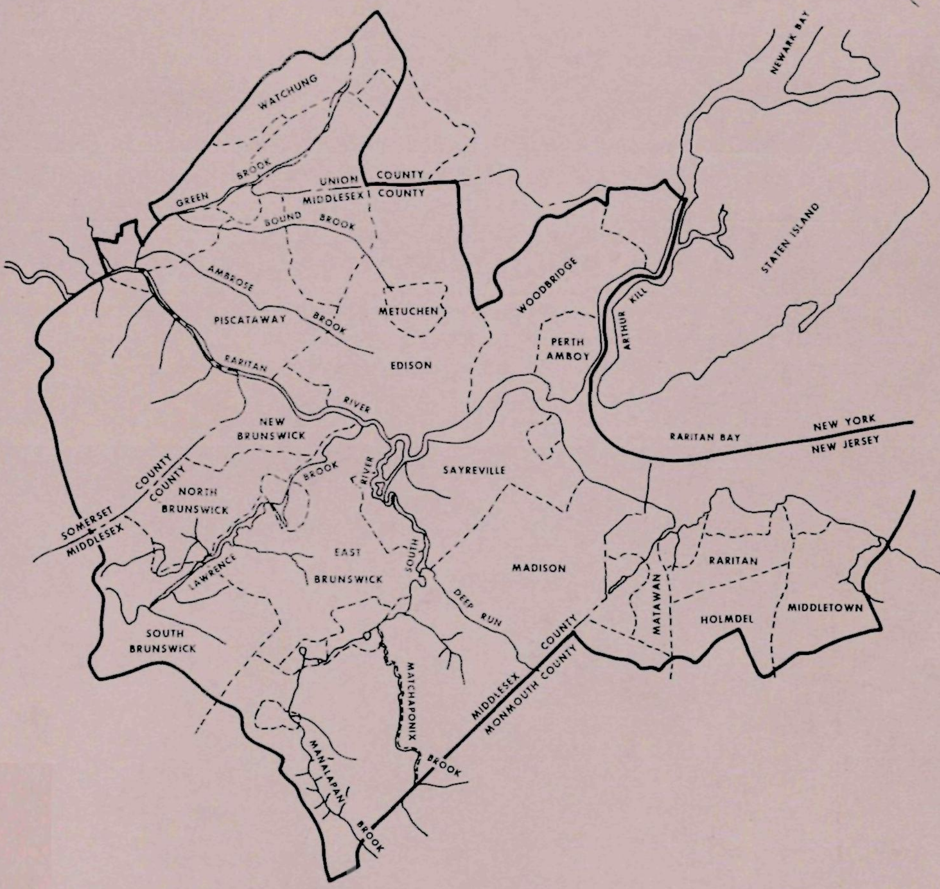
ENVIRONMENTAL IMPACT STATEMENT ON WASTEWATER TREATMENT FACILITIES CONSTRUCTION GRANTS FOR THE LOWER RARITAN RIVER BASIN AND FOR THE SOUTH SHORE OF RARITAN BAY

FINAL
JUNE 1973



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ENVIRONMENTAL IMPACT STATEMENT ON
WASTEWATER TREATMENT FACILITIES CONSTRUCTION GRANTS
FOR THE LOWER RARITAN RIVER BASIN AND
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PREFACE

This Environmental Impact Statement (EIS) deals with two wastewater treatment projects in the east-central part of New Jersey:

1. C-34-342-Middlesex County Sewerage Authority (MCSA) - expansion and upgrading of an existing sewage treatment plant;

2. C-34-312-Bayshore Regional Sewerage Authority (BRSA) - construction of a regional wastewater treatment plant and concomitant interceptors, pumping stations and force mains.

An EIS was deemed necessary for two reasons: the controversy surrounding each of these projects and the potential for significant environmental effects from the MCSA project.

The controversial aspect of the MCSA project is its service area. At present, the MCSA system serves most of the municipalities within the lower Raritan River basin. In connection with the proposed project, the New Jersey Department of Environmental Protection (NJDEP) directed that the MCSA's service area be enlarged to include a number of municipalities which now have independent sewerage systems. Three of these municipalities, Perth Amboy, Woodbridge and Carteret, objected to being included in the MCSA system. All three eventually accepted the NJDEP's directive, but none has yet executed a service agreement with the MCSA.

The MCSA project's major potential environmental impact is the effect of operation of the expanded plant on the water quality of Raritan Bay. The MCSA outfall extends 3.32 miles from the existing primary treatment plant to the dispersion basin in Raritan Bay. The plant effluent now contravenes water quality standards in effect for Raritan Bay. Moreover, even after secondary treatment is instituted, the effluent will contravene standards if the present discharge site is retained.

The controversial aspect of the BRSA project is its service area. There are now thirty-two wastewater treatment plants in the Bayshore area. The proposed project will regionalize sewage treatment in the Bayshore area, phasing out the smaller local treatment plants.

Keyport, Matawan Borough and Matawan Township are among the municipalities that have been or will be ordered by the NJDEP to join the BRSA. The municipalities oppose their inclusion in the BRSA. They would prefer to build their own secondary and then tertiary treatment facilities with effluent discharge to Raritan Bay and ground-water recharge. They argue that it is unreasonable of the NJDEP to force them to join the BRSA system, which will have ocean disposal of effluent, while allowing the MCSA to discharge treated effluent into Raritan Bay. Keyport and Matawan Borough have signed letters of intent to join the BRSA system. However, Matawan Township has yet to execute such an agreement.

A somewhat unusual situation exists with regard to funding of the MCSA project. In order to take advantage of fiscal '72 funds, the grant offer had to be made by December 31, 1972: that is, prior to the completion of the EIS process. Therefore, to insure that the project's potential environmental effects were given full consideration, the actual disbursement of funds was made contingent upon the outcome of the EIS process, as stipulated in the terms of the grant agreement:

> "Compliance with National Environmental Policy Act - This grant is subject to completion of a review required by the National Environmental Policy Act of 1969, 42 U.S.C. 4321 et seq. The Middlesex County Sewerage Authority (MCSA) hereby agrees to furnish information and otherwise cooperate with the Environmental Protection Agency (EPA) regional office staff in the National Environmental Policy Act (NEPA) evaluation and further agrees that no 'construction and project improvement costs' or obligations relating to such costs will be incurred unless and until the Regional Administrator notifies the

MCSA and the New Jersey State Department of Environmental Protection (NJSDEP) in writing that the NEPA review has been satisfactorily completed. The Regional Administrator may annul this grant if he determines as a result of the NEPA review that the project for which this grant has been awarded is environmentally unsound." (U.S. EPA, 1972).

G. M. Hansler

Gerald M. Hansler, P.E.
Regional Administrator

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SUMMARY

DATE: June 1973.

TYPE OF STATEMENT:

Final

RESPONSIBLE FEDERAL AGENCY:

Environmental Protection Agency, Region II.

TYPE OF ACTION:

Administrative.

DESCRIPTION OF ACTION INDICATING STATES AND COUNTIES AFFECTED:

Funds have been requested from the Environmental Protection Agency by representatives of the Middlesex County Sewerage Authority (MCSA) and the Bayshore Regional Sewerage Authority (BRSA) of Monmouth County in the State of New Jersey. Under consideration are projects which involve: 1) additions and alterations to the MCSA's existing sewage treatment plant, and 2) construction of sewers and a sewage treatment plant for the BRSA. Plans for construction of new outfalls or expansion of existing outfalls to serve the facilities are not included in these projects.

The waters of Raritan Bay will be affected; these waters are contiguous to the State of New York. The Atlantic Ocean will be affected in the areas east of Atlantic Highlands, New Jersey.

SUMMARY OF ENVIRONMENTAL IMPACT AND ADVERSE ENVIRONMENTAL EFFECTS:

The impact of these projects will be: 1) to improve the quality of receiving waters by providing secondary treatment of wastewater prior to discharge, 2) to allow cessation of wastewater discharge into inland streams that have low assimilative capacities, and 3) to provide the Bayshore communities of Monmouth County with centralized sewage treatment. The highly treated effluent will be introduced into the marine environment. There will also be a waste sludge produced at the treatment plants. This sludge must be disposed of in a manner that will not significantly disrupt the environment.

The discharge of effluents at the present MCSA disposal site will contravene water quality standards in Raritan Bay even after secondary treatment is instituted. Therefore, a more suitable disposal site must be selected by the MCSA in the near future.

Should the proposals be implemented, some adverse effects might be expected. They are: further lowering of ground-water levels, increased saltwater encroachment, and possible contamination of the marine environment at the sites of effluent and sludge disposal.

ALTERNATIVES CONSIDERED:

MCSA:

1. no action,
2. various degrees of expansion in service area.

Table 1 compares the alternative water quality management plans for the lower Raritan River basin.

BRSA:

1. no action,

TABLE 1

COMPARISON OF ALTERNATIVE WATER QUALITY MANAGEMENT PLANS
FOR THE LOWER RARITAN RIVER BASIN

Project Description	Costs (In Millions of Dollars, As of 1985) 1/				Environmental Effects	
	Total Capital Cost 2/	Average Annual Estimated Cost for 1985: Debt Service 3/	Operating Cost 4/	Total Annual Cost 5/	Specific	General
Alternative 1 (proposed) Partial expansion of MCSA system;South River drainage area in Monmouth County excluded	345.7 6/	24.4	8.01	32.4	Will allow for recharge to the headwaters of the South River.	Alternatives 1,2 and 3 should immediately reduce the BOD loadings on the bay thus improving the bay environment. However, as the 240 MGD maximum effluent flow is reached,the BOD,toxic materials, chloride,coliforms and suspended solids concentrations will increase,adversely affecting the bay ecosystem. In order to attain a marked improvement in the water quality of the bay,the bay outfall must be relocated. The addition of increasing amounts of nutrients as sewage effluent will increase the rate of eutrophication of the bay. Ground-water depletion will continue to be a problem in the Sayreville-South Amboy area until recharge equals withdrawal. Continued ocean disposal of sludge will have a detrimental effect on the dumping area.
Alternative 2 Maximum expansion of MCSA system to include the majority of municipal wastewater discharges in Middlesex County and part of Monmouth County.	344.5	24.3	7.32	31.6	Will divert all wastewaters in the service area to Raritan Bay with no option for recharge.	
Alternative 3 Minimum expansion of MCSA system;areas excluded are: Carteret,Woodbridge, Monmouth County area, Manalapan Brook drainage area in Middlesex County upstream of existing MCSA sewered area,all of South Brunswick.	373.1	26.4	8.04	34.4	Will allow for recharge in South River Basin; Will contribute treated sewage to Arthur Kill; Will allow for several smaller less cost-effective plants.	
Alternative 4 No action	-	-	-	-	-	Severe degradation of the bay will result. Water quality standards for the bay will be contravened

1/Cost estimates from Metcalf & Eddy, October 1972.
2/Total cost of interceptors, pumping stations,force mains and treatment plants planned for installation between the present and 2000.
3/Average annual cost for 40 year serial bonds at 6-1/2 percent.
4/Includes administrative costs,labor,materials,chemicals,electric power,fuel and maintenance for the sewerage system.
5/Total of average annual debt service and operating costs.
6/The estimated capital cost for the upgrading and expansion of the treatment plant is $93,000,000 as of June 1972.

2. regional sewerage system with bay outfall ,

3. regional sewerage system with ocean outfall.

Table 2 compares the alternative water quality management plans for the Bayshore area.

FEDERAL, STATE, AND LOCAL AGENCIES FROM WHICH COMMENTS HAVE BEEN REQUESTED:

Federal Agencies:

Department of Agriculture

Agricultural Stabilization and Research Service

Agricultural Research Service

Forest Service

Soil Conservation Service

Department of Commerce

National Oceanic and Atmospheric Administration

National Marine Fisheries Service

Department of Defense

Army Corps of Engineers (New York District)

Office of the Oceanographer of the Navy

Department of Health, Education and Welfare

Department of the Interior

National Park Service

United States Senate

Honorable Clifford P. Case

Honorable Harrison A. Williams

United States House of Representatives

Honorable Edward J. Patten

Honorable James J. Howard

TABLE 2

COMPARISON OF ALTERNATIVE WATER QUALITY MANAGEMENT PLANS FOR THE BAYSHORE AREA

Project Description	Construction Costs (Millions Of Dollars)		Environmental Effects
	Bayshore Treatment Plant 1/	Outfall Line 2/	
Alternative 1 Continuation of present practice of discharging treated effluents into tributary streams or just off-shore into the bay.	-	-	There will be continued degradation of the south shore of Raritan Bay and tributary streams. Water quality standards for the bay area and for tributary streams will be contravened.
Alternative 2 Regional treatment plant with outfall extending into the bay to a point where the water depth is at least 20 feet.	18.2	9.75	Several small primary treatment plants that cause degradation of the bay waters along the south shore of Raritan Bay will be eliminated. The contribution of waste effluent to the bay is insignificant when compared with sources of pollution in the bay.
Alternative 3 (under construction) Regional treatment plant with outfall parallel to the bay's shoreline and with final discharge into the ocean.	18.2	10.2	The elimination of all bayshore area wastes from Raritan Bay may improve water quality along the south shore of Raritan Bay.

1/Cost estimates from Kupper, 1972.
2/Cost estimates from Killam Associates, 1968.

State Agencies:

New Jersey State Department of Environmental Protection

New York State Department of Environmental Conservation

Local Agencies:

Executive Officers

Bound Brook Borough

Cranbury Township

East Brunswick Township

Edison Township

Franklin Township

Highland Park Borough

Madison Township

Metuchen Borough

Middlesex Borough

Monroe Township

New Brunswick City

North Brunswick Township

Piscataway Township

Dunellen Borough

Fanwood Borough

Green Brook Township

North Plainfield Borough

Scotch Plains Township

Sayreville Borough

South Bound Brook Borough

South Plainfield Borough

South River Borough

Spotswood Borough

South Amboy City

South Brunswick Township

Carteret Borough

Perth Amboy City

Woodbridge Township

Helmetta Borough

Jamesburg Borough

Marlboro Township

Holmdel Township

Keansburg Borough

Keyport Borough

Matawan Borough

Matawan Township

Middletown Township

Hazlet Township

Union Beach Borough.

DESCRIPTION OF THE PROPOSED PROJECTS

C-34-342-Middlesex County Sewerage Authority
Status - Final Design Completed

The MCSA was established in 1950. It was assigned the task of constructing and operating a sewerage system to serve the lower Raritan River drainage basin and adjacent areas. The 1970 population of the service area was about 727,000 persons. The population projection for the year 2000 is 1,550,000 persons.

The present sewerage system includes a 78 million gallons per day (mgd) primary treatment plant providing removals of 22 percent BOD (5-day) and 78 percent suspended solids (1971 annual averages). The proposed project calls for expanding the plant to a capacity of 120 mgd and upgrading it to provide secondary treatment. The upgraded plant has been designed for 90 percent removal of both BOD (5-day) and suspended solids. Plans to increase the capacities of the interceptors, pumping stations, force mains and the outfall are currently in the final design stage. However, these related facilities are not part of the proposed project.

The plant will employ the high-purity oxygen modification of the activated sludge process. The effluent will be chlorinated before it is discharged into Raritan Bay. Sludge will be processed by thickening, aerobic digestion and storage before being barged to sea for disposal. Ocean disposal of the sludge will be allowed as an interim procedure.

C-34-312-Bayshore Regional Sewerage Authority
Status - Under Construction

This project involves the construction of a regional wastewater treatment plant and concomitant interceptors, pumping stations and force mains. The treatment plant is a 6.0 mgd secondary system designed to utilize the step-aeration or completely-mixed activated sludge process. Four trunk interceptors will feed a regional interceptor at Union Beach leading to the plant. The treated effluent will be discharged through the Monmouth County Bayshore Ocean Outfall Authority's (MCBOOA) ocean outfall. Sludge will be concentrated and then incinerated at the plant site.

The addition of the Keyport-Matawan area to the BRSA system will necessitate an increase in plant capacity. Present plans call for an increase to 8.0 mgd by the end of 1974. Strict schedules for the connection of these additional areas to the BRSA system will prevent overloading of the treatment facilities.

BACKGROUND

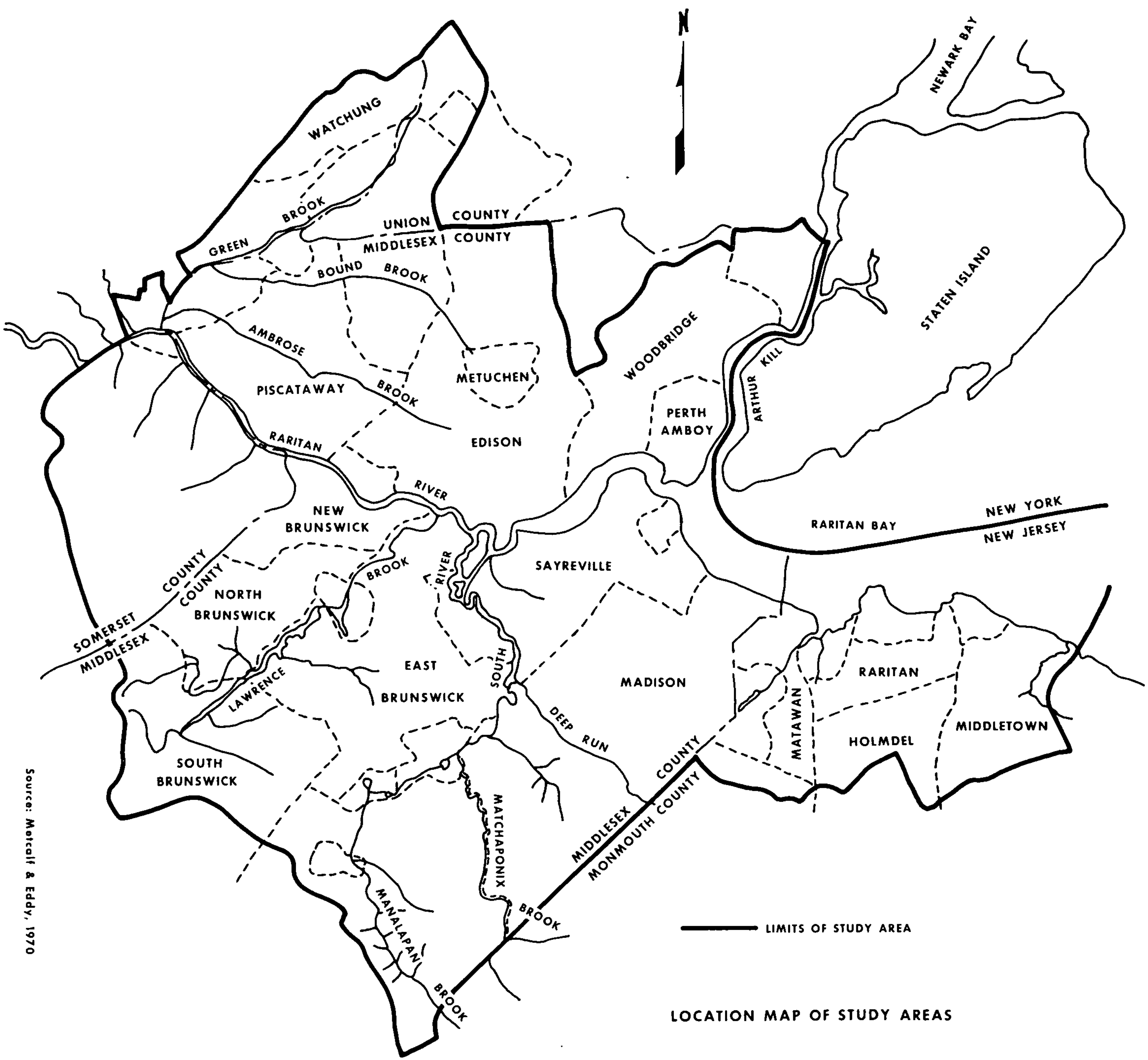
This Environmental Impact Statement is concerned with two separate geographical locales and, therefore, two separate study areas. The lower Raritan River basin includes all of the areas in Middlesex, Somerset and Union Counties that drain into the Raritan River between the northern boundary of the Borough of Bound Brook and the point at which the river discharges into Raritan Bay at the City of Perth Amboy. Collectively these areas comprise the lower Raritan River basin study area. The portion of the south shore of Raritan Bay (Bayshore area)1/ that extends from the City of South Amboy to Comptons Creek in Middletown Township, Monmouth County is referred to as the Bayshore study area.

The lower Raritan River basin drains an area of approximately 350 square miles, while the Bayshore area drains approximately 60 square miles. The limits of the basin and the bay study areas, including municipal and county boundary lines, are shown in Figure 1.

This section of New Jersey is heavily populated and highly developed, with an emphasis on residential land use. The topography of the area is relatively flat or gently sloping. The climate is temperate. In the most general terms, water supply is adequate and

1/ For the purposes of this report, South Amboy and Madison Township have been included in the lower Raritan River basin.

Figure 1



LOCATION MAP OF STUDY AREAS

Source: Metcalf & Eddy, 1970

water quality, while not good, is acceptable. In short, there are no natural impediments to further development of the area. Continued development is expected. The projects under consideration here will neither accelerate nor retard this growth.

A more detailed description of the area can be found in Appendix A. The appendix deals with such subjects as: geography, physical geography, land use patterns, population, water resources and water quality. It offers the reader the background information he needs to make an independent appraisal of the environmental effects of the proposed projects.

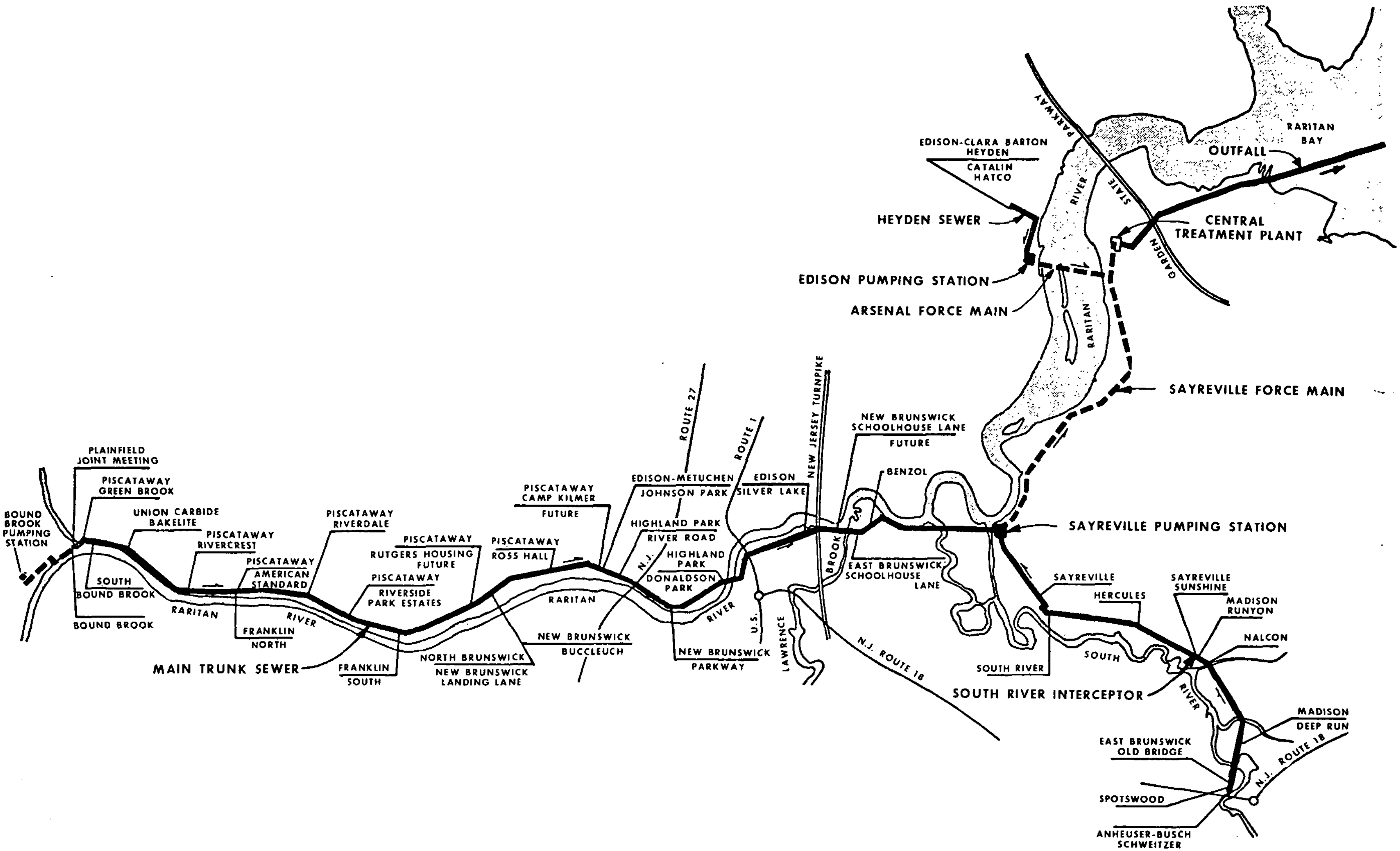
DETAILED DESCRIPTION OF THE EXISTING FACILITIES OF THE MIDDLESEX COUNTY SEWERAGE AUTHORITY (MCSA)

The MCSA provides sewage treatment for most of the area within the lower Raritan River basin. This sewerage system is comprised of two major interceptors, three pumping stations, the central treatment plant at Sayreville and an outfall into Raritan Bay. The system serves both municipalities and industries. In 1968, the MCSA estimated that the influent to its treatment plant was composed of equal amounts of municipal and industrial wastes.

Collection System

The trunk sewers, pumping stations and force mains operated by the MCSA receive sewage flows from municipal collection systems and convey them to the central treatment plant. Lateral collection facilities are not included in the MCSA's sewerage system, but connection trunks (consisting of syphons and other lines) by which participating municipalities are connected with the MCSA system are provided. The general layout of the sewerage system is indicated in Figure 2 (Metcalf &

Figure 2



GENERAL LOCATION MAP
MIDDLESEX COUNTY SEWERAGE AUTHORITY

Source: Metcalf & Eddy, October 1972

Eddy, October 1972).

The main trunk sewer is a gravity interceptor which parallels the Raritan River. It is approximately 11.5 miles in length and ranges in size from a 60-inch diameter pipe at Bound Brook to an 84-inch diameter pipe at the Sayreville pumping station. The Bound Brook pumping station, which has two pumps (500 gallons per minute (gpm) and 750 gpm capacities), provides a capacity of approximately 2 mgd.

The South River interceptor parallels the South River from Old Bridge to the Sayreville pumping station. The interceptor's total length is about 4.9 miles. The interceptor ranges in diameter from 45 inches at Old Bridge to 48 inches at the Sayreville pumping station. Flow in this sewer is controlled by gravity.

Wastewater is conveyed from the Sayreville pumping station to the central treatment plant via the 72-inch diameter Sayreville force main. The force main is 3.7 miles long. Four 35 mgd pumps provide the Sayreville pumping station with a capacity of approximately 140 mgd.

The Edison pumping station is fed by the 60-to 66-inch diameter Heyden gravity sewer. The station pumps wastewater under the Raritan River via the 60-inch diameter Edison force main (also called the Arsenal force main) to the Sayreville force main. The capacity of the Edison pumping station is approximately 68 mgd.

Total contributions to the MCSA sewerage system for the year 1971 are listed in Table 3.

Treatment System

The MCSA central treatment plant provides primary treatment for wastewater. Basically, raw sewage is treated by screening, grit removal,

TABLE 3

MCSA
FLOWS AND LOADINGS
1971

	Flow	Biochemical Oxygen Demand		Suspended Solids	
	mgd	mg/l	lb/day	mg/l	lb/day
Municipalities					
Borough of Bound Brook	1.15	210	2,018	410	3,934
East Brunswick Sewerage Authority	2.57	255	5,459	325	6,971
Township of Edison	9.85	158	12,949	230	18,903
Franklin Township Sewerage Authority	1.32	106	1,163	139	1,530
Borough of Highland Park	1.93	130	2,095	182	2,931
Madison Township Sewerage Authority	2.90	292	7,058	377	9,120
Borough of Metuchen	1.69	197	2,779	277	3,908
Borough of Middlesex	1.85	238	3,667	414	6,389
Monroe Township Municipal Utilities Authority	0.16	156	208	280	374
City of New Brunswick (includes Milltown)	12.90	338	36,387	363	39,000
Township of North Brunswick	3.64	179	5,433	324	9,827
Township of Piscataway	4.98	231	9,613	217	9,014
Plainfield Joint Meeting	10.31	166	14,313	303	26,027
Borough of Sayreville	3.48	393	11,392	220	6,380
Borough of South Bound Brook	0.47	143	561	160	627
Borough of South Plainfield	1.68	504	7,058	455	6,382
Borough of South River	1.70	129	1,836	220	3,118
Borough of Spotswood	0.60	226	1,131	237	1,184
	63.18	237	125,120	295	155,619
Industries					
Anheuser Busch, Inc.	0.53	5326	23,543	1218	5,382
Ashland Chemical Company	0.35	352	1,028	339	991
W.R. Grace and Company-Hatco Chemical Div.	0.71	6363	37,680	1510	8,941
Hercules, Incorporated	0.45	1165	4,372	1024	3,844
National Lead Company	0.56	74	347	4534	21,177
Peter J. Schweitzer Div.-Kimberly Clark Corp.	5.55	828	38,322	1611	74,553
Stauffer Chemical Company	0.35	2781	8,118	689	2,011
Tenneco Chemicals, Inc.	1.05	1208	10,582	80	704
Union Carbide Chemicals and Plastics Company	1.69	1260	17,763	244	3,441
	11.24	1512	141,755	1291	121,044
Totals	74.42	430	266,875	446	276,663

Source: Metcalf & Eddy, October 1972.

flocculation/clarification and chlorination. The sludge that is collected is thickened and stored before being barged to sea. Figure 3 is a schematic diagram of the existing treatment facilities.

Plant capacity is 78 mgd; the 1971 average flow was 73.3 mgd. Table 4 summarizes the monthly operating results for 1971. Average BOD (5-day) removal for 1971 was 22 percent, resulting in an average BOD (5-day) decrease from 350 milligrams per liter (mg/l) to 271 mg/l . (MCSA, 1971). Therefore, the average BOD (5-day) loading imposed on Raritan Bay would be approximately 167,000 lb/day.

For the purposes of the Raritan Bay model study (Appendix D), an effluent BOD (5-day) value of 400 mg/l was used. The use of this value was based on all available data. With an average effluent BOD (5-day) of 400 mg/l and a flow rate of 72 mgd, the 5-day BOD load on Raritan Bay is approximately 240,000 lb/day. Suspended solids removal for 1971 averaged 74 percent. With an average effluent concentration of 79 mg/l, suspended solids loading on Raritan Bay was approximately 48, 650 lb/day.

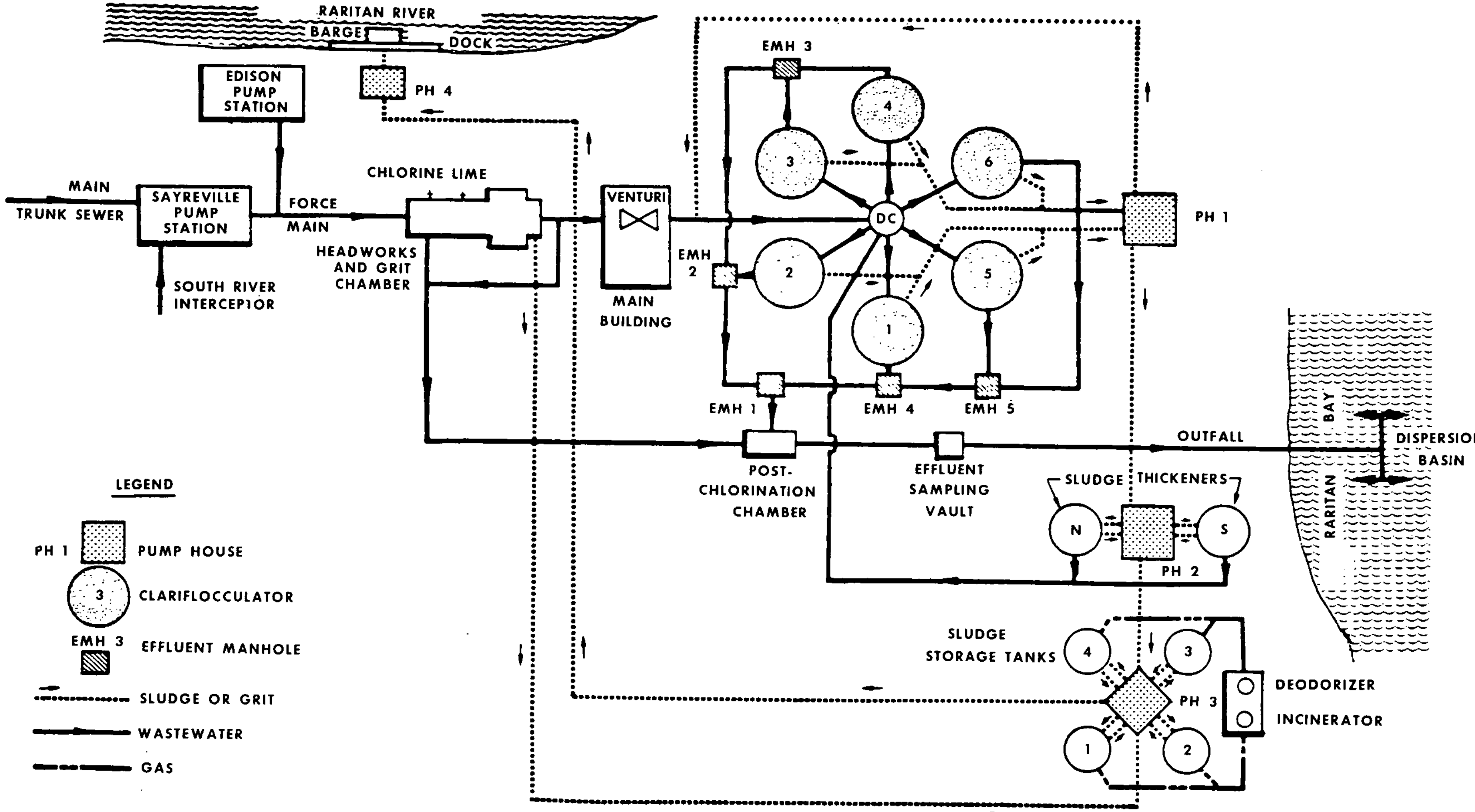
Raw sewage entering the treatment plant passes through the following treatment units:

Grit chambers - two, detritus type, each 35' x 35';

Venturi - (for flow measurement) - one, range 0 to 150 mgd, 84" x 37.9";

Distribution chamber - (for flash mixing) - one, 330 sq.ft. x 18 ft., three mixers, detention time - 1.22 minutes at 52 mdg;

Figure 3



SCHEMATIC FLOW DIAGRAM OF EXISTING MCSA TREATMENT FACILITIES

Source: Metcalf & Eddy, May 1972

TABLE 4

MCSA
SUMMARY OF OPERATING RESULTS
1971

1971 Month	Avg. Flow mgd	Chlorination: Residual Chlorine mg/l Avg.	Chlorination: Coliform Bacteria % of samples less than 0.2ml	BOD: Influent mg/l Avg.	BOD: Effluent mg/l Avg.	BOD: Reduction %	Suspended Solids: Influent mg/l Avg.	Suspended Solids: Effluent mg/l Avg.	Suspended Solids: Reduction %	Settleable Solids: Influent mg/l Avg.	Settleable Solids: Effluent mg/l Avg.	Settleable Solids: Reduction %
Jan.	71.26	1.00	97	390	314	19	251	77	70	10.5	0.05	100
Feb.	76.53	1.00	96	375	299	20	291	98	67	10.6	0.10	99
Mar.	80.15	1.00	94	358	263	26	280	84	72	10.8	0.12	99
Apr.	73.61	1.00	90	357	267	24	313	96	70	11.8	0.07	99
May	69.31	1.00	97	360	275	24	328	94	72	13.4	0.05	100
June	69.21	1.00	83	354	272	22	363	83	77	15.0	0.05	98
July	63.11	1.00	97	324	254	22	349	97	73	13.3	0.05	100
Aug.	77.97	1.00	93	304	229	24	269	64	76	13.1	0.05	96
Sept.	82.23	1.00	93	307	249	19	261	63	76	13.2	0.10	99
Oct.	73.15	1.00	94	386	303	21	302	63	80	13.6	0.09	99
Nov.	73.33	1.00	97	352	265	23	290	64	78	14.3	0.10	99
Dec.	76.14	1.10	90	329	266	18	258	62	77	12.7	0.07	99
Avg.	73.83	1.01	93	350	271	22	296	79	74	12.7	0.08	99
1970 Avg.	68.31	1.02	97	419	321	23	333	98	71	13.1	0.06	99
1969 Avg.	65.51	1.13	96	429	369	14	320	95	71	12.1	0.06	99
1968 Avg.	62.50	1.12	99	409	352	14	333	96	72	12.6	0.07	100
1967 Avg.	62.30	1.09	98	397	342	14	290	91	69	12.3	0.09	99

TABLE 4 (Cont'd)

MCSA
SUMMARY OF OPERATING RESULTS
1971

1971 Month	Sludge Handling: From Clarifiers to Thickeners: 1000 Cu.Ft. Per Day Avg.	% Solids Avg.	From Thickeners to Storage: 1000 Cu.Ft. Per Day Avg.	% Solids Avg.	From Storage to Barge: Wet Tons Per Month	% Solids Avg.
Jan.	406	0.36	27.1	8.4	25502	6.0
Feb.	391	0.38	26.5	7.4	26337	5.9
Mar.	539	0.35	27.6	7.8	26443	5.5
Apr.	529	0.44	28.4	7.6	28267	6.1
May	536	0.44	31.8	7.3	33644	6.1
June	557	0.57	32.9	8.3	35010	6.9
July	534	0.48	29.8	9.0	32199	7.3
Aug.	529	0.43	31.0	7.9	28040	6.9
Sept.	517	0.45	31.8	8.3	32279	6.8
Oct.	518	0.50	34.2	7.8	31958	6.2
Nov.	534	0.46	32.5	7.7	32215	6.3
Dec.	526	0.40	30.6	7.7	26337	6.0
Avg.	510	0.44	30.4	7.9	29853	6.3
1970 Avg.	481	0.45	28.7	8.6	29551	6.3
1969 Avg.	475	0.48	28.1	8.9	26919	6.9
1968 Avg.	531	0.45	26.8	8.6	26312	6.5
1967 Avg.	524	0.42	27.0	7.5	26070	6.1

Source: Middlesex County Sewerage Authority, 1971.

Clariflocculator tanks - six flocculation units, 55' diameter x 10.25' average water depth, 24,400 cu. ft. each, detention time (6 units) 2.1 hours at 78 mgd; six sedimentation units, 130' diameter x 12.5' average water depth, 153,000 cu. ft. each, detention time (6 units) 2.1 hours at 78 mgd.

Sludge processing units include:

Sludge thickeners - two, 80' diameter x 16' average water depth, 80,200 cu. ft. each, detention time at design flow 4 hours for liquid, 12 hours for sludge, sludge depth 10.5';

Sludge storage tanks - four, 80' diameter x 19' average water depth, 105,000 cu. ft. each, detention time at 78 mgd without chemical treatment 2.6 days.

Chlorination units are:

Chlorinators - pre-and post-chlorination capabilities are provided, ten units, capacity 8,000 lb/day chlorine each, total chlorine requirement 120 parts per million (ppm), average requirement at 78 mgd 78,000 lb/day, maximum requirement at 117 mgd 117,000 lb/day, detention time in existing outfall 62 minutes.

Screening, the usual treatment first given to raw sewage, takes place at the Sayreville pumping station before the sewage is delivered to the central treatment plant.

Outfall

After treatment and chlorination, the effluent is discharged to the 84-inch diameter outfall which extends 3.32 miles from the plant to the dispersion basin in Raritan Bay (Metcalf & Eddy, May 1972).

"The existing outfall line extends 1.25 miles from shore [the shore of the bay] and discharges through an 'H' diffuser. Each of the four diffuser ports has a diameter of 42 inches. The depth of diffuser to mean low tide is 10 feet. The 1971 average daily flow through the outfall line was 79 MGD. The peak design flow of the line is 130 MGD." (Pike,written communication, December 1972).

For the immediate future, the existing outfall line will be used for effluent disposal into Raritan Bay. However, effluent disposal at the existing discharge point will contravene water quality standards in effect for Raritan Bay. Therefore, in its grant agreement with the MCSA, EPA stipulated that the MCSA must select an outfall location at which the discharge of secondary treated effluent will not contravene standards (U.S. EPA, 1972).

DESCRIPTION OF THE FACILITIES OF THE BAYSHORE REGIONAL SEWERAGE AUTHORITY (BRSA)

Figure 4 indicates the service area of the BRSA. The service area includes the Borough of Union Beach, Hazlet Township, the Borough of Keansburg, the Borough of Keyport, the Borough of Matawan and the northern section of Holmdel Township. These communities have signed either service agreements or letters of intent to join the BRSA.

BAYSHORE REGIONAL SEWERAGE AUTHORITY SERVICE AREA

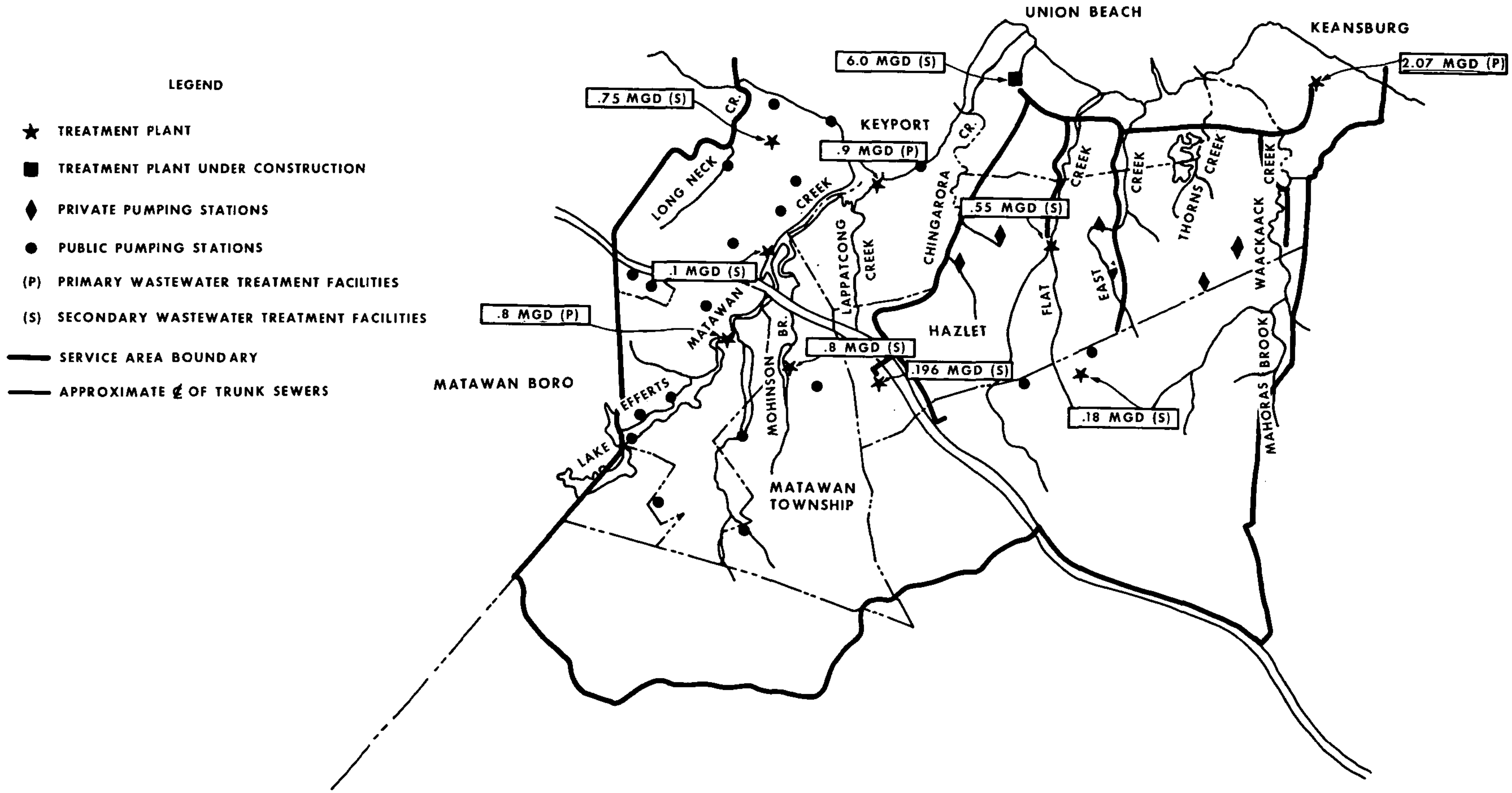


Figure 4

Source: NJDEP, 1971

Matawan Township and a portion of Marlboro Township will be required to join the BRSA; however, service agreements have not yet been executed. These areas will be required to join the BRSA system by the New Jersey Department of Environmental Protection, as substantiated by the following statement:

> "As I indicated in my previous letter to Matawan and Keyport, a copy of which was provided to the Monmouth County Bayshore Outfall Authority, the only arrangement acceptable to the State for regionalization of sewerage facilities in the area, including eligibility for federal and state construction grant funds would be for services to be provided to Matawan-Keyport Boroughs and a portion of Marlboro and Matawan Townships by an expanded Bayshore Regional Sewerage Authority system. We will not approve the construction of an additional treatment plant which would require the extension of the Bayshore Outfall Line from Union Beach to the Matawan-Keyport area." (Pike, written communication, June 1972).

Collection System

Four regional trunk sewers will connect at Union Beach to feed an interceptor to the Bayshore regional wastewater treatment plant. Regional pumping stations will be located at West Keansburg and at the Raritan Valley Sanitation Company's sewage treatment plant. This collection system is now under construction.

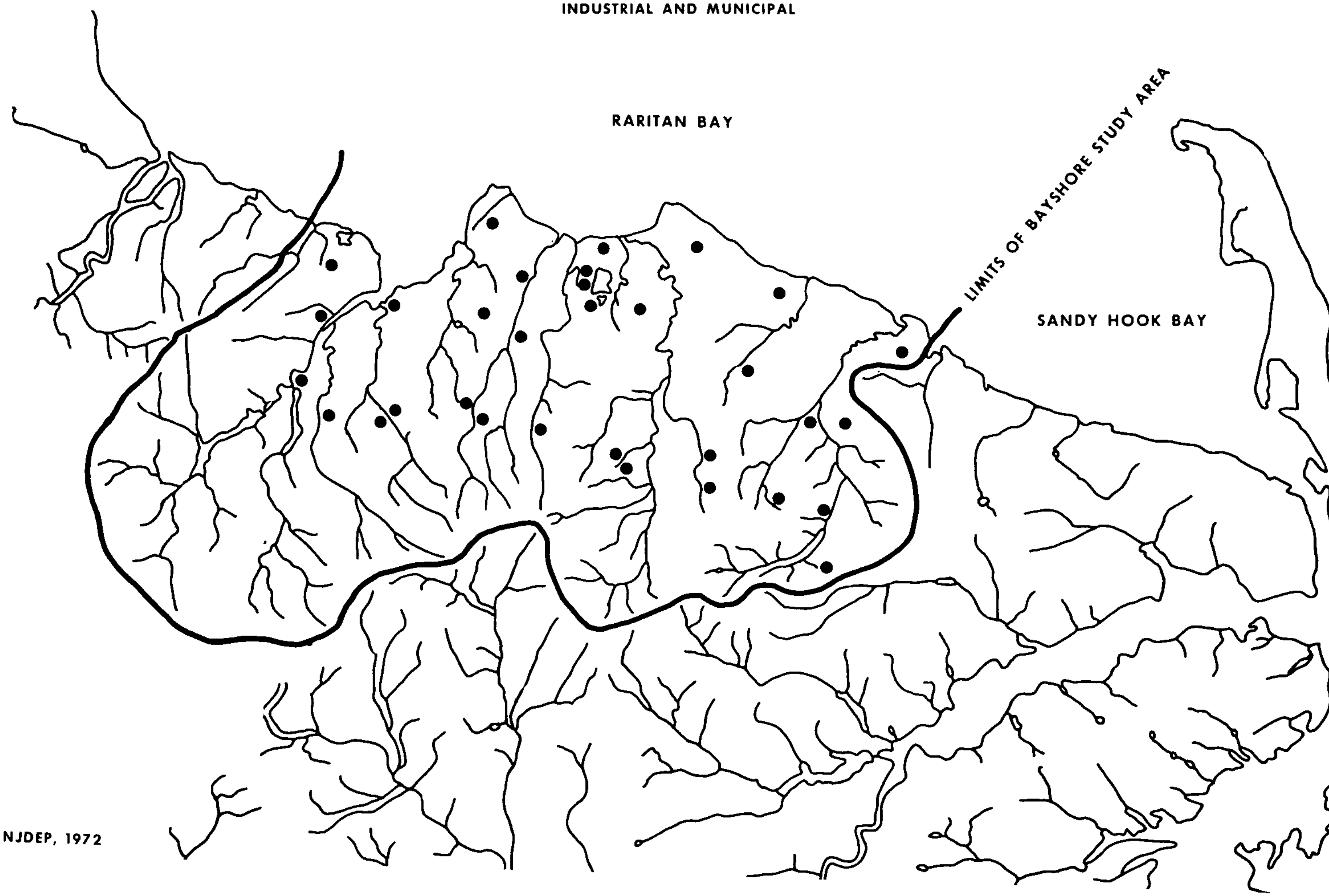
Treatment System

The existing treatment plants that will be abandoned when the BRSA facilities are put into operation are shown in Figure 5. The schedule for the abandonment of these plants has not yet been determined.

The regional wastewater treatment plant for the BRSA is a 6.0 mgd secondary treatment plant which will discharge to the ocean outfall being constructed by the MCBOOA. As designed, this treatment facility will serve Hazlet, Holmdel, Keansburg, and Union Beach. It is expected to reach design capacity by 1980.

SEWAGE TREATMENT PLANTS IN THE BAYSHORE STUDY AREA

INDUSTRIAL AND MUNICIPAL



Source: NJDEP, 1972

Figure 5

Keyport, Matawan Borough, Matawan Township and sections of Marlboro Township will also be served by this plant. Their inclusion will require an increase in plant capacity above the 6.0 mgd design flow. Present schedules call for expansion of the plant to 8.0 mgd.

The BRSA treatment plant is now under construction. By October 1973, it should be 50 percent operational, i.e., able to treat a wastewater flow of 3.0 mgd. By February 1974, the original plant design flow of 6.0 mgd should be realized as initial construction is completed. Projected completion date for the plant expansion to 8.0 mgd is October 1974.

Treatment will consist of grit removal, sedimentation, biological treatment (activated sludge), chlorination, sludge concentration and sludge incineration. Both suspended solids and BOD (5-day) removals are expected to be 90 percent. The design average sewage flow rate is 100 gallons per capita per day (gpcd) and the peak flow is 250 gpcd. The design BOD (5-day) and suspended solids loadings are each 250 mg/l or 0.21 pounds per capita daily.

