short term effects of wet weather discharges on the coliform level at Raritan Bay. The wet weather overflows occur on the average of about 90 times a year. The analysis assumed an instantaneous discharge of coliform from Elizabeth and Carteret, respectively, and evaluated how these discharges are advected and dispersed by the tidal movement.

Assuming coliforms are discharged at high-water slack at Elizabeth and Carteret respectively, the concentration at low-water slack, at the mouth of the Arthur Kill in Raritan Bay is:

$$C_{lws} = \frac{M}{fA\sqrt{4\ ENT\pi}} e \left\{- \frac{(X-U_f\ NT)^2}{4\ ENT} - KNT\right\}$$

(Page 639, Eg. 14.14 of Estuary and Coastaline Hydrodynamics, by A.T. Ippen)

Where M = total coliform counts discharged per overflow (not concentration)

A = Arthur Kill cross-sectional area, in mi^2
E = Dispersion coefficient, in mi^2/day
T = Tidal period (12.42 hrs) or 1/2 day
N = 0.5, 1.5, 2.5, 3.5
K = die-off rate (1/day)
U_f = freshwater velocity, a net volocity
X = Distance in miles from the point of discharge
= 12 for Elizabeth
= 8.5 for Carteret
f = Conversion factor to convert mi^3 to 100 ml
= 4.17×10^{13}

2. Model Applications

a. Arthur Kill System

Based on the NYC 208 Study and updated information, Table VI-3 shows the pollution sources and their total coliform loading from the New Jersey side. The 2 MGD raw sewage discharge at Tottenville, on the New York side, is also listed in this table. Inspection of the table shows that the major bacteria contributors are the 2 MGD of raw sewage at Tottenville, and the Cities of Elizabeth, Rahway, Carteret and Perth Amboy. Utilizing available information, the Cities of Carteret, Perth Amboy and Elizabeth were chosen for the following modeling calculations.

1) Carteret

The Carteret CSOs are located about 8.5 miles north of Raritan Bay, and directly discharge to the Rahway River about 1 mile from the Arthur Kill. The Carteret combined sewer system serves 2,200 acres, which is approximately 76% of the area of the Borough of Carteret.

It is estimated that the average daily pollutant loading from the Borough of Carteret CSOs (using total coliform as an indicator) is 1.15 MGD of flow at a total coliform concentration of 5×10^8 MPN/100. This concentration also will be used for later calculations. The estimated flow is based upon metered flow data presented in the Facility Plan for the Borough of Carteret, December, 1976. This data was also presented in Table 10 of the Borough's Water Quality Demonstration submitted in support of their application for funding under the Federal Marine Combined Sewer Overflow (MCSO) abatement program.

Total coliform levels in the CSO flow were estimated from "Urban Stormwater Management and Technology: An Assessment.", prepared by the USEPA. Approximately half of Carteret's flow is a dry weather, raw sewage discharge, which was assumed to have coliform levels of 10^9 MPN/100 ml. The remainder of the flow is a combined sanitary and storm flow at an assumed coliform level of 10^7 MPN/100 ml. These levels are confirmed by readings of coliform levels from the Borough's treatment plant, which have ranged as high as 59,000,000 MPN/100 ml. The concentration used in the analysis was a weighted average of the raw and combined discharges. However, one thing should be noted, the estimated or laboratory tested coliform number could be one order of magnitude off from the actual level present at the monitored stations.

2) City of Elizabeth

It is estimated that the average annual CSO discharge from the City of Elizabeth to the Elizabeth River and Arthur Kill is 665 million gallons or 1.83 MGD. This discharge includes an average of 0.26 MGD of overflow occurring during wet weather. The average total coliform concentration is estimated to be 5×10^8 MPN/100 ml, which will be used in the modeling analysis. According to the 1981 report entitled "City of Elizabeth, N.J., Combined Sewer Overflow Pollution Abatement Program" (1), the flow was obtained from a computer model that had been properly calibrated and verified with data collected in Elizabeth City. From the same model, the total coliform concentration in the CSO flow was estimated to be about 10^7 MPN/100 ml, which is within the range of CSO data reported in a 1974 EPA report entitled "Urban Stormwater Management and Technology: An Assessment." The total coliform concentration of raw sewage discharges is assumed to be 10^9 MPN/100 ml.

3) Perth Amboy

The Perth Amboy CSOs are located along the Arthur Kill and the Raritan River. There are a total of 15 dry weather CSOs with 8 on the Arthur Kill and 7 on the Raritan River. The Perth Amboy CSOs system serves 979 acres, contributory to the Raritan River. The total contributory area of 2,012 acres is approximately 66% of the total area of the City of Perth Amboy. The remaining 33% consists of industrial lands which abut the Arthur Kill and Raritan River but do not discharge into the City of Perth Amboy sewer system. The base CSO flow for the City of Perth Amboy is 2.7 MGD.

There is no known coliform concentration for the Perth Amboy CSOs. The total coliform concentration for dry weather CSO discharge was assumed to be 5×10^8 MPN/100 ml, and a combination of sewage and tidal inflow mixed discharge was assumed to have a coliform concentration of 2.5×10^7 MPN/100 ml.

4) Input Data

This section lists the input data needed for the steady-state and dynamic models as described in the former section. Tables VI-4 and VI-5 show the model parameters, taken either from the NYC 208 coliform model study, in the segments of the Arthur Kill, or from the previous section, from the coliform loading rate calculation. The steady-state and dynamic models will be used to calculate the total coliform response in the Arthur Kill from the point of discharge to its mouth at Raritan Bay, under seasonal conditions (winter and summer). The coliform die-off rate (k) is subject to adjustment due to the water temperature (T) and salinity effects. The adjustment equation is written as follows:

$$K = (0.8 + 0.01714 \times \text{salinity}) \times 1.07^{T-20}.$$

In utilizing these steady-state and dynamic models, the calculations for determining the net total coliform response in the receiving water are based on the following assumptions.

a) The Borough of Carteret and Cities of Elizabeth and Perth Amboy all discharge to the Arthur Kill.

b) The hydrologic and geometric characteristics are uniformly distributed within the Arthur Kill.

5) Results

a) Steady-State Condition

By using the information in Table VI-4 as input data for the steady state model, the net total coliform response in the Arthur Kill was calculated, based on existing conditions, and is shown in Table VI-6, for the summer season. Recently, the Cities of Perth Amboy, Carteret and Elizabeth have applied for 1985 Federal funding under the Marine CSO Abatement program. In support of these applications, the steady-state model was used to project the possible maximum improvement due to the proposed 80% control in the Arthur Kill. These results are shown in Table VI-6. This table shows the net total coliform profiles in the Arthur Kill from the Carteret and Elizabeth CSO discharges. It is very clearly indicated that, under the average steady-state condition, the Carteret and Elizabeth CSOs have a significant net impact on the Arthur Kill itself and even extend to the south, to its mouth in Raritan Bay, and north to the Newark Bay area. Examination of the total coliform level at the mouth of the Arthur Kill in Raritan Bay, where there is potential for commercial shellfish production and reopening beaches for swimming, shows that the Carteret CSO could contribute a net total coliform concentration of up to 5,000 MPN/100 ml in summer, and 14,000 MPN/100 ml in winter. Even the Elizabeth CSO discharge, which is located about 12 miles north of the Arthur Kill mouth and roughly 4 miles north of the Carteret CSO, still has a significant impact on this Raritan Bay area. The total coliform level at the mouth, due to the Elizabeth CSO discharge, is about 2,000 MPN/100 ml in summer. The impact of Elizabeth CSOs on Newark Bay is even more severe (up to 8×10^4 MPN/100 ml, in winter). Examination of the total coliform data collected by NJDEP, from 1982 to 1983, at sampling station 17 in Raritan Bay (approximately 1/4 mile south of the Arthur Kill mouth), shows the median total coliform level is about 3500 MPN/100 ml. Based on dye study results (Walker, 1967), the total coliform level at the mouth of the Arthur Kill, contributed by Carteret and Elizabeth, could be very easily dispersed to the NJDEP station 17 area. This evidently shows the large and direct impact from both CSO discharges.

The Perth Amboy CSO discharge, which is located at the Arthur Kill mouth, contributes 6000 MPN/100 ml of total coliform directly to the Raritan Bay.

Table VI-6 presents the total coliform loadings from the three project areas, and the estimated net contribution to total coliform levels at the mouth of the Arthur Kill, based on steady-state model (25a) projections, by assuming an 80% coliform loading reduction from the three projects. Because many factors affect the accuracy of a coliform data analysis, the three projects should be regarded as having impacts of the same order of magnitude. The existing total coliform level, based on the model projection, at the mouth of Arthur Kill, that is attributable to the three CSOs, is 14,300 MPN/100 ml. By comparison with the background wet-weather level of 23,900 MPN/100 ml and the dry weather level of 6,600, this appears reasonable, since input to the steady-state model includes both dry and wet-weather discharges.

Table VI-6 also shows that, with an 80% reduction of coliform loading from each CSO discharge, the total coliform concentration contributed by these three at the Arthur Kill mouth (the lowest that the coliform level can get) will still be 2,800 MPN/100 ml. By using a conversion factor of 4 for converting total to fecal coliforms, the minimum fecal coliform level which can be obtained at the Arthur Kill mouth is around 712 MPN/100 ml, which is at the margin of the SE2 criterion (700 MPN/100 ml). In other words, based on this model projection, with 80% control of these three CSO discharges, the fecal coliform level in the entire stretch of the Arthur Kill and its tidal tributaries cannot meet the SE2 criterion, regardless of other background pollution sources.

b) Dynamic condition

By using information from Table VI-5 as input data to the dynamic equation, the results are shown in Table VI-7.

The results in Table VI-7 show the estimated total coliform contribution from the Elizabeth, Carteret and Perth Amboy combined sewer systems at the third low water slack tide after a rainfall. The contributions are 4,400, 5,600, and 6,500 MPN/100 ml, respectively, from the existing Elizabeth, Carteret and Perth Amboy systems. With 80% control, the total contributions due to the remaining 20% loading input, are 880, 1,120 and 1,300 MPN/100 ml, respectively, from these three projects. Because many factors govern the accuracy of the coliform data anaysis, these three sources should be regarded as having about equal contributions. The total coliform contribution from the three sources is 16,500 MPN/100 ml. This accounts for about 70% of the 23,900 MPN/100 ml at Station AK-18 (at the mouth of Arthur Kill), which represents the coliform level about one day after a rainfall. The remaining 30% is attributable to other sources that discharge to the Arthur Kill.

Table VI-6 shows that the representative total coliform level at the mouth of the Arthur Kill during dry weather is about 6,600 MPN/100 ml. Our analysis, using the dynamic model, has determined that the net total coliform contribution from these three sources to the total coliform level at the Arthur Kill mouth, 2.25 days after a rainfall, is about 4,800 MPN/100 ml, and that from other sources is about 2,200 MPN/100 ml. The combined total level of 7,000 MPN/100 ml compares well with the sampling data of 6,600 MPN/100 ml.

Based on the dynamic model study, the same results can be obtained, in which the total coliform level contributed by these three CSO discharges, after control, is still at the margin of the SE2 criterion.

By comparing the calculated results from both the steady-state and dynamic models, as shown in Tables VI-6 and VI-7, with the coliform data in the Arthur Kill, general conclusions can be made as follows:

i. The major coliform contributors from the New Jersey side, causing the severe coliform problems in the Arthur Kill mainstem, are mainly due to the Borough of Carteret and the Cities of Perth Amboy and Elizabeth CSO discharges.

ii. The Cities of Perth Amboy, Carteret and Elizabeth CSOs do have a significant impact on the Raritan Bay. On the average, during the summer period, the Carteret and Elizabeth CSOs could contribute approximately 7,000 MPN/100 ml of total coliform to the mouth of the Arthur Kill in Raritan Bay, while in winter, the total coliform level could reach 20,000 MPN/100 ml.

iii. With 80% control of coliform loading from these three CSO discharges, model results showed that the fecal coliform concentration in the entire Arthur Kill, contributed by the remaining 20% of loading, still cannot meet the current SE2 criterion for the designated water use.

b. Newark Bay, Hackensack River and Passaic River

1) Input Data

With the exception of "Q_u" and "C_u", the input data (Table VI-8), which was used in the model, was obtained from the New York City 208 report. The parmeters used in the model are:

- Q = average freshwater flow (cfs)
- E = dispersion (mi^2/day)
- Q_W = avg. flow of CSO discharge (MGD)
- C_W = avg. concentration of CSO discharge (MPN/100 ml)
- T_S = summer temp. (^oC)
- T_W = winter temp. (^oC)
- A = cross sectional area at segment interface (ft^2)
- U = net tidal velocity (ft/s)
  and coliform decay (1/day)

The data obtained from the 208 report is the average data for the segments which receive CSO discharge in that particular system.

2) Results

Based on the previous input data, the computer results are shown in Figures VI-2 and VI-3 and Table VI-9. The results show that in the lower Passaic River, the fecal coliform levels peak at about 11,000 MPN/100 ml, at the assumed point of discharge (0 mile point), and then decrease to less than 800 MPN/100 ml, at mile point 5, in either direction of the discharge point. This analysis shows that the CSO contributed a significant impact on the lower Passaic River. As to the tidal Hackensack, the contribution to coliform bacteria from the CSOs is not as critical as that in the Passaic River. The peak fecal coliform level at the discharge point is only about 500 MPN/100 ml, which is below the SE2 standard.

Newark Bay did not show a significant increase of coliform level due to the CSO discharge. The peak fecal coliform level at the point of assumed discharge is less than 40 MPN/100 ml.

As to the Passaic and Hackensack Rivers, these systems all have a low to moderate level of freshwater flow. Therefore, there is only a low to moderate level of dilution, including tidal flow. There is a low net velocity (advection) in these systems and a fairly high density of dispersion. In such dispersion dominated systems, the impact is usually significant, as the primary impact spreads throughout the system but remains within the system. This causes serious problems on the Passaic River because of the impact of the very high volume of runoff.

D. Assessment Results and Discussion

1. Tidal Passaic River and Newark Bay

a. Dissolved Oxygen (DO)

The current use classifications of the tidal Passaic River are SE2, from Dundee Dam to the Second River, and SE3, from the Second River to Newark Bay. The minimum DO standard for SE2 is 4 mg/l, at any time, and for SE3 it is 3 mg/l at any time. A low DO profile exists in the tidal Passaic, except for the first 2 miles below the Dundee Dam. DO standards are frequently violated, particularlrly in the tidal Passaic, between the Second River and Newark Bay.

Contributing factors for the low DO levels in the tidal Passaic are (19): low flow due to upstream diversion (MA7C10 flow is only 23.1 CFS), incoming BOD from upstream point and nonpoint sources, CSO and urban runoff, benthic deposits and some industrial discharges. Of particular interest are the benthic deposits, especially below the Second River. Almost 2 mg/l, of the total DO deficit of 5 mg/l, has been attributed to the benthic demand (19), especially in the 4 mile stretch in the vicinity of Harrison and Kearny. Slow flow velocity, in this section, is conducive to the deposition of solids, while minimizing the reaeration potential. Substantial discharges of wastewater (Jersey City West) into the Hackensack River, especially near its mouth at Newark Bay, may also be contributing to the BOD loading of the lower, tidal Passaic. In addition, due to the already depressed levels of DO in Newark Bay, the tidal currents do not alleviate the DO problems in this segment of the Passaic River.

According to the Northeast New Jersey Water Quality Plan for the Urban Area (1977)(19), about 31% of the BOD inflow into the tidal Passaic are from point and nonpoint discharges in the feshwater Passaic. The remaining 69% of the BOD load is attributed to urban nonpoint sources such as CSO, urban runoff, leaching of polluted groundwater and benthic deposits. Incoming BOD load, according to 1970 data, from upstream sources, was about 14,000 lbs/day, exerting a DO demand in excess of 1 mg/l in the segment, extending from two miles below Dundee Dam to the point where the Passaic discharges into Newark Bay. Based on the modeling analysis, using the year 2000 projections, and assuming level 4 treatment (95% BOD and NBOD removal) for all treatment plants, the upstream BOD load will be reduced by about 3,000 lbs/day. This translates into a DO deficit improvement of only 0.4 mg/l. Further improvements may occur from upgrading treatment levels for discharges into the Newark Bay and Hackensack River, but it was estimated that the total improvement in the DO level from the point sources will still be under 1 mg/l. DO profiles for the tidal Passaic-Newark Bay, adapted from the NE New Jersey Water Quality Management Plan are illustrated in Figures VI-4 and VI-5(19).

The Interstate Sanitation Commission (ISC) conducted a study for the New York Harbor complex termed "DO Assimilative Capacity in the Harbor Complex," pursuant to Section 301(h)(9), in 1983. DO projections for 1981 and 1990 conditions, under various configurations, were computed using the New York Harbor model. CSO loads were computed using a rainfall/runoff model, assuming an average summer rainfall of 0.12 inch/day. Leakage and by-pass loads were also accounted for and the by-pass loads were assumed not to exist under 1990 conditions. The results of these DO projections are illustrated in Figures VI-6 and VI-7. Clearly, the DO criteria are violated in the tidal Passaic and Newark Bay under existing conditions, and will continue to be violated under the 1990 conditions for the Passaic River, even if all the treatment plants have achieved secondary treatment levels by then. In the tidal Passaic, below the Second River, the DO levels will be depressed to about 1.5 mg/l during the low flow summer conditions. As these projections are based on average summer rainfall, the water quality will be even worse following hot and rainy seasons.

CSO controls, as being planned for Northeast Urban New Jersey, if funded, will have some beneficial effects on the water quality. However, this may vary, depending on the specific area, as a recent (1983) CSO Study(3a), conducted for the Passaic Valley Sewerage Commissioners (PVSC), has indicated that CSO has only a marginal effect on the DO resources of the tidal Passaic. Similarly, Best Management Practices (BMP) for the control of nonpoint source (NPS) pollution, if implemented, will have some salutary effect on the water quality in the area. But, according to Jenq et al. (1983)(11) only about 60% of the NPS pollution is amenable to rectification, and controls beyond 40% may be too costly and provide only minimal improvement in the water quality. The extent of NPS pollution in the urban complex is shown in Table IV-8.

It has been determined in the modeling analyses, as mentioned earlier, that with advanced level treatment for point sources in the upstream Passaic and upgrading of treatment levels in the Hackensack and Newark Bay watersheds, the reduction in the DO deficit will be less than 1 mg/l. Furthermore, control of CSOs and urban runoff (assuming 100% control) will further reduce the DO deficit by another 1 mg/l (see Figure VI-5). Under these conditions the DO level at the critical point will improve to about 4 mg/l and hence will be the border-line for the SE2 stream classification. The real problem in the tidal Passaic is the benthic deposits(25b). Therefore, based on the findings of these recent studies, no real breakthrough in improvement of the DO levels in the tidal Passaic can be anticipated, until such time that enough dollars are committed and concrete measures are undertaken to control the urban runoff and to remove the existing benthic deposits (dredging etc). Therefore, the existing use classifications for the tidal Passaic (SE2 and SE3) will be retained for the near future. For now, the immediate concern should be the improvement of water quality to bring it at par with or above the current water quality standards.

The DO levels in Newark Bay are slightly better than those in the tidal Passaic. As shown in Figure VI-6, the DO criterion (3 mg/l) is generally met, except in the first mile from its junction with the Passaic and Hackensack Rivers. Point source pollution occurs mainly from the industrial complex around the Bay. There are no municipal discharges, except for the Jersey City West plant, which discharges into the mouth of the Hackensack River confluence. Here again, NPS pollution is a dominant factor in the deterioration of the water quality. A major portion of the DO deficit is attributable to a thick layer of benthic deposits, which has accummulated in the Bay over a long period of time. In addition, the water quality in the Newark Bay is heavily influenced (due to tides) by the tidal Passaic and Hackensack Rivers at the upper end, and the Arthur Kill at the lower end. This was demonstrated in a study conducted by Hsueh and Jenq(7a), who found somewhat higher levels of DO towards the middle of the Bay.

However, improvement in the water quality in Newark Bay is anticipated in the near future. This will come from upgrading of treatment levels for point sources in the Passaic and Hackensack basins. Further, the Jersey City West plant, a major source of pollution, may be abandoned under the proposed Hudson County 201 planning schemes. This would have a major beneficial effect on the water quality in the bay. 1990 projections for the Interstate Sanitation Commission (ISC) Study (301(h)), predict DO levels of just under 4 mg/l for the Newark Bay. All upstream municipal plants were assumed to have achieved a level of secondary treatment and all industrial facilities were assumed to employ Best Practicable Technology, for the 1990 conditions. Therefore, without effective control of CSOs and urban runoff and removal of benthic deposits, the DO levels in the Newark Bay are not likely to rise above 4 mg/l. It is, therefore, recommended that the existing SE3 classification for DO be retained for the near future.

b. Coliform Bacteria

There are no municipal discharges into the tidal Passaic. The major source of bacterial contamination in this section is the local CSOs, supplemented with urban runoff, leakages and some contribution from the upstream CSOs and point sources. Fecal coliform levels in the tidal Passaic generally exceed the criterion for the N.J. SE2 stream classification (770 MPN/100 ml). This is illustrated in Figure VI-8, which is based on 1970 summer low flow data (NE N.J. 208 Plan). Coliform levels are believed to be even higher following rain storms. Figures VI-9 and VI-10 present the mean fecal coliform levels, based on the 1970 and 1976 observed data, as reported in the New York City 208 Task Report (1978)(21). As seen, the coliform levels are above about 1000 MPN/100 ml in most of the tidal Passaic. Total coliform projections, for summer low flow conditions, for various alternatives, were also conducted as part of the NYC 208 Plan. Storm/CSO loads were generated by the rainfall - runoff simulator. The results of these projection analyses are displayed in Figures VI-12 through VI-15. Fecal coliform levels can be estimated by dividing total coliform levels by 4. It is clear, from these figures, that fecal coliform levels in the tidal Passaic are likely to surpass the N.J. SE2 criterion for all the alternative arrangements, including that of zero discharge. However, the accuracy of the projection analyses is suspect, due to extremely high coliform levels (possibly erroneous data) attributed to the upstream boundary. STORET data records, for the period 1974 - 1983, indicate, as shown in Table V-4, much lower total coliform levels below the Dundee Dam. The range of average fecal coliform levels in the STORET data is about 400-6,000 MPN/100 ml, as against a total coliform level of about 174,000 (equal to fecal coliform level of 43,500 MPN/100 ml), as reported in the NYC 208 Report.

A rough estimate of fecal coliform levels in the tidal Passaic, attributed to urban CSOs only, can be made from Figure VI-2. The fecal coliform profile in this figure was constructed by means of a simplified estuarine modeling analysis (25a), utilizing the CSO data in Table IV-5 (CSO inventory), and assuming all CSO discharges as one point source discharge at Harrison. The fecal coliform levels peak at about 11,000 MPN/100 ml, at the assumed point of discharge (0 mile point), and then taper off to less than 800 MPN/100 ml, at mile point 5, in either direction of the discharge point. This only illustrates the magnitude of the problem. The actual coliform profile will be much flatter due to the nonpoint nature of the discharge of the urban CSOs. However, it does indicate that, in parts of the tidal Passaic, CSOs alone would contribute sufficient bacterial pollution to violate the coliform standards.

Based on the foregoing projections and the observed data, the bacterial pollution, which mainly comes from CSOs and urban runoff, is likely to continue in the tidal Passaic for the near future. Only effective control and/or treatment of CSOs and storm runoff will obtain a significant reduction in the coliform levels. Presently no such control program is foreseen and, therefore, it is recommended that the existing stream classifications for the tidal Passaic, i.e. SE2, from Dundee Dam to the Second River, and SE3, from the Second River to Newark Bay, be retained.

Bacterial quality in Newark Bay is slightly worse than that in the tidal Passaic and the current coliform criterion for the SE3 classification (1,500 MPN/100 ml) is not being met. Dominant sources of coliform pollution are, again, CSOs, urban runoff and contributions from the Passaic and Hackensack Rivers and the Arthur Kill. The bacterial quality in the bay is likely to improve with upgrading of treatment levels in the region. However, it is unlikely that the coliform criterion for the SE2 classification (770 MPN/100 ml) will be satisfied in the Bay and, hence, the existing SE3 classification should be retained for the near future.

