STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT

DIVISION OF WATER POLICY AND SUPPLY

SPECIAL REPORT 21
SOUTH RIVER TIDAL DAM PROJECT

Raritan River Basin Water Resources Development
Sayreville Area, Middlesex County
New Jersey
1965

STATE OF NEW JERSEY

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AND ECONOMIC DEVELOPMENT

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ROBERT A. ROE, COMMISSIONER

DIVISION OF WATER POLICY AND SUPPLY

George R. Shanklin, Chief Engineer and Acting Director

WATER POLICY AND SUPPLY COUNCIL

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LETTER OF TRANSMITTAL

Honorable Robert A. Roe, Commissioner
Department of Conservation and Economic Development

Dear Sir:

I am transmitting herewith a report on the feasibility and desirability of the South River Tidal Dam Project in the Sayreville area in Middlesex County, New Jersey, which has been prepared in accordance with the provisions of the Water Supply Act of 1958 for legislative approval of the acquisition of lands and riparian rights required therefor with State Water Development Bond funds authorized for such acquisition by said Act and its companion Water Bond Act, and for authorization of funds for the immediate construction of the project recommended herein by the State in accordance with the provisions of said Act for such State-owned and operated water storage facilities. The tidal dam and recharge pond recommended herein would protect the fresh-water aquifer in the Old Bridge member of the Raritan Formation, augment the natural yield therefrom by artificial recharge from the South River, and provide means for stabilizing the current salt-water encroachment in the underlying Farrington Sand member which threatens to destroy the current uncontaminated fresh-water portion of that aquifer.

Engineering Report of Charles J. Kupper, Consulting Engineer retained by the Division to conduct the detailed surveys, studies and investigations to evaluate the practicability and soundness of the project and to develop preliminary designs and firm estimates of construction costs is transmitted in Part II. Report on the cost of acquistion of the Site is given in Part III. The results of a digital computer aquifer model analysis, conducted by the Ground Water Branch, Water Resources Division, U. S. Geological Survey in cooperation with the Division of Water Policy and Supply, are presented in Part IV to assist in the evaluation of the feasibility and desirability of constructing this tidal dam and recharge pond and in estimating the resulting benefits in terms of degree of protection and/or increased water supply for the allocation of charges for the reimbursement of costs to the State.

The report is the first of the reports authorized by Section 4(d) of the Water Supply Act of 1958 for continued surveys, investigations and studies to evaluate the desirability, practicability and availability of storage reservoir sites essential for the optimum, economical utilization of the water resources of the Millstone - Raritan Basin, including sites for the protection and recharge of ground-water resources. It supplements the investigations and conclusions of Special Report 17 on "Salt-Water Encroachment into Aquifers of the Raritan Formation in the Sayreville Area, Middlesex County, New Jersey." The effects of certain legal, hydrologic and other unique factors which are inherent in projects of this nature on the determination of just, reasonable and equitable charges for reimbursement of costs are presented for consideration by the Legislature and local interests in the preparation of supplemental legislation required for the authorization of this project.

Honorable Robert A. Roe

The information presented is of vital interest and importance for the safe development and protection of adequate local water resources essential for the continued growth and prosperity of this metropolitan section of New Jersey. I therefore recommend that this report be published as a Special Report of the Division of Water Policy and Supply for distribution to the Legislature and local interests.

Respectfully submitted,

George R. Shanklin
Chief Engineer and
Acting Director

DIVISION REPORT
PART I
INTRODUCTION

Objectives and Scope of Report

The objectives of this report are fourfold:

1. To provide in accordance with the provisions of the Water Supply Act of 1958 (R. S. 58:22), justification on the need for and feasibility of the South River Tidal Dam and Recharge Pond recommended herein for legislative approval of the acquisition of lands and riparian rights required therefor with State Water Development Bond funds authorized for such acquisition on the Millstone-Raritan watersheds by said Act and its companion Water Bond Act, and for authorization of funds at the earliest date possible for construction thereof by the State in accordance with the provisions of said Act for such State-owned and operated water storage facilities.

2. To present for approval of the project prior to completion of detailed construction drawings and specifications, the results of the hydrologic, geologic and soils investigations conducted in support of the feasibility of the project and for the preparation of sound, preliminary engineering designs to define the extent of land acquisition required for the optimum development of benefits.

3. To establish firm estimates of costs for construction of the project recommended herein and for acquisition of the lands and riparian rights required therefor, based on sound engineering investigations and designs and on actual field surveys showing the displacements and dislocations involved.

4. To estimate, so far as is practicable, the extent and character of the benefits to be derived from the construction of the project herein recommended, for evaluation and allocation of the charges to be made for the protection of existing diversions from the Old Bridge and possibly Farrington aquifers of the Raritan Formation, and for the additional supply of water to be created by the recharge features of said project for reimbursement to the State in accordance with the provisions of Section 10 of the Water Supply Act of 1958 of all bond indebtness incurred by the State in the investigation, acquisition, design and construction of this project.

The report is presented in four parts:

Part I - Division Report on the need for and feasibility of the proposed South River Tidal Dam and Recharge Pond Project, submitting firm estimates of cost, conclusions and recommendations.

Part II - Engineering Report prepared by Charles J. Kupper, Consulting Engineer of New Market, New Jersey, under contract with the Department of Conservation and Economic Development, Division of Water Policy and Supply for the conduct of surveys and hydrologic, geologic and soils investigations and the preparation of sound engineering designs.

Part III - Division Report on an estimate of cost and the extent of land acquisition required for the project based on data and surveys furnished by Robert J. Baier, licensed land surveyor, under sub-contract with Charles J. Kupper.

Part IV - Report on a digital computer aquifer model analysis of the extent and character of the benefits to be derived from the construction of the tidal dam and recharge pond, prepared by the Division of

Water Policy and Supply in cooperation with the Ground Water Branch, Water Resources Division, U. S. Geological Survey.

Availability of Water Resources

Within the area of Middlesex County south of the Raritan River (Figure 11, Part II), local water resources are limited to the highly developed ground-water aquifers of the Raritan Formation, and to the surface waters of Lawrence Brook, South River and the Raritan Estuary.

Lawrence Brook with a tributary drainage area of 45.0 square miles above the Weston Mills Intake Dam has been developed by Farrington Lake for water supply by the City of New Brunswick for a dependable yield of 8.5 million gallons daily.

South River is the fourth largest tributary of the Raritan River Basin with a long-term, average annual runoff of 117 million gallons daily off a drainage area of 124.7 square miles at the site of the tidal dam recommended herein. The high potentials of this basin, however, are limited by the lack of natural reservoir sites for the impoundment and storage of flood runoff. Thus, the dependable use of the surface waters of the South River is limited to dry season flow approximating 10-20 million gallons daily, and for recharge ponds similar to that developed in 1938 by the Duhernal Water System and that recommended herein.

The Raritan Estuary is brackish below head of tide at the Fieldville Dam. Construction of a tidal dam in the vicinity of Crab Island would convert this brackish estuary into a fresh water pool for utilization of the 90-million gallon per day sustained minimum low flow to be maintained at the U. S. Geological Survey Bound Brook stream gaging station by releases from storage in the Spruce Run and Round Valley reservoirs.

The Old Bridge and Farrington Sand members of the Raritan Formation are the principal, currently developed sources of water supply for public and private use. The Old Bridge Sand member is estimated by the U. S. Geological Survey to have an average natural recharge rate of about 30 million gallons a day. It was estimated that in 1942 when an average of about 23 million gallons daily was pumped from this sand, the sand was developed to about its safe yield. Additional supplies could be developed if accompanied by adequate facilities to provide artificial recharge to the sand. The Farrington Sand member in the area south of the Raritan River is estimated by the U. S. Geological Survey to have an average natural recharge rate of about 9.7 million gallons daily. It was estimated that with the distribution of pumpage in 1942, the safe yield of this sand was between 2 and 4 million gallons daily. A study of the conditions in this area for the distribution of pumpage during the period from November 1951 to March 1952 suggests that the safe yield of the sand was about 5 million gallons daily. (See Special Reports 7, 8, and 17)

Studies made during the late 1930's indicated that pumpage from the Farrington Sand member has induced salt water into the sand from the estuaries of the Raritan River and Washington Canal. The advancement of salt water in the sand since that time has caused some of the industries near Parlin and South Amboy to practically abandon their well fields. Danger of continued advancement of the salt water in the aquifer limits the distribution and intensity of diversions from the aquifer in Middlesex County and adjoining areas in Monmouth County.

Because of the danger of salt-water intrusion into the other major aquifer in the Raritan Formation - the Old Bridge Sand member - from the South River and the Raritan Bay, it is believed that the pumpage from this sand cannot be increased above the present rate of about 30 million gallons daily unless such development is accompanied by facilities to increase the recharge to the sand. Calculations indicate that the rate of recharge to the sand could be increased by about 30 million gallons by the South River Tidal Dam and Recharge Pond recommended herein.

Outside sources available for delivery through transmission pipelines to the area of this report are the Delaware and Raritan Canal water or via that Canal, the augmented surface waters of the Raritan Basin from stream flow regulation reservoirs on its South and North Branch tributaries, and the ground-water resources of the Coastal Plain to the south of this area.

Historical Background

The Division of Water Policy and Supply and its predecessor, the State Water Policy Commission, have published since 1937, three special reports, Numbers 7, 8, and 17, on the ground-water resources of Middlesex County with particular reference to salt-water intrusion into the Farrington Sand member of the Raritan Formation.

The Old Bridge and Farrington Sands, both members of the Raritan Formation, are the principal sources of water supply in the southeastern portion of Middlesex County.

In 1891, the City of Perth Amboy established its Runyon pumping station to deliver surface water from Tennent Brook. In 1897, the first wells at this station were drilled to the Farrington Sand which then contained water under artesian head, so that it was not necessary to pump water from the wells. As additional wells were drilled, increased draft lowered the head of the water in the aquifer until it finally became necessary to pump from the wells. The high iron content of the Farrington Sand water caused the switch in 1902 to the first wells drawing from the Old Bridge Sand, which has since become the principal source of water for the City of Perth Amboy.

The City of New Brunswick obtained water from springs in 1801, but this was abandoned in 1867 when a supply of surface water from Lawrence Brook was developed.

Industrial water supplies from wells now account for a major part of the ground water used within this portion of Middlesex County. This heavy industrial development has occurred very largely within the last 30 years and almost entirely within the last 60 years.

This development of large ground water supplies has coincided with, and to a large extent has depended upon the development of efficient machinery for pumping water from deep wells and of improving methods for drilling wells.

The most rapid increase in the industrial use of ground water began in 1914 when demand for water for wartime industries was felt.

The largest industrial water supply is the Duhernal Water System, which is operated jointly by the E. I. du Pont de Nemours & Company, Hercules Powder Company and the National Lead Company to assure a satisfactory and permanent water supply for their factories in the Borough of Sayreville. This is an outstanding example of co-operation towards a common end by companies that are to a considerable extent competitive in other matters.

The du Pont factory was established at Parlin in 1904. Greatly increased activities during the first World War caused the withdrawal of perhaps 1 or 2 million gallons daily of water from the Farrington Sand.

Hercules Powder Company, located in Sayreville several years after the war, used water to the extent of almost doubling the draft from the Farrington Sand in a very short time.

The National Lead Company's plant was established in 1935. The studies of the Farrington Sand up to that time seemed to indicate that its safe yield would not be exceeded by the additional draft that this plant would require. Even at that time the danger of salt-water intrusion had not been recognized.

During 1935-1937 the draft upon the Farrington Sand was increased some 40% above previous draft. The pumpage at the three plants and at Perth Amboy Water Works caused the water levels to be drawn down to such an extent that some concern was felt about the permanency of the supply. Data collected in connection with a study (Special Report 7) indicated that there might be danger of salt-water intrusion from the vicinity of the Washington Canal.

Faced with this serious condition, the above mentioned Duhernal Water System was developed in 1939 by the construction of a dam and re-charge pond on South River and wells adjacent thereto in the Old Bridge Sand. For the purpose of conserving water, both of these new wells to the Old Bridge Sand and the old wells of the three companies are operated, under one management, in such a manner as to maintain a low rate of with-drawal from the Farrington Sand to retard the advancement of salt water in that sand.

Subsequent investigation (Special Report 8, 1943) showed that the salt-water intrusion from the Washington Canal was well advanced, and indicated that there was imminent danger of the destruction of some of the water supplies unless the rate of pumping could be reduced substantially. By 1942, water from the Canal had advanced about 2 miles inland in the area between the Washington Canal, the South River and the well field at Parlin. (Figure 12, page 113, Special Report 8) This report also pointed out that the Old Bridge Sand member had been developed to about its safe yield.

In recognition of the need for additional regulations to control ground water diversions in areas where overdevelopment is prevalent or appears imminent, a private ground water diversion law was enacted in 1947. This law, Chapter 375, P.L. 1947 as amended (R.S. 58:4A-1 to 3), authorizes the New Jersey Department of Conservation and Economic Development, through the Water Policy and Supply Council of its Division of Water Policy and Supply to regulate the new diversion of subsurface and percolating waters of the State, in delineated areas, for private, industrial and other uses of water in excess of 100,000 gallons daily. This legislation of necessity recognizes the diversion from sources in use at the time of the delineation as must also the Public Potable Water Supply Diversion Law, (R. S. 58:1) prior to the enactment of that regulatory legislation in 1910. Sayreville and adjacent areas were delineated under R. S. 58:4A-1 to 3 on October 6, 1947.

The latest ground water investigation of the Sayreville area (Special Report 17) was undertaken as soon as funds were available in 1958 to determine (1) the advance of salt-water encroachment into the Farrington and Old Bridge Sand members of the Raritan Formation since the previous report in 1943, and (2) to determine the most feasible remedial measure to restrict the movement of salt water in the Farrington Sand member and to protect the Old Bridge Sand member from salt-water contamination.

Widespread salt-water encroachment in the Farrington Sand member has caused numerous wells to be abandoned in the Parlin area. These wells had produced some 8 mgd of industrial water supply. The greatest recent advance has been in the area south of Parlin even though total diversion in this area has been reduced from its peak rates of 9.7 ± mgd in 1936 and 8.7 ± mgd in 1947 to 4.8 ± mgd in 1962. If not restricted, the salt water intrusion threatens to render a considerable additional part of this aquifer unfit for use in the area south of Parlin.

There is no widespread salt-water encroachment problem in the Old Bridge Sand member. However, salt water from South River and the Raritan Bay could enter this sand if the fresh water level in this sand is lowered significantly near these places by pumpage. There is a slight advance of water from Deep Run, a tributary of South River, in the area of this report which has limited the intensity and distribution of pumping by the threat of further salt-water encroachment.

Remedial measures to restrict the movement of salt water in the Farrington Sand member are discussed in the 1962 Special Report 17. Protection of the Old Bridge Sand member from salt-water encroachment may be achieved by the construction of a tidal dam on the South River downstream from the intake area of said Sand. Special Report 17 discusses the potential benefits of such a dam.

<u>Previous Reports</u>

1937 - Special Report 7, Water Supplies from the No. 1 Sand in the Vicinity of Parlin, New Jersey.

1943 - Special Report 8, The Ground-Water Supplies of Middlesex County, New Jersey.

1958 - Report to the Borough of Sayreville by Charles J. Kupper, Consulting Engineer on the Engineering Study of a Proposed South River Tidal Dam.

1962 - Special Report 17, Salt-Water Encroachment into Aquifers of the Raritan Formation in the Sayreville Area, Middlesex County, New Jersey with a Section on a Proposed Tidal Dam on the South River.

Ground Water Diversion

The following published data from Special Reports 8 and 17, updated to 1962, on estimated average annual pumpage from the Farrington and Old Bridge Sand members of the Raritan Formation for public water supply and private industrial use are reproduced in Tables 1, 2, and 3 for ease in reference and analysis.

Also presented in Tables 4 and 5 are summaries of the "grandfather" diversion rights of record and of the maximum monthly average diversions authorized by approvals of the Water Policy and Supply Council and its predecessors from the Farrington and Old Bridge Sand members in the area south of the Raritan River.

A summary comparison for the calendar year 1962 of the total authorized diversion and the actual annual pumpage from the Farrington and Old Bridge Sand members of the Raritan Formation is given in the following table:

1962	FARRINGTON	OLD BRIDGE
Authorized Diversion:		
By W.P.&S. Council and predecessors	29.086 MGD	20.183 MGD
"Grandfather" Right	25.650	32.215
Total	54.736 MGD	52.398 MGD
Pumpage of Record *	8.981 MGD	29.717 MGD
Estimated Pumpage **	1.000	0.350
Total	9.981 MGD	30.067 MGD

* Includes reported diversion from "grandfather" right sources.

** Estimated pumpage from unreported "grandfather" right sources, estimated at grandfather rights in MGD x 0.33 x 120 divided by 365.

The natural recharge rates for the Farrington and Old Bridge Sands have been estimated by the U. S. Geological Survey in Special Reports 8 and 17.

For the areas covered by the preceding table, these estimates approximate:

Farrington Sand - 9.70 MGD

Old Bridge Sand - 30$\pm$ MGD

TABLE 1

AVERAGE PUMPAGE

OLD BRIDGE SAND

(Thousands of gallons per day)

References - 1917-1942 Table 5, Page 70, Special Report 8.
1943-1958 Table 2, Page 11, Special Report 17.
1959-1962 Compiled by Division from pumpage records for supplies in the Sayreville area.

Year	Public Supply	Industrial Supply	Total
1917	9,600	30	9,630
1918	10,740	30	10,770
1919	9,630	30	9,660
1920	9,930	30	9,960
1921	8,210	30	8,240
1922	9,060	80	9,140
1923	9,490	80	9,570
1924	8,240	80	8,320
1925	8,500	80	8,580
1926	8,270	80	8,350
1927	6,690	80	6,770
1928	6,910	80	6,990
1929	7,200	80	7,280
1930	6,470	80	6,550
1931	5,560	150	5,710
1932	4,920	360	5,280
1933	5,710	450	6,160
1934	6,580	470	7,050
1935	7,220	450	7,670
1936	6,860	450	7,310
1937	7,400	590	7,990
1938	7,200	1,650	8,850
1939	7,340	2,610	9,950
1940	7,370	6,350	13,720
1941	8,160	10,870	19,030
1942	7,630	15,430	23,060

TABLE 1 Continued

Year	Public Supply	Industrial Supply	Total
1943	8,486	14,160	22,646
1944	8,273	12,852	21,125
1945	8,450	12,282	20,732
1946	8,862	11,987	20,849
1947	8,462	10,640	19,102
1948	8,676	11,729	20,405
1949	7,942	13,397	21,339
1950	7,521	14,078	21,599
1951	8,312	15,333	23,645
1952	8,792	14,650	23,442
1953	10,079	15,628	25,707
1954	10,182	16,813	26,995
1955	7,919	15,233	23,152
1956	8,509	14,607	23,116
1957	9,010	14,398	23,408
1958	9,636	14,832	24,468
1959	12,450	16,625	29,075
1960	12,350	17,500	29,850
1961	10,979	19,125	30,104
1962	11,268	18,449	29,717

NOTE: Industrial pumpage 1919-1942, inclusive, partly estimated.

TABLE 2
AVERAGE PUMPAGE 1929-1942
FARRINGTON SAND

(Thousands of gallons per day)
Reference - Table 8, Page 108, Special Report 8. Includes Pumpage north of Raritan River.

Year	North of Raritan River	Duhernal Companies	Perth Amboy Water Dept.	Other Pumpage South of Raritan River	Total
1929	2,080	6,202	92	203	8,577
1930	1,970	5,964	877	309	9,120
1931	1,583	5,053	1,173	342	8,151
1932	1,240	4,352	1,198	398	7,188
1933	1,221	5,442	187	377	7,227
1934	1,315	6,570	135	369	8,389
1935	1,331	8,129	585	407	10,452
1936	1,879	9,094	655	408	12,036
1937	2,066	8,434	650	404	11,554
1938	1,874	5,495	0	408	7,777
1939	1,895	6,358	546	424	9,223
1940	1,975	4,785	301	402	7,463
1941	1,922	4,898	772	996	8,588
1942	1,875	4,015	620	556	7,066

TABLE 3
AVERAGE PUMPAGE
FARRINGTON SAND
(Thousands of gallons per day)

Reference: 1943-1958-Table 3, Page 13, Special Report 13
1959-1962-Compiled by Division from pumpage records for supplies in the Sayreville area.

From Table 3, Page 13, Special Report 17

Municipality	Use of Water	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
East Brunswick Township	Ind.	53	154	159	112	379	210	14	12	16	17
	P.S.	-	-	-	-	-	-	-	-	-	298
Madison Twp.	Ind.	-	-	730	2,382	3,743	3,509	2,087	2,960	2,718	2,974
	P.S.	679	1,402	964	804	1,574	1,875	2,178	1,799	1,807	1,485
Monroe Twp.	Ind.	30	30	30	30	30	30	30	30	30	30
	P.S.	123	136	127	141	198	213	191	168	186	184
Sayreville Borough	Ind.	3,304	2,748	2,731	2,765	2,815	1,619	306	286	133	143
	P.S. *	-	-	-	-	252	565	455	414	512	534
City of South Amboy	Ind.	224	224	224	224	224	224	224	224	224	224
	P.S.	-	-	-	-	-	-	-	-	-	-
South River Borough	Ind.	255	255	255	255	255	255	255	255	30	30
	P.S.	246	249	242	285	298	301	315	314	314	330
Spotswood Borough	Ind.	165	38	44	650	1,470	1,700	1,168	1,013	1,018	1,314
	P.S.	-	-	-	-	-	-	-	-	-	-
Total Industrial		4,031	3,449	4,173	6,418	8,916	7,547	4,084	4,780	4,169	4,732
Total Public Supply		1,048	1,787	1,333	1,230	2,322	2,954	3,139	2,695	2,819	2,831
Grand Total		5,079	5,236	5,506	7,648	11,238	10,501	7,223	7,475	6,988	7,563

* Wells belong to City of South Amboy

TABLE 3 (Continued)
AVERAGE PUMPAGE
FARRINGTON SAND
(Thousands of gallons per day)

Municipality	Use of Water	From Table 3, Page 13, Special Report 17 1953	1954	1955	1956	1957	1958	From Records of Division 1959	1960	1961	1962
East Brunswick Township	Ind.	-	9	59	119	301	114	133	179	239	413
	P.S.	380	460	575	640	901	947	1,200	1,197	1,085	1,216
Madison Twp.	Ind.	3,098	1,984	2,719	2,719	2,257	811	1,115	877	1,403	645
	P.S.	1,969	2,636	2,871	2,668	2,646	2,464	2,568	2,596	2,743	2,789
Monroe Twp.	Ind.	30	30	30	30	30	30	30	30	30	30
	P.S.	162	159	207	154	148	164	192	155	176	120
Sayreville Borough	Ind.	170	170	180	188	167	115	252	262	289	147
	P.S. *	508	441	407	368	408	400	318	334	309	300
City of South Amboy	Ind.	285	309	309	309	309	309	320	320	320	320
	P.S.	-	-	-	-	-	-	-	-	-	-
South River Borough	Ind.	30	30	30	30	30	30	30	30	30	30
	P.S.	361	505	531	465	489	435	730	740	796	902
Spotswood Borough	Ind.	1,796	1,904	1,801	1,536	2,082	1,971	2,630	2,063	2,057	2,069
	P.S.	-	-	-	-	-	-	-	-	-	-
Total Industrial		5,409	4,432	5,128	4,391	5,176	3,380	3,910	3,761	4,368	3,654
Total Public Supply		3,380	4,201	4,591	4,295	4,592	4,410	5,008	5,022	5,109	5,327
Grand Total		8,789	8,633	9,719	8,686	9,768	7,790	8,918	8,783	9,477	8,981

* Wells belong to City of South Amboy

TABLE 4

1962 AUTHORIZED AND GRANDFATHER DIVERSION RIGHTS FROM THE FARRINGTON SANDS SOUTH OF THE RARITAN RIVER

Appn. No.	Affidavit No.	Name	Diversion - MGD Authorized	Diversion - MGD Grandfather
	A28-2	Anheuser Busch Co.		0.778
P-53	A28-3	P. J. Schweitzer, Inc.	(1.000)	3.460
	A28-4	Sunshine Laundry		0.070
	A28-5	Hercules Powder Co.		7.488
	A28-6	Thomas & Chadwick		0.215
	A28-10	Milltown Industrial Sites		0.288
	A28-14	W R & C W Dey		0.865
	A28-15	Mustepha Ahmed		0.865
	A28-16	Charles H. Holster, Jr.		0.710
	A28-18	United Cork Co.		0.288
	A28-19	Phelps Dodge Copper Co.		0.864
P-2		Joseph Guerriero	0.360	
	A28-1	Duhernal Water System		4.610
P-16		John Konuk	0.120	
P-48		Charles Bonkoski	0.500	
P-69		Edward Collins	0.100	
P-80		Marvin Hulick	0.360	
P-84		Arthur Perrine	0.300	
P-124		Lawrence J. Smith	0.400	
P-184		Great Bay Chemical Co.	0.576	
		Cranbury Township		0.149
731		South River Borough	1.000	
996		East Brunswick Township	1.500	
		N. J. State Home for Boys	1.080	
1119		Madison Water Company	0.700	
1002		South Brunswick Municipal Utilities Authority	0.800	
1077		Forsgate Water Co.	4.500	
727		National Lead Co.	5.000	
876		Midtown Water Co.	1.250	
102		Perth Amboy City	10.000	
	A29-1	E. I. duPont Co.		5.000
P-200		Forsgate Farms, Inc.	0.540	
			29.086	25.650

NOTE: Where authorized diversion is enclosed in brackets, total diversion is limited by "grandfather rights"

TABLE 5

1962 AUTHORIZED AND GRANDFATHER DIVERSION RIGHTS
FROM THE OLD BRIDGE SANDS
SOUTH OF THE RARITAN RIVER

Appn. No.	Affidavit No.	Name	Diversion - MGD Authorized	Grandfather
P-4 + P-13 + P-90	A28-1	Duhernal Water System	(10.622)	23.872
	A28-14	W R & C W Dey		0.086
	A28-15	Mustepha Ahmed		0.086
	A28-17	J. F. Abeel		0.144
	A29-1	E. I. duPont		0.800
	A29-2	H. H. Monteath		0.288
P-1		Anheuser Busch	0.795	
P-145	A28-3	P. J. Schweitzer	(2.160)	6.540
P-200		Forsgate Farms	0.540	
102		Perth Amboy City	10.000	
1015		Sayreville Borough	3.000	
887		Spotswood Borough	0.500	
	A28-7	George W. Helme Co.		0.111
270		Jamesburg Water Co.	0.288	
1048		Browntown Water Co.	1.000	
731		South River Borough	0.250	
894		Westbury Water Co.	0.060	
875		Midtown Water Co.	0.750	
605		South Amboy	3.000	
	A29-3	Armstrong Cork Co.		0.288
			20.183	32.215

NOTE: Where authorized diversion is enclosed in brackets, total diversion is limited by "grandfather rights"

The total "rights" in the Farrington Sand approximate six times the estimated natural recharge to that formation. These "rights" in large part consist (1) of "grandfather rights" developed prior to the enactment of State regulatory controls in the areas now contaminated by salt-water encroachment and (2) of authorized diversions by the Water Policy and Supply Council and its predecessors in the newly developing upland outcrop areas of that formation. As indicated by the 1962 pumpage of 9.98 mgd, the diversion from this formation has of necessity, by reason of the salt-water encroachment, been reduced to approximate the estimated natural recharge of 9.7 mgd but the question of the equitable distribution of diversion is yet to be resolved.