The step-aeration type of activated sludge system will be employed. This system is preferred because it reduces peak oxygen demands, improves mixing, provides more effective utilization of aeration tank capacity and allows greater flexibility in operation. Additional flexibility has been designed into the plant so that it can be operated under conditions of the conventional activated sludge process. The plant has been designed to permit easy incorporation of advanced wastewater treatment processes at a later date.

The following units are included in the plant design:

- Mechanical bar screens with grinders;
- Three primary settling tanks - detention time 1.44 hours;
- Raw sludge grit collector;
- Three aeration tanks - detention time 5.4 hours;
- Three final settling tanks - detention time 2.3 hours;
- Chlorination tank - detention time 45 minutes;
- Two sludge concentrating tanks - maximum solids loading 8 lb/sq.ft./day, maximum hydraulic loading 600 gal/sq.ft./day;
- Sludge incineration equipment.

A sludge incineration system will be used at this facility to dispose of the organic solids removed in the treatment process. The incineration unit will be of the fluid-bed reaction type and will be designed to meet current air pollution emission standards. The system will be composed of a sludge disintegrator, four sludge centrifuges with chemical feed equipment, two reactor feed pumps, a reactor with preheat burner and fluidizing air blower, a scrubber, an ash pump and an ash dewatering unit. The entire system will be instrumented and automatically controlled to insure efficient operation at all times. The dewatered ash end product will be disposed of at the plant site through a fill operation.

Outfall

The effluent will be discharged to the Atlantic Ocean through the MCBOOA ocean outfall, which is under construction. The outfall will be connected to the BRSA wastewater treatment plant late in 1973 when the plant becomes 50 percent operational. No interim effluent disposal to local receiving waters is planned.

A 54-inch diameter emergency bypass line to a tributary of Raritan Bay will be constructed as part of the treatment facility project. It will normally be sealed and will be used only when an emergency prevents use of the ocean outfall.

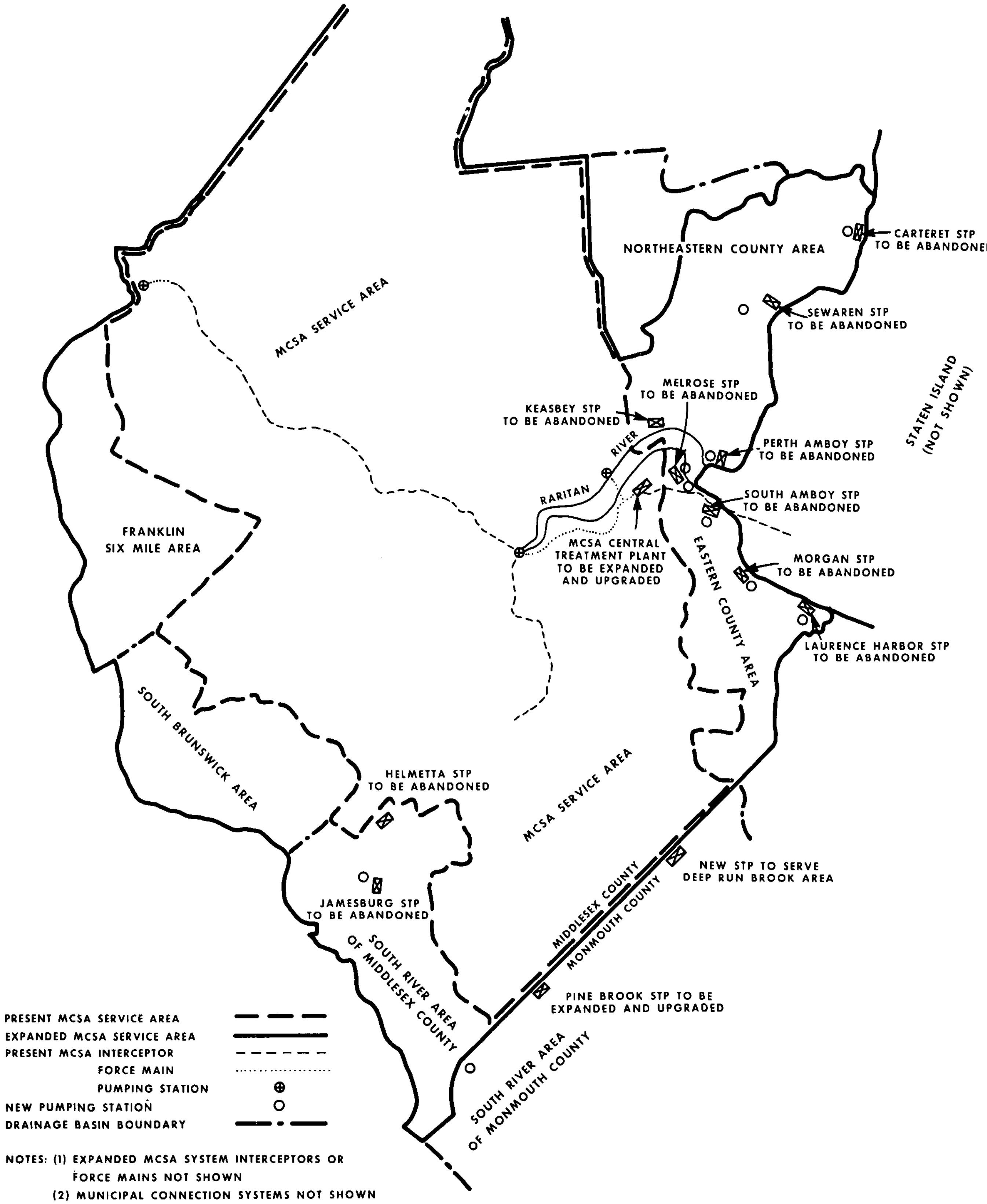
SUMMARY OF ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

As previously indicated (Figure 1), the geographic area of concern in this Environmental Impact Statement has been divided into two study areas: the lower Raritan River basin and the Bayshore. The two areas are considered separately because they lie in different drainage basins and, consequently, in different planning areas. Each planning area has independently developed alternatives for a regional sewerage system. Summaries of the alternative water quality management plans for each study area follow.

LOWER RARITAN RIVER BASIN

Three action alternatives are offered, each of which entails the expansion and upgrading of the existing MCSA sewerage system. Alternative 1 involves a partial expansion of the MCSA system in conjunction with construction or expansion of treatment plants in selected outlying areas. Alternative 2 calls for maximum expansion of the system to include the majority of municipal wastewater discharges in Middlesex County and a small section of Monmouth County. Alternative 3 requires a minimum expansion of the MCSA system along with construction or expansion of treatment facilities in outlying areas. The service areas associated with alternatives 1,2 and 3 are shown in Figures 6,7 and 8, respectively. A fourth alternative, that of no action, is also considered. Common to all plans are: 1) the exclusion of the Rahway Regional System from the MCSA service area, and 2) the continued inclusion of a section of Woodbridge in the Rahway Valley Sewage Authority's service area.

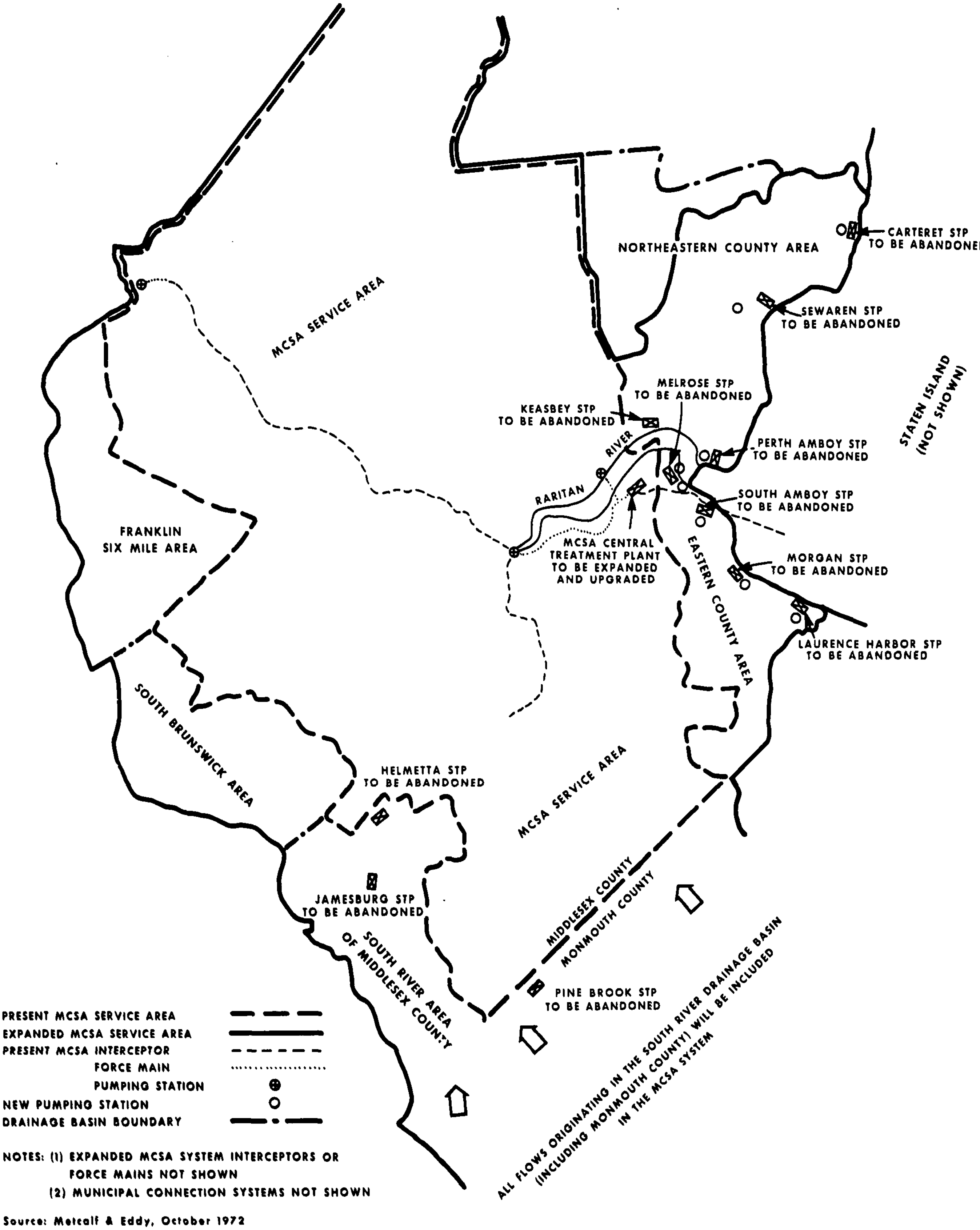
MCSA SYSTEM ALTERNATIVE 1



Source: Metcalf & Eddy, October 1972

Figure 6

MCSA SYSTEM ALTERNATIVE 2

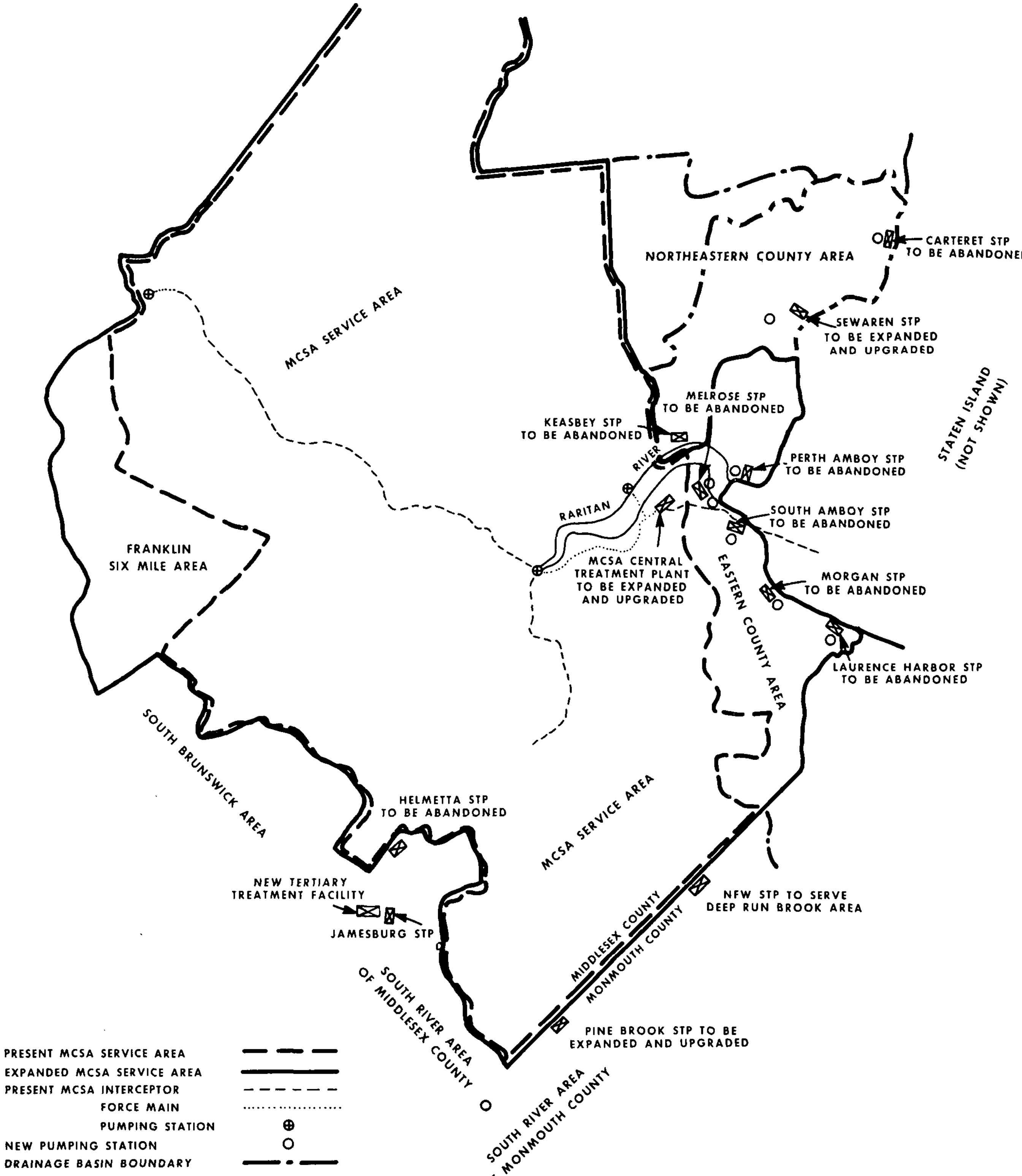


NOTES: (1) EXPANDED MCSA SYSTEM INTERCEPTORS OR FORCE MAINS NOT SHOWN
(2) MUNICIPAL CONNECTION SYSTEMS NOT SHOWN

Source: Metcalf & Eddy, October 1972

Figure 7

MCSA SYSTEM ALTERNATIVE 3



NOTES: (1) EXPANDED MCSA SYSTEM INTERCEPTORS OR FORCE MAINS NOT SHOWN
(2) MUNICIPAL CONNECTION SYSTEMS NOT SHOWN

Source: Metcalf & Eddy, October 1972

Figure 8

A summary of the average flows and loadings for alternatives 1, 2 and 3 is given in Table 5. Table 6 presents the estimated peak flows to each major facility and the planned future capacity of each facility.

BAYSHORE STUDY AREA

Water quality management plan alternatives within this area involve a series of regional treatment plants along the southern shore of Raritan Bay, with effluent disposal in either Raritan Bay or the Atlantic Ocean. Because of the low assimilative capacities of inland streams, treated wastewaters must be discharged to either the bay or the ocean.

There are three alternative plans for the Bayshore area. Alternative 1 allows continuation of present practices, i.e., discharging treated effluents into tributary streams or just off-shore into the bay. This practice would be permitted only as a temporary expedient until an acceptable alternative could be found. Alternative 2 calls for an outfall from each of the regional treatment plants extending into the bay to a point where the water depth is at least 20 feet. The third alternative requires construction of an outfall line parallel to the bay's shore line. The outfall line would collect the effluents from all regional sewerage systems and would discharge them into the Atlantic Ocean.

Both the BRSA and the Atlantic Highlands-Highlands Sewerage Authority have regional treatment plants under construction. The Township of Middletown Sewerage Authority (TOMSA) has a regional treatment plant in operation, with temporary discharge of effluent into Comptons Creek. In addition, an ocean outfall is being constructed by the MCBOOA.

TABLE 5

MCSA
SUMMARY OF ALTERNATIVE SEWERAGE PLANS
AVERAGE FLOWS AND LOADINGS

Treatment Plants 1/	1985 Avg. flow, mgd	1985 Effluent BOD 2/ lb/day	2000 Avg. flow, mgd	2000 Effluent BOD 2/ lb/day	Discharge Location
Alternative 1 (Recommended) 3/					
1. MCSA STP					
Design Project - Stage 1	114.5	42,900	162.8	61,100	
Future Additions 4/	28.6	6,100	41.9	9,500	
	142.1	49,000	204.7	70,600	Raritan Bay
2. Monmouth County STP (Plants @ Deep Run & Pine Brook)	7.7	1,600	17.1	3,800	South River
	149.8	50,600	221.8	74,400	
Alternative 2 5/					
1. MCSA STP					
Design Project - Stage 1	114.5	42,900	162.8	61,100	
Future Additions 4/					
Northeastern	20.9	4,700	27.2	6,200	
Eastern	2.3	500	3.5	800	
South River					
Middlesex County	3.1	600	6.1	1,300	
Monmouth County	7.7	1,600	17.1	3,800	
Franklin Six Mile	1.3	300	5.1	1,200	
Sub-Total	35.3	7,700	59.0	13,300	
Total	149.8	50,600	221.8	74,400	Raritan Bay
Alternative 3 6/					
1. MCSA STP					
Design Project - Stage 1	114.5	42,900	162.8	61,100	
Future Additions 4/	11.8	2,600	18.5	4,200	
Sub-Total	126.3	45,500	181.3	65,300	Raritan Bay
2. Sewaren STP	12.7	2,900	17.3	4,000	Arthur Kill
3. Monmouth County STP's 7/	7.7	1,600	17.1	3,800	South River
4. Jamesburg	3.1	600	6.1	1,300	South River
Total	149.8	50,600	221.8	74,400	

1/Does not include treatment plants which will be required in Millstone River area.
2/Estimated effluent BOD (5-day) following secondary treatment.
3/Under alternative 1, the existing treatment plants at Carteret, Keasbey, Sewaren, Perth Amboy, Melrose, South Amboy, Morgan, Laurence Harbor, Jamesburg and Helmetta would be abandoned by 1985.
4/MCSA will provide additional treatment capacity as required for any new future participants who enter into a service contract with the Authority. These may include Woodbridge, Carteret, Perth Amboy in the northeastern county area, and Helmetta and Jamesburg in the upper South River area.
5/Under alternative 2, the existing treatment plant at Pine Brook would be abandoned by 1985 in addition to those to be abandoned under alternative 1.
6/Under alternative 3, the existing treatment plants at Carteret, Keasbey, Perth Amboy, Melrose, South Amboy, Morgan, Laurence Harbor and Helmetta would be abandoned by 1985.
7/Flows from Master Sewerage Plan for Monmouth County (Killam Associates, 1966).

Source: Metcalf & Eddy, October 1972.

TABLE 6

MCSA
POSSIBLE SEWERAGE PLANS
PEAK FLOWS FOR MAJOR FACILITIES

Major Facility	Year 2010 Planned Capacity (mgd)	Year 2000 Peak Flow (mgd) For Alternative		
		1	2	3
Main Trunk Sewer	303	254	254	238
South River Interceptor	130	124	169	108
Sayreville Pumping Station	465	378	423	346
Sayreville Force Main	465	462	506	374
Outfall	600	504	551	430
Edison Pumping Station	109	73	73	31

Source: Metcalf & Eddy, October 1972.

DETAILED DESCRIPTION OF ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

The alternative courses of action summarized in the preceding section are described in detail below. Comparisons of the alternative water quality management plans for the lower Raritan River basin area and for the Bayshore area were presented in Tables 1 and 2, respectively.

LOWER RARITAN RIVER BASIN STUDY AREA
ALTERNATIVE I

Alternative 1, the proposed action, recommends expansion of the MCSA central treatment plant system's service area as shown in Figure 6. This alternative requires the construction of separate treatment facilities to serve the South River drainage area. The South River facilities will provide high degrees of treatment. After treatment, the effluent will be either discharged into tributary streams to maintain stream flow or used to replenish the ground water.

Service Area Additions

Under this plan, the MCSA central treatment plant system will be expanded in stages to include the following:

1. Present design service area for MCSA design project (120 mgd);
2. Additional area in northern Franklin Township (Six Mile Run);
3. South River area, including Jamesburg, Helmetta and part of Monroe Township (requires service contracts for Jamesburg and Helmetta);
4. Eastern county area of Madison Township (tributary to Laurence Harbor treatment plant);
5. Northeastern county area, including Perth Amboy, parts of Woodbridge and Carteret, and excluding the area served by

the Rahway Sewage Authority (requires service contracts with Woodbridge, Carteret and Perth Amboy).

Collection System

The capacities of the South River interceptor and the main trunk sewer, as well as the pump station and force main at Sayreville, will be expanded to handle peak flows expected in the year 2000.

Enlargement of the service area will require the construction of facilities to connect the newly incorporated areas with the MCSA system. Where possible, gravity interceptors will be used. However, flows from some areas will require pump stations and force mains. The major facilities to be provided in these areas are listed below.

1. Franklin Six Mile Area: No major facilities are required in the added area of northern Franklin Township. However, as this area develops, there will be a corresponding expansion of the existing collection system.

2. South Brunswick Area: The Lawrence Brook area of South Brunswick will be connected with the MCSA system via an interceptor in North Brunswick. This interceptor is now under construction.

Service contracts provide for a flow from South Brunswick to North Brunswick of up to 0.6 mgd. In addition, a recent service contract between Cranbury and South Brunswick provides for an interim discharge from Cranbury to South Brunswick of up to 0.3 mgd. This discharge could be conveyed to the MCSA treatment plant via North Brunswick.

3. South River Area of Middlesex County: The proposed improvements include facilities that will connect this area with the MCSA South River

interceptor. The plan requires a pumping station and a force main connecting Jamesburg and Helmetta to the MCSA South River interceptor at Old Bridge. Service contracts among MCSA, Helmetta and Jamesburg will be required prior to implementation of the plan. The existing sewage treatment plants at Jamesburg and Helmetta will be replaced by new pumping stations.

4. Eastern County Area: Interceptors, pump stations and force mains will connect the three existing plants in Morgan, Melrose and South Amboy to the MCSA regional treatment facility as part of the South Bay system. New force mains and gravity interceptors will connect Morgan and South Amboy to the MCSA plant, and Melrose to either the South Amboy line or directly to the MCSA plant. The three treatment plants are scheduled to be abandoned and replaced by new pumping stations.

The area in eastern Madison Township that is tributary to the existing Laurence Harbor treatment plant will be added to the MCSA system in the future. The Laurence Harbor plant will be replaced by a new pumping station. One plan proposes that the area be connected to the MCSA South River interceptor through the existing system in Madison. This plan would require a pump station at the treatment plant and a force main to the existing system near Cheesequake Creek. The area could also be connected to the MCSA facilities via the South Bay collection system through South Amboy. A final decision on the routing has not yet been made.

5. Northeastern County Area: The plan requires that Perth Amboy be connected to the regional MCSA facility. Perth Amboy's existing treatment facility will be abandoned and replaced by a pumping station. Sewage

flows will reach the MCSA central treatment plant via either South Amboy or Keasbey.

The plan also requires that Woodbridge's treatment plants at Keasbey and Sewaren be abandoned. Likewise, Carteret's treatment plant will be abandoned. A new pumping station will be constructed at Carteret and the existing pump station at Sewaren will be expanded. Force mains and gravity interceptors will connect Carteret, Sewaren and Keasbey to the Edison pump station.

In November 1971, the municipalities of Woodbridge, Carteret and Perth Amboy were ordered by the New Jersey Department of Environmental Protection to join the MCSA system. As of November 1972, service contracts with the MCSA had not been executed.

6. Rahway Valley Sewage Authority System: The Rahway Valley Sewage Authority will continue to serve the portion of Woodbridge Township that is already connected to the Rahway system. However, no additional flows will be accepted. Improvements that will provide secondary treatment are currently under construction at the Rahway system's treatment plant.

Treatment System

The MCSA regional treatment plant, which currently provides primary treatment, will be upgraded to provide secondary treatment. The high-purity oxygen modification of the activated sludge process will be used. The completely mixed activated sludge process, trickling filters and physical-chemical treatment were eliminated from consideration because of their relatively high cost and unreliability.

Table 7 outlines the design flows and loadings for the treatment plant. Facilities are designed to remove an average of 90 percent BOD and suspended solids. Disinfection will be provided through chlorination of the final effluent.

The proposed treatment facilities will be located adjacent to the existing plant on land acquired by the MCSA. The plant design includes:

Three aerated grit chambers - 11.0 minutes detention time 1/;

Six primary sedimentation tanks - 2.8 hours detention time;

Four oxygenation tanks with four stages per tank - 3.6 hours detention time without recirculation and 2.7 hours with recirculation;

Two aerobic digestors - 8.4 days detention time;

Twelve final settling tanks - 4.5 hours detention time, with six existing tanks being converted to final settling tanks to provide additional capacity;

Eight sludge thickening tanks - in addition to the two existing tanks;

Two sludge storage tanks -in addition to the four existing tanks to provide 10 days storage at 4.5 percent solids;

Six chlorination units-capable of administering 48,000 lb/day of chlorine.

1/All detention times are based upon a 120 mgd flow.

TABLE 7

MCSA
PRIMARY AND SECONDARY TREATMENT FACILITIES
DESIGN CRITERIA

	Initial	Design	Future
Flow - mgd			
Average annual	78	120	240
Maximum day	172	264	528
Peak (maximum hour)	195	300	600
Minimum hour	45	55	-
Suspended Solids			
Primary influent, mg/l	310	310	310
Loading, 1,000 lb/day			
Annual average	202	310	620
Maximum day	424	650	1,300
Maximum, 3-day average	333	510	1,020
Maximum, 17-day average	236	363	726
Maximum month, average	232	356	712
Biochemical Oxygen Demand (5-day)			
Primary influent, mg/l	450	450	450
Loading, 1,000 lb/day			
Annual average	293	450	900
Maximum day	470	720	1,440
Maximum, 3-day average	419	643	1,286
Average, 3-midweek days	322	495	990

Source: Metcalf & Eddy, October 1972.

In addition, an oxygen generation facility, operations building, process water building, vehicles and equipment maintenance building, trunk system maintenance building and several pumping stations will be constructed. The existing electric substation will be greatly expanded.

Plant layout allows for expansion at the site to an ultimate capacity of 240 mgd. Modular construction will be used to facilitate future plant expansion. Additional plant units will be provided as required.

The design capacity of the upgraded treatment plant is 120 mgd. The service area for this facility will generate an estimated 1985 flow of 114.5 mgd. The service area includes:

Present Participant	Est. Avg. 1970 Flow(mgd)	Est. Avg. 1985 Flow(mgd)
Industrial	10.26	17.32
Bound Brook	0.95	1.23
East Brunswick	2.31	6.83
Edison	8.29	14.89
Franklin (part)	1.10	4.13
Highland Park	1.93	1.86
Madison (part)	2.67	6.89
Metuchen	1.65	2.23
Middlesex	1.69	2.12
Monroe (part)	0.14	0.54
New Brunswick (including Milltown)	12.71	11.98
North Brunswick	3.52	6.55
Piscataway	4.25	7.44
Plainfield Joint Meeting	9.83	11.22
Sayreville (part)	2.72	5.44
South Bound Brook	0.36	0.46
South Plainfield	1.62	4.23
South River	1.62	2.40
Spotswood	0.31	1.10
New Areas		
Sayreville (part)		
Melrose	1.13	0.52
Morgan	0.38	1.16
South Amboy	0.80	1.31
South Brunswick		
Lawrence Brook	0	2.66
TOTAL	69.24	114.51

During 1974 (proposed completion date for the MCSA facility) and 1975, the following areas will join the MCSA system:

Participant	Est. Avg. 1970 Flow(mgd)	Est. Avg. 1985 Flow(mgd)
Carteret	2.99	4.29
Perth Amboy	6.00	8.25
Woodbridge		
Keasbey	1.20	1.89
Sewaren	4.20	6.47
Madison (part)	0.55	2.28
Helmetta	0.03	0.18
Jamesburg	0.30	0.51
Monroe (part)	0	2.37
Franklin		
Six Mile Run	0	1.26
TOTAL	15.27	27.50

When the projected flows from these municipalities are added to the projected flows from municipalities already within the MCSA system,the average daily flow for 1985 becomes about 140 mgd. This is approximately 20 mgd more than the plant's design capacity. In all probability, the design capacity of the upgraded MCSA treatment plant will be reached sometime before 1985.

There are basically two ways of providing for these increased flows.

1. Increase plant capacity: The oxygenation system has been designed on the conservative basis of an average BOD loading of 160 lb. per 1000 cubic feet of oxygenation tank volume. It is believed that the system can operate satisfactorily at average loadings of 215 lb. per 1000 cu. ft. Hydraulic capacity and dissolution equipment of the oxygenation tanks have been designed to permit this optimization. Should the system prove incapable of handling these higher loadings, the aerobic digesters can be easily converted for use as secondary oxygenation tanks.

Additional facilities, such as sedimentation tanks, will be required when sewage flows exceed 120 mgd. These facilities will be provided in the second stage of plant expansion (see "Implementation", p.38).

Approval of the Interim Basin Plan for the lower Raritan River drainage basin, IBP-NJ-33-40, is subject to the following condition:

> "When the proposed Perth Amboy, Carteret, Woodbridge, and other second stage municipal tie-ins are carried out prior to the second stage expansion (to 160 MGD) provisions are to be made to insure that the system will have adequate capacity to carry and treat these flows and that the connection of these municipalities will not cause a contravention of Water Quality Standards." (Hansler, written communication, 1973).

Therefore, flows beyond the original design expectations will receive satisfactory treatment.

2. Decrease loadings: The passage of the pretreatment bill in New Jersey and of the Federal Water Pollution Control Act Amendments of 1972 (FWPCAA) will result in the regulation of industrial discharges to municipal sewerage systems. Section 307 (b) of the FWPCAA 1972 will require removals of those pollutants which are either: 1) not susceptible to treatment by the municipal system or 2) capable of interfering with the operation of municipal treatment works. Regulations establishing these pretreatment standards are scheduled to be published by the EPA administrator by April 16, 1973. Compliance with the standards must be accomplished within three years of the date of promulgation. As a special condition of its grant to the MCSA, EPA required that the MCSA:

> ". . . adopt the necessary pretreatment requirements for wastes entering into its sewerage facilities as set forth in the rules and regulations to be promulgated and pretreatment guidelines to be issued by EPA in accordance with the Federal Water Pollution Control Act Amendments of 1972." (U.S. EPA, 1972).

Decreased flow rates can be expected in the future as infiltration and storm water inflows are eliminated. Some of the special conditions enumerated in EPA's grant to MCSA are:

"Special Grant Conditions - The Grantee agrees to perform the following:

a. The Grantee shall assert all reasonable efforts to assure that each participating municipality will:

(1) Adopt a resolution setting forth its agreement to study the infiltration and storm water problems associated with its sanitary sewerage system, which study is to be completed within 18 months from execution of this grant agreement. The study report, outlining the problems and setting forth implementation schedules for eliminating all sources of extraneous flows, is to be submitted to the MCSA and NJSDEP;

(2) proceed with any necessary corrective work in accordance with the approved implementation schedules resulting from the infiltration and storm water problem study;

b. The Grantee shall assert all reasonable efforts to assure that the City of New Brunswick will adopt a resolution setting forth its agreement to study the combined sewer system within the City, to identify alternative corrective programs, to select the most cost effective solution in compliance with the requirements of the NJSDEP and the EPA, and to establish an acceptable schedule for implementing the most desirable alternative. The report of such study, outlining a corrective program and implementation schedule, is to be submitted to the MCSA and the NJSDEP within 18 months from execution of this grant agreement." (U.S. EPA,1972).

Outfall

In a letter, dated December 20, 1972, to EPA's Water Programs Branch, the New Jersey Department of Environmental Protection made the following comments in response to the question: "What is the status of the MCSA outfall line?"

"At this time the decision as to the ultimate method of effluent disposal for MCSA has not been made. Detailed environmental, economic, scientific and technical studies will be conducted considering a number of alternatives before a decision is made. These studies should consider a range and combination of alternatives including, but not limited to:

1. Construction of a new outfall line to provide for a 25 year design flow of 240 MGD and a 25 year peak flow of 600 MGD. Alternative locations for the outfall:

   a. A relief outfall to the present discharge location. The estimated cost of this alternative is $23,000,000. The line will extend 1.25 miles into Raritan Bay. However, it is quite unlikely that this location will produce the required dilution of 50:1 seawater to sewage, and the site has a depth to mean low tide of only 10 feet.

   b. Relocation of discharge to a more suitable location in Raritan Bay. This line would extend approximately 6.75 miles from the shoreline and lie more than 20 feet below mean low tide. This site would probably provide a dilution of 50:1 seawater to sewage. A preliminary cost estimate of this alternative is $115,000,000.

   c. Relocation of discharge to the Atlantic Ocean beyond Sandy Hook. This line will require a 15 mile extension. Its location will provide the required dilution (50:1). A preliminary cost estimate of this alternative is $328,000,000.

   d. Discharge to the Raritan River. This alternative would require an advanced wastewater treatment plant to be constructed at the site of the MCSA facility if water quality is to be maintained in the Raritan River. A preliminary cost estimate of the outfall alone is $10,000,000.

2. Develop new approaches for reducing the quantity of wastewater for Raritan Bay disposal. This may be achieved by exploring potential wastewater reuse schemes. Ground water recharge, industrial recycling and industrial use of treated effluent should be considered." (Pike, written communication, December 1972).

The effects of discharging treated effluent through the present outfall were evaluated (Appendix D). On the basis of that evaluation, the following special grant conditions were imposed upon the MCSA:

"d. Since the Interim Basin Plan for the MCSA service area indicates that the existing point of discharge will contravene Water Quality Standards and preliminary analysis by the EPA indicates that there are other areas in Raritan Bay which are suitable for the outfall location and will not contravene Water Quality Standards, an appropriate outfall location will be selected by the Grantee.

"g. In addition to the right of EPA to withhold up to ten percent (10%) of the EPA grant funds pending proper completion of the approved project work, said retainage may be withheld until the Grantee:

(2) initiates construction of the extended outfall at a proper location in Raritan Bay . . . ." (U.S. EPA, 1972).

Implementation

Construction of the required MCSA facilities will be accomplished through three separately funded projects: 1) the treatment plant, 2) the interceptor system, and 3) the outfall. A detailed engineering design for the MCSA wastewater treatment plant has been completed. Preliminary designs for expansion of the MCSA trunk system, including the major trunk sewer, South River interceptor, Sayreville pump station and Sayreville force main, have been completed as have the preliminary designs for the outfall. Final design of these facilities has been authorized by the MCSA (Metcalf & Eddy, October 1972).

Expansion of the treatment plant will be accomplished in three stages.

Stage 1: Plant units constructed during this stage will allow treatment of an average flow of up to 120 mgd. The plans and specifications for this project are complete.

Stage 2: The addition of two primary and four secondary settling tanks, along with some equipment modifications in the oxygenation system, will increase the treatment capacity to an average annual flow of 160 mgd. This 160 mgd capacity will allow for a 10 year design life from the date that expansion is completed.

Stage 3: The construction of four more primary settling tanks, two oxygenation tanks and eight final settling tanks will increase the treatment capacity to the future design flow of 240 mgd. Additional components will be identical in design to the original structures. (Metcalf & Eddy, October 1972).

In addition to increasing the treatment plant's capacity, Stage 2 construction will expand the collection system. During Stage 2, interceptors, force mains, pumping stations and concomitant facilities will be constructed to convey sewage to the MCSA plant. Stage 2 construction will occur between 1975 and 1985.

Additional outfall capacity is to be provided during Stage 1 construction. Final design of the outfall facilities has been authorized by the MCSA. Design will be based on an estimated peak future flow of 600 mgd, or 250 percent of the average future flow of 240 mgd.

Two separate treatment facilities will serve the South River drainage area of Monmouth County.

1. The Pine Brook treatment plant will be expanded to 6.0 mgd. The plant will also be upgraded to provide advanced waste treatment with disposal of effluent to local streams or land. In addition to wastewaters generated within its own drainage basin, the Pine Brook plant will treat wastewaters originating in the Manalapan Brook area. This area will be served by a force main and a pumping station with a 0.5 mgd capacity.

2. A new treatment facility may be built in the Deep Run Brook area to serve Marlboro Township. This facility would provide advanced waste treatment. The effluent would be either discharged to streams or used in a land disposal operation. Construction of this project would begin sometime after 1980. Flows to the plant would be on the order of 1.5 mgd in 1985 and 2.5 mgd in 2000. An alternate to this plan would be the provision of facilities to pump the sewage from Marlboro Township to the Pine Brook treatment plant.

LOWER RARITAN RIVER BASIN STUDY AREA
ALTERNATIVE 2

As shown in Figure 7, alternative plan 2 maximizes the MCSA central treatment plant service area to include all of the lower Raritan River basin study area plus that natural drainage to the South River originating in Monmouth County. Under this plan, eleven existing treatment plants will close by 1985.

Collection System

The capacity of the existing MCSA collection system will be enlarged to allow: 1) increased flows from the existing service area resulting from increases in population and water use, and 2) flows from new municipal members of the MCSA. The capacity will be designed to handle flows for the year 2000.

Treatment System

Secondary treatment must be provided to meet water quality standards in Raritan Bay. The treatment system will be the same as that described for alternative 1. Of necessity, the average design capacity for alternative 2 will be 7.7 mgd greater in 1985 than that for alternative 1 and 17.1 mgd greater in 2000. This additional capacity will allow treatment of the flows from the Matchaponix, Deep Run and Manalapan Brook areas in Monmouth County.

Outfall

The design capacity of the outfall for this alternative is the same as that for alternative 1.

LOWER RARITAN RIVER BASIN STUDY AREA
ALTERNATIVE 3

According to alternative 3, the existing MCSA central treatment plant service area will undergo minimal expansion; adjacent areas will be required to provide their own treatment. Figure 8 indicates the area to be served by the MCSA system and the facilities in outlying areas which will have to be upgraded, expanded or replaced. Areas excluded from the MCSA central treatment plant service area under alternative 3 are:

1) Carteret
2) Keasbey and Sewaren
3) All areas of Monmouth County
4) Manalapan Brook drainage area within Middlesex County upstream of the existing MCSA sewered area
5) All of South Brunswick, including the Lawrence Brook watershed.

Other areas to be included in the MCSA system under this alternative are: the Six Mile Run area of Franklin Township, Perth Amboy, South Amboy, Morgan, Melrose and Laurence Harbor. Existing treatment plants serving these areas will be abandoned. The portion of Monroe Township that is tributary to MCSA will remain so.

Sewerage Systems

This alternative calls for six separate sewerage systems to collect and treat all wastewaters within the lower Raritan River basin study area.

Middlesex County Central Treatment Plant System

The areas contributing to this system are shown in Figure 8. The flows and loadings to the central treatment plant are given in Table 5. Expansion of trunk sewer lines and pumping stations will be required to handle flow increases. The treatment plant will be expanded and upgraded as in alternative 1, except that its future capacity will be less than that required by alternative 1.

Sewaren Sewerage System

An inter-municipal treatment facility will be built at Sewaren to handle the combined flows from the Keasbey and Sewaren Plants in Woodbridge, and from the Carteret wastewater treatment plant. The effluent will be discharged into the Arthur Kill. The concept of a treatment plant at this location includes: 1) tertiary treatment facilities to provide an effluent suitable for industrial water reuse and 2) sludge incineration.

Sewerage Systems for The South River Drainage Basin

Three separate facilities will be provided. Sewage generated within the South River drainage basin (including the Manalapan Brook natural drainage area), but outside of the existing MCSA service area will be treated at a tertiary treatment facility in the Jamesburg area. Sewage flows from this area are projected to be 3.1 mgd in 1985 and 6.1 mgd in 2000. The existing Helmetta plant will be abandoned.

The portion of the South River drainage area which is in Monmouth County will be served by two tertiary treatment plants located at the Middlesex-Monmouth County line (as described under alternative 1). These plants will discharge their effluents into the Deep Run and Matchaponix Brooks, both of which are tributary to the South River. Together, the plants will have a total flow of 11.2 mgd in 1985 and 23.8 mgd in 2000.

Sewerage System for The South Brunswick Area

The South Brunswick area in the Lawrence Brook drainage basin will be served by a regional facility near Plainsboro. The effluent will be discharged into the Millstone River. A higher degree of treatment will be required at this plant in order to maintain in-stream water quality.

Implementation Plans

The recommended implementation plan for this alternative is the same as that described for alternative 1. Major collection systems will be constructed or expanded during Stage 1 or Stage 2. All major structures will be designed for the peak flow after the year 2000. Where feasible, structures will be designed so that equipment can be added as required to maintain flows.

LOWER RARITAN RIVER BASIN STUDY AREA
ALTERNATIVE 4

Under this alternative, no changes will be effected in the existing system. The sewerage facilities will remain essentially as shown in Figure 2. Many of these facilities have either reached design capacity or will do so in the near future.

Collection System

The existing sewer systems and drainage basin delineations are shown in Figure 9 . Many of these systems are overloaded and cannot handle peak flows. Conditions will deteriorate rapidly due to increased development within the basin.

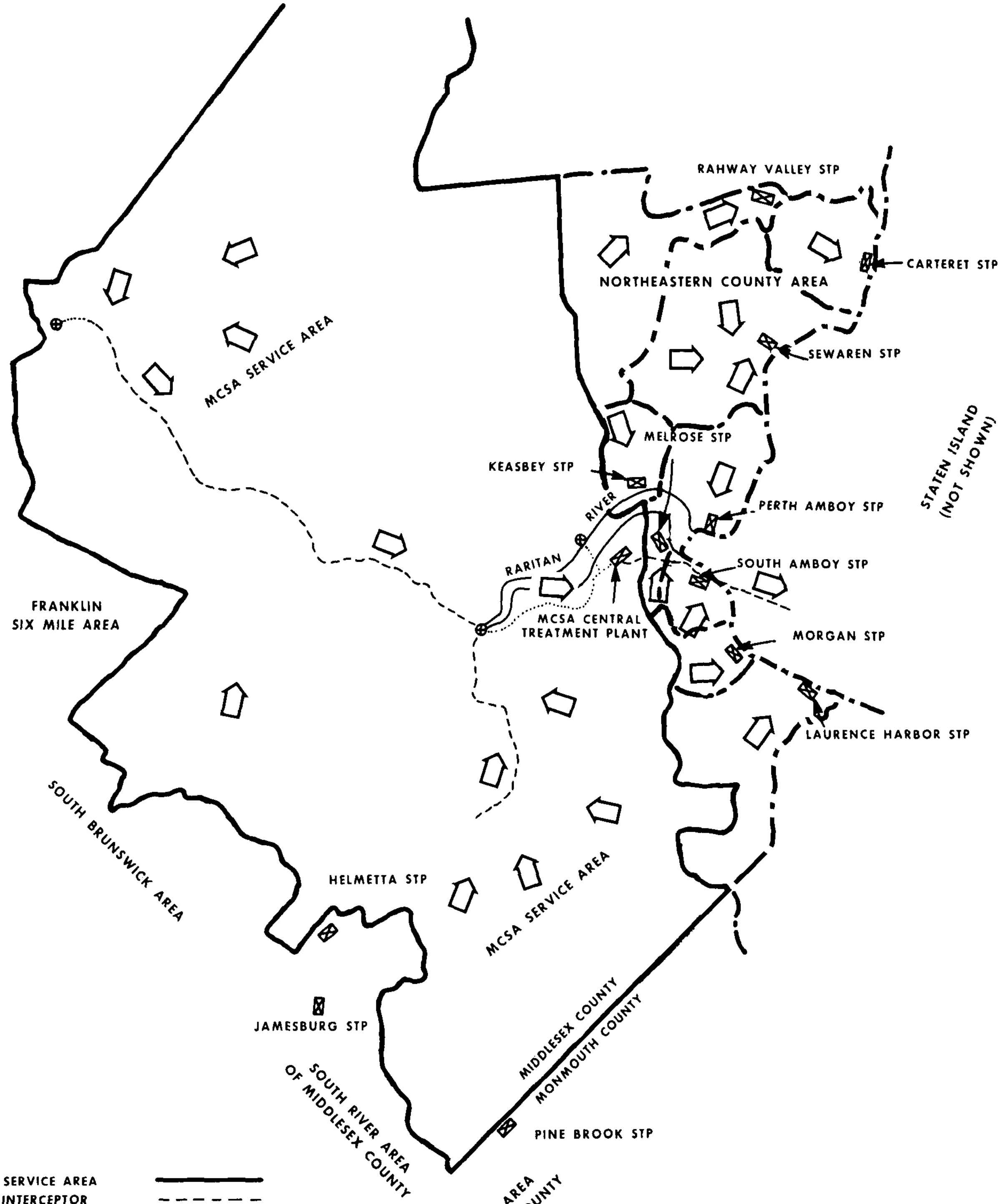
Treatment System

The MCSA central treatment plant, with its average design flow of 78 mgd, was overloaded by the average daily flow of 78.4 mgd for a nine month period of 1972. Continued growth in the MCSA service area will result in frequent sewage bypassing at the present facilities.

Furthermore, the existing treatment facilities are inadequate. None of the treatment plants within the lower Raritan River drainage basin produce effluents which meet current regulatory effluent standards.

Reduction of pollution loads entering Raritan Bay is required to meet the orders of the state of New Jersey. This reduction cannot be achieved without upgrading and expanding the existing treatment plants. Therefore, a no-action plan is unacceptable.

MCSA SYSTEM ALTERNATIVE 4



PRESENT MCSA SERVICE AREA
PRESENT MCSA INTERCEPTOR
FORCE MAIN
PUMPING STATION ⊕
BOUNDARIES OF MUNICIPAL SEWERED AREAS

NOTES: (1) MUNICIPAL COLLECTION AND DISPOSAL SYSTEMS NOT SHOWN
(2) MUNICIPAL CONNECTIONS TO MCSA SYSTEM NOT SHOWN
(3) ARROWS (⇨) INDICATE GENERAL DIRECTION OF WASTEWATER FLOWS

Source: Metcalf & Eddy, October 1972

Figure 9

BAYSHORE STUDY AREA 1/
ALTERNATIVE 1

The numerous treatment plants in the Bayshore area will be expanded and upgraded as necessary. The effluents from these plants will be discharged into inland streams or just off-shore into Raritan Bay. As indicated in Figure 5, there are now thirty-two wastewater treatment facilities within the study area. Several of these plants are currently discharging to the TOMSA's regional system. Others will join the BRSA's system in the future.

The alternative of employing many separate treatment plants is not considered desirable. It is contrary to the concept of regionalization as promulgated by the New Jersey Department of Environmental Protection and by the federal government. The multiple plant option will be permitted only until an acceptable alternative plan can be implemented (NJDEP, 1971).

BAYSHORE STUDY AREA
ALTERNATIVE 2

This alternative adheres to the concept of regionalized treatment of domestic wastewaters. Several large treatment plants will be provided along the southern shore of Raritan Bay. Two regional facilities will be required for the Bayshore study area: one in Union Beach and another in

1/As previously indicated, alternative 3 has already been adopted. Construction is proceeding on both the sewage treatment plant and the outfall. Therefore, this discussion of alternatives is for information purposes only. It recounts the available options and presents the rationale for choosing alternative 3.

Middletown near Belford. The Union Beach facility, which is currently under construction, is owned by the BRSA; the Middletown treatment plant is owned and operated by the TOMSA.

Under alternative 2, each of the regional plants will have its own outfall in Raritan Bay (see Figure 10). These outfalls will extend far enough into the bay to allow the discharge of treated effluent into 20 feet of water depth. This water depth is required to provide maximum dilution of the treated effluent. Providing separate bay outfalls for Middletown and Union Beach appears to be the most advantageous and economical means of effluent disposal under this alternative. (NJDEP, 1971).

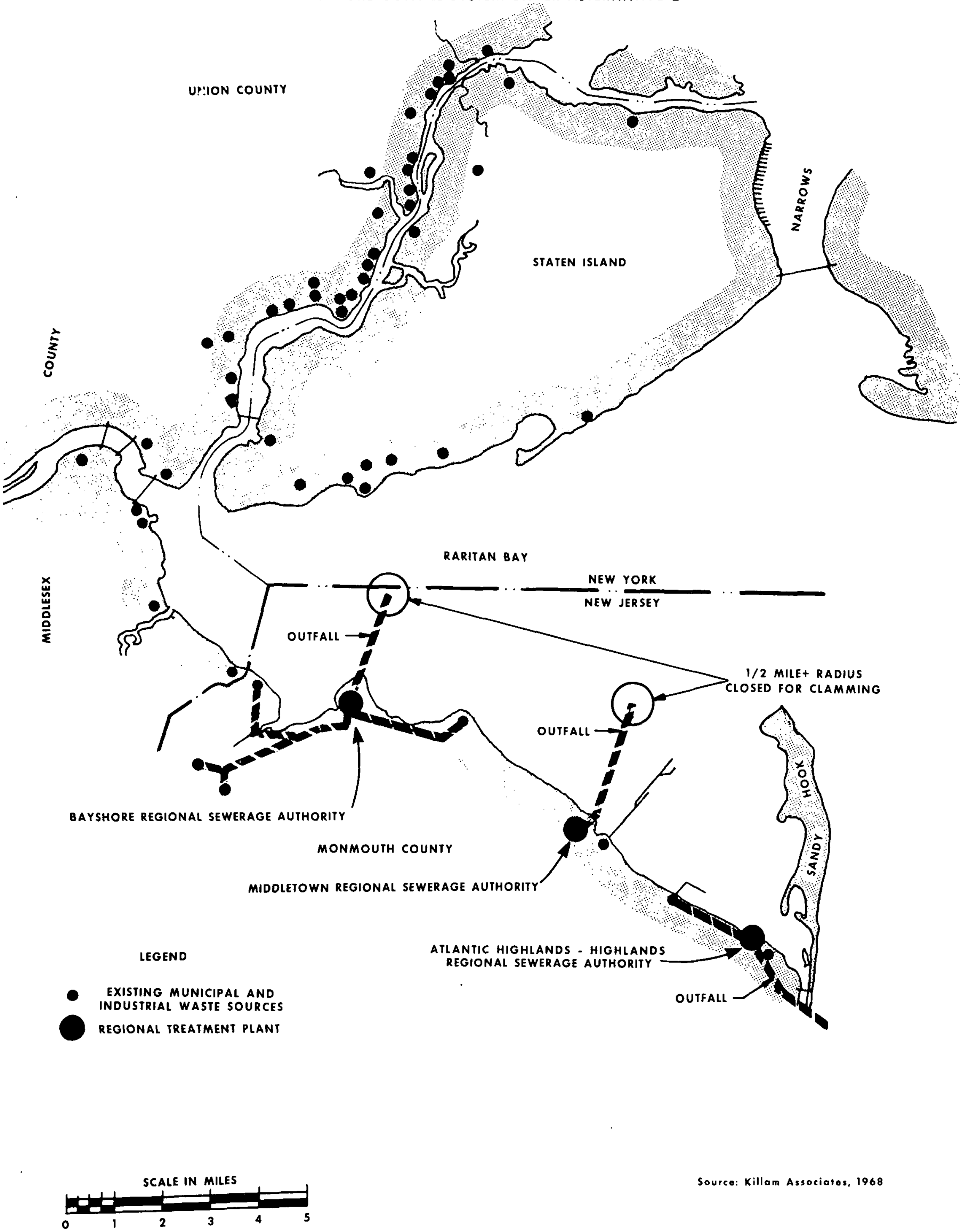
BAYSHORE STUDY AREA
ALTERNATIVE 3

With respect to the collection and treatment of wastewaters from the study area, alternative 3 is identical to alternative 2. Two regional systems will serve the entire area. With respect to effluent disposal, however, the alternatives differ. Alternative 3, unlike alternative 2, calls for an ocean outfall (See Figure 11). This alternative is favored by the New Jersey Department of Environmental Protection for the following reasons:

"1. The Bayshore outfall feasibility study showed the cost-effectiveness of four Raritan Bay discharges into 20 feet of water, as opposed to building one outfall line to the ocean to serve all northern Monmouth County discharges. 1/

1/The study showed the bay outfalls to be more cost-effective than the ocean outfall by $200,000. However, environmental factors were not taken into account.