2. <u>Tidal Hackensack River</u>

a. <u>Dissolved Oxygen</u> (DO)

Portions of the tidal Hackensack River are experiencing some of the worst water quality problems in the Northeastern New Jersey urban area. As evident in Figure VI-16, the Northeast New Jersey Water Quality Management Plan modeling analysis, based on 1970 data, has shown that DO levels may be as low as 1.2 mg/l in parts of the Hackensack River. Similarly, the Interstate Sanitation Commission's 301(h) Study projections predict very low DO levels in a large stretch of the Hackensack River. These projections were made for 1981 and 1990 conditions, using the New York Harbor Model. While current loads were utilized for the 1981 conditions, all treatment plants were presumed to have achieved secondary treatment levels for the 1990 conditions. DO profiles in the tidal Hackensack, based on the ISC Projections, are displayed in Figures VI-6 and VI-7. Currently, the tidal Hackensack has three stream classifications, depending upon the intended use. From the Oradell Dam to Overpeck Creek, the river is classified as SE1, while from Overpeck Creek to Berry's Creek, it is classified as SE2 and, thereon, to Newark Bay as SE3. The State DO criteria are being violated in all the three sections under existing conditions (see Figure VI-6)(19).

Various factors have combined to seriously degrade the water quality in the tidal Hackensack. Heavy upstream diversions, for potable use, reduce the river flow. MA7CD10 low flow, below Oradell Dam, has been estimated to be about 5 cfs (USGS). Consequently, not enough dilution is available to absorb the heavy downstream BOD loads. Most of this BOD load is attributed to point sources (see Table IV-8), with more than half being contributed by the Bergen County Utilities Authority's (BCUA) secondary facility in Little Ferry. The Jersey City West plant discharges about 36 MGD of primary effluent into the Hackensack River, near its mouth, in the vicinity of Newark Bay. DO problems are further aggravated by thermal discharges (3 generating stations) from the power plants. Based on the N.J. 303(e) report(19), out of an estimated total of 13,600 million BTU/hour of heated wastewater, which is discharged into the urban waters, more than 50% is dissipated in the Hackensack River. The higher the water temperature, the lower its DO concentration will be. Summer temperatures in excess of 100oF in the Hackensack River have been measured by the Hackensack Meadowlands Development Commission (HMDC). Additionally, BOD decay is accelerated at the higher temperatures, resulting in further depletion of the DO resource.

Nonpoint sources (NPS) also add significant loads of BOD into the tidal Hackensack. Important sources of NPS pollution are the urban runoff, including leachates from landfills (see Table IV-7), CSOs (see Table IV-5) and benthic deposits. The Hackensack Meadowlands are the principal landfilling area in Northern New Jersey. BOD loads, from landfill leachates in the urban complex, are illustrated in Table IV-7 and the locations of the landfills in the area are displayed in Figure IV-3. About 1.3 million pounds of BOD loading enters the northeast urban waters per year from the landfills, and almost 80% of this loading is discharged into the Hackensack River. This causes DO deficits in excess of 0.7 mg/l throughout the lower two-thirds of the tidal Hackensack River.

Components of the DO deficit in the tidal Hackensack, based on the Teledyne modeling analysis, are depicted in Figure VI-17(19). As shown, the inflow of BOD from the upstream boundary is virtually nil, while the downstream boundary (Newark Bay) is contributing substantial loadings of BOD.Also, the DO deficit, due to benthic demand, exceeds the DO deficit due to urban runoff. Photosynthetic activity appears to have some salutary effect on the DO resources of the Hackensack, but this is likely to vary seasonally.

Despite these acute pollution problems, the water quality in the tidal Hackensack is likely to improve in the near future. A large portion of the runoff load, attributed to leachates from the landfills, will be substantially reduced through the scientific management of the sanitary landfills, as outlined in the Hackensack Meadowlands Development Commission's Plan (HMDC 1970). It was estimated that, through these actions, runoff loading could be reduced from 41,000 to 21,000 lbs/day. In fact, the actions undertaken under this plan may have already resulted in improvements in the water quality of the Hackensack River. DO deficits, due to runoff, as discussed earlier, were based on 1970 data. Those conditions may have possibly been rectified by sanitary landfill control measures, undertaken under this plan.

Various point source control schemes, based on the 208 Plan (NE New Jersey) recommendations, are being considered for the Hackensack Basin. Primary treatment plants will either be phased out or upgraded to secondary or higher treatment levels. Larger plants will be expanded and upgraded to effectively handle the flows from the smaller plants to be abandoned, as well as to prevent overflow incidents. Under the N.J. Water Quality Management Plan recommendations(15), the Bergen County Utilities Authority's (BCUA) facility will be expanded to 80 MGD and upgraded to treatment level 3 (90% CBOD and NBOD removal). The beneficial effects of this arrangement are predicted in Figure VI-18. As shown, the minimum DO levels in the tidal Hackensack will be raised to about 4 mg/l (the existing minimum is under 2 mg/l). Another modeling analysis (Hudson County 201 Plan)(11a) substantiates this DO improvement (Figure VI-19). It is apparent, in Figure VI-19, that it is economically feasible to upgrade BCUA to level 3, to achieve a minimum DO level of 4 mg/l at any time in the Hackensack segment, which is currently experiencing the largest DO deficits. Additonally, the Jersey City West flow will be diverted to the Jersey City East facility, thus removing a large BOD load from the Hackensack River.

With the implementation of these point source pollution control schemes, a minimum DO level of 4 mg/l at any time can be expected in the tidal Hackensack and the portion of the river, now classified as SE3 (min. DO = 3 mg/l), will be qualified for upgrading to SE2 classification.

b. Coliform Bacteria

The fecal coliform profile for the tidal Hackensack, during the summer of 1970(19) is illustrated in Figure VI-16. As seen in the figure, the coliform criteria were violated in all of the tidal Hackensack, except in the last section, which is classified as SE3 (1,500 MPN/100 ml). Coliform density peaks in the neighborhood of Bergen County Utilities Authority's (BCUA) treatment facility and then tapers off in either direction due to the tidal action. This is an indication that the BCUA was a major contributor of bacteria in the Hackensack River at the time. Mean fecal coliform levels, for the 1970 observed data, as reported in the NYC 208 report, were also in excess of 1000 MPN/100 ml in most of the tidal Hackensack (Figure VI-9). Other sources of bacterial contamination, as in the tidal Passaic, have been CSOs, urban runoff and leakages(19).

As shown in Figures VI-12 through VI-15, based on the NYC 208 projection analysis, only the zero discharge alternative is likely to bring significant improvement in the bacterial quality of the tidal Hackensack. However, the accuracy of this analysis is suspect, due to the probable erroneous, high level coliform contribution from the upstream boundary. STORET data for the period 1974-1983, indicate, as shown in Table V-4, negligible bacterial contamination in the Hackensack River below the Oradell Dam.

The fecal coliform profile, in Figure VI-3, represents the extent of CSO impact on the bacterial quality in the tidal Hackensack. This profile is based on a simplified estuarine modeling analysis and the assumption that all CSOs were discharged as a point source near Berry's Creek. CSO input data was taken from Table IV-5 (CSO Inventory). As shown, unlike the Passaic River, the contribution to coliform bacteria from the CSOs is negligible in the Hackensack River.

Mitigation of the bacterial contamination in the tidal Hackensack is likely to occur as a result of the on-going pollution abatement plans, and through the urban runoff control measures undertaken by the Hacken- sack Meadowlands Development Commission (HMDC). The problem at the BCUA has since been rectified and the bacterial contamination from this source is presently negligible. In the absence of control of other major sources of bacterial pollution, based on the Teledyne Modeling Analysis(25b) the current fecal coliform levels in the tidal Hackensack can be reduced to below the 770 MPN/100 ml level with the upgrading of the BCUA facility. Consequently, the Hackensack River section between Berry's Creek and Route 1 and 9 crossing, currently classified as SE3, will be upgraded to the SE2 classification. However, based on the available data and studies, the present bacterial quality will not permit the attainment of the swimmable classification in the tidal Hackensack from Overpeck Creek to the Newark Bay. Coliform projections, based on the Teledyne Modeling studies (1973) have indicated that, for all wastewater discharge alternatives, including 99.99% coliform removal at the BCUA (a major past coliform source), the fecal coliform levels in the lower, tidal Hackensack, will still not meet the criterion for the swimmable classification (SE1)(25b). Therefore, the lower tidal Hackensack should retain its SE2 classification and thus remain non-swimmable. The accuracy and reliability of these projections were based on the state- of-art modeling techniques of the time. A great deal of progress has taken place in this field since then. For these reasons, a reevaluation of this segment of the Hackensack River, for possible reclassification, will be undertaken by the NJDEP, as soon as more recent studies and/or data become available.

3. Arthur Kill and Kill Van Kull

a. Dissolved Oxygen (DO)

Both the Arthur Kill and Kill Van Kull are currently classified as SE3, with a minimum DO standard of 3 mg/l. The DO profile for the Kill Van Kull, based on information contained in the Northeast New Jersey Water Quality Management Study(19) (1970 summer data), is illustrated in Figure VI-20. Apparently, the currently applicable DO criterion is met at the eastern end of the Kill Van Kull. The influence of heavily polluted Newark Bay on the water quality in the Kill Van Kull is evident from the gradual increase in the DO levels in the direction of the Upper New York Bay. Principal point sources of BOD are a primary facility in Bayonne, New Jersey, and a secondary facility on Staten Island. Other sources of BOD loads (see Table IV-8) are contributed by urban runoff and CSOs. A large portion of the DO deficit has been attributed to sediment oxygen demand(19). Large amounts of benthic deposits seem to have accummulated from urban runoff, CSOs, primary effluent and the tidal mixing with Newark Bay.

DO levels in the Kill Van Kull are likely to improve as a result of on- going water quality improvment schemes. The Bayonne facility is slated to be upgraded to the secondary treatment level or to be directed to a secondary treatment plant. In addition, other pollution abatement projects in the adjoining waterbodies (Newark and New York Bays), will further enhance the water quality in the Kill Van Kull. Figures VI-6 and VI-7 illustrate the DO projections for the Kill Van Kull for 1981 and 1990 conditions, respectively, based on the ISC 301(h) 1983 in- vestigations. While the 1981 profile reflects the existing loads, all the treatment plants in the urban complex were presumed to have attained secondary treatment levels for the 1990 conditions. As seen, the 1990 DO levels in the Kill Van Kull will be above 4 mg/l. According to the New York City 208 modeling analysis (1978)(21), the DO criterion of 4 mg/l will be satisfied in this waterbody, with all the treatment plants at the secondary level. NYC 208 Study projections are based on 1977 data and are depicted in Figure VI-21. The extent of SOD pollution as incorporated into this model was an underestimation (NYC 208 model sensitivity analysis - Figure VI-25). In addition the N.J. 303(e) Water Quality Management Plan(19) also indicates that the benthic oxygen demand has nearly as great an effect on DO depletion as the point source BOD loads. Based on current information, it is judged that, after these improvements in the treatment levels, the water quality for the SE2 classification will not be met. The Kill Van Kull waterway also interconnects the New York Harbor and Newark Bay. Based on the current pattern, developed by "NOAA"(6), it is found that, within one tidal cycle, the Kill Van Kull can represent the water quality of Upper New York Bay, during the flood current, and also represent the Newark Bay water quality during the ebbing tide. Therefore any upgrading of Kill Van Kull will also be contingent on the water quality improvements in these adjoining waterbodies. Therefore, it is recommended that, in terms of DO, the Kill Van Kull not be upgraded to an SE2 classification and remain at the current SE3 classification.

Very poor water quality in the Arthur Kill has been ascribed to heavy point as well as nonpoint source pollution. As shown in Figure VI-22, the DO levels may be close to zero in parts of the Arthur Kill. The DO profile in this figure has been computed using the NE N.J. Water Quality Management Study model(25b), based on 1970 summer data, and may represent the existing situation, as no major changes in the discharge patterns have occurred since that time. A later (1973) Hydroscience modeling study demonstrated similiar patterns of low DO levels. As seen in Figure VI-23, the N.J. 305(b) Report, based on 1974 data, came to similar conclusions. BOD loads from point sources mainly emanate from primary municipal plants, with some contribution from the industry in the urban complex. About 2 MGD of untreated sewage from Staten Island is also currently flowing into the Arthur Kill. The water quality picture is further confounded by the addition of sizable amounts of waste heat from nearby power plants. Summer temperatures in excess of 85^{o}F have been measured in the Arthur Kill and these high water temperatures may account for a portion of the DO deficit.

Other major sources of pollution included CSOs, urban runoff, thermal discharges and sediment oxygen demand (SOD). Most sewer systems in the metropolitan area are very old and characterized by substantial leakages. A sizable portion of the BOD loading may be attributed to leachates from the area landfills, particularly to a large solid waste dump site on Staten Island. Tidal mixing, with the waters of adjoining Newark Bay and Raritan Bay, does not alleviate the severe water quality problems, as these waterbodies have only marginally better water quality.

As illustrated in Figures VI-6 and VI-7 (ISC 1983 301(h) Study and NYC 208 Task Report, 1978), the DO projections, for the present and future (assuming all treatment plants at secondary level) conditions, do not predict substantial improvements in the DO levels in the Arthur Kill. Currently about 23,500 lbs/day of BOD (about 60% of the total point source load) flows into the Arthur Kill from Perth Amboy, Carteret and Sewaren sewage treatment plants. These three plants are slated to be phased out in the near future. According to the March, 1983 301(h) report the elimination of these three plants, with upgrades of other STPs to secondary, the DO is predicted to be still less than 4 mg/l (See Figure VI-6). Only the zero discharge alternative, (which is considered to be technically and economically infeasible at the present time) as shown in Figure VI-21, is expected to achieve a significant increase in the DO levels in the Arthur Kill. Consequently, the existing classification, i.e., SE3 (DO = 3 mg/l), should be retained for the Arthur Kill.

b. Coliform Bacteria

Figure VI-20 depicts the coliform profile in the Kill Van Kull, based on 1970 summer conditions(25b). As seen, the existing fecal coliform criterion(1500 MPN/100 ml) for the N.J. SE3 stream classification, is essentially met. The influence of the heavily polluted Arthur Kill and Newark Bay on the bacterial quality of the Kill Van Kull, is evident from the gradual fall in the coliform levels towards Upper New York Bay. Sources of bacterial pollution, other than these adjoining bodies, are CSOs and untreated sewage from Staten Island, and a primary treatment facility in Bayonne, N.J. Therefore, it is recommended that the Kill Van Kull not be upgraded to a swimmable classification.

Parts of the Arthur Kill are characterized by heavy bacterial contamination. Fecal coliforms ranging from about 1,000 MPN/100 ml, at the Raritan Bay end, to about 5,000 MPN/100 ml, at the Newark Bay end, were estimated by the Hydroscience modeling analyses (21) of the New Jersey waters. As seen in Figures VI-9 through VI-11, based on the NYC 208 Task Report(21), the same order of magnitude of fecal coliform concentrations were found to exist in parts of the Arthur Kill.

According to the NYC 208 report(21), the municipal wastewater treatment plants providing secondary effluent with disinfection do not contribute any significant coliform impact on the receiving waters. CSOs, raw sewage, leakages, bypasses and urban runoff are the dominant sources of bacterial pollution in the Arthur Kill. Of these, CSOs play a major role in the degradation of the water quality. The Borough of Carteret and Cities of Elizabeth and Perth Amboy, together, contribute about 8 MGD of CSO into the Arthur Kill. Additionally, about 2 MGD of raw sewage, from Tottenville, on Staten Island, also flow into the Arthur Kill.

NYC 208 coliform projection analysis(21) indicates (Figures VI-12 through VI-15) that only the zero discharge alternative(90% CSO capture) may improve the bacterial quality in the Arthur Kill, to the extent that it may qualify for upgrading to a swimmable classification from its existing non-swimmable classification.

A conservative estimation of the CSO impact from the New Jersey side, on the bacterial quality in the Arthur Kill, has been presented in Section VI-C of this report. This analysis was taken from a report(19a), prepared by the N.J. DEP, as part of a water quality demonstration, to assist the local communities to obtain federal grants for the control of their CSOs. Both simplified steady-state and dynamic modeling approaches were utilized to calculate the net increase of coliform levels at various points in the Arthur Kill due to CSO discharges. Coliform levels, computed under steady state conditions, are presented in Table VI-6. Apparently, CSOs alone will contribute about 14,000 MPN/100 ml (summer level) in the lower mouth of the Arthur Kill (about 12 miles south of the Elizabeth discharge). The coliform contributions to other parts (toward Newark Bay) of the Arthur Kill are much higher. If CSO controls were implemented, and assuming 80% reduction in the CSOs, the remaining 20% loading will still contribute about 3,000 MPN/100 ml in the lower mouth of the Arthur Kill. Dividing this number by 4 yields a fecal coliform level of about 700 MPN/100 ml. Considering coliform contributions from other sources, it is obvious that even with 80% CSO controls, the fecal coliform criteria for the SE2 stream classification (770 MPN/100 ml), will not be satisfied throughout the entire length of the Arthur Kill. The same order of magnitude of coliform levels, as shown in Table VI-7, were obtained by the dynamic modeling approach.

Obviously, the control of CSOs alone will not be sufficient to lower the coliform concentrations to a level below the criterion for a swimmable classification. Only an overall strategy, aimed at controlling all the potential sources (raw sewage, etc.) of pollution, will alleviate the severe coliform problems in the Arthur Kill. Only after such control programs have been identified, and the resulting improvement in the water quality has been determined, based on a more reliable technical projection tool, may the Arthur Kill be upgraded to a higher classification from its existing SE3 status.

4. Hudson River

a. Dissolved Oxygen (DO)

Since the Hudson River and Upper New York Bay are currently classified as suitable for fish propagation (SE2), a DO assessment to justify this use is not necessary.

b. Coliform Bacteria

The Hudson River is classified as an SE2 waterbody, with a fecal coliform criterion of 770 MPN/100 ml. Heavy bacterial pollution is currently present in most of the metropolitan Hudson, especially below its confluence with the Harlem River. As seen in Figure VI-24(25b) the fecal coliform profile is far above the existing criterion. These high fecal coliform levels are further substantiated from other periods of data observation, as illustrated in Figures VI-9 through VI-11. As shown, the fecal coliform density peaks at about 40,000 in the neighborhood of the Battery Park.

The principal sources of bacterial pollution in the Hudson River are the heavy discharges of untreated and inadequately treated sewage from New

York and New Jersey. Approximately 200 MGD of raw sewage flows into the Hudson River from New York City. Other sources of coliform pollution may be attributed to CSOs, urban runoff, plant and sewerline leakages and by-passes on both sides of the river. Figures VI-12 through VI-15 present the coliform projections in the Harbor complex, based on the NYC 208 report(20). Various treatment alternatives were considered in this projection analysis. As seen, with the secondary treatment alternative (all plants at the secondary level) the fecal coliform levels (assuming fecal coliform = total coliform/4) in the Hudson River, between the State line and its confluence with the Harlem River, will fall below the criterion for SE1 classification (200 MPN/100 ml). Therefore, in view of these anticipated improvements in the near future, the Hudson River segment, between the State line and its confluence with the Harlem River, is recommended to be upgraded to SE1 classification and, hence, made swimmable. However, for the Hudson River segment between the Harlem River junction and the Upper New York Bay, the secondary treatment alternative is predicted to only lower the fecal coliform levels to approximately the existing criterion (770 MPN/100 ml). The criterion for SE1 classification (FC = 200 MPN/100 ml) will still not be met. According to the NYC 208 Report, only the zero discharge alternative, with 90% CSO control, predicts sufficient coliform reductions to achieve the swimmable goals.. However, the NYC 208 report concluded that, based on environmental, technical and institutional factors, this alternative is not feasible. Even if implemented, the projected improvements in the water quality may still not materialize, since the precision of the NYC 208 water quality model to predict fecal coliform levels has not been demonstrated for the bacterial levels in question. Furthermore, the remaining 10% of the CSOs will still have some impact on the Hudson River(23,28). The alternative provides that the CSOs are to be captured and then given primary treatment followed by disinfection. The estimated reductions in the coliform bacteria, via chlorination of primary treated captured CSO, may have been overstated(13,14,22,24,26). It is also recognized that the applicability of steady state models to CSO and/or coliform bacteria analysis, is limited.

CSO abatement is the crucial factor in meeting the swimmable water quality goals. The zero discharge alternative entails in-line (sewers) and off-line storage, followed by primary treatment and disinfection. Based on the NYC 208 Study, the current costs associated with this CSO control scheme are estimated to be over 7 billion dollars (updated from the original (1975) 3.5 billion dollars). The engineering feasibility of this CSO control program, has not been established. A detailed study, involving over 600 major CSO points, generally distributed throughout the harbor region(7,13), is required. Therefore, pending detailed engineering evaluations of this alternative (90% of CSO control) and others, it is judged that its feasibility has not been demonstrated.

Based on current data and these assessments, the existing stream classification, i.e. SE2, should be retained for the Hudson River section between the Harlem River junction and the Upper New York Bay.

E. Water Pollution Abatement Programs Within the New Jersey/New York Metropolitan Area

1. New York State/New York City

New York State has required the City of New York to undertake a more detailed evaluation of CSO problems and abatement alternatives for the New York Harbor Complex.

During the same time period as the CSO study, the North River and Red Hook Water Pollution Control Facilities will begin to treat and provide disinfection for flow which are currently discharged without treatment to the Hudson River and the lower East River.

Continued monitoring during the time period will help to evaluate the predictive capability of the New York City 208 model and provide an up-to-date data base in order to determine if the swimmable goal is attainable.

Water Pollution abatement efforts by the City of New York were concisely summed up by Mr. Edward Wagner, Deputy Director for Plant Operations for New York City's Department of Environmental Protection, at the recent (April, 1984) I.S.C. Hearing relating to the proposed amendment of its Water Quality Regulations, Section 2.05(b), concerning year-round disinfection. We will quote an excerpt of the relevant portion of his testimony as follows:

> "There is evidence that the quality of the waters of the New York Harbor has been improving over recent years. Because of that improvement, it is appropriate to con tinue to look for feasible opportunities to achieve the water quality standards that are based on the classification systems of the States of New York, New Jersey and Connecticut. We applaud the ISC and the States of New Jersey and New York for bringing attention to perhaps one such possiblity at this time."

> "From the information in the public notice and the material offered by the ISC, it is clear that the issue at hand is the possibility of opening more of Raritan and Sandy Hook Bays for collection of shellfish for depuration purposes. My testimony will address that possiblity."

> "I want to emphasize that New York City is committed to doing what it can to meet established water quality standards. Any changes that we believe should be made to classifications and/or standards will be presented at other appropriate proceedings. So, in my presentation here, I will confine my remarks to what can and should be done to achieve a water quality level in Raritan and Sandy Hook Bays to permit shellfishing for depuration purposes."

"We all celebrated the recent completion of the upgradings of the Passaic Valley plant, the Middlesex County plant, the Yonkers plant, and a number of other plants in the district, and certainly New York City is proud of its record of upgrading nine of our twelve wastewater treatment plants to full secondary treatment. We are continuing to work hard to arrest the remaining major sources of water pollution in New York City. Those are primarily the raw sewage discharges from the Red Hook and North River drainage areas. You should be aware that we are pressing forward with construction and are, in fact, ahead of schedule. We presently expect that North River will be operational in December, 1986, and Red Hook a year later. In addition, we are well underway with the massive upgradings of the Owls Head and Coney Island plants from modified aeration to full step aeration. There are also a few small but intolerable raw discharges, due to problems in collection systems, that we are diligently working to correct to meet the compliance schedules in our SPDES permits. Under the guidance of the New York State Department of Environmental Conservation, we are going forward with the recently approved work plan for controlling combined sewer overflows. We see this as the next generation of water pollution control in the New York Harbor. Furthermore, we are more than halfway through a $3.2 million study for regulator improvements which will minimize dry weather leakage from combined sewer regulators. We certainly hope to see a similar effort relating to regulator leakage and combined sewer overflow control on the New Jersey side as well."