In the Old Bridge aquifer, the 1962 pumpage of 30.067 mgd adjusted for the Duhernal System pumpage of 6.9 mgd, still approximates the estimated natural recharge of that aquifer. The total "rights" as summarized in the preceding table includes total "rights" of 23.872 mgd for the Duhernal System from the Old Bridge Sand around its recharge pond on South River. While it is recognized that not all of this potential "right" of 23.872 mgd is available directly by artificial recharge from Duhernal Lake, the total "rights" for use of the Old Bridge Sand when reduced by that amount still approximates the estimated natural recharge of that formation.

This area is one of the most rapidly developing residential areas in the State. It is also a heavy developed industrial area which is supplied in the most part from privately developed and operated wells.

Both residential and industrial future development are currently handicapped by the potential lack of adequate undeveloped water resources required for continued expansion. Certain planning surveys indicate an increase of 12 mgd in water demand by 1975. Published data are available in reports of the Middlesex County Planning Board on water projections developed by its most competent Committee on Water.

The South River Tidal Dam and Recharge Pond recommended herein will provide the additional local water to meet future increase in demand, protect the existing use and "rights" from the Old Bridge Sand aquifer and provide, to some extent, for relief of the current pumpage from the Farrington Sand to curtail further advancement of the current salt-water encroachment face and to increase the availability of that aquifer for use in the more distant partially developed areas thereof.

On the basis of information developed to date, the following table is presented to evaluate the recharge which may be anticipated from the project recommended herein:

<u>Old Bridge Sand</u>

Estimated natural recharge protected by tidal dam	30 mgd
Estimated potential increase in the yield of Old Bridge Sand resulting from recharge pond	30 mgd
Estimated dependable surface water yield from recharge pond	*
Total potential supply available with tidal dam and recharge pond	60 mgd

Old Bridge Sand (Continued)

1962 pumpage from Old Bridge Sand adjusted for Duhernal Lake pumpage	28 mgd
Net increase from recharge of Old Bridge Sand	32 mgd
Probable required substitution of Old Bridge water for current pumpage in Farrington Sand to curtail salt-water encroachment in that aquifer	6 mgd
Net increase in total supply available for the area of study	26 mgd

NOTE * Surface water storage capacity in recharge pond must be utilized to maintain compensation release flow.

The Problem

The water supply problem in this area south of the Raritan River is twofold:

One is the protection of the current use of some 30 mgd from the Old Bridge Sand and the artificial recharge of that aquifer to meet future needs for water.

The other problem is the stabilization of the current salt-water front in the Farrington Sand and the reclamation of as much as is practicable of the current contaminated portion of that aquifer.

Due to the lack of action when this salt-water encroachment was first recognized and to the lack of authority on the part of the State at that time to compel such action, many of the original wells to the Farrington Sand aquifer have been destroyed. Continued withdrawal from wells to the Farrington Sand located in the near vicinity of the current salt-water front will eventually destroy those wells and, if this practice is continued, may eventually render a still larger portion of this aquifer unfit for use. Reduction of this diversion from the Farrington Sand in this area to stabilize the current salt-water encroachment front is essential. The quantity of water involved is estimated to approximate 5 to 6 mgd.

Such stabilization can be obtained from recharge of the aquifer as proposed by the Crab Island tidal dam or by reduction in present diversion and the substitution therefor of diversion from the Old Bridge Sand. If hydraulic continuity exists between the Old Bridge and Farrington Sand members of the Raritan Formation in this area as has been indicated in some areas, some protection of the Farrington Sand aquifer may be developed by the higher static ground-water level created in the Old Bridge Sand which overlies the Farrington aquifer, but the extent and magnitude of such recharge to the Farrington Sand cannot be confirmed until after the South River Tidal Dam Project has been completed and placed in operation for some years. It may also be possible to increase this recharge to the Farrington Sand by the construction of caisions in the two aquifers to increase this interchange of water.

In view of the small quantity of water involved and the expense and time required to remove the salt water from the currently contaminated portions of the Farrington Sand, the cheapest and most practical method for the protection of the uncontaminated portions of the Farrington Sand for the continued use in the outlying areas sufficiently distant from the current salt-water encroachment front to permit safe development of the maximum natural recharge of that aquifer in those areas, is the substitution of water from the increased yield of the Old Bridge Sand aquifer created by the South River Tidal Dam and Recharge Pond herein recommended for current and future diversions from the Farrington Sand in the immediate vicinity of the current salt-water encroachment front. Such procedure will necessitate the voluntary surrender of legal rights of certain interests to currently developed sources in the Farrington Sand - legal rights which are of no practical value when the sources involved become contaminated, but which must be equitably resolved through cooperative efforts of all parties interested in the use and protection of the fresh ground-water resources of both members of the Raritan Formation in the area of this report.

The first and more critical problem is the protection of the fresh ground-water resources of the Old Bridge Sand from salt water contamination. Failure to undertake the early construction of a tidal dam for protection of the Old Bridge Sand must result in the imposition of limitations on further diversion under the regulatory control features of R. S. 58:1 and Chapter 375, P. L. 1947 for regulatory control of ground-water diversions for public, potable and private use respectively.

With comparable recharge pond levels, the protection of the Old Bridge Sand may be accomplished by either the South River Tidal Dam recommended herein or the larger and more expensive Crab Island Tidal Dam Project which is advocated by certain local interests as being preferable because of its more widespread benefits. Except as stated previously through the interchange of water between aquifers, the water supply direct benefits from the South River Project would be limited to the Old Bridge Sand whereas such benefits from the Crab Island site would include the larger fresh water pool on the Raritan Estuary, and some limited direct protection and recharge to the Farrington Sand aquifer located upstream of the Crab Island site, subject to the reclamation first of the contaminated portions of that aquifer. However, there would be possible continued salt-water encroachment through gaps located downstream of that site in the diabase dike as discussed in more detail in Special Report 17.

If found to be economically feasible by studies currently being conducted by the U. S. Corps of Engineers, a Crab Island Dam may cost about $20,000,000. Preliminary cost estimate developed by this report for the tidal dam across South River, including recharge pond, is $4,700,000.

It is imperative that some action be taken at once to protect the Old Bridge Sand aquifer from salt-water intrusion. Of the various methods discussed previously, the positive approach recommended herein for the construction of the South River Tidal Dam and Recharge Pond Project is considered to be preferable to a negative approach involving the imposition of restrictions on future diversions and the attendant curtailment of continued development. By reason of its higher cost and its effect on other aspects of the use and development of the Raritan Estuary, the Crab Island Project must be justified on potential benefits other than water supply. Pending such determinations, the estimated $4,700,000 cost of the South River Project recommended herein is, and should be considered, as "interim insurance" to assure through artificial recharge the continued, uninterrupted development in the "area of influence" of this project and to protect by the tide barrier the current use and "rights" of diverters in said area, which, in all probability, would be jeopardized by continued unrestricted pumpage without this protection.

The above "area of influence" is considered here and in the rest of this report to be a semi-circular area with a radius of 5 miles with the center at the proposed dam site. Adjustments in degree of influence would be considered of the existing recharge ponds being used by the City of Perth Amboy and the Duhernal Water System.

NEW JERSEY WATER SUPPLY LAW OF 1958

State Water Program

The New Jersey Water Supply Law of 1958 and its companion Water Bond Act provide, at no cost to the taxpayer, a state-wide water program to supplement the regulatory control previously exercised by the State under Title 58, Chapter 1, Revised Statutes. The legislation directs the State to provide the initiative and foresight essential to the maximum conservation, protection and equitable allocation of its surface and subsurface water resources. It places with the Department of Conservation and Economic Development, through its Division of Water Policy and Supply, the authority and responsibility for the formulation and conduct of a three-fold State Water Program:

1. To insure through long-range planning, the availability of adequate future supplies of water in all parts of the State;
2. To assure through long-range, intensive investigations, the protection and the sound and orderly development of the State-wide ground-water resources; and
3. To provide, as and when authorized in the State's interest by specific legislation, the new water required to meet future demands by the design, construction and operation of storage facilities to augment natural water resources.

Surface Water Program

The basic principles and procedures established by this legislation for the development of the surface water program are as follows:

1. General authorization and funds are given the Division of Water Policy and Supply to conduct engineering studies, preliminary designs, surveys, investigations, and land appraisals as may be required to evaluate the desirability, practicability and availability of storage sites essential to the maximum, economical utilization of the water resources of the Millstone-Raritan Basin and other areas of the State.
2. Essential storage sites are to be acquired by the Department of Conservation and Economic Development or otherwise protected to insure availability for use when required, as and when specifically authorized in the State's interest by the Legislature after public hearing.
3. Storage sites are to be developed as and when specifically authorized by the Legislature after public hearing, subject to referendum approval of the bond issue required and authorized therefor.

In accordance with these procedures, the need for new sources of water in the interest of the State would be investigated and certified by the Water Policy and Supply Council after public hearings as required to evaluate the effect of the quantity of water to be developed on other interests.

Authorized Project

The principles and procedures established for the Spruce Run and Round Valley Reservoirs authorized by the Water Supply Act of 1958 and applicable to future authorized projects of similar nature may be summarized as follows:

1. Authorized Projects are:

(a) To be designed, constructed and operated by the Department through its Division of Water Policy and Supply;

(b) To be limited to the provision of storage facilities to augment natural water resources for treatment and delivery, as required, in facilities to be financed, constructed and operated by the users of the water developed;

(c) To provide water for sale so far as is practicable for all needs involved, and for low flow augmentation as specified by the legislation authorizing acquisition of the site involved;

(d) To provide storage for substantial increase in the minimum natural low flows to be sustained for recreation, sanitation, and other non-consumptive, riparian uses; and

(e) To permit public use of storage area for recreation, swimming, fishing and boating compatible with the primary use for the supply of water.

2. Each reservoir project shall be separately justified economically from the sale of water therefrom.

3. Total cost of development and operation for each project is to be borne by the users of the water developed thereby for sale.

4. All State funds previously authorized specifically for the acquisition and for detailed investigation of the merits of a storage site or facility shall be refunded to the State from the bond issue authorized and approved for the development of that site.

5. Each reservoir project is to be constructed when, and only when, assurances satisfactory to the Commissioner of Conservation and Economic Development have been obtained that the net revenue to be derived from sale of water to be developed by that reservoir is or will be adequate to reimburse the State for all bond indebtedness, including interest and other charges, incurred in the design, construction, acquisition, and investigations connected therewith.

6. Water is to be allocated, after public hearing by the Water Policy and Supply Council, for sale from the reservoir and stream channel downstream thereof in accordance with the laws, principles and procedures established for the just and equitable allocation of the natural undeveloped water resources of the State and in conformance with the principles and procedures established and recognized by common law applicable to the diversion and use of water in this State.

7. All water used for public potable purposes is to be treated by the purchaser in a manner satisfactory to the State Department of Health before use.

8. Water is to be sold on a contractual demand charge basis:

(a) At just, reasonable and equitable rates as established after public hearing by the Commissioner of Conservation and Economic Development for each project;

(b) In accordance with the recommendations of the Water Policy and Supply Council for the type of use involved; and

(c) To cover operating cost and provide the net revenue required, as discussed previously, to refund all development costs involved in that project.

9. Upon repayment of the principal, interest and other charges said charges for each project are to be adjusted to operating expenses for the water sold.

Application to Tidal Dam Projects

The State Water Program authorized by the Water Supply Act of 1958 offers an equitable and practical procedure for the protection and augmentation of the natural ground-water resources of the State. This program provides a positive approach for the solution of problems in the Coastal Plain area where fresh-water aquifers are endangered or are threatened to be endangered from salt-water intrusion, and where slightly brackish water aquifers can be economically reclaimed and converted into fresh-water aquifers. With minor modification of the reimbursement provisions of the Water Supply Act of 1958 to recognize the indeterminate factors involved in ground-water development when limited to the provision of storage facilities such as tidal dams and recharge ponds, the development features of the Surface Water Program are considered to be applicable to the ground-water resources of New Jersey to provide the storage and tidal dam facilities required for the artificial recharge of ground-water aquifers in areas of heavy pumpage to augment and protect the natural yield.

By limiting State participation to the development of water storage facilities, the State assumes only responsibility for the conservation of her natural ground-water resources to protect and increase, through the orderly development of tidal dams and/or recharge ponds, the availability of fresh, ground-water aquifers for the diversion and use by all interests at their expense. No competition is created thereby in the delivery and distribution of water to and in areas of demand or in the diversion of such water resources.

Complications, however, involving indeterminate hydrological questions which are difficult if not nigh impossible to resolve under strict legal procedures, and legal rights in developed and undeveloped sources are created in evaluating a sound, equitable, reasonable and just basis for the allocation or assessment of charges for reimbursement to the State of costs incurred by such developments. This problem is of particular importance in areas such as that to be served by the proposed South River Project where previous rights to developed sources in another aquifer must be voluntarily surrendered or condemned in order to equitably resolve the availability of fresh ground water for all interests in the area covered by this report.

The above complications would be partially resolved by extending the State participation in the construction and operation of storage facilities to include the construction and operation of wells and pumping facilities to utilize the increased yield developed by the recharge facility, in which event a definite quantity of water would be developed for sale for reimbursement to the State. This approach, however, would place the State in competition with local interests in the use of natural ground-water resources since any such diversion by wells around the recharge facility would affect to some degree the natural ground-water resources adjacent thereto. Such interference, if any, could be resolved through judicial procedures as provided by R. S. 58:1 and Chapter 375, P.L. 1947, wherein the Water Policy and Supply Council, through public hearings, would determine the quantity of water which could be diverted by the State-owned and operated wells without undue interference to adjoining interests.

Neither of these procedures, however, provide a practical solution for establishing charges or assessments for the reimbursement of the State for the costs of tidal dams constructed solely for the protection of fresh ground-water aquifers. For such conditions, the benefit would be limited to the currently developed sources, there being no additional water provided for the use on undeveloped lands.

The equitable resolutions of these questions are essential in order to comply with the basic concept of the 1958 State Water

Program for the development and protection of water resources at no cost to the State. In the realization that recommendations or suggestions relative to these questions would be most helpful in obtaining authorization for the development at State expense of the project herein recommended, these questions, admittedly most difficult, were referred when the engineering studies presented in Part II were initiated, to a local unofficial South River Tidal Dam Steering Committee, organized under the direction of the Middlesex County Planning Board from representatives of both public water supply and industrial interests. The Committee is to be thanked for its conscientious effort to resolve these questions but, unfortunately to date, no recommendations or suggestions are available for submission in this report to the Legislature to assist in the resolution of this matter. A proposed method for the reimbursement of costs for this project is submitted below for the consideration of the Legislature and local interests.

Cost Reimbursement

As a salt water-barrier only, the proposed South River Tidal Dam provides positive insurance against salt-water intrusion to the current authorized diversion and use of some 30 mgd from the Old Bridge Sand. After stripping the bed of the lake created by that dam, the artificial ground-water recharge potentials therefrom have been estimated to increase the amount of the natural safe use of the Old Bridge Sand by some 30 mgd. For the combined project recommended herein, the barrier dam would provide positive protection to both the current use and the anticipated increased yield in the "area of influence" indicated by the Digital Computer Analysis in Part IV.

The estimated unit cost per million gallons daily for the tidal barrier dam and appurtenant works required only for the protection of the current use and authorized diversions from the Old Bridge Sand will approximate $125,000. The corresponding unit cost for the complete tidal dam and recharge pond project recommended herein would be $67,000 per mgd, based on the anticipated total recharge of 60 mgd from the recharge pond.

On the basis of the water supply presently developed, 50 percent of the cost of the complete project could be allocated for reimbursement from demand charges to be made on either current water use from the Old Bridge Sand at the time of completion of the project, or authorized diversions from said aquifer at that time to recognize the positive benefits developed by this project. Since water use varies from year to year, it is recommended that authorized diversion be adopted as the basis for this allocation.

The balance of the cost is considered to be chargeable on some sound, equitable basis to the increased water supply developed by this project which would recognize the principal factors influencing such artificial recharge as developed by the digital computer aquifer model studies presented in Part IV of this report.

For the purpose of developing and presenting a reimbursement formula for the consideration of the Legislature and local interests, the 1962 water consumption has been used in Table 6 to evaluate the probable cost of this project to public and industrial water interests in the portion of the Old Bridge Sand aquifer considered to be benefited by this project. It is to be emphasized that the allocations developed by Table 6 are first approximations which will have to be refined if this method is found to be acceptable.

The letter "I" is used in Column 7 to designate the "insurance" payment against salt-water intrusion.

The letter "B" is used in Column 7 to designate the payment due to benefits of increased water level created by the recharge pond.

Values of "B" are developed from the digital computer analysis. A weighted figure is obtained by multiplying the change in water level (feet) by the discharge rate (mgd) used in the analysis. This product is then used for prorating the remaining 50 percent of the total project cost among interests considered to receive benefits from this increased recharge.

Column 11 shows the demand charge "P" in dollars for each allocation. This demand charge is the sum of the "I" and "B" values listed for each user of Old Bridge water.

The above formula recognizes currently developed sources but provides for no allocation of cost for benefits to undeveloped sources.

This deficiency could be adjusted by periodic recomputation of allocations as new sources are developed to the end that upon complete reimbursement of the cost of this project, each benefactor therefrom at that time will pay only its proportional share of the total cost.

The formula also fails to consider what charge, if any, is equitable to the users of water from the Farrington Sand which may be benefited by the increased static head in the Old Bridge Sand as discussed previously, particularly those which are to receive a substitute supply from increased yield in the Old Bridge Sand in order to curtail the salt-water advance in the Farrington Sand and those which benefit in areas distant from that salt-water encroachment face from the increase in the availability of water created by this substitution.

TABLE 6
PAYMENT OF COST FORMULA DEVELOPMENT
SOUTH RIVER TIDAL DAM

	No.on Map	Average Change Water Level * ft.	1962 Discharge rate per node MGD	(3) x (4)	% of (5)	(6) x 2000	1962 Use Total M.G.	% of (8)	(9) x 2000 I	(7) + (10) P
1	2	3	4	5	6	7	8	9	10	11
Geo.Helme Co.	115	0.10	.023	.0023	0.03	$ 600	8.568	0.12	$ 2,400	$ 3,000
Spotswood W.Co.	120	0	.220	0	0	0	98.444	1.35	27,000	27,000
P.J.Schweitzer	11	0.60	2.828	1.6968	15.50	310,000	1050.573	14.65	293,000	603,000
Anheuser Busch	114	2.70	.761	2.0558	18.85	377,000	296.016	4.22	84,400	461,400
Duhernal System	100	0.34xx	4.670#	1.5900	14.52	290,400	1700.000#	23.70	474,000	764,400
Perth Amboy W.W.	1	5.70xxx	.910##	5.1800	47.30	946,000	2798.512	39.00	780,000	1726,000
Sayreville Boro	29	0.20	1.824	0.3650	3.34	66,800	656.666	9.12	182,400	249,200
J. Monteath Co.		0	.020	0		0	5.606	0.08	1,600	1,600
Browntown W.Co.	41	0.10	.504	0.0504	0.46	9,200	184.315	2.56	51,200	60,400
South Amboy	6	0	.953	0		0	366.256	5.10	102,000	102,000
Westbury W. Co.		0	.0154	0		0	5.606	0.08	1,600	1,600
Sayrewood Shopping Center		0	(1.00)	0		0	1.250	0.02	400	400
	TOTALS			10.9403	100.00	2000,000	7172.000	100.00	2000,000	4000,000

NOTES
1. Columns 2,3 and 4 from Digital Analysis for wells considered to be located in "area of influence."
* Average change in water level at node or nodes used in Digital Computer Analysis.
xx Average of 3 nodes used in Digital Computer Analysis to represent well field.
xxx Average of 8 nodes used in Digital Computer Analysis to represent well field.
Two-thirds of total use assumed derived as artificial recharge from Duhernal Lake.
Seven-eighths of total use assumed derived as artificial recharge from Tennent Pond.

SOUTH RIVER TIDAL DAM PROJECT

The State, through the Department of Conservation and Economic Development, Division of Water Policy and Supply, in a companion program authorized by the Water Supply and Water Bond Acts of 1958 of detailed geological and hydrological studies and ground water investigations throughout the State finds that there is urgent need for the development of water storage facilities on South River of the Raritan Watershed for the conservation, protection and development of the ground water resources of the Sayreville and adjacent areas of Middlesex and Monmouth Counties through the provision of storage and tidal dam facilities for artificial recharge of ground-water aquifers in areas of heavy pumpage and for the protection of such areas from surface water pollution and salt-water encroachment. This need was set forth in the report "Salt-Water Encroachment into Aquifers of the Raritan Formation in the Sayreville Area, Middlesex County, New Jersey, with a section on a proposed tidal dam on the South River." (Special Report 17).

The proposed tidal dam on South River would provide stream flow regulation storage and fresh water for recharging the Raritan aquifers and for protection against the damage of salt-water intrusion.

Accordingly, there being a need for a sound engineering design and a firm estimate of cost for the proposed South River Tidal Dam project, a contract was entered into, under the authority of Section 4 (d) of the Water Supply Act of 1958, between the State of New Jersey, acting through the Director, Division of Purchase and Property, in the Department of the

Treasury, for and on behalf of the Department of Conservation and Economic Development, Division of Water Policy and Supply, and Charles J. Kupper, Consulting Engineer of New Market, New Jersey, on November 30, 1962 for that purpose.

The engineering designs and cost estimates developed under that contract and presented in Part II of this report have been reviewed and accepted by the Division for recommendation of the authorization of funds for the acquisition of the lands and riparian rights required for this project and for the construction thereof with the exception of the method recommended for stripping the recharge pond area, which will be investigated further before final decision is made as to that feature of this project. It is not considered that modification of that feature of the recommended design will materially affect the costs.

The Dam and Spillway

The purpose of a tidal barrier dam is twofold: To prevent (1) underground flow and (2) surface flow of tidal salt water which may enter exposed outcrop areas of a fresh-water aquifer within the stream channel and thereby create salt-water contamination when pumpage from such aquifer induces water from the channel into the aquifer.