BAYSHORE OUTFALL SYSTEM UNDER ALTERNATIVE 2



Source: Killam Associates, 1968

Figure 10

BAYSHORE OUTFALL SYSTEM UNDER ALTERNATIVE 3

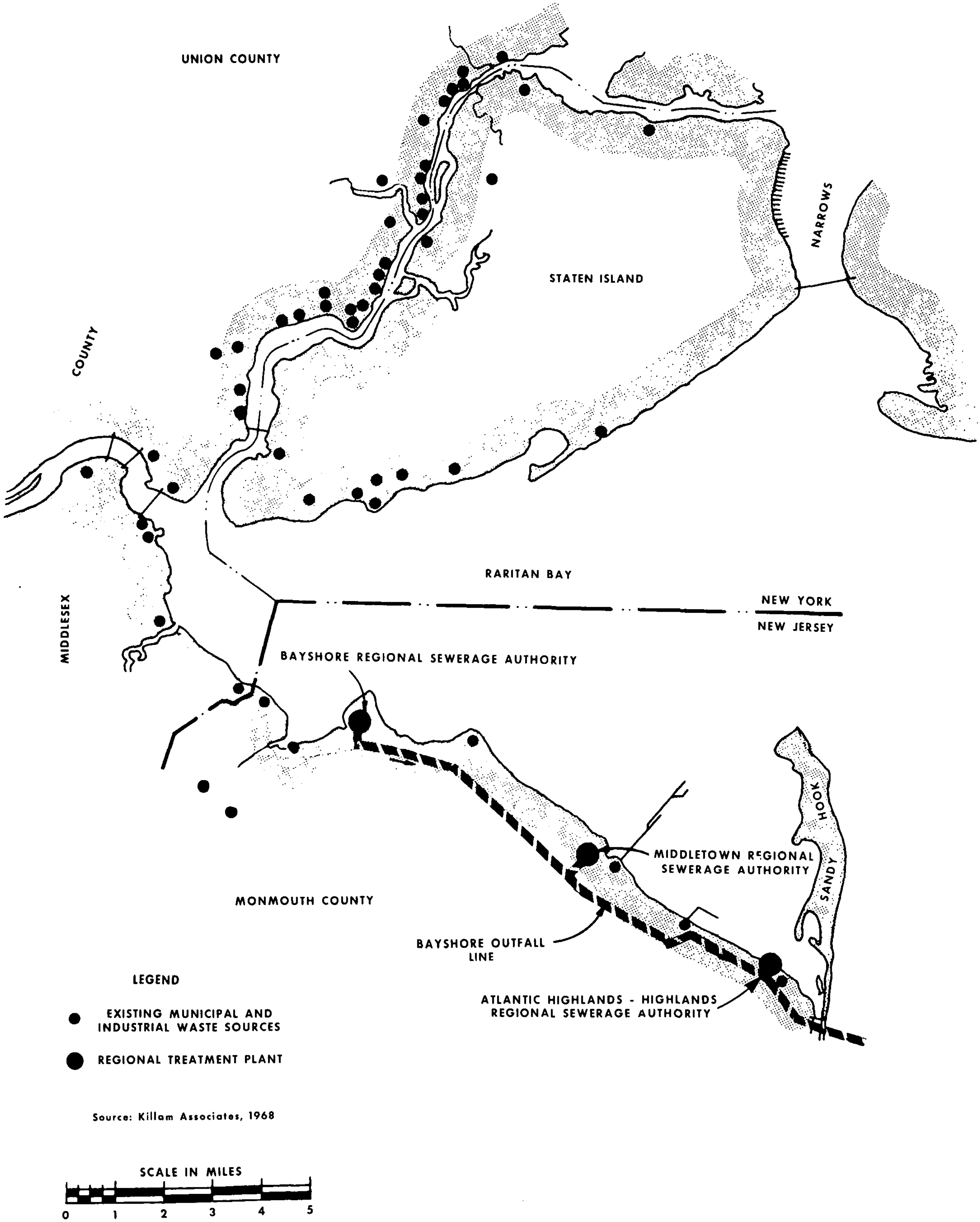


Figure 11

"2. Diversion of wastewaters to the Atlantic Ocean from Monmouth County will bring about maximum improvement in Raritan Bay water quality, and will conform to the State's overall plan for wastewater management in northern Monmouth County. Northeast Monmouth County Sewerage Authority has been required to divert its discharge from the Shrewsbury River to the Atlantic Ocean, thus improving water quality in the Navesink-Shrewsbury estuary and reducing the pollutional load on Sandy Hook Bay. Participation in the Bayshore Outfall by Atlantic Highlands-Highlands Regional Sewerage Authority, Middletown Township Sewerage Authority and Bayshore Regional Sewerage Authority compliments this strategy at a cost comparable to the Raritan Bay alternative.

"3. The Bayshore Outfall may serve in the future as a homogeneous source of treated wastewater which may be reused for lower water use applications with or without additional treatment, as the individual situation dictates. It is important to note that wastewater may be drawn off at any point along the alignment of the outfall, and at a rate determined by the need. The long-range flexibility offered by this option is a significant factor favoring the ocean outfall concept and is in conformance with the spirit of the new federal water pollution law.

"4. Advanced wastewater treatment with effluent wastewater disposal in the near shore Raritan Bay waters is not considered to be a suitable alternate at the present time for Bayshore communities. This alternative has the following disadvantages:

a. It would encourage the creation of small wastewater management service areas which would operate independent of one another.

b. Areawide coordination and management of the wastewater resources from several agencies would be difficult to accomplish because of jurisdictional independence and the small quantities of wastewater available at each site.

c. A series of Raritan Bay outfalls lacks the flexibility of the Bayshore Outfall. Advanced wastewater treatment facilities would have to be built at each location in order to accomplish reuse in the future. Since reuse requirements have not been established for the wastewater, the treatment processes required for reuse cannot be specified at this time. In addition, advanced wastewater treatment technology will improve in the future. For these reasons, it is desirable to delay construction of Advanced wastewater treatment systems if suitable and cost-effective alternatives exist for meeting water quality standards.

"5. The Bayshore Outfall Authority has the advantage of bringing the management of the wastewater resource under the control of a County Authority which is responsive to the needs of all of the residents of Monmouth County. It also creates an areawide institution which could sponsor subsequent wastewater reuse projects." (Pike, written communication, December 1972).

MONMOUTH COUNTY BAYSHORE OCEAN OUTFALL AUTHORITY (MCBOOA)

The MCBOOA was formed to construct and operate an ocean outfall to serve the Bayshore area of Monmouth County.

The outfall line, which is under construction, will provide an outlet for each of the proposed regional treatment plants or the existing plants. It will function as a force main. The line will be about 80,000 feet long and, generally following the alignment of the New Jersey Central Railroad, will traverse the Bayshore communities. It will begin in the vicinity of Union Beach, extend to Highlands, and cross under the Shrewsbury River to Sandy Hook. The outfall portion of the line will extend approximately 3,300 feet into the ocean where the water depth is about 25 to 30 feet.

ENVIRONMENTAL IMPACT OF THE PROPOSED PROJECTS

The proposed projects have both environmental and socio-economic implications. Environmental considerations include the effects on aquatic and terrestrial ecosystems caused by 1) construction, and 2) operation of the facilities. Socio-economic impacts are generally of a secondary nature: for example, changes in population, land use patterns, water supply, energy sources, transportation and solid wastes. The primary and secondary environmental impacts of the proposed projects are discussed below.

MIDDLESEX COUNTY SEWERAGE AUTHORITY PROJECT

Environmental Impact Of Construction

Proper design and construction of the MCSA project will lessen the potential for detrimental environmental effects. Nevertheless, steps must be taken to insure against environmental destruction. One of these steps will be the strict enforcement of the Contract Specifications, especially those sections dealing with specific procedures for minimizing detrimental effects and for restoring any areas damaged during construction.

The Stage 1 construction consists of upgrading the existing treatment plant to provide secondary treatment and expanding it to a capacity of 120 mgd. During construction, the impact on the aquatic environment should be limited to the effect of silt loads being carried by surface water runoff. Detention ponds at the site will be used to collect runoff. This will allow sedimentation of the silt load to occur prior to discharge of the runoff water into the Raritan River. In addition, contractors will be required to institute effective temporary erosion control measures.

Federal guidelines (FWQA, 1970) require continuation of the same degree of treatment by the existing plant during the alteration period. If this is not feasible, a minimum of primary treatment and disinfection shall be provided at all times. The bypassing of raw sewage during the construction of additions shall not be allowed. The construction schedule for this project allows continuation of primary treatment while the plant is being expanded and upgraded.

Both during and after construction, the MCSA treatment plant project should have a minimal effect on the terrestrial environment. Some dust may be expected to result from construction activities; however, this will not be a significant problem. The main access road at the treatment plant site is paved; this will reduce dust generation caused by ingress and egress of traffic at the plant. The contractors are required to provide and maintain temporary roads and to take adequate measures to control dust during construction periods.

Environmental Impact Of Operation

Treated municipal waste discharges commonly contain four constituents which, when present in sufficient quantities, can impair estuarine water quality. These constituents are: 1) organic matter, 2) pathogenic organisms, 3) dissolved solids, and 4) suspended solids.

In general terms, the organic matter remaining in the effluent after treatment can undergo decomposition in the estuary, exerting a demand on the dissolved oxygen of the receiving water. This demand can result in depletion of the dissolved oxygen in the discharge area. At times of inadequate chlorination, human pathogens may prevent the use of the receiving water for recreation and shellfishing.

Dissolved solids may be present in concentrations sufficient to affect the salinity of the receiving water. However, unless the amount of industrial waste is excessive, the dissolved solids entering the estuary are not likely to be significant. Of greater significance is the presence of nitrates and phosphates. High concentrations of these nutrients will encourage nuisance growths of algae and marine plants. Toxic materials may also be present in the dissolved solids portion of the effluent.

Sufficiently high quantities of suspended solids can reduce the depth of light penetration. Furthermore, suspended solids can clog the gills or similar transfer membranes of aquatic organisms.

Each of these four constituents will be present to some degree in the effluent from the MCSA treatment plant. Among other things, the following describes the anticipated effect of these constituents on the waters of Raritan Bay.

Organic Matter

At a flow of 72 mgd and an average effluent BOD (5-day) of 400 mg/l, the MCSA plant is currently discharging 240,000 lb BOD (5-day)/day into the western end of Raritan Bay. This discharge is the major source of pollution in the area (FWPCA, 1967).

The proposed project should reduce the effluent BOD (5-day) to 50 mg/l with an associated bay loading of 32,600 lb/day in 1975. However, as the plant approaches its capacity (120 mgd), the BOD (5-day) loadings will rise to 50,000 lb/day. Metcalf & Eddy (1969) report that the bay can assimilate 100,000 lb BOD (5-day, 20^{o}C)/day and still maintain a 50 percent saturated dissolved oxygen content or 3.5 mg/l dissolved oxygen. This would allow retention of the present outfall location.

This statement is based on the following assumptions:

1. 90 percent BOD removals will be effected at all times;
2. water quality standards will require 3.5 mg/l dissolved oxygen or 50 percent saturated dissolved oxygen content.

The second assumption is no longer valid. If the water quality standards are revised, as recommended by the FWPCAA 1972, the minimum acceptable dissolved oxygen level in Raritan Bay will be 5.0 mg/l.

In order to determine the degree of contravention of water quality standards that would be brought about by the discharge from the MCSA treatment plant, a model study of Raritan Bay was conducted by Region II, EPA. This study is included as Appendix D.

A general description of the Raritan Bay system, as it relates to this study, is included in Appendix A. The present waste sources affecting the systems are also enumerated. It is important to note that the MCSA discharge represents by far the largest point source discharge within the Raritan Bay system. The estimated 240,000 lb/day BOD (5-day) and 405,000 lb/day ultimate oxygen demand (UOD) account for approximately 90.4 percent and 89.4 percent of the total load of each respective constituent discharged into the bay from all known point sources. The actual MCSA discharge site is located approximately 1,000 feet south of Great Beds Light. It is unique in that a dredged dispersion basin has been provided to a depth of 35 feet in an otherwise shallow region, averaging about 9.0 ft. mean sea level (MSL) depth. The MCSA discharge in conjunction with the second major point source, the discharge from the City of

Perth Amboy, represents over 96 percent of the total BOD (5-day) loading to the Raritan Bay system from all identified municipal and industrial sources.

The conclusions drawn from the model study of Raritan Bay are:

1. The discharge from the existing MCSA treatment plant is the most significant wastewater point source in the bay system. This discharge is largely responsible for the DO contraventions exhibited in the vicinity of the discharge site.

2. The mathematical model developed in this analysis adequately represents the kinetics and distribution of in-stream DO concentrations resulting from wastewater discharges to the bay system from all known point sources.

3. Based on the estimated ultimate oxygen demand loading of 350,000 lb/day for the year 2020, the discharge of secondary effluent from the MCSA high-purity oxygen treatment facility at the present outfall site will result in contravention of both the New Jersey and the Interstate Sanitation Commission (ISC) water quality standards.

4. The analysis demonstrates that as the MCSA discharge point is moved out into the bay, there is more effective dilution of the discharge. There is also more adequate utilization of the natural assimilative capacity of the bay and less severe water quality degradation in the critical inner bay region.

5. Relocation of the discharge site to a point near the mouth of Keyport Harbor (segment 46)1/ results in marginal DO conditions in the inner bay region.

1/Figure D-1, Appendix D, shows the segmentation of Raritan Bay.

6. Relocation of the discharge site to a point near the center of the bay system (segment 16) results in acceptable DO conditions in the central bay and marginal conditions in the boundary areas.

7. Based on the estimated loading for the year 2020 and a minimum allowable DO level of 5.0 mg/l, it appears that a suitable MCSA outfall site must be located in the deeper waters of the central bay.

Dissolved Solids

The water quality data presented in Table A-14 (Appendix A) show that both phosphorus and nitrogen compounds are present in concentrations sufficient to support algal blooms. The FWPCA (1967) found that on only one sampling date between June 1963 and July 1964 were the number of cells per milliliter (ml) of bay water less than 10,000. The FWPCA (1967) also found that during the summer, the number of cells/ml was seldom less than 100,000.

Additional nutrient input from the MCSA plant could well aggravate the present productivity situation by increasing the intensity and frequency of blooms. Furthermore, if the industrial wastes are pretreated or are not discharged into the MCSA system, present biological levels of productivity could be enhanced due to the absence of toxic elements. The absence of toxic materials coupled with the presence of additional nutrients in the discharge may have a synergistic effect on the productivity of the bay.

Pathogenic Organisms

The MCSA project is not expected to effect a significant reduction in the total coliform numbers in the bay. There may be some improvement in the area of the MCSA outfall and conditions along the south shore of Raritan Bay should measurably improve.

However, the project will affect only a small portion of the coliform sources currently contributing to the system. Coliform data presented in Table A-14 (Appendix A) show high total coliform counts in the northeastern part of the bay and in the Arthur Kill. Since vast quantities of coliforms enter the bay from the Narrows and from the Arthur Kill, an overall reduction in the numbers of coliform organisms in the bay cannot be expected.

The large numbers of coliforms that enter Raritan Bay from the Narrows may prohibit the opening of certain areas in the bay to commercial shellfishing. In fact, the remaining open areas in Sandy Hook Bay (Figure 12), which is part of the Raritan Bay system, may have to be closed. (Meyer, oral communication, 1972).

Sludge Disposal

Sludge disposal poses a complex problem regardless of the alternative being considered. Every wastewater treatment facility, whether it is primary, secondary or tertiary, removes solids from influent wastewater flows. Disposing of these solids in an environmentally acceptable manner is a continuing problem.

The New York metropolitan area faces special sludge disposal problems. Since it is a major urban area, land is at a premium. Economic and aesthetic considerations severely limit the number of suitable landfill sites. The problem is compounded by the exceptionally large volumes of sewage sludge that are generated by the area's many treatment plants. Moreover, because of the potential air pollution effects, sludge incineration

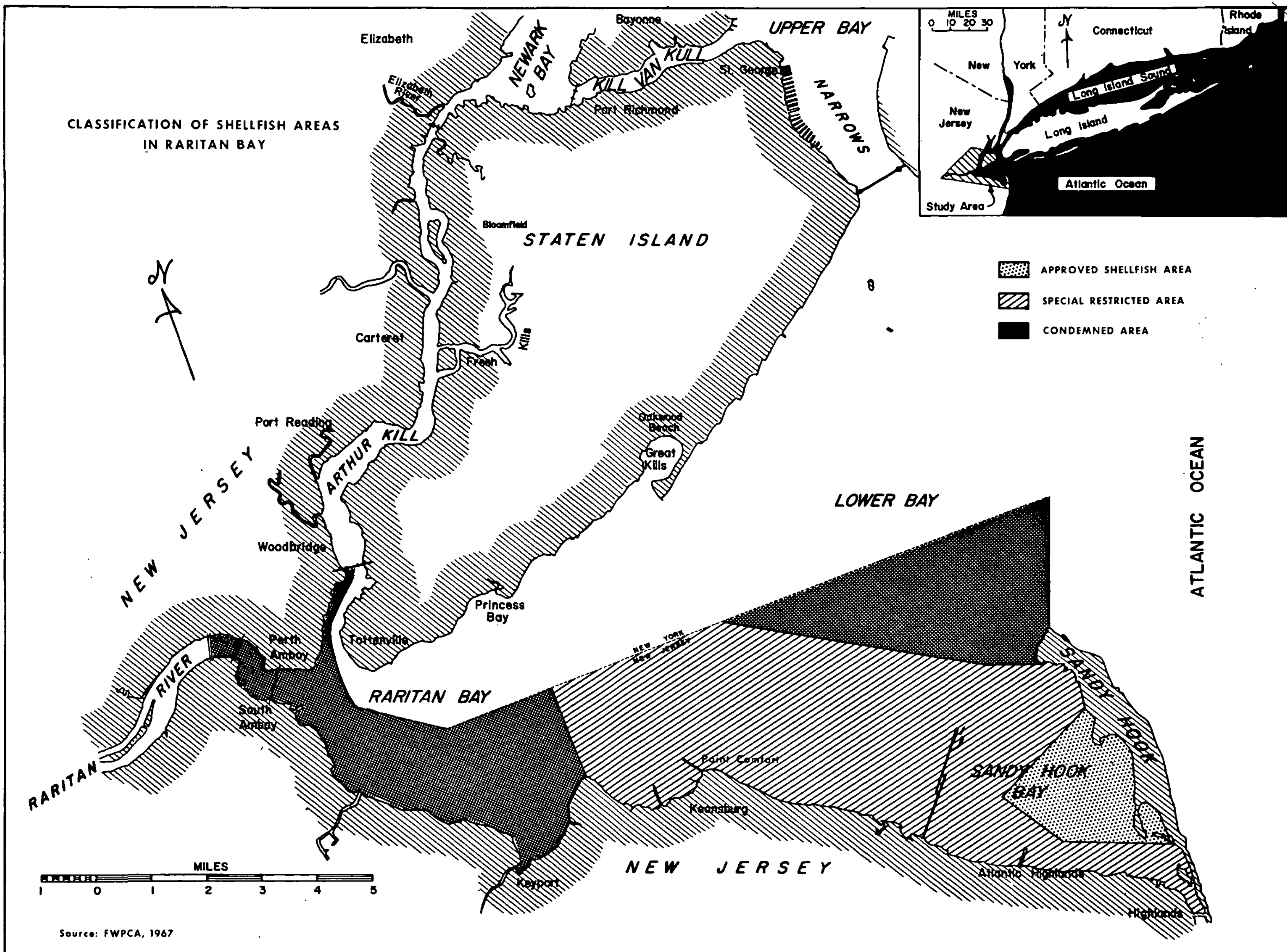

CLASSIFICATION OF SHELLFISH AREAS
IN RARITAN BAY
APPROVED SHELLFISH AREA
SPECIAL RESTRICTED AREA
CONDEMNED AREA
MILES
0 10 20 30
Connecticut
Rhode Island
New York
New Jersey
Long Island Sound
Long Island
Atlantic Ocean
Study Area
Elizabeth
Bayonne
UPPER BAY
NEWARK BAY
KILL VAN KULL
Elizabeth River
St. George
Port Richmond
NARROWS
Bloomfield
STATEN ISLAND
Carteret
Fresh Kills
Port Reading
ARTHUR KILL
NEW JERSEY
Woodbridge
Oakwood Beach
Great Kills
LOWER BAY
ATLANTIC OCEAN
Princess Bay
Perth Amboy
Tottenville
RARITAN RIVER
South Amboy
RARITAN BAY
NEW YORK
NEW JERSEY
SANDY HOOK
SANDY HOOK BAY
Point Comfort
Keansburg
Keyport
NEW JERSEY
Atlantic Highlands
Highlands
MILES
1 0 1 2 3 4 5
Source: FWPCA, 1967

Figure 12

is not considered an acceptable alternative at this time.

Conventional methods of sludge disposal must be further studied, and the most effective means for ultimate disposal of sludge in this area must be instituted. Recognizing these needs, the EPA has established the following policy for all wastewater treatment projects in Nassau County, Westchester County and New York City in New York State, and for those New Jersey waste treatment systems bordering on waters of New York Harbor, including the Kill Van Kull, Arthur Kill and Raritan Bay.

All applicants for grants for the construction of wastewater treatment works in the New York metropolitan area will provide the following:

"1. An agreement to adopt and enforce an effective industrial waste ordinance. This will result in the necessary removal of heavy metals and other toxic materials from wastes entering the municipal systems.

"2. The applicant must agree to develop a program for sludge management which would result in the abandonment of ocean disposal of sludge. This program development, and determination of the most acceptable ultimate disposal method for sludge, must be completed by June 30, 1976. The method chosen must be in operation by June 30, 1977. The time period until June 30, 1976 will be used to implement the regional strategy for a thorough evaluation and demonstration of alternatives and management of the solids problem on a regional basis.

"3. The projects as proposed must provide for adequate sludge treatment prior to ocean disposal. Acceptable treatment would include anaerobic digestion, aerobic digestion with maintenance of optimum temperatures or equivalent treatment.

"4. On the basis of the agreement as outlined above, the following grant conditions would be applied to all such projects:

'Approval of this Federal grant is based upon ocean disposal of adequately treated sludge as an interim measure. This approval is contingent upon the following:

a. The adoption and enforcement of an effective industrial waste ordinance to minimize the amounts of heavy metals and other toxic substances discharged to the municipal system. Materials and allowable amounts included in the industrial waste ordinance will be established by the State and the E.P.A.

b. The development of an acceptable sludge management program to result in the abandonment of ocean disposal. This program, to be submitted to and approved by the State and the E.P.A., must be fully developed by June 30, 1976. Implementation of the program must be initiated by June 30, 1977.

c. As part of the development of an acceptable sludge management program, the authority agrees to cooperate with the U.S.E.P.A. in exploring cooperative and joint solutions with other operating sewerage agencies.' "(Johnson, written communication, 1972).

Upon agreement with the above grant conditions, the requirement for cessation of ocean disposal of digested sludge will be temporarily waived. Ocean disposal of sludge at the present MCSA disposal site, 4.5 nautical miles southeast of Ambrose Light (see Figure 13), will be continued on an interim basis.

Air and Noise Pollution

The air pollution effects of the proposed project are expected to be minimal. Since the oxygenation process utilizes covered tanks rather than open aeration tanks, odors due to treatment will be minimized. In addition, the aerobic digesters used in treating the sludge will be covered. Gases from the sludge storage tanks will be deodorized before discharge to the atmosphere.

The primary source of noise in the treatment plant will be the blowers which supply air to the channel aeration systems throughout the plant. These blowers will be located in an insulated room of the combined blower-and-operations building; this will reduce the noise to an unobjectionable level. The main air compressors for the oxygen generation facility will likewise be housed in an insulated building to minimize

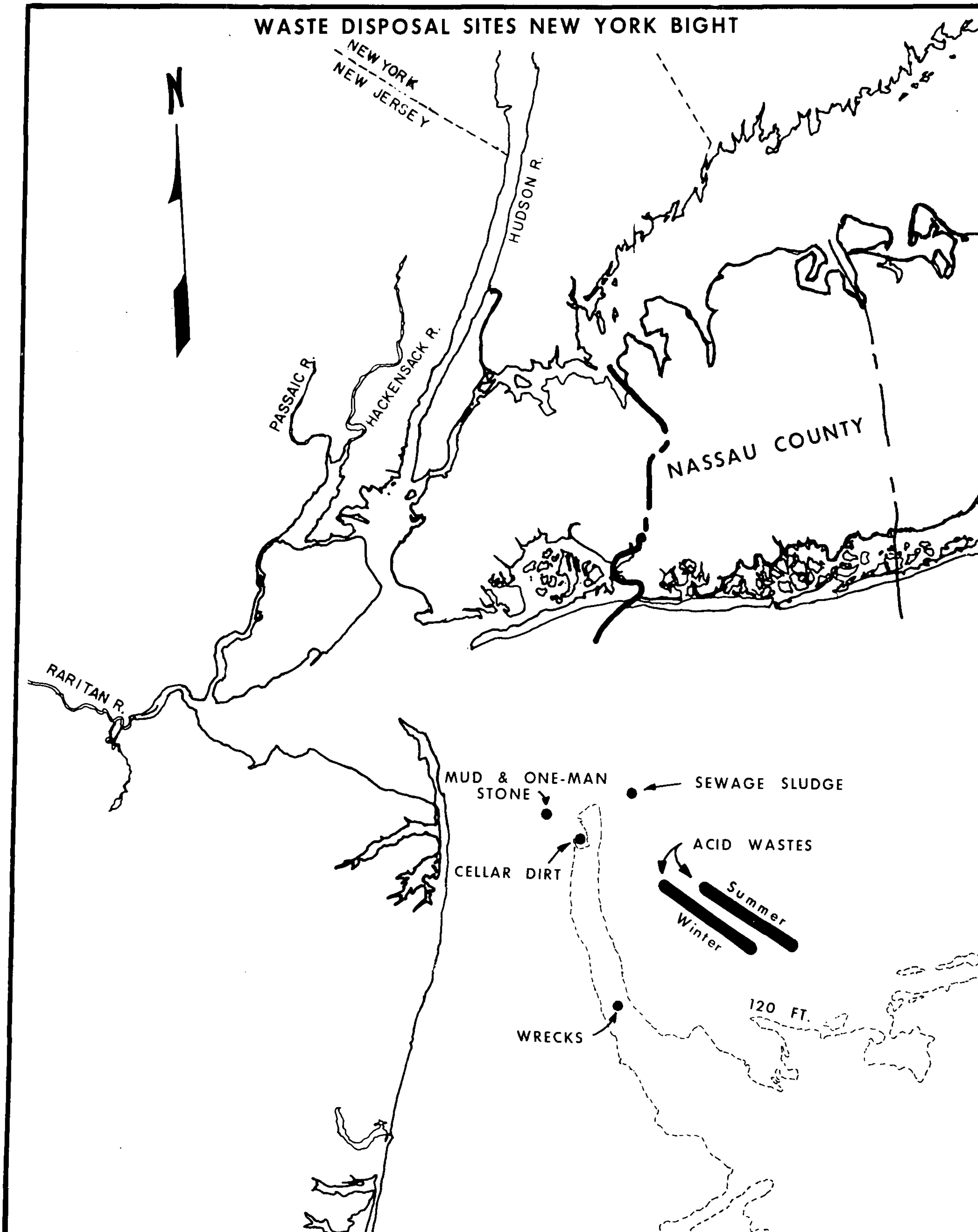

WASTE DISPOSAL SITES NEW YORK BIGHT
N
NEW YORK
NEW JERSEY
HUDSON R.
HACKENSACK R.
PASSAIC R.
NASSAU COUNTY
RARITAN R.
MUD & ONE-MAN STONE
SEWAGE SLUDGE
ACID WASTES
CELLAR DIRT
Summer
Winter
120 FT.
WRECKS

Figure 13

the possibility of noise pollution. Circulation compressors for the oxygenation system will be located in the blower galleries between each pair of oxygenation tanks.

It is anticipated that the impact of noise from the treatment plant operation will be minimal within the plant complex and will be negligible beyond the boundaries of the plant.

BAYSHORE REGIONAL SEWERAGE AUTHORITY PROJECT

Environmental Impact of Construction

The BRSA's treatment plant is now under construction on a twenty-five acre wetland site. The treatment plant proper will occupy about six of these acres. The remainder will serve as a buffer zone and as the site of future plant expansion. Since wetlands are extremely sensitive to any kind of activity, construction will have an inherently adverse effect on the area.

During construction, some air and noise pollution will be generated. However, the contractor's adherence to the Contract Specifications will minimize these effects.

Environmental Impact of Operation

The sludge incineration system that will be used at this facility is of the fluid-bed reaction type. It will be designed to meet current air pollution emission standards. The entire system will be instrumented and automatically controlled to insure effective operation. The dewatered ash end product will be disposed of on-site in a landfill operation.

SECONDARY ENVIRONMENTAL IMPACTS

Both the lower Raritan River basin and the Bayshore area are centrally located between New York City and Philadelphia. The areas are served by an elaborate highway network running along north-south and east-west orientations. Rail and bus commuter service is available to New York City. Development of the northern and central portions of the lower Raritan River basin and the northern section of the Bayshore area has been extensive. Development will continue in these areas as allowed by the land use plans of the municipalities.

The geographical conditions, i.e., location, topography, soil types and water resources, tend to foster unlimited growth. Without the proposed projects, the water quality of the receiving water bodies would become further degraded. The proposed projects are not likely to have any effect on either the rate or extent of development. Rather, they are a means of mitigating the adverse effects of what appears to be inevitable growth.

ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSED PROJECTS BE IMPLEMENTED

In the preceding section, the environmental effects of the proposed projects were enumerated. Most of the adverse impacts can be avoided entirely or can be reduced to a point at which they are no longer significantly adverse. Those adverse impacts which cannot be avoided are described below.

MIDDLESEX COUNTY SEWERAGE AUTHORITY PROJECT

During construction at the MCSA treatment plant site, there will be a loss of existing wildlife habitat. The habitat is neither extensive nor of good quality. After construction and landscaping are completed, habitat for birds and small game should be improved. As a result of construction, the wildlife habitat along roads into the plant site will be less suitable. However, the disruption associated with construction will be temporary and of little long-term significance.

Operation of the upgraded and expanded plant will be accompanied by several unavoidable adverse effects. These effects are primarily water-oriented. As indicated in Appendix A, ground-water resources in the area of South River and Sayreville have been overdeveloped. This overdevelopment has led to saltwater intrusion. Continued withdrawal of water from these aquifers in excess of the amount of water recharged to the aquifers will intensify the saltwater intrusion. However, proper water resource management techniques, possibly including ground-water recharge, could reverse this trend.

As indicated in the section entitled "Environmental Impact of the Proposed Projects", the ultimate disposal of sludge will present a problem regardless of the method employed. Partial digestion of the sludge followed by barging of the sludge to a designated ocean disposal site could cause severe deterioration of the dumping area, decreasing the area's desirability as a marine habitat. The primary cause of such deterioration would be the covering over of benthic areas with solids.

There will also be a depletion of the dissolved oxygen in the disposal area. If the sludge represents a large industrial waste input, the concentration of toxic materials, such as heavy metals, in the sludge will tend to be high. Pretreatment or exclusion of industrial wastes could significantly reduce the adverse effect.

The discharge of treated effluent into Raritan Bay will adversely affect the bay as follows: 1) the amount of organic matter, both residual and unstable, will increase; 2) the amount of chlorine introduced into the system will significantly increase as the volume of treated effluent increases; 3) the amount of biostimulants entering the system will significantly increase as the volume of treated effluent increases.

BAYSHORE REGIONAL SEWERAGE AUTHORITY PROJECT

Construction of the BRSA treatment plant in the wetlands is certain to adversely affect the area. Moreover, since the wetlands are highly sensitive, the adverse effects will extend beyond the six acres used for initial construction. As previously indicated, construction has already begun and the area cannot be restored to the desired natural state.

RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

MIDDLESEX COUNTY SEWERAGE AUTHORITY PROJECT

The upgrading and expansion of the existing treatment plant will enable the MCSA to achieve the water quality goals stipulated in orders issued by the New Jersey Department of Environmental Protection. However, operation of the plant and discharge of the treated effluent may still affect the productivity of the estuary. The amounts of residual carbon compounds and nitrogenous and phosphorous compounds will increase as the amount of sewage treated at the plant increases.

Operation of the existing sewage treatment plant involves the disposal in one basin of ground water withdrawn from the aquifers in another basin. Plant expansion will result in increased water diversion; this, in turn, will promote greater localized saltwater intrusion and further decline of the ground-water levels.

BAYSHORE REGIONAL SEWERAGE AUTHORITY PROJECT

The construction and operation of the BRSA treatment plant will enable the region to achieve the water quality goals stipulated in orders issued by the New Jersey Department of Environmental Protection. The project will also allow the anticipated population growth within the region to occur without further degradation of the inland waters and the waters along the south shore of Raritan Bay.

As with MCSA, operation of the BRSA sewage treatment plant will involve the disposal in one basin of ground water withdrawn from the aquifers in another basin. The results of this practice will be similar to those noted for the MCSA project.

IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED PROJECTS SHOULD THEY BE IMPLEMENTED

In addition to the local short-term inconveniences and insults to the environment that are associated with the projects, there will be some local long-term effects. These are:

1. Operation of the expanded MCSA treatment plant will contribute to the further decline of the water table in the area of South River and Sayreville. Associated with a lowering of the water table are: 1) an increase in well depths required for public water supply, 2) an increase in the rate of saltwater intrusion into the freshwater aquifers, and 3) the possibility of land subsidence.

2. Wetland habitat is rapidly disappearing along the entire eastern seaboard. The siting of wastewater treatment plants, such as the BRSA project, in wetlands further reduces this acreage.

3. Both projects will entail some destruction of wildlife habitat. Sewer construction will necessitate the loss of some shade trees. Plant construction will remove open land areas from use as wildlife habitat.

4. Unless the utmost care is taken, short-term insults to the environment could become long-term ones. If wetland areas are not backfilled to the proper grades, they could be converted to less productive "upland-type" habitats. Spoils must be confined and ultimately removed.

5. Although the sludge disposal procedure is an interim action, the MCSA project will produce a net increase in the amount of digested sludge being dumped at sea. The effects of this practice on the receiving body have not been precisely determined, but they are generally

considered undesirable. Large quantities of "strange" or foreign substances, such as pesticides, residual carbon compounds and heavy metals, are being dumped into the ocean with little knowledge of the consequences. However, in the New York metropolitan area, sludge dumping will probably cause less harm to the environment than incineration. Sufficient land is not available for land disposal.

6. Materials dumped at sea will not be available for conservative uses.

DISCUSSION OF PROBLEMS AND OBJECTIONS RAISED BY ALL REVIEWERS

INTRODUCTION

According to the requirements of the National Environmental Policy Act of 1969, as stated in the Environmental Protection Agency's "Preparation of Environmental Impact Statements: Interim Regulation" (January 17, 1973):

> "Final statements. . . shall summarize the comments and suggestions made by reviewing organizations and shall describe the disposition of issues surfaced (e.g., revisions to the proposed action to mitigate anticipated impacts or objections). In particular, they shall address in detail the major issues raised when the Agency position is at variance with recommendations and objections (e.g., reasons why specific comments and suggestions could not be accepted, and factors of overriding importance prohibiting the incorporation of suggestions). Reviewer's statements should be set forth in a Comment and discussed in a Response. In addition, the source of all comments should be clearly identified."

Immediately following this Introduction is a list of the reviewers of the draft Environmental Impact Statement (EIS). This is followed by a section entitled "Comments and Responses." Only significant criticisms have been included in this section. Compliments have been disregarded. All comments dealing with a particular subject have been synthesized into a representative statement, incorporating the major points made by each reviewer. Each comment is followed by the EPA's response.

LIST OF REVIEWERS OF THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

Bayshore Regional Sewerage Authority
915 Union Avenue
Union Beach, New Jersey 07735
Fred Varlese, Chairman
May 30, 1973*

Interstate Sanitation Commission
10 Columbus Circle
New York, New York 10019
Thomas R. Glenn, Jr., Director and Chief Engineer
May 23, 1973*

League of Women Voters of Monmouth County, New Jersey
c/o Mrs. Thomas R. Crane
312 Euclid Avenue
Loch Arbour, New Jersey 07711
May 15, 1973*

Matawan Township Municipal Utilities Authority
Matawan Township, New Jersey
Frederick A. Almerino, Chairman
May 25, 1973*

Middlesex County Planning Board
County Administration Building
Kennedy Square
New Brunswick, New Jersey 08901
Douglas S. Powell, Director
May 11, 1973*

Middlesex County Sewerage Authority
Sayreville, New Jersey 08872
A. J. Popowski, Executive Director
May 22, 1973*

Monmouth County Environmental Council
Monmouth County Planning Board
One Lafayette Pl.
Freehold, New Jersey 07728
Robert W. Clark, Senior Planner
May 21, 1973*

Monroe Township Municipal Utilities Authority
Middlesex County, New Jersey
c/o George Hartman 3rd, Chairman
Jamesburg, New Jersey 08831
May 22, 1973*

*Letter dated

New Jersey State Department of Environmental Protection
Division of Water Resources
John Fitch Plaza
P.O. Box 1390
Trenton, New Jersey 08625
John W. Gaston, Supervising Environmental Engineer
Water Quality Management and Planning Section
June 5, 1973*

U.S. Department of Agriculture
Soil Conservation Service
1370 Hamilton Street
P.O. Box 219
Somerset, New Jersey 08873
W.J. Parker, State Conservationist
May 21, 1973*

U.S. Department of Commerce
Washington, D.C. 20230
Sidney R. Galler, Deputy Assistant
Secretary for Environmental Affairs
May 29, 1973*

U.S. Department of Health, Education, and Welfare
Region II
26 Federal Plaza
New York, New York 10007
Frederick H. Sillman, M.D., Assistant Regional Director for
Health and Regional Environmental Officer
May 30, 1973*

U.S. Department of Housing and Urban Development
Newark Area Office
Gateway 1 Building, Raymond Plaza
Newark, New Jersey 07102
Roy A. Cuneo, Environmental Clearance Officer
May 22, 1973*

U.S. Department of the Army
New York District, Corps of Engineers
26 Federal Plaza
New York, New York 10007
F.R. Pagano, Chief, Engineering Division
May 22, 1973*

U.S. Department of the Navy
Office of the Oceanographer of the Navy
200 Stovall Street
Alexandria, Virginia 22332
B.E. Stultz, Commander, CEC, U.S.N., Assistant
Chief of Staff for Environmental Quality
May 22, 1973*

*Letter dated

U.S. Environmental Protection Agency
Water Quality and Non-Point Source Control Division
Washington, D.C. 20460
Albert J. Erickson, Director
May 15, 1973*

*Letter dated

COMMENTS AND RESPONSES

Capacity and Infiltration

Comments:

1. The flow and population projections of the Middlesex County Planning Board (MCPB) for the future beyond 1980 tend to be higher than those shown in Tables 6 and A-5 in the draft EIS.
2. Perth Amboy, which has some combined sewers, may find itself with an infiltration problem.

Reviewer:

Middlesex County Planning Board

Responses:

1. The flow and population data given in the tables were obtained from the consulting firm of Metcalf & Eddy in October 1972 for this EIS. The data used in the EIS are lower than those published by the MCPB in 1971, but they were the only projections available when design of the treatment plant was begun. Estimates of population served differ by about 160,800: an increase of about 10 percent for the year 2000.

   The present treatment facility is designed for the year 1985 at 120 mgd. Future expansion will involve modular construction of additional treatment units to a planned ultimate capacity of 240 mgd. At the higher MCPB population projection, the year 2000 flow would be 248 mgd. The ultimate capacity of this modular treatment plant can be increased if future population increases make it necessary.

2. Perth Amboy is similar to New Brunswick in that it has an old sewerage system and probably has an infiltration problem. The New Brunswick problems are discussed in the EIS.

Construction Restraints

Comments:

1. Permits from the Department of the Army are required for those outfalls and pipelines crossing navigable waters of the United States.
2. The following information should be included in the EIS:
   a. Expansion of the MCSA regional plant should be made on land above 10.9 feet Mean Sea Level, which is the elevation of the 100 year tide.
   b. Expansion of the Pine Brook plant should be on land above the 58.5 foot Mean Sea Level contour, the elevation of the 100 year flood.
   c. Plant site selection for the Deep Run plant should be coordinated with the New York District Corps of Engineers to insure that the plant site will be above the 100 year flood level.

Reviewer:

U.S. Department of the Army, N. Y. District Corps of Engineers

3. "Consideration should be given to including a statement indicating that construction plans will include the use of one or more measures for the control of erosion and drainage from sediment based on guidelines set forth in the 'Standards for Soil Erosion and Sediment Control in New Jersey'," adopted 6/14/72 by the New Jersey State Soil Conservation Committee.

Reviewer:

U.S. Department of Agriculture, Soil Conservation Service

4. In order to achieve maximum public health protection and resources utilization in the event that shellfish areas are opened in the future, the Shellfish Sanitation Program recommends that duplicate chlorine contact tanks designed to provide a minimum contact time of 30 minutes at peak hourly flow either be constructed as part of the project or be built at some later date when receiving water quality has sufficiently improved.
5. Automatic alarms are recommended for chlorine utilization monitoring devices and chlorination units in the MCSA plant.

Reviewer:

U.S. Department of Health, Education, and Welfare

Responses:

1. It is stated in the draft EIS that plans for the construction of new outfalls or the expansion of existing outfalls to serve the facilities are not part of the proposed projects and,therefore, have not been included in the EIS.
2. and 3. The statements have been included.
4. The detention time in the plant outfall pipe will be 60 minutes at average flow (120 mgd) and 27.5 minutes at peak flow (300 mgd). This time will be available for chlorination, and is a suitable substitute for a chlorine contact tank system. When the outfall is extended to deeper bay waters, the chlorine contact time will be increased.
5. The chlorination equipment that will be provided at the MCSA treatment plant will provide for control of the effluent chlorine residual and for the safety of plant personnel. There are no alarms provided to indicate the bypassing of raw sludge.

Gateway National Recreation Area

Comment:

No consideration was given in the draft EIS to the effects of the projects on the proposed Gateway National Recreation Area.

Reviewer:

U.S. Department of Housing and Urban Development

Response:

On a long-term basis, the effect of the projects would probably be to improve the water quality of the area, thus benefiting the region planned for recreational use.

Geology

Comment:

It is requested that the following information be added to the aquifer description:

1. Magothy-Raritan formation
    a. thickness: 600-2000 ft
    b. natural recharge: 1 mgd/mi^2
    c. porosity: 46% (average)
    d. specific capacity: 20 gpm/ft
    e. specific yield: 41%
    f. coefficient of permeability: 296 gpd/ft^2 (average)
2. Brunswick Shale
    a. thickness: 600-9000 ft
    b. semi-artesian to water table condition
    c. natural recharge: 0.5 mgd/mi^2 (limited storage in fracture zones)
    d. specific capacity: 1.8 gpm/ft (average)

3. English formation

    a. thickness: 0-75 ft

    b. natural recharge: 0.5 mgd/mi^2

    c. porosity: 44% (average)

    d. specific capacity: 3 gpm/ft (average)

    e. coefficient of permeability: 300 gpd/ft^2

    f. coefficient of storage: 27,000

Reviewer:

New Jersey State Department of Environmental Protection

Incineration of Sludge

Comment:

While incineration of sludge at the MCSA plant is not considered an acceptable alternative because of the potential air pollution problems, it is proposed for the BRSA project. There is no discussion of the reasons why incineration is acceptable for the BRSA plant but unacceptable for the MCSA plant.

Reviewer:

U.S. Environmental Protection Agency, Water Quality and Non-Point Source Control Division

Response:

The EPA regional strategy for the elimination of ocean disposal of sludge does not consider sludge incineration an acceptable alternative in the New York metropolitan area at the present time. The metropolitan area consists of Nassau and Westchester Counties and New York City in New York State and those parts of New Jersey that border on waters of New York Harbor, including the Kill Van Kull, the Arthur Kill and Raritan Bay, This includes both the MCSA and the BRSA sites.

The MCSA plant is in the section of the metropolitan area that already violates primary air pollution standards for particulates. This section is in immediate danger of violating the secondary standards as well. BRSA, on the other hand, is in a relatively "clean" area having only minor particulate problems. The effluent from the plant's stacks would not contravene primary or secondary standards.

Landfill of Wetlands

Comments:

1. The EIS does not contain a discussion of the use of incinerated ash from the BRSA plant as landfill with regard to its impact on the surface or ground water as a result of leaching or runoff.

Reviewer:

U.S. Environmental Protection Agency, Water Quality and Non-Point Source Control Division

2. At the BRSA facility, the landfill of incinerated sludge must be strictly limited to the area essential to the expansion and operation of the plant. This should be carefully checked periodically by state and federal officials.

Reviewer:

League of Women Voters, Monmouth County, N.J.

Responses:

1. As stated in the draft EIS, the sludge from the BRSA plant will be incinerated before disposal. The ash will be removed to an onsite landfill operation. The residue is expected to be inert and,therefore, will not present a health hazard. At a properly operated landfill,

the potential for pollution of the surface or ground water through leaching or runoff is essentially nonexistent.

2. The EPA agrees that care should be taken in the landfill area to preserve the integrity of the surrounding marshlands. Periodic checks will be made to insure satisfactory operation of the landfill.

<u>Outfall</u>

Comments:

1. Has the impact of placing the MCSA outfall in Station 16 been evaluated for the Navesink and Shrewsbury Rivers? Improvement in the upper sections of the bay should not be achieved at the expense of losing areas in Sandy Hook Bay and the river that until recently have been clean enough for clamming.

Reviewer:

League of Women Voters, Monmouth County, N.J.

2. Concerning the outfall location for the Middlesex County sewage, the alternatives for discharge in the center of Raritan Bay will probably cause the "restricted" areas to be reclassified as "prohibited". This would reduce the likelihood of any portions of Raritan Bay being reopened to the harvesting of shellfish in the immediate future.

Reviewer:

U.S. Department of Health, Education, and Welfare

Responses:

1. The description of the different outfall locations in the draft EIS were included for academic discussion only. The actual outfall site has not yet been chosen. The site selection will be made after due consideration of the impact on the bay.

2. The draft EIS was not intended to determine the outfall location for the MCSA plant. The site selection can only be made after appropriate environmental studies have been completed. With respect to closing of the bay to shellfishing, the MCSA outfall location is not of paramount importance. There are other sources contributing to pollution of the bay that by themselves would mandate the prohibition of commercial shellfishing. (See p. 53-54).

Plankton Blooms

Comment:

Studies should be initiated to answer questions about causes, cures, remedial and control measures associated with marine plankton blooms. The interstate source of the Raritan Bay and the occurrence of these blooms along substantial portions of the coastal states puts this problem beyond the efforts of individual states. In our opinion, the EPA should take the lead in studying this phenomenon to insure its proper investigation so that the complex question of algae blooms may be resolved in an objective, scientific manner.

Reviewer:

New Jersey State Department of Environmental Protection

Response:

The value of such a project is obvious. A request for financial support of such a study should be addressed to the Grants Administration Division, U.S. Environmental Protection Agency. The request will be reviewed and evaluated by specialists in the Office of Research and Monitoring.

Service Area

Comments:

1. The Deep Run area of Marlboro Township should be included in the MCSA system.

Reviewer:

Middlesex County Planning Board

2. While it is so stated on page 141, Table A-24, the New Jersey Department of Environmental Protection (NJDEP) order of 2/18/66 did not specify connection of Matawan Township to the Bayshore Regional Sewerage Authority's system.

3. In the preface on page ii, it was stated that "Keyport, Matawan Borough and Matawan Township were among the municipalities ordered by the NJDEP to join the BRSA. The muncipalities protested the directive proposing instead to build their own secondary...facilities...." Matawan Township at the present time operates a secondary facility which complies with NJDEP standards. The Matawan Township Municipal Utilities Authority was not ordered by NJDEP to join the BRSA system but did take part in a study to evaluate a proposal by Matawan and Keyport Boroughs for a regional facility. To our knowledge, the BRSA never proposed a contract with the Matawan Township Municipal Utilities Authority to provide treatment of the Township's wastewaters.

Reviewer:

Matawan Township Municipal Utilities Authority

Responses:

1. The interim basin plan submitted by the NJDEP and approved by the EPA recommends that "better water management can be attained by limiting the extent of regionalization and by providing separate plants in headwaters areas (Manalapan and Marlboro Townships) with advanced treatment and/or land disposal."

   This would minimize adverse effects on basin hydrology from exportation of wastewaters from the headwaters of South River, which includes the Deep Run area. In its comments on the interim basin plan, the EPA recommended that Marlboro Township supply the Deep Run drainage area with its own treatment plant to provide advanced treatment and/or land disposal, as needed.

2. The date listed in Table A-24, page 141, is the date of the initial action requiring abatement. The abatement measure specified in the last column of the table is the current abatement action directed at the municipal discharger, as indicated in the text.

3. The Matawan Township Municipal Utilities Authority currently operates secondary treatment plants at Cliffwood Beach, Strathmore, and River Gardens. These plants have capacities of 0.75 mgd, 0.80 mgd, and 0.10 mgd, respectively. They are now operating satisfactorily and will continue to meet State standards as long as they produce an effluent with 80% of the BOD removed.

   A goal of regionalization in the Bayshore area is to eliminate the inland STP discharges because of the low assimilative capacity of the inland streams. In keeping with this concept, the Matawan Township Municipal Utilities Authority would be required to join a regional sewerage system and discharge treated wastewaters away from these inland waterways.

   In a letter to the EPA dated December 6, 1972, the BRSA indicated that meetings with representatives of Matawan Township had been held on May 6, 1970 and on July 1, 1971. The purpose of the meetings was to obtain commitments for sewerage service. The BRSA has not actively pursued service agreements with Matawan Township because the township is satisfactorily operating its secondary treatment facilities.

   In a letter to EPA dated November 6, 1972, the NJDEP indicated that a proposed regional sewerage system to serve Matawan Township, Matawan Borough, Keyport Borough, and a portion of Marlboro Township, with discharge to the Monmouth County Bayshore Ocean Outfall Authority's (MCBOOA) system, was less cost effective than connection of these communities to the BRSA system. In addition, the MCBOOA outfall is located near the BRSA plant. The MCBOOA opposes any plan that does not require the Matawan-Keyport area to tie into the BRSA system. Pursuant to NJSA 40:36A, the MCBOOA has the statutory authority to prevent the construction of any competing system within the MCBOOA's area.