2. New Jersey

A brief summary of the multiple water pollution abatement programs, both prospective and ongoing, within the State of New Jersey follows:

a. Section 201 Construction Grants Program - In New Jersey, massive upgradings to full secondary treatment of the Passaic Valley and Middlesex County plants (the two largest dischargers in the State) have been completed. In addition, the first four of the six projects on the approved FY-85 Construction Grants Priority List (see Table VI-10) to be funded during 1985, are within, and their discharges impact, the New York Harbor/Raritan Bay complex:

1- City of Perth Amboy	$ 13,600,000*
2- Hudson County M.U.A.	$ 85,960,000
3- Sayreville-South Amboy	$ 7,421,000*
4- Old Bridge Township	$ 6,643,000*

* These projects have had segments funded previously

b. The State of New Jersey strongly urges and supports the proposed amendments of the Interstate Sanitation Commission's Water Quality Regulations, Section 2.05(H) to require all discharges to the I.S.C. District Waters to disinfect year-round.

c. CSO-Control Program - The State of New Jersey D.E.P. considers certain CSO abatement programs as a priority item (see Table VI-11), as evidenced by this report; and most design work by the applicants has been completed for some time, awaiting the necessary funding source According to the NYC 208 Study(20), the total cost of 90% CSO capture in the New Jersey study area was estimated to be $360 million dollars, based on 1975 costs.

d. Nonpoint Source Control Programs - The State Stormwater Control Act has been legislated but implementation is at the local municipal and county level. The implementation is dependent on funding still to be appropriated by the State Legislature.

e. Point Source Control - The State has recently assumed responsibility for the NPDES Program from E.P.A. and is working vigorously to eliminate the backlog of permits requiring renewal. Industries requiring oil and grease separation of their stormwater runoff are now regulated under the NJPDES system.

-10)

Table VI-1

TIDE CHARACTERISTICS

Location	Height Difference		Velocity Ratio (Max.)	
	High Water	Low Water	Flood	Ebb
Kill van Kull				
Bergen Point	+0.1 ft	0	1.0	1.0
Newark Bay				
Port Newark Terminal	+0.6 ft	0	0.8	0.8
Passaic River				
Newark	+0.6 ft	0	0.4	0.3
Hackensack River				
Kearny Point	+0.5 ft	0	0.5	0.4
Little Ferry	+0.8 ft	0	N/A	N/A
Western Side of Upper Bay				
Jersey City	-0.1 ft	0	N/A	N/A
Arthur Kill				
Perth Amboy	N/A	N/A	0.6	0.6
Elizabeth Port	N/A	N/A	0.9	0.7

TABLE VI-2

SUMMARY OF TRIBUTARY FRESHWATER FLOWS

Verification Period	Freshwater Flow (cfs) at Hackensack River	Passaic River	Raritan River	South River	Bear Mountain
Summer 1965	0	79	128	32	3200
Summer 1970	9	185	380	0	5300
Summer 1975	21	1267	1023	192	11800
September 1975	21	1267	1023	192	11800
Nov.-Dec. 1976	3	386	432	75	18400
July 1977	28	207	330	45	7631

Table VI-3

THE MAIN COLIFORM CONTRIBUTORS FOR THE DIRECT DISCHARGE OF THE ARTHUR KILL AND RARITAN BAY

Source Type	Source Name	Receiving Water	Coliform load (total)x10^{13} MPN/Day	% of Total
Point Source**	Elizabeth J.M.	Elizabeth River	0.9	
"	Linden Roselle	Rahway River	0.2	
"	Rahway Valley	Rahway River	0.4	
"	Carteret	Arthur Kill	0.05	
"	Perth Amboy	Arthur Kill	0.06	
"	Woodbridge	Arthur Kill	0.7	
"	Middlesex County	Raritan River	1.4	
"	Tottenville (N.Y.)	Arthur Kill	930	10.0
Raw Sewage (CSO)	Elizabeth	Elizabeth River	3440**	36.4
"	Linden-Roselle	Rahway River	833	9.0
"	Rahway	Rahway River	1333	14.1
"	Carteret**	Arthur Kill	2170**	23.0
"	Perth Amboy	Arthur Kill	253**	3.0
"	Woodbridge	Arthur Kill	451	
Miscellaneous Point Source	(storm Humble Oil sewer)		26.0	
"	Merck & Company		0.1	
"	South Amboy	Raritan Bay	0.1	
"	Madison Town		0.2	
"	Clifford Beach		0.1	
"	Matawan Borough		0.2	
"	Keyport		0.1	
"	Keansburg		0.3	
"	Middle-Belford		0.6	
"	Atlantic High lands	Sandy Hook Bay	0.2	
"	Highlands	Sandy Hook Bay	0.1	
			9441x10^{13} or 9.41x10^{16}	

* Table taken from NYC 208 report (1978)
** Data updated and calculated by Consultants

Table VI-4

Input Data for the Steady-state Model

Parameter	Perth Amboy	Carteret CSO	Elizabeth CSO
Q (cfs)	155	155	297
E ($mile^2$/day)	15.0	15.0	15.0
Qw (MGD)	2.64	1.15	1.82
Cw ($\frac{MPN}{100ml}$)	$2.5x10^7$	$5x10^8$	$5x10^8$
Ts (^oC) Summer	22	22	22
Tw (^oC) Winter	5	5	5
u (ft/sec)	0.0047	0.0047	0.0047
Salinity (ppt)	13	13	13

Table VI-5

Input Data for the Dynamic Equation

Parameter	Carteret CSO	Perth Amboy	Elizabeth CSO
M (MPN/overflow)	$8.9x10^{16}$	$2.5x10^{15}$	$1.12x10^{16}$
A (ft^2)	33,000	33,000	33,000
E ($\frac{mile^2}{day}$)	15.0	15.0	15.0
T (hr)	12.42	12.42	12.42
N_1	0.5	0.5	0.5
N_2	1.5	1.5	1.5
Ks(sec^{-1}) Summer	0.00001273	0.00001273	0.00001273
Kw(sec^{-}) Winter	0.0000043	0.0000043	0.0000043
V_f (ft/sec)	0.0047	0.0047	0.0047
X (mile)	8.5	0.5	12.0
f (conversion factor)	$4.17x10^{13}$	$4.17x10^{13}$	$4.17x10^{13}$

Table VI-6

SUMMARY OF STEADY-STATE TOTAL COLIFORM LEVELS (MPN/100 ml)

AT ARTHUR KILL MOUTH (AK-18)

Condition	Elizabeth CSO	Carteret CSO	Perth Amboy CSO	Background T.C	
				Wet We.	Dry We.
Existing TC Load (10^{13} MPN/Day)	3,440	2,170	253	N/A	N/A
TC Level without control	3,300	5,000	6,000	23,900	6,600
TC Level After Control (80%)	660	1,000	1,200	N/A	N/A

Table VI-7

SUMMARY OF DYNAMIC MODEL ANALYSIS OF TOTAL COLIFORM LEVELS
(MPN/100ml)

At Arthur Kill Mouth

Conditions	Elizabeth	Carteret	Perth Amboy	Subtotal	Other Sources	Total
Without Project	4,400	5,600	6,500	16,500	7,400	23,900
With Project	880	1,120	1,300	3,300	7,400	10,700

Table VI-8

INPUT DATA FOR THE SIMPLIFIED MODEL #

PARAMETER	HACKENSACK RIVER	NEWARK BAY	PASSAIC RIVER (PVSC-NEWARK/KEARNY)
Avg. Q (cfs) 7/77	170.0	633.0	292.5
Avg. E (mi^2/day)	1.5	6.0	3.30
Q_w (MGD)	5.56	3.9	52.4
*C_w (MPN/100 ml)	$6.0x10^6$	$6.0x10^6$	$6.0x10^6$
T_s (°C)	24.4	24.4	24.4
T_w (°C)	5.0	5.0	5.0
A (ft^2)	$1.59x10^4$	$8.11x10^4$	$4.7x10^3$
u (f/s)7/'77	.011	.0078	.06
coliform decay rate (1/d) '7/77	0.986	1.24	0.9271

* Input data taken from NYC 208

Table VI-9

RESULTS OF COMPUTER PRINTOUTS FOR TC

Lower Passaic River

DISTANCE	COLIFORMS (MPN)
-5.00	2898.26
-4.50	3820.98
-4.00	5037.47
-3.50	6641.24
-3.00	8755.62
-2.50	11543.14
-2.00	15218.13
-1.50	20063.13
-1.00	26450.63
-0.50	34871.71
0.00	45973.81
0.50	35658.58
1.00	27657.80
1.50	21452.17
2.00	16638.91
2.50	12905.61
3.00	10009.95
3.50	7764.00
4.00	6021.98
4.50	4670.82
5.00	3622.82

Hackensack River

DISTANCE	COLIFORMS (MPN)
-5.00	37.44
-4.50	56.36
-4.00	84.83
-3.50	127.68
-3.00	192.19
-2.50	289.29
-2.00	435.45
-1.50	655.45
-1.00	986.60
-0.50	1485.05
0.00	2235.34
0.50	1495.62
1.00	1000.69
1.50	669.54
2.00	447.98
2.50	299.73
3.00	200.55
3.50	134.18
4.00	89.78
4.50	60.07
5.00	40.19

Newark Bay

DISTANCE	COLIFORMS (MPN)
-5.00	13.81
-4.50	17.35
-4.00	21.80
-3.50	27.38
-3.00	34.39
-2.50	43.20
-2.00	54.27
-1.50	68.17
-1.00	85.63
-0.50	107.56
0.00	135.12
0.50	107.72
1.00	85.89
1.50	68.48

Table VI-9 Continued

RESULTS OF COMPUTER PRINTOUTS FOR TC

Newark Bay

DISTANCE	COLIFORMS (MPN)
2.00	54.59
2.50	43.53
3.00	34.70
3.50	27.67
4.00	22.06
4.50	17.59
5.00	14.02

Table VI-10

NEW JERSEY FISCAL YEAR 1985 PROJECT PRIORITY LIST IN THE STUDY AREA

Rank	Name	Costs ($1000's)
1	City of Perth Amboy	9,223
13	Woodbridge Township	35,979
2	Middlesex County UA	7,800
3	Old Bridge Twp. SA	6,644
4	Borough of Sayreville	1,600
221	Borough of Sayreville	165
10	Hudson County UA (Jersey City)	33,923
11	Hudson County UA (Jersey City W.)	38,180
12	Hudson County UA (Jersey City)	50,168
19	Hudson County UA (Jersey City)	102,475
20	Hudson County UA (Jersey City)	141,373
21	Hudson County UA (Hoboken)	53,903
22	Hudson County (Hoboken)	52,639
23	Hudson County UA (Bayonne)	36,363
24	Hudson County UA (Bayonne)	48,265
14	Bergen County UA (Triboro)	8,861
67	Bergen County UA (Triboro)	1,128
186	Bergen County UA	15,400
15	Carteret Borough	10,200
16	N. Arlington-Lyndhurst Jt. Mtg.	8,269
70	N. Arlington-Lyndhurst Jt. Mtg.	611
17	No. Burlington Co. RSA (North)	4,250
52	Rockaway Valley Reg. SA	1,650
71	No. Bergen Twp.	110
83	Linden-Roselle SA	10,389
84	Ridgewood Village	1,490
178	Bridgewater Twp. SA	1,634
187	Jt. Mtg.-Essex-Union	10,000
188	Newark City	9,350
189	Rahway Valley SA	4,400

Table VI-11

FISCAL YEAR 1985 PROJECT PRIORITY LIST
CSO CORRECTION PROJECTS IN NEW JERSEY

Name	Ineligible category costs ($1000's)
Bergen County UA	10,993
Carteret Borough	9,922
Edgewater, Borough of	51
Elizabeth City	50,342
Hudson County UA (Bayonne)	9,852
Hudson County UA (Hoboken)	9,238
Hudson County UA (Jersey City)	6,480
Passaic Valley SC	68,000
Perth Amboy, City of	22,000
Rahway Valley SA	3,300
TOTAL	190,178

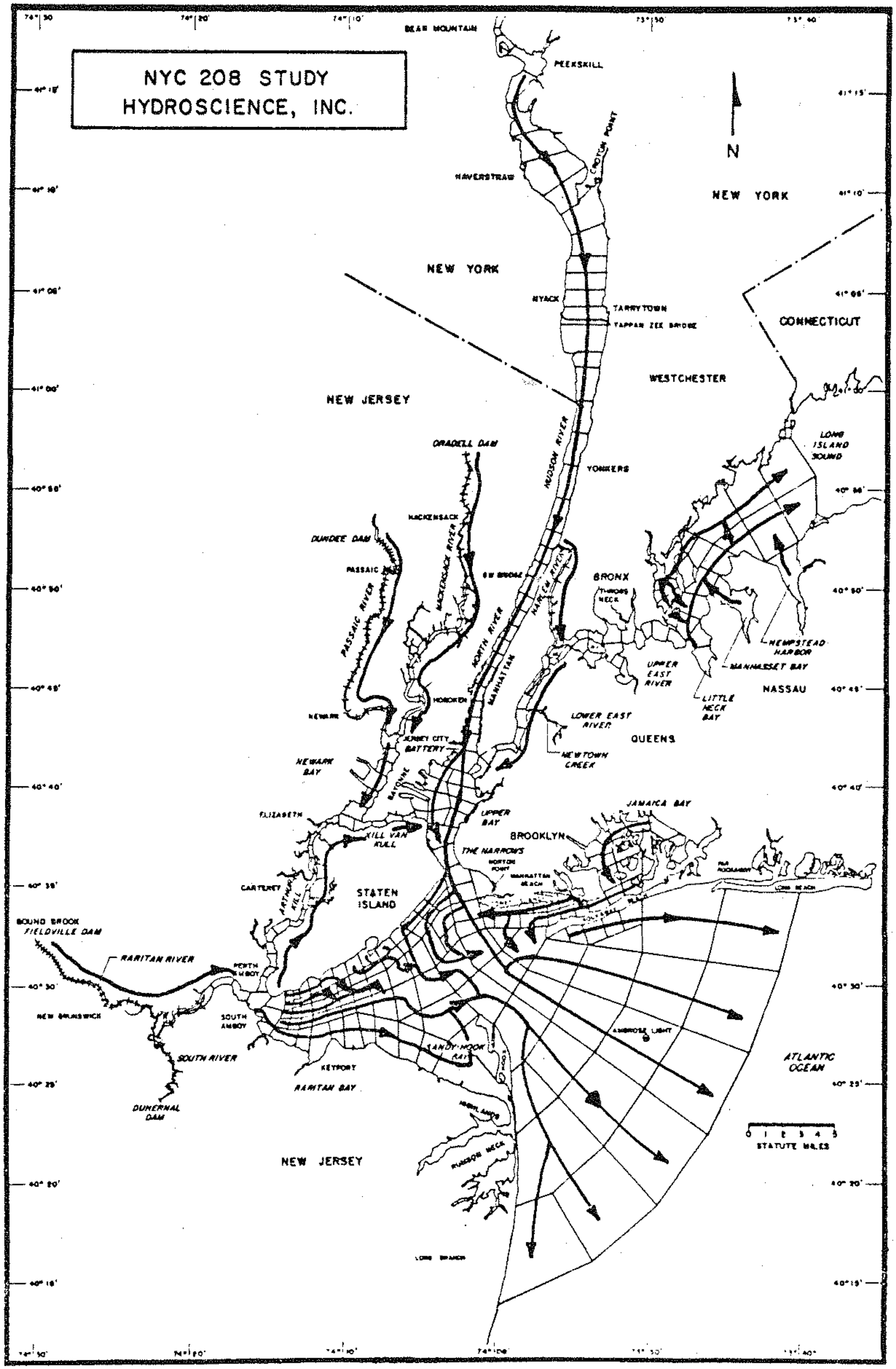


Figure VI-1

ILLUSTRATION OF FLOW ROUTING IN STEADY STATE MATHEMATICAL MODEL

Figure VI-2

FECAL COLIFORM CONTRIBUTION FROM CSO IN PASSAIC RIVER

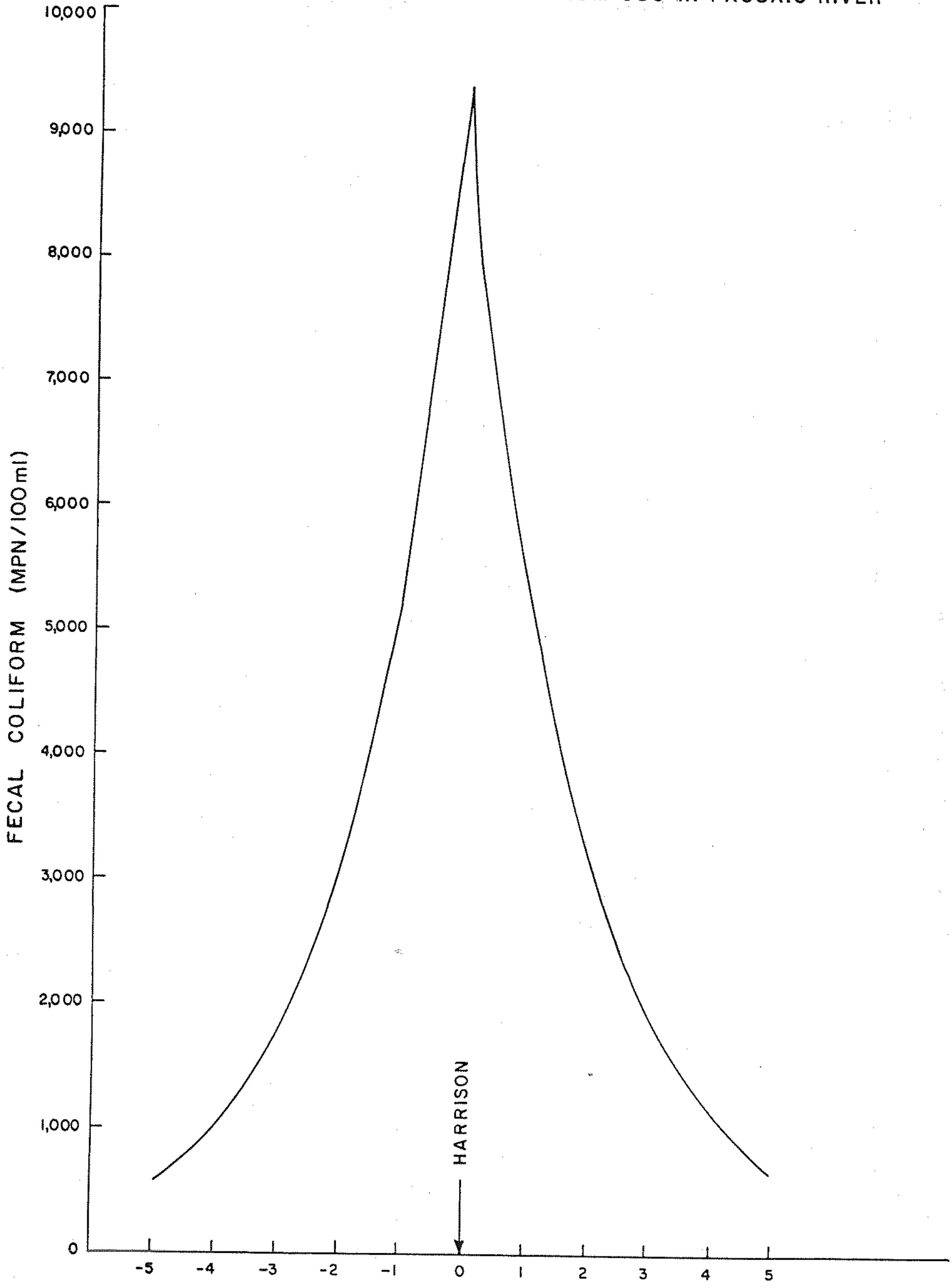


Figure VI-3

FECAL COLIFORM CONTRIBUTION FROM CSO IN HACKENSACK RIVER

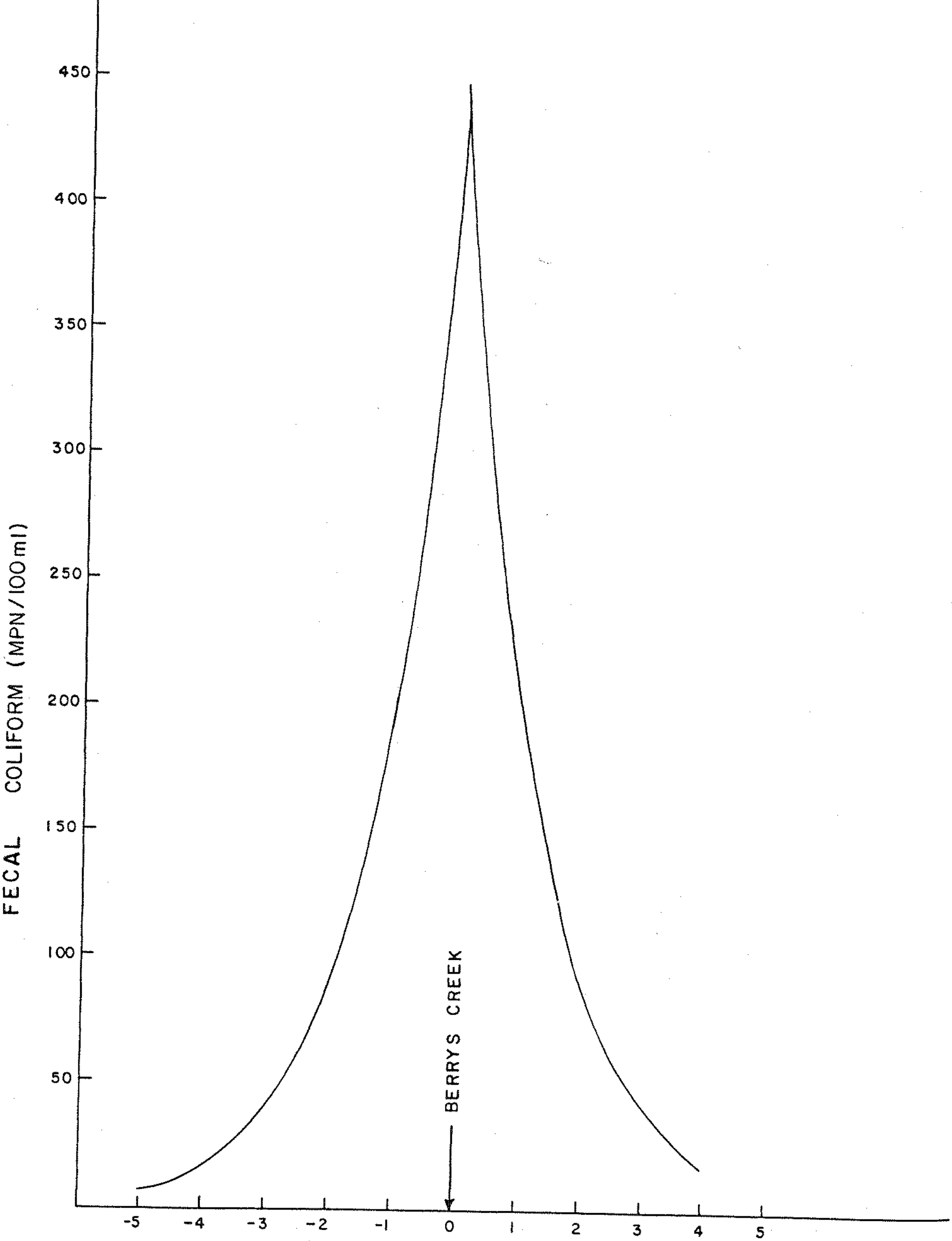


Figure VI-4

DISSOLVED OXYGEN PROFILE FOR PASSAIC RIVER–NEWARK BAY (1970)