Prevention of underground flow of salt water is achieved by construction of clay core of the earth fill embankment sections and the concrete base of the spillway section through the Old Bridge Sand down to and into the impervious Woodbridge Clay Strata. Prevention of underground flow around the ends of the barrier dam is obtained by location of the barrier dam in sites where suitable outcrops of impervious clay strata are available for tying the clay core of the dam into such impervious strata at reasonable costs. Criteria for surface tidal backwater should be based on a safe height of the dam embankment and spillway section to obviate the possibility of overtopping by extreme high tides.

The recommended barrier dam is a rolled earth fill embankment with an impervious core located on the South River about 1600 feet downstream from the confluence of Tennent Brook and the river.

The site was selected after extensive geologic investigation, borings and soil sampling made of three probable locations. The site selected is the shallowest in reference to depth to the Woodbridge Clay Strata, being on the fringe of the outcrop of the Old Bridge Sands, and provides for suitable outcrops of the Woodbridge Clay Strata adjacent to the ends of the dam. This foundation will provide, with the impervious clay core, a satisfactory salt-water barrier to prevent intrusion into the Old Bridge aquifer by tidal movement upstream in the South River.

The concrete - Bascule gated spillway is located on the west embankment of the South River at an angle of 65 degrees to the centerline of the dam and will be constructed on the same foundation material, providing a positive cutoff. The site selected coincides with one of two South River stream crossings being planned by the Middlesex County Planning Board. The dam embankments will require widening and a bridge abutment and pier would have to be constructed if and when a stream crossing is made. No increase in the cost of the tidal barrier dam has resulted from this consideration.

The above clay core will prevent underground movement of salt water flow under and around the ends of the barrier dam. Satisfactory protection against overtopping by extreme high tides is achieved by the top of dam design elevation of 12.0 feet above mean sea level, which corresponds to a high tide elevation which may be expected to be equalled or exceeded, on the average, once in 200 years.

The 200-foot spillway with a 5-foot high Bascule gate is adequate when gate is lowered to elevation 3.75 feet, to pass a corresponding estimated 50-year design flood of 5240 cubic feet per second.

The gate at full height elevation of 8.75 feet is adequate to stop a high tide of 25-year frequency. The property taking line at contour elevation 9.0 provides for satisfactory operation of the Bascule gate against a high tide backwater with an estimated frequency of 35 years. Should the fresh water lake be flooded with brackish water, the lake could be emptied, flushing out the saline water.

<u>Recharge Pond</u>

The 350-acre pond created by the construction of this dam is located in a portion of the outcrop area of the Old Bridge Sand where the head of 7.50 feet above mean sea level created by the impoundment will provide potential artificial recharge to that aquifer estimated to approximate 30 mgd after stripping of the impounded area of silt, mud and other impervious material to expose said sands.

The furrowing procedure recommended by the Consulting Engineer for exposing the Old Bridge Sand within the impoundment area is subject to further investigation before final designs are completed. While that procedure would reduce the need for and the initial cost of removal of unsatisfactory material from the recharge areas of the pond, slumpage of the unstable and somewhat fluid material left in the bed of the pond adjacent to the furrows may eventually re-seal the exposure of Old Bridge Sand in the troughs created by this method and thereby reduce materially the initial recharge capacity.

Road and Utility Relocations

In order to maintain existing roads that are below elevation 9.0 feet and within the inundated area, approximately 13,500 feet of roads will have to be raised. They are about equally divided as to type, or class, of roads.

Two bridges require raising.

One gas line will require additional anchorage, another will be raised in conjunction with a roadway.

Islands or peninsulas will be constructed around or to utility poles, to elevation 12.

Storm sewers and culverts will have to be installed, relocated, or altered to accommodate the new conditions created by the inundation of the reservoir area. A 100-foot wide berm will be constructed along the South River interceptor sewer for inspection and maintenance thereof and all manholes and siphon chambers are to be raised to elevation 12.

Effect on Navigation

At the present time, there are two riparian grants being used that will be affected by the proposed South River Tidal Dam. They are grants of two tracts to the South River Sand Co., September 1, 1963, Liber U-1, page 321. Rate per foot $2.00. Amount $1,082.00. Their location, with grants not now in effect, are shown on Plates 18 and 19.

Compensation Flow Releases

A compensating flow release of 15 mgd (23.4 cubic feet per second) would be required, based on 125,000 gallons per day per square mile drainage area at the tidal dam.

During periods of low flow, however, that quantity of water, 15 mgd., must be made available for recharge to the Old Bridge aquifer in order to meet the secondary purpose of the project; namely, recharge to the Old Bridge aquifer.

Stream flow records at the Duhernal gaging station show that for a 20-year period the flow of 23.4 cfs (15 mgd) occurred 95% of the time, 46.8 cfs (30 mgd) occurred 83% of the time, and 70.2 cfs (45 mgd) occurred 67% of the time, indicating that the 23.4 cfs quantity representing release flow requirement would occur naturally, on the average, on every day of the year except for a maximum of 18 days.

The release of compensation flows during the above mentioned periods would be wasted to the ocean and be of no benefit. The river should be considered to be part of the estuary of Raritan Bay, subject to tidal flow, obviating this requirement.

In any case, the quantity of water passing through the trunk sewer paralleling the South River passing the proposed dam site should be credited to any such compensating release flow requirement.

Recreational Use

The 350-acre pond should lend itself very well to limited recreational development without undue interference with the aquifer recharge process. Due to the recharge objective of the project, normal water level in the impoundment will be maintained at elevation 7.50 by the controlled Bascule gate on the spillway. However, storage level may be drawn down below that elevation should compensation flow releases be required, which would affect recreational activities during sustained low stream flows.

Total Cost Estimate

The estimate of cost for the complete project, as presented below, is limited for reasons previously discussed to the cost for the development of the water storage facilities (i.e., tidal barrier dam, recharge pond and appurtenant work) recommended by the preliminary design presented in Part II of this report. These costs represent the extent to which it is considered that the State may participate in the State Water Programs authorized by the Water Supply Act of 1958 for reimbursement of total bond indebtness incurred in any project from sale of water developed by that project. They do not include the costs for the construction of wells and pumping facilities, delivery mains, etc. to develop or utilize the recharge potentials of this project, which are considered to be costs to be financed by the users of the recharge developed.

The cost estimate is based on the detailed construction cost estimates developed by the Consulting Engineer as presented in Part II of this report, adjusted for reasonable assumptions as to construction and cost increase contingencies, cost of engineering and supervision of construction, interest rates and dates of beginning and completing of construction. Land acquisition cost estimates are given in more detail in Part III. Actual costs, which depend upon prices prevailing at the date of acquisition and construction, may be increased in the event of unanticipated delay in the authorization of this project.

Summary of Costs

Item	Cost Based on 1962 Prices
Basic Construction Cost:	
Dam, Spillway and Bascule Gate	$1,901,000
Relocation of roads and utilities	281,000
Alteration of bridges	46,000
Alteration of storm and other sewers	508,000
Dikes and fills around pond	253,000
Total Cost - Barrier Dam	$2,989,000
Cost of stripping pond bed for ground-water recharge	$ 266,000
Total Basic Construction Cost	$3,255,000
Cost and construction contingencies	$ 255,000
Total Construction Cost	$3,510,000
Real estate and riparian rights	$ 600,000
Tax lieu payments during construction	92,000
Engineering, legal and administration - 10%	351,000
Interest during construction	141,000
Total Cost	$4,694,000
Say	$4,700,000

CONCLUSIONS

In the light of the need for the tidal dam on the South River as herein developed and in summary of the hydrologic and geologic investigations presented in Part II of this report, it is concluded that:

1. The South River Tidal Dam provides protection of the Old Bridge aquifer against an irreparable loss by salt-water intrusion.

2. By adequate stripping off the muck and impervious silt from the permeable Old Bridge Sand, more effective recharge to same may be achieved which would provide some 30 million gallons per day additional yield to the aquifer.

3. The reservoir created provides for limited use for recreation facilities.

4. Foundation conditions are satisfactory for the construction of an earth fill dam and concrete spillway.

5. Satisfactory material is available in close proximity of the dam site for proper construction of the earth fill dam with an impervious core.

6. The use of a 5-foot Bascule gated spillway provides for adequate capacity for the discharge of flood water, adequate protection against extreme high tides and great flexibility of operation.

RECOMMENDATIONS

1. It is recommended that the South River Tidal Dam and Recharge Pond be constructed as soon as possible after the final design and construction drawings and specifications are filed from Charles J. Kupper, Consulting Engineer, as Phase II of contract with the State for the following reasons:

   a. To protect the Old Bridge aquifer against salt-water intrusion;

   b. To provide an additional water supply estimated at 30 million gallons per day, through artificial recharge, which would be made available for the continued growth in the area of influence; and

   c. To provide water that may be pumped from the natural underground reservoir to further develop existing facilities.

2. It is further recommended that the Surface Water Program defined by the Water Supply Act of 1958 be modified to include the development of diversion facilities as part of the storage program in order to make more effective use of the potential artificial recharge developed by said storage, and to provide for the direct sale by the State of the increased availability of water developed from said storage.

3. In support of the above Recommendation No. 2, it is recommended that a supplemental economic report be made to investigate and evaluate the present and future economic necessity of the South River Tidal Dam and Recharge Pond Project herein recommended to the area affected thereby.

ACKNOWLEDGMENTS

Sincere acknowledgment is made of information and assistance furnished by officials of the various water systems in this area of this study and by the members of South River Tidal Dam Steering Committee and staff of the Middlesex County Planning Board. Acknowledgment is particularly due to Allen Sinnott, District Geologist, U. S. Geological Survey, and his Trenton Ground Water Branch Office staff for their invaluable aid.

The preparation of Parts I, III and IV of this report has been made by Raymond A. Webster, Supervising Engineer, Bureau of Water Control, who also served as project engineer for preparation of the report and designs submitted by Charles J. Kupper, Consulting Engineer in Part II. Invaluable assistance was given by Charles A. Appel, Principal Engineer Groundwater, Bureau of Water Resources, who is also author of Special Report 17, in the review of this report. The contribution of Dr. Irwin Remson in the digital computer analyses presented in Part IV is gratefully appreciated.

PART II

ENGINEERING REPORT

SOUTH RIVER TIDAL DAM PROJECT

PREPARED FOR THE

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT

DIVISION OF WATER POLICY AND SUPPLY

STATE OF NEW JERSEY

CHARLES J. KUPPER
CONSULTING ENGINEER
NEW MARKET, NEW JERSEY

November 1963

November 14, 1963

State of New Jersey
Department of Conservation
& Economic Development
Division of Water Policy and Supply
Trenton, New Jersey

Gentlemen:

We are pleased to transmit herewith our report entitled "South River Tidal Dam" in accordance with the terms of our contract dated November 27, 1962.

This report presents information relative to the construction of a tidal dam on the South River in the vicinity of South River, New Jersey. The dam will provide protection from further salt water intrusion and increase the natural yield by artificial recharge of the Old Bridge Sand Member of the Raritan Formation.

The dam will provide a recharge pond of approximately 750 million gallons of water over the intake area of the Old Bridge Sand Member. Flow will be controlled by a Bascule Gate in the spillway section which will pass the design flood of 5240 cfs. The inundated area will be stripped in parallel rows in order to obtain maximum long life recharge areas.

It has been shown that the construction of a tidal dam will provide a method for the safe development and protection of the local water resources.

Respectfully submitted,

Charles J. Kupper

CHARLES J. KUPPER

CJK
CJKjr:rf

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SUMMARY

The two-fold purpose of constructing a tidal dam on South River is to impound the river and form a recharge pond on the intake area of the Old Bridge Sand Member of the Raritan Formation and prevent further salt water intrusion into the aquifer.

In order to obtain maximum recharge of the sand, the area has to be stripped and a system of gear tooth stripping has been chosen. In order to do this,alternate parallel strips are excavated in trapazoidal cross section which simulate the rack teeth of an involute gear. The advantages to this are that the surface area for recharge has been increased and only the bottom area will be subject to silting, thereby allowing recharge even after silting has occurred. The silt will be removed when the sluice gates of the outlet structure are opened.

The earth dam has been located along a ridge of the Woodbridge clay which was located by the soil borings which provides a minimum depth for the core wall. This proposed alignment also coincides with one of the two proposed highway locations submitted by the Middlesex County Planning Board. The spillway has been located at a skew to and on the westerly end of the dam.

The elevation of the spillway has been set at +3.75 feet with a five foot Bascule Gate which will effectively raise the elevation to +8.75 feet. The gate will be automatically positioned in order to maintain the water surface

elevation at +8.75 feet and will allow the design flood to pass through the reservoir without raising the water level. When extreme high tides develop, the gate will also provide a physical barrier between the fresh and salt water. An outlet structure has been located through the dam in order to give an additional method of lowering the impounded water surface and removing the accumulated silt.

The preliminary cost estimate for the tidal dam has been estimated at $3,805,000. This includes the earth dam, spillway, Bascule Gate, excavation for berms, stripping, relocation of roads, bridges, sewers, and utilities and required land.

INTRODUCTION

PURPOSE

The primary consideration of this report is for the establishment of an additional water supply facility and protect the Raritan aquifers from any further salt water intrusion. In order to provide this, the study has been directed toward the construction of a tidal dam which will provide both a fresh water pond as a means of artificial recharge of the ground-water aquifers and tide control to prevent salt water contamination.

AUTHORITY AND SCOPE

This report was prepared under the terms of a contract entered into on November 30, 1962 between the STATE OF NEW JERSEY, acting through the Director, Division of Purchase and Property, on behalf of the Department of Conservation and Economic Development, Division of Water Policy and Supply, (hereinafter referred to as the "Director") and Charles J. Kupper, Consulting Engineer of 15 Stelton Road, New Market, in the County of Middlesex and the State of New Jersey, (hereinafter referred to as the "Engineer"). The authority under which this contract was executed was the Water Supply Act of 1958.

The Engineer was retained to conduct surveys, investigations and studies deemed necessary for a proposed earth fill dam to be known as South River Tidal Dam and for the removal of impervious silt and organic materials within the impoundment area to expose the Old Bridge member of the

Raritan Formation and to make a preliminary report in accordance with the following outline:

1. Review of geologic and other data for possible locations of the South River Tidal Dam.
2. Surveys, borings and subsurface investigations to designate alignment of dam and depth of the diaphragm cut-off required.
3. Conduct topographic surveys to delineate the size and storage capacity of the area, relocation of roads, reconstruction or modification of bridges and culverts and the required lands for construction.
4. Soil borings and soil analysis for location and availability of material for earth filled dam.
5. Extent and estimated cost of stripping the impervious silt and organic material in the impoundment area to expose the Old Bridge sand for the effective artificial recharge of the sand.
6. Hydrologic studies for the determination of extreme high tides, design flood and spillway.
7. Determine the structural and hydraulic criteria for the spillway and earth filled sections.

8. Recommendation for measurement and control of compensating release flows.
9. Investigate riparian grants and rights effected by the construction of the tidal dam.
10. Investigate electric power requirements.
11. Preparation of schematic plans of pertinent structures and controls for the dam.
12. Prepare cost estimates for the proposed construction, and stripping or removal of impervious silt and organic material in the area, and the cost of raising or relocating roadways, utilities and bridges.

MATERIAL ACCOMPANYING REPORT

Accompanying and made part of this report is a set of thirty nine drawings. To include these in the bound report would prove to be cumbersome due to the size of the drawings. The plans indicate the following information: topographic surveys, plan and profile of streams, riparian grants, relocation of roads, location of utilities, geology, soil borings and cross-sections of earth dam and spillway. An index of this material is shown in Table I on page 5.

ACKNOWLEDGEMENT

Acknowledgement is due and gratefully given to the many individuals and organizations who contributed valuable

Information and helpful cooperation during the investigations made for this report.

REFERENCES

A list of references used during this study is included in this report as Appendix A.

SUBCONTRACTORS

The following is a list of subcontractors that have been utilized for various phases of this study.

American Air Surveys, Inc.
Photogrammetry and Mapping

G. Albert Platt
Surveys

Jersey Testing Laboratories, Inc.
Soil Borings and soil tests

Robert J. Baier
Property Lines and Property Owners

TABLE I

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5-16 *	Topographic Plan with Proposed Contours
17 *	Plan and Profile - South River, Deep Run and Tennent Brook
18-19	Riparian Grants and Leases Affected by the Inundation
20,20A 21,22	Proposed Relocation of Roads and Details
23	Utility Drawing - Jersey Central Power & Light Co. Transmission Lines and Sub-stations.
24	Utility Drawing - South River Interceptor Sewer, Duhernal & Perth Amboy Water Lines
25	Miscellaneous Sewer Details
26	Utility Drawing. - Gas Lines and Oil Lines
27	Plan of Geology - Dam Site and Well Fields
28 *	Plan of Soil Borings and Typical Soil Profile
29,30	Plan of Soil Borings
31,32	Plan and Profile Soil Borings, Centerline of Dam
33,34	Schematic Plan and Profile of Dam
35	Typical Cross-Section of Earth Dam
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37,38	Plan of Earthwork
39	Typical Earthwork Cross-Sections

Note
* Not included in published report but available on request.

GEOLOGY

The South River Drainage Basin lies entirely within the Coastal Plain-Physiographic Province, which includes all of New Jersey south of the Raritan River and east of a line extending from New Brunswick to Trenton.

The general geology has been thoroughly investigated and reported in Special Report No. 8 by Barksdale. Figure 1 is a generalized geologic cross section in Parlin, New Jersey of the Raritan Formation showing the gentle dip of approximately 40 to 45 feet per mile to the southeast.

Within the South River Basin the Old Bridge Sand and the Farrington Sandof the Raritan Formation are the principal sources of ground water. There are alternating beds of clay, sand and gravel in the Raritan Formation. The sand beds have been informally named by the Geological Survey of New Jersey and the clays by the ceramic industry because of their economic importance. The sand and clay layers in the Raritan Formation are, in order of their depth, as follows:

Amboy Stoneware Clay
Old Bridge Sand Member(No.3 Sand)

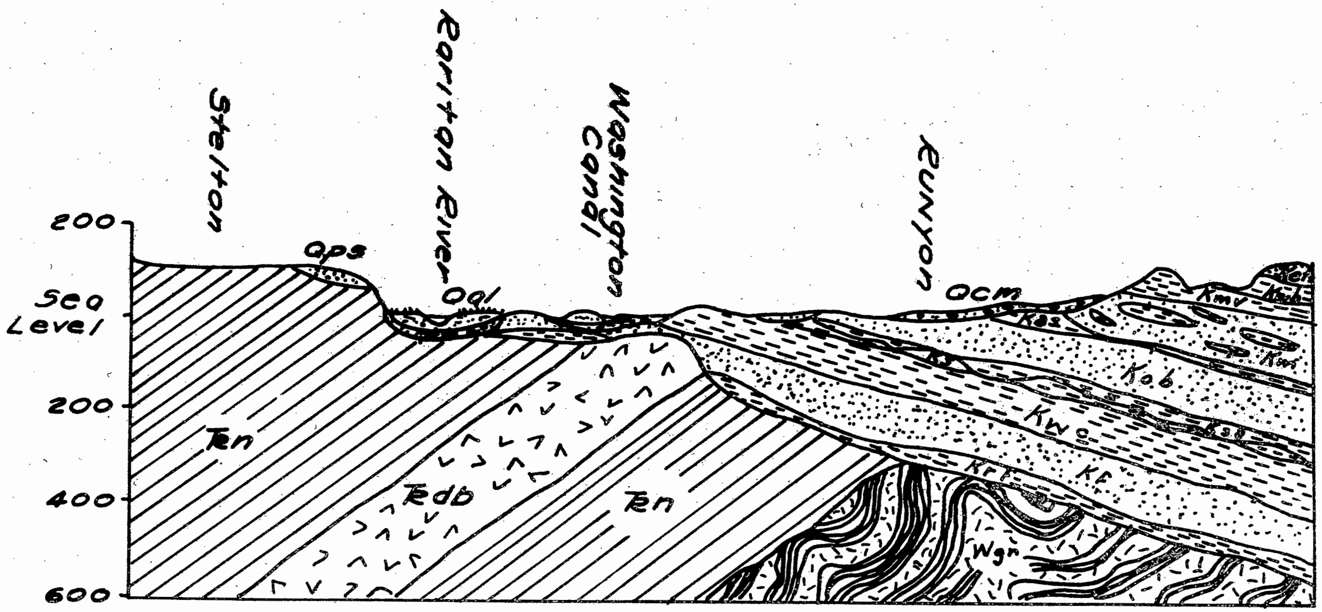
South Amboy Fire-Clay
Sayreville Sand Member(No.2 Sand)

Woodbridge Clay
Farrington Sand Member(No.1 Sand)

Raritan Fire Clay

The Old Bridge Sand is the most productive aquifer of the Raritan Formation. This sand has an outcrop area of approximately 25 square miles which extends from the Raritan Bay near South Amboy to the Jamesburg Area. Along the outcrop area the Old Bridge Sand is exposed to the direct infiltration of precipitation. The thickness of the Old Bridge Sand was determined by other from both surface exposures and wells was found to generally range from 80 to 110 feet, local irregularities of lesser thickness and interspersed clay lenses are frequent.

FIGURE I



CRETACEOUS

QUATERNARY

Qal	Alluvium
Qcm	Cape May fm.
Qps	Pensauken fm.

Ket	Englishtown sand
Kwb	Woodbury clay
Kmv	Merchantville clay
Km	Magothy fm.
Kas	Amboy stoneware clay
Kob	Old Bridge sand
	SAND

Ksa	South Amboy fire clay
Ks	Sayreville sand
Kwc	Woodbridge clay
Kf	Farrington sand
Krf	Raritan fire clay
	CLAY

TRIASSIC

Tedb	Diabase sill
Ten	Newark group

PRE - CAMBRIAN

Wgn	Wissahickon

Generalized geologic section from Stelton through Runyon to the county line.

SOURCE: Figure 3 " The Ground- Water Supplies of Middlesex County, New Jersey Special Report 8 " By Henry C. Barksdale, et al, State of New Jersey, State Water Policy Commission.

SUBSURFACE INVESTIGATION

Before proceeding with a plan of actual subsurface investigation, a study was made of all available sources of information dealing with the soils and geology of the area. This review included agronomic, soil and geologic maps as well as water supply reports which provided general soil properties and actual graphic logs of test borings such as those made by the Corps of Engineers for the New Jersey Ship Canal (Washington Ship Canal). Boring logs from the Middlesex County Sewerage Authority South River Interceptor Sewer Line and well logs from the Borough of Sayreville well field were also studied. The results of these logs appear as borings 206 through 261 respectively in Appendix B.

Based on these findings, it was decided to locate the dam across South River within the general area starting from Tennents Brook north one mile to Pond Creek. This established the general area of the dam site.

Along the one mile stretch of river, approximately 50 medium bore holes were put down 20' to 40' to clay. These borings located the top surface of the Woodbridge Clay beneath the Old Bridge Sand. Using the field boring logs, a contour map was made showing the approximate surface of the clay. A study of this map revealed a ridge of clay at an average elevation of -12 along a bearing of N 57.50E which follows the northern boundary of the Old Bridge Sand intake area. The Centerline of the dam was located on top of this ridge to provide a minimum depth of core well. This minimum depth of core wall, then, was the primary consideration as far as locating the dam was concerned. With the site selected, a series of about 22 bore holes were extended 60 blows into the clay along the centerline of the dam to check the location of the dam to establish a site location for the spillway, and to evaluate the physical and structural properties of the soil. The results of the tests performed on soil samples from these holes are tabulated in the structural criteria on page 16.

Four deep soil borings were extended into the Woodbridge Clay which is the next major member beneath the Old Bridge sand. This clay layer was found to be an average of 75' thick. Beneath this layer is found the Farrington (No. 1) sand, one of the better aquifers in this region. The boring logs for these holes (31F, 195F, 196F, and 197F), 127 auger holes for depth of peat quantities and 26 medium cased holes are included in Appendix B. A complete plan of soil borings including those of the interceptor and well field are shown on sheets 27 through 29 of the drawings.

A schematic profile along the centerline of the dam and spillway is shown on sheets 33 and 34 of the drawings.

The earth section consists of a clay core to control seepage and an outside shell to provide stability. The core will start inside the east abutment at station 3+50 and extend the full length of the dam to station 28+50. At about station 14+00 the east bank of the river stands at elevation +9 which at first appears to be a good terminus for the dam. However, all the material above the gray clay consists of highly permeable recently deposited sands. Since the axis of the dam is at the northern boundary of the Old Bridge Sand member the core was extended across these permeable sands to the Old Bridge Sand, near the point where it rises to an elevation of 70'. Thus, the extended core prevents seepage of water through these highly permeable recent sand deposits and provides full benefit of the high head recharge to the Old Bridge Sand.

The soil profile on sheet 28 of the drawings shows a typical cross section of the Old Bridge Sand in the vicinity of the dam along the line of Old Bridge Road from Duhernal Dam two miles northeast to the Sayreville well field. Although the sand is 65 feet thick at the well field, it is only 40 feet thick along the rest of the cross section which is perpendicular to the dip of the sand layer.