Therefore, although Matawan Township has not been ordered to join the BRSA system, current wastewater management planning by the NJDEP aims for the township's inclusion in the BRSA system sometime in the future. Based upon this planning, the EPA has approved expansion of the BRSA interceptor system which is currently under construction.

Water Budget of the Area

Comments:

1. Upgraded treatment and maximum reuse of both sludge and effluent in the relatively near future would be desirable.

Reviewer:

League of Women Voters, Monmouth County, N.J.

2. Policy and guidelines should be developed to provide for adequate water recharge to offset the massive withdrawals and transfer of water from one part of the area to another by such a large regional system.

Reviewer:

U. S. Department of Housing and Urban Development

3. Water quality and analysis models should be applied to the entire basin, not just to Raritan Bay.

Reviewer:

Middlesex County Planning Board

Responses:

1. EPA agrees that both upgraded treatment and maximum reuse would be advantageous.
2. At the outset of upgraded plant operation, the need for ground-water recharge will be insignificant. At present, tertiary treatment with ground-water recharge or sale of renovated water to industry is not feasible. In the future, when wastewater reuse becomes important and when technology is more advanced, the system could be modified as needed.
3. A study is currently being done on a large part of the Raritan basin. The EPA is funding the study which is being carried out by a consultant.

Water Quality Standards

Comments:

1. Contravention of the water quality standards is unacceptable. There should be a coordinated effort by all agencies concerned to develop a policy and guidelines prior to plan implementation.

Reviewer:

U.S. Department of Housing and Urban Development

2. Mention of the New York State Water Quality Standards should be made, especially since one of the discharge points being considered is located in the waters of that state.

Reviewer:

U.S. Environmental Protection Agency, Water Quality and Non-Point Source Control Division

Responses:

1. The present means of effluent disposal will cause difficulties at times, with respect to the water quality standards. However, delaying the project until the outfall is completed is not justified. Operation of the system to provide secondary treatment will immediately reduce the BOD loadings on the bay, improving the bay environment. The outfall should be constructed and connected to the plant before the flows from the plant become great enough to produce excessively high BOD loadings.
2. Since the final site for the proposed MCSA outfall may be in the waters of New York State, the effluent would be required to meet the NYS water quality standards. Along with the New Jersey standards, those of New York are undergoing revision under federal regulations (See p. 139 and Appendix B). The waters of the bay which would be affected by the outfall are designated Classes SA and SB for tidal saltwaters and Special Class I for the Raritan Bay, N.Y. The water quality standards presented for these waters are exerpted from "Classifications and Standards Governing the Quality and Purity of Waters of New York State" (Parts 700-703, Title 6, Official Compilation of Codes, Rules and Regulations, by the New York State Department of Environmental Conservation). The standards are as follows:

   701.4 Classes and Standards for tidal salt waters.

   Class SA

   Best usage of waters. Shellfishing for market purposes and any other usages.

Quality Standards for Class SA Waters

	Items	Specifications
1.	Floating solids; setteable solids; oil; sludge deposits	None attributable to sewage,industrial wastes or other wastes.
2.	Garbage,cinders,ashes,oils, sludge or other refuse	None in any waters of the marine district as defined by State Conservation Law.
3.	Sewage or waste effluents	None which are not effectively disinfected.
4.	Dissolved oxygen	Not less than 5.0 parts per million.
5.	Toxic wastes, deleterious substances, colored or other wastes or heated liquids	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor or sanitary condition thereof or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
6.	Organisms of coliform group	The median MPN value in any series of samples representative of waters in the shellfish growing area shall not be in excess of 70 per 100 milliliters.

Responses:

1. The present means of effluent disposal will cause difficulties at times, with respect to the water quality standards. However, delaying the project until the outfall is completed is not justified. Operation of the system to provide secondary treatment will immediately reduce the BOD loadings on the bay, improving the bay environment. The outfall should be constructed and connected to the plant before the flows from the plant become great enough to produce excessively high BOD loadings.
2. Since the final site for the proposed MCSA outfall may be in the waters of New York State, the effluent would be required to meet the NYS water quality standards. Along with the New Jersey standards, those of New York are undergoing revision under federal regulations (See p. 139 and Appendix B). The waters of the bay which would be affected by the outfall are designated Classes SA and SB for tidal saltwaters and Special Class I for the Raritan Bay, N.Y. The water quality standards presented for these waters are exerpted from "Classifications and Standards Governing the Quality and Purity of Waters of New York State" (Parts 700-703, Title 6, Official Compilation of Codes, Rules and Regulations, by the New York State Department of Environmental Conservation). The standards are as follows:

   701.4 Classes and Standards for tidal salt waters.

   Class SA

   Best usage of waters. Shellfishing for market purposes and any other usages.

Quality Standards for Class SA Waters

Items	Specifications
1. Floating solids; setteable solids; oil; sludge deposits	None attributable to sewage, industrial wastes or other wastes.
2. Garbage, cinders, ashes, oils, sludge or other refuse	None in any waters of the marine district as defined by State Conservation Law.
3. Sewage or waste effluents	None which are not effectively disinfected.
4. Dissolved oxygen	Not less than 5.0 parts per million.
5. Toxic wastes, deleterious substances, colored or other wastes or heated liquids	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor, color, odor or sanitary condition thereof or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
6. Organisms of coliform group	The median MPN value in any series of samples representative of waters in the shellfish growing area shall not be in excess of 70 per 100 milliliters.

Class SB

Best usage of waters. Bathing and any other usages except shellfishing for market purposes.

Quality Standards for Class SB Waters

Items	Specifications
1. Floating solids; settleable solids; oil; sludge deposits	None attributable to sewage, industrial wastes or other wastes.
2. Garbage,cinders,ashes,oils, sludge or other refuse	None in any waters of the marine district as defined by State Conservation Law.
3. Sewage or waste effluents	None which are not effectively disinfected.
4. Dissolved oxygen	Not less than 5.0 parts per million.
5. Toxic wastes, deleterious substances,colored or other wastes or heated liquids	None alone or in combination with other substances or wastes in sufficient amounts or at such temperatures as to be injurious to edible fish or shellfish or the culture or propagation thereof, or which in any manner shall adversely affect the flavor,color,odor or sanitary condition thereof; and otherwise none in sufficient amounts to make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

702.3 Special Class I for Raritan Bay

Best usage of waters. Fishing and any other usages except bathing or shellfishing for market purposes.

Quality Standards for Class I Waters

Items	Specifications
1. Floating solids; settleable solids; sludge deposits	None which are readily visible and attributable to sewage, industrial wastes,or other wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.
2. Garbage,cinders,ashes,oils, sludge, or other refuse	None in any waters of the marine district as defined by State Conservation Law.
3. Sewage or waste effluents	Effective disinfection if required by Interstate Sanitation Commission.
4. Dissolved oxygen	An average of not less than 50 per cent saturation during any week of the year, but not less than 3.0 parts per million at any time.
5. Toxic wastes,oil,deleterious substances colored or other wastes, or heated liquids	None alone or in combination with other substances or wastes in sufficient amounts to be injurious to edible fish and shellfish, or the culture or propagation thereof, or which shall in any manner affect the flavor,color,odor, or sanitary condition of such fish or shellfish so as to injuriously affect the sale thereof, or which shall cause any injury to the public and private shellfisheries of this State; and otherwise none in sufficient amounts to impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. The water quality management plans for the lower Raritan River - Raritan Bay area must be implemented to insure optimum use of available land and water resources.

2. In order to meet current water quality standards for the lower Raritan River - Raritan Bay, the MCSA must enlarge and upgrade its existing sewage treatment plant.

3. After appropriate studies, as required by Part IV, d of the grant agreement, the MCSA must select an effluent disposal method and site which will not cause contravention of the water quality standards set for the receiving water.

4. Socio-economic and environmental considerations dictate that Matawan Township and portions of Marlboro join the BRSA.

5. Several existing sewage treatment plants are located on "reclaimed" wetlands and at least one sewage treatment facility is being constructed in the wetlands.

6. The MCSA now practices ocean disposal of sewage sludge. On an interim basis, the MCSA will practice ocean disposal of the digested sludge from its expanded treatment facility. Upon completion of the regional program for sludge disposal in the New York metropolitan area, the program will mandate and the MCSA must adopt the least environmentally damaging disposal method.

RECOMMENDATIONS

1. Both the MCSA and the BRSA should continue to comply with the implementation schedules specified in the orders issued by the New Jersey Department of Environmental Protection. This includes the establishment of service agreements with each of the municipalities that has been directed

by the Department of Environmental Protection to join the MCSA or the BRSA.

2. The MCSA should immediately begin enlarging and upgrading its existing treatment facility, as described in the proposed plan (alternative 1). Final design of interceptors should be completed as expeditiously as possible.

3. After appropriate studies, as required by Part IV, d of the grant agreement, the MCSA should select the location and design of the plant outfall such that the discharge will not contravene the water quality standards set for the receiving water.

4. Matawan Township and portions of Marlboro should sign service agreements with the BRSA.

5. Federal funds shall not be granted " . . . for the construction of municipal waste water treatment facilities or other waste-treatment-associated appurtenances which may interfere with the existing wetland ecosystem except where no other alternative of lesser environmental damage is found to be feasible." 1/

6. As part of the development of an acceptable sludge management program, the MCSA has agreed to cooperate with the EPA in exploring possible solutions to the sludge disposal problem in the New York metropolitan area.

1/William D. Ruckelshaus, Administrator, U.S. Environmental Protection Agency, February 21, 1973, Administrator's decision statement no. 4: EPA policy to protect the nation's wetlands, U.S. Environmental Protection Agency, Washington, D.C.

ABBREVIATIONS USED

BOD	-	Biochemical oxygen demand
cfs	-	Cubic feet per second
COD	-	Chemical oxygen demand
DO	-	Dissolved oxygen
fps	-	Feet per second
g/l	-	Grams per liter
gpcd	-	Gallons per capita per day
gpd	-	Gallons per day
gpm	-	Gallons per minute
l	-	Liter
m^2	-	Square meters
m^3	-	Cubic meters
mgd	-	Million gallons per day
mg/l	-	Milligrams per liter
ml	-	Milliliter
MSL	-	Mean sea level
NH_3	-	Ammonia
NOD	-	Nitrogenous oxidation demand
ppb	-	Parts per billion
ppm	-	Parts per million
ppt	-	Parts per thousand
STP	-	Sewage treatment plant
UOD	-	Ultimate oxygen demand

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APPENDIX A

BACKGROUND

GEOGRAPHIC AREA

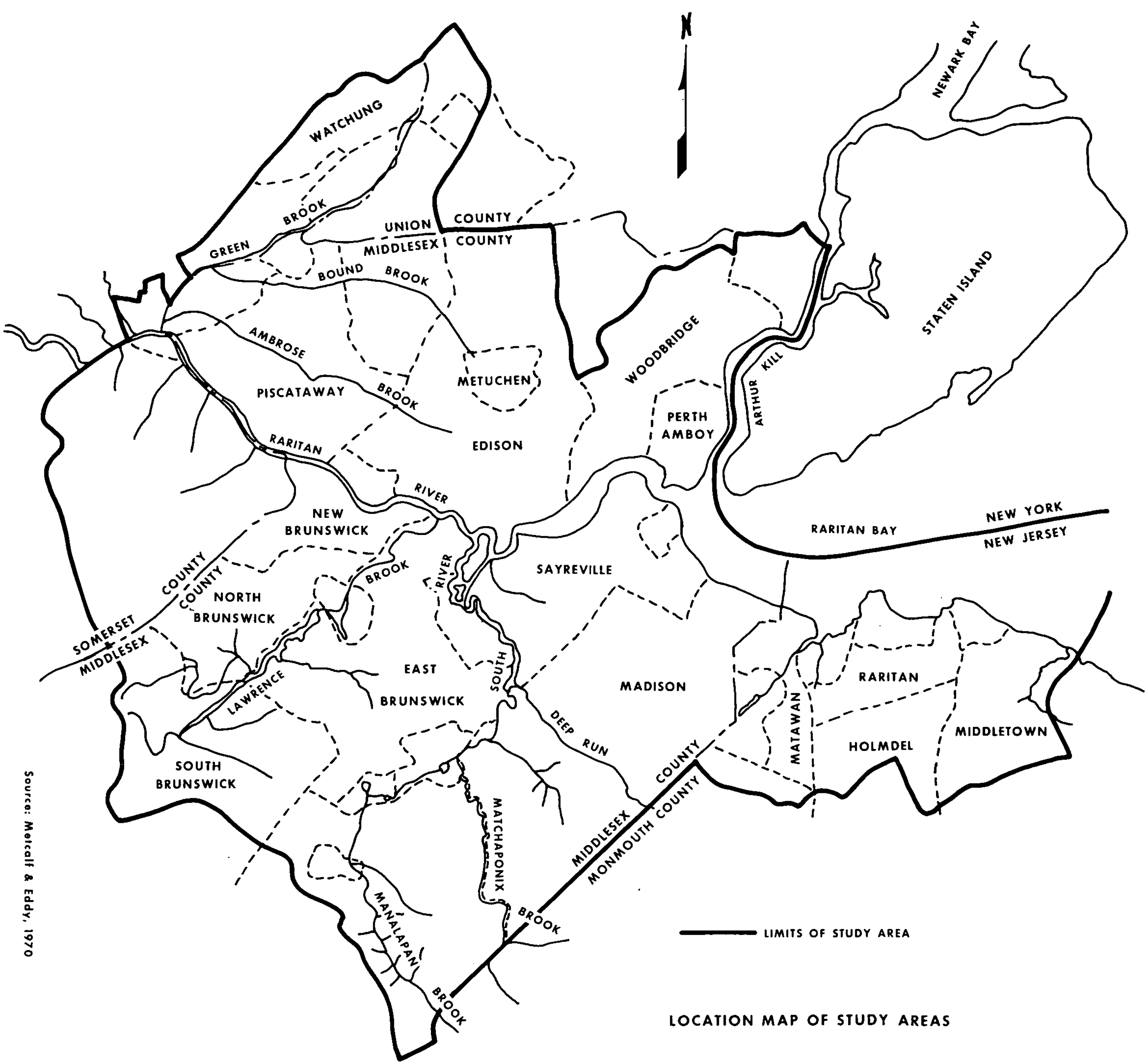
Political Boundaries

This Environmental Impact Statement is concerned with two separate geographical locales and, hence, two separate study areas. The lower Raritan River basin includes all of the areas in Middlesex, Somerset and Union Counties that drain into the Raritan River between the northern boundary of the Borough of Bound Brook and the point at which the river discharges into Raritan Bay at the City of Perth Amboy. Collectively these areas comprise the lower Raritan River basin study area. The portion of the south shore of Raritan Bay (Bayshore area)1/ that extends from the City of South Amboy to Comptons Creek in Middletown Township, Monmouth County is referred to as the Bayshore study area.

The lower Raritan River basin drains an area of approximately 350 square miles, while the Bayshore area drains approximately 60 square miles. The limits of the basin and the bay study areas, including municipal and county boundary lines, are shown in Figure A-1.

1/For the purposes of this report, South Amboy and Madison Township have been included in the lower Raritan River basin.

Figure A-1



Source: Metcalf & Eddy, 1970

LOCATION MAP OF STUDY AREAS

Proximity to Population Centers

The lower Raritan River basin and the Bayshore area are both located in close proximity to the major metropolitan population centers of New York and Philadelphia. The New Brunswick-Perth Amboy area is approximately 35 miles from New York City and 60 miles from Philadelphia.

Proximity to Transportation Systems

The study areas are situated in the northeast corridor between New York and Philadelphia. The New Jersey Turnpike, with several key interchanges in Middlesex County, transverses the central part of the study areas. The Garden State Parkway, which is located in the eastern part of the study areas, conveys traffic from northern New Jersey and New York City to the New Jersey shore. Interstate Highway 287 runs east-west through the study areas. Traveling west from Perth Amboy, I-287 connects with Interstate 78 to Pennsylvania. Traveling east, it connects with the Outerbridge Crossing to Staten Island and New York. Other major highways in the study areas include: U.S. Routes 1 and 9 and State Routes 18, 34, 35 and 36. Interstate 95 is routed through the study areas, but construction has not yet begun.

All of the major airports serving the New York metropolitan area (Newark, Kennedy and LaGuardia) are easily accessible from the study areas. There are also several smaller airports located either within the study areas or in close proximity to them.

The Penn Central Railroad's main line service from New York to Philadelphia and Washington passes through New Brunswick. The Jersey Central main line runs through Perth Amboy, South Amboy, Matawan and Hazlet and then turns south. Several other railroad lines, including the New York and Long Branch, the Lehigh Valley, the Raritan River and the Reading, provide freight service to and from the area. Railroad passenger service is available at several points within the study areas for commuters to Newark, New York, Trenton and Philadelphia.

Bus service is provided on all major highways in the study areas. Express bus service is available for commuters to Newark and New York City.

PHYSICAL GEOGRAPHY OF THE STUDY AREAS

Topography

The topography of the lower Raritan River basin is relatively flat. Elevations range from zero to about 500 feet above mean sea level; the higher elevations are in the vicinity of the Watchung Mountains at the northwestern limits of the basin. The lower Raritan drainage basin lies in two distinct physiographic provinces. The northwestern portion of the basin lies in the Piedmont province and the southeastern part of the basin lies in the Atlantic Coastal Plain province. Kümmel (1940) describes the surface of the Piedmont as ". . . chiefly a lowland of gently rounded hills separated by wide valleys, with some ridges and isolated hills rising conspicuously above the general surface". The Atlantic Coastal Plain, which extends eastward from the Piedmont province, is characterized by a gently sloping surface.

The Bayshore area is entirely within the Atlantic Coastal Plain province. A prominent ridge stretches southwest from Raritan Bay to Clarksburg and then trends south. This ridge forms a divide between the streams draining into the Atlantic Ocean on the east and the streams draining into the Raritan and Delaware Rivers on the north and west. (Jablonski, 1968).

Geology

More than 600 million years ago, during the late Precambrian period, the oldest known rocks underlying the study areas were deposited as sands and muds. The accumulation of a great thickness of overlying sediment created sufficient heat and pressure to form sandstones, shales and arkoses. These consolidated rocks were later intruded by igneous rocks and altered to form gneisses and schists.

Deposits of Continental sediments were subsequently laid down during the Triassic period by streams originating in the highlands to the west. The Triassic deposits were later tilted, faulted and eroded over a time span of approximately 100 million years.

In early Upper Cretaceous times, the land surface sloped gently to the southeast at about 60 feet to the mile. The land was submerged by the sea and Upper Cretaceous sands and clays were deposited in alternating layers dipping to the southeast.

An interval of erosion ensued and the landward edges of the Cretaceous deposits were removed. The next advance of the sea occurred 60 million years ago during the Tertiary period. Sands, clays and gravels were deposited on the older Cretaceous materials. Most of the Tertiary sediments were removed by erosion along with many of the older Cretaceous deposits.

During the Quaternary period, there were four advances of great ice sheets. There is evidence of only the Wisconsin drift remaining. This drift blankets the northern third of Middlesex County. In addition, sand and gravel were deposited along the coastal areas by melt waters from the glaciers.

Rocks of Precambrian and Paleozoic age form a basement complex upon which rest rocks of Triassic and Cretaceous age. The Piedmont province is almost completely underlain by the Triassic rocks. The rocks consist mainly of shale and sandstone with interbeds of lava and sills of diabase or basalt.

Unconsolidated clay, sand and gravel deposits of Cretaceous and Tertiary age underlie the Atlantic Coastal Plain southeast of the Piedmont province. Throughout both of the study areas, Quaternary deposits form a thin and discontinuous mantle of unconsolidated sediments over older rocks. (Barksdale et al., 1943).

Climatology

The climate of the study areas, as exemplified by that of the City of New Brunswick, is temperate. The average annual temperature is between 50 and 55^{O}F. January and February, the coldest months, have a mean temperature of 32^{O}F and July, the warmest month, has a mean of 75^{O}F. Temperatures have ranged from below -5^{O}F in February to about 105^{O}F in July. Water temperatures follow a similar distribution pattern, ranging from 32 to 79^{O}F.

The average annual precipitation in the study areas is 45 inches. February has the lowest monthly average, while August has the highest. The period from May to September has the highest average rainfall.

Annual snowfall averages between 20 and 30 inches. Precipitation data for New Brunswick are presented in Table A-1.

Prevailing winds in the study areas are northwesterly during the colder months of the year and south to southwest during the warmer months. At Sandy Hook, almost 20 percent of the total wind duration is from the northwest; winds from the north and northeast each occur slightly more than 15 percent of the time.

Major Drainage Basins

The major drainage basins within the lower Raritan River basin and the south shore of Raritan Bay are: South River, Lawrence Brook, Green Brook, Raritan River and the Bayshore. The drainage basins are shown in Figure A-2.

South River Basin

The South River drainage basin is located in the southeastern part of the lower Raritan River basin region. For the most part, the area is level.

The South River is the second largest waterway in Middlesex County. It flows in a northerly direction and extends for a distance of about 8.5 miles south of the Raritan River. The South River is tidal to Old Bridge. The total tributary area of this basin is 132 square miles. The upper portion of the basin is relatively undeveloped, while the lower portion is experiencing extensive residential development. The average flow from this basin is about 131 cubic feet per second (cfs).

Lawrence Brook Basin

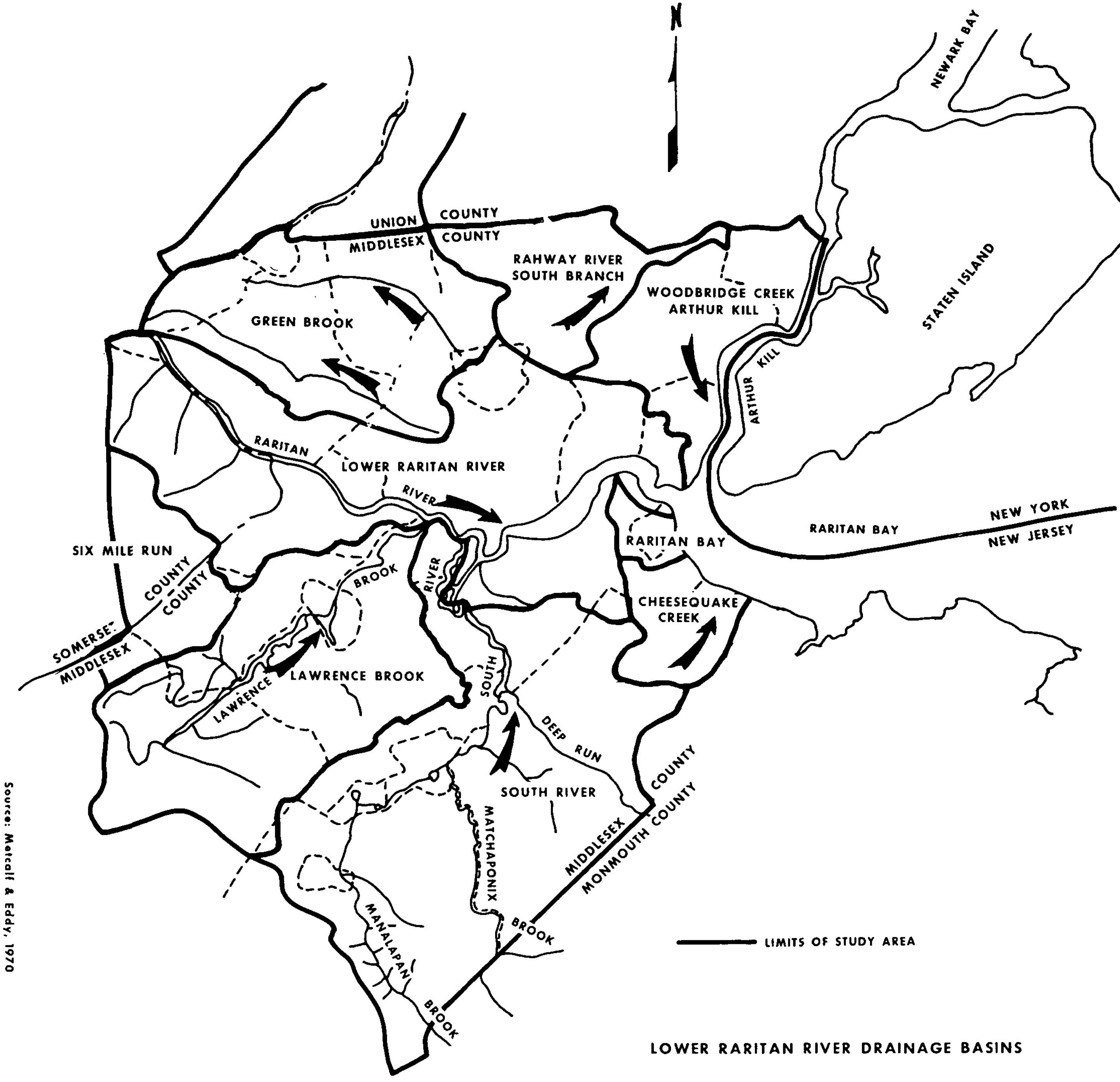
The Lawrence Brook drainage basin has a tributary area of about 47 square miles and lies to the northwest of the South River basin.

TABLE A-1

AVERAGE MONTHLY AND ANNUAL PRECIPITATION IN INCHES AT NEW BRUNSWICK

Month	New Brunswick
January	3.34
February	2.77
March	3.75
April	3.48
May	3.75
June	3.63
July	4.53
August	4.70
September	4.06
October	3.16
November	3.64
December	3.17
Annual Average	43.98
No. of Years of Record through 1963	109

Source: Metcalf & Eddy, October 1972.



LOWER RARITAN RIVER DRAINAGE BASINS

Source: Metcalf & Eddy, 1970

Figure A-2

In general, the topography of this basin is level. The soil is generally pervious on the east side of the brook and impervious on the west side. Lawrence Brook is tidal up to Westons Mills Pond. The average flow from the basin to the Raritan River is about 37 cfs. The upper portion of the drainage basin is still relatively undeveloped, while the lower portion is undergoing intensive development.

Green Brook Basin

The tributary area of the Green Brook drainage basin is about 66 square miles. The Watchung Mountains form the northern boundary of this basin. With the exception of areas adjacent to the Watchungs, the land in this drainage basin is relatively flat.

Land use within the basin is primarily residential, although there is some commercial and industrial development. The average flow from the basin into the Raritan River is about 12 cfs.

Lower Raritan River Basin

This drainage basin includes all areas that drain directly into the Raritan River. The basin tributary area is approximately 50 square miles. The topography along the river is relatively flat, although there are some steep inclines. The Raritan is the largest river in Middlesex County. Near the mouth of the Raritan, there has been considerable industrial development along the banks. Other areas of high industrial development are scattered along the river. The average flow of the Raritan at the point of its discharge into Raritan Bay is 1,400 cfs.

Bayshore Drainage Area

The tributary area of the Bayshore drainage basin is approximately 70 square miles. The topography is generally flat or gently sloping.

Areas of a somewhat higher elevation can be found in the western section of the basin around Keyport and Holmdel. There has been considerable residential, commercial and industrial development near the shore areas. The interior regions are just now being converted from rural agricultural areas to residential areas. The average flow from the drainage basin into Raritan Bay is approximately 100 cfs.

LAND USE PATTERNS

This section deals with the land use patterns predominating in the study areas. As indicated in Figure A-1, the lower Raritan River basin encompasses most of Middlesex County and substantially smaller segments of Somerset and Union Counties. The Bayshore area includes all or part of nine Monmouth County communities. Data on this subject were taken from three principal sources. The Middlesex County Planning Board's Comprehensive Master Plan No. 9 (1970) provided most of the land use information on the lower Raritan River basin. Two publications of the Monmouth County Planning Board, a detailed study on land use patterns (1967) and a general development plan for the county (1969), supplied most of the data used in the discussion of the Bayshore area.

Lower Raritan River Basin

Within the lower Raritan River basin, 38,600 acres are devoted to residential use, making this the dominant type of land use (see Table A-2). Individually, none of the commercial use categories contains more than 10,000 acres. In combination, however, manufacturing, wholesaling, retailing, services, transportation, construction and mining activities account for the second highest amount of land occupied (26,500 acres).

TABLE A-2

LOWER RARITAN RIVER BASIN STUDY AREA
LAND USE
1967

	Acres	Percent of Total	
DEVELOPED	90,051		38.7
Residential	38,612	16.5	
Non-Residential	51,439	22.2	
Manufacturing	5,685	(2.5)	
Wholesale	1,355	(0.6)	
Transportation, Communications, Public Utilities; Construction	6,959	(3.0)	
Mining	824	(0.3)	
Retail	1,872	(0.8)	
Services; Finance, Insurance and Real Estate	9,804	(4.3)	
Government	3,871	(1.7)	
Public Open Space	6,568	(2.8)	
Roads, Streets, Highways	14,495	(6.2)	
UNDEVELOPED	142,069		61.2
Vacant including Agriculture	125,856	54.2	
Agriculture	23,958	(10.3)	
Water and Swamp	16,213	7.1	
TOTAL: DEVELOPED AND UNDEVELOPED	232,120		100.0

Source: Metcalf & Eddy, October 1972.

Roads, streets and highways rank third on the land use scale (14,500 acres) followed by government, public educational activities and publicly owned and maintained recreation and open space lands (10,439 acres).

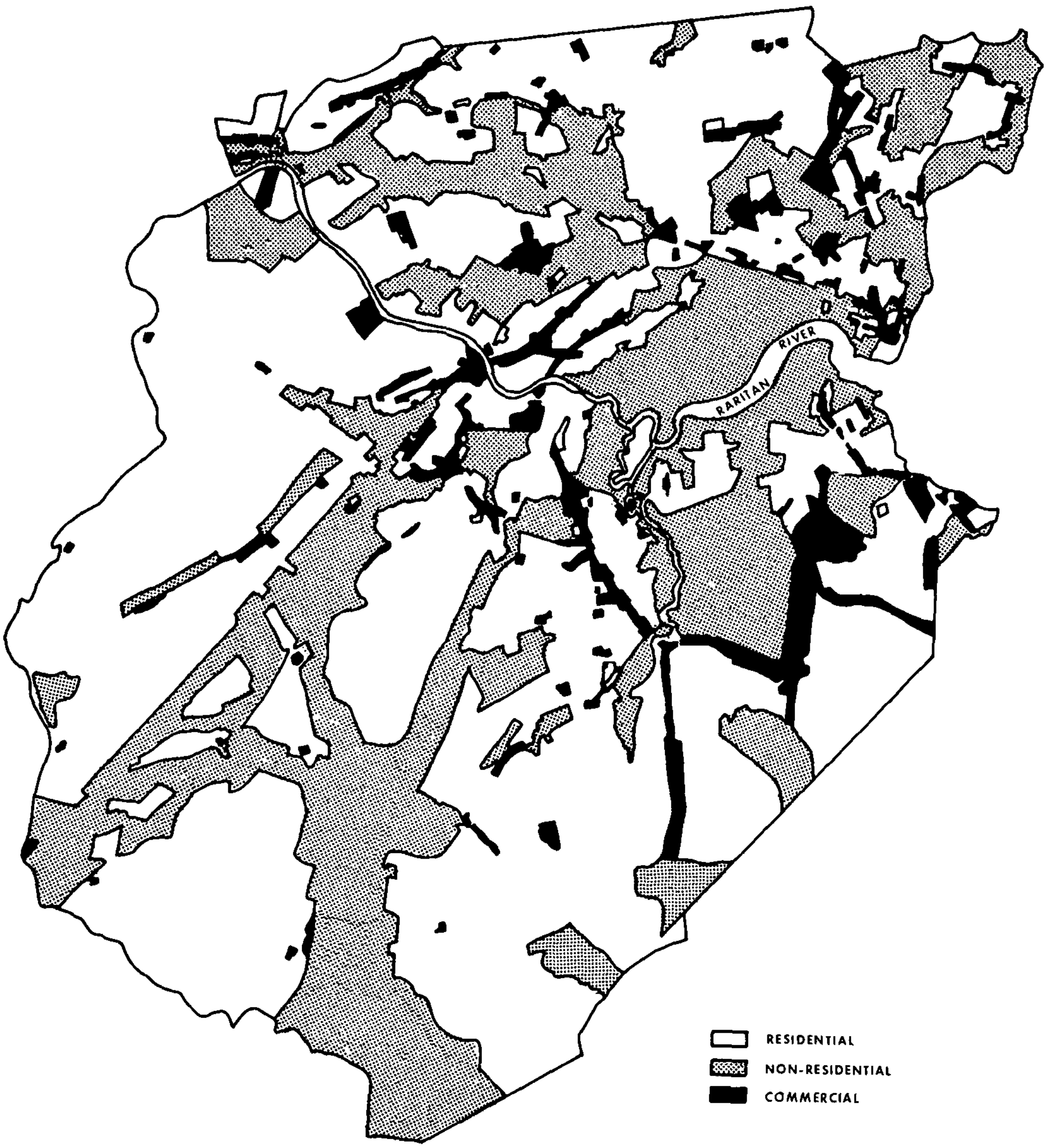
In the non-structural land use sector, agricultural activities utilize a considerable amount of land. However, the number of acres used for agricultural purposes cannot be accurately estimated because farmlands have been included in the pool of vacant lands potentially available for development. Water and swamp lands also account for a significant portion of the total area. While water and streams have no development potential, marshes and swamps often give way to development in areas experiencing the pressures of urbanization.

The trend toward development, particularly residential development, in the study area is evident. Figure A-3 shows the 1967 zoning distribution in Middlesex County. The eastern and central regions of Middlesex County 1/ are the most highly developed residential areas. Together they comprise 71 percent of the total land in the study area, yet they account for 95 percent of all housing units and 90 percent of all residential acres.

The eastern, central and southern regions of the county also differ according to residential density. The eastern region, which is the one most heavily influenced by the spread of urbanization outward from New York City, supports about 5.7 dwelling units per net acre. The density

1/In 1967, the Middlesex County Planning Board divided the county into three regions: east, central and south.

ZONING IN MIDDLESEX COUNTY
1967



Source: Metcalf & Eddy, October 1972

Figure A-3

declines with distance from New York: the central region having 3.9 and the southern region having 2.0 dwelling units per acre.

These density differences are partially attributable to the positions taken by the respective communities within the area on the desirability of apartment construction. Apartment houses comprise approximately the same percentage of the total housing in both the eastern and central regions, 24 percent in the eastern region and 27 percent in the central region. Multiple unit dwellings abound in the older core cities, such as Perth Amboy and New Brunswick. Furthermore, recent waves of apartment construction are extending these multiple unit dwellings into the surrounding, primarily single-family, communities.

Zoning is the single most important element in the formation of a community's character. However, zoning cannot be viewed as a permanently fixed force in shaping residential density or locational patterns. The tendency in zoning is toward acceptance and incorporation of new factors. As urbanization widens its sphere of influence, as land prices rise, and as public utilities spread outward, zoning is modified to accommodate these new pressures.

True to this pattern, the study area has experienced: 1) the reduction of single-family dwelling lot size requirements as public utilities have penetrated outlying areas, 2) the proliferation of apartment zoning in areas initially restricted to single-family residential use, and 3) the attempt to satisfy ever-increasing demands for housing through apartments by rezoning vacant commercially or even industrially zoned lands when residentially zoned areas have reached saturation.

As of 1967, 5,685 acres in Middlesex County were used for manufacturing purposes. This figure represents 2.4 percent of all developed land in the county. Most of these industrially developed lands are located in the eastern and central regions of the county. Industrial land use is expected to double by the year 2000, bringing the number of industrially developed acres to approximately 10,000.

Commercial interests are also concentrated in the eastern and central sections of the county. At present, 20,815 acres are engaged by commercial interests, representing 7 percent of the county's total land area. Land use studies have projected that the amount of commercially developed land will increase to 26,990 acres by 1985 and 33,759 acres by 2000.

In 1967, 10,439 acres in the county were classified as public or quasi-public lands. By 1980, this type of public land use is expected to increase 25 percent. As mentioned above, wetlands account for a significant portion of the county's total land area. In 1967, the Middlesex County Planning Board designated 16,213 acres as water and swamp areas. About 2,000 of these acres are expected to be officially classified as wetlands by the New Jersey Department of Environmental Protection under the Wetlands Act of 1970 (N.J.S.A. 13:9A-1 et seq.).

Bayshore Area

Table A-3 summarizes land use in the Bayshore area in 1966. As indicated in Table A-3, the major types of land use in descending order are: residential development (9,600 acres), public and quasi-public lands (7,700 acres), roads and streets (3,400 acres) and industrial and commercial development (2,800 acres). Agriculturally developed land,

TABLE A-3

BAYSHORE STUDY AREA
LAND USE
1966

Type Of Use	Number of Acres		% Of Total Area		% Of Developed Area	
Residential	9,677.3		19.92		40.96	
One Family	9,430.3		19.40		39.92	
Lot Size Less Than 10,000 Sq.Ft.		2,892.8		5.96		12.24
Lot Size 10-30,000 Sq.Ft.		5,848.2		12.03		24.75
Lot Size 30,000 Sq.Ft.(2.5 Acres)		689.3		1.42		2.92
Lot Size 2.5-10 Acres		0		0		0
Multiple Dwelling	159.7		0.33		0.68	
Hotel,Motel,Rooming Houses	87.3		0.18		0.37	
Business	785.2		1.62		3.32	
Industry	2,000.4		4.11		8.47	
Light Industry & Public Utility		1,792.3		3.68		7.59
Heavy Industry		208.1		0.43		0.88
Public and Quasi-Public	7,689.3		11.97		32.55	
Parks		1,050.7		1.05		4.45
Public Schools & Buildings		1,589.3		3.28		6.73
Quasi-Public Buildings & Open Uses		1,036.9		2.14		4.39
Churches		92.8		0.19		0.39
Cemeteries		86.8		0.18		0.37
Federal Government		2,477.7		2.35		10.49
Garden State Parkway		1,355.1		2.78		5.74
Beach Ownership	32.0		0.06		0.14	
Private		19.3		0.03		0.08
Public		12.2		0.02		0.05
Quasi-Public		0.5		0.01		0.02
Roads and Streets	3,440.7		7.08		14.56	
Total Developed Area	23,624.9		46.81		100.00%	
Agriculture,Woodland & Vacant	26,841.7		53.19			
Total Area	50,466.6		100.00%			

Source: Monmouth County Planning Board, 1967.

woodland and vacant land account for 26,841 acres.

As in Middlesex County, housing is the primary type of land development in the Bayshore area. Currently, more than one half of Monmouth County's industrial development is based in the Bayshore area. Traditionally, industry has chosen to locate near the shore areas. However, this trend is now changing with more and more industrial concerns opting for inland locations. Consequently, while the Bayshore area's industrial involvement should continue to grow, the rate of increase will be far lower than in other areas of the county.

Commercial property in the Bayshore area amounts to 785 acres. Most of the early commercial development was confined to the downtown areas of the older towns. More recent commercial development has occurred principally along Routes 35 and 36 in a pattern commonly referred to as strip development.

The Bayshore area has 7,689 acres in the public or quasi-public sector. The general development plan for the county recommends that public and quasi-public holdings be increased by 25 percent in the future.

As per the Wetlands Act of 1970, the New Jersey Department of Environmental Protection has decided that 5,000 acres in Monmouth County will be classified as wetlands. Between Middlesex and Monmouth Counties, approximately 7,000 acres of wetlands are eligible for official classification by the New Jersey Department of Environmental Protection. To date, 3,022.44 acres in the lower Raritan River basin and the Bayshore areas between Route 9 - Garden State Parkway and Atlantic Highlands have been mapped and classified by the Department. (Hammton, oral communication, 1973).

POPULATION

Lower Raritan River Basin

The population changes that occurred between 1940 and 1970 in each of the municipalities included either in whole or part in the study area are listed in Table A-4. The largest population increases took place in the townships of East Brunswick, Edison, Madison, Piscataway and Woodbridge over the twenty year period from 1950 to 1970. Over that same time span, the city of New Brunswick experienced only a slight population increase and Perth Amboy's population actually decreased.

The total population of the basin study area is expected to grow from the 1970 figure of 757,000 to 1,239,000 by 1985 and to 1,689,000 by 2000. Over the next thirty years, the eastern and central regions will more than double in population. Table A-5 presents population estimates for 1985 and 2000 according to drainage area. A residential density of 23.1 persons per acre is predicted for the eastern region by the year 2000. In comparison, the residential density of the central region is expected to be 16 persons per acre.

North of the Raritan River, development will continue to fill in the remaining vacant areas. This is the established pattern of development in both the eastern and central regions. South of the Raritan River, there will be a continued diffusion of population and industry along three major highway corridors. In the southern part of the eastern region, particularly in Madison Township, the opportunities for location along Routes 9 and 34 will be utilized, resulting in major development. In the southern part of the central region, particularly in East Brunswick, undeveloped pockets of land along Route 18 will be filled in, as will

TABLE A-4

LOWER RARITAN RIVER BASIN STUDY AREA
POPULATION CHANGES
1940-1970

	Total Population				Percent Of Change			
	1940	1950	1960	1970	1940-50	1950-60	1960-70	1950-70
Middlesex County								
Carteret	11,976	13,030	20,502	23,137	8.8	57.3	12.9	77.6
Cranbury	1,342	1,797	2,001	2,253	33.9	11.4	12.6	25.4
Dunellen	5,360	6,291	6,840	7,072	17.4	8.7	3.4	12.4
East Brunswick	3,706	5,699	19,965	34,166	53.8	250.3	71.1	499.5
Edison	11,470	16,348	44,799	67,120	42.5	174.0	49.8	310.6
Highland Park	9,002	9,721	11,049	14,385	8.0	13.7	30.2	48.0
Jamesburg	2,128	2,307	2,853	4,584	8.4	23.7	60.7	98.7
Madison	3,803	7,366	22,772	48,715	93.7	209.2	113.9	561.3
Metuchen	6,557	9,879	14,041	16,031	50.7	42.1	14.2	62.3
Middlesex	3,763	5,943	10,520	15,038	57.9	77.0	42.9	133.0
Milltown	3,515	3,786	5,435	6,470	7.7	43.6	19.0	70.9
Monroe	3,034	4,082	5,831	9,138	34.5	42.8	56.7	123.9
New Brunswick	33,180	38,811	40,139	41,885	17.0	3.4	4.3	7.9
North Brunswick	4,562	6,450	10,099	16,691	41.4	56.6	65.3	158.6
Perth Amboy	41,242	41,330	38,007	38,798	0.2	8.0	2.1	6.1
Piscataway	7,243	10,180	19,890	36,418	40.5	95.4	83.1	257.7
Plainsboro	925	1,112	1,171	1,648	20.2	5.3	40.7	48.2
Sayreville	8,186	10,338	22,553	32,508	26.3	118.2	44.1	214.5
South Amboy	7,802	8,422	8,422	9,338	7.9	0.0	10.9	10.9
South Brunswick	3,129	4,001	10,278	14,058	27.9	156.9	36.8	251.4
South Plainfield	5,379	8,008	17,879	21,142	48.9	123.3	18.3	164.0
South River	10,714	11,308	13,397	15,428	5.5	18.5	15.2	36.4
Spotswood	1,868	2,905	6,567	8,846	55.5	126.1	34.7	204.5
Woodbridge	27,191	35,758	78,846	98,944	31.5	120.5	25.5	176.7
	217,077	264,872	433,856	583,813	22.0	63.8	34.6	120.4

TABLE A-4 (Cont'd)

LOWER RARITAN RIVER BASIN STUDY AREA
POPULATION CHANGES
1940-1970

	Total Population				Percent Of Change			
	1940	1950	1960	1970	1940-50	1950-60	1960-70	1950-70
Somerset County								
Bound Brook	7,616	8,374	10,263	10,450	9.9	22.6	1.8	24.8
Franklin	5,912	9,601	19,858	30,389	62.4	106.8	53.0	216.5
Green Brook	763	1,155	3,622	4,302	51.4	213.6	18.8	463.8
North Plainfield	10,586	12,766	16,993	21,796	20.6	33.1	28.3	105.9
South Bound Brook	1,928	2,905	3,626	4,525	50.7	24.8	24.8	134.7
Watchung	1,158	1,818	3,312	4,750	57.0	82.2	43.4	310.2
	27,963	36,619	57,674	76,212	31.0	57.5	32.1	172.5
Union County								
Fanwood	2,310	3,228	7,693	8,920	39.7	138.3	15.9	286.1
Scotch Plains	4,993	9,069	18,491	22,279	81.6	103.9	20.5	436.3
Plainfield	37,469	42,366	45,330	46,862	13.1	7.0	3.4	25.1
	44,772	54,663	71,514	78,061	22.1	30.8	9.2	74.4
Total	289,812	356,154	563,044	738,086	22.9	58.1	31.1	107.2

Source: Metcalf & Eddy, October 1972.

TABLE A-5

LOWER RARITAN RIVER BASIN STUDY AREA
PRESENT AND ESTIMATED FUTURE POPULATION
BY DRAINAGE AREAS

Municipalities	Total Area, Acres	Year 1970 Total Population 1/	Year 1970 Estimated Population Served 2/	Year 1985 Estimated Population Served	Year 2000 Estimated Population Served
Middlesex County Sewerage Authority Area					
Present Participants					
Bound Brook 3/	1,024	10,450	12,200	14,500	15,500
East Brunswick	14,344	34,166	20,100	61,500	81,600
Edison	19,254	67,120	55,700	105,400	126,500
Franklin(Part) 3/	13,080	30,389	24,500	42,900	49,400
Highland Park	1,215	14,385	16,900	17,300	18,300
Madison(Part)	19,634	48,715	37,100	72,000	127,400
Metuchen	1,779	16,031	18,000	20,000	18,700
Middlesex	2,171	15,038	14,700	18,100	22,400
Monroe(Part)	2,215	9,138	3,100	5,600	19,600
New Brunswick	3,467	41,885	50,700	58,600	68,600
Milltown	960	6,470	6,900	7,400	8,600
North Brunswick	7,628	16,691	14,500	31,800	43,400
Piscataway	12,296	36,418	26,800	62,000	79,900
Plainfield Joint Meeting 4/	15,576	112,731	100,400	132,000	147,300
Sayreville(Part)	8,323	24,996	22,100	34,800	50,400
South Bound Brook	512	4,525	4,600	5,400	6,200
South Plainfield	5,349	21,142	14,500	34,500	44,100
South River	1,902	15,428	17,300	21,100	23,700
Spotswood	1,708	8,846	7,800	11,100	16,400
Sayreville(Part)					
Melrose	690	1,831	1,600	5,000	5,500
Morgan	2,854	5,681	5,000	12,500	14,500
South Amboy	1,702	9,338	10,500	12,000	15,300
South Brunswick					
Lawrence Brook	11,596	14,058	0	14,500	34,700
Total	149,279	565,472	485,000	800,000 5/	1,038,000
Northeastern County Area					
Carteret	3,177	23,137	23,200	30,772	38,170
Perth Amboy	3,862	38,798	38,000	52,464	61,525
Woodbridge					
Keasbey	2,640		12,000	15,349	18,238
Sewaren	7,344		30,000	53,312	65,631
Rahway	5,780		55,000	69,013	84,676
Total	22,803	———	158,200	220,910	266,240
Eastern County Area					
Madison(Part)	5,487		5,800	24,308	28,732
South River Area Within Middlesex County					
Helmetta	557		300	1,425	2,275
Jamesburg	557		3,500	5,314	5,366
Monroe(Part)	12,102		0	25,219	47,197
Total	13,216	———	3,800	31,958	54,832
Other Areas					
Franklin					
Six Mile Run	8,187	———	0	14,356	49,690
Grand Total, All Areas	198,972		652,800	1,263,314	1,437,494

1/From 1970 U.S. Census.
2/From 1968 Projections of Middlesex County Planning Board.
3/Outside Middlesex County.
4/Includes Dunellen in Middlesex County and Fanwood, Green Brook, North Plainfield, Scotch Plains, and Watchung outside of Middlesex County.
5/Population used for design.

Source: Metcalf & Eddy, October 1972.

vacant areas in the southwestern section between Route 18 and the New Jersey Turnpike. A third channel of growth will emerge along Route 27 in the central and southern regions. Development will be most pronounced in Franklin Township and in North and South Brunswick Townships.

Bayshore Area

The past, present and projected populations for each of the municipalities in the Bayshore area are listed in Table A-6. The townships of Hazlet, Matawan and Middletown have the highest population counts. The total population of the municipalities within the Bayshore area is expected to grow from the 1970 figure of 133,200 to 188,500 in 1985 and to 227,500 in 2000. This will amount to a 50 percent increase in population during the first fifteen year period and a 20 percent increase during the second fifteen year period. The most dramatic increases will occur in Holmdel, Matawan and Middletown Townships. Most of the other Bayshore municipalities will experience more moderate increases in population.

Since the Bayshore area is already highly developed, future development will be mainly a filling in of isolated vacant areas. Only in sections of Holmdel, Matawan and Middletown Townships will any kind of intensive development be possible. As in the lower Raritan River basin area, highway locations will determine the most likely sites for development in the Bayshore area.

TABLE A-6

BAYSHORE STUDY AREA
ESTIMATED POPULATION

Municipalities	1968 Population	1972 Population	1985 Population	2000 Population	% Increase	
					1968-85	1985-2000
Holmdel	5,430	6,750	16,000	25,500	194.7	59.4
Keansburg	7,400	9,730	9,500	12,000	28.3	26.3
Keyport	7,720	7,630	12,000	14,000	55.4	16.7
Matawan Bor.	8,220	9,210	12,000	13,000	46.0	8.3
Matawan Twp.	17,430	18,140	29,000	32,000	66.4	10.3
Middletown	51,430	56,930	75,000	90,000	45.8	20.0
Hazlet	20,200	22,530	26,000	29,000	28.7	11.5
Union Beach	6,430	6,530	9,000	12,000	40.0	33.0

Source: Monmouth County Planning Board, 1969.

NATURAL RESOURCES

Surface Waters

Flow data for the surface waters in the study areas are presented in Table A-7.

Streams

The major streams in the study areas are: Manalapan Brook, Matchaponix Brook, Ambrose Brook, Green Brook and Bound Brook. Some of the minor streams are: Ireland Brook, Cedar Brook and Barclay Brook. The water quality classifications assigned to these streams by the state of New Jersey are shown in Figure A-4. Definitions of these classifications are presented in Appendix B.

The streams in the study areas are fed by either surface water runoff or ground-water discharge. In periods of drought, most of the smaller streams flow at less than 1 cfs. During these times of reduced stream flow, the assimilative capacity of a stream is at its lowest. Consequently, the stream is subject to significant deterioration from the waste materials being pumped into it.

South River

The South River is one of the major tributaries to the Raritan River system. The Middlesex County portion of the South River drainage basin amounts to 72.6 square miles.

The South River is tidal up to the dam that is located just below the confluence of the river with Tennent Brook. The tidal portion of the South River is classified as TW-1 by the state of New Jersey. Above the dam, the river is classified as FW-2. (See Appendix B).