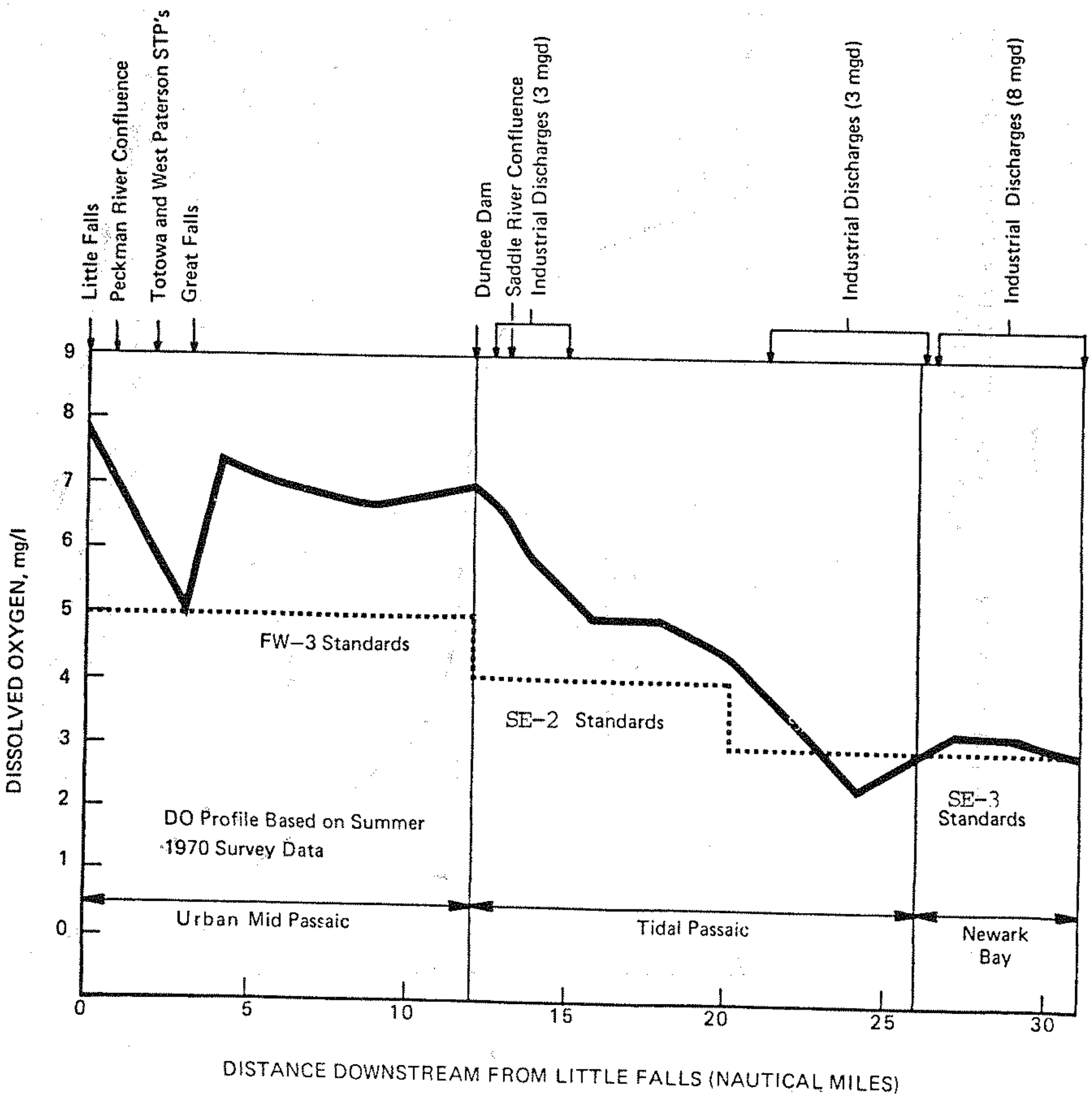
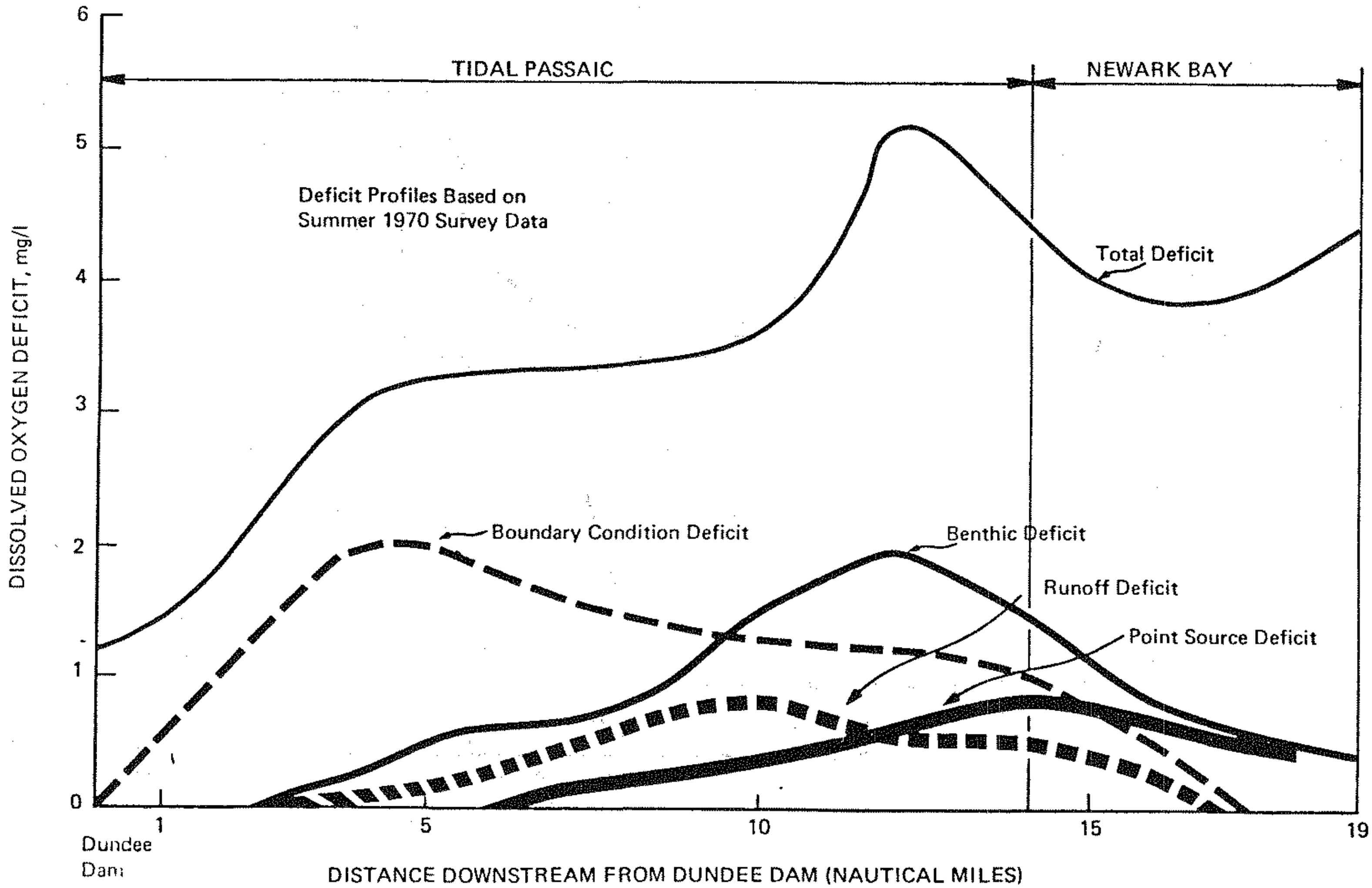
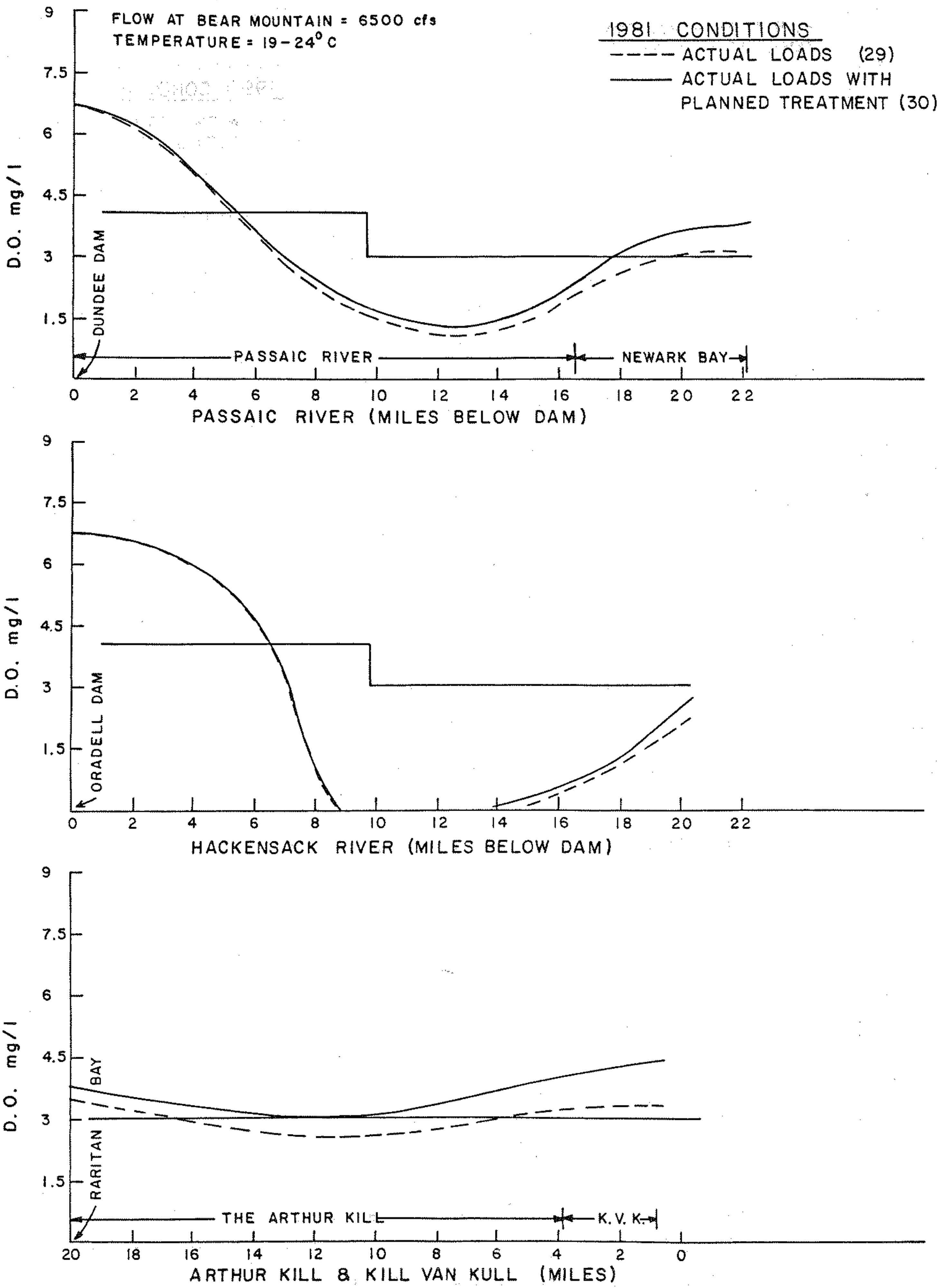


Figure VI-5

DISSOLVED OXYGEN DEFICIT COMPONENTS FOR TIDAL PASSAIC RIVER
NEWARK BAY (1970)





FLOW AT BEAR MOUNTAIN = 6500 cfs
TEMPERATURE = 19 – 24° C
1981 CONDITIONS
ACTUAL LOADS (29)
ACTUAL LOADS WITH PLANNED TREATMENT (30)
D.O. mg/l
9
7.5
6
4.5
3
1.5
DUNDEE DAM
PASSAIC RIVER
NEWARK BAY
0 2 4 6 8 10 12 14 16 18 20 22
PASSAIC RIVER (MILES BELOW DAM)
ORADELL DAM
HACKENSACK RIVER (MILES BELOW DAM)
RARITAN BAY
THE ARTHUR KILL
K. V. K.
20 18 16 14 12 10 8 6 4 2 0
ARTHUR KILL & KILL VAN KULL (MILES)

Figure VI-7

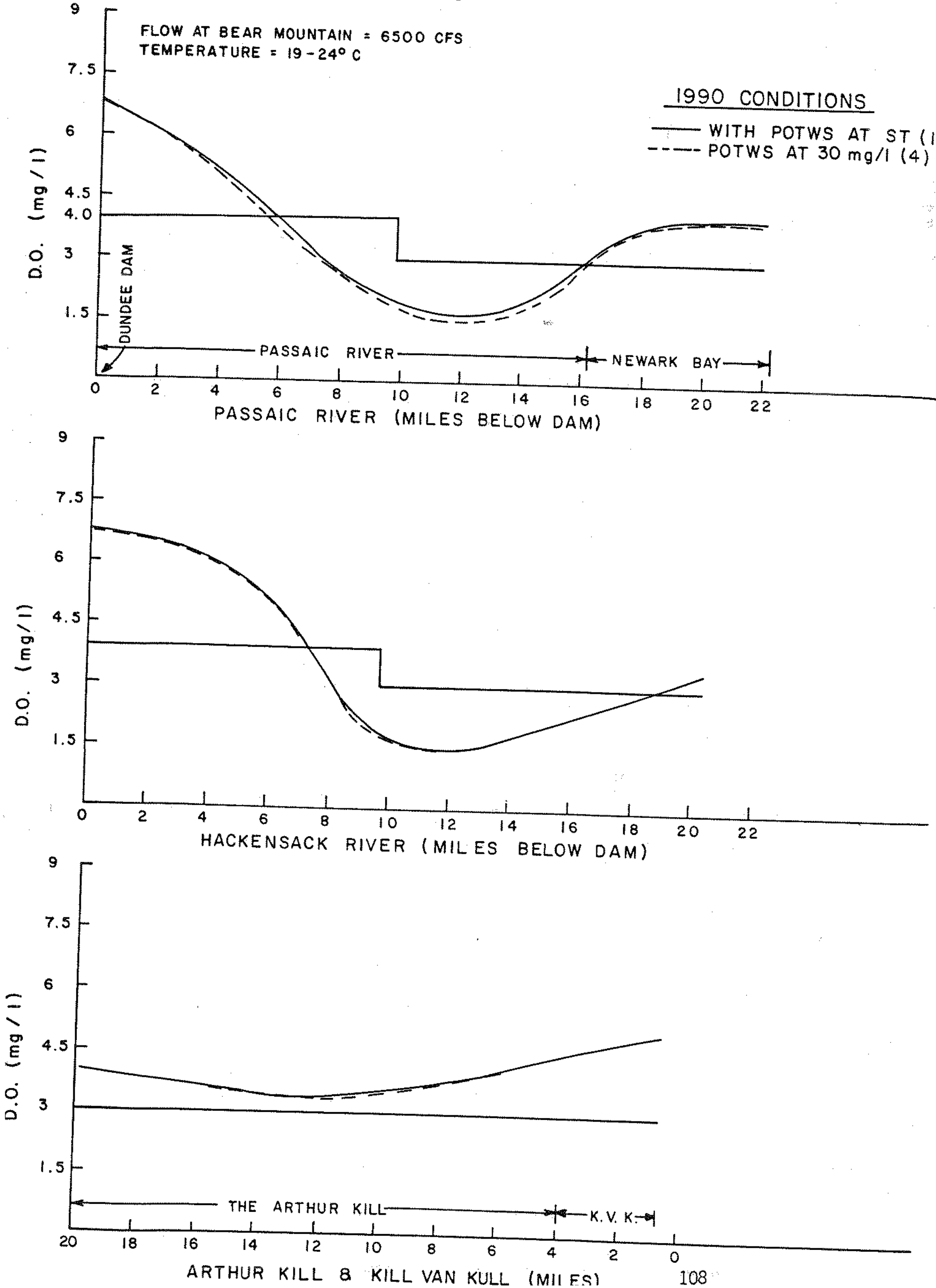
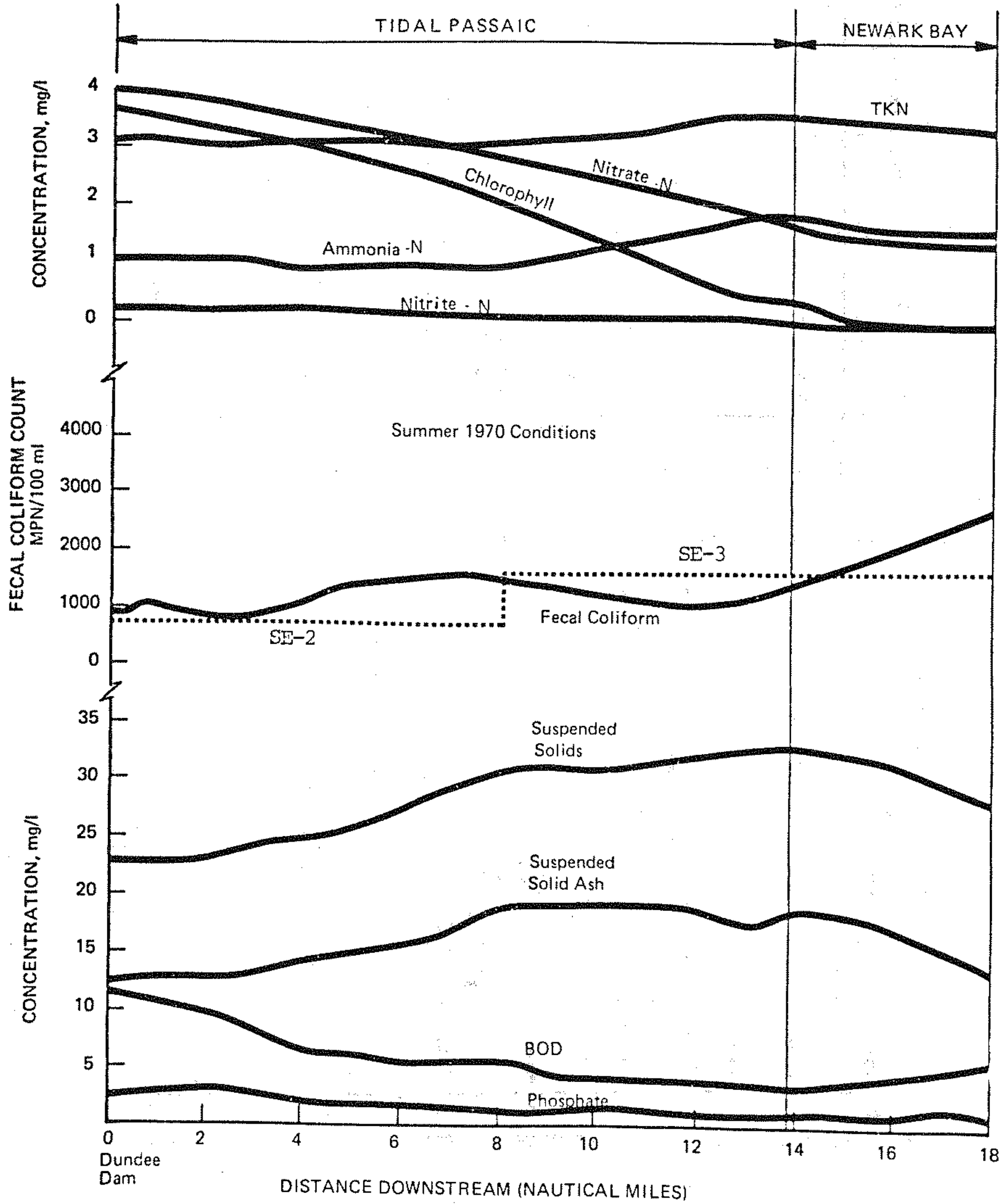

FLOW AT BEAR MOUNTAIN = 6500 CFS
TEMPERATURE = 19-24° C
1990 CONDITIONS
WITH POTWS AT ST (1)
POTWS AT 30 mg/l (4)
D.O. (mg/l)
DUNDEE DAM
PASSAIC RIVER
NEWARK BAY
PASSAIC RIVER (MILES BELOW DAM)
HACKENSACK RIVER (MILES BELOW DAM)
THE ARTHUR KILL
K.V.K.
ARTHUR KILL & KILL VAN KULL (MILES)

Figure VI-8

WATER QUALITY PROFILES, PASSAIC RIVER – NEWARK BAY (1970)



Source: Teledyne, 1973

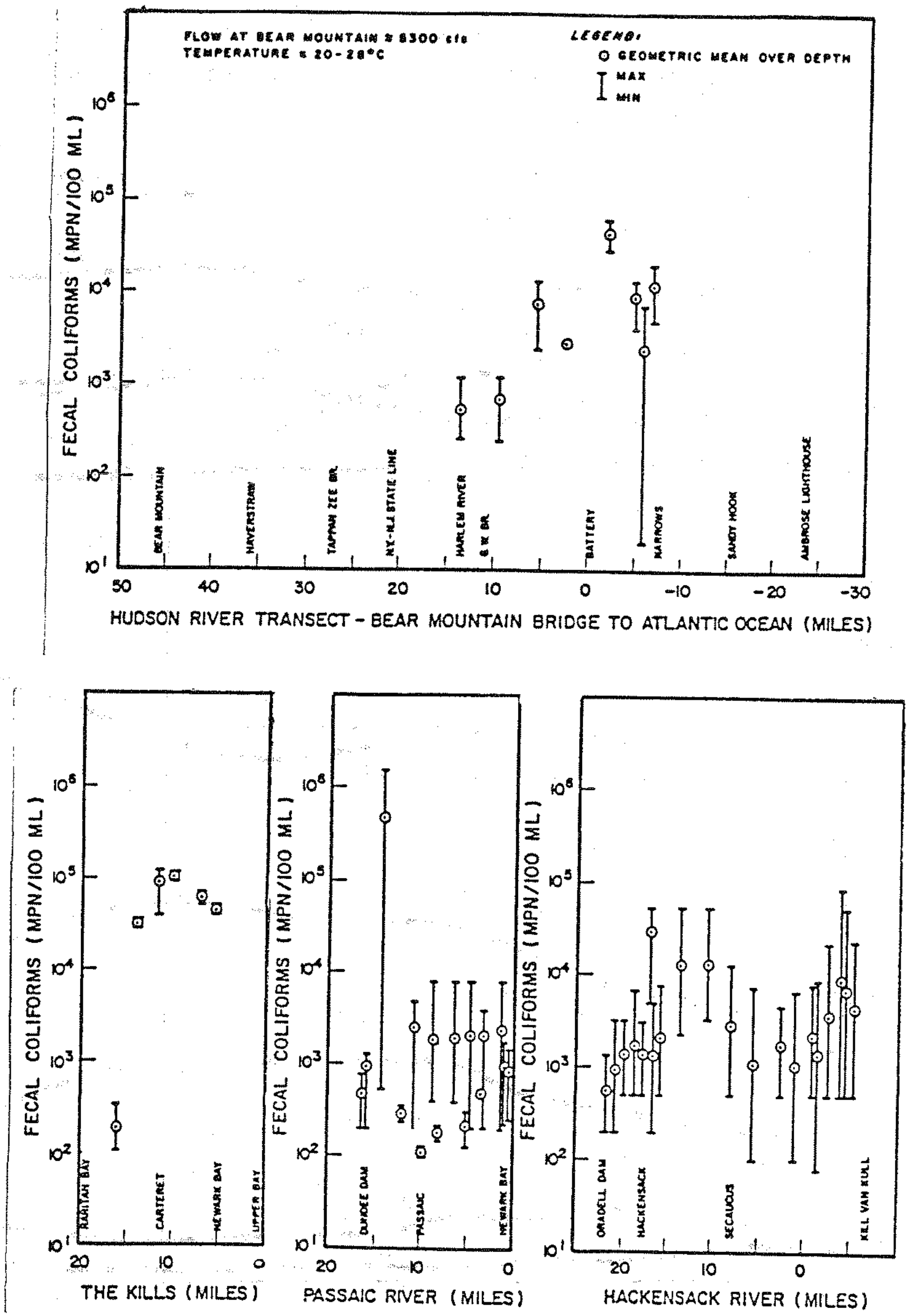


FIGURE VI-9
FECAL COLIFORM DATA
(JUNE 8 TO SEPTEMBER 24, 1970)