BORROW AREAS

The very general geologic nature of the area suggests that an earth dam with a clay core would be the best type of dam structure to use.

The clay core material can be obtained from pits above and below the easterly end of the dam. Here the Woodbridge clay comes to within six feet of the surface. The clay is typically a gray silty clay (CL) with some area of gray clayey silt (ML) as classified by the Unified Classification System and shown in Table II.

The sandy overburden on top of the clay will be used to construct an earth dyke along the Middlesex County Sewerage Authority South River Interceptor Sewer and to construct berms to power pole lines in the inundated area thereby allowing access for inspection and maintenance.

The material for the shell of the dam will be that material excavated for the entrance channel to the spillway on the west side of the river.

TABLE II

CASAGRANDE CLASSIFICATION OF SOILS

MAJOR DIVISION		Soil Group Sym-bols	Soil Groups & Typical Names	GENERAL IDENTIFICATION	
				Dry Srength	Other Pertinent Examinations
Coarse-Grained Soils	Gravel & Gravelly Soils	GW	Well-graded gravel and gravel-sand mixtures; little or no fines.	None	Gradation, Grain shape.
		GC	Well-graded gravel-sand-clay mixtures; excellent binder.	Medium to high	Gradation, grain shape binder examination, wet and dry.
		GP	Poorly graded gravel & gravel-sand mixtures; little or no fines.	None	Gradation, grain shape
		GF	Gravel with fines, very silty gravel, clayey gravel poorly graded gravel-sand-clay mixtures	Very slight to high	Gradation, grain shape, binder examination, wet and dry.
	Sands & Sandy Soils	SW	Well-graded sands & gravelly sands; little or no fines.	None	Gradation, grain shape.
		SC	Well-graded sand-clay mixtures; excellent binder	Medium to high	Gradation, grain shape, binder examination, wet and dry.
		SP	Poorly graded sands; little or no fines.	None	Gradation, grain shape.
		SF	Sand with fines, very silty sands, clayey sands, poorly graded sand-clay mixtures	Very slight to high	Gradation, grain shape, binder examination, wet and dry.
Fine-Grained Soils (containing little or no coarse-grained material).	Fine-grained soils having low to medium com-pressibility	ML	Silts (inorganic) and very fine sands, Mo, rock flour, silty or clayey fine sands with slight plasticity	Very slight to Medium	Examination wet (shaking test and plasticity).
		CL	Clays (inorganic) of low to medium plastic-ity, sandy clays, silty clays, lean clays.	Medium to high	Examination in plastic range.
		OL	Organic silts and organic silt-clays of low plasticity.	Slight to Medium	Examination in plastic range, odor
	Fine-grained soils having high com-pressibility	MH	Micaceous or diatoma-ceous fine sandy and silty soils; elastic silts.	Very Slight to medium	Examination wet (shaking test and plasticity).
		CH	Clays (inorganic) of high plasticity; fat clays	High	Examination in plastic range.
		OH	Organic clays of medium to high plasticity	High	Examination in plastic range, odor
Fibrous organic soils with very high com-pressibility.		Pt	Peat and other highly organic swamp soils.	Readily identified	

LEGEND FOR SOIL GROUP SYMBOLS

C- Clay, plastic-inorganic soil.
F- Fines, material 0.1 mm.
G- Gravel, gravelly soil.
H- High compressibility.

L-Relatively low to medium compressibility
M-Mo, very fine sand, silt, rock flour.
O-Organic silt, silt clay or clay.

P-Poorly graded
Pt-Peat, highly organic fibrous soil
S-Sand, sandy soil.
W-Well graded

STRIPPING AND RECHARGE

Aside from stripping in the form of clearing and grubbing in the areas of construction, consideration has been given to stripping the impermeable peat from on top of the more permeable Old Bridge Sand.

The permeability of peat samples taken at the dam site ranges from 10^{-4} to 10^{-2} cm/sec. (centimeter per second) while the Old Bridge Sand has a permeability in the range of 10^{-2} to 10^{-1} cm/sec, about ten to one or greater than that of peat.

Removing the peat by stripping would expose the more permeable Old Bridge Sand member of the Raritan Formation for more effective recharge. However, this benefit would not last long since the very still waters of the impounded area would cause settlement of even the finest sediments which would again form an impervious layer on top of the sand. Not even the largest of outlet structures could remove all of this silt effectively, especially in the areas more distant from the dam site.

A system that would provide a more effective recharge of the sand might be termed "gear tooth stripping". If a flat area adjacent to the river is at elevation +3.0 feet, alternate parallel strips are excavated in trapazoidal cross section to form valleys say at elevation -1.0 feet and the material thus removed is placed as fill on the adjacent parallel strips to form ridges of trapazoidal cross section at elevation say +7.0 feet. The result would simulate the rack teeth of an involute gear with depth of eight (8) feet and a pitch equal to twice the width of the parallel strips. The surface area would be increased to two or three times the original area with the same average driving head. Also, only the valley area (1/4 to 1/6 of the total surface area) would be subject to excessive silting and the general elevation of silt areas would be kept low. This silt could be cleaned out more easily in the valleys where higher velocities could be developed during the flushing action created by opening the sluice gates of the outlet structure. For most effective flushing and recharge these parallel strips should be pointing downstream at an angle of about 60^o to the direction of South River and be located on the thicker outcrop areas of the Old Bridge Sand.

The benefit to be derived from gear tooth stripping is more long-life recharge surface area per acre of inundated area. The principle involved here need not be confined to gear tooth stripping. Wherever berms or access routes are constructed to sewer lines or utility poles the long-life recharge surface area has been increased. Berms constructed along existing estuaries such as Tennent Brook or Deep Run along the South River, would accomplish the same objective.

This method will provide 115 acres of vertical, long life recharge areas in the impounded area of 380 acres.

STRUCTURAL CRITERIA

The structural criteria used for the stability design of the earth filled sections of the dam are as follows:

Water		
Fresh water unit weight	pcf	62.5
Salt water unit weight	pcf	64.0
Silt		
Horizontal pressure	psf/ft.	85.0
Vertical pressure	psf/ft.	120.0
Woodbridge Clay		
Permeability cm/sec.		
Undisturbed, horizontal	10^{-5}	
Undisturbed, vertical	10^{-5}	
Saturated at maximum density	10^{-6}	
Unconfined Compressive Strength(TSF)		
Undisturbed	1.0	
Saturated at maximum density	2.3	
Liquid Limit (average)	30.7	
Plastic Limit (average)	21.5	
Specific Gravity (average)	2.25	
Density Characteristics		
In-place density, wet(pcf)	127.0	
Natural moisture content %	25.0	
Maximum dry density (pcf Mod.)	108.0	
Optimum moisture content %	11.0	
Swellage at maximum density %	16.5	
Cohesion (TSF)	0.4	
Angle of Internal Friction ϕ	30°	
Average Standard Penetration Test blows per foot within top 5 feet of clay layer	20	

Design Bearing Capacity TSF	1.0
Coefficient of sliding	0.05

Old Bridge Sand

Permeability @ max. density cm/sec.	10^{-2}
Specific gravity	2.70
Density characteristics	
Maximum dry density pcf	118
Optimum moisture content %	11.5
Angle of internal friction ϕ	36°
Saturated unit weight pcf	136.7

Peat

Permeability cm/sec.	10^{-2} to 10^{-4}
Organic content (dry basis) %	25 to 50

Concrete

Unit Weight plain(spillway) pcf	140
Reinforced pcf	150
Compressive strength psi	3000

Steel

Allowable tensile strength psi	20,000

HYDROLOGY

GENERAL

Water is one of our most valuable natural resources and without it no form of life is possible. The demands upon this resource are becoming more severe as the population increases. Hydrology is the science that deals with the processes governing depletion and replenishment of the water resources of the land areas of the earth.

WATER RESOURCE

Eventually all precipitation is dissipated in the following manner:

1. Evaporation into the atmosphere
2. Transpiration by plant life
3. Ground infiltration
4. Surface runoff

The above methods all contribute eventually to either a gain or loss in our water supplies and are governed by the topographical, geological and climatic conditions and the type and amount of vegetation cover. Evaporation is a rather small factor, except where there are large water surface areas, and is therefore normally grouped with transpiration to account for a percentage of the precipitation. The remainder of the precipitation goes into infiltration or runoff. These two components are the primary source of all water supplies.

The vast quantities of water stored underground may be tapped by means of wells thereby eliminating the need

for large surface storage areas. If the quantity of ground water pumped each year does not exceed the annual replenishment by precipitation then the supply may be considered permanent. In the Coastal Plain where there is hydraulic continuity with saline waters, excessive pumping induces salt water to enter the aquifers. In this case, a surface reservoir over the aquifer intake area will provide an excellent method of recharging the aquifer.

Surface runoff is the amount of excess water that is not used in the other three processes. This run-off appears in the form of flowing streams and may be due to an immediate storm or the delayed action of melting snow. If the stream bed has cut through a water bearing aquifer, ground water will also appear as runoff and usually is the reason for sustained flows in streams after storm waters have subsided.

PRECIPITATION AND EVAPORATION

The primary source of fresh underground water is precipitation. The average annual precipitation in the State of New Jersey has been found to be approximately 46 inches. Transpiration and evaporation combined, account for about half the total precipitation. The balance infiltration and runoff, is used for all water supplies. At present, a large part of the runoff portion of precipitation eventually finds its way to the ocean and is lost. Construction of the proposed dam will impound a large portion of this runoff, thereby putting a surcharge on the intake area of the Old Bridge Sands.

An evaporation station was established at Runyon, New Jersey in 1924 and a record was maintained until 1942. Using these figures, evaporation for the pan is approximately 31.4 inches per year. Assuming the evaporation from a pond or lake to be about 70 percent of the pan, the evaporation is approximately 22 inches per year.

SURFACE RUNOFF AND STORAGE

Surface runoff includes all measurable water flowing in streams above tide level but is not the total runoff of precipitation. In addition to measurable surface runoff, there is the discharge of unconfined aquifers directly to the sea which is unknown and could be a considerable amount. The precipitation, which enters the ground water supply,moves through the earth and could be discharged again into the streams as either springs or bank seepages and is considered as surface runoff as well as flood waters. Heavy concentrated precipitation and melting snows which rapidly moves across the land surface without entering the ground water is surface runoff in the form of flood waters.

A continuous record of the South River flow at the Duhernal Dam has been maintained since 1939 by the U. S.

Geological Survey. Figures 2 and 3 show a monthly hydrograph and mass diagram of the river flow for the period of 1939 to date.

As shown on the monthly hydrograph, the lowest flow of 11.5 cfs was reached in August, 1957, but was not sustained. The curve started to rise immediately and reached a peak in January, 1958 of 281 cfs with a larger peak of 393 cfs in March, 1958. The latter peak was due to the heavy snows that had fallen in February and were melting. During the winter months the infiltration capacity is normally lowered by the frost penetration and therefore the runoff is increased which is another reason for the peak flows.

DETERMINATION OF DESIGN FLOOD

In order to establish a spillway capacity, a design flood must be determined for the drainage area of South River above the dam site. According to charts prepared by the Division of Water Policy and Supply the 50 year flood for this drainage basin was established at 5240 cfs. An independent study was made of the 23 year peak discharge records for South River at Duhernal Dam. These results were then extrapolated two miles downstream to the dam site to yield a 50 year design flood of 5300 cfs. Therefore, the design flow was confirmed to be at 5240 cfs.

A second study was made to compare the drainage area discharge characteristics of seven streams in the vicinity

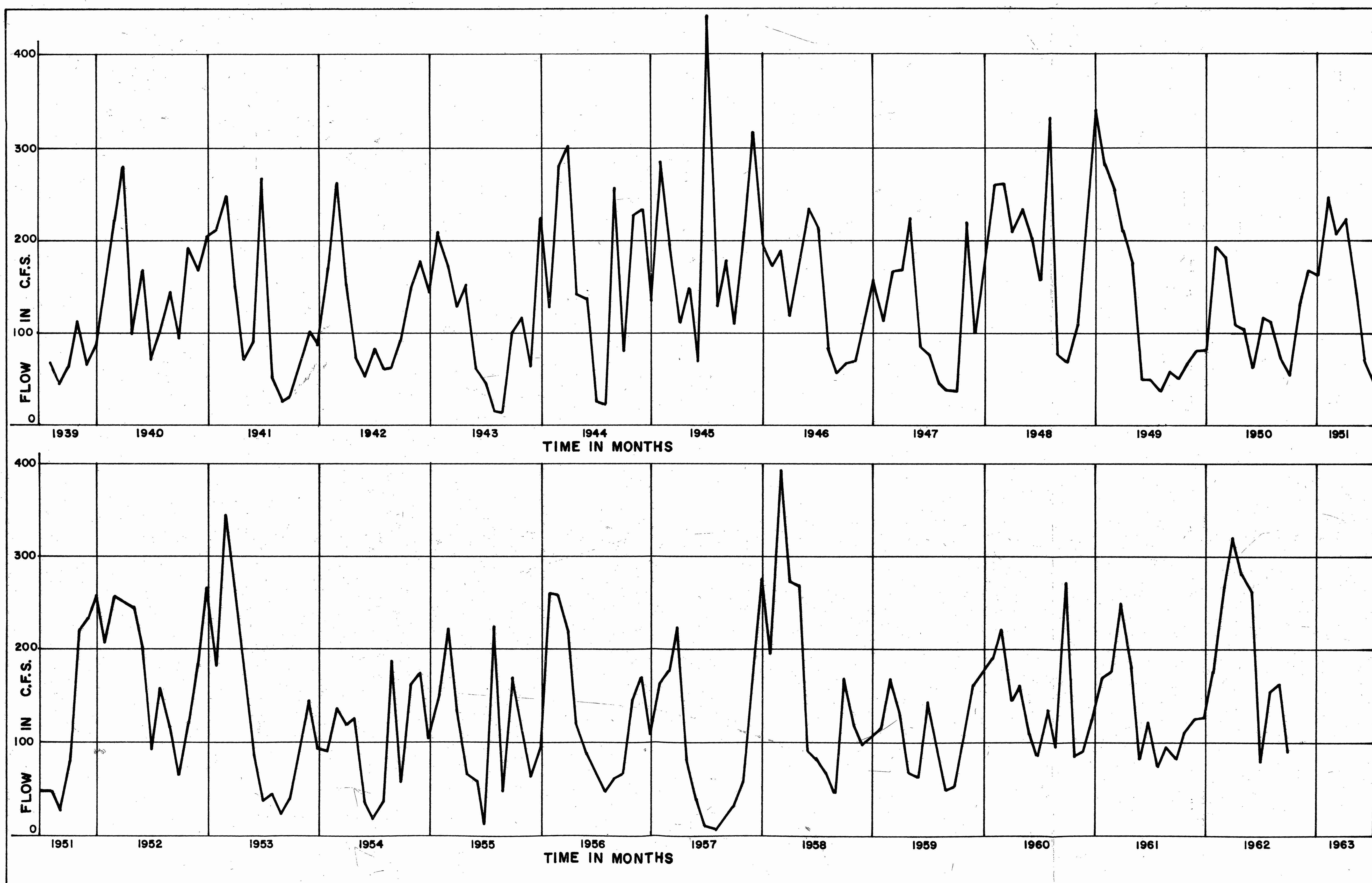


FIGURE 2

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DIVISION OF WATER POLICY AND SUPPLY

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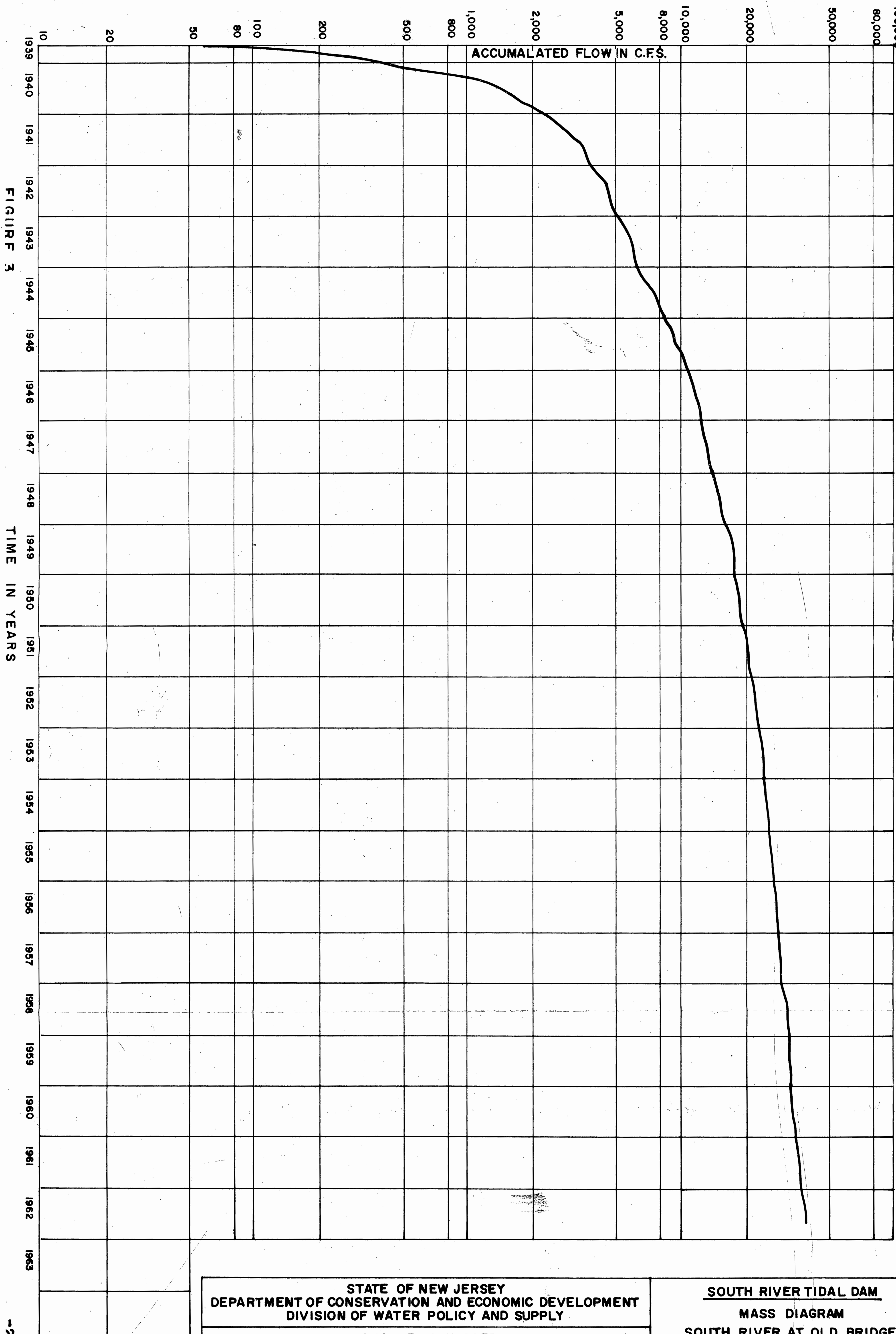
SOUTH RIVER TIDAL DAM
MONTHLY HYDROGRAPH
SOUTH RIVER AT OLD BRIDGE
1939 — 1962



STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

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SOUTH RIVER TIDAL DAM

MASS DIAGRAM
SOUTH RIVER AT OLD BRIDGE
AUGUST 1939 TO SEPTEMBER 19

of South River. The tabulated results of this study are shown in Table III on the following page. Although some of these rivers are not entirely within the Coastal Plain, they do provide results for streams of similar precipitation and climatic conditions. Figure 4 shows these values plotted in the form of area-discharge curves as a function of flood frequency.

FLOOD CONTROL

The maximum discharge recorded was 4250 cfs on September 15, 1944. Figure 5 shows the inflow hydrograph at Duhernal dam for this critical storm. The accumulated rainfall was approximately 8.5 inches in 78 hours with 5 inches falling in the first 40 hours. The rain stopped for about 17 hours and the remaining 3.5 inches fell in 10 hours. The peak flow was recorded at the dam approximately 40 hours after the peak rainfall was recorded. Two other critical storms were analysed and similar situations were encountered as shown in Figures 6 and 7.

When rain starts to fall on drainage basins, it does so at varying intensities over the area. A portion never reaches the ground in the beginning because it is intercepted by trees, grass, buildings and so forth. Another portion flows into depressions and later either soaks into the ground or evaporates. The remainder flows

TABLE III

DRAINAGE AREA - DISCHARGE CHARACTERISTICS
FOR SEVEN STREAMS IN THE VICINITY OF SOUTH RIVER

Number	Name & Location	#Years Recorded	Area (mi^2)	FLOOD FREQUENCY IN YEARS					
				50	25	10	5	2	1
(1)	Lawrence Brook @ Farrington Dam	35	34.4	2800	2340	1775	1372	858	293
(2)	Matawan Creek @ Matawan	22	6.11	1620	1450	1105	866	519	38
(3)	Millstone River near Kingston	16	171.0	10400	9250	7700	6305	4307	973
(4)	Assumpink Creek @ Trenton	39	89.4	2960	2700	2300	1956	1410	385
(5)	Crosswicks Creek @ Extonville	21	83.6	3570	2810	2610	2207	1509	308
(6)	Matchaponik Brook @ Spotswood	5	43.9	(2460)	(2240)	(1890)	1607	1248	910
(7)	South River @ Old Bridge	23	94.6	4250	3750	3050	2500	1660	383
	South River @ Dam Site Extrapolated from Old Bridge		124.7	5300	4680	3800	3120	2070	480

Discharges shown in cubic feet per second

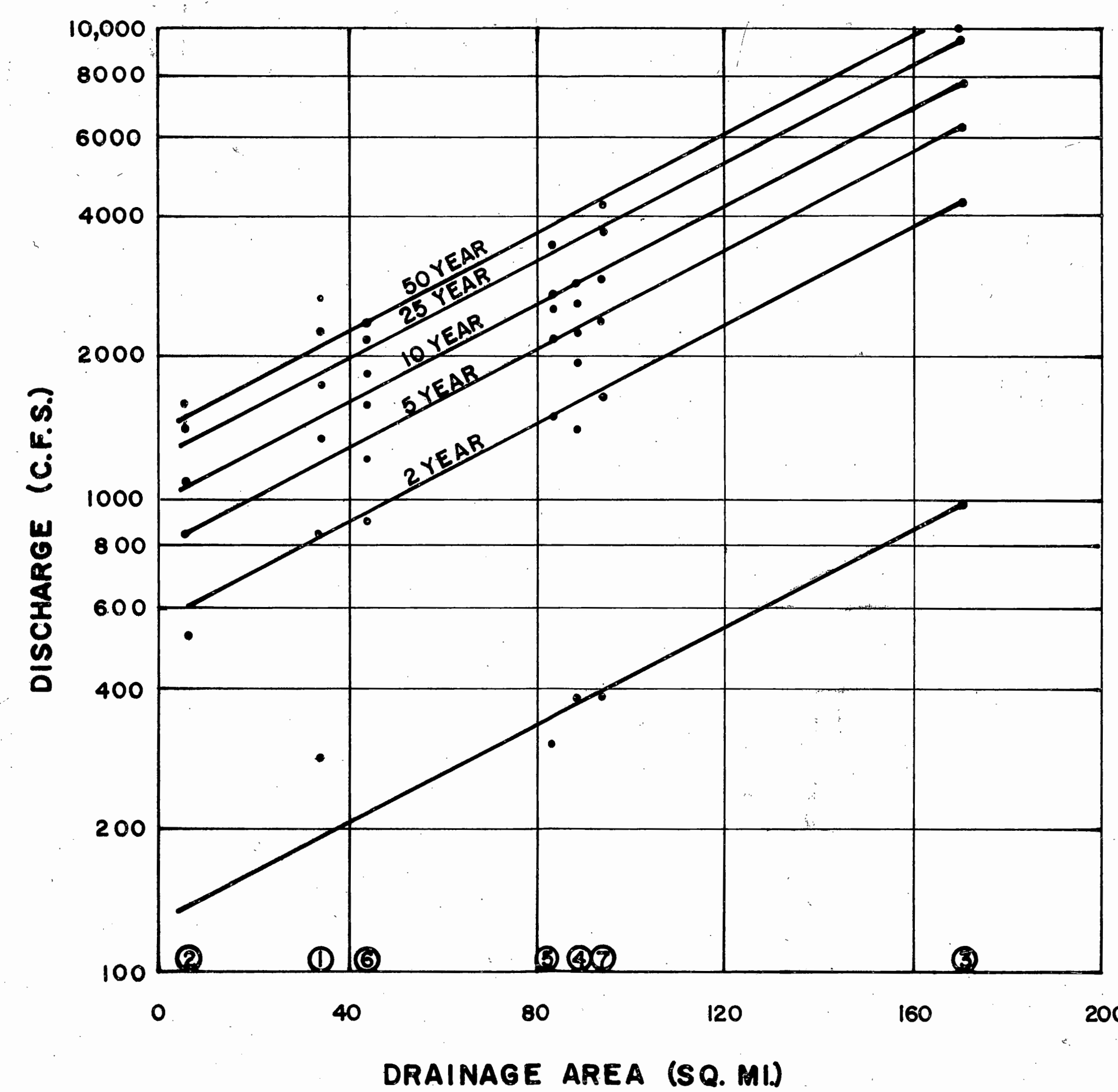

FIGURE 4

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DIVISION OF WATER POLICY AND SUPPLY