TABLE A-7

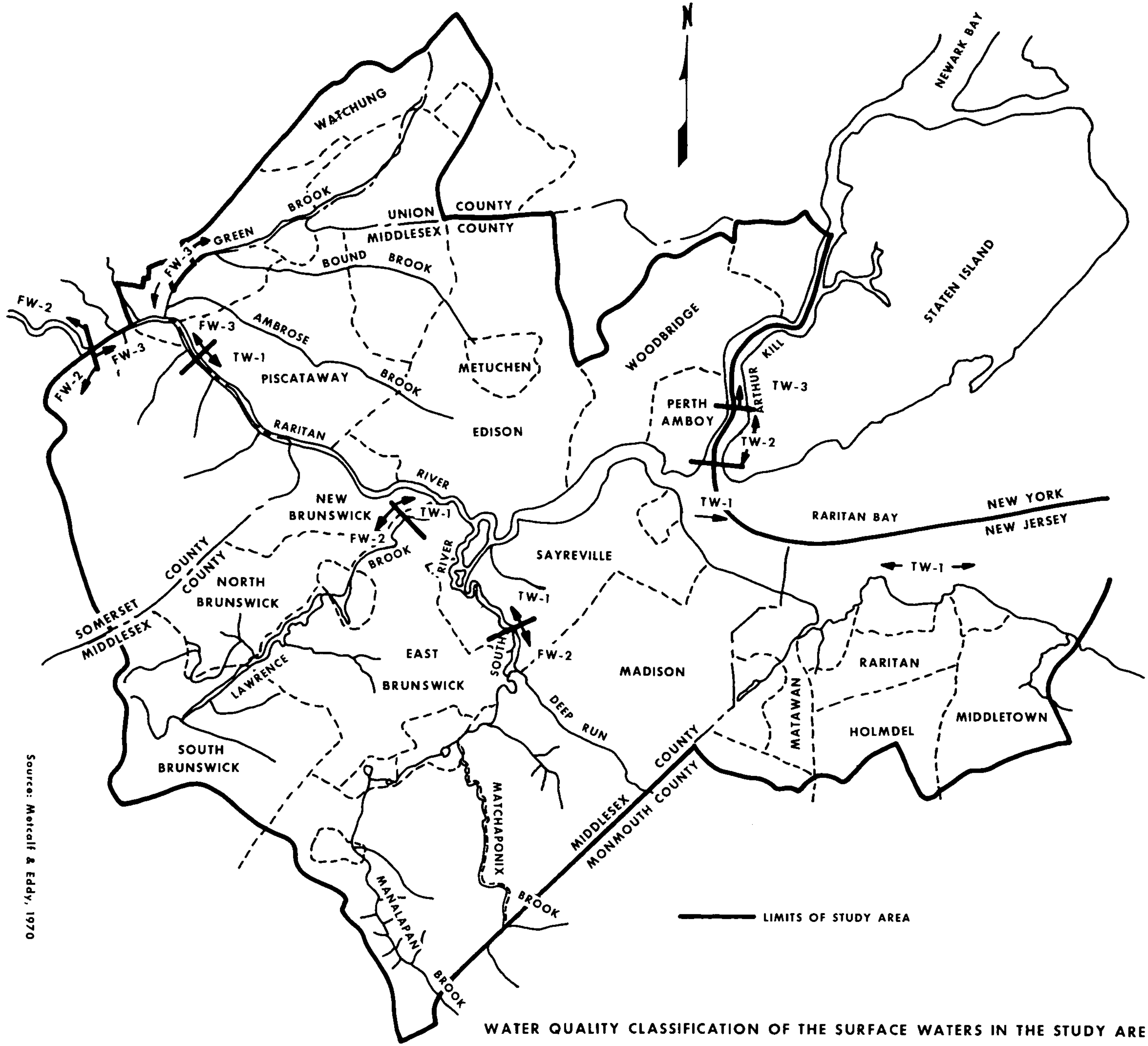
FLOW DATA FOR SURFACE WATERS
IN THE LOWER RARITAN RIVER BASIN
AND THE BAYSHORE STUDY AREAS

Gaging Station Location	Drainage Area sq. miles	Avg. or Mean Discharge cfs	Maximum Discharge cfs	Minimum Discharge cfs
Manalapan Brook at Spotswood	40.7	61.3 avg.	1,650	0
Green Brook at Plainfield	9.75	11.7 avg.	2,890	0
Lawrence Brook at Farrington Dam	34.4	37.2 avg.	2,980	0
Matchaponix Brook at Spotswood	43.9	62.5 avg.	2,050	0
South River at Old Bridge	94.6	131 avg. 122 1/ mean 135 2/ mean	4,880 670 1/ 1,250 2/	- 23 1/ 12 2/
Raritan River at Bound Brook	785	1,162 avg. 950 1/ mean 1,028 2/ mean	46,100 14,000 1/ 23,700 2/	- 123 1/ 102 2/

1/Discharge values for 1969.
2/Discharge values for 1970.

Source: FWPCA, 1967.

Figure A-4



WATER QUALITY CLASSIFICATION OF THE SURFACE WATERS IN THE STUDY AREAS

Source: Metcalf & Eddy, 1970

There are two sampling stations on the river: an upstream station in the Town of Old Bridge and a downstream station in the Town of South River. Water quality data for the South River are contained in Table A-8. These data reveal that between the Old Bridge station and the South River station there is a marked increase in the BOD (5-day), ammonia-nitrogen, nitrite-nitrogen, nitrate-nitrogen, total phosphate-phosphorus, total coliform and fecal coliform values. These values indicate that the river is severely degraded as it moves downstream from Old Bridge to South River.

Raritan River

For part of its length, the Raritan River is classified as FW-3 waters. This classification is applied to the river from the point at which the Millstone River joins the Raritan to the Fieldville dam downstream. From the Fieldville dam to the mouth of the Raritan, the river is classified as TW-1 waters. (See Appendix B).

The Raritan River is a natural stream with a low gradient. In general, the stream is shallow, averaging in depth from 3 to 4 feet at normal flows. At low flow, the stream below the American Cyanamid dispersion dam (also known as the Calco dam) is reduced to a depth of less than 1 foot.

Major tributaries to the Raritan River are:

1. Millstone River - 35 miles long, drainage area of 300 square miles;

2. Green Brook - enters Raritan River below Bound Brook, drainage area of 49 square miles;

3. Lawrence Brook - enters Raritan River below New Brunswick, drainage area of 45 square miles;

TABLE A-8

WATER QUALITY DATA FOR THE SOUTH RIVER
1965-1972

Parameter 1/	Old Bridge 2/ Station	South River 3/ Station
DO mg/l	8.37	6.58
BOD (7-day) mg/l	3.40	4.39
pH	5.61	6.46
Total ALK. mg/l as $CaCO_3$	10.54	37.09
ORG.-N mg/l	1.035	1.43
NH_3-N mg/l	0.53	1.74
NO_2-N mg/l	0.05	0.343
NO_3-N mg/l	2.50	5.40
Total PO_4 mg/l	0.53	0.617
Total COLI per 100 ml	5131	16997
FECAL COLI per 100 ml	538	2871

1/All numbers reported are mean values of samples collected from 1965 to 1972.
2/From bridge at South Amboy Road, Old Bridge, N.J.
3/From Causeway Bridge at Route 535, South River, N.J.

Source: U.S. EPA, n.d., STORET.

4. South River - enters Raritan River below town of South River, drainage area of over 100 square miles.

The Raritan River is non-tidal down to the Fieldville dam. Flow in the river is maintained at a minimum of 139 cfs at the Calco dam. This flow is obtained by regulation of flows from the Spruce Run Reservoir in compliance with the statute setting a minimum flow in the river. It has also been reported that on August 28, 1971, during the height of Hurricane Doria, the discharge of the river at the Calco dam was 46,100 cfs, the highest flow ever recorded at this station.

Table A-9 shows the water quality of the freshwater portion of the lower Raritan River. This portion extends from the confluence of the Millstone and Raritan Rivers to the Fieldville dam. As one proceeds downstream, the rapid deterioration of the water quality becomes apparent. At station RF-13, which is above the Calco dam, water quality, while not good (high BOD, NO_3-N, total PO_4 and total coliform), is far superior to that at station RF-11, which is just above the Fieldville dam.

According to the New Jersey Department of Environmental Protection (October 1972), the water quality above the Calco dam is generally suitable for those uses prescribed for FW-3 waters, with the exception of primary contact recreation. Below the Calco dam, the only designated use of these waters that is still possible is industrial and agricultural water supply. However, many industrial and agricultural consumers cannot use this water because of the color, odor and chemicals that are present.

The following information on the water quality of the Raritan River just below the Calco dam was submitted by the New Jersey Department of

TABLE A-9

WATER QUALITY DATA FOR THE FRESHWATER PORTION OF THE LOWER RARITAN RIVER 1968-1972

Parameter 1/	Station 2/ RF-13	RF-12	RF-11
DO mg/l	10.51	8.75	7.93
BOD (7-day) mg/l	5.54	7.08	7.72
pH	7.43	7.07	6.96
Total ALK. mg/l as $CaCO_3$	51.76	41.57	43.62
ORG. N mg/l	1.35	8.69	2.97
NH_3-N mg/l	0.148	3.57	4.02
NO_2-N mg/l	0.020	0.0528	0.0516
NO_3-N mg/l	1.05	1.228	1.16
Total PO_4 mg/l	0.69	1.29	1.40
Total COLI per 100 ml	13772	40490	157834
FECAL COLI per 100 ml	1440	2403	8335

1/All numbers reported are mean values of samples collected from 1968 to 1972.
2/Station Location: RF-11 - Upstream of Fieldville Dam
RF-12 - Main Street Bridge - South Bound Brook
RF-13 - Upstream of American Cyanamid Outfall.

Source: U.S. EPA, n.d., STORET.

Environmental Protection (October 1972):

NH_3 - Generally elevated by 2ppm after addition of the American Cyanamid Company's effluent.

Phenols - Not present in measurable quantities in the stream. However, chlorophenols, which are formed during chlorination, are not detected by the standard test for phenols. Thus, normal monitoring allows a series of toxic materials to enter the river undetected.

DO - In the past, dissolved oxygen levels frequently fell below the present stream standard of 4.0 mg/l. Recently completed additions to the American Cyanamid treatment plant (additional aeration) have relieved a significant amount of oxygen demand. Oxygen levels are now usually well above the 4.0 mg/l standard. During periods of low flow, the dissolved oxygen levels (especially in the area of the Fieldville dam) are expected to occasionally drop below the standard.

Dissolved Solids - The American Cyanamid Company's discharge normally elevates the dissolved solids level of the Raritan River. Depending on plant production schedules, this can be an insignificant (i.e., 2ppm during summer plant shutdown) or a significant (i.e., over 500ppm added to the normal stream level of 160ppm during periods of peak production) increase.

Color - The American Cyanamid discharge changes the color of the river water from its normal green to gold-brown. This color change, while not measurable using standard testing procedures, is readily apparent upon visual observation of the river.

Odor - A strong chemical odor is imparted to the Raritan River by the American Cyanamid discharge.

The water quality of the tidal portion of the river is shown in Table A-10. The data indicate a general improvement in water quality from station RT-10 to RT-1. The BOD (7-day), organic-nitrogen, ammonia-nitrogen, total coliform and fecal coliform values all point to a marked improvement in water quality at the downstream station.

Tables A-9 and A-10 show that the heaviest pollution occurs around stations RT-1 and RF-11. The coliform data also indicate the presence of significant sources of pollution around stations RT-9, RT-7, RT-6 and RT-5, all of which are in the vicinity of New Brunswick. Although water quality greatly improves between station RT-10 and station RT-1, the overall water quality of the lower Raritan River remains severely degraded.

The results of studies done by the Federal Water Pollution Control Administration (1967) show that water quality around the Landing Lane Bridge is directly related to river flow and to wastewater discharges entering upstream of the Fieldville dam. The lower portion of the river, around stations RT-1 and RT-2, is degraded at low tide by waters from Raritan Bay.

The Raritan River between its confluence with the Millstone River and the Calco dam supports a diverse, balanced population representative of a fairly clean waterway. Table A-11 shows the fish population at three sites on the river: above the Calco dam, below the Calco dam, and above the Fieldville dam. The stations below the Calco dam exhibit a significant decrease in fish species diversity.

TABLE A-10

WATER QUALITY DATA FOR THE TIDAL PORTION OF THE RARITAN RIVER
1969-1972

Parameter 1/	Station 2/									
	RT-1	RT-2	RT-3	RT-4	RT-5	RT-6	RT-7	RT-8	RT-9	RT-10
DO mg/l	5.68	5.95	6.06	6.53	6.79	7.02	7.27	7.95	8.01	8.14
BOD (7-day)mg/l	4.09	4.37	4.67	5.09	5.64	5.67	8.44	8.81	8.56	8.79
pH	7.21	7.10	6.93	6.99	7.05	6.99	7.04	7.02	6.99	6.90
Total ALK.mg/l as $CaCO_3$	82.45	70.15	60.27	51.57	49.24	47.91	43.86	46.07	51.41	45.85
ORG.-N mg/l	1.414	1.437	1.68	2.01	2.53	2.82	3.06	3.10	3.16	3.24
NH_3-N mg/l	1.500	1.774	2.08	2.43	2.81	3.86	3.44	4.33	4.62	4.39
NO_2-N mg/l	0.0978	0.1104	0.1174	0.1218	0.0958	0.0896	0.0954	0.0756	0.078	0.0536
NO_3-N mg/l	1.07	1.684	2.206	2.30	1.76	1.55	1.278	1.202	1.109	1.189
Total PO_4 mg/l	1.006	1.069	1.1163	1.117	1.02	1.104	1.204	1.225	1.268	1.568
Total COLI per 100 ml	7897	13167	28368	60417	102871	90939	53845	96535	85032	187337
FECAL COLI per 100 ml	785	1302	2139	4939	8141	6454	3505	8558	9441	9222

1/All values reported are mean values of samples collected from 1969 to 1972.
2/Station location:

Station No.	Station Description
Raritan River	
RT-1	Victory Bridge
RT-2	Opposite Arsenal Dock
RT-3	Opposite Central Jersey P & L
RT-4	Conf. South R. & Raritan R.
RT-5	Turnpike Bridge
RT-6	Route #1 Bridge
RT-7	Albany Street Bridge
RT-8	Landing Lane Bridge
RT-9	Off Marconi Road
RT-10	Downstream Fieldville Dam

Source: U.S. EPA, n.d., STORET.

TABLE A-11

FISH SPECIES PRESENT AT THREE SITES ON THE RARITAN RIVER
1971

Fish Species	Upstream of Calco Dam	Downstream of Calco Dam	Upstream of Fieldville Dam
American Eel	X		
Black Crappie	X	X	X
Bluespotted Sunfish	X		
Pumpkinseed Sunfish	X	X	X
Redbreasted Sunfish	X		
Largemouth Bass	X	X	X
Smallmouth Bass	X		
Rock Bass	X	X	X
Carp			X
Eastern Silvery Minnow	X	X	
Golden Shiner	X	X	
Spottail Minnow	X		
Banded Killifish		X	X
Redfin Pickerel	X		
Channel Catfish			X
Northern Brown Bullhead			X
Tadpole Madtom	X		
Johnny Darter	X	X	

X indicates presence.

Source: NJDEP, October 1972.

Benthic macroinvertebrate data show dramatic differences among the stations. Above the Calco dam, there are 32 different species represented. Below the dam, the number declines by 75 percent. An examination of the species present indicates that only the most pollutant-tolerant benthic species can survive below the Calco dam. Tables A-12a, b and c contain data for these sites.

From May to June 1972, the New Jersey Department of Environmental Protection carried out a survey of sessile organisms in the Raritan River. Table A-13 shows the results of this study. Above the Calco dam, 17 algal species were isolated in addition to 6 Tendipedidae larvae. One hundred yards below the dam, no algae were collected,but large numbers of Tendipedidae larvae were isolated. At the Queens Bridge in South Bound Brook, 6 algal species, 1 amoeba and many Tendipedidae larvae were isolated. The vast differences in species diversity and total organism counts between the above-dam and the below-dam sites support the chemical data which indicate a highly polluted condition downstream of the Calco dam.

Dean and Haskins (1964) reported that prior to 1959, under heavily polluted conditions, no freshwater benthic macroinvertebrate species were found below the Fieldville dam. They further reported that of the 17 marine species that were identified, only the barnacle Balanus improvisus extended 5.3 miles above the mouth of the river. The other species extended only 2.85 miles above the mouth.

In 1958, the Middlesex County Sewerage Authority constructed a trunk sewer and, thereby, eliminated much of the waste discharge into the Raritan River. A rapid repopulation of the waters below the Fieldville dam occurred.

TABLE A-12a

BENTHIC MACROINVERTEBRATE POPULATION
RARITAN RIVER-ABOVE CALCO DAM
1971

Order	Family or Subfamily	Genera
Diptera	Tendipedidae	Tendipes
	Simuliidae	
	Tipulidae	Helius
		Limonia
	Pelopiinae	
	Culicidae	
Ephemeroptera	Ephemeridae	Ephoron
		Potamanthus
	Baetidae	Ephemeralla
		Baetis
		Tricorythodes
Tricoptera	Hydropsychidae	Hydropsyche
Plecoptera	Peltoperlidae	Peltoperla
	Perlidae	Neoperla
Coleoptera	Haliplidae	
	Dryopidae	
	Psephenidae	Psephenus
Megaloptera	Sialidae	Sialis
	Corydalidae	Corydalus
Odonata	Coenagrionidae	
Amphipoda	Talitridae	Hyalella
	Gammaridae	Gammarus
Decapoda	Astacidae	Cambarus
Opisthopora	Haplotaxidae	Haplotaxis
	Lumbricidae	
Plesiopora	Tubificidae	Tubifex
Rhynchobdellida	Hirudidae	Helobdella
Pulmonata	Lymnaeidae	Lymnaea
	Physidae	Physa
	Planorbidae	
Pelecypoda	Margaritanidae	Margaritifera

Source: NJDEP, October 1972.

TABLE A-12b

BENTHIC MACROINVERTEBRATE POPULATION
RARITAN RIVER-BELOW CALCO DAM
1971

Order	Family or Subfamily	Genera
Diptera	Tendipedidae Pelopiinae	Tendipes Metriocnemus Pentaneura
Ephemeroptera	Ephemeridae	Ephoron
Tricoptera	Hydropsychidae	Hydropsyche
Coleoptera	Elmidae	
Plesiopora	Tubificidae	Tubifex
Amphipoda	Gammaridae	Gammarus
Pulmonata	Physidae	Physa

Source: NJDEP, October 1972.

TABLE A-12c

BENTHIC MACROINVERTEBRATE POPULATION
RARITAN RIVER-ABOVE FIELDVILLE DAM
1971

Order	Family or Subfamily	Genera
Diptera	Tendipedidae Pelopiinae Simuliidae	*Tendipes* *Pentaneura*
Ephemeroptera	Ephemeridae	*Ephoron*
Tricoptera	Hydropsychidae	*Hydropsyche*
Megaloptera	Sialidae	*Sialis*
Odonata	Coenagrionidae	
Plesiopora	Tubificidae	*Tubifex*
Arhynchobdellida		
Pulmonata	Lymnaeidae Planorbidae	*Lymnaea*

Source: NJDEP, October 1972.

N.J. UN Rat 11-489

" " " 2

Ep 902 74-252 ✓

" " 76-501 ✓

" 1.2 x74 ✓

I 67.2 x50 ✓

Pg 100, 101, 103, 104, 105 93

TABLE A-13

SESSILE ORGANISMS
RARITAN RIVER
MAY-JUNE 1972

Raritan River above Calco Dam

Cocconeis
Ankistrodesmus
Meridion
Scenedesmus
Nitzschia
Cladophora
Gomphosphaeria
Trachelomonas
Mallomonas
Rhodomonas
Spirulina
Melosira
Staurastrum
Euglena
Eudorina
Pediastrum
Navicula

Tendipedidae Larvae

Raritan River - 100 Yards below Calco Dam

Tendipedidae Larvae

Raritan River - At Queen's Bridge

Asterionella
Scenedesmus
Ankistrodesmus
Navicula
Amoeba
Mallomonas
Staurastrum

Tendipedidae Larvae

Source: NJDEP, October 1972.

In 1958, there were 6 freshwater and 21 marine species present; in 1959, the number had increased to 8 freshwater and 28 marine species. At the end of their study, Dean and Haskins observed that biotic recovery had progressed to the point where the quantitative distribution of species conformed to that of nonpolluted estuaries.

Raritan Bay

Classification

All of the waters within the Raritan Bay system have been classified as TW-1 waters by the state of New Jersey (See Appendix B).

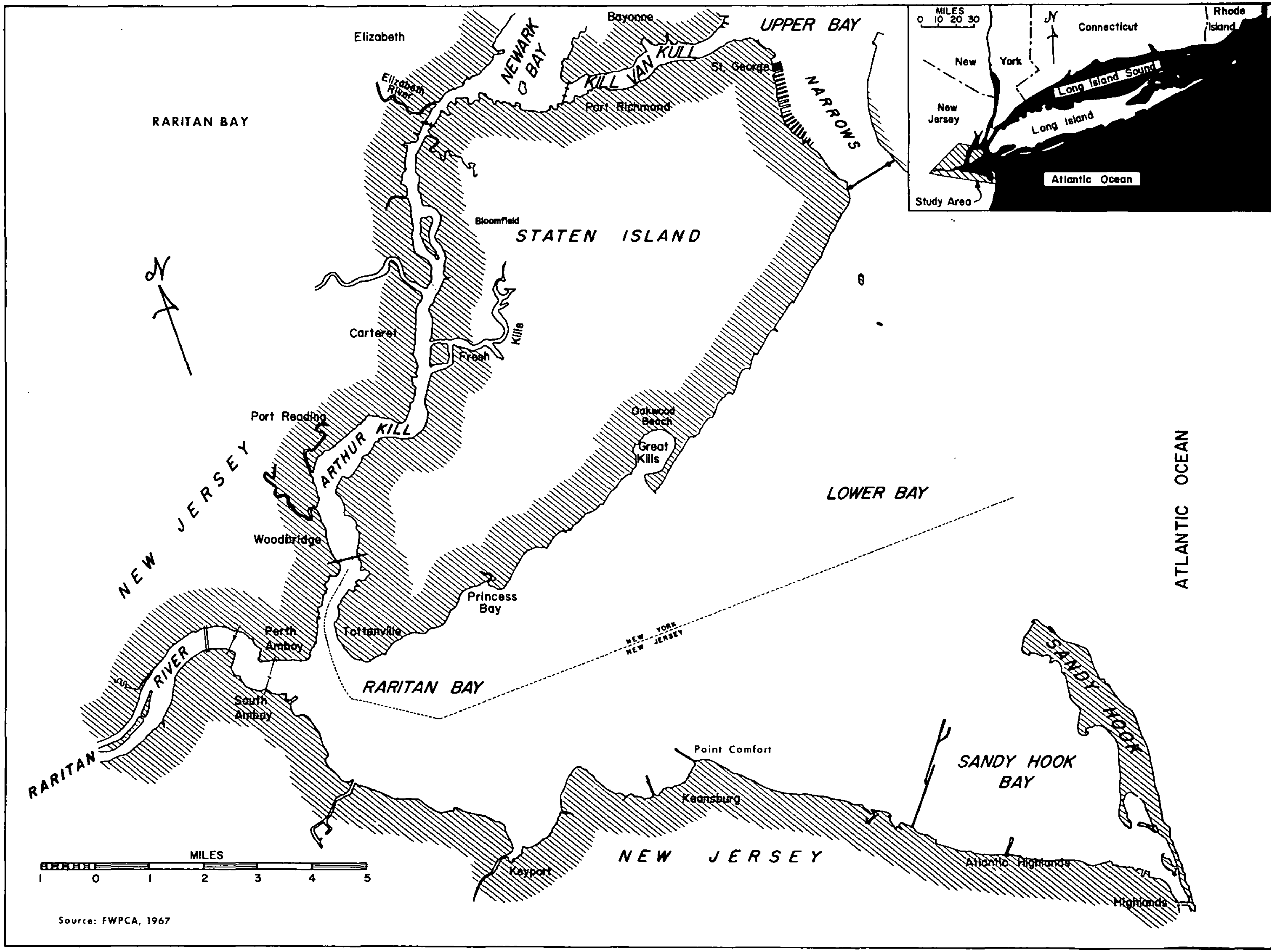
Physical Description

The Raritan Bay system is divided into three hydrologic areas: 1) Raritan Bay, which is located in the western portion of the system; 2) the Lower Bay, which stretches from Point Comfort eastward to Sandy Hook, and 3) Sandy Hook Bay, which is generally southeast of the Point Comfort - Sandy Hook transverse (Figure A-5).

The entire system is a shallow estuary, having a mean depth of less than 15 feet and a surface area of 1670×10^6 square feet. The floor of the bay slopes fairly uniformly and gently toward the central axis where the depths are approximately 22 feet in Raritan Bay and 28 feet in Lower Bay. Maximum depths in the bay are on the order of 30 feet, excluding the major shipping channels which have depths of up to 40 feet.

The system is characterized by a number of peripheral shoals located along the Staten Island and the south shore beaches: a factor which bears significantly on the hydrodynamic patterns exhibited in the bay.

Figure A-5



RARITAN BAY
Elizabeth
NEWARK BAY
Bayonne
UPPER BAY
KILL VAN KULL
St. George
Elizabeth River
Port Richmond
NARROWS
Bloomfield
STATEN ISLAND
Carteret
Fresh Kills
Port Reading
ARTHUR KILL
Oakwood Beach
Great Kills
NEW JERSEY
LOWER BAY
ATLANTIC OCEAN
Woodbridge
Princess Bay
Perth Amboy
Tottenville
NEW YORK
NEW JERSEY
RARITAN BAY
RARITAN RIVER
South Amboy
SANDY HOOK
SANDY HOOK BAY
Point Comfort
Keansburg
NEW JERSEY
Atlantic Highlands
Keyport
Highlands
MILES
1 0 1 2 3 4 5
Source: FWPCA, 1967
MILES
0 10 20 30
New York
Connecticut
Rhode Island
New Jersey
Long Island Sound
Long Island
Atlantic Ocean
Study Area

Hydrology

The waters that are primarily responsible for the general flow patterns within the system enter the basin from opposite ends: from the Raritan River on the west and through the Verrazano Narrows and Lower Bay 1/ on the east. The general tendency within the system is the creation of a discernible large-scale counterclockwise gyre of slowly circulating water masses (Jeffries, 1962).

The bay is the recipient of small natural freshwater inputs from the Arthur Kill, Matawan Creek and the Navesink River. The only one of significance, the Arthur Kill, is not a substantial source of freshwater. Rather it is a large surge basin contributing to the complex mixing processes existing at the head of the bay. The significance of this tributary is that it represents a large source of both biodegradable and potentially toxic substances. These substances are dispersed throughout the Kill and eventually enter the western portion of the Raritan Bay system.

The generally counterclockwise flow patterns exhibited within the bay have been substantiated by surveys of salinity, iron and suspended solids profiles. These surveys have indicated that flushing in Raritan Bay is accomplished by a net tidal drift which is westward along the north shore and eastward along the south shore (Ayers et al., 1949).

1/The source water across this boundary is actually a mixture of Hudson River water and sea water having an average salinity of 27 parts per thousand (ppt).

The southwesterly thrust of higher salinity waters flooding in from the Verrazano-Lower Bay area along the Staten Island shore is impeded and eventually diverted along a southerly course in the vicinity of Great Kills Harbor due to the influence of Old Orchard Shoal (Ayers et al., 1949). The resultant diversion of this inland (Hudson) thrust appears to exert an action which accelerates the seaward movement of fresh water (Raritan) along the south shore of Raritan Bay while, at the same time, damming back the waters accumulated in the head of the bay (Jeffries, 1962).

The effect of the Raritan River influent on bay circulation patterns is limited largely to the south shore area of the bay. The seaward drift due to this Raritan influence is on the order of 0.5 miles per day west of Conaskonk Point with a range of 0.25 to 0.5 miles per day. The net detention time within the head of the bay is on the order of 6 tidal cycles or approximately 3 days under average flow conditions (Ketchum, 1950). This is comparable to both the 7 day travel time from the Raritan River confluence to Conaskonk Point (Ayers et al., 1949) and the reported overall flushing time of 32 to 42 tidal cycles or 16 to 21 days for the entire bay (Jeffries, 1962).

The hydrodynamics of Sandy Hook Bay have not yet been adequately defined. Along the traverse extending from Sandy Hook to Norton Point, it has been noted that ebb tides are generally stronger and flow somewhat longer than the flood. Tidal velocities and the resultant dispersion characteristics are greater along this interface than in any other area of the bay, with the exception of the Verrazano Narrows. Average and peak tidal velocities along this interface are on the order of 1.7 and 4.2 feet per second (fps), respectively (USGS, Current Charts, 1956), as compared with an average tidal velocity throughout Raritan Bay of 0.8 fps (Hydroscience, 1968). With the exception of this turbulent outer boundary area, the tidal velocities and tidal range generally increase as the bay narrows toward its head. The maximum velocity readings are 1.0 fps off Point Comfort, 1.5 fps at Great Beds Channel, and 2.5 fps in the lower Raritan River (Ayers et al., 1949). Conversely, tidal velocities generally decrease along nearshore areas due to extensive shoaling; tides are frequently so weak (less than 1/6 knot) that the direction of tidal flow becomes more variable. This phenomenon is particularly evident in the head of the bay where intertidal reverses and the resultant eddies often retard the exchange of water over the shoals along the south shore.

In summary, the bay is a predominantly dispersive system containing a number of inlet or confined areas that are highly susceptible to degradation. The only places in which the non-tidal drifts would clearly remove pollution from the area are around the northern tip of Sandy Hook and in the main New York channel (Ketchum, 1950). Even though it is a predominantly dispersive system, the bay exhibits both large-and small-scale circular water movements. At times, these circular movements tend either to prevent the intrusion of pollutants into certain areas of the bay or to entrap pollutants within those areas.

<u>Water Quality</u>

The U.S. Public Health Service conducted Enforcement Conferences on Raritan Bay in 1961, 1963 and 1967 because the discharge of domestic and industrial wastes into the bay was causing pollution of interstate waters. The water quality data listed below have been extracted from the proceedings of the 1967 conference (FWPCA, 1967).

Water temperature - mean values were uniform throughout the bay averaging 15 to 16°C. A calculated range of thermal values was -1.3 to 26.1°C.

Chloride - mean chloride concentrations averaging from 11,000 to 12,000 mg/l were uniform throughout the bay.

BOD (5-day) - observed values ranged from an average of 3 to 4 mg/l in the western end of the bay to less than 2 mg/l at the ocean extremity. The highest observed values were in the range of 11 to 12 mg/l.

Dissolved oxygen - average dissolved oxygen concentrations ranged from 6 mg/l at the mouth of the Arthur Kill to 9 mg/l in the center of the bay along a band reaching from Prince's Bay, Staten Island to Sandy Hook Bay. East and north of this band, average dissolved oxygen levels decreased to 6 mg/l. The highest average dissolved oxygen level, 10 mg/l, was found in Sandy Hook Bay. Minimum dissolved oxygen values recorded were approximately 2 mg/l at all stations, except at the mouth of the Arthur Kill where levels as low as 1.4 mg/l were observed.

Bacteriological density - high densities of total and fecal coliform were found at the Narrows and at the junction of the Arthur Kill with the Raritan River. Coliforms appeared to radiate into the bay from these two foci. A straight band, running from lower Staten Island to Sandy Hook Bay, was characterized by the lowest mean counts of coliforms. It is believed that this band represents the edge of the two radiating sources.

Data obtained during federal surveillance operations from 1969 to 1972 (Table A-14 and Figure A-6) show that the waters at the western end of the bay and around Staten Island are in a degraded state. This observation is supported by the higher nitrate-nitrogen values and lower dissolved oxygen values recorded in these areas.

TABLE A-14

WATER QUALITY DATA FOR RARITAN BAY 1/
1969-1972

Parameter 2/	Station																		
	34	463	64	33	32	58	59	30	45	27	24	22	5	102	70	7	11	13	15
DO mg/l	6.20	7.11	7.90	7.20	8.26	7.39	8.17	9.63	8.66	9.35	9.55	8.78	8.84	6.69	7.53	7.87	8.03	9.66	10.71
pH	7.73	8.0	8.0	7.70	8.40	7.80	7.90	8.20	8.30	-	-	-	-	7.40	7.60	7.40	-	-	-
NO_3-N mg/l	.392	.960	.600	.413	.423	.443	.413	.320	.400	.337	.28	.29	.25	.27	.33	.255	.227	.223	.210
Kjeldahl-N mg/l	1.60	1.343	1.33	1.62	1.58	1.73	1.24	1.097	1.36	.957	.697	.913	.997	.765	.795	.810	.520	.550	.710
Total PO_4 mg/l	.258	.180	.220	.280	.210	.250	.23	.186	.197	.143	.157	.120	.133	.210	.175	.155	.170	.110	.177
TOC mg/l	7.43	7.34	6.20	6.81	5.24	6.32	8.96	7.25	6.93	5.92	4.59	4.12	6.11	4.85	4.90	3.80	3.87	3.86	4.83
Total Coli per 100 ml	11435	3568	6724	4665	1630	2793	959.6	275.6	342.9	1700	1541	2824	5853	63596	19538	10521	3446	333	210.8
Fecal Coli per 100 ml	1123	322	549	524	87.7	292	128.6	53.9	57.3	252.7	111	530	945	10765	3409	2624	1391	57.4	24.7
Salinity g/l	21.8	17.90	18.75	21.08	21.14	20.49	20.59	22.62	20.85	22.04	22.13	22.8	22.74	22.52	21.72	23.24	23.36	23.7	22.43

1/The sampling sites are shown in Figure A-6.
2/All values reported are mean values of samples collected from 1969 to 1972.

Source: U.S. EPA, n.d., STORET.

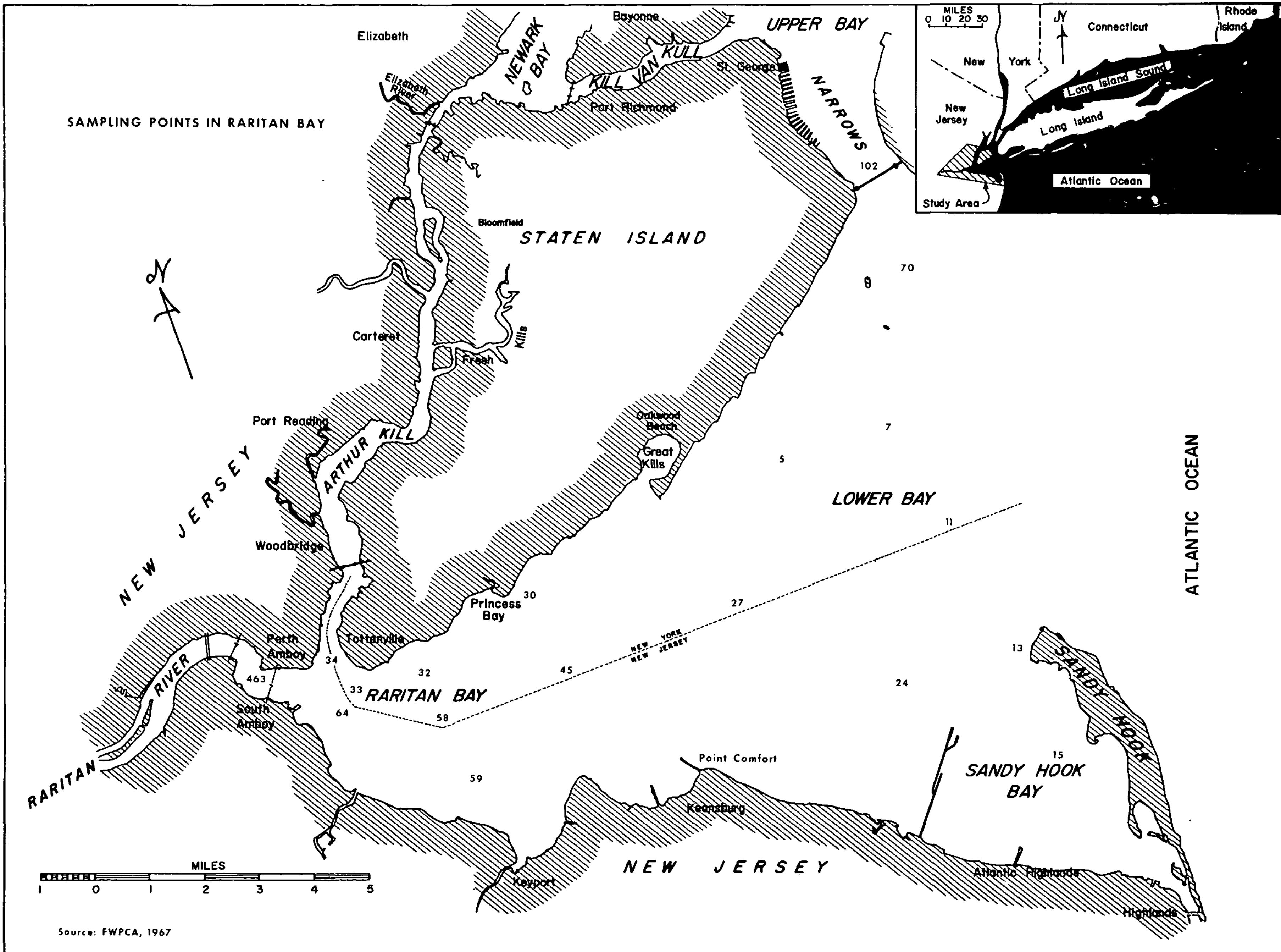

SAMPLING POINTS IN RARITAN BAY
Elizabeth
NEWARK BAY
Bayonne
KILL VAN KULL
UPPER BAY
St. George
NARROWS
Elizabeth River
Port Richmond
102
Bloomfield
STATEN ISLAND
70
Carteret
Fresh Kills
Port Reading
ARTHUR KILL
Oakwood Beach
Great Kills
7
5
NEW JERSEY
LOWER BAY
11
ATLANTIC OCEAN
Woodbridge
30
Princess Bay
27
Tottenville
NEW YORK
NEW JERSEY
13
Perth Amboy
34
32
45
24
463
33
RARITAN BAY
SANDY HOOK
RARITAN RIVER
South Amboy
64
58
15
Point Comfort
SANDY HOOK BAY
59
Keansburg
MILES
1 0 1 2 3 4 5
Keyport
NEW JERSEY
Atlantic Highlands
Highlands
Source: FWPCA, 1967
MILES
0 10 20 30
New York
Connecticut
Rhode Island
Long Island Sound
New Jersey
Long Island
Atlantic Ocean
Study Area

Figure A-6

Flora and Fauna

Phytoplankton

During extensive studies of the bay, Patten (1962) made the following observations.

1. The two most significant phytoplankton species in Raritan Bay were the diatom *Skeletonema costatum* and the chlorophyte *Nannochloris atomus*.

2. Species diversity in the lower bay area was greater and more stable than that at the river mouth.

3. The spring bloom began in the lower bay. The dominant species were *Skeletonema costatum*, *Nitzschia seriata* and *Rhizosolenia setigera*. The population density of *S. costatum* was 2 to 15 times higher in the lower bay region than at the mouth of the river. In the summer, *N. atomus* became dominant with the bloom starting at the river mouth and spreading to the lower bay.

Chlorophyll *a* values ranged from zero to 162.8 mg/l. Gross productivity was found to be 10 times that recorded by Conover (1956) for Long Island Sound. Oxygen productivity figures ranged from 0.11 ml/l/day to 6.70 ml/l/day.

In studies carried out between 1962 and 1964 (FWPCA, 1967), the dominant nannoplankton species was *Nannochloris atomus*, a green algae which comprised 50 to 99.9 percent of the total population. It imparted a turf grass green color to the water. The dominant netplankton species was *Skeletonema costatum*, a diatom which comprised from less than 1.0 to more than 99 percent of the netplankton. A dinoflagellate, *Peridinium trichoidum*, dominated the netplankton in August and September of 1962 and again in 1964.

On September 20, 1962, a red tide occurred off Point Comfort. The organism was *Goniaulax*, a known toxic dinoflagellate. Patten (1961) observed red tides in the bay caused by *Massartia rotundata*, a flagellate.

Zooplankton

Zooplankton studies by Jeffries (1959) showed that the zooplankton population consisted principally of copepods, which are dominated by two genera, *Acartia* and *Eurytemora*. There were brief periods during the spring and summer when various meroplanktonic larval forms dominated, but these periods were short-lived. Jeffries also found that *Acartia clausii* dominated Raritan Bay during the winter and was gradually replaced by *Acartia tonsa* during the warmer months. *Acartia tonsa* appeared first at the head of the bay; its numbers increased in the lower bay as *Acartia clausii* decreased in numbers. During the spring, when low salinities occurred and *Acartia* was at an ebb,two species of *Eurytemora* were at their peak. (Jeffries, 1959).

Studies carried out by the Federal Water Pollution Control Administration (1967) showed that large numbers of zooplankton were present from November 1963 to August 1964. Zooplankton density generally decreased from the outer bay towards the mouth of the Raritan River. Copepods comprised 72 percent of the total zooplankton; the predominant genus was *Acartia.* Rotifers and larval benthic forms were other major components of the zooplankton. In late May and early June 1964, juvenile copepods of the genus *Acartia* appeared in densities approximating 100,000 individuals/m^3, causing a red appearance on the surface of inner Raritan Bay.

Benthos

The U.S. Public Health Service (1963) determined that the benthic conditions of the bay were characterized by fine sand particles along with some silts and clays. Sampling indicated that a different benthic community existed at each of the six sampling stations (Figure A-7). The populations at each station were characterized by low species diversity. Polychaete worms were common at all stations and were dominant at Stations II and VI. Amphipods were found at all Stations except VI and were dominant at Station III. The dominant species at Station IV was the soft-shelled clam Mya arenaria. The greatest numbers of organisms were found at Stations III and IV and the lowest numbers at Station VI.

Another study, which was conducted by the Federal Water Pollution Control Administration (1967) in the area of the present MCSA outfall, revealed that species diversity increased proportionally with distance from the pollution source. The types of benthic organisms and their relative numbers found during a 1964 survey are presented in Table A-15.

There are two economically important shellfish species in Raritan Bay: Mya arenaria, the soft-shelled clam, and Mercenaria mercenaria, the northern quahog or hard clam. As of 1960, 90 percent of the existing shellfish areas were closed due to pollution by sewage. An epidemic of infectious hepatitis was traced to consumption by the stricken individuals of raw clams harvested in Raritan Bay. Figures A-8 and A-9 show the distribution and density of shellfish in Raritan Bay (FWPCA, 1967).

Recreation

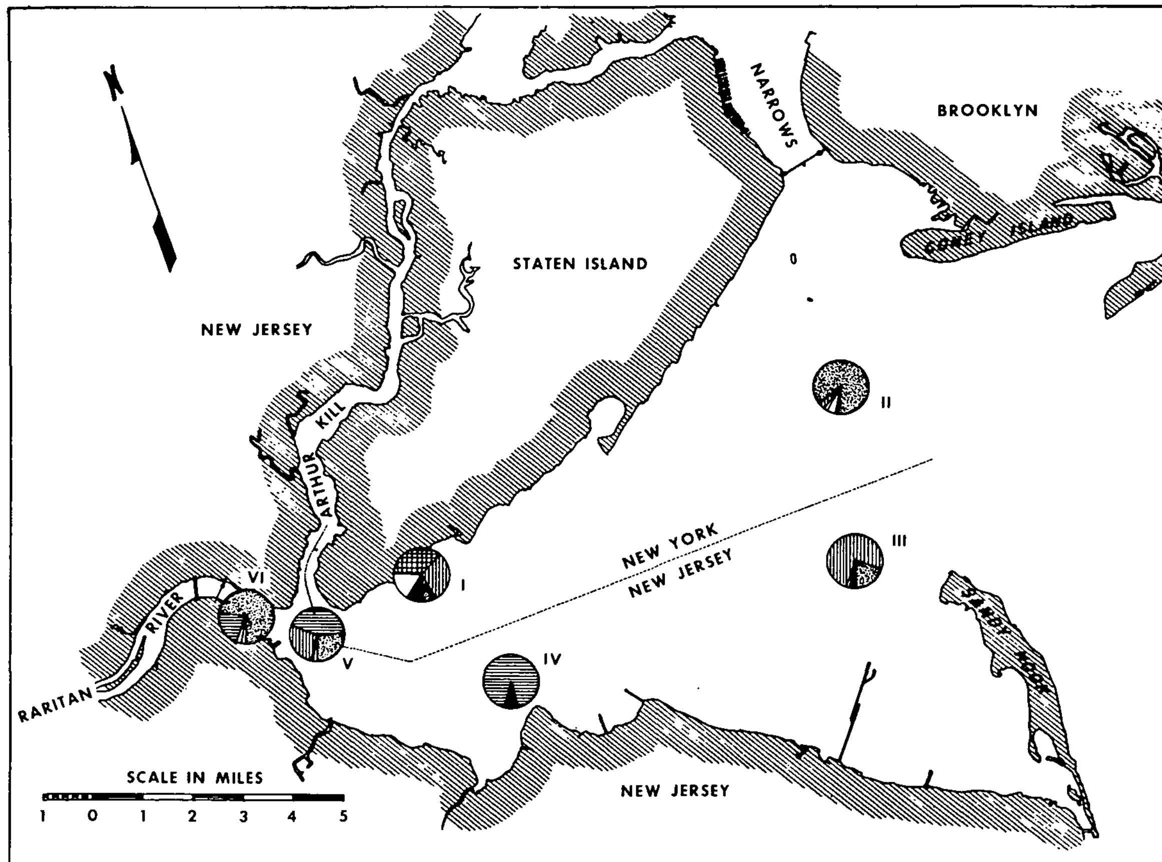
In 1963, the Federal Water Pollution Control Administration (1967) conducted a survey of the recreational uses of Raritan Bay. The proximity of the bay to large population centers made the determination of the existing and the potential use patterns desirable.

Figure A-7

BENTHIC POPULATIONS IN RARITAN BAY

PERCENT OF TOTAL BENTHIC POPULATIONS

	STATION					
	I	II	III	IV	V	VI
POLYCHAETA	8	87	20	4	27	73
MYA ARENARIA	-	-	-	92	42	23
AMPHIPODA	30	4	76	3	28	-
ISOPODA	36	2	<1	<1	1	2
GASTROPODA	18	5	<1	<1	2	2
OTHERS	8	2	2	-	-	-



Source: USPHS, 1963

TABLE A-15

PERCENTAGE OF BENTHOS AT REPRESENTATIVE STATIONS IN RARITAN BAY 1964

Month	Station 62				Station B				Station 29				Station H			
	PW	AC	SC	O	PW	AC	SC	O	PW	AC	SC	O	PW	AC	SC	O
Feb.	0	0	0	0	76	6	0	18	67	17	0	16	8	92	0	0
May	100	0	0	0	65	15	0	20	33	66	0	1	15	85	0	0
Aug.	0	0	100	0	35	28	10	27	74	19	7	0	55	38	0	7

PW = Polychaete Worms
AC = Amphipod Crustaceans
SC = Soft Shell Clams
O = Others: All types of organisms that comprised separately less than 5% of the total.

Source: FWPCA, 1967.

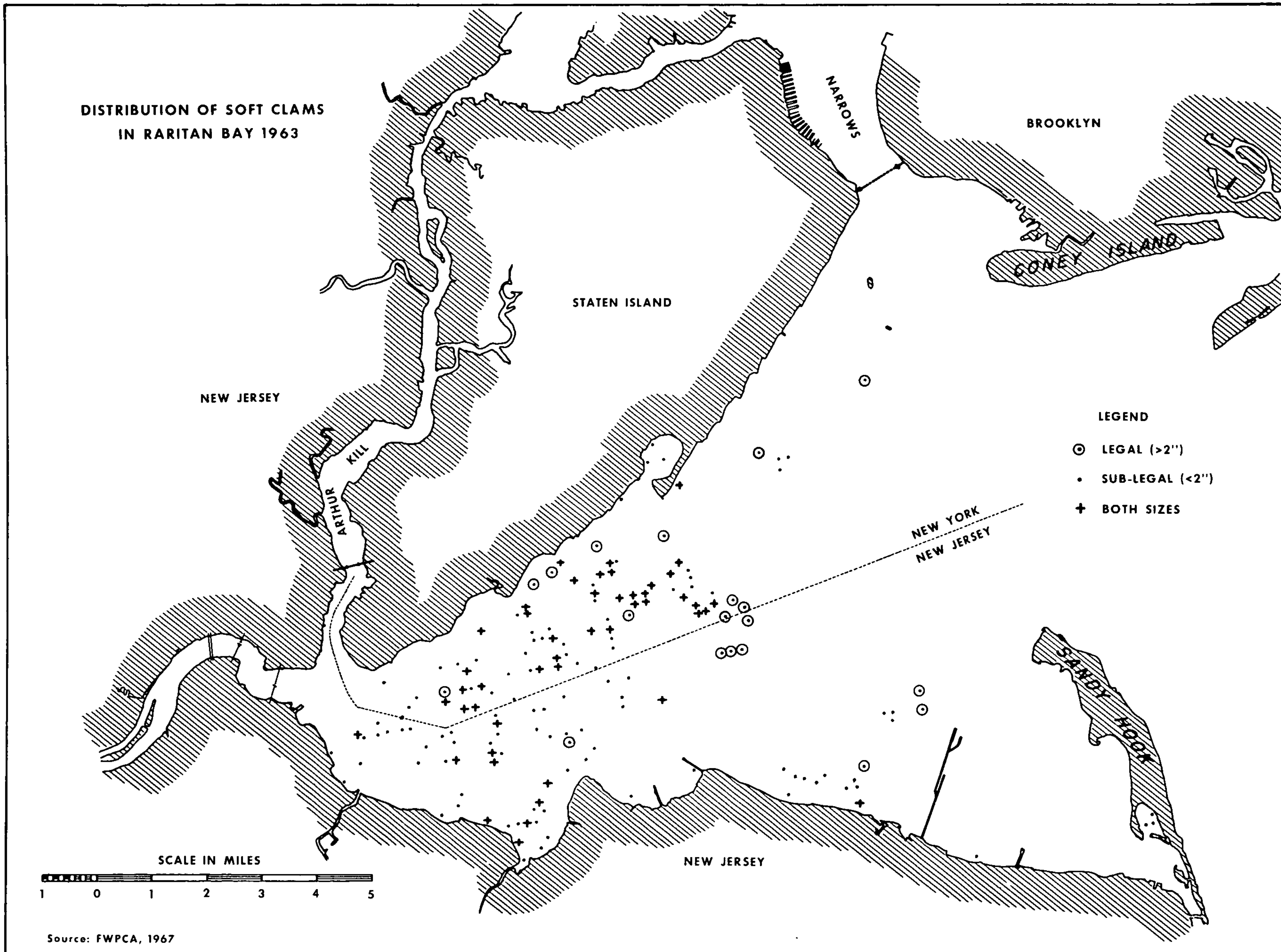
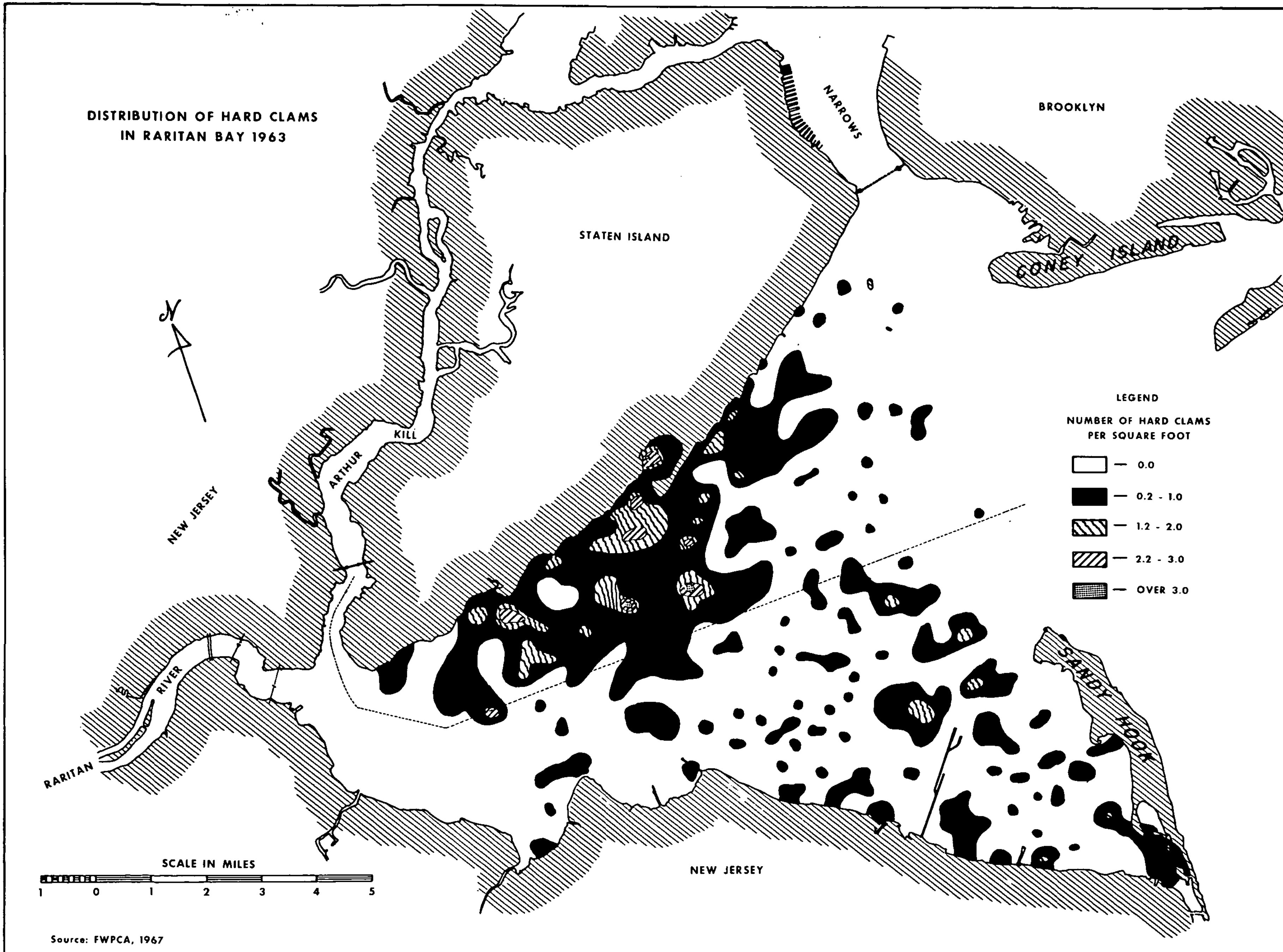

DISTRIBUTION OF SOFT CLAMS
IN RARITAN BAY 1963
NARROWS
BROOKLYN
STATEN ISLAND
CONEY ISLAND
NEW JERSEY
ARTHUR KILL
LEGEND
LEGAL (>2")
SUB-LEGAL (<2")
BOTH SIZES
NEW YORK
NEW JERSEY
SANDY HOOK
SCALE IN MILES
1 0 1 2 3 4 5
NEW JERSEY
Source: FWPCA, 1967

Figure A-8



DISTRIBUTION OF HARD CLAMS
IN RARITAN BAY 1963
N
STATEN ISLAND
NARROWS
BROOKLYN
CONEY ISLAND
ARTHUR KILL
NEW JERSEY
RARITAN RIVER
SANDY HOOK
NEW JERSEY
LEGEND
NUMBER OF HARD CLAMS
PER SQUARE FOOT
— 0.0
— 0.2 - 1.0
— 1.2 - 2.0
— 2.2 - 3.0
— OVER 3.0
SCALE IN MILES
1 0 1 2 3 4 5
Source: FWPCA, 1967

Figure A-9

According to the survey, there were 59 bathing beaches in active use on Raritan Bay and the Arthur Kill, serving an estimated 1 million users. This heavy use occurred in spite of the fact that a bacteriological analysis showed water quality to be impaired by the presence of domestic sewage. Operators opined that if water quality could be improved, at least 16 million users could be accommodated at a potential income of $8 million annually.