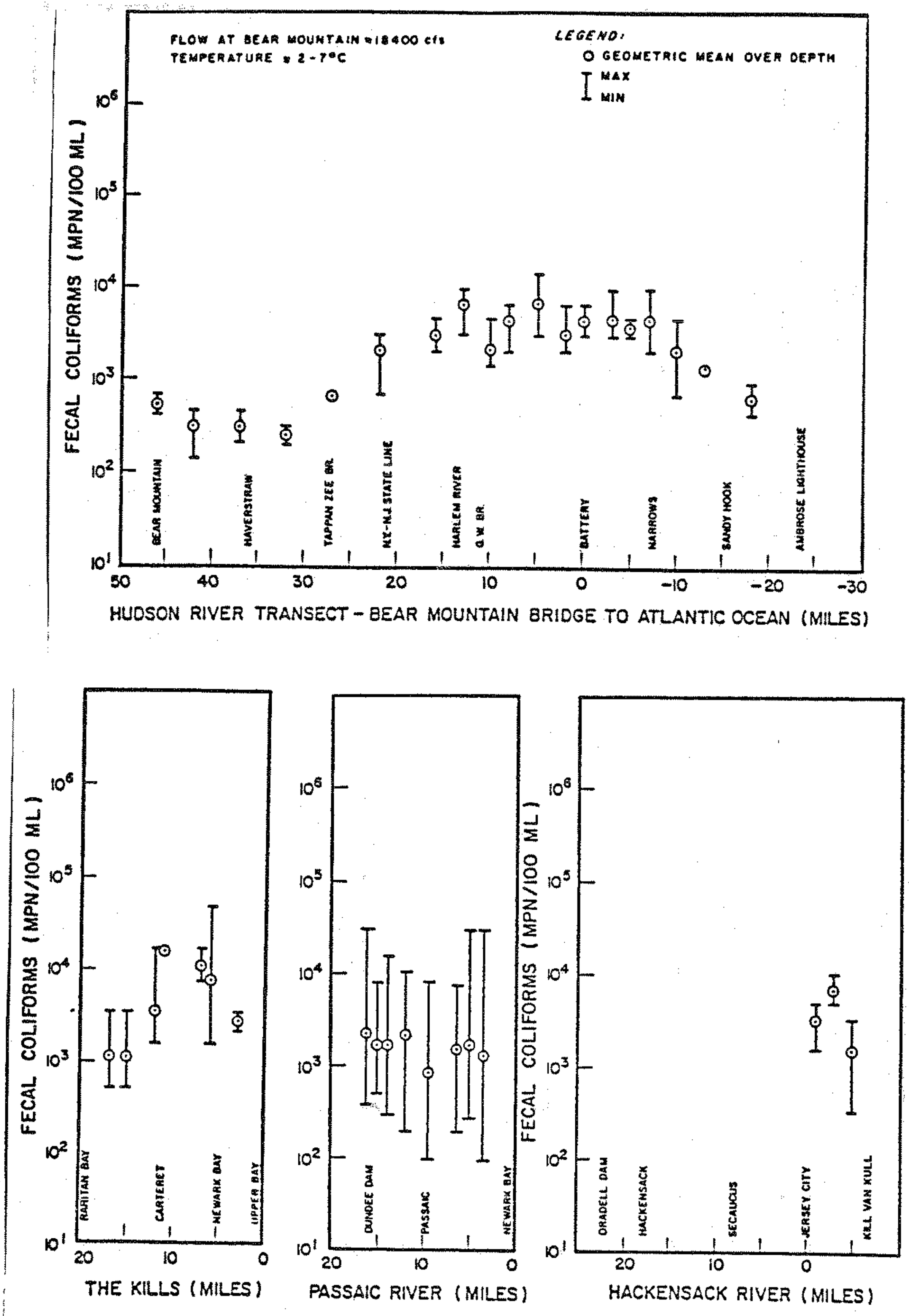


FIGURE VI-10
N.Y.C. 208 FECAL COLIFORM DATA
(NOVEMBER 29 TO DECEMBER 17, 1976)

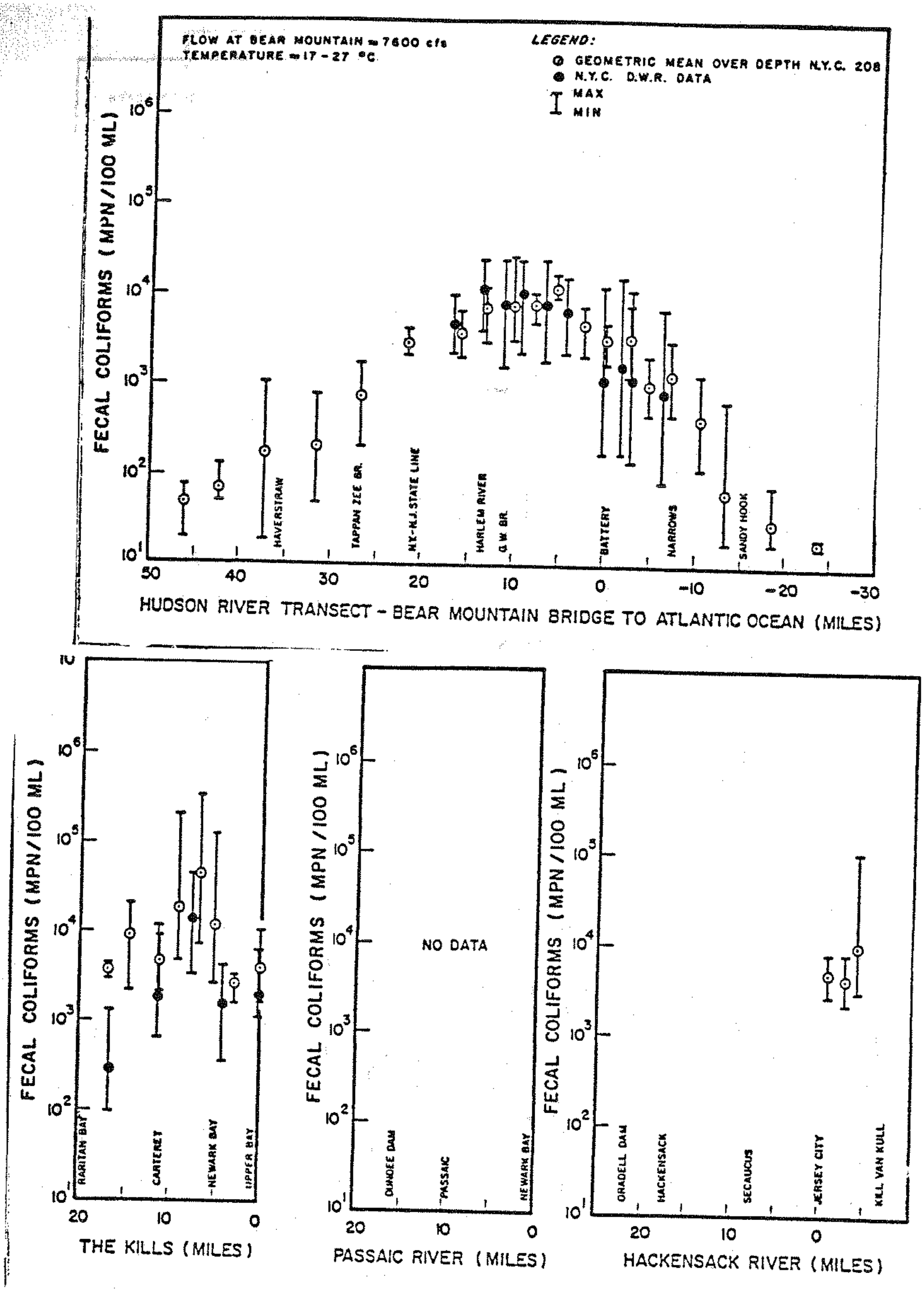


FIGURE VI-11
FECAL COLIFORM DATA
(JUNE 15 TO SEPTEMBER 28, 1977)

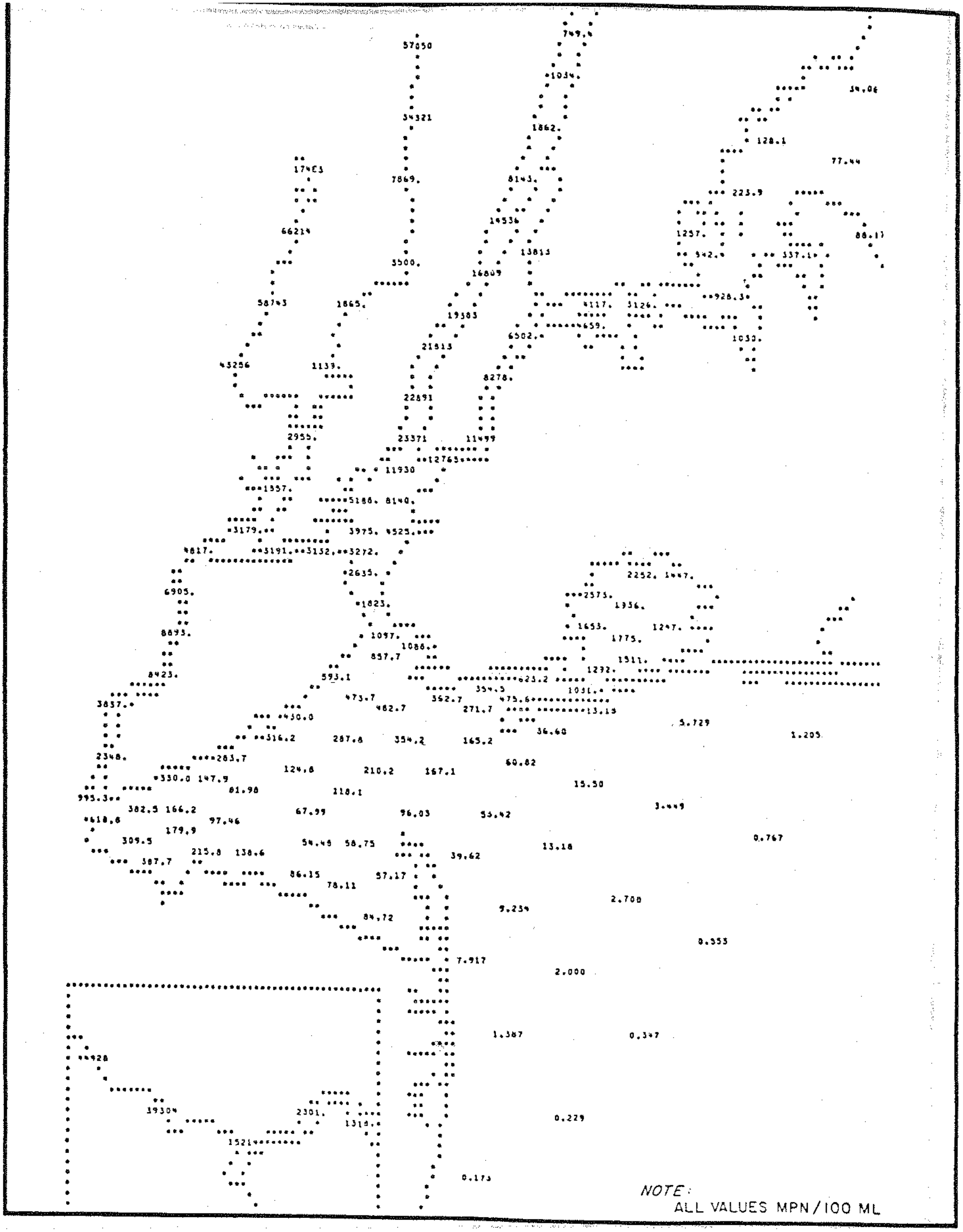


FIGURE VI-12
PREDICTED MEDIAN TOTAL COLIFORM BACTERIA CONCENTRATIONS
BASELINE CONDITION

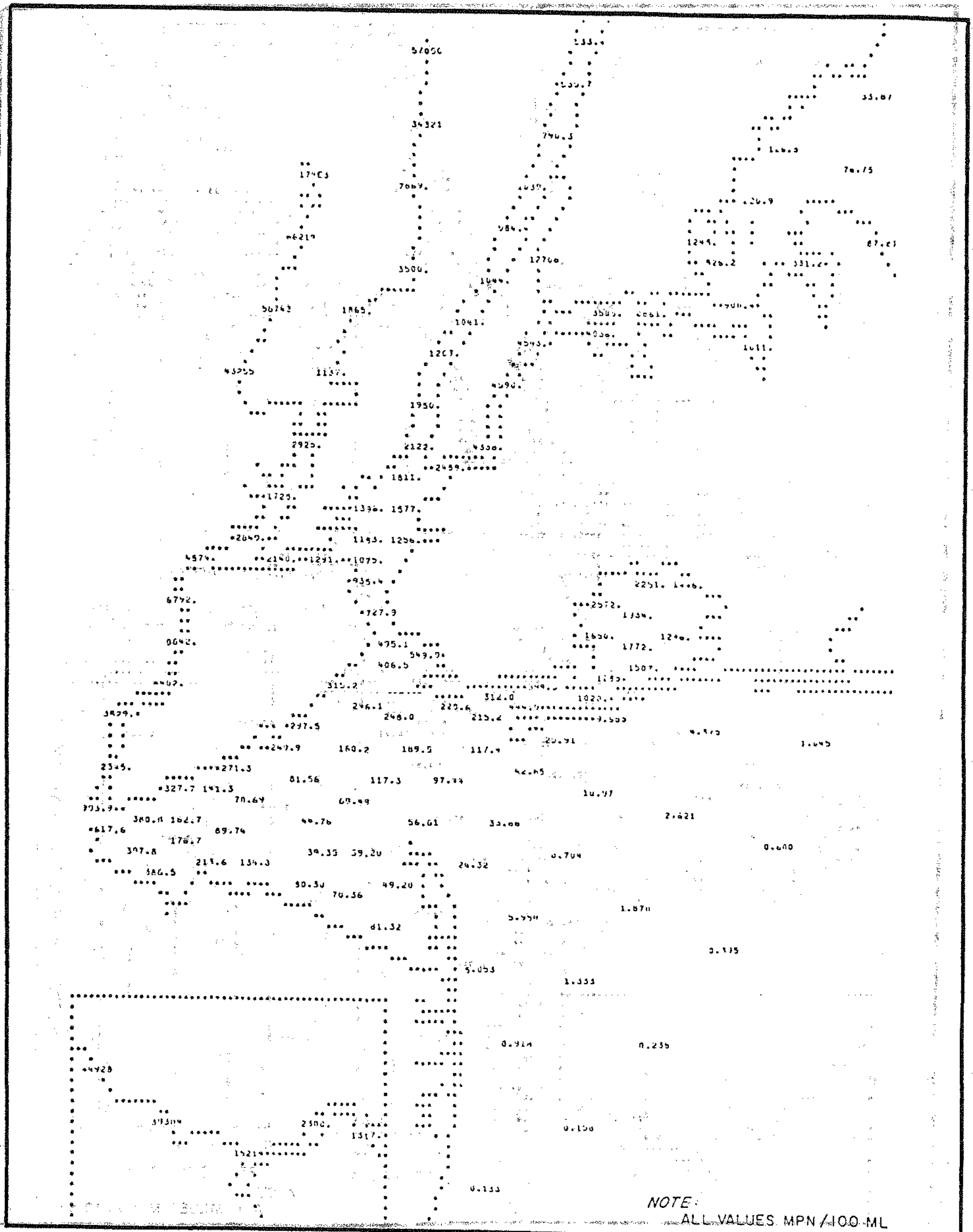


FIGURE VI-13
PREDICTED MEDIAN TOTAL COLIFORM BACTERIA CONCENTRATIONS
SECONDARY TREATMENT ALTERNATIVE

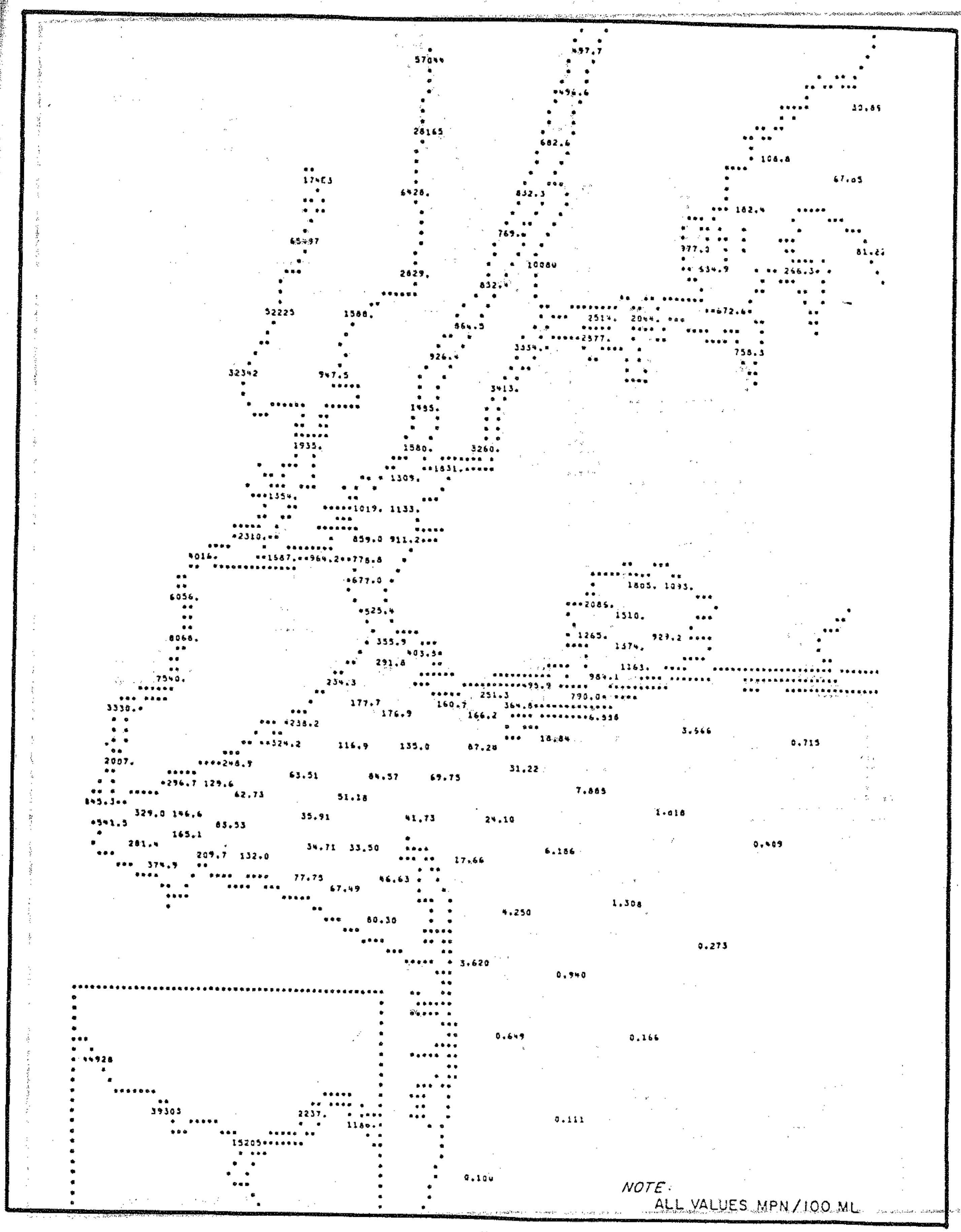


FIGURE VI-14
PREDICTED MEDIAN TOTAL COLIFORM BACTERIA CONCENTRATIONS
SECONDARY TREATMENT + 50 PERCENT CSO
TREATMENT ALTERNATIVE

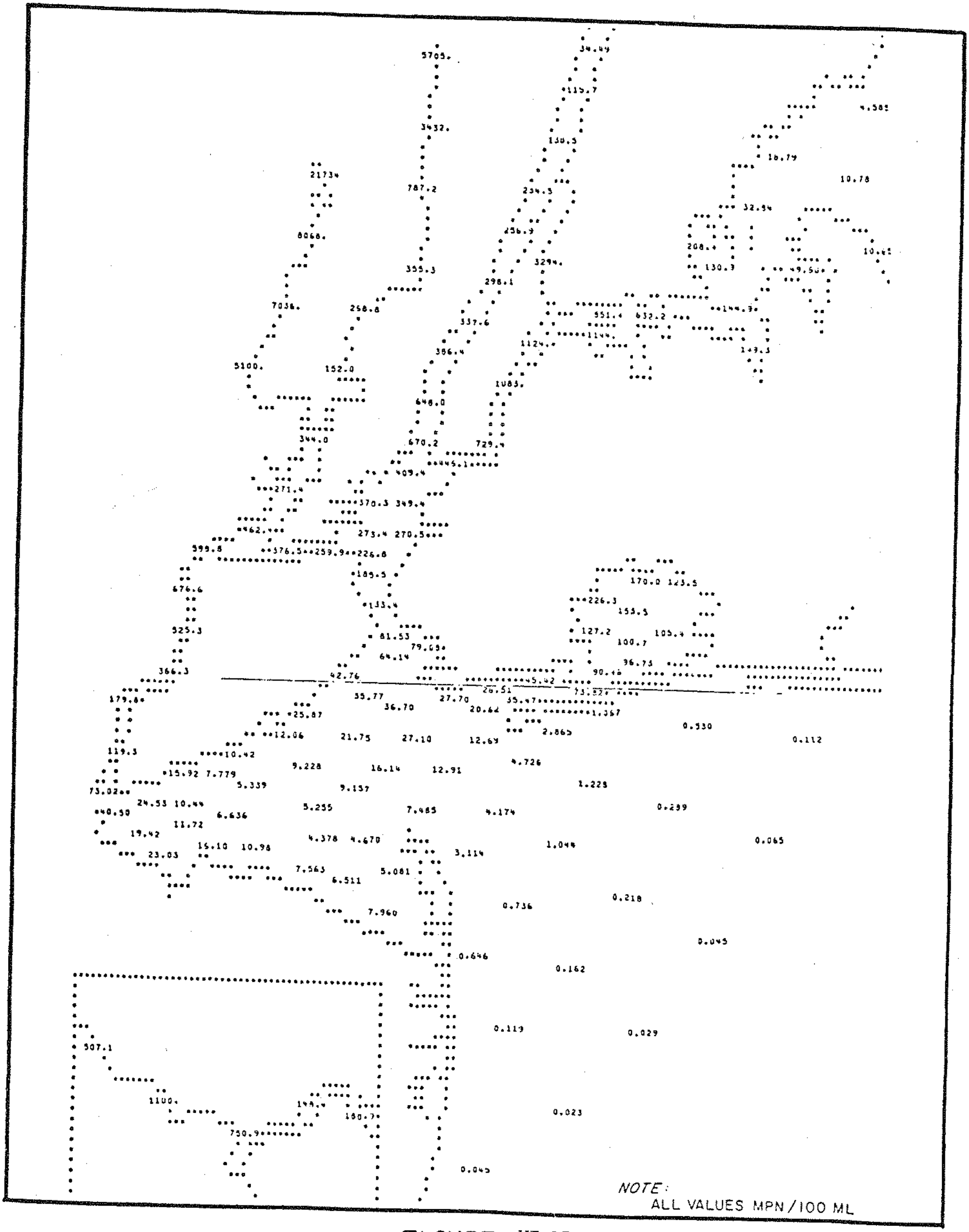
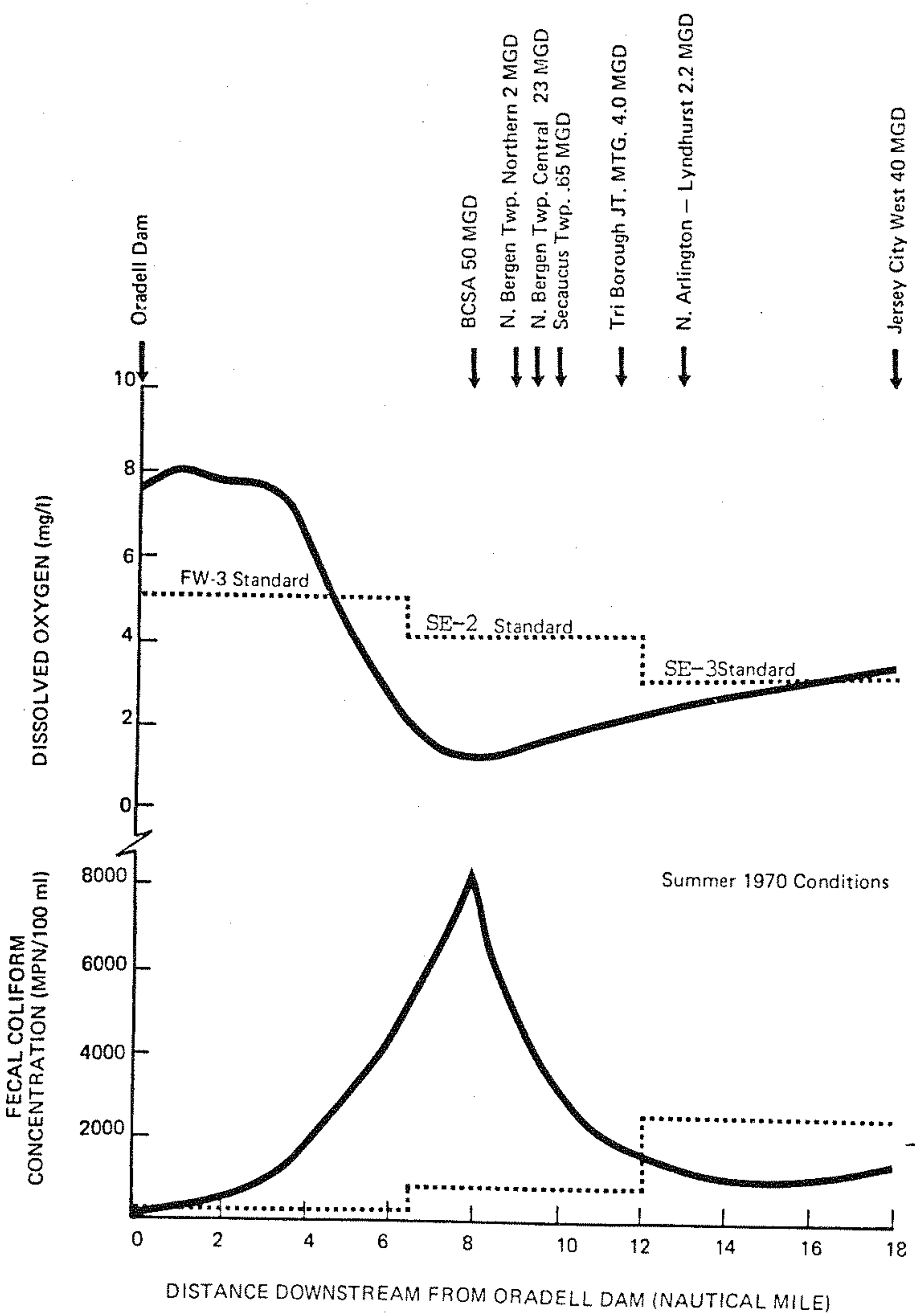