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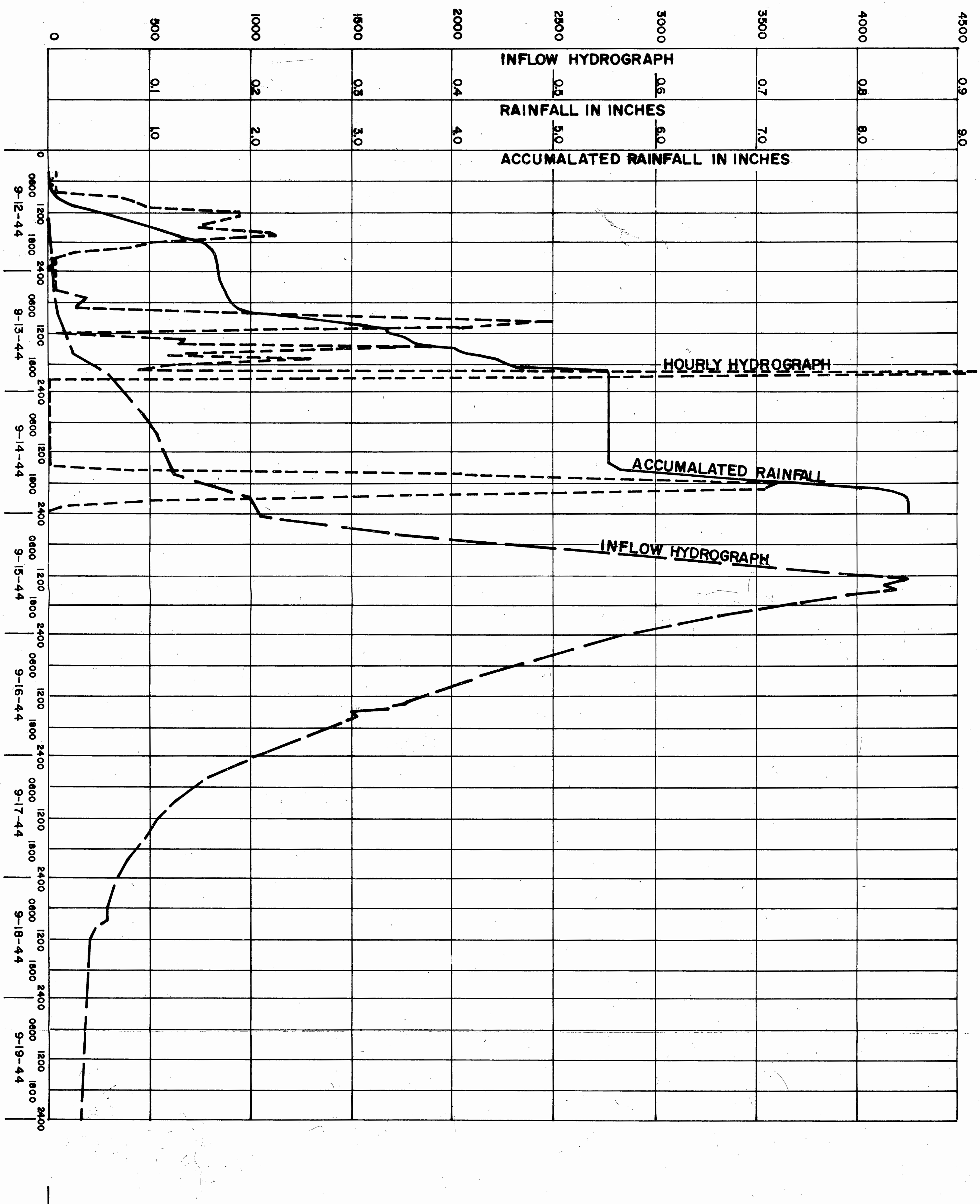
SOUTH RIVER TIDAL DAM
DRAINAGE AREA
DISCHARGE CHARACTERISTICS OF SEVEN STREAMS
IN VICINITY OF SOUTH RIVER

FIGURE 5



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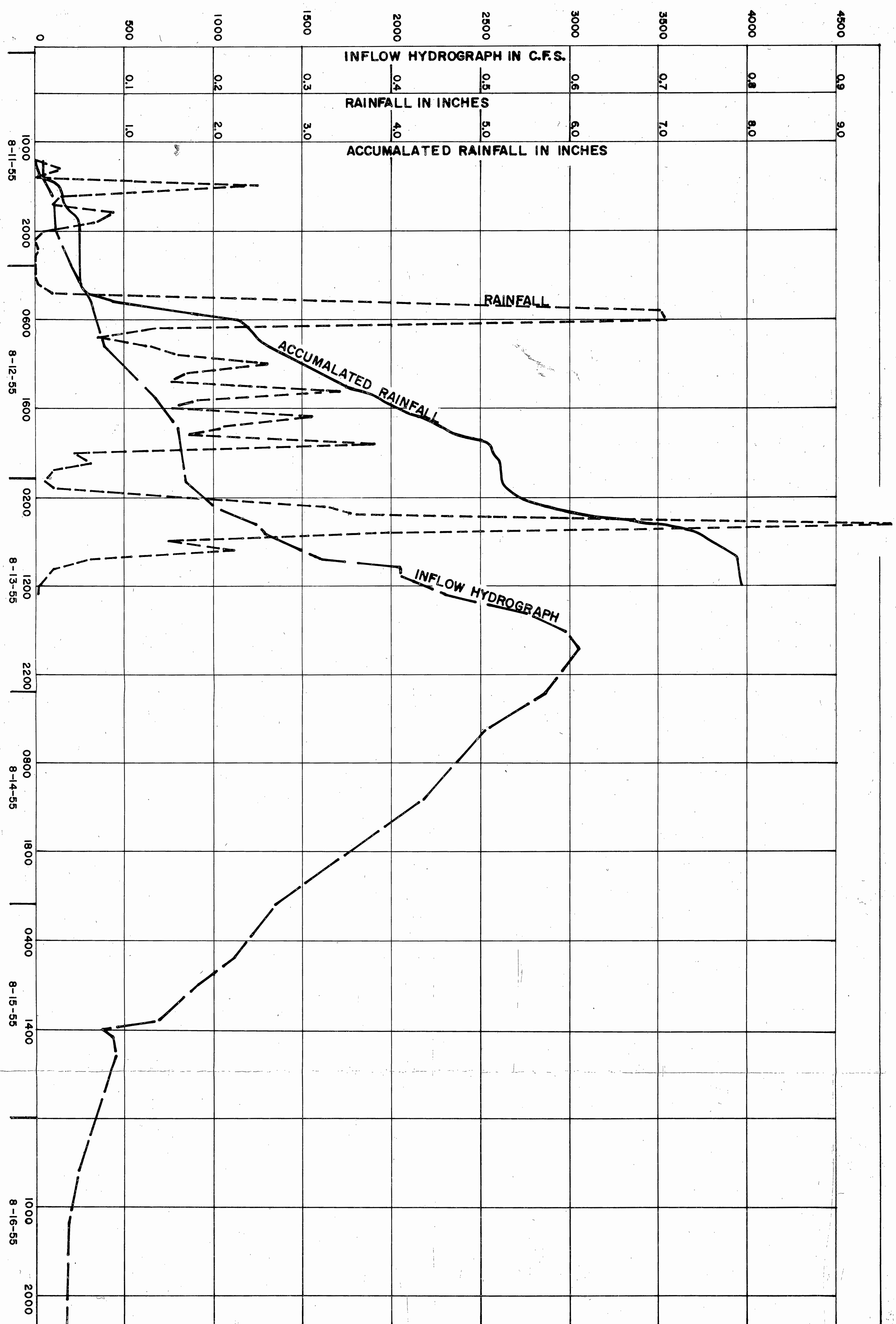
SOUTH RIVER TIDAL DAM

SOUTH RIVER AT OLD BRIDGE
CRITICAL STORM - SEPTEMBER 194

FIGURE 6



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DIVISION OF WATER POLICY AND SUPPLY

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SOUTH RIVER TIDAL DAM

SOUTH RIVER AT OLD BRIDGE
CRITICAL STORM— AUGUST 1955

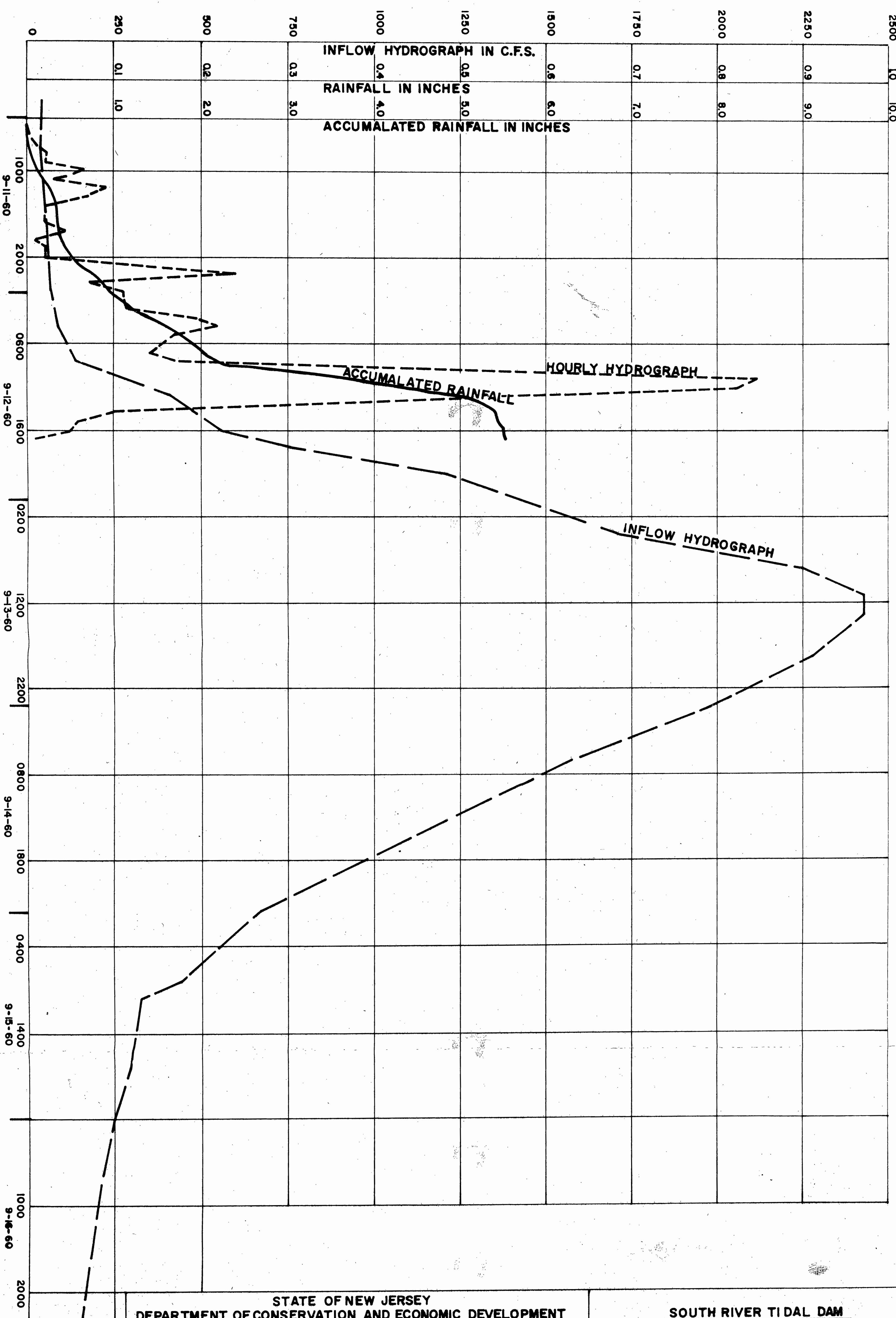

FIGURE 7

TIME IN HOURS

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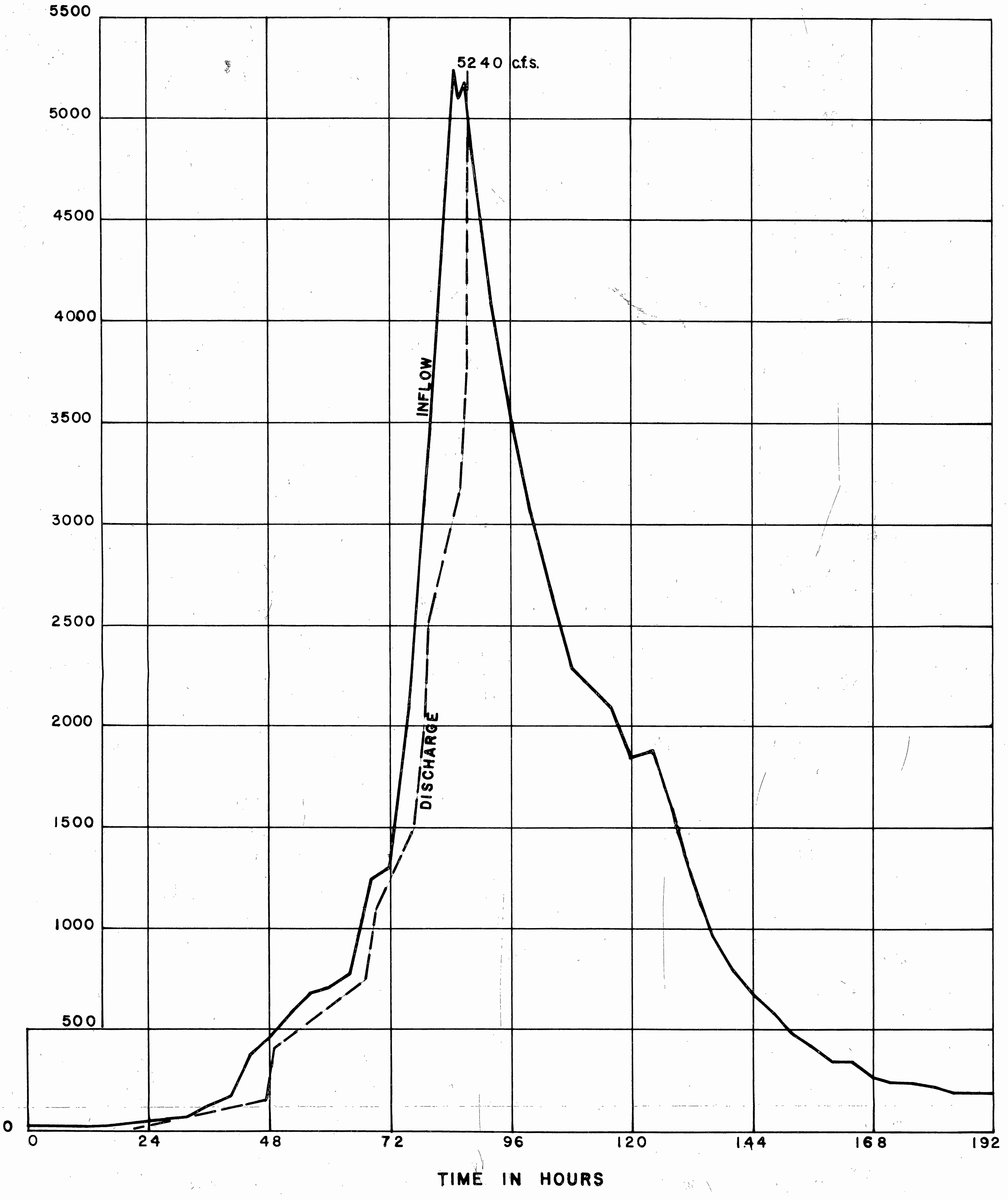
SOUTH RIVER TIDAL DAM
SOUTH RIVER AT OLD BRIDGE
CRITICAL STORM – SEPTEMBER 1960

overland toward the streams, but in traveling, a percentage infiltrates into the soil. Eventually the remainder of the rain does find its way to the streams and shows up on the hydrograph as surface runoff. This lag is shown on the hydrographs for the three storms.

The peak discharge of a river can be reduced by storing a portion of the surface runoff until after the crest of the flood has passed. The construction of a reservoir on the stream produces beneficial results at all downstream points. The two main types of storage are controlled and uncontrolled. The proposed South River Tidal Dam will be controlled storage. This is achieved by the use of gates in the impounding structure to regulate the overflow. Assuming the storm of September, 1944 to be similar in nature to the fifty year design flood of 5240 cfs, we arrive at the inflow hydrograph as shown in Figure 8.

In order to make a realistic study of the effects of the dam it has been assumed that the water surface in the reservoir is at elevation +7.5 feet. The Bascule Gates can be lowered to increase the spillway discharge capacity and if necessary the sluice gates can be opened. In calculating the design flood the lowering of the gates was the only thing considered. When the gates are lowered to an elevation of +5 feet the discharge is equal to the peak of the design flood with a constant water surface elevation of +8.75 feet and will cause approximately a

FIGURE 8



STATE OF NEW JERSEY DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT DIVISION OF WATER POLICY AND SUPPLY	SOUTH RIVER TIDAL DAM
CHARLES J. KUPPER CONSULTING ENGINEER NEW MARKET, N.J.	HYDROGRAPH 50 YEAR FLOOD

three (3) hour lag in the crest of the flood, as shown in Figure 8.

TIDES

The U. S. Coast and Geodetic Survey maintain records of tides at a number of stations. Records were obtained for two stations and correlated to the South River in the vicinity of the proposed dam. The highest elevation on record for New York City is +7.9 feet. This elevation corrected and applied to South River would be approximately +8.8 feet which would be the tide for a fifty year storm. A high tide frequency curve for the Battery, New York City, with an extrapolated frequency curve for the South River at South River, New Jersey is shown in Figure 9.

The primary function of the dam is to prevent surface and underground flow of tidal salt water upstream. The spillway has to be at an elevation higher than spring tides. In severe storms, the tides are extreme and could rise above the spillway. This would seldom occur and would be for a relatively short duration. Crests of the dam would be constructed higher than the spillway thereby keeping the salt water pollution to a minimum. By constructing the dam and keeping out salt water a fresh water lake is formed and will provide water for a constant recharge of the Old Bridge Sand.

SAFE YIELD

The safe underground yield is not only a function of rainfall and evaporation but it also depends upon the

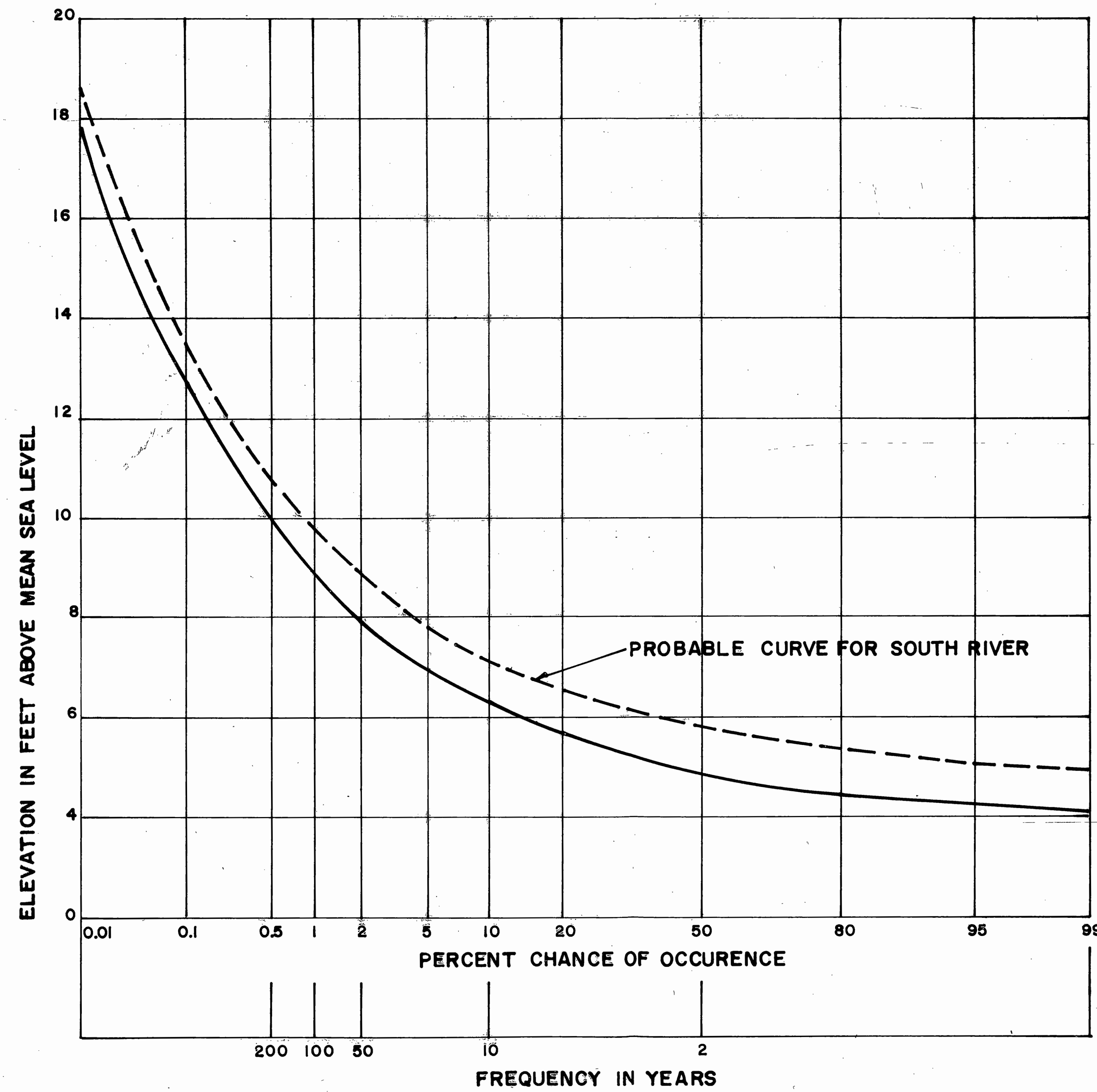


FIGURE 9

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DIVISION OF WATER POLICY AND SUPPLY

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SOUTH RIVER TIDAL DAM

TIDE FREQUENCY
AT THE BATTERY
NEW YORK CITY

relation between runoff and percolation. These factors are dependent on the mechanical characteristics of the aquifer and the overlying strata. The percolation is reduced when the overlying strata is composed of very fine and impervious material and the runoff is greatly increased.

When the well, taking its supply from an aquifer such as the Old Bridge Sands, is controlled by the ground water table, is pumped, an inverted cone forms in the ground water about the well and is called the cone of depression. The apex of the cone is the well casing at the level to which the water is drawn down while it is pumped. The vertical distance between the normal surface of the ground water and the apex of the cone is called drawdown. The circle where the circumference of the cone of depression cuts the surface of the normal ground water table is the zone of influence.

It is often desirable to locate a well such that its area of diversion will extend to a perennial surface water body that can provide quantities of water comparable to the total well discharge without being depleted. By inducing water from such a surface water source it may be possible to maintain a rate of withdrawal many times the maximum rate that would have been possible if the system were limited to its other sources of aquifer replenishment. Obviously the permeability of any materials that separate the surface water body from the aquifer affect the rate at which water can be induced into the aquifer in response to any particular hydraulic gradient. The accumulation of materials such as silts and muds in the bed of the surface water body could significantly reduce the infiltration capacity of the system. Hence, it is essential to have a means of removing such fine-grain materials from the reservoir bed of the South River Tidal Dam to provide optimum conditions for potential recharge into the Old Bridge sand. It is believed that the proposed gear stripping procedure can provide these optimum reservoir bed conditions.

GROUND WATER RECHARGE

The location of the proposed dam has been chosen to obtain maximum ground water storage and ground water replenishment. Sheet 27 of the drawings shows the intake area of the Old Bridge Sand within the South River Basin which is presently replenished only by meteoric precipitation and will be partially inundated by the new reservoir. In order to increase the rate of recharge the semi-impervious mantel of silt and vegetation will be stripped and therefore expose a larger area of the Old Bridge Sand.

Factors determining the rate at which water can penetrate into an aquifer from a surface supply are: (1) permeability of the aquifer, (2) permeability of material on the bottom of the surface reservoir and (3) the hydraulic gradient established between the surface water and the aquifer.