Recreational boating records indicated that 5,480 vessels berthed in or adjacent to the bay. The Fish and Wildlife Service of the U.S. Department of the Interior estimated that the recreational fin and shellfishing, crabbing, and waterfowl industries have a combined annual worth of $468,000. Furthermore, the Fish and Wildlife Service estimated that this combined value could reach $1.5 million annually. (FWPCA, 1967).

Arthur Kill

Classification

The waters of the Arthur Kill are classified as TW-2 from Raritan Bay to the Woodbridge River. From the Woodbridge River to Newark Bay, the Arthur Kill is classified as TW-3. (See Appendix B).

Physical Description

The Arthur Kill forms a boundary between Middlesex County in New Jersey and Richmond County in New York. The Kill is 13 miles long with an average width of one-half mile. The center channel is maintained at a depth of 35 feet by periodic dredging. It is relatively free of sediment; however, areas outside the main channel are extremely prone to accumulations of polluted sediments.

Hydrology

The tide enters this estuary at the northern terminus from the Kill Van Kull and Newark Bay and at the southern terminus from Raritan Bay. A slight increase in salinity occurs at the Raritan Bay terminus.

On October 19, 1972, the U.S. Environmental Protection Agency conducted a dye study to determine current and dispersion in the Arthur Kill area (see Appendix D). A dye release was made just below the Outerbridge Crossing at low water slack. The dye first traveled upstream with the incoming current and then reversed its travel direction at the turn of the tide. After four days, the dye was uniformly dispersed throughout the western end of Raritan Bay. The net seaward movement of the dye mass was about 9 miles over a period of 8 tidal cycles.

Water Quality

Data collected from August 1962 to September 1964 (FWPCA, 1967) show that the Kill is severely degraded. BOD (5-day) values averaging about 6ppm at Carteret and low dissolved oxygen levels support this general observation.

At the 1967 Enforcement Conference for Raritan Bay, the following data were presented.

Water temperature - average water temperatures ranged from 14.5 to 15.4^{o}C at Perth Amboy. The highest water temperatures were recorded in the southern end of the Kill.

Chloride - average chloride values at the southern end of the Kill were approximately 13,500 ppm. Chloride values decreased to an average of 11,500 ppm in Newark Bay. Slight increases were observed in the vicinity of Carteret.

BOD (5-day) - the average BOD (5-day) was 3 ppm at Outerbridge Crossing and 6 ppm at Carteret. Values as high as 12 ppm were observed near Carteret. Sliding scale BOD determinations indicated that toxic materials were present in the Kill water.

COD - the average COD values throughout the Kill ranged from 110 to 135ppm. The highest average, 135 ppm, was recorded at Sewaren.

Dissolved oxygen - dissolved oxygen values averaged 6 ppm near Perth Amboy and 2.5 ppm at Carteret. Zero values were recorded north of Carteret. Dissolved oxygen values were also depressed in areas of active dredging.

Phenol - phenol values of 800 parts per billion (ppb) were recorded near the Rahway River; high concentrations were also observed at Carteret. The range of values was 0.06 to 800 ppb.

Oil - oil was frequently observed on the Kill surface. Quantitative studies of mud samples indicated heavy deposits of oil in the bottom muds of the Kill. Highest concentrations were found in Woodbridge Creek where 50 grams of dry mud produced 32 grams of oil. At the Outerbridge Crossing, a value of 0.08 grams of oil per 50 grams of dry mud was recorded. (FWPCA, 1967).

Flora and Fauna

An ecological survey of the Arthur Kill by the Raytheon Company showed that:

"1. Plankton numbers and diversity in the Kill appeared to be below average [in comparison with Raritan Bay];

"2. The principal problem in the Kill appears to be low dissolved oxygen concentration." (reported in NJDEP, October 1972).

Phytoplankton cell numbers were unevenly distributed along the length of the study area with peak numbers occurring at sewage treatment plant effluent sites near Fresh Kill and Raritan Bay. Table A-16 lists the species that were found and the stations at which they were found. Figure A-10 shows the sampling site locations on the Kill.

Benthic organisms were collected primarily at channel stations. Most of the organisms were either highly motile, allowing them to move with water quality changes, or characteristic of silty, muddy environments. The non-edible shrimp, Crangon septemspinosus, was widespread and numerous. Other bottom invertebrates that were collected, all in small numbers, included: several kinds of crabs (lady crab, Ovalipes ocellatus; blue crab, Callinectes sapidus; mud crab, Neopanope texana); snails (especially the common mud snail, Nassarius obsoletus); soft-shelled or "steamer" clams (Mya arenaria); and barnacles.

As distance north of Raritan Bay increased, there was a progressive decrease in the numbers of fish observed at stations on the Kill. Species diversity also declined as one proceeded from stations on Raritan Bay to stations on the Kill. The only species found in significant numbers in the Arthur Kill was the pollutant-tolerant killifish. Species that are commonly found in relatively clear waters containing an adequate supply of dissolved oxygen (e.g., the bay anchovy) were collected primarily near the entrance of the Kill to Raritan Bay. A list of the organisms collected in the Arthur Kill is presented in Table A-17.

Studies conducted by the Federal Water Pollution Control Administration showed that the average total phytoplankton density in the Arthur Kill from October 1963 through September 1964 was 125,000 cells/ml at

TABLE A-16

PHYTOPLANKTON DISTRIBUTION AND ABUNDANCE IN THE ARTHUR KILL
1972

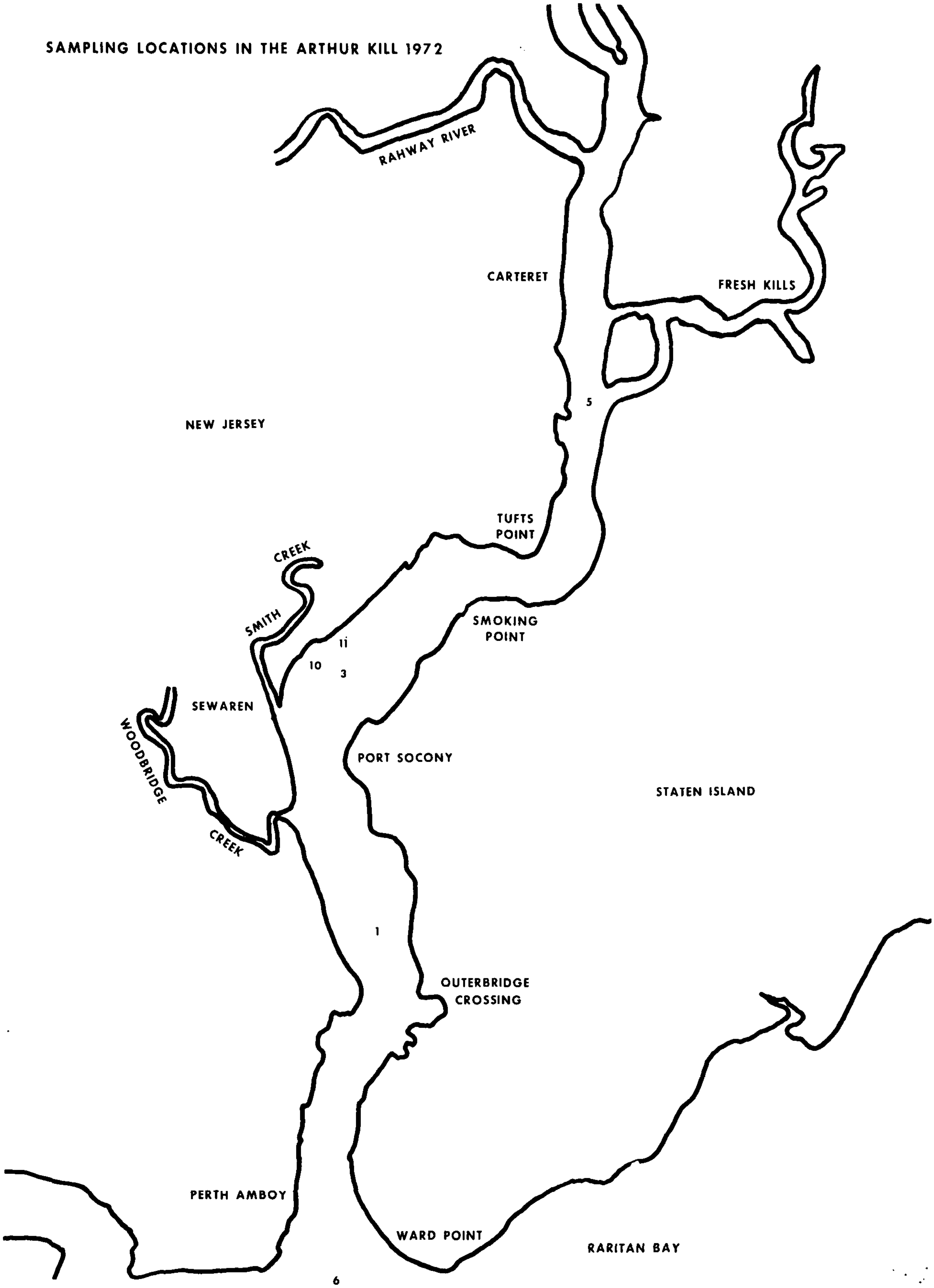
Species	Types	Stations 1/ Fresh Kill 5	3	Intake 11	Effluent 10	1	Raritan Bay 6
Asterionella	D	C	C	A	A	R	A
Coscinodiscus	D	C	R	C	C	C	R
Coscinosira	D		C				
Diatoma	D(FW)	R	R	R	C	C	R
Leptocylyndricus	D			C			
Licomorpha	D		R	R			
Melosira	D			C			
Navicula	D	R	C	C	A	C	A
Nitzschia	D			C	C	R	
Pinnularia	D						R
Rhizosolenia	D	C	R			C	C
Thalassionema	D	R					
Thalassiosira	D			C	C		
Mesodinium	F		R				C
Peridinium	F		R		C		R
Ankistrodesmus	G(FW)	A	A	A	A	A	A
Closterium	G(FW)		R				
Cryptomonas	G				C		
Kirchneriella	G(FW)	C	C		C	R	C
Rhodomonas	G	R		R			
Unknown	G				C		
Number of Types		9	12	11	11	8	10

D = Diatom
F = Flagellate
G = Green
FW = Fresh Water Species

A = Abundant
C = Common
R = Rare

1/The sampling sites are shown in Figure A-10.

Source: Raytheon Company data in NJDEP, October 1972.



Source: Raytheon Company Data in NJDEP, October 1972

Figure A-10

TABLE A-17

ZOOPLANKTON SPECIES FOUND IN THE ARTHUR KILL
1972

Scientific Name	Common Name
Anguilla rostrata	American eel
Syngnathus fuscus	Pipefish
Limanda ferruginea	Yellowtail flounder
Sarsia mirabilis	Jellyfish
Nemopsis bachei	Jellyfish
Leptoplana ellipsoides	Flatworm
Polydora ciliata	Segmented worm
Nereis arenoceodonta	Segmented worm
Gammarus annulatus	Amphipod
Unidentified cirripedia	Barnacle larvae
Podon leuckarti	Cladoceran
Temora longicornis	Copepod
Acartia tonsa	Copepod
Tortanus discaudatus	Copepod
Centropages hamatus	Copepod
Pseudocalanus minutus	Copepod
Calanus finmarchicus	Copepod
Eurytemora hirundoides	Copepod
Pandalus montagui	Shrimp
Crangon septemspinosus	Snapping shrimp

TABLE A-17 (Cont'd)

ZOOPLANKTON SPECIES FOUND IN THE ARTHUR KILL
1972

Scientific Name	Common Name
Carcinus maenas	Green crab
Edotea montosa	Isopod
Nerocila munda	Isopod
Edotea triloba	Isopod
Neomysis americana	Ghost shrimp
Unidentified gastropod	Snail
Nassarius trivitatus	Snail
Sagitta elegans	Arrow worm
Autolytus cornutus	Segmented worm
Myriochele heeri	Segmented worm
Melita dentata	Amphipod
Polinices triseriata	Moon snail

Source: Raytheon Company data reported in NJDEP, October 1972.

Perth Amboy and 200,000 cells/ml at Carteret. Average net phytoplankton for the same period was approximately 6,000 cells/ml at Perth Amboy and 5,000 cells/ml at Carteret. Nannoplankton comprised 95 percent of the total phytoplankton. Densities of netplankton were highest during the spring bloom of Skeletonema costatum, which was the principal netplankton species. During late spring, summer and fall, diatoms of the genus Thalassiosira were dominant. (FWPCA, 1967).

Densities of zooplankton were approximately 11,500/m^3 at the mouth of the Arthur Kill (Perth Amboy) and at Port Reading, and approximately 7,000/m^3 at Carteret. Most zooplankton were types adaptable to wide ranges of salinity. Zooplankton increased markedly during the spring and summer. Local distribution of zooplankton appeared to be dependent upon dissolved oxygen concentrations.

Table A-18 presents the results of benthic organism studies conducted by the Federal Water Pollution Control Administration (1967). Figure A-11 pinpoints the location of each of the sampling stations on the Arthur Kill. Three sampling runs were made on the Kill (October 1, 1963, November 14, 1963 and June 15, 1964). Eleven miles of bottom, from Station 501 to Station 509, were devoid of benthic organisms. Samples taken at the other stations on the Kill showed that there was little seasonal variation with regard to density of organisms or species diversity. Benthic organisms were never found in excess of 800 per square meter nor were there more than seven different species present at any station.

Dominant organisms were tube dwelling segmented worms, principally Polydora lignii. These are considered pollutant-tolerant organisms.

TABLE A-18

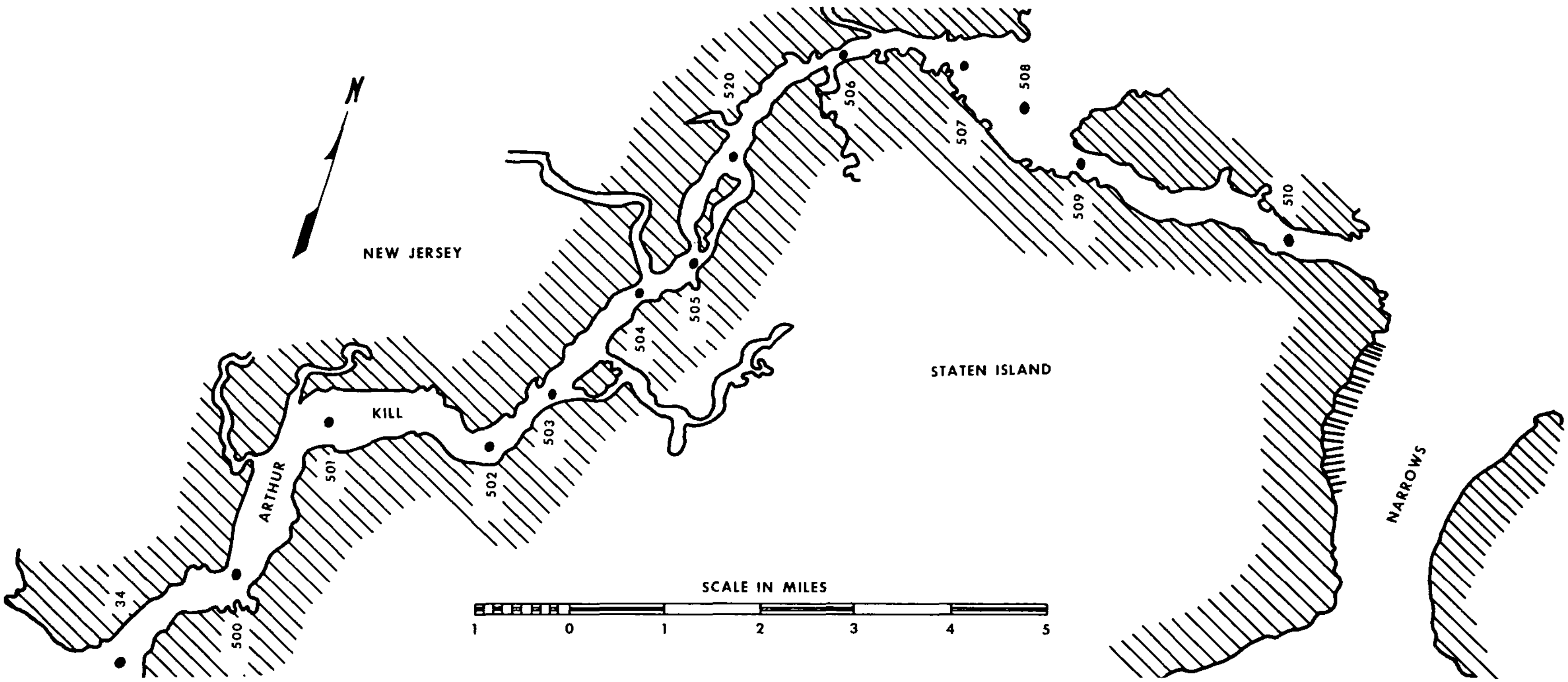
ARTHUR KILL BENTHOS SURVEY
OCTOBER 1963

Sta.1/	Avg. No. of Organisms per Square Meter	Avg. No. of Species per Square Meter	Dominants	Odor	Observations
34	95	1.5	Polychaetes	Slight Oil	Small shells (1/4"-1/2"),wood
500	175	5.3	Polychaetes	Slight Oil	No shells,plant material
501	0	-	-	Oil	Few *Mya* shells(1/4"), plant material
502	3	0.3	-	Oil	No shells,plant material
503	0	-	-	Oil	No shells, little plant material
504	0	-	-	Oil	No shells, little plant material
505	0	-	-	Oil	Little plant material
520	0	-	-	Oil	Nothing else
506	0	-	-	Oil	Little plant material
507	0	-	-	Oil	Nothing else
508	3	0.3	Polychaetes	Oil,H_2S	Nothing else
509	582	4.0	Polychaetes	Oil,H_2S	2 *Mya* shells (1"), little plant material
510	594	8.7	Polychaetes	Oil,H_2S	Plant material

1/The sampling sites are shown in Figure A-11.

Source: FWPCA, 1967.

Figure A-11



SAMPLING LOCATIONS IN THE ARTHUR KILL 1963

Source: FWPCA, 1967

From June 24 to July 1, 1964, a field bioassay study was conducted (FWPCA, 1967). Three types of test organisms, killifish, mud crab and shrimp, were placed in cages and immersed at four stations in the Kill and at a station in Prince's Bay, Staten Island, which served as a control for the test. In addition to live caged animals, traps were placed at the same locations to permit observation of growth of attached organisms. The results of this study (Table A-19) showed that stations 504 and 520 were highly polluted with no organisms surviving more than two days.

Other tests indicated that the observed toxicity to aquatic life in the Kill is largely attributible to the low levels of dissolved oxygen (FWPCA, 1967).

Hydrogeology

Geological Formations

The geologic formations of the study areas are listed in Table A-20. The formations which are sufficiently thick and permeable to yield at least 100,000 gallons per day (gpd) per well are underlined in Table A-20. In order of their importance as aquifers in the study areas, they are:

1. Magothy and Raritan formations
2. Brunswick shale (including Stockton formation)
3. Wisconsin stratified drift
4. Englishtown formation
5. Pennsauken formation
6. Mount Laurel sand and Wenonah formation.

Only the Magothy and Raritan formations and the Brunswick shale can be considered major aquifers in the areas under discussion. Figure A-12

TABLE A-19

BIOLOGICAL SURVIVAL STUDY
ARTHUR KILL
1964

Station	Organisms In Time Est. Date	Organisms Out Number Survived	% Survival	Time Diff. Hrs.	Temp °C In & Out	Salinity ppt	DO mg/l	Observations
Control (Prince's Bay)	1130 6-24 Fish 3 Crabs 7 Shrimp 10	1400 7-1 3 5 3 (7 escaped)	84.6	170.5	20.5	24.70	10.15	Plant and animal growth on pilings where trap attached. After 1 week heavy plant and animal growth on trap.
500	1200 6-24 Fish 3 Crabs 6 Shrimp 1	1430 7-1 1 5 3 (3 escaped)	75.0	170.5	21.6	23.96	5.30	Plant and animal growth where attached. Heavy plant and animal growth on trap after 1 week.
504	1315 6-24 Fish 3 Crabs 6 Shrimp 6	1135 6-26 0 0 0	0	46.7	23.4	21.41	0.4	Pilings and trap free of growth.
520	1400 6-24 Fish 0 Crabs 7 Shrimp 10	1155 6-26 0 0	0	46.0	23.4	20.71	0.3	Pilings and trap free of growth.
507	1340 6-24 Fish 3 Crabs 6	1235 6-26 0 2	13.3	47.0	22.5	21.04	1.3	Algal growth on pilings. Trap free of growth.

Source: FWPCA, 1967.

TABLE A-20

STRATIGRAPHIC TABLE FOR MIDDLESEX COUNTY 1/

Cenozoic sequence

  Quaternary system

    Recent series
      Alluvium
      Eolian deposits

    Pleistocene series
      Wisconsin drift
      Cape May formation
      Pensauken formation

UNCONFORMITY

Mesozoic sequence

  Cretaceous system

    Upper Cretaceous series
      Mount Laurel and Wenonah sands
      Marshalltown formation
      Englishtown sand
      Woodbury clay
      Merchantville clay
      Magothy formation
      Raritan formation
        Amboy stoneware clay
        Old Bridge sand member
        South Amboy fire-clay
        Sayreville sand member
        Woodbridge clay
        Farrington sand member
        Raritan fire-clay

UNCONFORMITY

  Triassic system

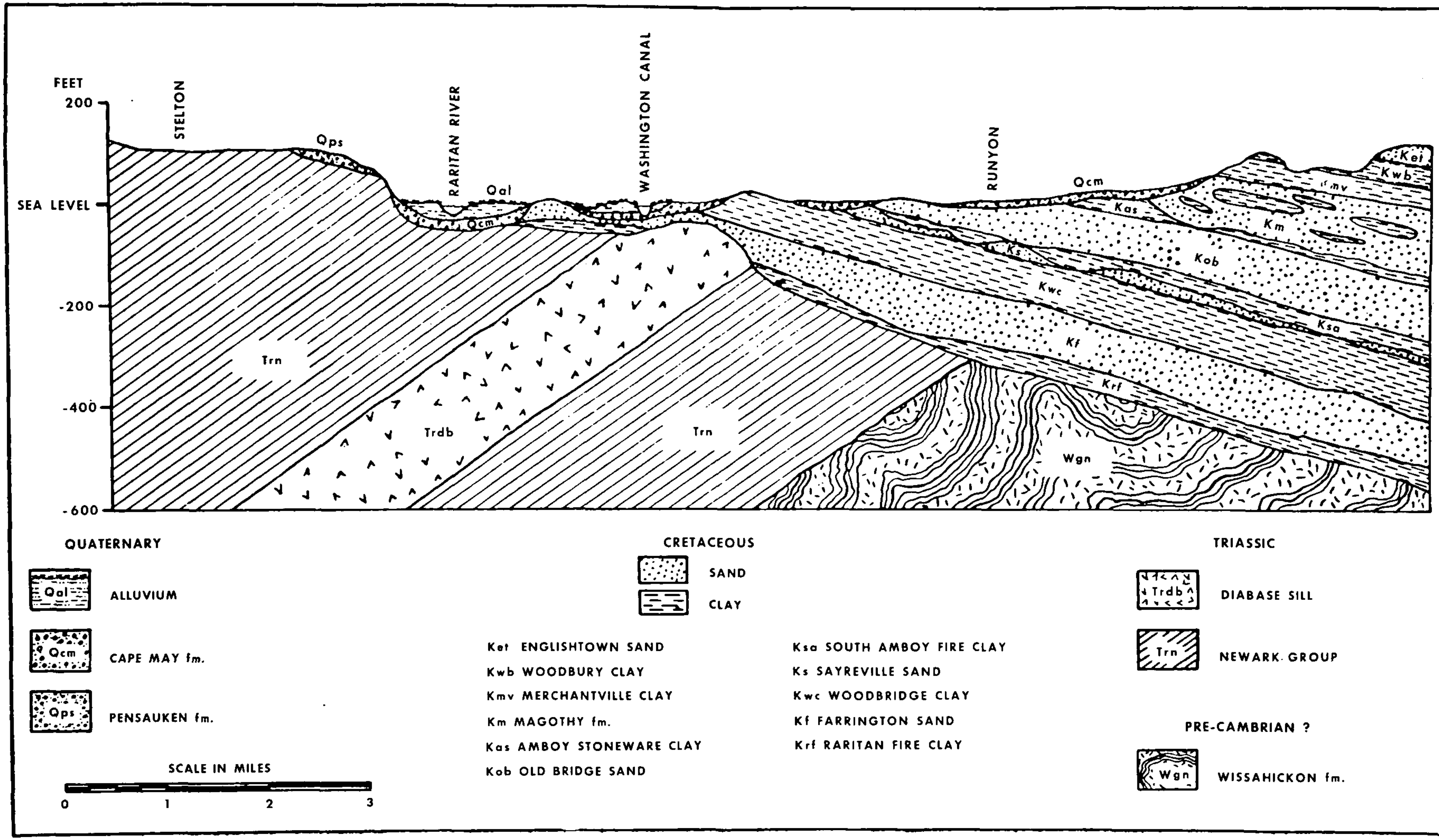
    Upper Triassic series (Newark group)
      Brunswick shale
      Lockatong formation
      Stockton formation

UNCONFORMITY

Proterozoic sequence (?)
  Pre-Cambrian (?)
    Wissahickon formation

1/Underscoring indicates that formation will yield at least 100,000 gpd per well.
Source: NJDEP, October, 1972.

Figure A-12



Source: Barksdale et al., 1943

GENERALIZED GEOLOGIC SECTION OF MIDDLESEX COUNTY is a geologic cross section of the area from Stelton through Runyon which illustrates the configuration of the geologic formations.

Deposits of Quaternary age overlie most of the area. The deposits consist mainly of permeable sand and gravel, except for relatively impermeable alluvium along some stream channels. These deposits are hydrologically important primarily because they absorb and transmit water to underlying aquifers.

Magothy and Raritan Formations

Although the Magothy and Raritan formations are distinct geologic units, they are frequently in direct hydraulic contact and are considered part of the same aquifer system. Northeast of Jamesburg, the Raritan formation has been divided into 7 members, 3 of which are water-bearing (Table A-20). Southwest of Jamesburg, the Raritan formation is undifferentiated. Of the 3 recognizable aquifers in the formation north of Jamesburg, only the Old Bridge and Farrington sands are important.

Prior to the onset of ground-water withdrawal, the natural discharge from the aquifers to streams, Raritan Bay and the ocean equaled the natural recharge. Recharge occurred in the higher outcrop areas and most was discharged within the outcrop to areas at a lower elevation. A substantial amount of water also traveled beneath some of the confining clays to discharge at more distant points. This constant discharge and higher head kept brackish water from moving inland into the aquifers. Ground water was under water-table conditions in the outcrop areas and under artesian conditions downdip.

The withdrawal of ever-increasing quantities of water from this aquifer system has locally altered the flow pattern in several areas.

Consequently, former discharge areas are now recharge areas and the amount of water being discharged to streams has diminished greatly. The Spotswood-South Amboy area has been the site of the most extensive water development. In this area, a total of 42.6 mgd was removed from the Raritan aquifer system through wells in 1971.

Due to this intense rate of pumpage, the amount of water withdrawn from this aquifer in the Sayreville area probably exceeds the amount recharged through precipitation. Consequently, Duhernal, Perth Amboy and Sayreville have constructed artificial recharge facilities to supplement natural recharge.

The Duhernal Water Company, the P.J. Schweitzer Company and the Anheuser Busch Company all pump from wells adjacent to Duhernal Lake, which was constructed on the South River in order to recharge the Old Bridge sand. These three companies withdrew an average of 20 mgd of water in 1971. Although the amount of water that is recharged varies, a study done in 1969 (NJDEP, October 1972) estimated that an average of 12 mgd of Duhernal Lake water was artificially recharged to the wells.

Perth Amboy recharges the Old Bridge sand through a canal system fed by Tennent Pond and Deep Run. Studies conducted by Barksdale in 1941 indicated that about 5 mgd, or virtually the entire low flow of Tennent Brook, were being used to recharge the aquifer (reported in NJDEP, October 1972). A recharge pond on Deep Run is now in the planning stage. This pond will increase the yield of the well field by 4 mgd.

In 1972, Sayreville Borough completed recharge ponds having a total surface area of 66 acres. These ponds were designed to recharge the Old Bridge sand. It is expected that this facility will increase the yield from the Bordentown well field by about 4 mgd.

Pumpage from the Farrington sand of the Raritan formation in the area between South Amboy and Spotswood was 13.26 mgd in 1971. Because of saltwater intrusion into this aquifer, the center of pumpage has shifted inland from Sayreville. The salt water was induced into the aquifer as a result of heavy pumpage by the DuPont and Hercules Companies. (Barksdale and Debuchananne, 1946). The salt water has moved about one mile inland from the vicinity of the Washington Canal. A smaller, but indefinite amount of saltwater intrusion has also occurred north of South Amboy, where brackish water has moved toward the National Lead Company.

Saltwater intrusion into the Farrington sand prompted a proposal in the early 1930's to construct a tidal dam on the South River. The dam was intended to prevent a similar fate from befalling the Old Bridge sand. However, a 1969 study by the New Jersey Bureau of Water Resources Planning and Management showed that saltwater intrusion could be prevented more economically by: 1) sound well field management, and 2) recharge to maintain heads above sea level in the vicinity of brackish water. The study also showed that nearly the entire benefit of the tidal dam would be to the Perth Amboy and Duhernal well fields. (NJDEP, October 1972).

Under natural conditions, the quality of water from the Raritan-Magothy aquifer system is good, except for the fact that the water frequently contains high concentrations of iron. The outcrop area of sand units of the Raritan-Magothy formation are highly susceptible to surface pollution. Contamination of some of Sayreville's wells has been attributed to poor waste disposal practices on the outcrop of the Old Bridge sand. Similar practices have caused contamination of some of Perth Amboy's wells. With the exception of saltwater intrusion, contamination of the Raritan-Magothy aquifer in this area has been of a local nature.

Brunswick Shale

Except for a small area between Milltown and Kingston, nearly all of the bedrock in the lower Raritan River basin study area north of a line between Carteret and Plainsboro consists of the Brunswick shale. The Brunswick shale is the most extensive outcrop in New Jersey. It is a dull red shale interbedded with siltstone and sandstone layers. The Brunswick shale is composed of fine grained, relatively impermeable sediments and therefore, has a very low permeability.

Ground water from the Brunswick shale is usually hard to very hard. Both sulfate and carbonate-bicarbonate hardness is common. As a rule, very deep wells have a higher total dissolved solids content than do shallower wells.

Several cases of ground-water contamination in the area have been reported. There are many cases of septic tanks polluting domestic wells because once contaminated water reaches the fracture systems, it moves rapidly with a minimum of renovation. If hydraulic gradients are toward pumping wells, sanitary sewers may leak their contents into the fractures causing similar results.

Englishtown Formation

The Englishtown formation crops out in a band extending southwest from Keansburg through Englishtown. The Englishtown formation is separated from the aquifer of the Raritan-Magothy formation by the Merchantville formation and the Woodbury clay, which together function as the lower confining layer.

The study areas take in only the outcrop area of the Englishtown formation where water is primarily under water-table conditions. Only low capacity wells are found in this area.

Management of Ground-Water Resources

Under the provisions of N.J.S.A. 58:4A-1 and 2, the Water Policy and Supply Council of the Division of Water Resources of the New Jersey Department of Environmental Protection may delineate "protected" areas. In these areas, no person, corporation or agency of the public may divert or obtain water from subsurface sources in excess of 100,000 gpd without first obtaining a permit from the Division of Water Resources. When a permit is granted, the diversion must be reported.

The first area to be delineated was a portion of Middlesex County in 1947. Other parts of the study areas were subsequently delineated; the last of these achieved "protected" status in 1968. Those private well owners who had equipped their wells with 70 gpm (100,000 gpd) or larger pumps prior to the designation of an area as "protected" were only required to file an affidavit stating the pump's capacity. A permit was a prerequisite for all subsequent diversions.

Water Resources

Use of Ground Water

Table A-21 shows the ground-water use from 1965 to 1971 in both Middlesex County and the Bayshore area of Monmouth County. It is apparent that the Raritan formation supplies most of the ground water (approximately 60 percent) used in Middlesex County and all of the ground water used in Monmouth County. Table A-21 also shows that the total ground-water usage increased from 1965 to 1969, but has decreased in the last two years. In Monmouth County, ground-water usage has increased each year, while in Middlesex County, the use of ground water from the Brunswick shale has decreased steadily from 1965 to the present.

TABLE A-21

WATER USE (mgd) IN THE STUDY AREAS
1965-1971

SOURCE	YEAR						
	1965	1966	1967	1968	1969	1970	1971
Ground Water							
Brunswick Shale	27.85	26.89	26.81	27.83	29.38	27.27	24.05
Raritan Formation							
Old Bridge Sands	28.41	29.59	30.47	29.54	30.32	30.17	29.72
Farrington Sands	10.23	11.38	10.48	12.36	14.04	14.83	14.37
Un-differentiated Raritan Formation							
Within Middlesex Co.	0.48	0.61	0.63	0.60	0.62	0.64	0.69
Within Monmouth Co.	6.19	7.30	7.23	8.56	8.96	9.48	9.87
Total Ground Water Used	73.16	75.77	75.62	78.89	83.32	82.39	78.70
Surface Water							
New Brunswick Water Dept.	12.63	12.39	12.88	12.98	13.80	14.07	14.10
No. Brunswick Water Dept.	1.55	1.86	1.93	1.77	2.05	2.04	2.01
Middlesex Water Co.	4.20	4.22	4.47	4.17	4.37	14.69	19.66
Bound Brook Water Dept.	0.82	1.05	1.27	1.17	1.17	1.07	0.79
Total Surface Water Used	19.20	19.52	20.55	20.09	21.39	31.87	36.56
Total Ground and Surface Water Used	92.36	95.29	96.17	98.98	104.71	114.26	115.26

Source: NJDEP, October 1972.

Use of Surface Water

The amount of surface water used from 1965 to 1971 is shown in Table A-21. As indicated, the surface water demand nearly doubled during that seven year span. The largest increase occurred in the Middlesex Water Company system where the rate of consumption rose from 4.20 mgd to 9.66 mgd.

Total Water Use

Total water use for the study areas is also shown in Table A-21. The present and projected water demand for the study areas is shown in Table A-22. The table indicates that there will be a 100 percent increase in the water demand by the year 2000.

Table A-22 shows the available water supplies, the projected water deficiencies, the improvement of supplies and the sources of supplies within the study areas. Water to meet future needs will probably come mainly from the development of the Raritan River and the proposed Six Mile Run Reservoir.

Soils

The soil associations of the study areas are mapped in Figure A-13. Significant characteristics of these associations are presented in Table A-23. Examination of these characteristics reveals that the soils and topography offer little impediment to urban development. For the most part, topography and drainage are suited to development.

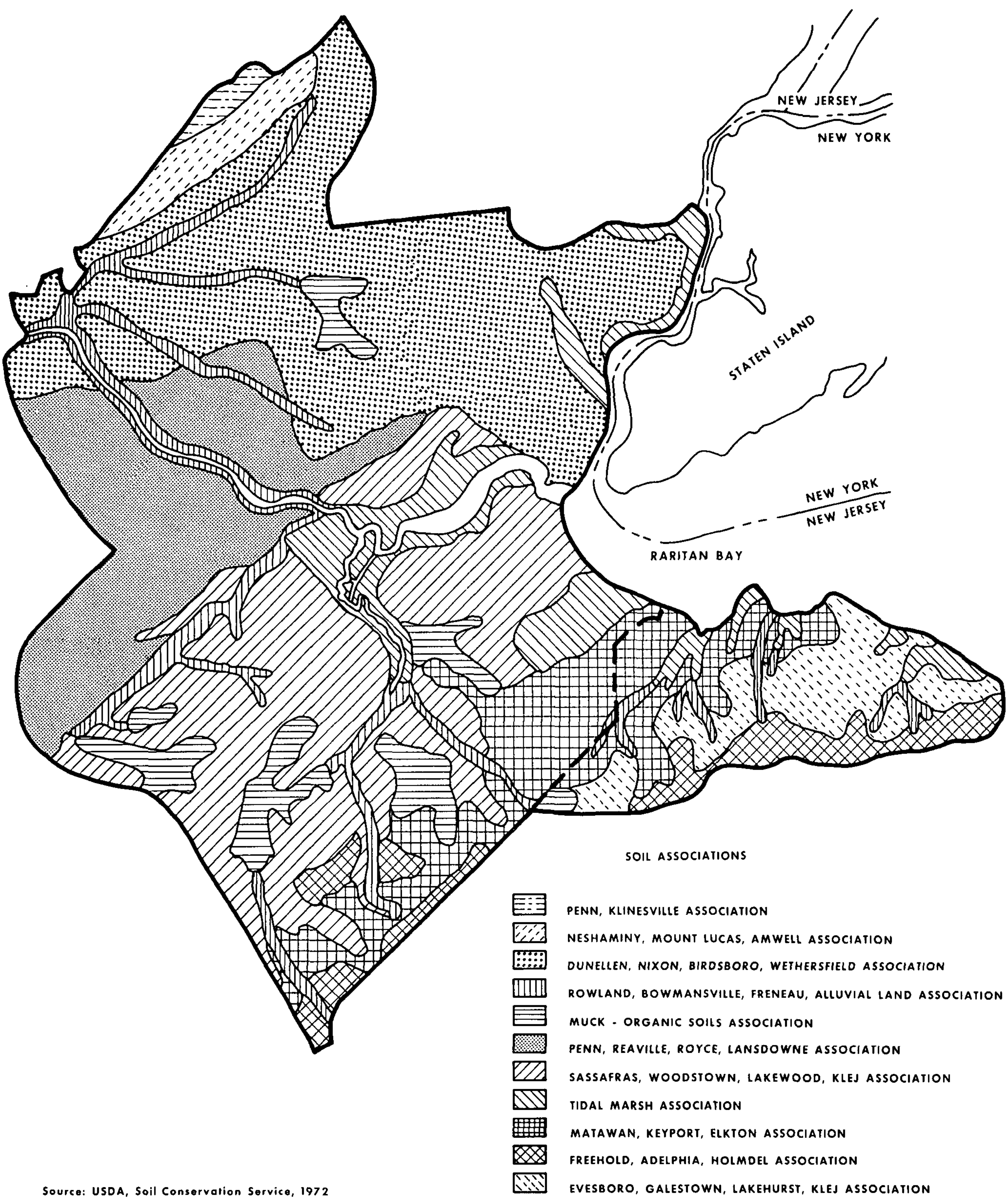
TABLE A-22

WATER SUPPLY AND DEMAND (mgd) IN THE STUDY AREAS
1970-2000

Sub-Area	1970 Present Supply	1970 Demand	1980 Demand	1980 Additional Capacity Required	1990 Demand	1990 Additional Capacity Required	2000 Demand	2000 Additional Capacity Required	Source of Additional Supplies
Elizabethtown Water Co.	32	32	50	18	78	46	116	84	Raritan and Delaware River water
Middlesex Water Co.	35	26	35	0	46	11	61	26	Six Mile Run Reservoir
Franklin Township	5	5	7	2	9	4	12	7	Raritan and Delaware River water
Perth Amboy	11	11	13	2	15	4	17	6	Local ground water
New Brunswick, East Brunswick, Milltown and Personal Product	22	17	20	0	23	1	27	5	Six Mile Run Reservoir
Sayreville and South River	10	4	6	0	8	0	10	0	None needed
North Brunswick	8	2	3	0	4	0	4	0	None needed
South Brunswick	3	1	2	0	3	0	3	0	None needed
Madison Township, Monroe, Jamesburg, Helmetta, Spotswood and Cranbury	5	5	7	2	9	4	12	7	Local ground water
South Amboy	1	1	2	1	3	2	3	2	Local ground water
Duhernal, Anheuser Busch, and Kimberly Clark	21	21	22	1	23	2	24	3	Local ground water
Bound Brook and South Bound Brook	2	2	2	0	3	1	4	2	Raritan River water
Monmouth County Study Area	16	16	22	6	30	14	41	25	Local ground water
Additional capacity required									
Ground Water				12		26		43	
Surface Water				20		63		124	
Total				32		89		167	

Source: NJDEP, October 1972.

SOIL ASSOCIATIONS IN THE STUDY AREAS



Source: USDA, Soil Conservation Service, 1972

Figure A-13

TABLE A-23

SOIL ASSOCIATIONS IN THE LOWER RARITAN RIVER BASIN AND SOUTH SHORE OF RARITAN BAY

Soil Association Name	Soil Association Number	Acres	Drainage		Topography	Present Land Use
			Surface	Permeability		
Penn, Klinesville	1	1,100	Poor to good	Good	Flat to gently rolling	Grassland Urban development
Neshaminy, Mount Lucas, Amwell	2	4,200	Poor or less Steep land	-	Simple & steep slopes	Forest Urban development
Dunellen, Nixon, Birdsboro Wethersfield	3	51,900	Good exception a)areas of high water tables b)flat land or depressions	-	Undulating to gently rolling	Isolated produce farms Urban development
Rowland, Bowmansville, Freneau, Alluvial land	4	18,600	Poor due to high water table	-	Level with simple slopes	Idle Unimproved pastures
Muck - organic soils	5	11,500	Poor	-	Depressional	Idle Cranberry or blueberry bogs
Penn, Reaville, Royce, Lansdowne	6	27,800	Well drained except for flat areas	Slow to moderate	Undulating; not on steeper slopes	Dairy farming
Sassafras, Woodstown, Lakewood Klej	7	3,500	Highly variable	-	Undulating to rolling	Potato and dairy farming
Tidal marsh	8	11,100	Very poor	-	Flat; at or near ocean tide level	Parkland Idle
Matawan, Keyport, Elkton	9	19,200	Highly variable	Slow to moderate; perched water tables common	Flat to rolling	Vegetable farming Orchards Urban development
Freehold, Adelphia, Holmdel	10	8,100	Moderate to moderately well	-	Level to undulating	Extensively cropped
Evesboro, Galestown, Lakehurst, Klej	11	11,000	Highly variable Poor in depressions	-	Undulating to hilly	Woodland Pasture

Source: USDA, Soil Conservation Service, 1972.

WATER AND WASTEWATER

Water Quality

Water Quality Problems

Surface Waters

The study areas are afflicted with a number of water quality problems. The most serious problems are the result of: 1) the additon of toxic substances to the waterways, and 2) the addition of waste materials in excess of a receiving stream's assimilative capacity.

This section of New Jersey is highly industrialized. Many industries discharge their wastes into existing sanitary sewer systems. The municipal systems are often incapable of effecting the treatment required by these complex and exotic industrial wastes. For example, the municipal STP may effect little or no removal of toxic substances or it may simply concentrate the toxic materials for disposal at sea. Still other industries discharge inadequately treated wastes directly into receiving streams.

Many small treatment plants at stream headwaters are operated with minimal supervision. Many are operated beyond plant capacity. The result is the release of excessive organic loads into the streams.

Ground Water

Saltwater intrusion is the most significant ground-water quality problem. The problem will become more and more aggravated until ground-water consumption is balanced by ground-water recharge. Unless steps are taken to increase the amount of water recharged to the Magothy and Raritan formations, the serious ground-water problem existing in the Sayreville-South River area will continue.

Water Quality Standards

As indicated in Figure A-4, streams within the study areas are now classified as FW-2, FW-3, TW-1, TW-2 or TW-3. New Jersey State standards for these classifications are given in Appendix B. In accordance with Section 303 (a) of the FWPCAA 1972 (PL 92-500), these standards have been reviewed by the EPA and appropriate changes will be promulgated. The proposed changes are also given in Appendix B; they include revision of the New Jersey standards to Federal Use Classifications A or B.

Among other things, the standards stipulate the degrees of treatment required. Present New Jersey standards require that discharges into FW-2 or FW-3 waters ". . . shall be treated to a degree providing, as a minimium, ninety per cent (90%) of reduction of biochemical oxygen demand at all times. . ." and that discharges into TW-1 waters ". . .shall be treated to a degree providing, as a minimum, eighty percent (80%) of reduction of biochemical oxygen demand at all times. . .", (Appendix B). Under the FWPCAA 1972, the ". . .minimum treatment required for any wastewater must be such that discharges shall meet effluent limits." (Appendix B).

Enforcement Conference Requirements

In 1961 the Surgeon General of the U.S. Public Health Service, under the provisions of the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq.), called a conference on the pollution of the interstate waters of Raritan Bay and adjacent waters. As a result of this conference, the Public Health Service established the Raritan Bay Project to undertake a study of these waters to provide scientific data on which further pollution control programs could be established. (FWPCA, 1967).

Conferences were held in 1963 and 1967 to present the data that had been collected. The recommendations made at the 1967 conference are presented in Appendix C.

Abatement Actions

Current abatement actions directed at municipal dischargers are listed in Table A-24. Table A-25 lists the current abatement actions for industrial dischargers.

Wastewater Discharges

The major discharges, those greater than 100,000 gpd, entering the waterways of the study areas are listed in Tables A-26a, b and c. The waterways that receive these discharges are: 1) the Raritan River and its tributaries, 2) the Arthur Kill, and 3) the southwestern portion of Raritan Bay.

1. The Raritan River and its tributaries: The section of the river under consideration here extends from the confluence of the Raritan with the Millstone River at Manville to Raritan Bay. Discharges into this section of the Raritan are listed in Table A-26a.

2. The Arthur Kill: The portion of the Arthur Kill that lies south of the Rahway River is of concern here. Only those discharges originating along the New Jersey shore are included in Table A-26b.

3. The southwestern portion of Raritan Bay: Wastewater discharges originating along the southwestern shore of Raritan Bay (from the point at which the Raritan River enters the bay to the Middletown regional wastewater treatment plant) are included in Table A-26c.

An examination of the minor discharges, which are not enumerated in this report, indicates that the minor discharges have a significant

TABLE A-24

REQUIRED ABATEMENT ACTIONS
MUNICIPALITIES

Municipalities	Type of Action	Date of Action	Specified Abatement
Carteret	Outstanding court order	No pending action	Connect to MCSA Abandon plant
Madison Township	Administrative order	2/18/66	Connect to MCSA Abandon plant
Middlesex County Sewerage Authority	Administrative order	2/18/66	Expand & upgrade plant
Perth Amboy	Administrative order	2/18/66	Connect to MCSA Abandon plant
Sayreville-Melrose	Administrative order	2/18/66	Connect to MCSA Abandon plant
Sayreville-Morgan	Administrative order	2/18/66	Connect to MCSA Abandon plant
South Amboy	Administrative order	2/18/66	Connect to MCSA Abandon plant
Woodbridge-Keasbey	Administrative order	2/18/66	Connect to MCSA Abandon plant
Keyport	Administrative order	2/18/66	Bayshore Reg'l Sewerage Authority
Matawan Borough	Administrative order	2/18/66	Bayshore Reg'l Sewerage Authority
Matawan Township (2 plants)	Administrative order	2/18/66	Bayshore Reg'l Sewerage Authority

Source: NJDEP, October 1972.