FIGURE VI-15
PREDICTED MEDIAN TOTAL COLIFORM BACTERIA CONCENTRATIONS
ZERO DISCHARGE ALTERNATIVE

Figure VI-16

1970 DISSOLVED OXYGEN AND FECAL COLIFORM CONDITIONS
HACKENSACK RIVER



Source: Teledyne 1973

Figure VI-17

DISSOLVED OXYGEN DEFICIT COMPONENTS – HACKENSACK RIVER (1970)

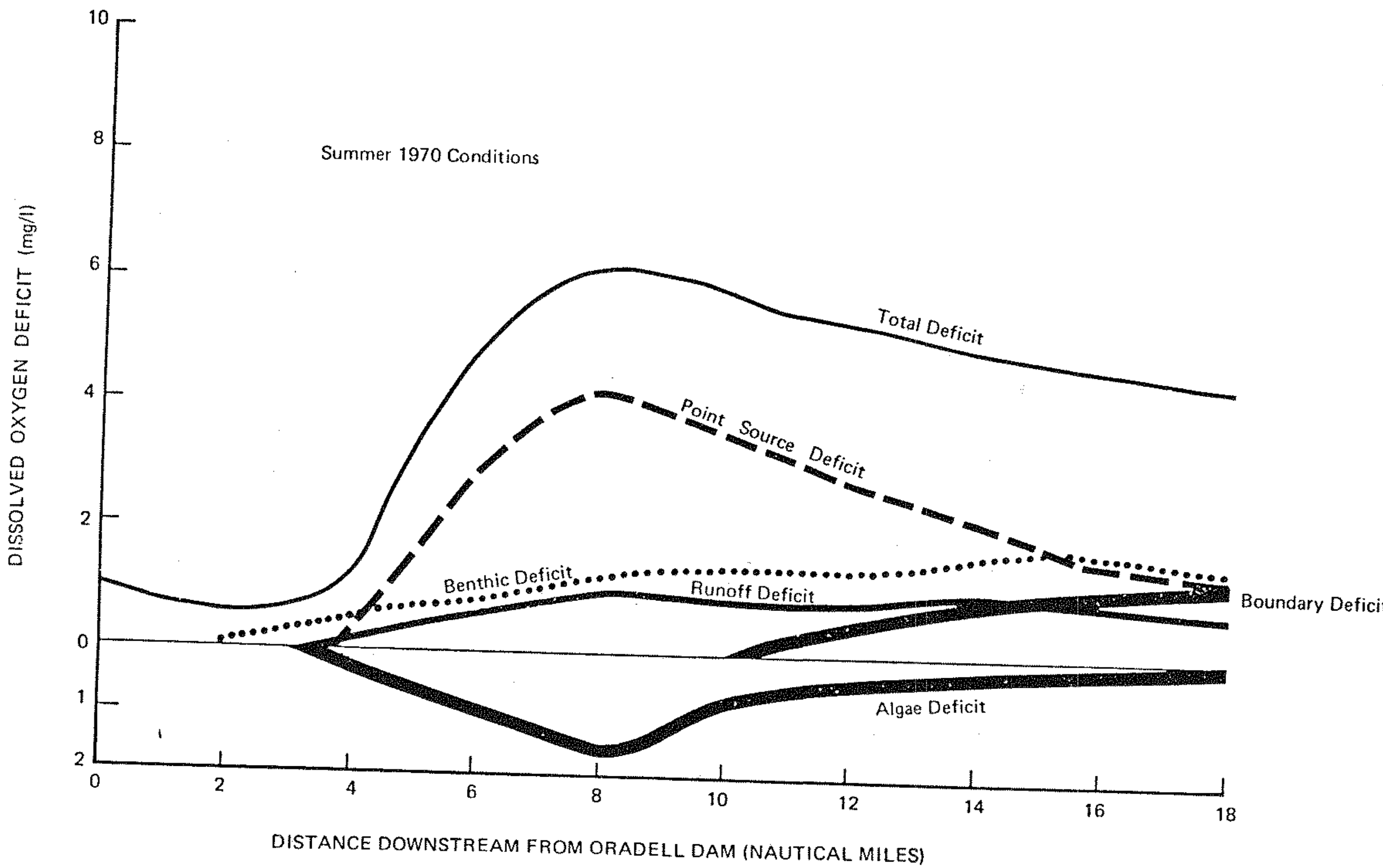
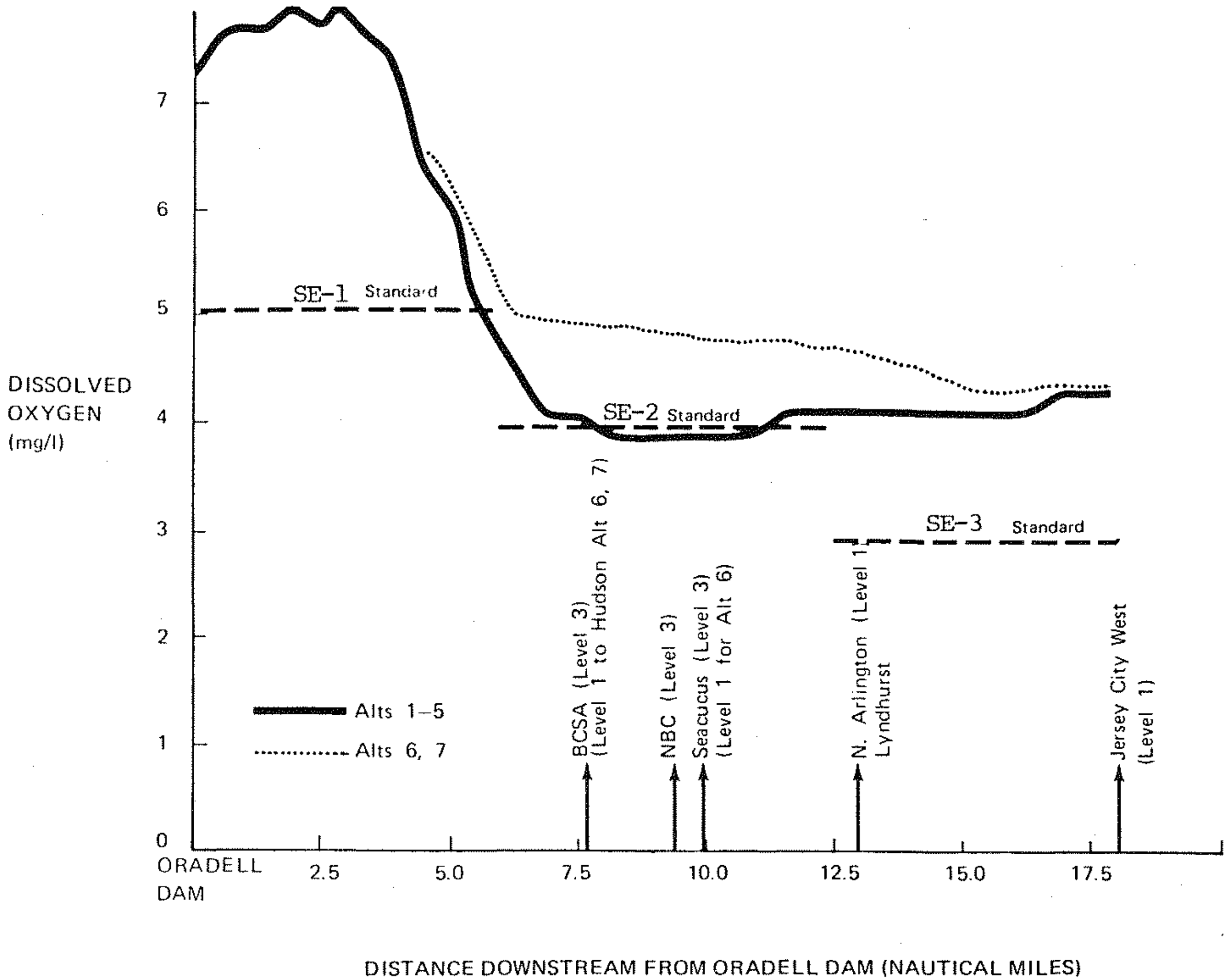


Figure VI-18

PROJECTED DISSOLVED OXYGEN PROFILE FOR BERGEN COUNTY ALTERNATIVES
MA7CD10 FLOW



DISSOLVED OXYGEN IN HACKENSACK RIVER (SEG. 75)
VERSUS COST OF UPGRADING TREATMENT PLANT

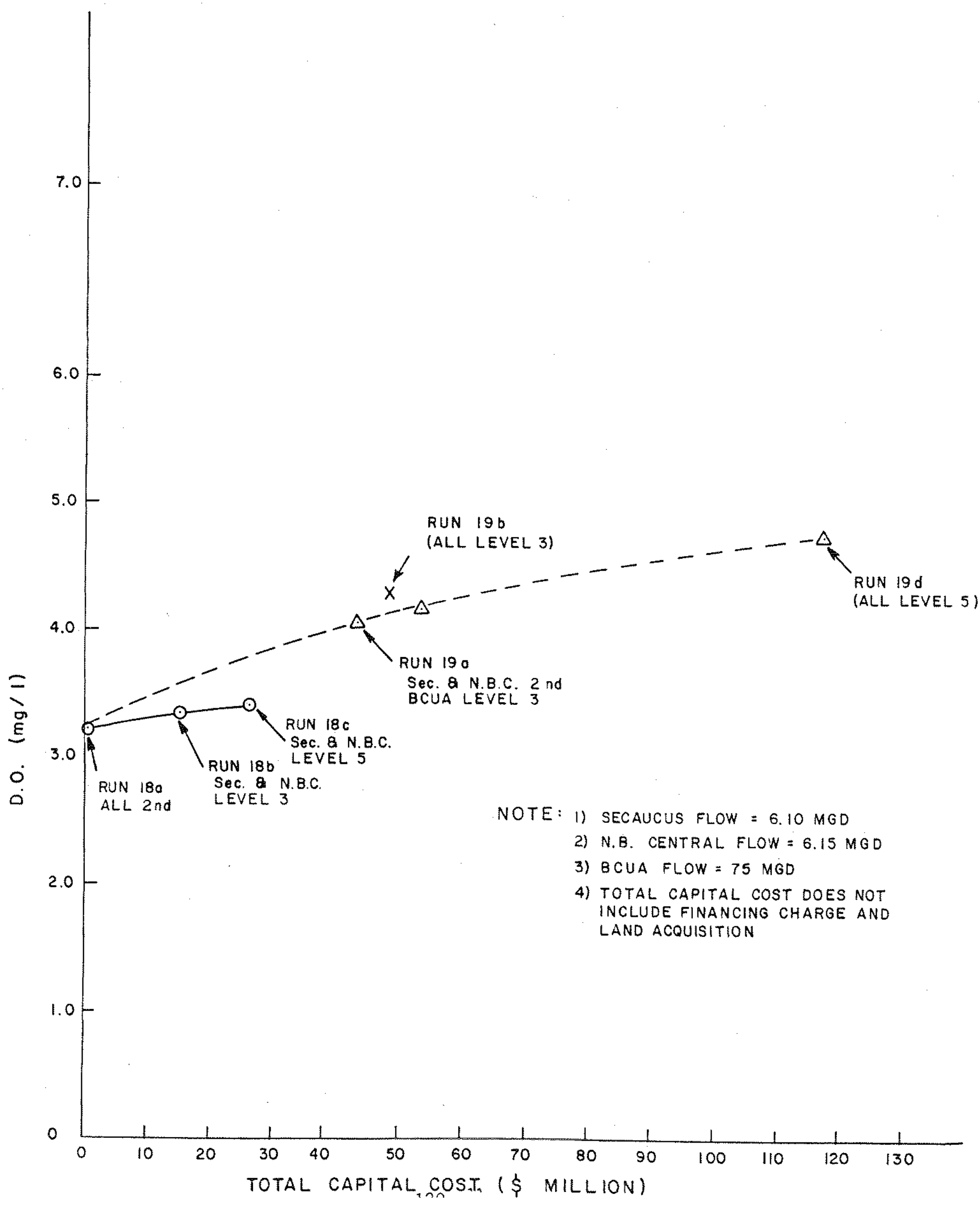
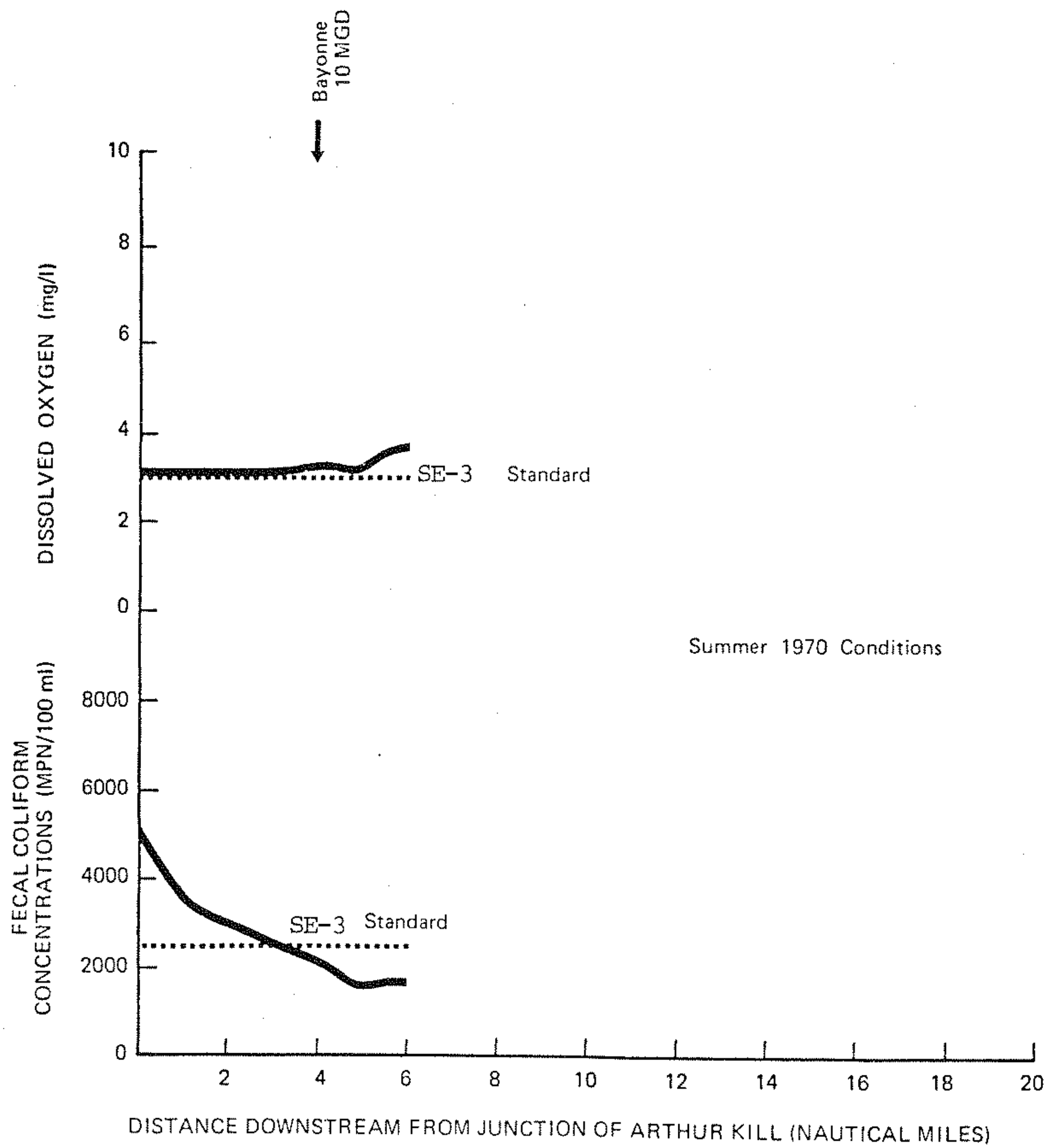


Figure VI-20

1970 DISSOLVED OXYGEN AND FECAL COLIFORM CONDITIONS
KILL VAN KULL



Source: Teledyne, 1973

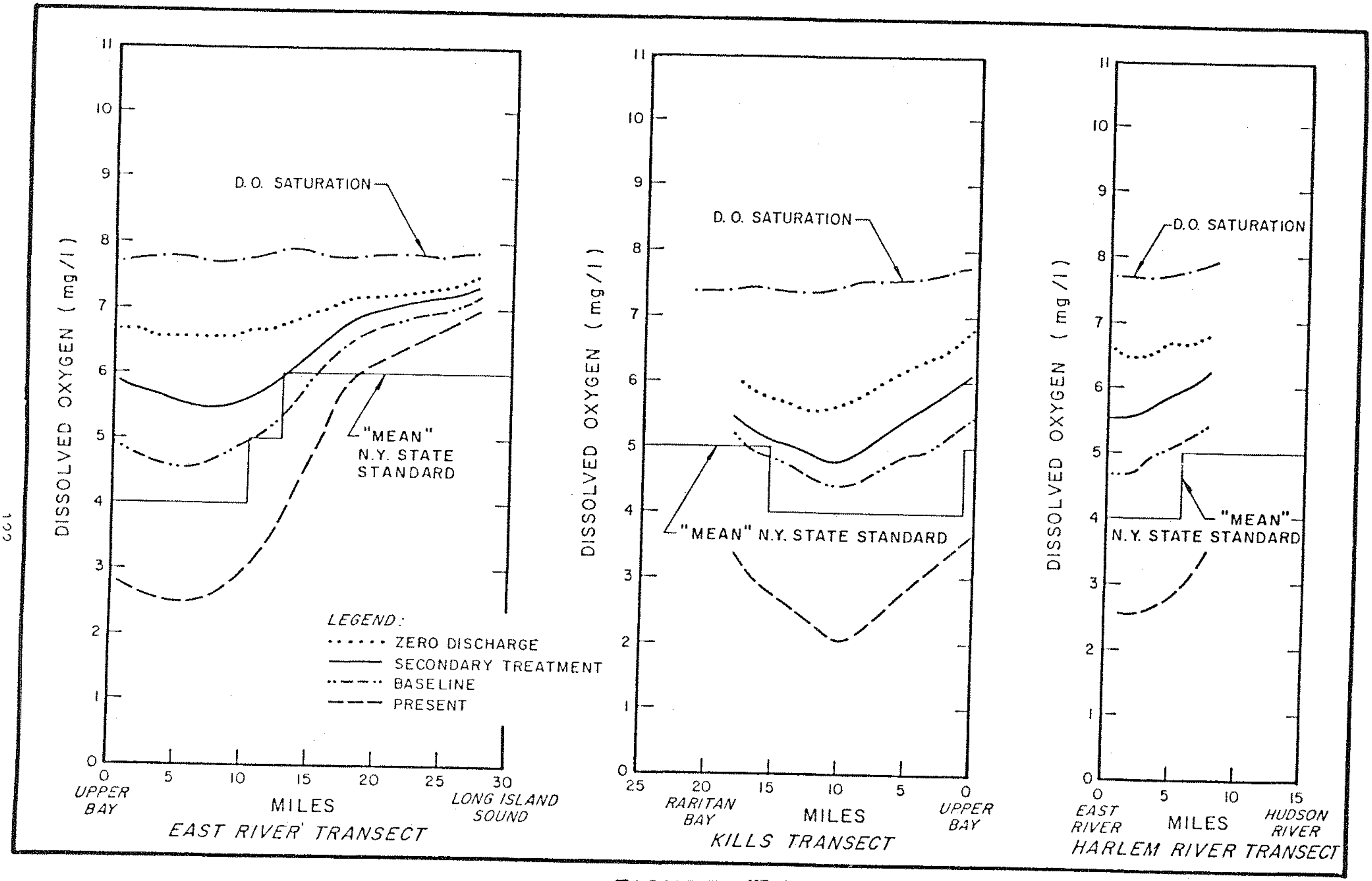
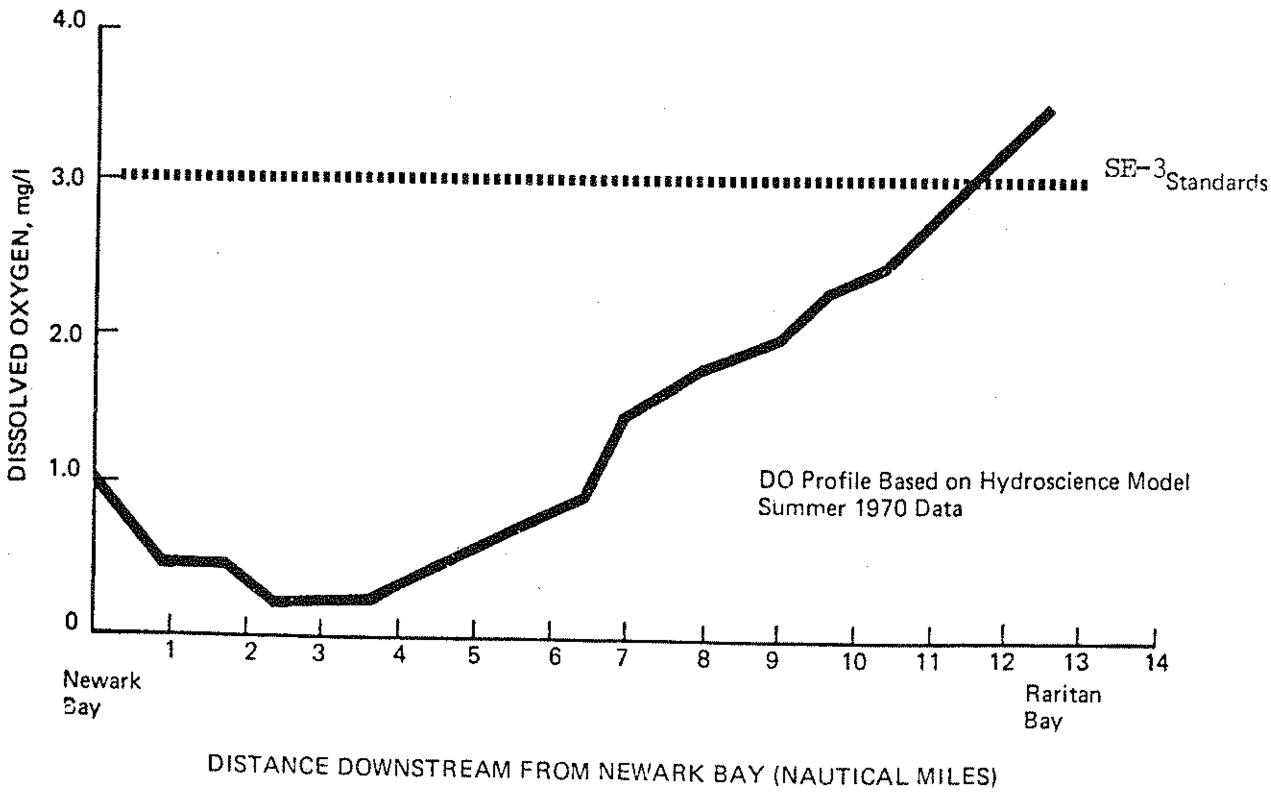


FIGURE VI-21

PREDICTED DISSOLVED OXYGEN CONCENTRATIONS
ZERO DISCHARGE ALTERNATIVE, SECONDARY TREATMENT ALTERNATIVE,
BASELINE CONDITION AND PRESENT CONDITION