In order to determine the actual quantity of water from the surface reservoir which will recharge the aquifer,

would be a difficult task due to (1) the change in thickness of the aquifer, (2) varying diameters of the existing wells, (3) limited data on pumping tests, (4) a limited number of observation wells. The coefficient of permeability estimated by others is between 1000 and 1500 gallons per day per square foot. The thickness of the aquifer and the extent of removing impermeable material in the reservoir are the primary variables.

The coefficient of transmissibility is defined as the rate of flow of water in gallons per day which will flow through a one foot width of a given aquifer with a unit hydraulic gradient under prevailing conditions. This coefficient is the product of the aquifer thickness and the aquifer permeability.

Based on the Theis Non-Equilibrium formula, the actual coefficient of transmissibility, obtained by pumping tests from the Borough of Sayreville well field, ranges between 11,300 and 33,400 gpd per foot with an average value of 21,200 gpd per foot. With an average depth of 65 feet for the aquifer (as per well logs), the average coefficient of permeability is 326 gpd per square foot. Using this coefficient of permeability, the coefficient of transmissibility is found to be 13,050 gpd per foot.

The recharge rate has been calculated to be 1.28 million gallons per day for the entire pond area with no pumping of wells using the following information: (1) the reservoir is considered as the prime source of recharge, (2) the aquifer is in direct contact with the

reservoir, (3) the average thickness of the aquifer is 40 feet (as per soil borings), (4) the coefficient of permeability of the aquifer is 326 gpd per square foot, (5) minimum constant water surface elevation of +7.50 feet.

In order to determine the quantity of water induced from the reservoir, a hypothetical system of wells has been developed. This system consists of 50 wells, one (1) foot in diameter on a line 500 feet from the reservoir and spaced 500 feet apart. The wells will be pumped uniformly at a rate of 500 gpm with a maximum of 35' drawdown. The total of discharge from these wells will be 36 mgd. This discharge could be increased if the (1) diameter of the wells is increased (2) wells are spaced closer to the reservoir and closer to each other. The calculation is also based upon the reservoir being in direct contact with the aquifer which will be accomplished by the proposed stripping.

HYDRAULIC CRITERIA

The hydraulic criteria used for the design of the spillway and the earth filled sections of the dam are as follows:

Maximum Elevation of impounded water surface	9.00
Regulated average Elevation of impounded water surface (regulated by Bascule Gate)	7.5
Maximum Elevation of top of Bascule Gate	8.75
Elevation of Top of Spillway	3.75
Elevation of Outlet Structure	8.0
Flood Frequency Characteristics for South River at the dam site (cfs)	
100 year flood	6000
* 50 year flood	5300
25 year flood	4600
10 year flood	3800
5 year flood	3120
2 year flood	2070
1 year flood	480
* Design Flood 50 year	5240
Flow characteristics for South River at Duhernal Dam (cfs-23 year record)	
Maximum Discharge	4250 cfs
Average Discharge	139 cfs
Minimum Discharge	11.5 cfs
Design Flows for South River at proposed dam site (cfs)	
Design Flood	5240
Minimum Discharge	18

Flood Frequency Characteristics
for South River at the dam site
(Feet above M.S.L.)

50 year flood tide	8.8
25 year flood tide	8.1
10 year flood tide	7.2
5 year flood tide	6.6
2 year flood tide	5.8
1 year flood tide	5.1

Tide Characteristics for
South River at the dam site
(Feet above M.S.L.)

Highest Tide	8.8
M.H.W.	3.15
M.T.L.	0.90
M.L.W.	-1.35
Lowest Tide	-5.35

SOUTH RIVER TIDAL DAM

The salt water encroachment into the Farrington Sand member of the Raritan formation has been advancing steadily from the Washington Canal along the Raritan River and South River toward the Sayreville area of Middlesex County. The Old Bridge Sand is exposed to tidal action in the South River near Old Bridge.

The proposed South River Tidal Dam will provide stream flow regulation and storage of fresh water for artificially recharging the Raritan Formation aquifers and therefore provide protection against the danger of salt water intrusion.

The primary function of the fresh water pond is to recharge the ground water supply and a secondary function could be recreational facilities. In order to maintain the primary function these recreational facilities would have to be restricted.

INUNDATED AREA

The proposed alignment of the South River Tidal Dam is shown on various sheets in the accompanying material. With a flow line elevation of +9.0 feet, approximately 450 acres will be inundated and approximately 750 million gallons of water will be impounded. Figure 10 indicates the capacity, water surface area and evaporation as a function of the elevation. The total drainage area for the South River above the proposed dam is 124.7 square miles and is shown in Figure 11.

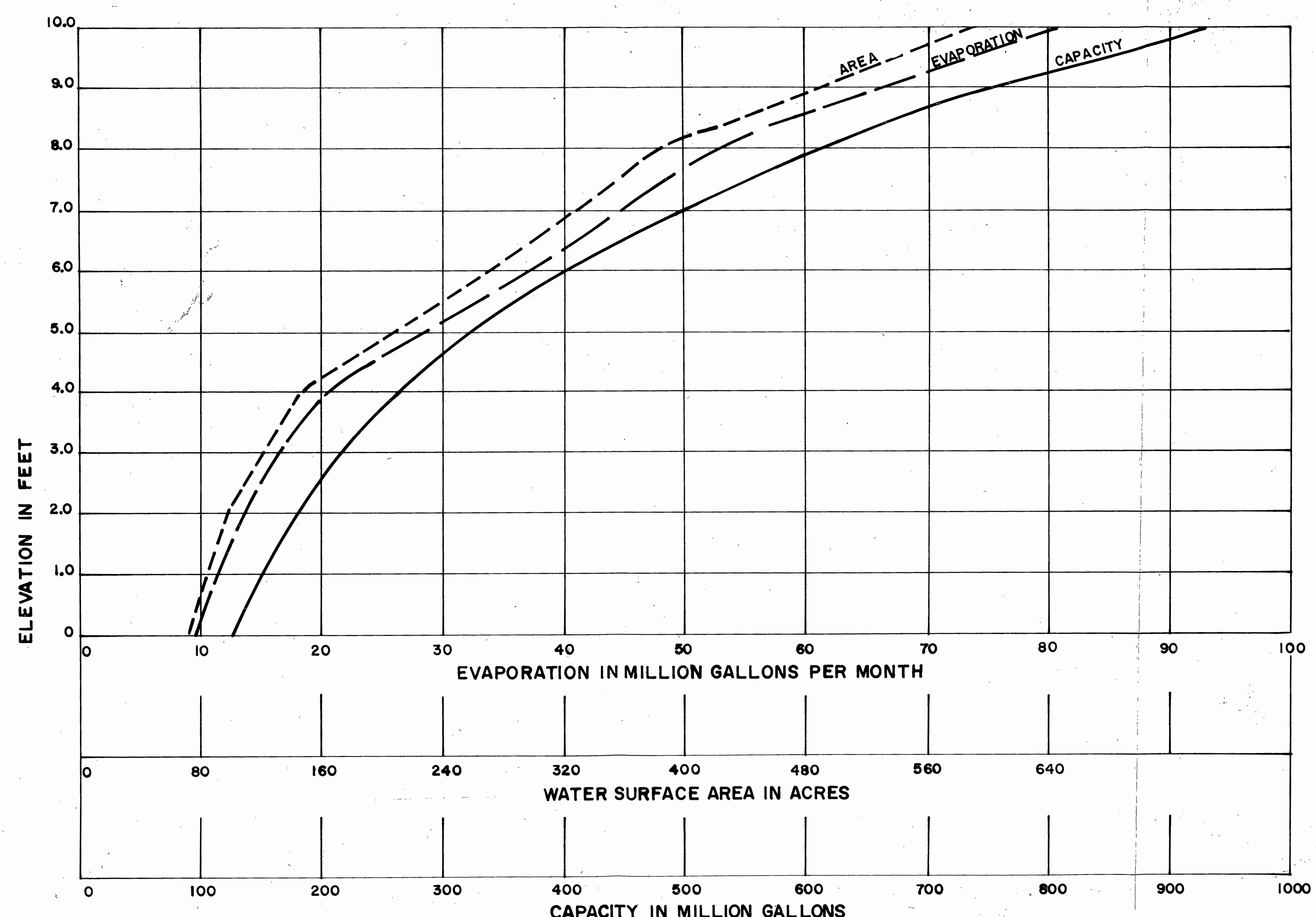

FIGURE 10

STATE OF NEW JERSEY
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DIVISION OF WATER POLICY AND SUPPLY

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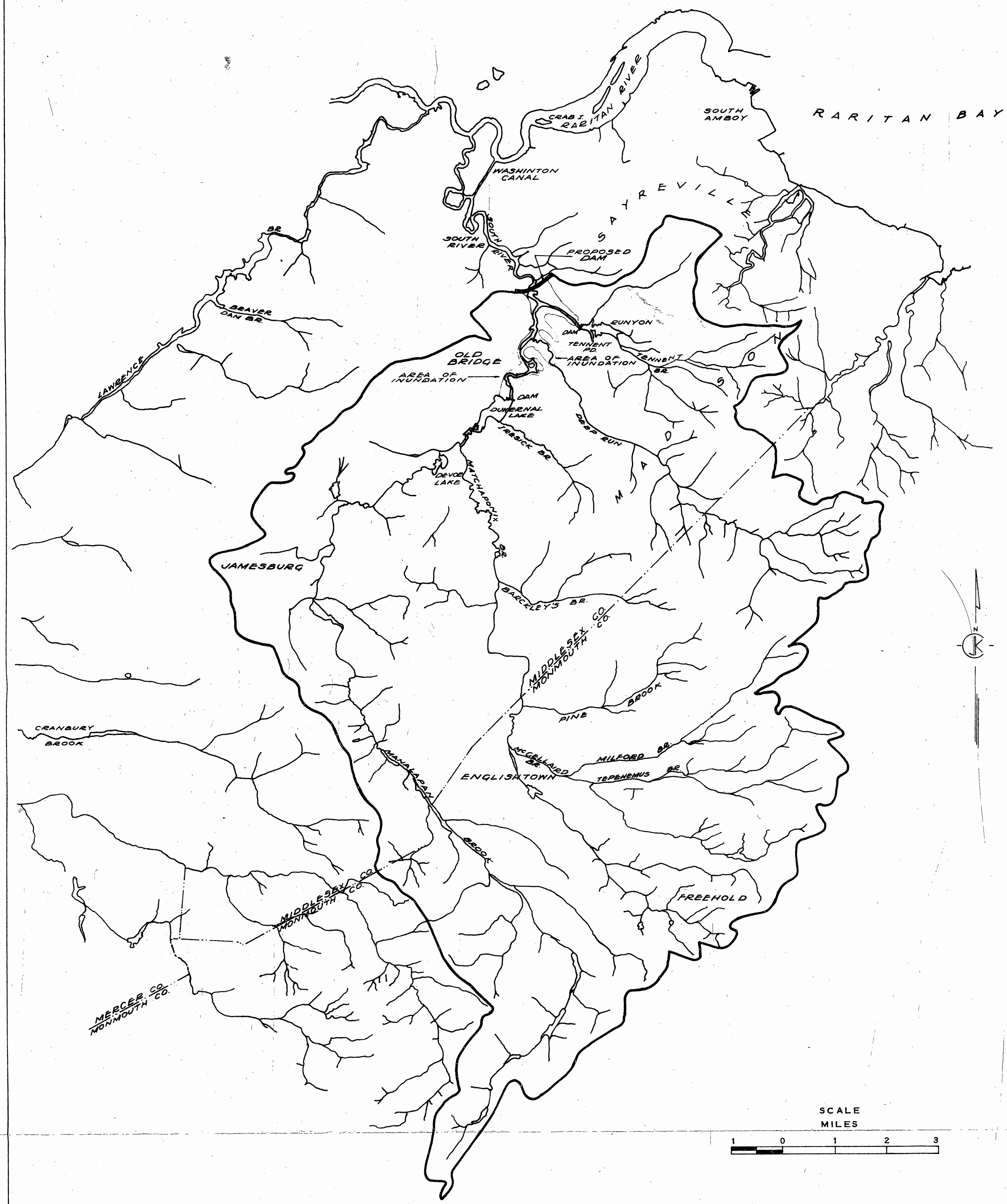
SOUTH RIVER TIDAL DAM
ELEVATION vs CAPACITY
WATER SURFACE AREA AND EVAPORATION

FIGURE II



STATE OF NEW JERSEY DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT DIVISION OF WATER POLICY AND SUPPLY	SOUTH RIVER TIDAL DAM SOUTH RIVER DRAINAGE AREA
CHARLES J. KUPPER CONSULTING ENGINEER NEW MARKET N.J.	

The proposed fresh water pond will encompass property in the four following communities:

Township of East Brunswick

Township of Madison

Borough of Sayreville

Borough of South River

The land required for the project has been established by the tax map duplicates in each community, and includes all land to the elevation of +9 feet.

LOCATION OF DAM SPILLWAY AND OUTLET STRUCTURE

The top surface of the Woodbridge Clay was found by plotting the information obtained from the soil borings. A ridge of this clay with an average elevation of -12 feet was encountered in the vicinity of the northern boundary of the Old Bridge sand intake area. In order to provide a minimum depth for the core wall, this alignment (N57°30'E) was selected for the centerline of the dam.

Although the primary purpose of this study was to design an earth dam, the Middlesex County Planning Board requested that consideration be given to the possibility of using the dam as a future highway crossing. One of the two proposed highway locations submitted by the planning board does coincide with the selected location of the earth fill dam.

The spillway section has been located on the west embankment of the South River at an angle of 65° to the centerline of the dam. This alignment for the spillway was chosen for the following reasons: (1) to allow the spillway to discharge into the present direction of flow of the river thereby creating the least amount of change in the existing flow pattern of the river downstream, (2) construction will be in a relatively dry area of undisturbed soil, (3) the clay layer is at a higher elevation allowing for a shallower foundation pit and a positive cut off can be extended directly into the impervious clay and (4) the spillway will not create a problem for a future highway bridge.

Almost complete freedom in the final design of any future four lane bridge is gained by locating the spillway at a skew to the main dam. The spillway abutments will be of reinforced concrete with the easterly abutment increased in section to serve as a future bridge abutment. In this project no bridge abutment will be provided for the westerly side which again allows for more freedom in the final bridge design with regards to alignment, grades and spans.

An outlet structure was located in this study to (1) give a method of lowering the impounded water surface, (2) remove accumulated silt which would tend to decrease the rate of recharge into the Old Bridge sand and (3) accept a future multi-lane highway without alterations.

DESIGN CRITERIA

The spillway crest elevation of +3.75 feet is considered to be the most economically feasible height. Tidal fluctuation is of equal importance as a criteria for design, because a tidal dam can not function effectively as a salt water barrier if it does not withstand all, or nearly all, tides. The highest tide elevation on record in New York City is +7.9 feet which would be approximately +8.8 feet when applied to the South River. The possibility of the extreme high tides overflowing the spillway crest will be eliminated by a Bascule gate which will effectively raise the spillway elevation to +8.75 feet. The gate will be five (5) feet in height and 200 feet wide. A typical cross-section of the spillway and Bascule gate is shown on sheet 36 of the drawings.

The cross section of the earth dam was selected having a berm twenty (20') feet in width with 3:1 slopes and is shown on sheet 35 of the drawings. To accept a multilane highway the berm would have to be eighty (80') feet in width which would be a seventy-five percent (75%) increase in the earth fill quantities.

At this time this would not be feasible; therefore, the study was completed as an earth dam making provisions in the spillway and outlet structure for the possible future expansion of the berm. Therefore, this allows a reasonable first cost for the dam with provisions for a future multilane highway crossing at the dam site.

Since the South River is tidal, the impounded area could never be drained to below mean low water or an elevation of -1.35 feet. The outlet structure was studied in a number of locations but could not satisfy all the requirements previously stated. The outlet structure was therefore situated adjacent to the spillway and perpendicular to the centerline of the dam. By making the south wing wall of the east abutment parallel to the centerline of the dam it will serve as the inlet headwall and sluice gate structure, and the northerly wing wall of the east abutment is the downstream head-wall. These headwalls provide positive cut off against seepage at the ends of the outlet structure. Additional cut off will be provided along the culvert within the earth dam. The forty (40') feet of rip rap apron for the spillway will serve to dissipate the discharge energies from the outlet structure. The box culvert outlet structure is 145 feet long and can be constructed in the clay on a fill of about five (5) feet. The southerly wing wall will be continued east past the sluice gate and return into the earth dam at the point which allows construction of a berm eighty (80') feet wide at an elevation of +12.0 feet with a 3:1 slope back towards the outlet structure.

MEASUREMENT AND CONTROL OF FLOW

As already pointed out this Tidal Dam is a rather unique structure, particularly in the area of flow control.

Not only is there a need to control the water flowing downstream from the reservoir into the South River but the controls must prevent any flow of salt water from the downstream portions of South River into the reservoir during extreme high tides. Once the water surface elevation of the reservoir is established it would be desirable to regulate the flow in order to keep this water surface elevation constant.

In order to accomplish the objectives of (a) controlling the flow of South River over the dam, (b) preventing inflow of salt water from the downstream areas of South River during extreme high tides and (c) providing a constant impounded water surface, the Bascule Gate was selected as the means of flow control. The Bascule Gate is essentially a long plate 5 feet high and 200 feet long with its long edge welded to a torque tube. The gate is mounted on top of the spillway with the axis of the torque tube parallel to the longitudinal axis of the spillway. By rotating the torque tube the gate rotates 90^{o} from an essentially vertical position during minimum flows to a horizontal position during peak flows. In the up position the top of the gate will be at elevation +8.75 ft., the maximum expected 50 year flood tide elevation. In the down position the gate will lie flat (the upstream surface of the gate will be curved to match the contour of the spillway section at an elevation of 3.75, seven inches above tidal Mean High Water (M.H.W.).

The gates will have automatic controls which will maintain a constant water surface elevation (within a 3 inch tolerance) of the impounded water of 7.5 feet. The torque system is hydraulic with provisions made for manual control.

When there is a minimum overflow the gate would be in the up position at elevation 7.5. If heavy rains caused a surge of water to enter the reservoir, the water surface would be maintained at +7.5 feet by the automatic positioning of the gate. Typical discharge-elevation curves are shown in Figure 12.

If all electrical power systems to the controls were to fail when the gate was in the up position during a peak discharge, the gate could be lowered (pushed down) by the upstream water pressure through a manual operation of the hydraulic control valves. By using an emergency high pressure surge tank, the gate could be pushed up again as the flow subsides. If another surge hit the reservoir, the gate could again be lowered. All the above manual operation would be accomplished without power and still keep the constant water surface elevation.

If an extreme high tide developed during minimum stream flow the gate could be kept up to provide a physical barrier between the fresh and salt water. If the flood tide developed at a peak discharge, only slight mixing would occur at the spillway with the gate open.

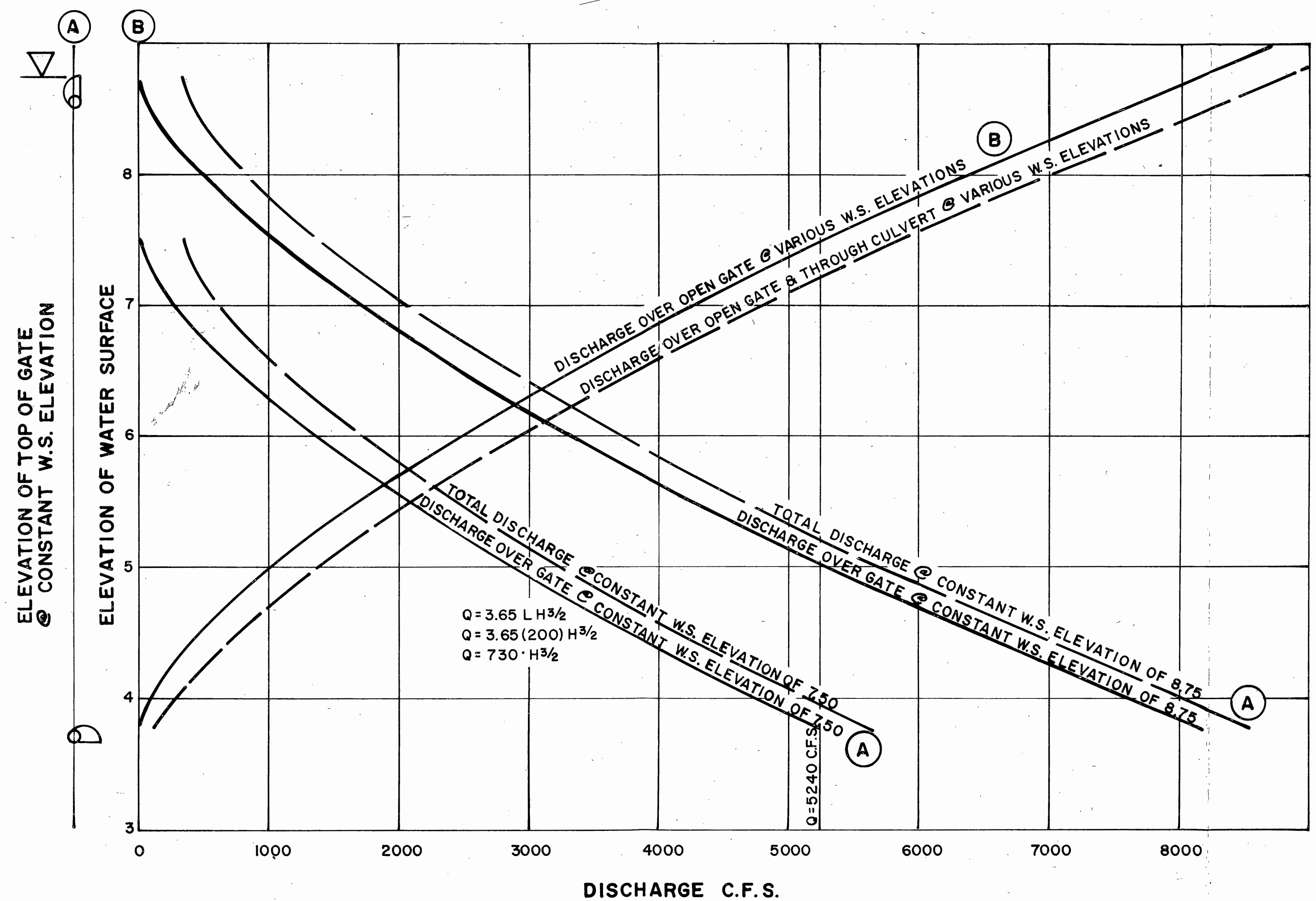


FIGURE 12

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

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CONSULTING ENGINEER NEW MARKET, N.J.

SOUTH RIVER TIDAL DAM
DISCHARGE–ELEVATION CHARACTERISTICS FOR SPILLWAY

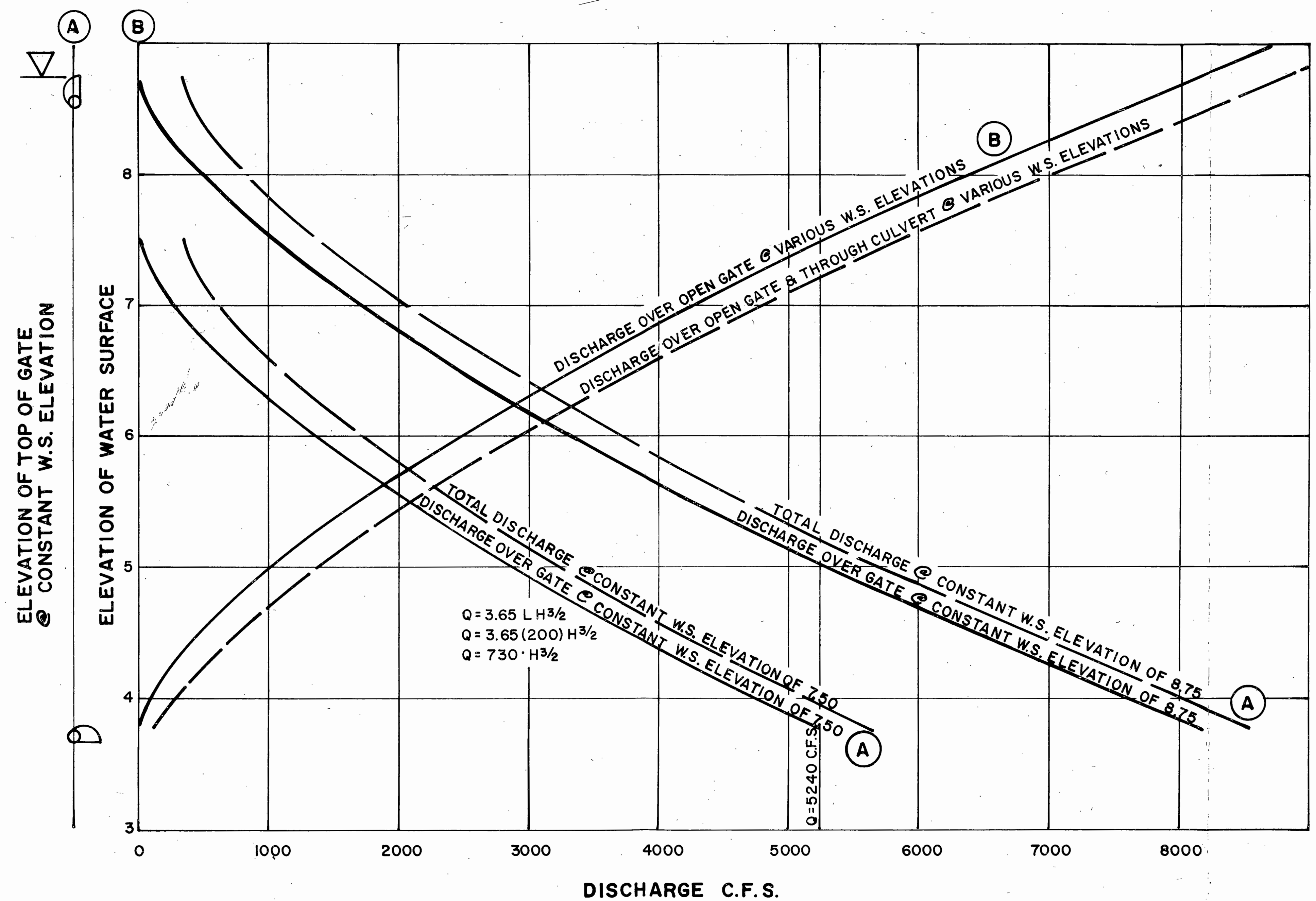

FIGURE 12

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

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CONSULTING ENGINEER NEW MARKET, N.J.