TABLE A-25

REQUIRED ABATEMENT ACTIONS
INDUSTRIES

Industry & Location	Type of Action	Date of Action	Specified Abatement
Hess Oil & Chemical Corp. Woodbridge	Administrative order	3/20/72	Cease & desist discharging industrial wastewater or polluting material from sewer or drain into the Arthur Kill
U.S. Metals Refining Co. Carteret	EPA-RAPP	Initial meeting 2/1/72	Negotiated agreement underway
Philip Carey Manufacturing Co. Perth Amboy	Court order		Tie in all discharges to sanitary sewers
National Lead Co. Sayreville	Administrative order	11/8/71	Industrial wastewater treatment plant
American Cyanamid Woodbridge	Administrative order	5/3/72	Upgrade existing facilities
Hatco Chemical Co. Woodbridge	Court order	11/17/67	Connect to MCSA (Connection made, however,discharges still present)
American Cyanamid Bridgewater Township	Court order	5/17/72	Negotiated agreement

Source: NJDEP, October 1972.

TABLE A-26a

MAJOR WASTEWATER DISCHARGES *
RARITAN RIVER AND ITS TRIBUTARIES

Municipality or Industry	Receiving Water	Flow Rates-mgd Design	Flow Rates-mgd Actual	Effluent Characteristics	Treatment
Air Products & Chemicals Inc., Chemicals Group Middlesex	Ambrose Brook		0.188 3/	Cooling water	
American Cyanamid Bound Brook	Cuckles Brook	25.0 3/	23.8 3/	BOD_5=4170#/day NH_3-N=6350#/day Kjeldahl-N= 9730#/day	Neutralization, settling, activated sludge with 5 mgd primary effluent from Somerset-Raritan Valley plant for seed
Anaconda Co. Perth Amboy	Raritan River		2.25 3/	Cooling water BOD_5=100#/day NH_3-N=30#/day As, Cu, Se, Zn and Te	
Anheuser-Busch, Inc. East Brunswick	South River		0.78 3/	Cooling water	
Philip Carey Co. Perth Amboy	Raritan River		0.12 3/	BOD_5=2.7#/day	No treatment
Ford Motor Co. Metuchen	Mill Brook		0.330 3/	Cooling water BOD_5=35#/day Kjeldahl-N= 8#/day	
Essex Chem. Corp. Sayreville	Burt Creek		0.50 3/	Cooling water	
Central Jersey Sewer Co., Marlboro	Barclay Brook	.370 4/	.371 4/		Secondary treatment
Chesebrough-Ponds, Inc. Perth Amboy	Raritan River		.148 3/	Cooling water Oil and Grease	
E.I. DuPont deNemours & Co., Photo Products Dept., Parlin	Selover Creek		2.24 3/	BOD_5=130#/day Oil, Grease, Phenols and Ag	Lagooning
E.I. DuPont deNemours & Co., Fabric & Finishes Dept. Parlin	Selover Creek		0.50 3/		
Jamesburg Home for Boys	Matchaponix Brook		.15 5/		
Jamesburg Municipal	Manalapan Brook	.25 6/	.47 6/	BOD_5=125mg/l	Primary with chlorination
Jersey Central Power & Light, Werner Gen. Sta. South Amboy	Raritan River		197.8 3/	Cooling water	
Sayreville Gen. Sta.	Raritan River		309.6 3/	Cooling water	Settling pond
Manville Borough	Raritan River	2.0 4/	1.82 4/		Secondary with chlorination

* See Table A-26c for sources.

TABLE A-26a (Cont'd)

MAJOR WASTEWATER DISCHARGES*
RARITAN RIVER AND ITS TRIBUTARIES

Municipality or Industry	Receiving Water	Flow Rates-mgd Design	Flow Rates-mgd Actual	Effluent Characteristics	Treatment
Public Service Elec. & Gas Co., Central Gas Plant Keasbey	Raritan River		0.74[3/] Summer 5.4[3/] Winter	Cooling water	
Pine Brook Sewer Co. Manalapan Township	Pine Brook		0.9[6/]		Secondary
Mideast Anodizing Corp. South Brunswick	Pigeon Swamp	0.26[2/]			
Keasbey	Kinsey Creek	1.35[6/]	1.00[6/]	BOD_5=177 mg/l	Primary with chlorination
Rahway Valley	Rahway River				Primary with chlorination
Perth Amboy	Raritan River	10.0[6/]	7.2[6/]		Primary with chlorination
Titanium Pigment Div. Sayreville	Raritan River		38.1[3/]	Cooling water	
Tenneco Chemicals,Inc. Plastics Division Nixon	Raritan River		0.392[3/]	Cooling Water	
Whittier Oaks Marlboro	Barclay Brook				
University Heights, Rutgers University Piscataway	Raritan River	0.50[6/]	0.64[6/]	BOD_5=4 mg/l	Trickling filter
American Cyanamid Co. Keasbey					
Sinclair-Koppers Co., Inc.					
Koppers Company,Inc.					

*See Table A-26c for sources.

TABLE A-26b

MAJOR WASTEWATER DISCHARGES*
ARTHUR KILL

Municipality or Industry	Receiving Water	Flow Rates-mgd Design	Actual	Effluent Characteristics	Treatment
Hess Oil & Chemical Co. Woodbridge	Arthur Kill		0.36 5/		Oil separation, holding pond
American Smelting & Refining Co. Perth Amboy	Arthur Kill		7.3 3/	BOD_5=500#/day Kjeldahl-N= 290#/day As and Cu	
Bird & Son, Inc. Perth Amboy	Spa Spring Creek		0.33 3/	BOD_5=60#/day Cooling water	Screens and settling basins
Carteret	Arthur Kill	3.0 6/	2.7 6/	BOD_5=500 mg/l Storm water flows 40 mgd	Primary and chlorination
Chevron Oil Co., Eastern Division Perth Amboy	Woodbridge Creek		63.6 3/	BOD_5=2500#/day NH_3=N=950#/day Kjeldahl-N=330#/day	Oil separation and lagooning
Sewaren	Arthur Kill	6.0 6/	9.0 6/	BOD_5=159 mg/l	Primary and chlorination
Public Service Elec.& Gas Sewaren Gen. Sta.	Arthur Kill		835 3/	Cooling water	
Shell Oil Co. Sewaren	Woodbridge Creek		0.86 6/	Cooling water Boiler water	Oil separation
U.S. Metals Refining Co. Carteret	Arthur Kill		31.85 3/	NH_3-N=10,000#/day NO_3-N=100#/day Kjeldahl-N= 10,000#/day Zn,Pb,Cu,Ag and Cd	No treatment
FMC Inorganic Chem. Div. Carteret	Arthur Kill		6.0 6/	PO_4-P=500#/day	No treatment
Copper Pigment & Chemical Co.	Woodbridge River		0.5 3/	COD=27-283 mg/l Cyanide=1-141mg/l Cu=0.1-275 mg/l	No treatment
American Agricultural Chem. Co., Carteret					No treatment
Reichold Chemicals, Inc. Carteret					
Armour Agric. Chem. Co. Carteret					No treatment
General American Transportation Co. Carteret					Oil separators
Sinclair-Koppers Co. Port Reading					
Koppers Co., Forest Products Division Port Reading					

*See Table A-26c for sources.

TABLE A-26c

MAJOR WASTEWATER DISCHARGES*
RARITAN BAY

Municipality or Industry	Receiving Water	Flow Rates-mgd Design	Flow Rates-mgd Actual	Effluent Characteristics	Treatment
Matawan Borough	Matawan Creek	0.800[2/]	1.48[2/]	BOD_5=1000#/day NH_3-N=173#/day	Primary
Matawan Township Municipal Utilities Auth. Cliffwood Beach	Whale Creek	0.750[2/]	0.524[2/]	BOD_5=321#/day NH_3-N=102#/day	Secondary
River Gardens	Matawan Creek	0.8[2/]	0.7[2/]	BOD_5=58#/day NH_3-N=7#/day	Secondary
Strathmore	Mohingson Creek	0.8[1/]	0.85[1/]	BOD_5=212#/day NH_3-N=57#/day	Secondary
Keyport	Bay	1.0[2/]	0.94[2/]	BOD_5=811#/day NH_3-N=108#/day	Primary
	Draining Ditch to Bay		0.190[3/]	BOD_5=8800#/day NH_3-N=86#/day	Flotation,equalization,neutralization,chemical precipitation
Jersey Central Power & Lighting; Union Beach	Raritan Bay		372[3/]	Cooling	Proposed facility
Lanvin-Charles of the Ritz; Holmdel	East Creek	0.168[2/]	0.161[2/]		Secondary
Keansburg	Raritan Bay	2.07[1/]	2.4[2/]	BOD_5=1350#/day NH_3-N=150#/day	Primary
Lily Tulip Cup Corp. Holmdel	Mahores Brook	0.50[1/]	0.15[1/]	BOD_5=13#/day NH_3-N=3#/day	Lagoons
MCSA	Raritan Bay	78	73.8	BOD_5=167,000#/day	Primary;See text
South Amboy	Unnamed stream	1.00[1/]	0.80[1/]	BOD_5=1200#/day	Primary and chlorination
Sayreville-Morgan	Raritan Bay	0.300[6/]	0.15[6/]	BOD_5=225#/day	Primary and chlorination
Melrose	Raritan Bay	0.1[6/]	0.3[6/]		Primary and chlorination
Madison Township-Lawrence Harbor	Raritan Bay	1.50[6/]	0.8[6/]	BOD_5=195 mg/l	Primary and chlorination
South Amboy Power & Light	Raritan Bay		100[6/]	Cooling water	
Mideast Anodizing South Amboy	Raritan Bay		0.26[6/]	Low pH,heavy metals,Al,Zn	Neutral and lagoons
Bayshore Regional	Atlantic Ocean	6.0		BOD_5=1250#/day	Secondary-under construction; See text

*Sources:
1/NJDEP, 1971.
2/N.J. Dept. of Health, 1972.
3/U.S. EPA, 1971-72.
4/N.J. Dept. of Health, 1970-72.
5/Metcalf & Eddy, 1968.
6/NJDEP, October 1972.

cumulative effect on the quality of the receiving waters. The discussion of present water quality reflects these effects.

APPENDIX B

CLASSIFICATION OF THE SURFACE WATERS OF THE RARITAN RIVER BASIN INCLUDING RARITAN BAY

Pursuant to authority vested in it under the provisions of Chapter 12, Title 58 of the Revised Statutes, the State Department of Health hereby promulgates the following classifications of the surface waters of the Raritan River Basin, including the Raritan Bay. Standards of Quality to be maintained in these waters as established by the State Department of Health are attached hereto.

I. A. Class FW-2- The Raritan and Millstone Rivers and tributaries upstream of the confluence of the Raritan and Millstone Rivers.

B. Class FW-2- The Middle Brook upstream of the intake of the Bound Brook Water Company.

C. Class FW-2- The South River and tributaries upstream of the proposed tidal dam site and the Lawrence Brook area upstream of Weston Mills Dam.

D. Class FW-2- The Swimming River upstream of the intake of the Monmouth Consolidated Water Company.

II. A. Class FW-3- The main stem of the Raritan River from its confluence with the Millstone River to the Fieldsville Dam.

B. Class FW-3- The Middle Brook below the intake of the Bound Brook Water Company.

C. Class FW-3- The Green Brook and its tributaries.

D. Class FW-3- All other tributaries to the Raritan River between the Millstone River and the Fieldsville Dam.

E. Class FW-3- The nontidal reaches of all other tributaries to the Raritan River and Raritan Bay downstream from Fieldsville Dam.

III. Class TW-1- The main stem of the Raritan River and the tidal reaches of tributaries thereto from Fieldsville Dam to and including the Raritan Bay and the tidal reaches of its tributaries, exclusive of the Arthur Kill. These waters are not a source of public potable water supply and, therefore, standards of quality and criteria referring exclusively to water supplies are not applicable. The standards of quality and bacterial criteria for shellfish growing areas are applicable only in areas where shellfish harvesting is permitted by the Department.

These waters shall be maintained in a condition suitable for all recreational purposes.

Filed with Secretary of State: March 22, 1965

Effective Date: April 15, 1965

REGULATIONS CONCERNING TREATMENT OF WASTEWATERS, DOMESTIC AND INDUSTRIAL, SEPARATELY OR IN COMBINATION, DISCHARGED INTO THE WATERS OF THE RARITAN RIVER BASIN INCLUDING THE RARITAN BAY

WHEREAS, the State Department of Health is charged with the responsibility for the Stream Pollution Control Program, including the approval of the designs of wastewater treatment facilities, in the State of New Jersey, and

WHEREAS, the citizens of this State, particularly the citizens in the Raritan Valley, have been obliged in recent years to suffer repeatedly the consequences of serious oxygen depletion and other exemplifications of stream pollution in fresh water sections of the Raritan River as well as in the tidal estuary thereof, said exemplifications of stream pollution constituting threats to the public health, comfort or property of citizens of this State, and

WHEREAS, the State Department of Health did promulgate rules and regulations entitled "Regulations Establishing Certain Classifications to be Assigned to the Waters of this State and Standards of Quality to be Maintained in Waters so Classified," effective September 1, 1964 and

WHEREAS, the State Department of Health has concluded after extensive investigations and analyses of factual data assembled thereby that more intensive treatment of wastewaters must be provided throughout the Raritan River Basin in order to attain water quality specified by the aforesaid regulations of the Department, and

WHEREAS, the State Department of Health is of the opinion that the attainment and maintenance of water quality in the Raritan River Basin as specified by the aforesaid regulations of the Department is necessary in order to abate a present threat to the public health, comfort or property of citizens of this State,

NOW,THEREFORE, the State Department of Health promulgates the following regulations entitled "Regulations Concerning Treatment of Wastewaters, Domestic and Industrial, Separately or in Combination, Discharged into the Waters of the Raritan River Basin including the Raritan Bay."

NEW JERSEY STATE DEPARTMENT OF HEALTH

Roscoe P. Kandle, M.D.
State Commissioner of Health

REGULATIONS CONCERNING TREATMENT OF WASTEWATERS, DOMESTIC AND INDUSTRIAL, SEPARATELY OR IN COMBINATION, DISCHARGED INTO THE WATERS OF THE RARITAN RIVER BASIN INCLUDING THE RARITAN BAY

Pursuant to authority vested in it under the provisions of Chapter 12, Title 58 of the Revised Statutes, the State Department of Health hereby promulgates the following regulations concerning treatment of wastewaters, domestic and industrial, separately or in combination, discharged into the waters of the Raritan River Basin.

I. Henceforth, domestic wastes, separately or in combination with industrial wastes, prior to discharge into waters of the Raritan River Basin classified as FW-2 or FW-3, shall be treated to a degree providing, as a minimum, ninety percent (90%) of reduction of biochemical oxygen demand at all times, including any four-hour period of a day when the strength of the wastes to be treated might be expected to exceed average conditions.

II. Henceforth, industrial wastes, prior to discharge into waters of the Raritan River Basin, classified as FW-2 or FW-3, shall be treated to a degree providing as a minimum, ninety percent (90%) of reduction of biochemical oxygen demand at all times and such further reduction in biochemical oxygen demand as may be necessary to maintain water in the River after dispersion of treated industrial waste effluents as specified in the rules and regulations entitled "Classification of the Surface Waters of the Raritan River Basin including Raritan Bay," effective April 15, 1965.

III. Henceforth, domestic wastes, separately or in combination with industrial wastes, prior to discharge into waters of the Raritan River Basin classified as TW-1, shall be treated to a degree providing, as a minimum, eighty percent (80%) of reduction of biochemical oxygen demand at all times, including any four-hour period of a day when the strength of the wastes to be treated might be expected to exceed average conditions.

IV. Henceforth, industrial wastes prior to discharge into waters of the Raritan River Basin, classified as TW-1, shall be treated to a degree providing, as a minimum, eighty percent (80%) of reduction of biochemical oxygen demand at all times and such further reduction of biochemical oxygen demand as may be necessary in order to maintain the waters of the River of a quality as specified by the rules and regulations entitled "Classification of the Surface Waters of the Raritan River Basin Including Raritan Bay," effective April 15, 1965.

V. It is recognized, especially in connection with some industrial wastes, that the pollution load imposed upon the waters of the Basin cannot be evaluated fully exclusively by the biochemical oxygen demand test; therefore, each industrial waste problem shall be considered individually and treatment shall be required as needed to effect compliance with the Water Quality Criteria established for the various classifications of waters in the Basin.

VI. Treatment standards set by these regulations are the minimum acceptable for the Raritan River Basin. Treatment more intensive than that specified hereinabove shall be provided whenever it is determined by the State Department of Health in a particular situation that such treatment is necessary.

Filed with Secretary of State: December 23, 1965

Effective Date: February 1, 1966

SECTION 3.2 - SURFACE WATER QUALITY CRITERIA FOR FW-2 WATERS

CLASS FW-2 - Fresh surface waters approved as sources of public water supply. These waters shall be suitable for public potable water supply after such treatment as shall be required by the Department.

These waters shall also be suitable for the maintenance, migration and propagation of the natural and established biota; and for primary contact recreation; industrial and agricultural water supply and any other reasonable uses.

3.2.1 FLOATING SOLIDS, SETTLEABLE SOLIDS, OIL, GREASE, COLOR AND TURBIDITY

None noticeable in the water or deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota. None which would render the waters unsuitable for the designated uses.

3.2.2 TOXIC OR DELETERIOUS SUBSTANCES INCLUDING BUT NOT LIMITED TO MINERAL ACIDS, CAUSTIC ALKALI, CYANIDES, HEAVY METALS, CARBON DIOXIDE, AMMONIA OR AMMONIUM COMPOUNDS, CHLORINE, PHENOLS, PESTICIDES, ETC.

None, either alone or in combination with other substances, in such concentrations as to affect humans or be detrimental to the natural aquatic biota or which would render the waters unsuitable for the designated uses. None which would cause the Potable Water Standards of the Department for drinking water to be exceeded after appropriate treatment.

3.2.3 TASTE AND ODOR PRODUCING SUBSTANCES

None offensive to humans or which would produce offensive tastes and/or odors in water supplies and fauna used for human consumption. None which would render the waters unsuitable for the designated uses.

3.2.4 pH

Between 6.5 and 8.5.

3.2.5 DISSOLVED OXYGEN

(a) Trout Production Waters - Not less than 7.0 mg/l at any time.

(b) Trout Maintenance Streams - Daily average not less than 6.0 mg/l. Not less than 5.0 mg/l at any time.

(c) Trout Maintenance Lakes - Daily average not less than 6.0 mg/l. Not less than 5.0 mg/l at any time.

In eutrophic lakes when stratification is present, not less than 4.0 mg/l in or above the thermocline where water temperatures are below 72°F. At depths where the water is 72°F. or above, daily average not less than 6.0 mg/l and not less than 5.0 mg/l at any time.

(d) Nontrout Waters - Daily average not less than 5.0 mg/l. Not less than 4.0 mg/l at any time.

3.2.6 TEMPERATURE

(a) Trout Production Waters - Natural temperatures shall prevail except where properly treated wastewater effluents may be discharged. Where such discharges occur, stream temperatures shall not be raised more than 1°F.

(b) Trout Maintenance Streams - No heat may be added which would cause temperatures to exceed 2°F. over the natural temperatures at any time or which would cause temperatures in excess of 68°F.

Reductions in temperatures may be permitted where it can be shown that trout will benefit without detriment to other designated water uses. The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

(c) Trout Maintenance Lakes - No thermal alterations except where it can be shown to benefit the designated uses.

(d) Nontrout Waters - No thermal alterations, except in designated mixing zones, which would cause temperatures to deviate more than 5°F. at any time from natural stream temperatures or more than 3°F. in the epilimnion of lakes and other standing waters.

No heat may be added, except in designated mixing zones, which would cause temperatures to exceed 82°F. for small mouth bass or yellow perch waters or 86°F. for other nontrout waters.

The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

3.2.7 RADIOACTIVITY

Current U.S. Public Health Service Drinking Water Standards shall apply.

3.2.8 BACTERIAL QUALITY

Fecal coliform levels shall not exceed a geometric mean of 200/100 ml. Samples shall be obtained at sufficient frequencies and at locations and during periods which will permit valid interpretation of laboratory analyses.

Appropriate sanitary surveys shall also be carried out as a supplement to such sampling and laboratory analyses.

FW-3

SECTION 3.3 - SURFACE WATER QUALITY CRITERIA FOR FW-3 WATERS

CLASS FW-3 - Fresh surface waters suitable for the maintenance, migration and propagation of the natural and established biota; and for primary contact recreation; industrial and agricultural water supply and any other reasonable uses.

3.3.1 FLOATING SOLIDS, SETTLEABLE SOLIDS, OIL, GREASE, COLOR AND TURBIDITY

None noticeable in the water or deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota. None which would render the waters unsuitable for the designated uses.

3.3.2 TOXIC OR DELETERIOUS SUBSTANCES INCLUDING BUT NOT LIMITED TO MINERAL ACIDS, CAUSTIC ALKALI, CYANIDES, HEAVY METALS, CARBON DIOXIDE, AMMONIA OR AMMONIUM COMPOUNDS, CHLORINE, PHENOLS, PESTICIDES, ETC.

None, either alone or in combination with other substances, in such concentrations as to affect humans or be detrimental to the natural aquatic biota or which would render the waters unsuitable for the designated uses.

3.3.3 TASTE AND ODOR PRODUCING SUBSTANCES

None offensive to humans or which would produce offensive tastes and/or odors in fauna used for human consumption. None which would render the waters unsuitable for the designated uses.

3.3.4 pH

Between 6.5 and 8.5.

3.3.5 DISSOLVED OXYGEN

(a) Trout Production Waters - Not less than 7.0 mg/l at any time.

(b) Trout Maintenance Streams - Daily average not less than 6.0 mg/l. Not less than 5.0 mg/l at any time.

(c) Trout Maintenance Lakes - Daily average not less than 6.0 mg/l. Not less than 5.0 mg/l at any time.

In eutrophic lakes when stratification is present, not less than 4.0 mg/l in or above the thermocline where water temperatures are below 72°F. At depths where the water is 72°F. or above, daily average not less than 6.0 mg/l and not less than 5.0 mg/l at any time.

(d) Nontrout Waters - Daily average not less than 5.0 mg/l. Not less than 4.0 mg/l at any time.

3.3.6 TEMPERATURE

(a) Trout Production Waters - Natural temperatures shall prevail except where properly treated wastewater effluents may be discharged. Where such discharges occur, stream temperatures shall not be raised more than 1°F.

(b) Trout Maintenance Streams - No heat may be added which would cause temperatures to exceed 2°F. over the natural temperatures at any time or which would cause temperatures in excess of 68°F.

Reductions in temperatures may be permitted where it can be shown that trout will benefit without detriment to other designated water uses. The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

(c) Trout Maintenance Lakes - No thermal alterations except where it can be shown to benefit the designated uses.

(d) Nontrout Waters - No thermal alterations, except in designated mixing zones which would cause temperatures to deviate more than 5°F. at any time from natural stream temperatures or more than 3°F. in the epilimnion of lakes and other standing waters.

No heat may be added, except in designated mixing zones, which would cause temperatures to exceed 82°F. for small mouth bass or yellow perch waters or 86°F. for other nontrout waters.

The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

3.3.7 RADIOACTIVITY

Current U.S. Public Health Service Drinking Water Standards shall apply.

3.3.8 BACTERIAL QUALITY

Fecal coliform levels shall not exceed a geometric mean of 200/100 ml. Samples shall be obtained at sufficient frequencies and at locations and during periods which will permit valid interpretation of laboratory analyses.

Appropriate sanitary surveys shall also be carried out as a supplement to such sampling and laboratory analyses.

TW-1

SECTION 3.4 - SURFACE WATER QUALITY CRITERIA FOR TW-1 WATERS

CLASS TW-1 - Tidal waters approved as sources of public potable water supply. These waters shall be suitable for public potable water supply after such treatment as shall be required by the Department.

These waters shall be suitable for shellfish harvesting where permitted.

These waters shall also be suitable for the maintenance, migration and propagation of the natural and established biota; and for primary contact recreation; industrial and agricultural water supply and any other reasonable uses.

3.4.1 FLOATING SOLIDS, SETTLEABLE SOLIDS, OIL, GREASE, COLOR AND TURBIDITY

None noticeable in the water or deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota. None which would render the waters unsuitable for the designated uses.

3.4.2 TOXIC OR DELETERIOUS SUBSTANCES INCLUDING BUT NOT LIMITED TO MINERAL ACIDS, CAUSTIC ALKALI, CYANIDES, HEAVY METALS, CARBON DIOXIDE, AMMONIA OR AMMONIUM COMPOUNDS, CHLORINE, PHENOLS, PESTICIDES, ETC.

None, either alone or in combination with other substances, in such concentrations as to affect humans or be detrimental to the natural aquatic biota or which would render the waters unsuitable for the designated uses. None which would cause the Potable Water Standards of the Department for drinking water to be exceeded after appropriate treatment.

3.4.3 TASTE AND ODOR PRODUCING SUBSTANCES

None offensive to humans or which would produce offensive tastes and/or odors in water supplies and biota used for human consumption. None which would render the waters unsuitable for the designated uses.

3.4.4 pH

Between 6.5 and 8.5.

3.4.5 DISSOLVED OXYGEN

(a) Trout Maintenance Waters - Daily average not less than 6.0 mg/l. Not less than 5.0 mg/l at any time.

(b) Nontrout Waters - Daily average not less than 5.0 mg/l. Not less than 4.0 mg/l at any time.

3.4.6 TEMPERATURE

(a) Trout Maintenance Streams - No heat may be added which would cause temperatures to exceed 2°F. over the natural temperatures at any time or which would cause temperatures in excess of 68°F.

Reductions in temperatures may be permitted where it can be shown that trout will benefit without detriment to other designated water uses. The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

(b) Nontrout Waters - No heat may be added except in designated mixing zones, which would cause temperatures to exceed 85°F., or 82°F. in yellow perch waters, or which will cause the monthly mean of the maximum daily temperature at any site, prior to the addition of any heat, to be exceeded by more than 4°F. during September through May, or more than 1.5°F. during June through August. The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

3.4.7 RADIOACTIVITY

Current U.S. Public Health Service Drinking Water Standards shall apply.

3.4.8 BACTERIAL QUALITY

(a) Approved Shellfish Harvesting Waters - Where harvesting of shellfish is permitted, requirements established by the National Shellfish Sanitation Program as set forth in its current manual of operations shall apply.

(b) All Other Waters - Fecal coliform levels shall not exceed a geometric mean of 200/100 ml.

Samples shall be obtained at sufficient frequencies and at locations and during periods which will permit valid interpretation of laboratory analyses.

Appropriate sanitary surveys shall be carried out as a supplement to such sampling and laboratory analyses.

TW-2

SECTION 3.5 - SURFACE WATER QUALITY CRITERIA FOR TW-2 WATERS

CLASS TW-2 - Tidal waters suitable for secondary contact recreation but not primary contact recreation; the maintenance of fish population; the migration of anadromous fish; the maintenance of wildlife and any other reasonable uses.

3.5.1 FLOATING SOLIDS, SETTLEABLE SOLIDS, OIL, GREASE, COLOR AND TURBIDITY

None noticeable in the water or deposited along the shore or on the aquatic substrata in quantities detrimental to the natural biota. None which would render the waters unsuitable for the designated uses.

3.5.2 TOXIC OR DELETERIOUS SUBSTANCES INCLUDING BUT NOT LIMITED TO MINERAL ACIDS, CAUSTIC ALKALI, CYANIDES, HEAVY METALS, CARBON DIOXIDE, AMMONIA OR AMMONIUM COMPOUNDS, CHLORINE, PHENOLS, PESTICIDES, ETC.

None, either alone or in combination with other substances, in such concentrations as to be detrimental to fish or inhibit their natural migration or which would render the waters unsuitable for the designated uses.

3.5.3 TASTE AND ODOR PRODUCING SUBSTANCES

None offensive to humans or which would produce offensive tastes and/or odors in biota used for human consumption. None which would render the waters unsuitable for the designated uses.

3.5.4 pH

Between 6.5 and 8.5.

3.5.5 DISSOLVED OXYGEN

Not less than 4.0 mg/l at any time.

3.5.6 TEMPERATURE

No heat may be added, except in designated mixing zones, which would cause temperatures to exceed 85^{o}F., or which would cause the monthly mean of the maximum daily temperature at any site, prior to the addition of any heat, to be exceeded by more than 4^{o}F. during September through May, or more than 1.5^{o}F. during June through August. The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

3.5.7 RADIOACTIVITY

Current U.S. Public Health Service Drinking Water Standards shall apply.

3.5.8 BACTERIAL QUALITY

Fecal coliform levels shall not exceed a geometric mean of 770/100 ml. Samples shall be obtained at sufficient frequencies and at locations and during periods which will permit valid interpretation of laboratory analyses.

Appropriate sanitary surveys shall also be carried out as a supplement to such sampling and laboratory analyses.

TW-3

SECTION 3.6 - SURFACE WATER QUALITY CRITERIA FOR TW-3 WATERS

CLASS TW-3 - Tidal waters used primarily for navigation, not recreation. These waters shall be suitable for fish survival and the passage of anadromous fish and for any other reasonable uses.

3.6.1 FLOATING SOLIDS, SETTLEABLE SOLIDS, OIL, GREASE, COLOR AND TURBIDITY

None noticeable in the water or contributing to the formation of sludge deposits.

3.6.2 TOXIC OR DELETERIOUS SUBSTANCES INCLUDING BUT NOT LIMITED TO MINERAL ACIDS, CAUSTIC ALKALI, CYANIDES, HEAVY METALS, CARBON DIOXIDE, AMMONIA OR AMMONIUM COMPOUNDS, CHLORINE, PHENOLS, PESTICIDES, ETC.

None, either alone or in combination with other substances, in such concentrations as to cause fish mortality or inhibit their natural migration or which would render the waters unsuitable for the designated uses.

3.6.3 TASTE AND ODOR PRODUCING SUBSTANCES

None offensive to humans or which would produce offensive tastes and/or odors in fauna used for human consumption. None which would render the waters unsuitable for the designated uses.

3.6.4 pH

Between 6.5 and 8.5.

3.6.5 DISSOLVED OXYGEN

Not less than 3.0 mg/l at any time.

3.6.6 TEMPERATURE

No heat may be added, except in designated mixing zones, which would cause temperatures to exceed 85^{o}F., or which would cause the monthly mean of the maximum daily temperature at any site, prior to the addition of any heat, to be exceeded by more than 4^{o}F. during September through May, or more than 1.5^{o}F. during June through August. The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

3.6.7 RADIOACTIVITY

Current U.S. Public Health Service Drinking Water Standards shall apply.

3.6.8 BACTERIAL QUALITY

Fecal coliform levels shall not exceed a geometric mean of 1500/100 ml. Samples shall be obtained at sufficient frequencies and at locations and during periods which will permit valid interpretation of laboratory analyses.

Appropriate sanitary surveys shall also be carried out as a supplement to such sampling and laboratory analyses.

DESCRIPTION OF FEDERAL USE CLASSIFICATION - A & B

Federal Class A: Primary Water Contact Recreation and Other Uses.*

A surface water source intended for uses where the human body may come in direct contact with the raw water to the point of complete body submergence and for use in propagation and maintenance of desirable (indigenous) aquatic biota. The raw water may be ingested accidentally and certain sensitive body organs such as eyes, ears, nose and so forth may be exposed to the water. Although the water may be ingested accidentally it is not intended to be used as a potable supply unless acceptable treatment is applied. The water may be used for swimming, water skiing, skin diving and other similar activities, as a raw water source for public water supply, for growth and propagation of desirable (indigenous)populations of fish, other aquatic and semi-aquatic life and wildlife both marine and fresh water, for agricultural/industrial water supply, and for navigation.

Federal Class B: Fish, Wildlife and Other Aquatic and Semi-Aquatic Life and Other Uses.*

A surface water source suitable for all Class A uses except primary contact recreation. The uses include the growth and propagation of desirable (indigenous) populations of fish, other aquatic and semi-aquatic life and wildlife both marine and freshwater. The water may be used for trout habitat, warm water fish habitat, wildlife habitat and other similar uses and is also suitable for secondary water contact recreation such as fishing, boating or activities where ingestion of the water is not probable, as a raw water source for public water supply, for agricultural/industrial water supply, and for navigation.

*Criteria for Classes A and B are equal to or more stringent than those of the USPHS applicable to a raw water source for public water supply.

Minimum Federal Water Quality Criteria

1. General Water Quality Criteria

All surface waters shall meet generally accepted aesthetic qualifications and shall be capable of supporting diversified aquatic life. These waters shall be free of substances attributable to discharges or waste as follows:

1.1 Materials that will settle to form objectionable deposits.

1.2 Floating debris, oil, scum, and other matter.

1.3 Substances producing objectionable color, odor, taste, or turbidity.

1.4 Materials, including radionuclides, in concentrations or combinations which are toxic or which produce undesirable physiological responses in human, fish and other animal life, and plants.

1.5 Substances and conditions or combinations thereof in concentrations which produce undesirable aquatic life.

2. Specific Water Quality

2.1 For All Waters

2.1.1 Key Parameters

2.1.1.1 Dissolved Oxygen (DO)

a) Cold Fresh Waters (Trout Spawning)
Not less than 7.0 mg/l from other than natural conditions.

b) Cold Fresh Waters (Trout)
Not less than 6.0 mg/l except that the DO may be between 5.0 and 6.0 for not more than 4 hours within any 24 hour period provided the water quality is favorable in all other respects and normal daily and seasonal fluctuations occur. In large streams that have some stratification or that serve principally as migratory routes DO levels may range between 4.0 and 5.0 mg/l for periods up to 6 hours, but in no case shall the DO be below 4.0 mg/l.

c) Fresh Waters (Streams, Unstratified Lakes and Epilimnion of Stratified Lakes)
Not less than 5.0 mg/l except that the DO may be between 4.0 and 5.0 mg/l for not more than 4 hours within any 24 hour period provided the water quality is favorable in all other respects, but in no case shall the DO be less than 4.0 mg/l.

d) Fresh Waters (Hypolimnion of Stratified Lakes)
Not less than 6.0 mg/l from other than natural conditions.

e) Marine Waters (Coastal)
Not less than 5.0 mg/l from other than natural conditions.

f) Estuarine Waters (Estuaries and Tidal Tributaries)
Not less than 5.0 mg/l from other than natural conditions. A DO of between 4.0 and 5.0 mg/l will be permitted for infrequent intervals and for limited periods of time where salinity is reduced (near the salt line), but at no time shall the DO be less than 4.0 mg/l.

2.1.1.2 Temperature

a) Cold Fresh Waters (Trout Spawning)
Natural temperatures shall prevail except where properly treated wastewater effluents may be discharged. Where such discharges occur, stream temperatures shall not be raised more than 1^{o}F.

b) Cold Fresh Waters (Trout)
No heat may be added which would cause temperatures to exceed 2^{o}F over the natural temperatures at any time or which would cause temperatures in excess of 68^{o}F.

Reductions in temperatures may be permitted where it can be shown that trout will benefit without detriment to other designated water uses. The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

c) Trout Maintenance Lakes
No thermal alterations except where it can be shown to benefit the designated uses.

d) Fresh Waters (Streams Unstratified Lakes, Epilimnion of Stratified Lakes)
No thermal alterations, except in designated mixing zones which would cause temperature to deviate more than 5^{o}F. at any time from natural stream temperature or more than 3^{o}F. in the epilimnion of lakes and other standing waters. No heat may be added, except in designated mixing zones, which

would cause temperatures to exceed 82^{o}F. for small mouth bass or yellow perch waters or 86^{o}F. for other non-trout waters.

The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

e) Hypolimnion of Stratified Lakes
Unless a special study shows that a discharge of a heated effluent into the hypolimnion or pumping water from the hypolimnion (for discharging back into the same water body) will be desirable, such practice shall not be permitted.

f) Estuarine Waters
No heat may be added, except in designated mixing zones, which would cause temperatures to exceed 85^{o}F., or which would cause the monthly mean of the maximum daily temperature at any site, prior to the addition of any heat, to be exceeded by more than 4^{o}F. during September through May, or more than 1.5^{o}F. during June through August. The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

g) Marine Waters
No heat may be added, except in designated mixing zones, which would cause the temperature to exceed 80^{o}F. or which would cause the monthly mean of the maximum daily temperature at any site, prior to the addition of any heat, to be exceeded by more than 4^{o}F. during September through May; or more than 1.5^{o}F. during June through August. The rate of temperature change in designated mixing zones shall not cause mortality of the biota.

2.1.1.3 Dissolved Solids

a) Fresh Waters
Maximum dissolved solids of 500 mg/l or one third above (133%) natural characteristic levels, whichever is less.

b) Marine Waters
Not applicable.

2.1.1.4 Dissolved Gas

a) Cold Waters (Fresh & Marine)
Total dissolved gas pressure not to exceed 110 percent of existing atmospheric pressure.

2.1.1.5 Phosphorus as total P shall not exceed 100 mg/l in any stream nor exceed 50 mg/l in any reservoir, lake, or at any point where it enters these receiving waters.

2.1.1.6 Suspended, Colloidal or Settleable Solids: None from waste water sources which will cause deposition or be deleterious for the designated uses.

2.1.1.7 Oil and Floating Substances: No residue attributable to waste water nor visible oil film nor globules of grease.

2.1.2 Radioactivity (USPHS - Drinking Water Standards shall apply)

2.1.2.1 Gross Beta 1,000 picocuries per liter in the absence of Sr^{90} and alpha emitters.

2.1.2.2 Radium 226 3 picocuries per liter

2.1.2.3 Strontium-90 10 picocuries per liter

2.2 Class A Waters

2.2.1 Microbiological - shall not exceed a geometric mean of 200 fecal coliforms (MPN) per 100 ml.

2.2.1 a) Shellfish - National Shellfish Sanitation Program (NSSP) microbiological standards shall apply, i.e. shall not exceed a median of 70 total coliforms (MPN) per 100 ml.

2.2.2 pH - shall be maintained between 6.5 and 8.3

pH - Marine - Normal range of pH must not be extended at any location by more than $\pm$ 0.1 pH unit. At no time shall the pH be less than 6.7 or greater than 8.3.

2.2.3 Taste and Odor Producing Substances - None in amounts that will interfere with use for primary contact recreation, potable water supply or will render any undesirable taste or odor to edible aquatic life.

2.2.4 Color and Turbidity - a Secchi disc shall be visible at a minimum depth of 1 meter.

2.3 Class B Waters

2.3.1 Microbiological - shall not exceed a geometric mean of 10,000 total coliforms or of 2,000 fecal coliforms (MPN) per 100 ml (Fecal coliform counts are preferred).

2.3.1 a) Shellfish - National Shellfish Sanitation Program (NSSP) standards shall apply, i.e. shall not exceed a median of 70 total coliforms (MPN) per 100 ml.

2.3.2 pH - shall be maintained between 6.0 and 9.0.

pH - Marine - Normal range of pH must not be extended at any location by more than $\pm$ 0.1 pH unit. At no time shall the pH be less than 6.7 or greater than 8.5.

2.3.3 Taste and Odor Producing Substances - None in amounts that will interfere with the use for potable water supply or will render any undesirable taste or odor to edible aquatic life.

2.3.4 Color and Turbidity

a) Cold Waters - 10 Jackson Turbidity units (JTU)

b) Warm Waters - 50 Jackson Turbidity units (JTU)

c) Marine Waters - a Secchi disc shall be visible at a minimum depth of 1 meter.

3. Mixing Zones

The total area and/or volume of a receiving stream assigned to mixing zones shall be limited to that which will: 1) not interfere with biological communities or populations of important species to a degree which is damaging to the ecosystem; 2) not diminish other beneficial uses disproportionately.

4. Zones of Passage

In river systems, reservoirs, lakes, estuaries and coastal waters, zones of passage are continuous water routes of the volume, area and quality necessary to allow passage of free-swimming and drifting organisms with no significant effects produced on their populations. These zones must be provided wherever mixing zones are allowed.

Because of varying local physical and chemical conditions and biological phenomena, no single value can be given on the percentage of river width necessary to allow passage of critical free-swimming and drifting organisms so that negligible or no effects are produced on their populations. As a guideline, mixing zones should be limited to no more than 1/4 of cross-sectional area and/or volume of flow of stream or estuary, leaving at least 3/4 free as a zone of passage.

5. Analytical Testing

All methods of sample collection, preservation, and analysis used in applying any of the rules and regulations in these standards shall be in accord with those prescribed in "Standard Methods for the Examination of Water and Waste Water," Thirteenth Edition, or any subsequent edition with other generally accepted procedures.

6. Stream Flow

The water quality standards shall apply at all times except during periods when flows are less than the average minimum seven-day low flow which occurs once in ten years.

7. Minimum Treatment Requirements

The minimum treatment required for any wastewater must be such that discharges shall meet effluent limits as established under section 402 of the 1972 Amendments and shall not cause the Federal Criteria for in-stream water quality contained herein to be contravened.

Required Changes in New Jersey Water Quality Standards.

Items*	State/Federal Classification	Required Changes**
3.1	Class FW-1/A	Satisfactory as written. Federal Criteria contained in 1, 2.1, 2.2, 5 and 6 must apply.
3.2	Class FW-1/A	
3.2.1 Floating solids, etc.		Federal Criteria 1.1, 1.2 & 1.3 must apply.
3.2.2 Toxic or Deleterious Subs.		Federal Criteria 1.4 & 2.1.2 must apply.
3.2.4 pH		Federal Criteria 2.2.2 must apply.
3.2.5 DO		Federal Criteria 2.1.1.1 must apply, specifically:
b.		$\geq$ 6.0 mg/l
c.		$\geq$ 6.0 mg/l; Eutrophic Lakes: $\geq$ 5.0 mg/l and $\geq$ 6.0 mg/l
d.		$\geq$ 5.0 mg/l (2.1.1.1c)
		Appropriate Federal Criteria contained in 1, 2.1, 2.2, 3, 4, 5, 6 and 7 not cited above must also apply.
3.3	Class FW-3/A	
3.3.1 Floating Solids, etc.		Federal Criteria 1.1, 1.2 and 1.3 must apply.
3.3.2 Toxic or Deleterious Subs.		Federal Criteria 1.4 & 2.1.2 must apply.
3.3.4 pH		Federal Criteria 2.2.2 must apply.
3.3.5 DO		Federal Criteria 2.1.1.1 must apply, specifically:
b.		$\geq$ 6.0 mg/l
c.		$\geq$ 6.0 mg/l; Eutrophic Lakes: $\geq$ 5.0 mg/l and $\geq$ 6.0 mg/l
d.		$\geq$ 5.0 mg/l (2.1.1.1c)
		Appropriate Federal Criteria contained in 1, 2.1, 2.2, 3, 4, 5, 6 and 7 not cited above must also apply.

*Items refer to section of "Rules and Regulations Establishing Surface Water Quality Criteria."

**Except as otherwise noted, changes refer to sections of "Minimum Federal Water Quality Criteria."

Items*	State/Federal Classification	Required Changes**
3.4	Class TW-1/A	
3.4.1 Floating Solids, etc.		Federal Criteria 1.1, 1.2 & 1.3 must apply.
3.4.2 Toxic or Deleterious Subs.		Federal Criteria 1.4 & 2.1.2 must apply.
3.4.4 pH		Federal Criteria 2.2.2 must apply.
3.4.5 DO		Federal Criteria 2.1.1.1 must apply, specifically:
a.		≥ 6.0 mg/l (2.1.1.1b)
b.		≥ 5.0 mg/l (2.1.1.1c)
3.4.6 Temp.		Federal Criteria 2.1.1.2 must apply.
		Appropriate Federal Criteria contained in 1, 2.1, 2.2, 3,4,5, 6 and 7 not cited above must also apply.
3.5	Class TW-2/B	
Use Description		The use description must be upgraded to include as a minimum the propagation as well as maintenance of fish and wildlife (Federal Class B)
3.5.1 Floating Solids, etc.		Federal Criteria 1.1, 1.2 & 1.3 must apply.
3.5.2 Toxic or Deleterious Subs.		Federal Criteria 1.4 and 2.1.2 must apply.
3.5.5 DO		Federal Criteria 2.1.1.1 must apply.
3.5.6 Temp.		Federal Criteria 2.1.1.2 must apply.
		Appropriate Federal Criteria contained in 1, 2.1, 2.3, 3,4, 5,6 and 7 not cited above must also apply.
3.6	Class TW-3/B	
Use Description		The use description must be upgraded to include as a minimum the propagation and maintenance of fish and wildlife (Federal Class B)
3.6.1 Floating Solids, etc.		Federal Criteria 1.1, 1.2 and 1.3 must apply.
3.6.2 Toxic or Deleterious Subs.		Federal Criteria 1.4 and 2.1.2 must apply.
3.6.5 DO		Federal Criteria 2.1.1.1 must apply.
3.6.6 Temp.		Federal Criteria 2.1.1.2 must apply.

Items*	State/Federal Classification	Required Changes**
		Appropriate Federal Criteria contained in 1, 2.1, 2.3, 3,4,5, 6 and 7 not cited above must also apply.
3.7	Class CW-1/A	
3.7.1 Floating Solids, etc.		Federal Criteria 1,1, 1.2 and 1.3 must apply.
3.7.2 Toxic or Deleterious Subs.		Federal Criteria 1.4 and 2.1.2 must apply.
3.7.4 pH		Federal Criteria 2.2.2 must apply.
3.7.6 Temp.		Federal Criteria 2.1.1.2 must apply.
		Appropriate Federal Criteria contained in 1,2.1, 2.2,3,4,5, 6 and 7 not cited above must also apply.
3.8	Class CW-2/B	
3.8.1 Floating Solids, etc.		Federal Criteria 1.1, 1.2 & 1.3 must apply.
3.8.2 Toxic or Deleterious Subs.		Federal Criteria 1.4 & 2.1.2 must apply.
3.8.6 Temp.		Federal Criteria 2.1.1.2 must apply.
		Appropriate Federal Criteria contained in 1, 2.1, 2.3,3,4,5, 6 and 7 not cited above must also apply.

APPENDIX C

RECOMMENDATIONS OF THE RARITAN BAY AND ADJACENT WATERS ENFORCEMENT CONFERENCES

On the basis of Project studies the following recommendations were made in order to reclaim study area waters for maximum beneficial uses (FWPCA 1967).

1. Treatment facilities provide a minimum of 90% removal of BOD and suspended solids, and effective year round disinfection (effluent coliform count of no greater than one per ml in more than 10% of samples examined) at all municipal plants discharging directly to these waters. Program to be carried out in accordance with following time schedule:

   a. Complete plant design no later than December 1, 1967;

   b. Initiate construction no later than June 1, 1968;

   c. Place in operation no later than June 1, 1970;

unless existing orders specify completion dates earlier than the above, in which case the earlier dates must be met.

2. Industrial plants shall improve practices for the segregation and treatment of wastes so as to effect maximum reduction of the following:

   a. Acids and alkalis

   b. Oil and tarry substances

   c. Phenolic and other compounds that contribute to taste, odor and tainting of fin and shellfish meat

   d. Nutrient materials, including nitrogenous and phosphorous compounds

   e. Suspended material

   f. Toxic and highly colored wastes

g. Oxygen requiring substances

h. Heat

i. Foam producing discharges

j. Bacteria

k. Wastes which detract from optimum use and enjoyment of receiving waters.

Industrial treatment facilities to accomplish such reduction must provide removals at least the equivalent of those required for municipal treatment plants. Such facilities or reduction should be provided in accordance with the following time schedule:

a. Completion of engineering studies and design by December 1, 1967;

b. Commence construction by June 1, 1968;

c. Place in operation by June 1, 1970;

unless existing orders specify compliance dates earlier than the above, in which case the earlier dates must be met.

3. Qualified resident operators (licensed or certified) be provided at each treatment plant.

4. Facilities and procedures be established at each treatment facility to provide laboratory control.

5. Automatic instrumentation and recorders be required for flow and chlorination feed or residual control to permit prompt and effective supervision by plant operators and water pollution control agencies.

6. Priority for construction grants be established so affected communities may obtain funds to meet the requirements outlined above.

7. Recognition be given to the problems which will arise as a result of the continued population growth in the area, which may lead to the necessity for tertiary or other advanced wastes treatment techniques. All new

facilities should be planned with sufficient site space to permit future expansion for such treatment.

8. State regulations be extended to require wastes treatment facilities or holding tanks on all vessels and recreational boats using the area. If holding tanks are to be used, adequate dockside facilities be required to ensure proper disposal of wastes.

9. Conferees meet every six months to review and initiate progress on water quality improvements.

10. Conferees will investigate additional proposals to safeguard water quality in the study area, to include but not be limited to:

a. Relocation of the main shipping channel through Raritan Bay to improve circulation characteristics;

b. Selection of areas for dredging for construction materials;

c. Suitable outfall locations for waste effluents to include possible trunk systems to divert effluents from the Arthur Kill.

APPENDIX D

RARITAN BAY MODEL STUDY 1/

Any natural water system may be viewed as a unique mathematical system consisting of a specific combination or array of complex interacting subsystems, each of which exhibits singular geometric, hydrodynamic and kinetic properties. The physical response of the system to a particular pollutant discharge may be described by a set of differential equations which represent the individual properties of each subsystem and the effect of each subsystem on adjoining segments. The model used was developed by Hydroscience (1970). Following segmentation of the estuary, a steady-state mass balance was formulated around each of the interconnected segments within the system. This was done using basic differential equations which were solved simultaneously via the Gauss-Seidel elimination technique.

The purpose of mathematically modeling a natural water system is to reproduce observed natural phenomena through the application of mathematical techniques on a segment-by-segment basis.

In the finite difference approach used in the analysis of the Raritan Bay system, the initial procedure consisted of the development of an adequate segmentation scheme based upon known wastewater input locations, and geometric, hydraulic and circulation factors. The Raritan Bay system was

1/From: Raritan Bay system analysis: two-dimensional water quality model, an unpublished report prepared by EPA, Region II, New York, N.Y.

divided into an arbitrary number of discrete segments in which there were no steep pollutant concentration gradients and in which the concentrations were considered uniform, i.e., the segments approximated completely mixed water volumes. Inherent in the analysis was the assumption of vertical homogeneity or the absence of any vertical stratification of the water quality constituent being modeled.

The general counterclockwise circulation patterns existing within the Raritan Bay system formed the primary basis for the segmentation (Figure D-1). Adjustments were made based upon the work of the Woods Hole Oceanographic Institute (Ayers et al., 1949), Ketchum (1951), Jeffries (1962) and U.S. Geological Survey Current Charts (USGS, 1956).

The final grid pattern generally consists of smaller segments near the head of the bay region where the major waste inputs are located and where water quality conditions are usually more critical. The segmentation thus allows greater definition of specific pollutant distributions in this area of concern and avoids the possibility of excess concentration gradients within individual sections. Segments located west of the Raritan Bay-Lower Bay boundary line at Point Comfort are predominantly less than 1.5 square miles in surface area, while in the Lower Bay and Sandy Hook Bay, the segmentation consists of larger sections due to the smaller observed pollutant gradients, the lesser definition of specific flow paths and the absence of any significant point waste sources. Figure D-1 illustrates the segmentation system.

The pollutant transport mechanisms within the Raritan Bay system are the freshwater excursions due to the natural and artificial water sources and the dispersive mixing provided by the semi-diurnal tidal oscillations.