Figure VI-22

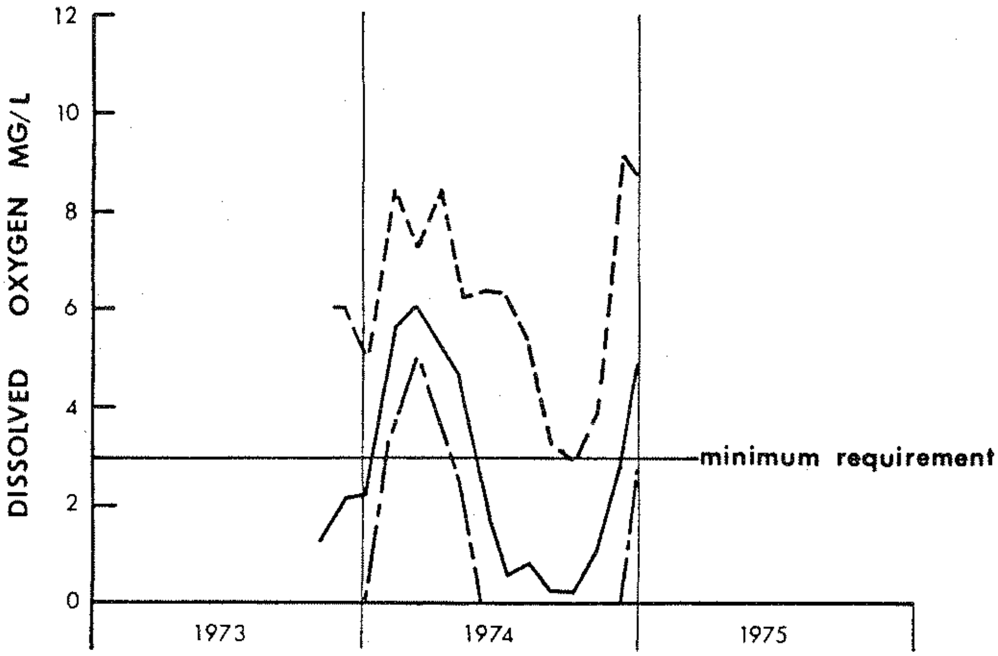
DISSOLVED OXYGEN PROFILE, ARTHUR KILL (1970)



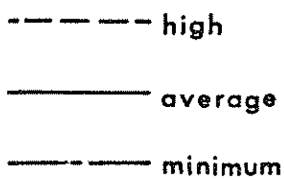
Source: Hydroscience, 1975

Fig. VI-23

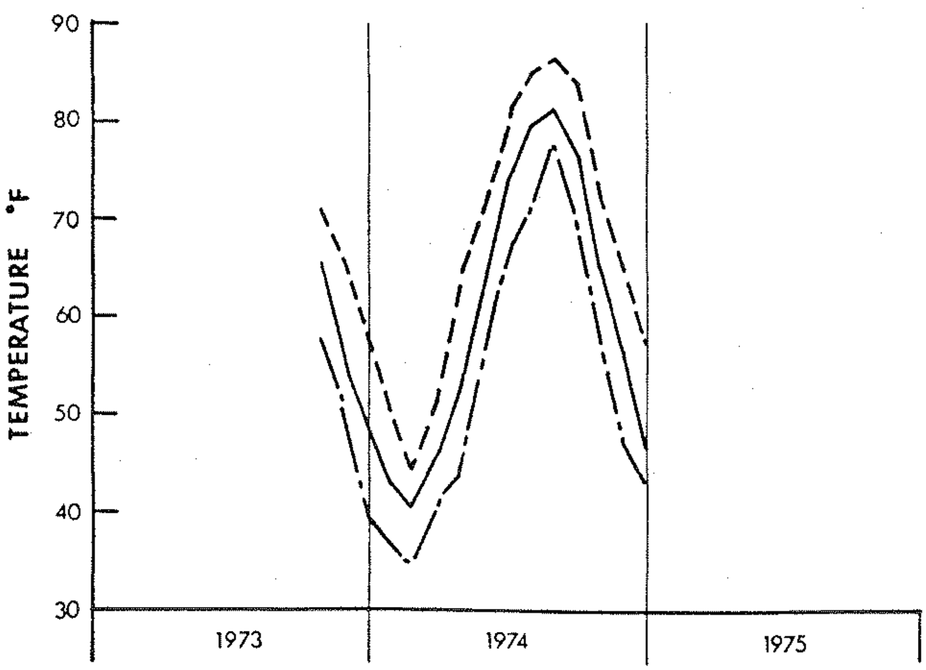
DISSOLVED OXYGEN PROFILE FOR ARTHUR KILL



Source: N. J. 305 (b) Report, 1975



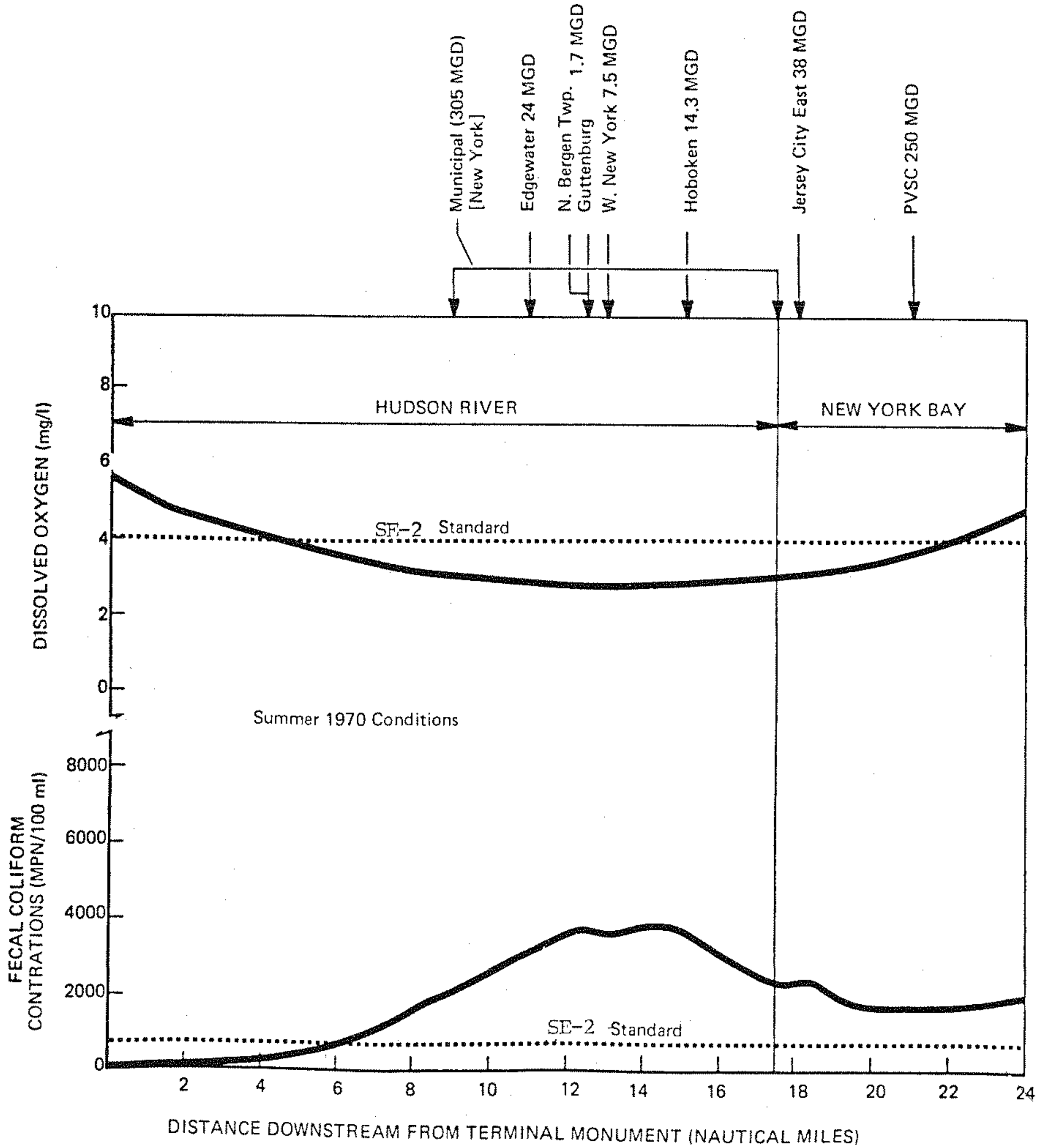
TEMPERATURE PROFILE FOR ARTHUR KILL



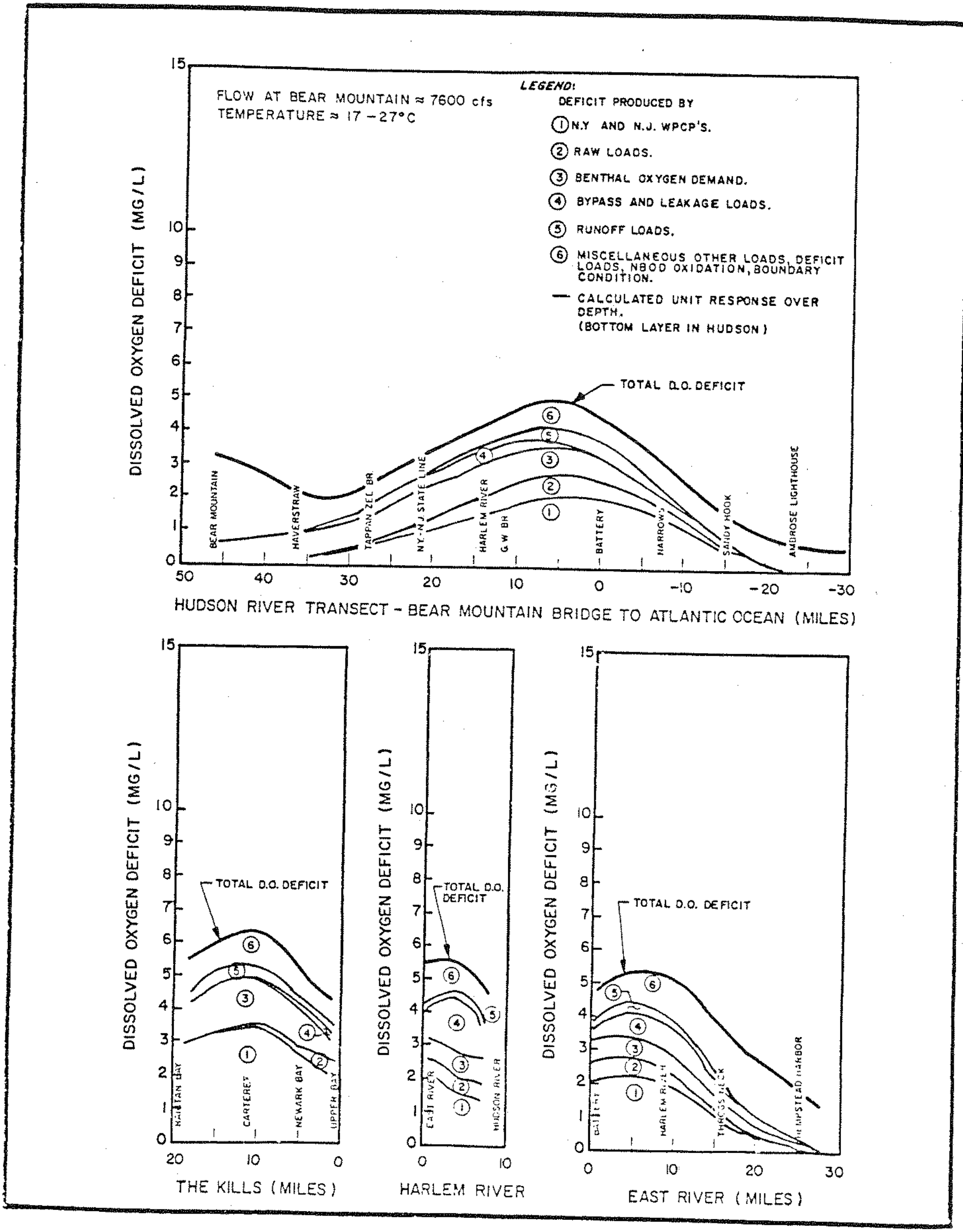
Source : N. J. 305 (b) Report, 1975

Figure VI-24

1970 DISSOLVED OXYGEN AND FECAL COLIFORM CONDITIONS HUDSON RIVER/NEW YORK BAY



Source: Teledyne, 1973



UNIT DEFICIT RESPONSE BY SOURCE

FIGURE VI-25

VII. Cost Estimates

A. Costs for Point Source and CSO Controls

1. Regional Waters

The New York City 208 Study regional analysis of several alternatives for water quality projection showed that only the zero discharge alternative would meet the regionwide water quality goals of fishable/swimmable waters. The zero discharge plan is interpreted to mean no discharge of pollutants beyond the level that would normally exist in the receiving waters. The plan would include secondary treatment at all WPCP's followed by tertiary or advanced waste treatment including reverse osmosis. In addition, 90% of the CSOs would be captured and treated, and the dry weather leakage at regulators would be substantially stopped. In fact, the zero discharge alternative, requiring advanced wastewater treatment for all WPCP's, would only further enhance the instream DO concentration, but not significantely reduce the coliform bacteria level in the receiving waters. The abatement of CSOs and urban runoff is the crucial factor to meeting swimmable water quality, after secondary treatment of dry weather flow.

The NYC 208 Study estimated that it would cost 3.5 billion dollars (based on the 1975 dollar value) to capture 90% of regionwide CSO in the in-line and off-line storage system. When calculated out to current costs, due to inflation, the 3.5 billion dollars would amount to approximately 7 billion. This amount is considered too large to be socially acceptable, especially in light of todays budgetary constraints at all levels of government.

In addition to being socio-economically unacceptable, the technical feasibility of the zero discharge alternative is also questionable. Although some portion of the 90% of the combined sewer overflows proposed to be controlled, will be captured using available in line storage, most will have to be stored underground. This would be highly impractical in an area such as New York City, which already has extensive tunnelling for subway systems. In addition, if additional tunneling were feasible, the social disruption due to construction activity would not be acceptable.

Therefore, since the SE1 (fishable-swimmable goal) is considered unattainable for the majority of the 208 study area at this time, the decisions regarding upgrading, as they relate to New Jersey waters, will be detailed in the following section.

2. New Jersey Waters

The overall cost of upgrading New Jersey sewage treatment plants in the study area, from primary to secondary, is $706,442,000 (see Table VI-10). The total cost of 90% CSO capture in the New Jersey study area (excluding the Passaic and Hackensack Rivers and Newark Bay) was estimated as $360 million based on 1975 costs (NYC 208 Study). The updated cost would be about 700 million dollars, which is close to the total cost of upgrading the New Jersey sewage treatment plants from primary to secondary. This CSO control cost is considered to be socially unacceptable at the present time.

The cost effective analysis for point source control for the Hackensack River has been specifically demonstrated by the consultant (Lawler, Matusky Engineers). The cost of upgrading all facilities to level 3 would be approximately $53 million, and the DO level would be raised to approximately 4.2 mg/l (SE2). Upgrading all plants to level 5, close to the zero discharge level, would raise the DO concentration to approximately 4.7 mg/l and would cost about $117 million dollars for this small water body. Clearly, this is a very large expenditure for a relatively small improvement in water quality (see Figure VI-19).

For both the tidal Passaic and Newark Bay (Newark Bay is heavily influenced by the lower Passaic), the critical factor for the attainment of higher uses will be the the control of urban runoff (including CSO) and benthic pollution, which constitute more than 60% of the BOD loads. As of this time, no such control programs are in the planning process. If implemented, these control measures will improve the DO levels in the tidal Passaic by about 3 mg/l. Further control of upstream point and nonpoint sources and other undefined diffuse (ditches, etc.) sources, will add another 1 mg/l to the DO resources of the lower Passaic(19).

Apparently, there appears to be a potential for substantial improvements. But the vital question is whether these non-point source controls are technically and economically feasible. Total control of urban run-off as described in Chapter VI, may be impractical. A determination of the effectiveness and the feasibility of such programs, can only be made after detailed studies, exploring engineering as well as socio-economic aspects, have been conducted. A preliminary CSO study (3a) for the PVSC (Passaic Valley Sewerage Commissioners) district, has recently (1983) been completed. According to this report CSOs have minimal effects on the DO resources of the lower Passaic River and that they constitute only a minor part of the total NPS pollution which mainly consists of storm runoff and benthic deposits. It has been recommended in that report that any program to clean up the lower Passaic, would need to include possible dredging of the benthal deposits, control of the storm water and the removal of floatable materials. Best Management Practices (BMPs) were also shown to exihibit realistic potential in the mitigation of urban pollution. The report also concluded that insufficient storage capacity, in-line and off-line, is available in the urban area for the capture of the CSOs. One possibility, as discussed in this report, was the storage and eventual treatment of the CSO discharges within deep rock tunnels, located far below the existing surface. Although very expensive, this alternative was found to be capable of eliminating or substantially reducing the CSO loadings during severe storms. Estimated costs for the regional capacity for CSOs only (excluding storm runoff) range from 350 to 450 million dollars (ENR = 4100). A newer, perhaps less costly method of large volume storage would be satellite storage facilities, but would require detailed site-specific evaluations. It, therefore, appears that storage and treatment of CSOs alone may cost over 500 million dollars. If storm water (uncombined), the major source of BOD loading, is also included in the control program, the costs may exceed one billion dollars. Similarly, the removal of benthic deposits will also be extremely expensive. Presently, no cost analysis and technical feasibility for the removal of benthal pollution are available. It is, therefore, obvious that detailed technical investigations, including cost-benifit analyses, will have to be conducted, before any concrete steps can be taken to improve the water quality in the lower Passaic and Newark Bay.

In the meantime, being least expensive, Best Management Practices (BMP) and non-structural controls should be encouraged, to improve the water quality in the lower Passaic watershed. These measures will alleviate urban pollution but in themselves will be insufficient to improve the water quality to the extent to meet the standards for higher uses. Street sweeping is already practiced, though not optimally, by most communities in the metropolitan area. Further BMP controls, such as sewer and catch basin cleaning, etc., will be helpful in mitigating the acute water quality problems in the tidal Passaic.

B. Nonpoint/Other Pollution Source Controls - Efficiency and Costs

Nonpoint pollution sources can be major contributors to pollutant loads in receiving waters. Oxygen-demanding wastes and bacteria, as well as other pollutants, are contributed from both stormwater runoff and through combined sewer overflows. Runoff itself contributes both BOD and bacteria, as well as other pollutants, washed from the streets and buildings in the urban areas. The runoff flows also cause discharges from the CSO regulators, which include untreated, diluted wastewater, containing BOD and very high levels of bacteria.

Because most of the runoff from the study area is discharged through CSOs, control of CSOs would provide the most significant reductions in nonpoint pollution to the receiving waters. Table VI-11, shows the costs of providing an 80% reduction in discharge from certain CSOs in the study area.

The costs of providing other nonpoint source controls are more difficult to quantify, because the type of control needed depends on local conditions and, often, on the availability and cost of land. The effectiveness of nonpoint source controls varies as well. The following discussion summarizes information available on some popular methods of nonpoint source controls for urban runoff.

1. Street Sweeping

a. Description

Street sweeping can reduce the amount of pollutants that accumulate on a street or parking area surface between storm events, which is assumed to reduce the pollutant load that is washed off by runoff. Estimates of the actual efficiency of street sweeping in reducing pollutant loadings, vary significantly. The recent EPA National Urban Runoff Program (NURP)(4) studied actual end-of-pipe concentrations of pollutants, under swept and unswept conditions. Their conclusions were that: "Benefits of street sweeping (if any) are masked by the large variability of the EMCs (event mean concentrations), therefore, the benefit is certainly not large (e.g. less than 50 percent), and an even larger site data base is required to further identify the possible effect." (4). The report also concludes, however, that street cleaning may be useful in some cases, particularly in "urban neighborhoods where the general level of cleanliness could be significantly improved"(4).

Other studies have focused on the reduction in pollutant loads on street and parking area surfaces and indicate that significant load reductions can be achieved depending on sweeper type. Daily efficiencies, of broom-type sweepers are: solids 87%, BOD_5 20%, nitrogen 10-25% and phosphorus 2-30%. For broom and vacuum cleaning (advanced sweeping) approximate efficiencies are: solids (dry weight) 90%, BOD_5 60%, PO4-P 85% and heavy metals 85%[27].

b. Costs

The median capital costs of street sweeping varies, depending on area, from around $7/curb-mile in 1977 dollars[27]. Other estimates are $5.95 to $23.36 per curb-mile swept (4).

2. Detention Basins

a. Description

Detention basins generally are designed to limit the flow of water during runoff periods and discharge the water during later dry periods. However, there are a number of design alternatives which vary markedly in purpose, efficiency and cost.

1) Dry Basins

These basins are equipped with an outlet which limits outflow. Flows, in excess of the maximum allowable flow, back up in the basin temporarily. Pollutant reduction efficiency is insignificant to poor.

2) Wet Basins

This section describes a variety of types of basin, which maintain a permanent pool of water. Runoff from a storm displaces all or part of the previous water. Such basins are capable of very effective pollutant reduction, although the design of an individual basin can result in actual efficiencies that range from poor to excellent.

Table VII-1 shows observed performance of "wet" detention basin at selected NURP sites. Basin size is the primary indicator of performance, as given by the table. The largest basins (those with the lowest overflow rates and largest volume ratios) have a higher removal efficiency than the smaller basins. The smallest basin retains less than 5 percent of the mean storm runoff volume after the storm event, while the larger basins are of such volume that the mean storm displaces only about 10 percent of the available volume. Thus, since settling is the primary mechanism for removing pollutants in these basins, the smaller ones allow little time for pollutant removal (4).

Little data are available on the efficiency of removal of coliform bacteria. Data collected, as part of the NURP Study at the Unqua site on Long Island, for 8 storms which varied in size, showed total coliform concentration reduced by 94 percent, fecal coliform by 91 percent and fecal streptococcus by 95 percent. Thus, wet basins may be quite efficient in removal of indicator bacteria (4).

b. Costs

The costs of providing detention basins for urban runoff controls are very difficult to quantify because they depend so heavily on site-specific characteristics, including land acquisition costs. In addition, Figure VII-1 gives the costs of wet detention basins, varying with size of the basin, the area served, and the removal efficiency for TSS. This information is summarized in Table VII-2.

3. Recharge

a. Description

Increased infiltration of urban runoff reduces the amount of runoff reaching surface waters. Methods to increase infiltration or directly recharge runoff can result in effective reductions in urban runoff quantities and improvement in quality. However, further study is necessary to fully evaluate the potential for groundwater contamination. Also, suitable local conditions must exist to allow recharge. The existing development throughout most of the study area limits the ability to use such methods.

A wide variety of methods exist for recharge, ranging from large retention basins, capturing runoff from a wide area, to units serving individual developments, including infiltration trenches, percolating catch basins, and porous pavement. The size of the device and the premeability of the soil determines how much runoff can be percolated and not reach surface waters.

An example of removal efficiency of recharge devices is shown in Figure VII-2. This figure, from NURP data, is based on precepitation in the Great Lakes, which is roughly comparable to conditions in the Northeast. Clearly, basin size and soil permeability determine effectiveness (4).

b. Costs

Cost data is limited and, of course, depends on the site selected. An example is that of recharge basins in Fresno, California, where installed capital costs were $933,750 to $5,587,000. Annual operating costs ranged from $1,625 to $7,975 (4).

C. Conclusions

The greatest reductions in coliform and oxygen-demanding loadings to local receiving waters would be achieved by reduction in CSOs. The total costs of all CSO projects suggested for the area, are anticipated to be in excess of 7 billion dollars (90% CSO capture).

It is nearly impossible to quantify the costs of further reductions in urban runoff loads, in the study area, by other nonpoint source controls. Land area is scarce and expensive for large-scale wet basins or recharge devices, which are the most effective methods. Street-sweeping is already in place in some areas, and the data provided by NURP indicates that large-scale improvements in runoff quality would not be expected through an improvement in, or expansion of, street sweeping.