SOUTH RIVER TIDAL DAM
DISCHARGE–ELEVATION CHARACTERISTICS FOR SPILLWAY

There are many possible combinations of discharge and flood tide too numerous to mention here. However, it should be clear that all situations can be handled by the system. It can accomplish all three objectives simultaneously, even under extremely adverse emergency conditions.

During extreme discharge conditions the outflow structure can also be opened and these effects are also shown in Figure 12. The primary regulatory device for discharge flows and extreme tides will be the Bascule Gate.

Discharge measurements should be made at the dam site. Any tide measurements made in the vicinity of the dam would invariably include discharge effects which would be very hard to compensate for in reducing the readings to tide elevations. However, a scale of elevations will be established on a downstream abutment wall from which the combination flood tide and tail water elevation could be read during extreme conditions. If deemed necessary by the State an electrical time recording station, for tide elevation can be placed in the gate house.

The elevation of the reservoir and the top of the gate will be transmitted to the gate house and individually recorded in addition to the spillway discharge measurements. The discharge measurement over the spillway will be recorded on weekly charts.

RIPARIAN GRANTS AND LEASES

The location of each of the riparian grants and leases is shown on sheet 18 and 19 of the drawings in the accompanying material. At present the only two grants being used that will be affected by the proposed South River Tidal Dam are to the South River Sand Company which is still in operation. A list of the grants and leases and their present status is presented in Table IV below.

TABLE IV

Riparian Grants and Leases
Located in South River Tidal Dam Area

1. Legislative Grant to United Delaware and Raritan Canal Company, Camden and Amboy Railroad and Transportation Company and New Jersey Railroad and Transportaion Company, March 31, 1863. (Bridge Structures are being used at this Location)

2. Where Deep Run crosses Pennsylvania Railroad Legislative Grant to United Delaware and Raritan Canal Company, Camden and Amboy Railroad Transportation Company, and New Jersey Railroad Transportation Company, March 31, 1863. (Bridge structures are being used at this location.)

3. License to Frank H. Vliet (File #527 to use dock at $5.00 per year Dated Dec. 4, 1916 to Jan. 1, 1918 (Not being used)

4. Lease to South River Sand Company, Sept. 27, 1926. Amount $1,129.80 Rental $79.08, Rate per ft. $2.00 Liber N, page 11, Lease cancelled May 4, 1936.

5. Grant of two tracts to the South River Sand Co., September 1, 1936, Liber U-1, page 321, Rate per ft. $2.00, Amount $1,082.00 (This Grant is being used).

6. Lease to New York Granite Brick Company, March 22, 1906 Frontage 260', price per ft. $2.00, Amount $520.00 Annual rental $36.40 Liber Q-681. Foreclosed November 15, 1934.

7. Grant to Paragon Brick Company, August 18, 1930, Liber D2, page 96, rate per ft. $2.00, Amount $304.78.

The grant to Paragon Brick Company, item 7 above, is located downstream from the South River Tidal Dam and therefore will not be affected.

ROADS AND UTILITIES

The first step in the investigation of Roads and Utilities which might be affected by the Tidal Dam was a review of all available topographic and road maps.

Complete copies of the topographic maps of the proposed inundated area were sent to twenty-seven municipalities, Utility Companies, Industrial and Transportation Companies requesting that they indicate on these plans any underground structures, equipment or other type of structure which might be affected by the proposed construction of the Dam.

The Middlesex County and the New Jersey State Highway Engineering Departments provided available plans and maps of bridges, roads and storm drains in the area.

This information along with that obtained from field and aerial surveys was used as a basis for the study of Roads and Utilities.

ROADS

For purposes of this report, roads have been classified as follows:

Class A	Two lane primary roads with shoulders and high type pavements
Class B	Two lane secondary roads
Class C	Gravel roads
Class D	Access roads and driveways

In order to maintain the flow of traffic sections of roads that are below elevation +9 feet and within the inundated area will have to be raised. The roads affected are shown on sheets 20, 20A and 21 of the drawings and are listed below.

Class A	Old Bridge-South Amboy Road West of River Road to east of Tennents Brook; approximately 4000 feet.
Class C	Entrance road to South River Sand Company Plant; approximately 650 feet.
	Water Works Road extending from west of Deep Run to east of Tennents Brook; totaling approximately 3700 feet.
Class D	There are various access sand roads through the inundated area which have to be raised or relocated to provide continuation of use to owners at the fringe area of the reservoir. The material for this work will be taken from within the inundated area. The length is estimated at approximately 5000 feet.

The total quantity for each of the road classifications is as follows:

Class A	4000 feet
Class C	4350 feet
Class D	5000 feet

BRIDGES

There are two bridges that have to be raised as their present road grade is below the inundation level of elevation +9. One is the Old Bridge-South Amboy Road Bridge crossing Deep Run and the other is the Water Works Bridge crossing Deep Run further up stream.

These bridges will have the present concrete deck and guard rails removed; the present abutments raised and a new precast concrete deck and guard rails erected. This will bring the finished road grade to an elevation +11.0 feet in each case.

Any accumulation of debris on the water surface upstream from the railroad and highway bridges can be alleviated during the process of silt removal through the outlet structure.

Raising the bridges in this manner will restore the same traffic service as is now provided by the existing structures.

The location of these bridges is shown on sheet 22 of the drawings.

GAS LINES

The New Jersey Natural Gas Company required additional anchorage structures where their 10 inch gas main is suspended across the South River easterly of the Emerson Street-Matawan Road Bridge; due to the raising of the water level to elevation 9.

The Public Service Electric and Gas Company has gas service mains parallel to the Old Bridge-South Amboy Road and requires the lines be raised to approximately three feet below finished road grade in the areas where the roads are raised. The service lines which are now in use and located in the future inundated areas will be capped off or relocated.

The location of the gas lines is shown on sheet 26 of the drawings.

UTILITY POLES

After conferences with the Jersey Central Power & Light Company representatives, it was found that the Company wanted to be paid for moving their lines and obtaining new easements outside the inundated area. Therefore, it was decided to build islands and peninsulas to elevation 12, making their structures as accessible for maintenance and inspection as they are now.

A similar procedure will be followed where the pole lines run along the roads; the fill will be widened beyond the shoulder of the road to include the pole locations at approximately the road grade elevation.

Sheet 23 of the drawings shows the locations of the primary lines and substations in the vicinity of the project.

STORM SEWERS

Storm sewers and culverts will have to be installed, relocated and altered including construction of catch basins and inlet structures to accommodate the new conditions created by the inundation of the reservoir area, which alters the location and use of existing drainage discharge areas by raising the water level to elevation 9.

The more concentrated changes and additions take place in areas where the roads are raised; namely: Old Bridge-South Amboy Road, and Water Works Road. There are some alterations to the drainage systems in the New

Jersey State Highway Route 18 area. The construction of berms throughout the area to maintain accessibility to utilities and the protection of low lying developed areas creates another demand for additional culverts.

The outfall lines of several industries in the area will be affected by the inundation and methods for continuing existing service must be provided. They are as follows: Quigley Company, Anheuser-Busch Inc., South River Sand Company, Sunshine Biscuit, Inc. and Peter J. Schweitzer Division Kimberly Clark Division.

In spite of the intensive survey to locate the outfall lines and storm drainage affected by inundation there might still be some lines not yet determined and therefore they will have to be provided for if the situation arises.

See drawings Sheets 20, 20A and 21.

SOUTH RIVER INTERCEPTOR SEWER

All of the manholes and siphon chambers will be raised to elevation 12.

A one hundred foot wide berm will be constructed along the entire pipe line for inspection, maintenance and the construction of a dual line. This berm will be extended to include the connection line from the National Lead Company.

The Perth Amboy Water Company will require the relocation of some operating mechanisms, extensions to suction lines and protection to suction wells and water mains as they are below elevation 9. A berm will be constructed in some areas to elevation 12 to protect structures and make as accessible for inspection and maintenance as they are now.

The proposed berm and relocations are shown on sheets 25 and 39 of the drawings.

REQUIRED LAND

Robert J. Baier, Sub-Contractor, determined the location and ownership of all properties within the limit of contour 10. The property lines were shown on a set of drawings, including a list of the property owners names and addresses.

This information has been turned over to the State of New Jersey, Department of Conservation and Economic Development, Division of Water Policy and Supply, Attention: Mr. Raymond A. Webster, Supervising Engineer, at a previous date.

In order to reduce the overall cost of the project, it has been determined to include only the land within the limit of contour 9. Highly developed areas that lie below elevation 9 will be protected by dikes and filled to an elevation above the dikes thereby providing natural drainage to the reservoir.

FINANCIAL REQUIREMENTS

Immediate capital funds for acquisition of real estate, construction, engineering, legal and administrative expenses are required for major water supply projects.

Preliminary construction costs have been prepared using the preliminary engineering plans and soil borings. Actual costs will be those prevailing at the date of construction predicated on firm competitive bids from reputable contractors. A summary of costs is shown in Table V.

Table V

Preliminary Construction Cost Estimate
South River Tidal Dam

Raising manholes, siphon and meter chambers, Middlesex County Sewerage Authority	$ 8,000.
Road Relocation	200,000.
Bridges	46,000.
Storm Drains	32,000.
Gear Tooth Stripping	266,000.
Excavation for Berms	176,000.
Required Real Estate and Dikes	1,000,000.
Earth Dam, Spillway and Bascule Gate	1,901,000.
Sanitary Sewers	95,000.
Relocation for Industries and Utilities	81,000.
Total	$ 3,805,000.

Financing requirements must include in addition to construction costs, provision for engineering, legal and administrative expenses, interest during construction and contingencies.

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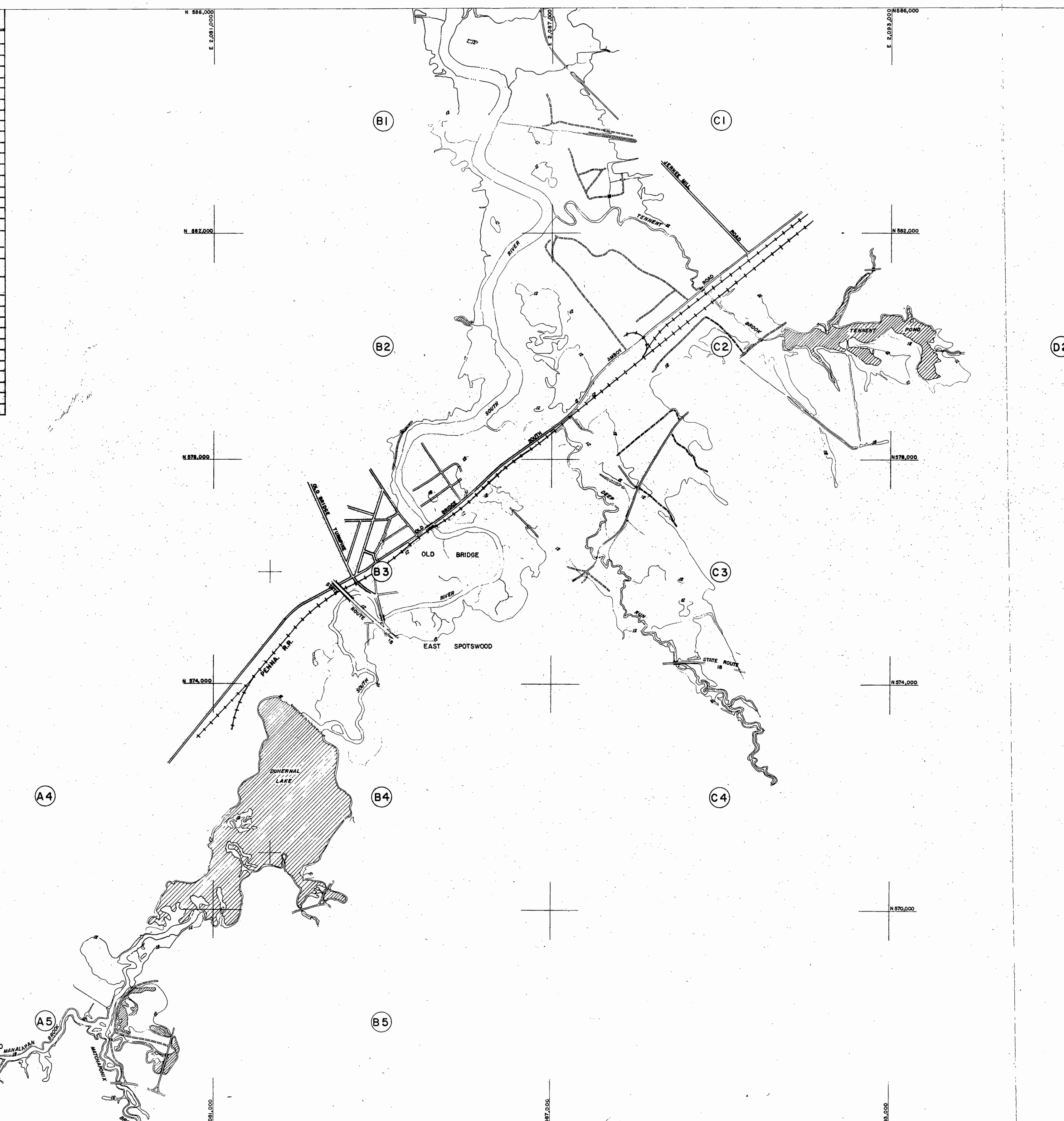
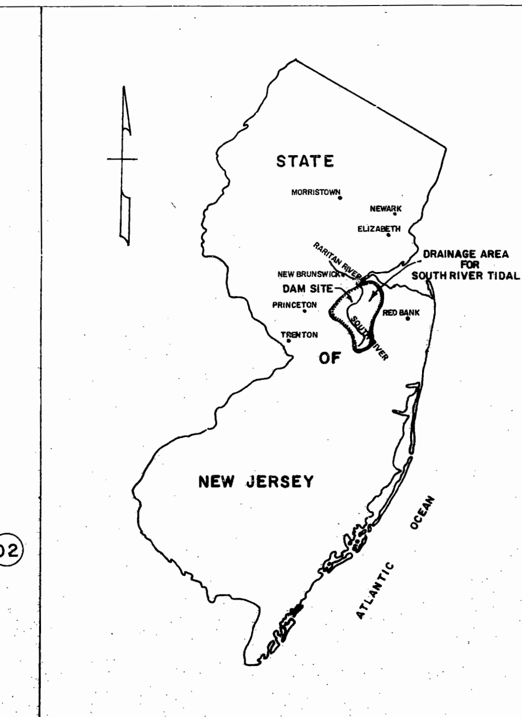
"Surface Water Records of New Jersey, 1961"

"Surface Water Records of New Jersey, 1962"

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

INDEX





VICINITY MAP

LEGEND

M.C.S.A. —— MIDDLESEX COUNTY SEWERAGE AUTHORITY- SOUTH RIVER INTERCEPTOR SEWER
M.T.S.A. —— MADISON TOWNSHIP SEWERAGE AUTHORITY-TRUNK SEWER
o S.C. —— SIPHON CHAMBER
o M.H. —— MANHOLE
o C.B. —— CATCH BASIN
C.P. —— CONCRETE PIPE
S.P. —— STEEL PIPE
T.P. —— TRANSITE PIPE
C.M.P. —— CORRUGATED METAL PIPE
C.I.P. —— CAST IRON PIPE
T.C.P. —— TERRA COTTA PIPE
△ 6130 —— N.J.G.C.S. MONUMENT
EL. —— ELEVATION-N.J.G.C.S. (U.S.C.&G.S.) DATUM-MEAN SEA LEVEL
CONTOUR LINE
PROPERTY LINE
TOWNSHIP BOUNDARY LINE
M.S.C.A. SEWER LINE
POWER LINE
GAS LINE
STRIPPING LINE
BERM LINE
PROPERTY ACQUISTION LINE
DIKE LINE
GEAR TOOTH STRIPPING

TO: THE COMMISSIONER, DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT, STATE OF NEW JERSEY, DIRECTOR, DIVISION OF WATER POLICY AND SUPPLY AND CHARLES J. KUPPER, CONSULTING ENGINEER.

THIS IS TO CERTIFY THAT THIS CONTOUR AND PLANIMETRIC MAP IS BASED ON PHOTOGRAMMETRIC ENGINEERING DONE UNDER THE SUPERVISION OF THE UNDERSIGNED, IN ACCORDANCE WITH THE SPECIFICATIONS DATED DECEMBER 31, 1962

Edward B. Van Cott C.E.
NAME

PROFESSIONAL ENGINEER AND LAND SURVEYOR
NEW JERSEY LICENCE NO. 8233

SURVEYS BY:
G. Albert Platt
G. ALBERT PLATT
PROFESSIONAL ENGINEER AND LAND SURVEYOR
NEW JERSEY LICENCE NO. 3382
TOMS RIVER, NEW JERSEY

PREPARED BY
AMERICAN AIR SURVEYS, INC.
907 PENN AVENUE
PITTSBURGH, PA.
L 772

CHARLES J. KUPPER
CONSULTING ENGINEER
NEW MARKET, N.J.

1000 500 0 1000 2000 3000 4000
SCALE 1" = 1000'
12' CONTOUR SHOWN

REVISIONS

NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

SOUTH RIVER TIDAL DAM SITE
INDEX AND VICINITY MAP
CONTRACT NO. WR-16 SHEET NO. 1 OF 39
INDEX SHEET

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

1. GRANT TO PARAGON BRICK COMPANY, AUGUST 18, 1930, LIBER D2 PAGE 96, RATE PER FT. $2.00, AMOUNT $304.78.

2. LEASE TO NEW YORK GRANITE BRICK COMPANY, MARCH 22, 1906, FRONTAGE 260', PRICE PER FT. $2.00, AMOUNT $520.00, ANNUAL RENTAL $36.40. LIBER Q-681. FORECLOSED NOVEMBER 15, 1934.

3. LEASE TO SOUTH RIVER SAND COMPANY, SEPTEMBER 27, 1926. AMOUNT $1,129.80, RENTAL $79.08, RATE PER FT. $2.00. LIBER N, PAGE 11, LEASE CANCELLED MAY 4, 1936.

4. GRANT OF TWO TRACTS TO THE SOUTH RIVER SAND COMPANY SEPTEMBER 1, 1936, LIBER U-1, PAGE 321. RATE PER FT. $2.00. AMOUNT $1,082.00.

5. WHERE DEEP RUN CROSSES PENNSYLVANIA RAILROAD. LEGISLATIVE GRANT TO UNITED DELAWARE AND RARITAN CANAL COMPANY, CAMDEN AND AMBOY RAILROAD AND TRANSPORTATION COMPANY AND NEW JERSEY RAILROAD AND TRANSPORTATION COMPANY, MARCH 31, 1863.

SOUTH RIVER TIDAL DAM SITE
MIDDLESEX COUNTY NEW JERSEY

MAP SHOWING AREA OF THE RIPARIAN GRANTS AND LEASES AFFECTED BY THE INUNDATION

SCALE: 1" = 400' DATE: SEPT. 1963

CHARLES J. KUPPER
REG. PROF. ENGR. NO. 1556
15 STELTON ROAD NEW MARKET, N.J.

NO.	DATE	DESCRIPTION	CHKD.	APPRD.

REVISIONS

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DRAWN ______ APPROVED ______
TRACED ______

CONTRACT NO. WR-16 SHEET NO. 18 OF 39

MATCH LINE TO SHEET 19

SCALE 1" = 400' (400 200 0 400 800 1200 1600) CONTOUR INTERVAL 4

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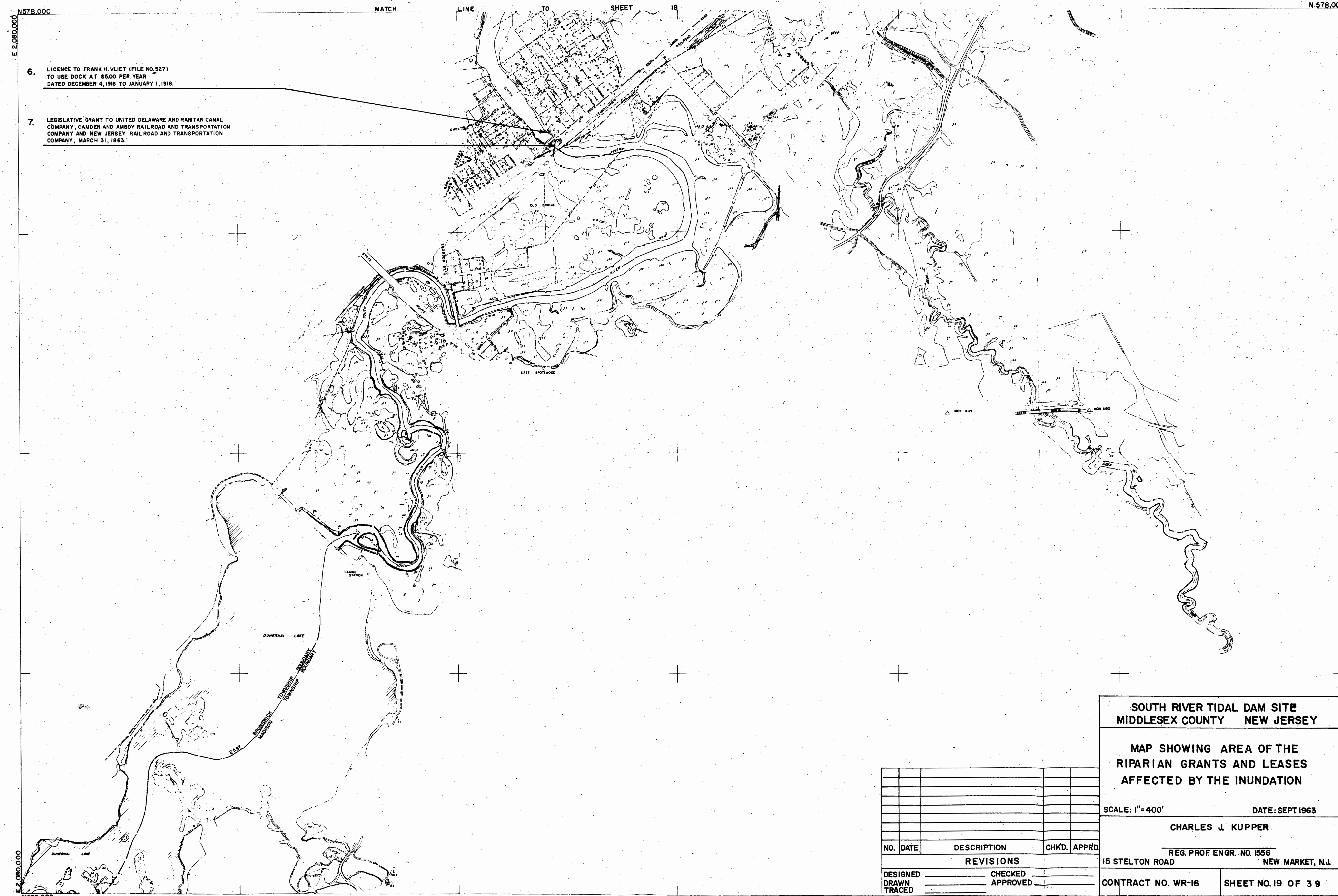
A 772

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



6. LICENCE TO FRANK H. VLIET (FILE NO. 527)
TO USE DOCK AT $5.00 PER YEAR
DATED DECEMBER 4, 1916 TO JANUARY 1, 1918.

7. LEGISLATIVE GRANT TO UNITED DELAWARE AND RARITAN CANAL COMPANY, CAMDEN AND AMBOY RAILROAD AND TRANSPORTATION COMPANY AND NEW JERSEY RAILROAD AND TRANSPORTATION COMPANY, MARCH 31, 1863.