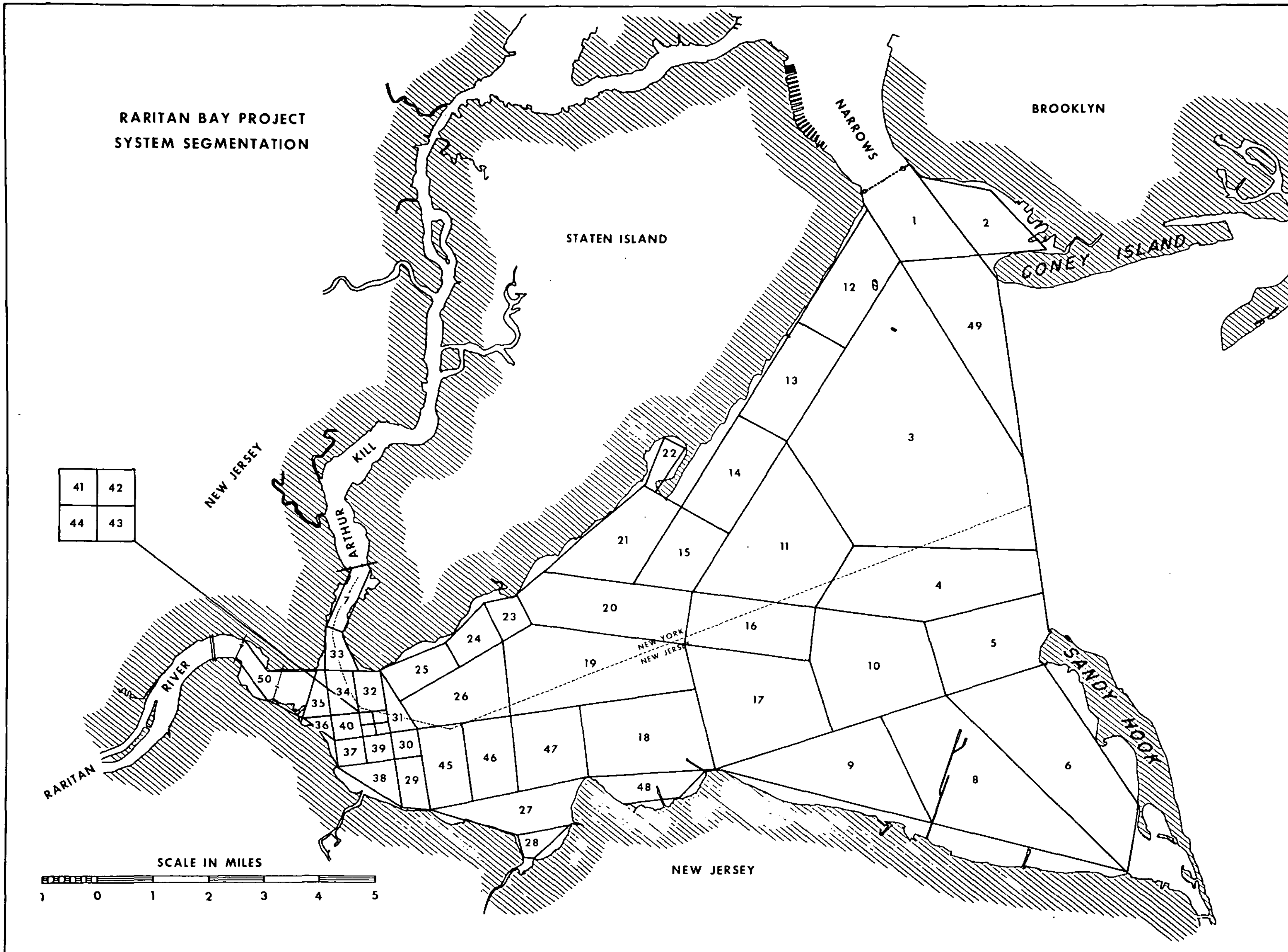

RARITAN BAY PROJECT
SYSTEM SEGMENTATION
STATEN ISLAND
BROOKLYN
NARROWS
CONEY ISLAND
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
SANDY HOOK
NEW YORK
NEW JERSEY
NEW JERSEY
SCALE IN MILES
1 0 1 2 3 4 5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

Figure D-1

The dispersive transports utilized in the model verification and subsequent water quality projections are expressed as dispersion coefficients. A dispersion coefficient has been assigned to each of the model interfaces; these coefficients are indicated in Figure D-2. In many natural estuarine systems, lateral dispersion is 1/2 to 1/10 the longitudinal dispersion. In the Raritan Bay system, these parameters are of the same order. This is mainly due to the two-dimensional nature of the large-scale circulation patterns and the many smaller eddy formations. Initial estimates of these coefficients were provided by tidal current charts and the empirical Four-Thirds Law.

In addition to the dispersive transport, the freshwater (advective) transport must be considered. The primary excursion routes for the advective paths were assumed to be along preassigned circulatory channels and/or other direct routes to the ocean. Wastewater effluent flows were determined largely from Interstate Sanitation Commission (ISC, 1971)and STORET (U.S. EPA,n.d.) data. River flow data were obtained from USGS (1964) stations in the Raritan Basin,e.g., Raritan River at Calco dam, South River at Old Bridge, and on the Lamington River, and were extrapolated to the mouth of the Raritan River at Perth Amboy. All data pertinent to the individual segments within the system, e.g., MSL depths, section volumes, interfacial areas, characteristic length, were obtained from U.S. Coast and Geodetic Survey Map No. 369-SC (New York Harbor, 1971).

The major test for the validation of a model relies upon the verification of calculated water quality responses through comparison with actual observed data. Throughout the application of the model to the Raritan system, it was assumed that the system parameters, e.g.,

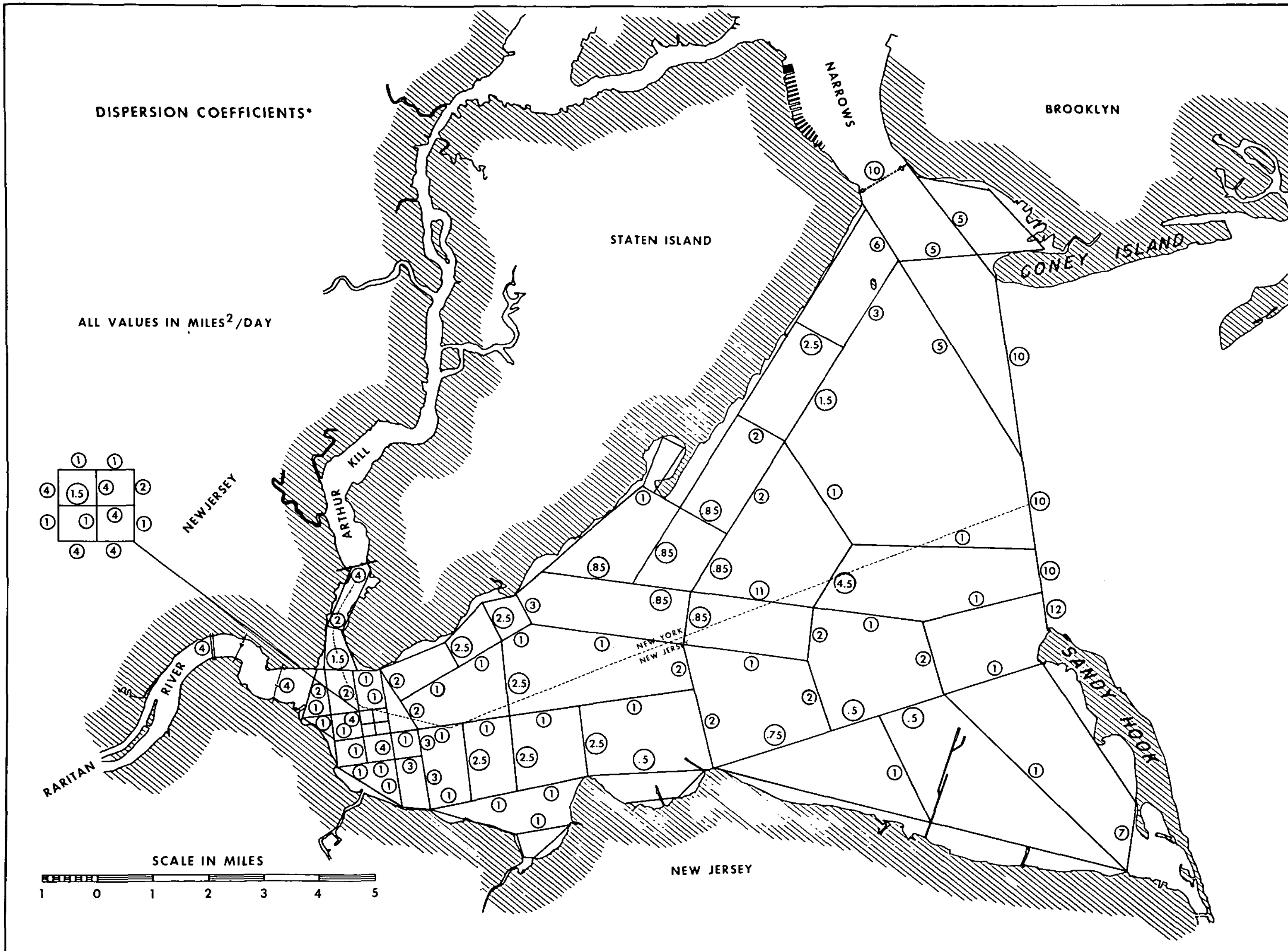

DISPERSION COEFFICIENTS*
ALL VALUES IN MILES²/DAY
STATEN ISLAND
BROOKLYN
NARROWS
CONEY ISLAND
SANDY HOOK
NEWJERSEY
ARTHUR KILL
RARITAN RIVER
NEW YORK
NEW JERSEY
NEW JERSEY
SCALE IN MILES
1 0 1 2 3 4 5

Figure D-2

dispersion coefficients, flow routing and quantification, were known _a priori_ values. Yet, in many cases, the tools that would have allowed more precise specification of these parameters were not available. The order of magnitude of many of the parameters is known through either past research, empirical correlations or, in rare cases, independent analyses specifically designed to determine a particular unknown.

In order to verify the transport mechanisms inherent in the model, a conservative (non-degradable) constituent was traced from a known source location as it was advected and/or dispersed throughout the system. Quite often, tracer dyes, such as Rhodamine B, are utilized for this purpose. However, in the absence of such artificial sources, salinity (or chloride) is the most common constituent traced. The basic assumption behind the selection is that the identical transport mechanisms will operate on discharged pollutants as on the tracer introduced to the system through ocean boundaries or known point sources.

CHLORIDE VERIFICATION

Chloride sources in the bay range in magnitude from the 175,000 lb/day discharged by MCSA to the relatively insignificant loads contributed by the Highlands and Atlantic Highlands facilities. Data pertinent to all chloride point sources were obtained from STORET surveys for the months of August and September over the 10-year range from 1962 to 1972 (U.S. EPA,n.d.).

In order to compute the chloride concentrations, the chlorinity was specified for all boundaries within the system. Along the coastal traverse, these values ranged from 15.20 ppt at segment 4 to 15.65 ppt at segment 3. The chloride concentrations established for the Raritan River and the Arthur Kill boundaries were 13.00 ppt and 13.70 ppt, respectively. All chloride boundary condition concentrations were based upon observed 10-year mean values, as were the advective input flows.

The calculated 10-year mean chloride profiles have been superimposed on the August-September chloride values observed over the same time period (Figure D-3), "Goodness of fit" between the observed and calculated chloride values was evaluated by the application of two statistical analyses: 1) a Student's 't' test was performed at each station to determine the 95 percent confidence limits around observed values, and 2) the mean standard deviation of all observed values was obtained from the STORET system. The calculated chloride contours (isoclors) fell well within the range of predictions permissible under each of these statistical analyses.

DISSOLVED OXYGEN VERIFICATION

Past water quality surveys in the Raritan Bay system have indicated specific regions wherein present water quality standards, as represented by the New Jersey State TW-1 classification and the Interstate Sanitation Commission (ISC) 'A' classification, are contravened. Most notably, the minimum required DO levels of 4.0 mg/l (New Jersey State) and 5.0 mg/l (ISC) are contravened in the head of the bay area in the vicinity of the MCSA discharge, in the Arthur Kill and in the tidal stretch of the Raritan River. For this reason, the DO analysis included in this report is limited largely to that portion of the bay system which is located west of Point Comfort, with the exception of the discussion of boundary condition influences.

The in-stream DO levels in the bay area are an important index of water quality conditions since certain minimum concentrations of this

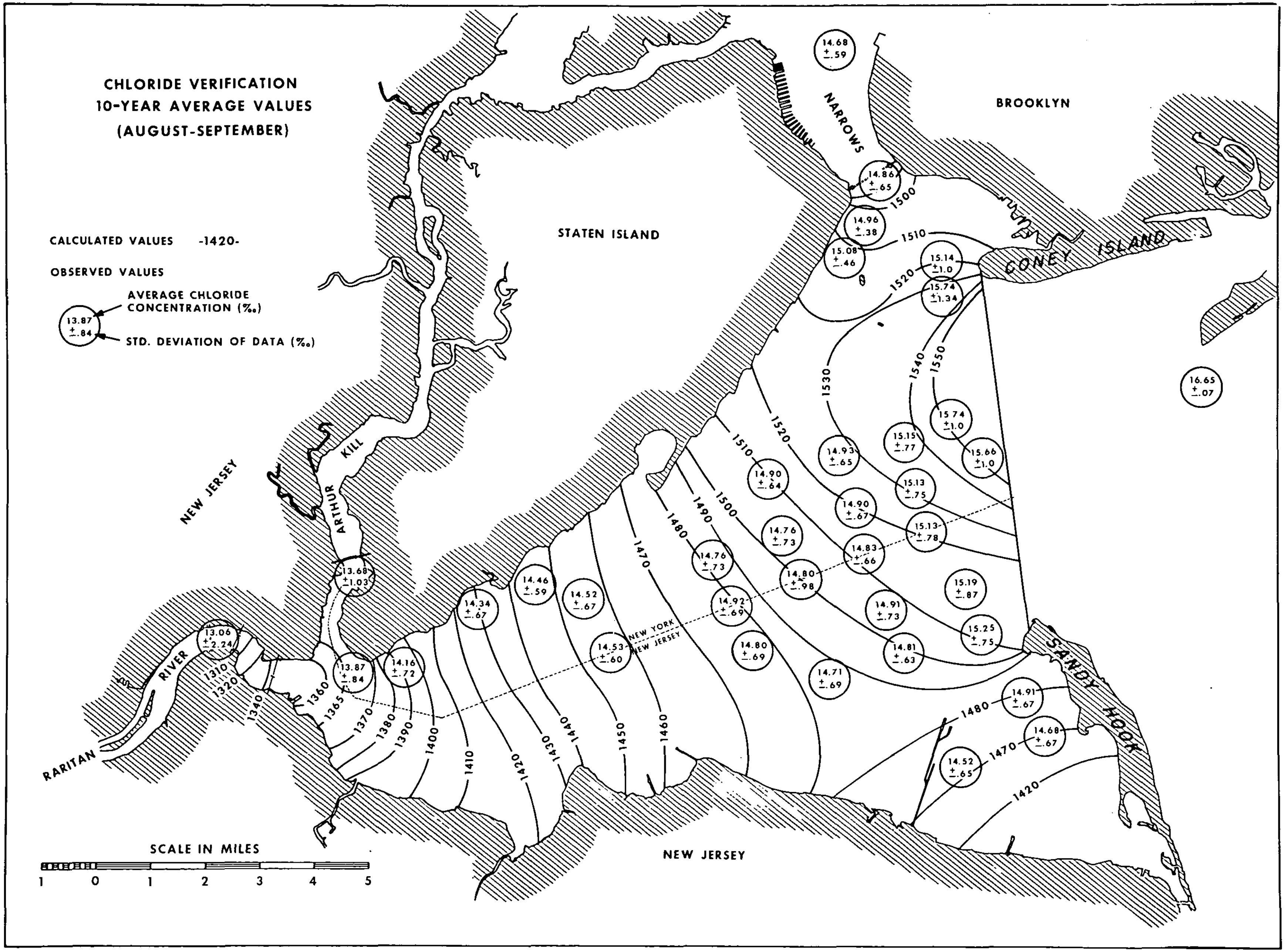

CHLORIDE VERIFICATION
10-YEAR AVERAGE VALUES
(AUGUST-SEPTEMBER)
CALCULATED VALUES -1420-
OBSERVED VALUES
AVERAGE CHLORIDE CONCENTRATION (‰)
STD. DEVIATION OF DATA (‰)
13.87 ±.84
STATEN ISLAND
BROOKLYN
NARROWS
CONEY ISLAND
SANDY HOOK
NEW JERSEY
ARTHUR KILL
RARITAN RIVER
NEW YORK
NEW JERSEY
SCALE IN MILES
1 0 1 2 3 4 5
14.68 ±.59
14.86 ±.65
14.96 ±.38
15.08 ±.46
15.14 ±1.0
15.74 ±1.34
16.65 ±.07
15.74 ±1.0
15.15 ±.77
14.93 ±.65
15.66 ±1.0
14.90 ±.64
15.13 ±.75
14.90 ±.67
14.76 ±.73
15.13 ±.78
14.83 ±.66
14.76 ±.73
14.80 ±.98
13.68 ±1.03
14.46 ±.59
14.52 ±.67
14.92 ±.69
14.91 ±.73
15.19 ±.87
14.34 ±.67
13.06 ±2.24
15.25 ±.75
14.53 ±.60
14.80 ±.69
14.81 ±.63
13.87 ±.84
14.16 ±.72
14.71 ±.69
14.91 ±.67
14.68 ±.67
14.52 ±.65
1500
1510
1520
1530
1540
1550
1490
1480
1470
1460
1450
1440
1430
1420
1410
1400
1390
1380
1370
1365
1360
1340
1320
1310

Figure D-3

constituent are necessary for the survival of many aquatic organisms. The major sources and sinks of DO in the Raritan Bay system are carbonaceous and nitrogenous oxygen demands, benthic uptake from organic sediments, photosynthetic production and respiration, and atmospheric reaeration. The general background of each of these processes and their particular significance and quantification in the Raritan Bay system are discussed below.

Biochemical Oxygen Demand

When wastewater is discharged into a stream or estuary, the decomposable organic matter becomes an energy source for the organisms in the environment. The BOD of an effluent is a measure of the oxygen consumed when specific micro-organisms utilize this organic matter as an energy source and break down the more complex compounds to simpler products. There are two stages of BOD; the first stage is due to carbonaceous BOD and the second is due to nitrogenous oxidation demand (NOD). The rate at which oxygen is utilized during both of these processes is mainly dependent upon in-stream temperatures and pH. Both decomposition kinetics, carbonaceous BOD and NOD, are aerobic, although different individual species are responsible for each.

The 5-day BOD concentrations for the three major discharges in the Raritan Bay system, MCSA and Perth Amboy in New Jersey and Oakwood Beach on Staten Island, were obtained from the STORET system for the period of July 12-22, 1971. These values were 400 (MCSA), 290 (Perth Amboy), and 35 (Oakwood Beach) mg/l which represent 240,000, 17,300 and 3,800 lb/day BOD (5-day), respectively. The corresponding NOD contributions of these three major discharges according to the STORET data were 44,800 (MSCA), 4,500 (Perth Amboy) and 5,350 (Oakwood Beach) lb/day. Implicit in the model analysis is the assumption that the NOD decay (removal) rate is identical to the BOD rate and, thus,both deoxygenation processes occur simultaneously. The BOD decay rate (Kr) for all segments in the bay system was assumed to be 0.25/day at 20^{0}C.

The temperatures utilized for the DO verification were those recorded by the July 12-22, 1971 ISC survey. However, 10-year mean August-September values were applied for the subsequent DO projections for the design year 2020.

Photosynthetic Sources

It was observed that during the July 1971 survey, supersaturation of dissolved oxygen occurred periodically, especially in the Sandy Hook Bay area where average DO values were on the order of 9.44 mg/l and 9.16 mg/l. Specific analyses to determine the extent of this phenomenon (FWPCA, 1969) at two stations near the head of the bay recorded net O_2 production of approximately 2.0 mg/l/day in the upper 9 feet of water.

To account for this phenomenon, an average dissolved oxygen source was added to various segments in the head of the bay area in the Conaskonk Point-Point Comfort vicinity. Net values of 1.0 mg/l/day in Keansburg Harbor (section 48), 0.9 mg/l/day in Keyport Harbor (sections 27 and 28) and 0.10 mg/l/day in the deeper central area (sections 18, 19, 20, 23, and 47) were incorporated into the model to allow for photosynthetic effects. No photosynthetic sources were included for the extreme western bay area due to the suppressant effects of the generally more turbid water, the probable toxicity from Arthur Kill discharges and the greater zooplankton respiratory rates which tend to offset any O_2 production.

Benthal Oxygen Demand

Sludge deposits are present in the head of the bay area, especially in adjacent embayments. These deposits are largely due to the relatively high amount of suspended matter in the primary effluents from the treatment facilities. There are no estimates of the magnitude of the resultant oxygen demand represented by these benthal deposits. It is possible that a significant portion of this uptake has been suppressed by toxic substances originating in the Arthur Kill and subsequently settling in the more shallow and quiescient areas of this inner bay region. For the purposes of this analysis, the benthic sinks were assumed to be zero in all segments of the inner bay area.

Atmospheric Reaeration

Aside from photosynthetic oxygen production, the only remaining oxygen source in the inner bay area is due to atmospheric reaeration. The rate of reaeration is directly proportional to the DO deficit, the in-stream temperature and the turbulence of the water; it is inversely proportional to the depth of the water body. The value of the reaeration coefficient (K_A) for the Raritan Bay ranges from 0.3/day near the mouth of the Raritan River to 0.1/day at the Raritan Bay-Lower Bay boundary at Point Comfort (Hydroscience, 1968). Accordingly, the reaeration coefficient was set at 0.20/day for all segments within the inner bay area.

Verification Procedure

The period chosen for verification of the calculated dissolved oxygen profiles was July 12-22, 1971. The joint ISC - New Jersey State survey undertaken at that time provided the dissolved oxygen data.

The BOD and DO deficit boundary conditions set for the survey period were based on 10-year August-September mean water quality conditions observed at stations closest to each specific boundary. These conditions were:

Segment	BOD (mg/l)	DO deficit (mg/l)
1	2.28	3.20
7	2.26	4.75
50	2.26	3.90

The BOD and DO deficit concentrations at the coastal interfaces between Sandy Hook and Norton Point and at the Shrewsbury-Navesink interface were assumed to be zero.

The Raritan River flow of 250 cfs that was observed over the survey period was determined from USGS (1964) data and was extrapolated on a flow per unit drainage area basis to the mouth of the Raritan at Perth Amboy.

The distribution of dissolved oxygen throughout the critical inner bay area (west of Point Comfort) was calculated for the July 1971 survey period using the outlined assumptions and the referenced parameters. For purposes of comparison, the individual DO profiles have been plotted along with the DO values observed during the joint survey (Figure D-4).

Application of the Students 't' 95 percent confidence limits test and the standard error comparison test indicated that the agreement between the calculated and observed isopleths represents excellent simulation of the dissolved oxygen kinetics and distribution throughout the western bay area.

EFFECT OF INDIVIDUAL WASTE SOURCES

A number of additional DO analyses were performed to assess the effect of individual waste sources on in-stream DO distributions and,

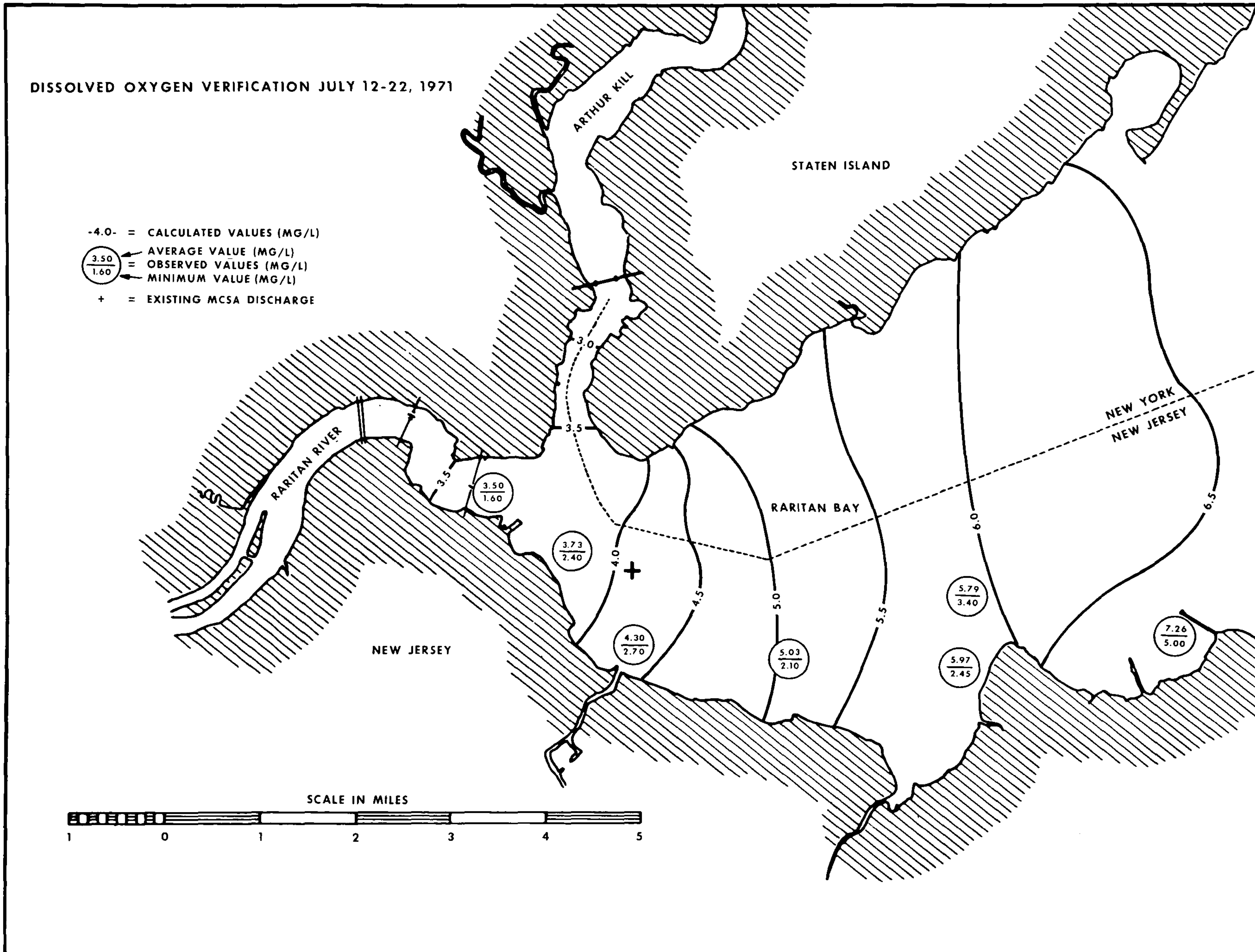

DISSOLVED OXYGEN VERIFICATION JULY 12-22, 1971
-4.0- = CALCULATED VALUES (MG/L)
AVERAGE VALUE (MG/L)
3.50 / 1.60 = OBSERVED VALUES (MG/L)
MINIMUM VALUE (MG/L)
+ = EXISTING MCSA DISCHARGE
ARTHUR KILL
STATEN ISLAND
RARITAN RIVER
RARITAN BAY
NEW YORK
NEW JERSEY
NEW JERSEY
3.0
3.5
3.5
4.0
4.5
5.0
5.5
6.0
6.5
3.50 / 1.60
3.73 / 2.40
4.30 / 2.70
5.03 / 2.10
5.79 / 3.40
5.97 / 2.45
7.26 / 5.00
SCALE IN MILES
1 0 1 2 3 4 5

Figure D-4

thereby, to facilitate evaluation of future abatement proposals. The particular analyses undertaken were based upon the July 1971 survey period and the individual DO deficit response under the following conditions:

1) Middlesex County Sewerage Authority alone,
2) Boundary effects.

The DO deficits caused by each of these particular conditions during the survey have been plotted in Figures D-5 and D-6. In both cases, the 250 cfs Raritan River flow routing and background photosynthetic effects were assumed to be constant.

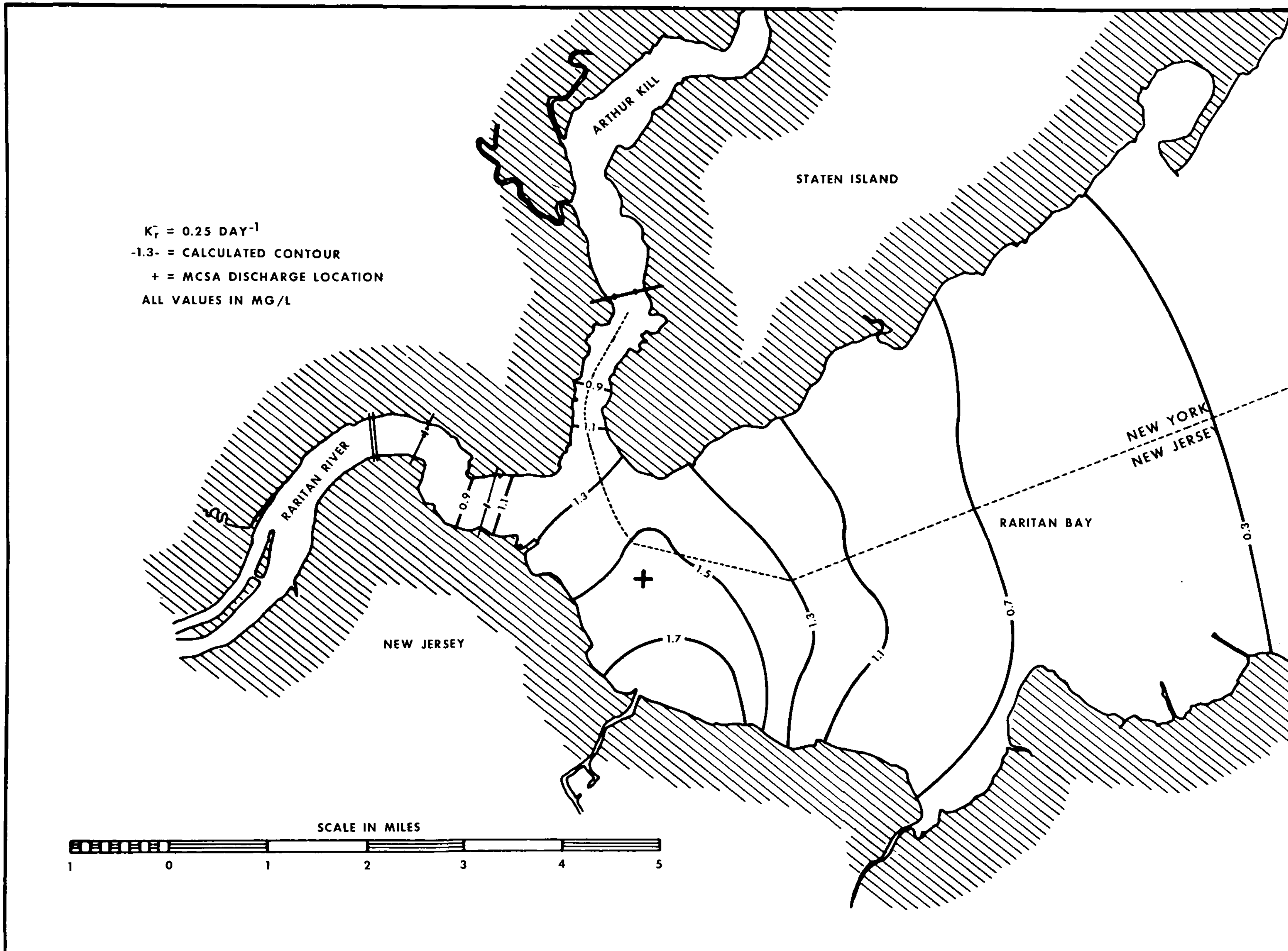
EFFECT OF ALTERNATE ABATEMENT MEASURES

Based upon the hydrodynamic parameters, substantiated by the salinity verification, and the dissolved oxygen kinetic parameters, substantiated by the DO verification, it was possible to determine the effects of any number of alternate abatement proposals, from outfall relocation to higher degrees of treatment and flow augmentation. Each of the alternatives was evaluated on the basis of year 2020 wastewater flows and the estimated 140 cfs Raritan River average daily flow, which is exceeded 95 percent of the time. All other parameters, e.g., benthal demand and photosynthetic production, were assumed to remain constant. However, the flow routing was adjusted for each particular analysis.

MCSA DISCHARGE AT EXISTING OUTFALL SITE

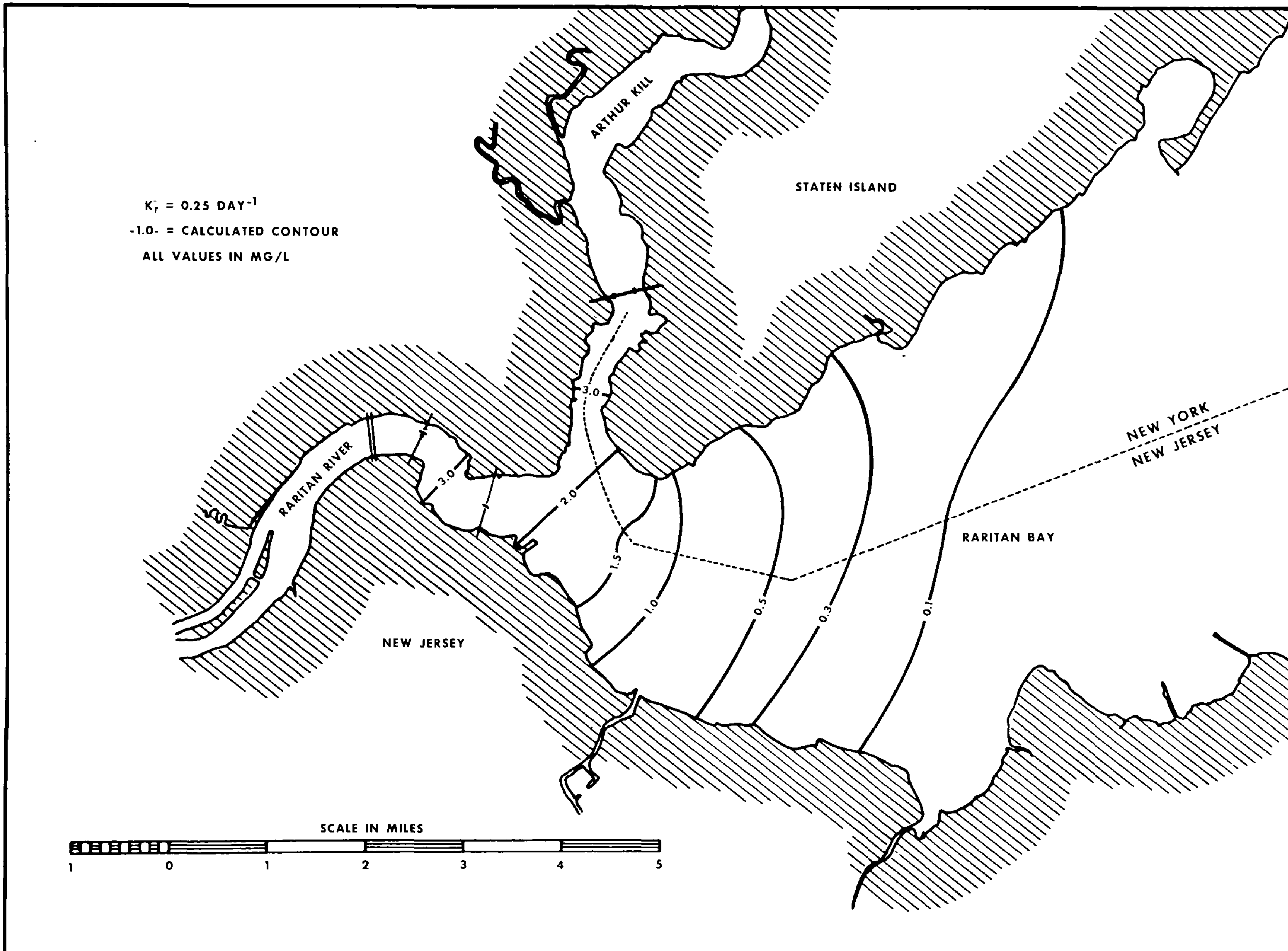
The estimated wastewater discharge from the MCSA facility in the 2020 analysis was 240 mgd (372 cfs). This represents an ultimate oxygen demand (UOD) equal to 350,000 lb/day. This estimate is based upon an average effluent BOD (5-day) of 50 mg/l and an average ammonia (NH_3) concentration of 20 mg/l. The Oakwood Beach facility will contribute a UOD

Figure D-5



DISSOLVED OXYGEN DEFICIT DUE TO MCSA DISCHARGE - JULY, 1971

Figure D-6



DISSOLVED OXYGEN DEFICIT DUE TO BOUNDARY CONDITION EFFECTS - JULY, 1971 equal to 34,000 lb/day based upon a design capacity of 40 mgd and effluent BOD (5-day) and NH_3 concentrations of 35 and 11 mg/l, respectively. All other existing point waste sources are assumed to be serviced by either the MCSA or the MCBOOA and, as such, are not included in the analysis. Boundary conditions for BOD (5-day) and DO deficit are identical to those used in the DO verification analysis.

The calculated DO distribution for the inner bay area (Figure D-7) indicates that the 4.0 mg/l DO criteria (New Jersey State) will be contravened in the extreme western sector of the bay and in the lower Raritan River and the Arthur Kill. The larger area,wherein contravention of the 5.0 mg/l criteria (ISC) can be expected,extends from the 4.0 mg/l isopleth to a point approximately 1 mile east of the present discharge site. Contravention may be even more severe if the boundary conditions at the Raritan and Arthur Kill interfaces worsen or if benthal sinks begin to exert a more significant deficit due to the abatement of possible toxic suppressants from the Arthur Kill discharges.

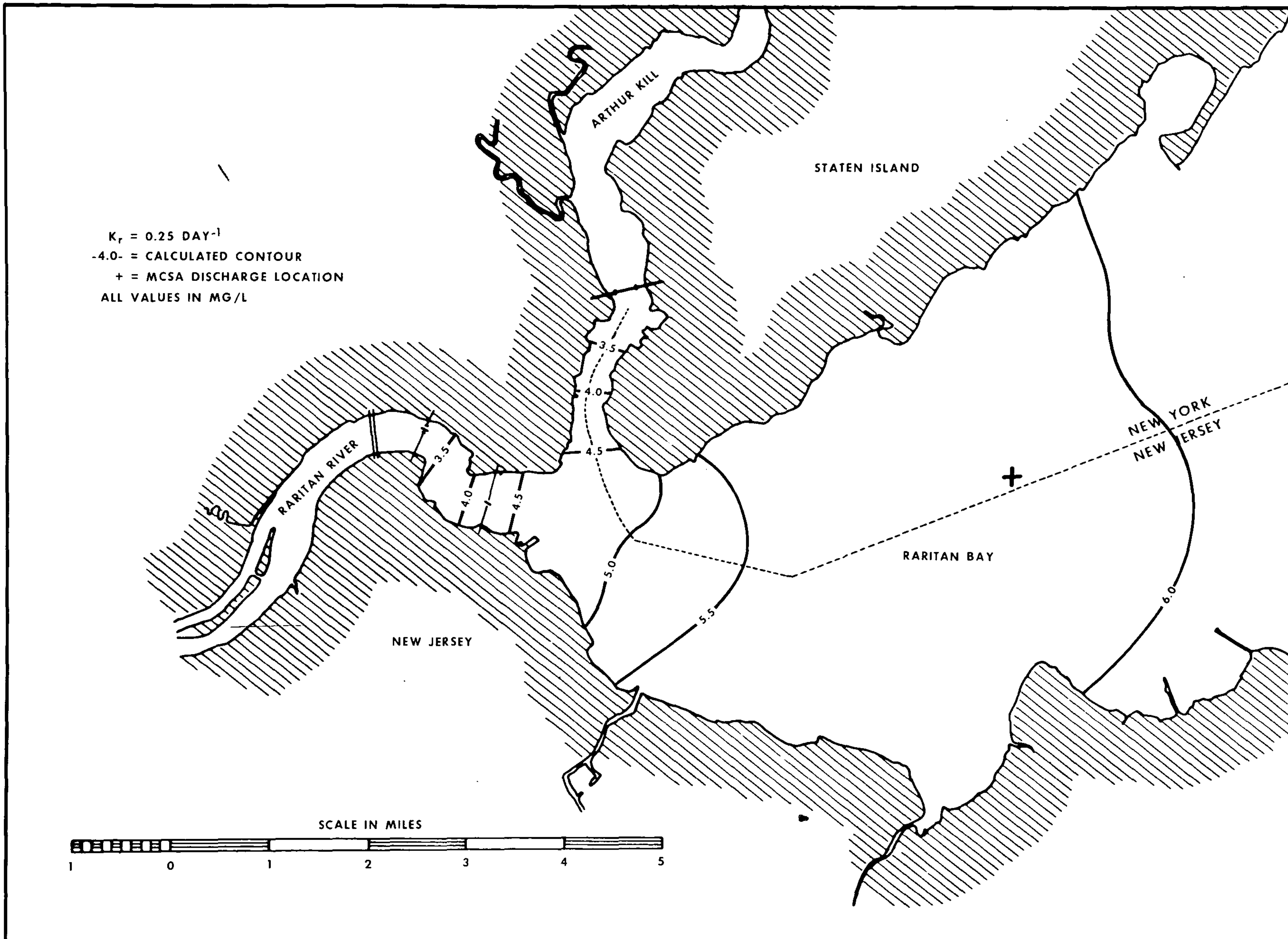
MCSA DISCHARGE OFF KEYPORT HARBOR

The specific wastewater discharges and system parameters used in the analysis of the relocation of the MCSA discharge to segment 46 (at the mouth of Keyport Harbor) are identical to those employed in the previous analysis for discharge at the present outfall site. The calculated DO profiles (Figure D-8) indicate a general abatement of the DO contraventions within the inner bay area when compared with the previous MCSA discharge analysis at the existing site. The results indicate a minimum DO of 3.26 mg/l in the Arthur Kill, as opposed to 3.01 mg/l in the same segment for the present site analysis. Both analyses indicate that contravention of the 4.0 mg/l and 5.0 mg/l minimum DO criteria will occur. However, relocation of the outfall to section 46 will allow greater dispersion of the MCSA discharge throughout the bay. This will lessen the severity of the effluent's impact on the oxygen resources of the more critical areas within the system.

MCSA DISCHARGE IN CENTRAL BAY AREA

The specific wastewater discharges and system parameters used in the analysis of the relocation of the MCSA discharge to segment 16 in the central bay area are identical to those employed in the analysis at the existing outfall site. The calculated DO distribution (Figure D-9) indicates that the discharge into the central bay area will abate the DO contraventions in that area and in the inner bay area. Discharge into the central bay area will also promote better DO distribution at the mouth of the Raritan River and at the southern terminus of the Arthur Kill.

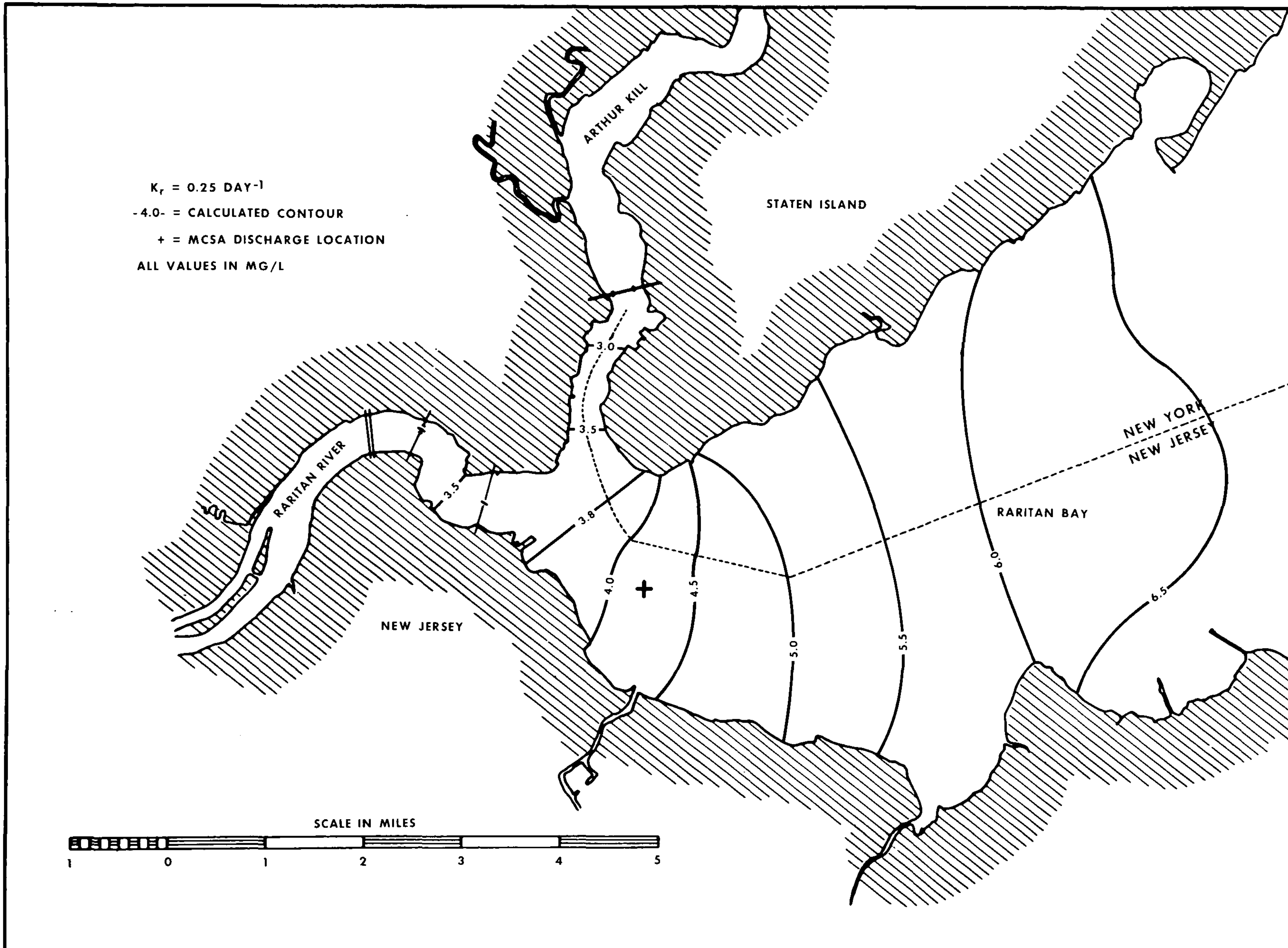
In summary, the analysis presented adequately simulates present water quality conditions and indicates the relatively disadvantageous nature of the head of the bay area as a discharge site. Investigations into alternate outfall sites also demonstrate that the impact of the MCSA discharge generally decreases as the discharge site is moved further out into the bay where it comes under the influence of the more predominant circulation patterns within the Raritan Bay system proper.



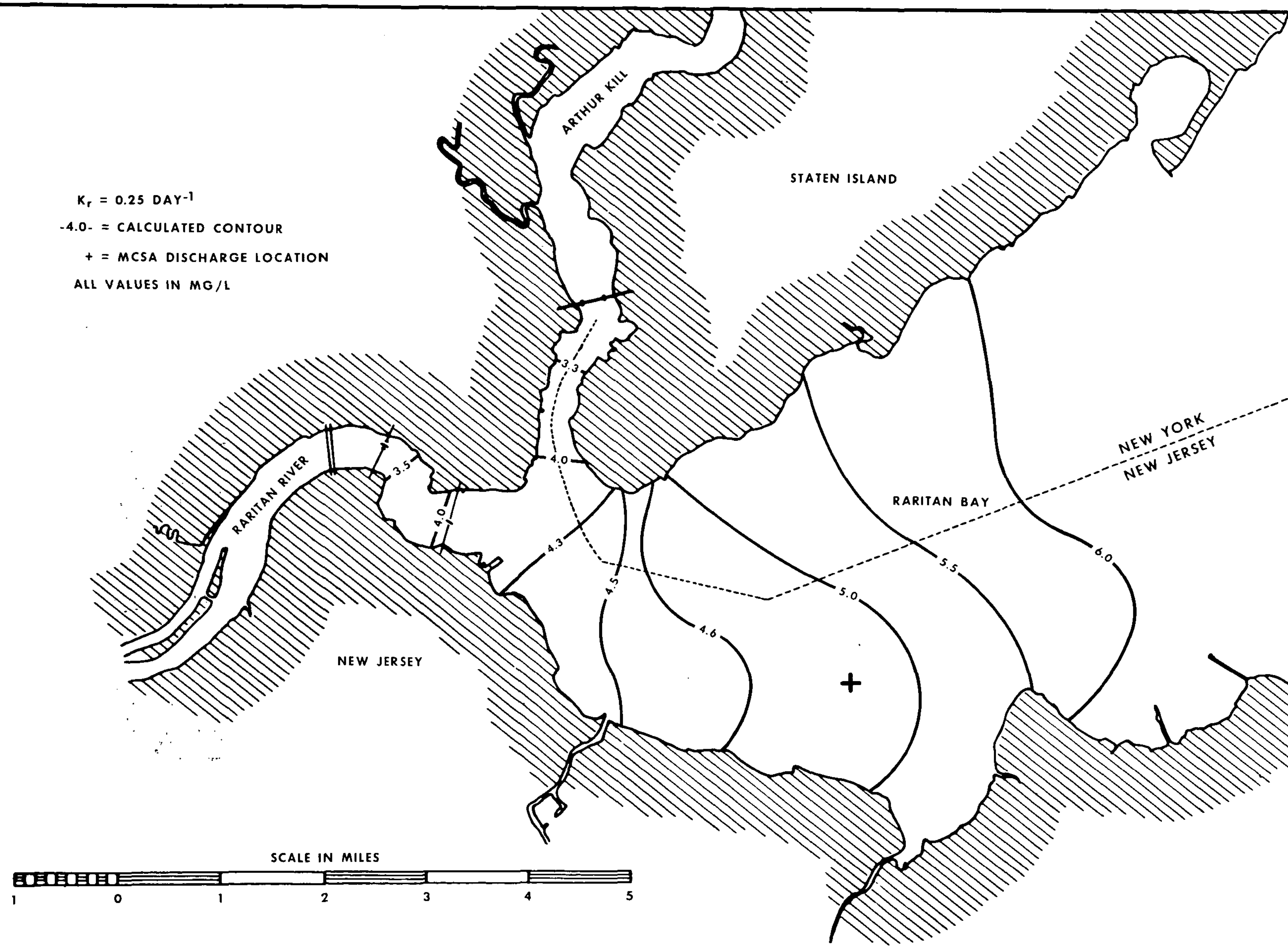
CALCULATED DISSOLVED OXYGEN DISTRIBUTION FOR MCSA DISCHARGE IN CENTRAL BAY AREA - YEAR 2020

Figure D-9

Figure D-7



CALCULATED DISSOLVED OXYGEN DISTRIBUTION FOR MCSA DISCHARGE AT PRESENT OUTFALL SITE - YEAR 2020



CALCULATED DISSOLVED OXYGEN DISTRIBUTION FOR MCSA DISCHARGE OFF KEYPORT HARBOR - YEAR 2020

Figure D-8