Table VII-1

COMPARISON OF MASS REMOVALS AT VARIOUS NURP PROJECTS

Project and Site	# of Storms	Size Ratios: Overflow Rate*	Size Ratios: Volume Ratio**	AVERAGE MASS REMOVALS All Monitored Storms (Percent): TSS	BOD	COD	TP	TKN	T.Cu	T.Pb	T.Zn
Lansing Mich.											
Grace St N	18	8.75	0.05	(-)	14	(-)	(-)	(-)	(-)	9	(-)
Grace St S	18	2.37	0.17	32	3	(-)	12	7	(-)	26	(-)
Ann Arbor Mich											
Pitt-AA	6	1.86	0.52	32	21	23	18	14	.	62	13
Traver	5	0.30	1.16	5	(-)	15	34	20	.	.	5
Swift Run	5	0.20	1.02	85	4	2	3	19	.	82	(-)
Long Island NY											
Unqua	8	0.08	3.07	60	(TOC=7)		45	(-)	.	80	.
Washington DC											
Westleigh	32	0.05	5.31	81	.	35	54	27	.	.	26
Lansing											
Waverly Hills	29	0.04	7.57	91	69	69	79	60	57	95	71
NIPC											
Lk. Ellyn	23	0.10	10.70	84	.	.	34	.	71	78	71

Note:

* Overflow rate = (mean runoff rate)/(basin surface area)

** Volume ratio = (basin volume)/(mean runoff volume)

(-)= Indicates negative removal

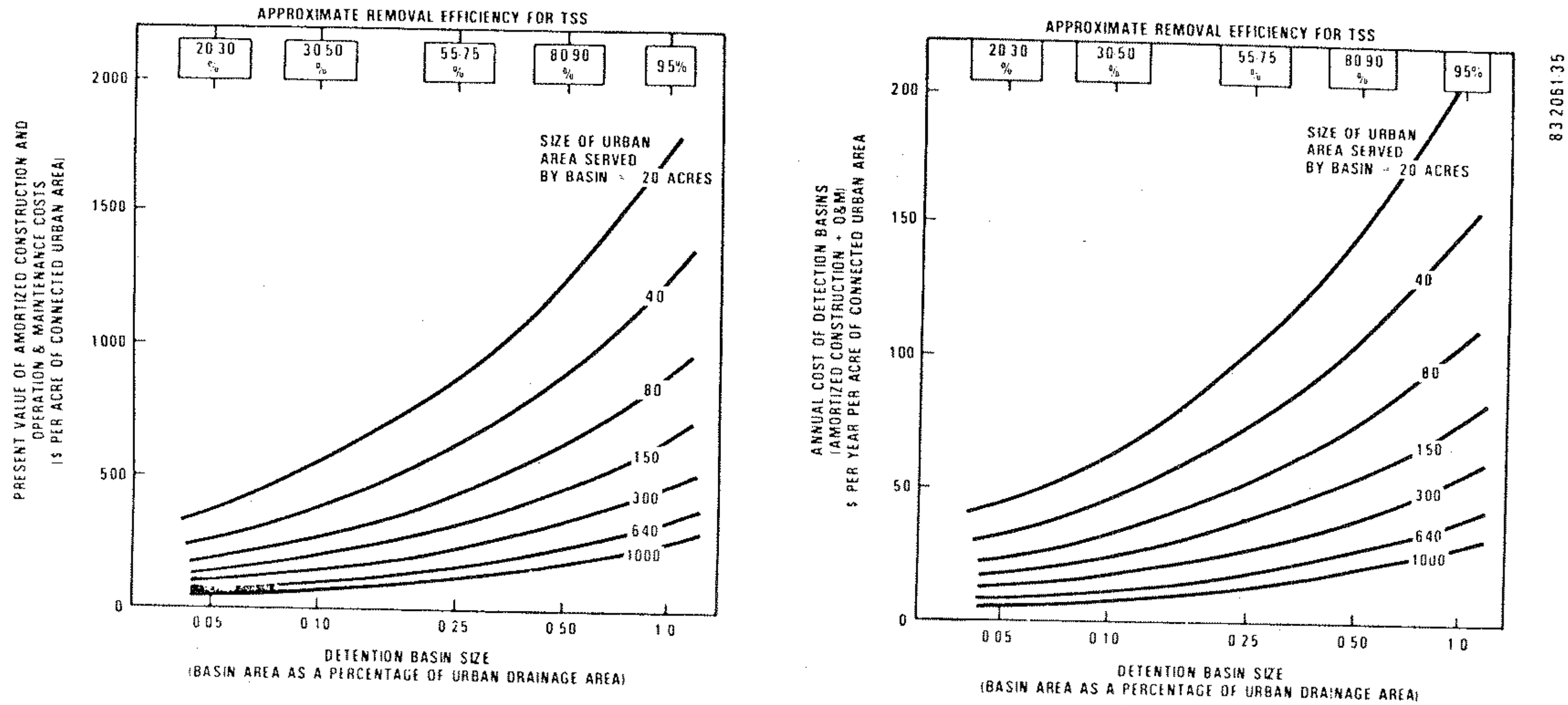
. = Indicates pollutant was not monitored

Source: EPA, 1983

Table VII-2

Summary of Wet Detention Basin Costs

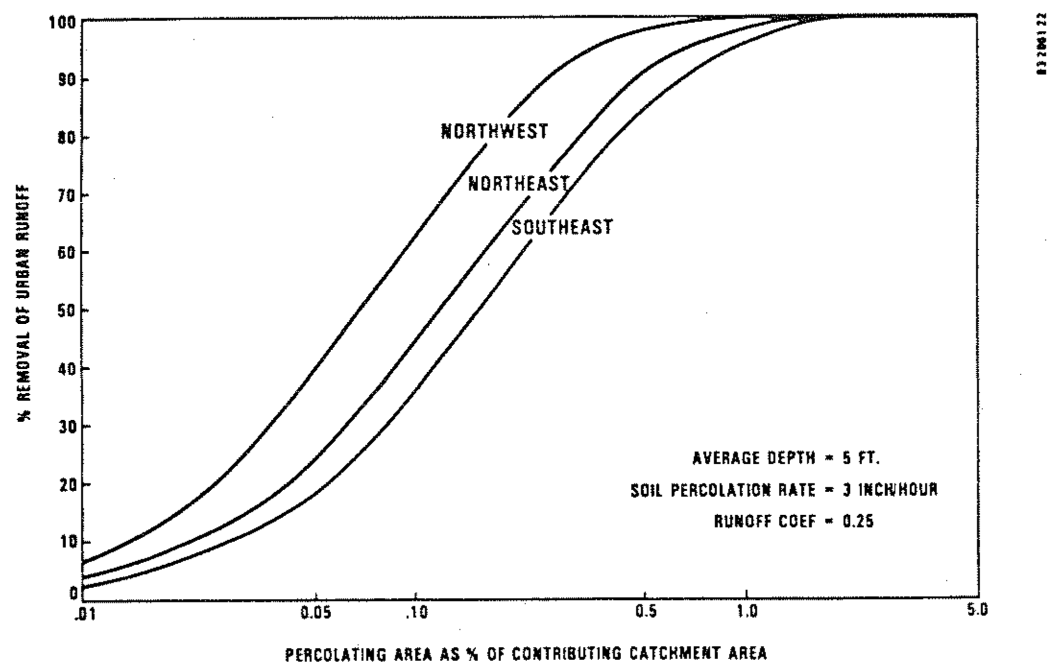
Area Served	Approximate Level of Control (% TSS Reduction)	Cost per Acre of Urban Area (Approximate) Present Value	Annual Cost
20-40 ac	50	$500-700	$ 60-80
	90	$1000-1500	$125-175
640-1000 ac	50	$100	$10
	90	$250	$25

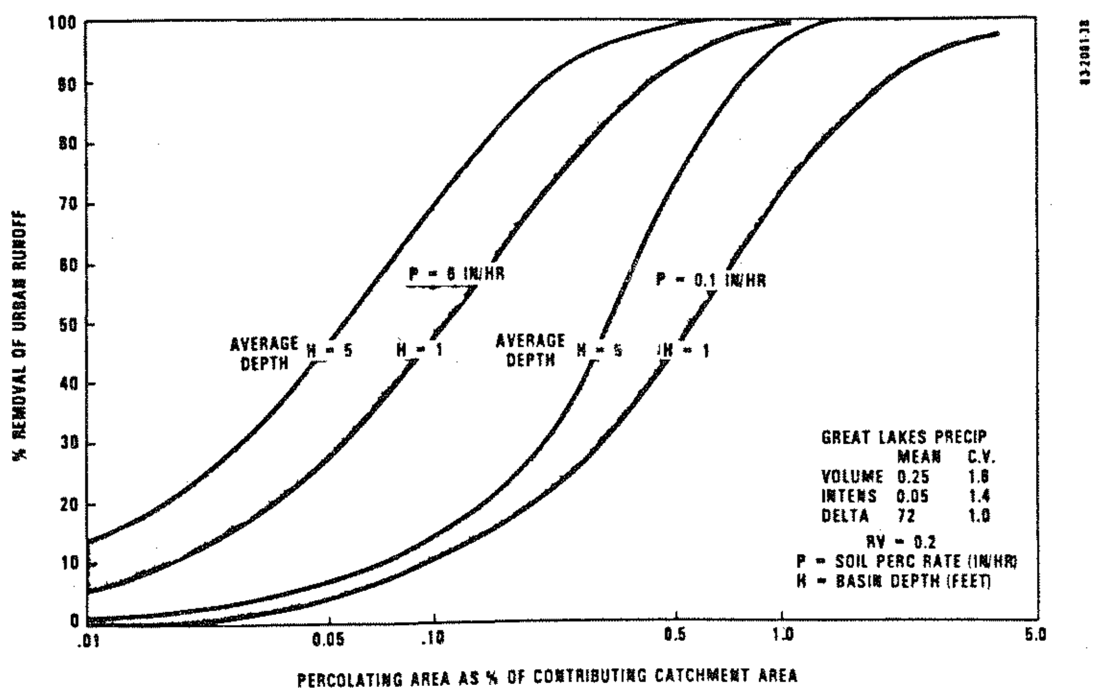


BASIS WET BASINS-CONSTRUCTION COSTS 40% GREATER THAN FIGURE 8 2
ANNUAL O&M COST 5% OF BASE CONSTRUCTION COST
BASIN AVG DEPTH 3 5 FEET
INTEREST RATE 10%
BASIN LIFE 20 YEARS

Source: EPA, 1983

Figure VII-1 Cost of Urban Runoff Control Using Wet Detention Basins





Source: EPA, 1983

Figure VII-2 Long Term Average Performance of Recharge Devices

VIII. Recommendations for Future Action

The current water quality standards classifications are shown in Figure VIII-1. Based upon this study, the following waters are recommended for upgrading:

1. The Hackensack River (from the Route 1 and 9 crossing to Berry's Creek) from SE3 to SE2.

2. The Hudson River (from the Harlem River confluence to the N.J. - N.Y. border) from SE2 to SE1.

These proposed changes are shown in Figure VIII-2.

It is further recommended that the following programs and studies be instituted or continued:

1. On-going studies to determine the extent of water quality improvements resulting from low cost and technically feasible programs, such as regulator leakage correction, and non-structural controls, such as street sweepings, etc.

2. Enhancement of the Harbor Complex monitoring network, tailored to determine the water quality improvements resulting from the anticipated upgrading of public wastewater plants.

3. Consideration of area-wide and site-specific studies and/or corrective actions to restore the intended uses, such as shellfishing, bathing, etc.

4. Continuation of inter state cooperation in water quality improvement programs in the Harbor complex. Continuation of steering committee coordination in assessment of specific problems, such as upgrading of stream uses, if and when warranted.

5. Confirmation and implementation of ongoing and required efforts, such as New York City regultor leakage control. New Jersey - City wide abatement studies and New Jersey CSO abatement studies.

6. Implementation of the permits program.

Figure VIII-1

EXISTING CONDITIONS

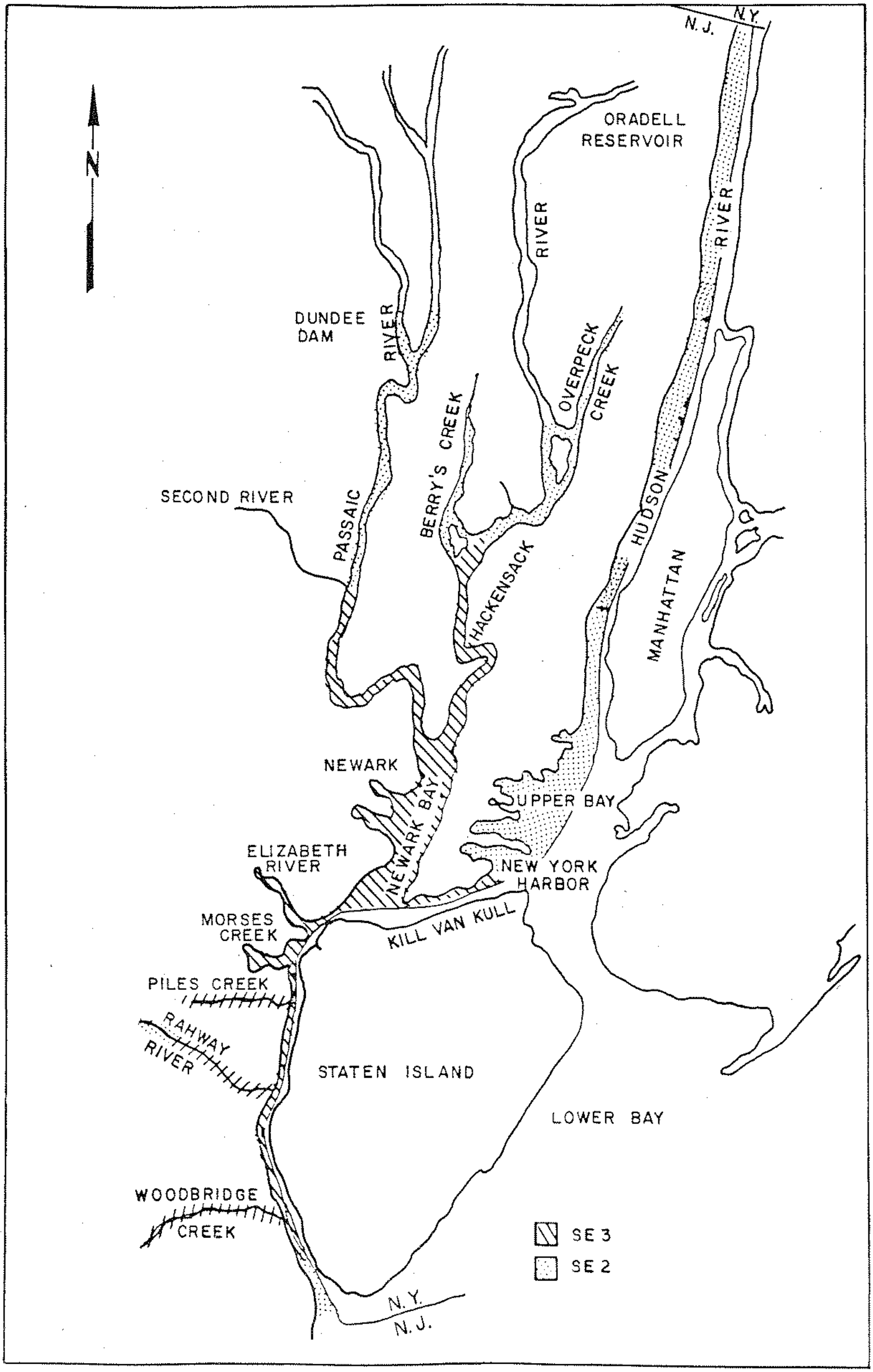
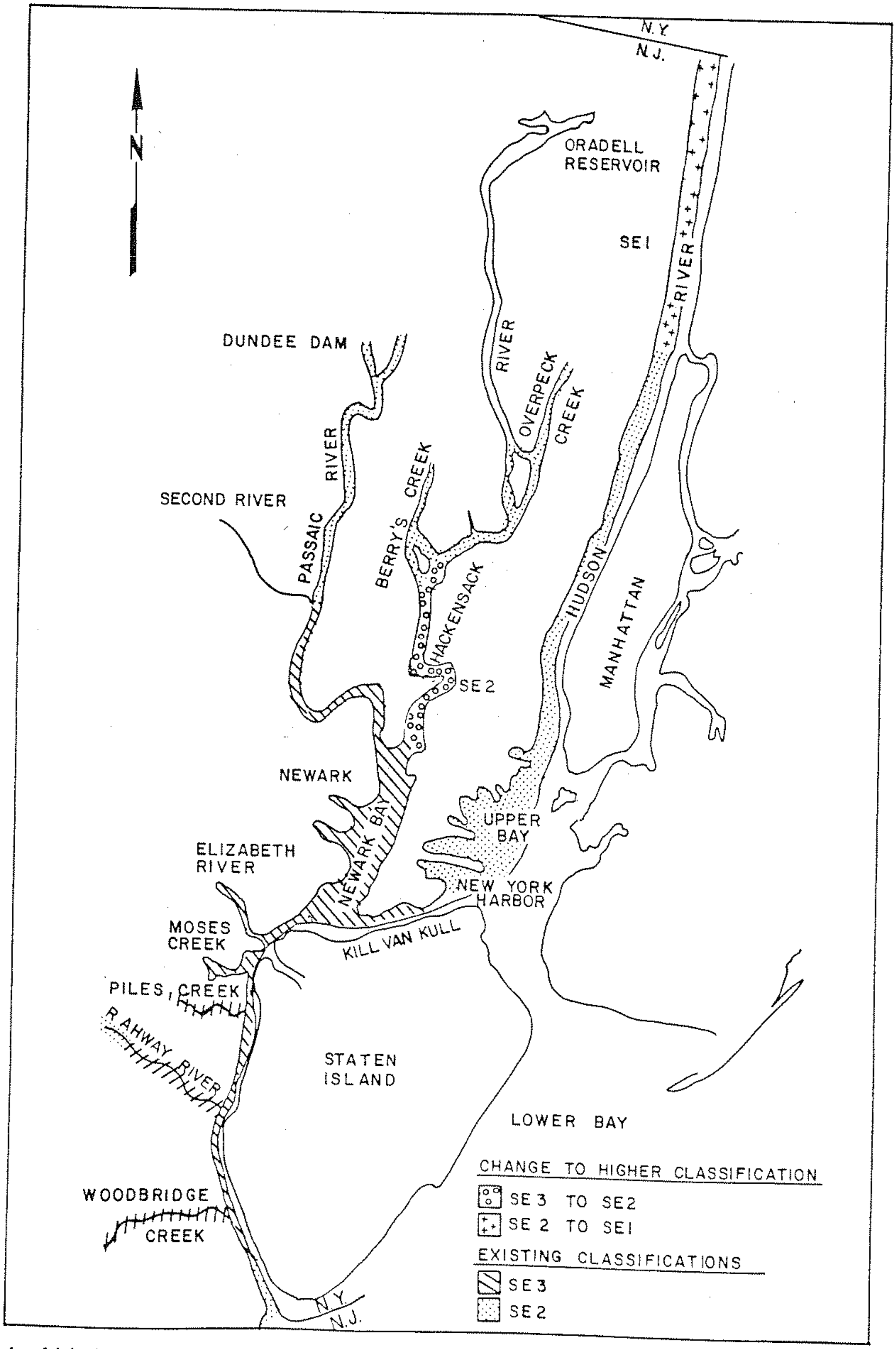


Figure VIII-2



1. ALL PLANTS AT SECONDARY LEVEL
2. BERGEN COUNTY UTILITIES AUTHORITY'S (BLUA) FACILITY AT LEVEL 3 TREATMENT

BIBLIOGRAPHY

1. Clinton Bogert Associates, "Combined Sewer Overflow, Pollution Abatement Program, City of Elizabeth", August 1981.

2. Drehwing, F., et al., O'Brien & Gere Engineers, Inc., "Disinfection/ Treatment of Combined Sewer Overflows, Syracuse, New York", EPA-600/2-79-134.

3. Elston T. Killam Associates, Inc., "Overflow Analysis to Passaic Valley Sewerage Commissioners, Passaic River Overflows", 1976.

3a. Elson T. Killam Associates, Inc., "Passaic Valley Sewerage Commissioners Combined Sewer Overflow Facility Plan", 1983.

4. Environmental Protection Agency, Water Planning Division, "Results of the Nationwide Urban Runoff Program", December 1983.

5. H. Thomas Carr Associates, "City of Perth Amboy, Marine Combined Sewer Overflow Abatement Program", December 1984.

6. Havens and Emerson Inc., - Hazen and Sawyer in Association," 201 Wastewater Facilities Plan, Hudson County Utilities Authority", 1979.

7. Hazen and Sawyer Engineers, "Summary Report, City-Wide Regulator Improvement Program, Inventory and Assessment", April, 1985.

7a. Hsueh, Shing-Fu, Jenq, Tzay-Rong, "Impact of Sewage Bypass on Newark Bay," Assimilative Capacity of the Oceans for Man's Wastes, Taipei, April, 1982.

8. Interstate Sanitation Commission, "Annual Report of Interstate Sanitation Commission", 1975 to 1984.

9. Interstate Sanitation Commission, "Dissolved Oxygen Assimilative Capacity in the New York Harbor Complex", March 1983.

10. Jenq, Tzay-Rong, Christopher G. Uchrin, Marvin L. Granstrom and Shing-Fu Hsueh, "A Linear Program Model for Point-Nonpoint Source Control Decisions: Theoretical Development", Ecological Modeling, Elxivier Scientific Publishing Co., Amsterdam. 1983.

11. Jenq, Tzay-Rong, Marvin L. Granstorm, Shing-Fu Hsueh, and Christopher G. Uchrin, "A Phosphorus Management LP Model Case Study", Water Resources Bulletin, American Water Resources Association. August, 1984.

11a. Lawler, Mutusky & Skelly Engineers, "Hudson County Utility Authority, Updated 201 Wastewater Facilities Plan, Planning Area 1", 1985.

12. Mayer, M.A., Crane Co., "Microstraining and Disinfection of Combined Sewer Overflows - Phase III", EPA-670/2-74-049.

13. Mytelka, A.I., et al, Interstate Sanitation Commission, "Combined Sewer Overflow Study for the Hudson River Conference", EPA-R2-73-152.

14. Moffa, P.E., et al., "Bench - Scale High-Rate Disinfection of Combined Sewer Overflows with Chlorine and Chlorine Dioxide", EPA-670/2-75-021.

15. New Jersey Department of Environmental Protection, "Northeast New Jersey Water Quality Management Plan", April 1979.

16. New Jersey Department of Environmental Protection, DWR, "New Jersey Surface Water Quality Standards", October, 1984.

17. New Jersey Department of Environmental Protection, "1982 New Jersey State Water Quality Inventory Report, Section 305(n)", June 1983.

18. New Jersey Department of Environmental Protection, BSAWLA, "Steady State Water Quality Modeling of Conventional Pollutants in the Berry's Creek", May 1984.

19. New Jersey Department of Environmental Protection, "Water Quality Management Basin Plan, Northeast New Jersey Urban Area, Section 303(e)", December 1976.

19a. New Jersey Department of Environmental Protection, BSAWLA, "Water Quality Management Assessment Due to Marine CSO Abatement Along the New Jersey Shore", August 1985.

20. New York City Department of Environmental Protection, "Rainfall Runoff and Statistic Receiving Water Model, PCP Task 225", March 1978.

21. New York City Department of Environmental Protection, "Areawide Waste Treatment Management Planning Program, Section 208", March 1978.

22. Olivieri, V.P. et al., The Johns Hopkins University, "Microorganisms in Urban Stormwater", EPA-600/2-77-087.

23. Pitt, R. and M. Bozeman, Woodward Clyde Consultants, "Water Quality and Biological Effects of Urban Runoff on Coyote Creek" Phase I-Preliminary Survey", EPA 600/2-80-104.

24. Pontius, U.R., et al., Pavia-Byrne Engineering Corp., "Hypochlorineation of Polluted Stormwater Pumpage at New Orleans", EPA-670/2-73-067.

25. Tetra Tech Inc., "Stressed Water Evaluation for the Hudson-Raritan Estuary", February 1984.

25a. Thomann, Robert V., "Systems Analysis and Water Quality Management", 1984.

25b. Teledyne Iscotopes, "Mathematical Model for Water Quality, Volumes I to V", NJDEP, 1973.

26. USEPA, "Proceeding of Workshop on Microorganisms in Urban Stormwater", EPA-600/2-76-244.

27. Wanielista, Mastin P., "Stormwater Management Quantity and Quality", Ann Arbor Science Public Inc., Ann Arbor, Michigan, 1978.

28. Yorsef, Y., et al., University of Central Florida, "Urban Stormwater and Combined Sewer Overflow Impact on Receiving Water Bodies - Proceedings of National Conference", EPA-600/9-80-056.