SOUTH RIVER TIDAL DAM SITE
MIDDLESEX COUNTY NEW JERSEY

MAP SHOWING AREA OF THE RIPARIAN GRANTS AND LEASES AFFECTED BY THE INUNDATION

SCALE: 1" = 400'
DATE: SEPT. 1963

CHARLES J. KUPPER
REG. PROF. ENGR. NO. 1556
15 STELTON ROAD NEW MARKET, N.J.

NO.	DATE	DESCRIPTION	CHK'D.	APPR'D.

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CONTRACT NO. WR-16
SHEET NO. 19 OF 39

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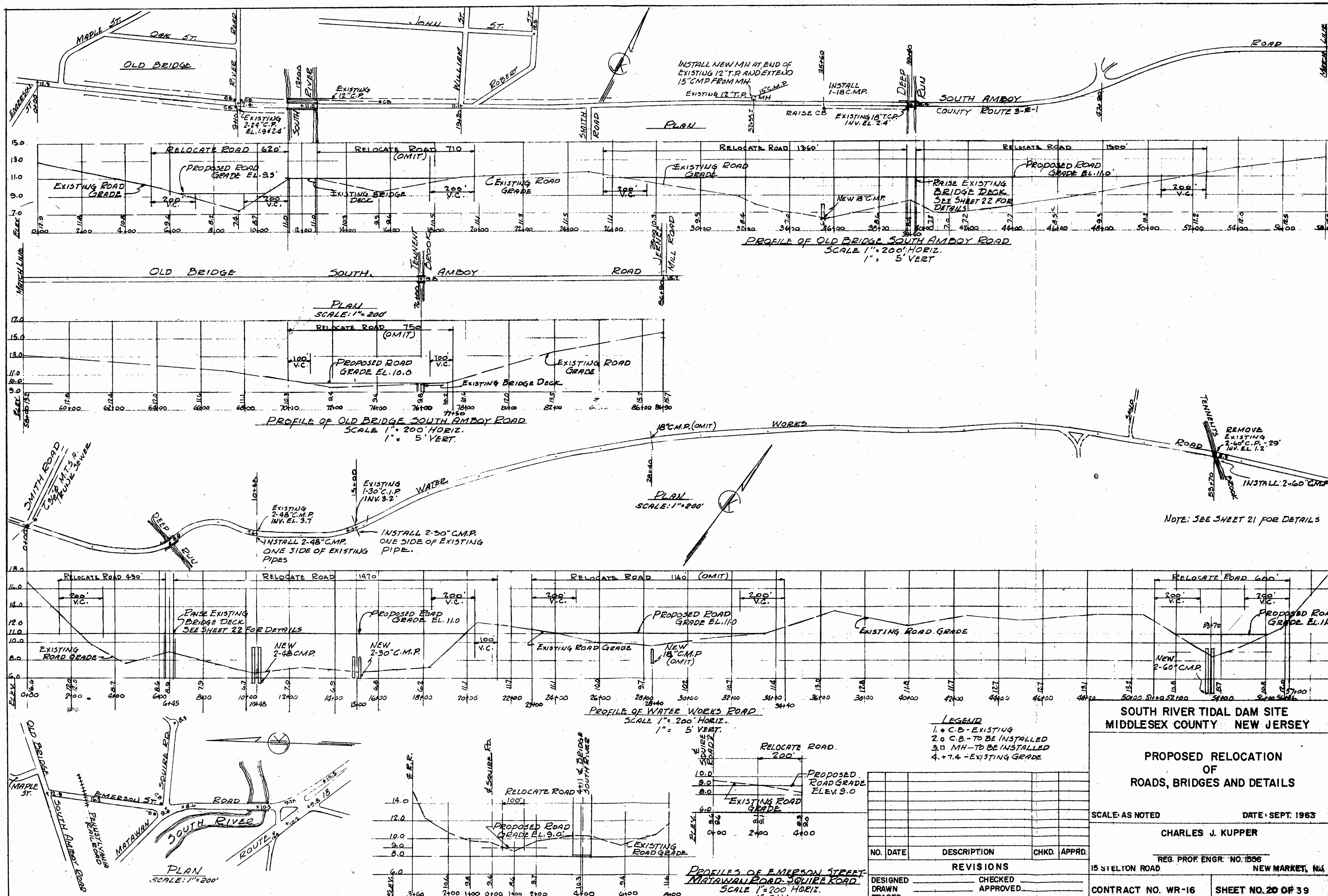
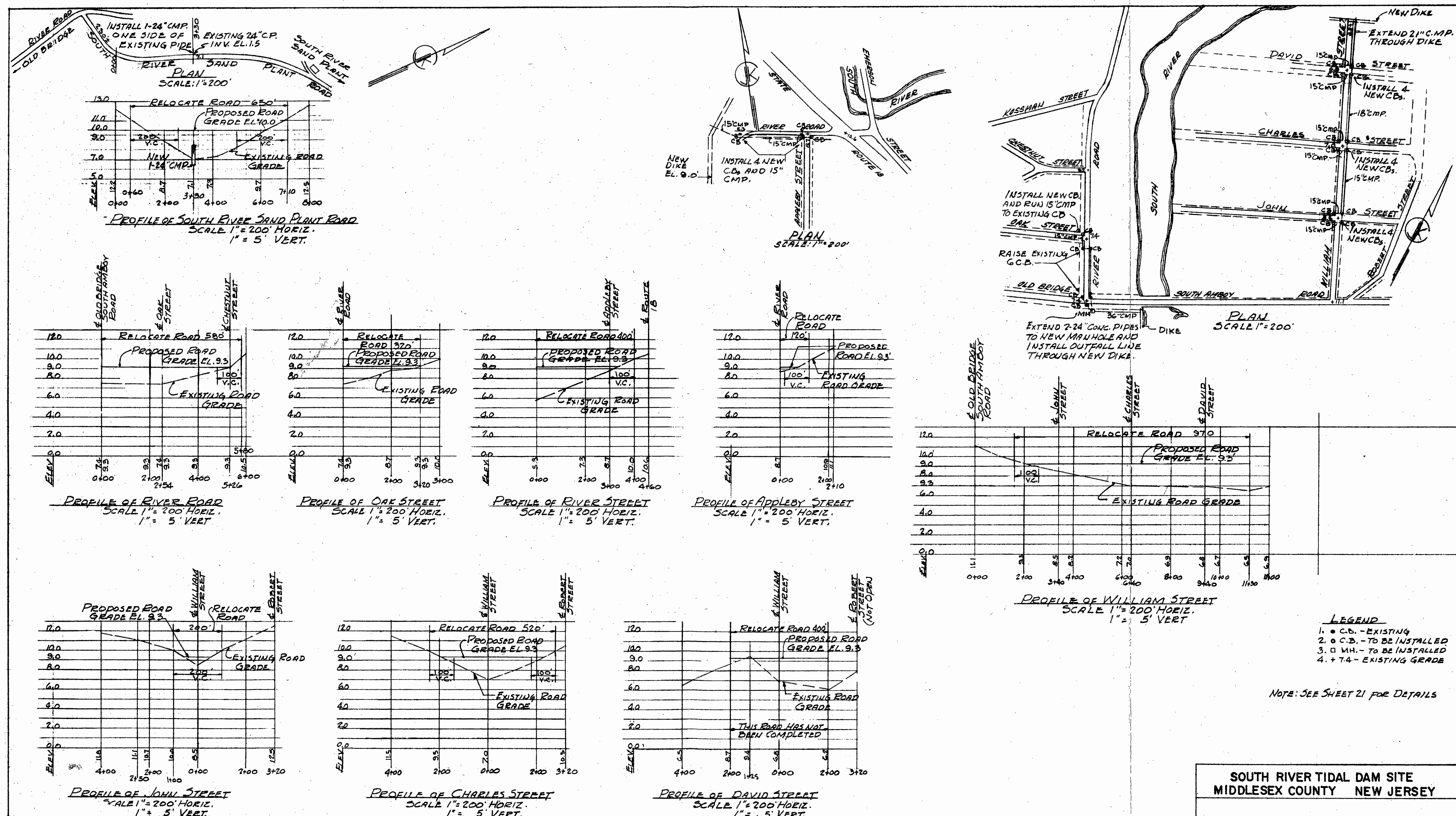
SCALE 1" = 400'   400 200 0 400 800 1200 1600   CONTOUR INTERVAL 4

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY





SOUTH RIVER TIDAL DAM SITE
MIDDLESEX COUNTY NEW JERSEY

PROPOSED RELOCATION OF ROADS, BRIDGES AND DETAILS

SCALE: AS NOTED — DATE: SEPT. 1963

CHARLES J. KUPPER
REG. PROF. ENGR. NO. 1556
15 STELTON ROAD, NEW MARKET, N.J.

NO.	DATE	DESCRIPTION	CHKD.	APPRD.

REVISIONS

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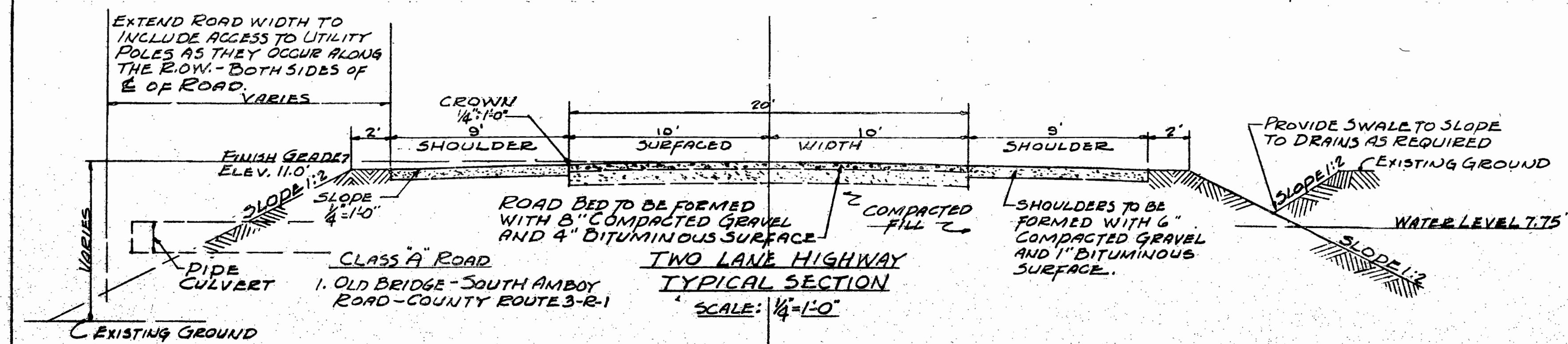
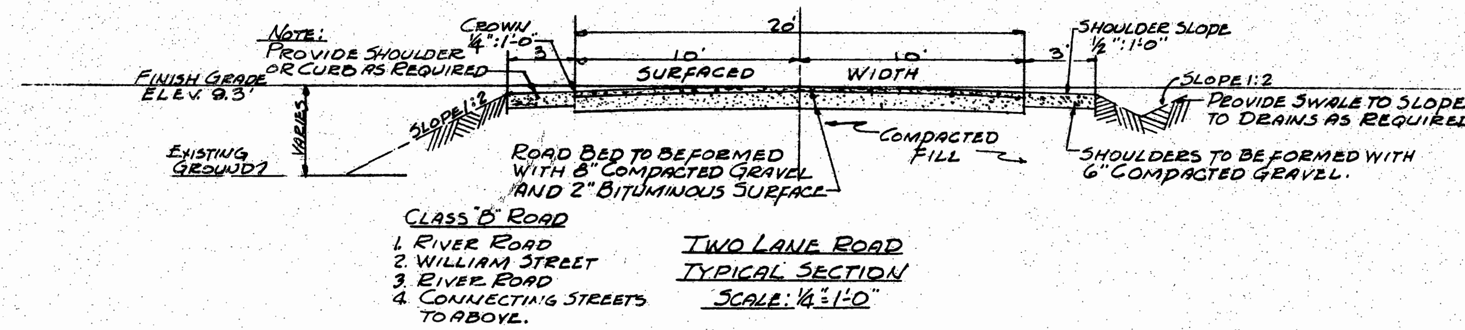
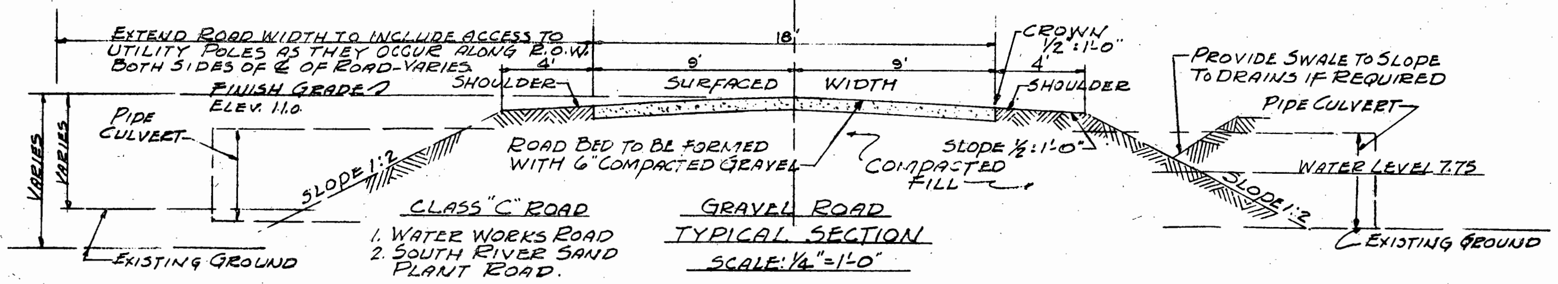
DRAWN ______ APPROVED ______
TRACED ______

CONTRACT NO. WR-16 — SHEET NO. 20A OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY







NOTE: SEE SHEETS 20 AND 20A FOR LOCATION

NO.	DATE	DESCRIPTION	CHKD.	APPRD.

REVISIONS

DESIGNED ______ CHECKED ______
DRAWN ______ APPROVED ______
TRACED

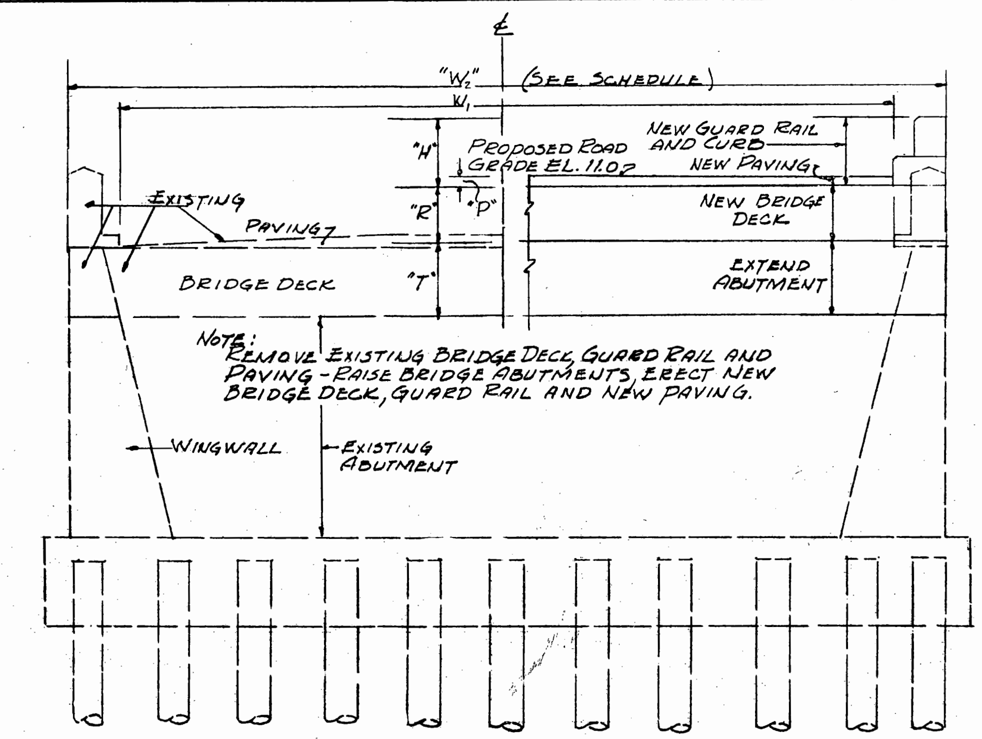
SOUTH RIVER TIDAL DAM SITE
MIDDLESEX COUNTY NEW JERSEY

PROPOSED RELOCATION
OF
ROADS, BRIDGES AND DETAILS

SCALE: AS NOTED DATE: SEPT. 1963

CHARLES J. KUPPER
REG. PROF. ENGR. NO. 1556
15 STELTON ROAD NEW MARKET, N.J.

CONTRACT NO. WR-16 SHEET NO. 21 OF 39

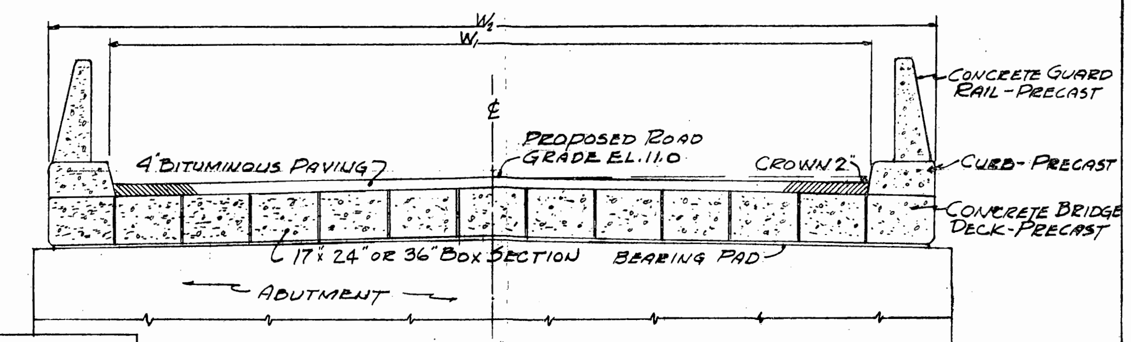


TYPICAL END SECTION
NO SCALE

LOCATION	L	H	R	S	T	V	W₁	W₂	P
OLD BRIDGE-SOUTH AMBOY ROAD BRIDGE	31'	4'±	1.4'	28'	3.4'±	1.5'	23.3'	26.3'	0.3'
WATER WORKS ROAD BRIDGE	35.4'	4'±	1.4	30	3.5'±	2.7'	24.3'	28.3'	0.3'

SCHEDULE

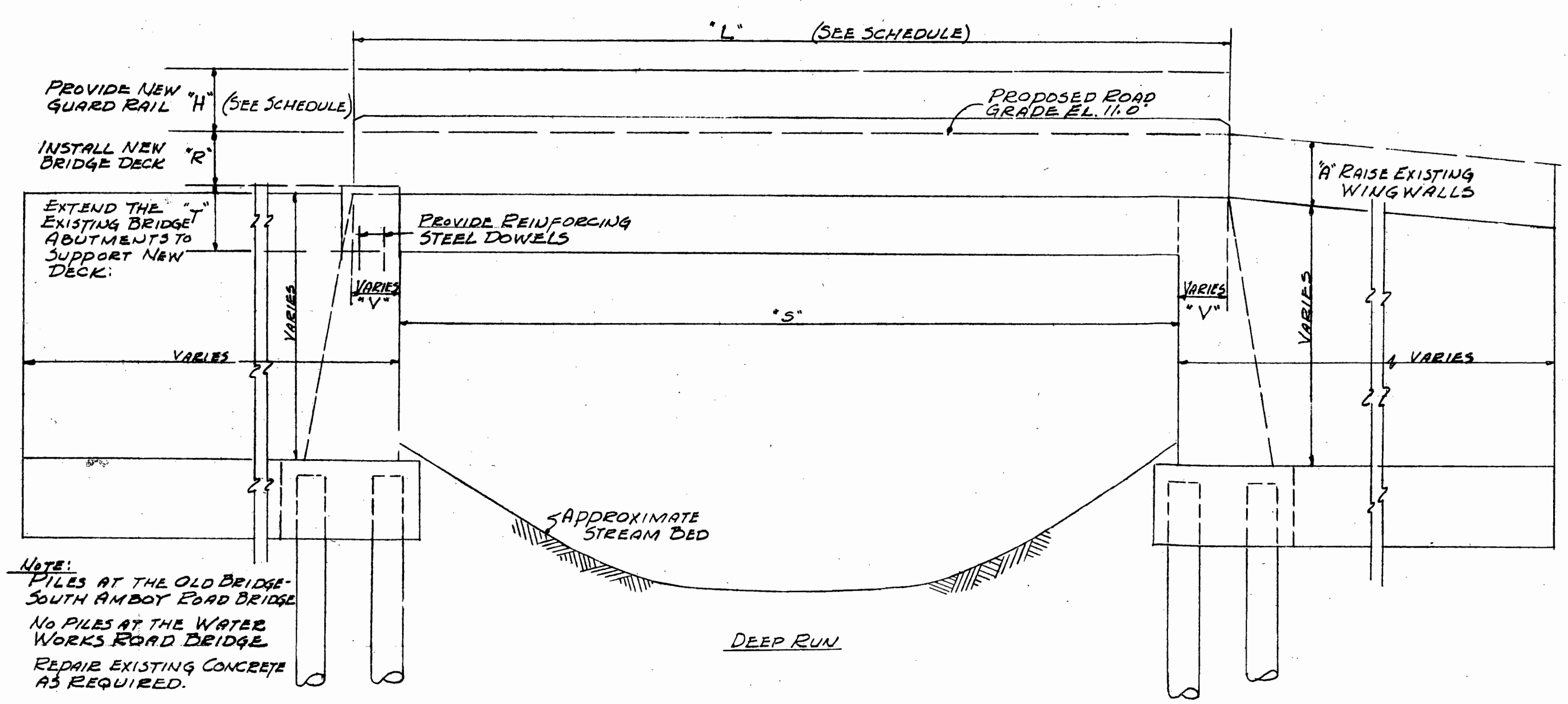
NOTE: ALL DIMENSIONS TO BE CHECKED IN FIELD.



TYPICAL SECTION SHOWING NEW DECK, GUARD RAIL AND PAVING
NO SCALE

	LOCATION	ELEV ℄ ROAD	DEPTH	ELEV. OF BOTTOM	LENGTH	ROAD WIDTH	FOOT WALK	TOTAL WIDTH	TYPE OF BRIDGE
1.	EMERSON ST. & SOUTH RIVER 1927	10.3	3.0	BOTTOM 12x12 CAP 7.3'	89'	23.9'	6.3	30.2	STEEL & GIRDERS TIMBER BENTS
2.	OLD BRIDGE-SOUTH AMBOY ROAD & SOUTH RIVER	11.0	3.5	7.5	136.7	30.1	8.0	45.0	REINF. CONCRETE
3.	RAILROAD BRIDGE & SOUTH RIVER	11.8	4.3	7.5	137'	2 TRACKS		25'	REINF CONCRETE
4	SOUTH AMBOY ROAD & DEEP RUN-1914 TO BE RAISED	8.4	2.6	5.8	31'	23.3	—	26.3	REINF. CONCRETE SLAB
5.	RAILROAD BRIDGE & DEEP RUN	9.8	4.2	5.6	31'±	2 TRACKS		25'±	REINF CONCRETE
6.	SOUTH AMBOY ROAD & TENNENT BROOK 1915	9.8	2.4	7.4	28.3	23.6	—	25.6	REINF. CONCRETE SLAB
7.	RAILROAD BRIDGE & TENNETT BROOK	11.8	3.5	8.3	29'±	2 TRACKS		25'±	STEEL GIRDERS
8.	WATER WORKS ROAD & DEEP RUN-TO BE RAISED	8.9	3.2	5.7	34'	24.3	—	28.3	REINF. CONCRETE STEEL GIRDERS
9.	ROUTE 18 & DEEP RUN	15.8	—	BOTTOM 12x12 CAP 12.70	NOT AFFECTED			—	WOOD GIRDERS ON TIMBER BENTS

BRIDGES IN INUNDATED AREA



NOTE: PILES AT THE OLD BRIDGE-SOUTH AMBOY ROAD BRIDGE
NO PILES AT THE WATER WORKS ROAD BRIDGE
REPAIR EXISTING CONCRETE AS REQUIRED.

TYPICAL ELEVATION
NO SCALE

NOTE: SEE SHEET 20 FOR LOCATION

NO.	DATE	DESCRIPTION	CHKD.	APPRD.

REVISIONS

DESIGNED ______ CHECKED ______
DRAWN ______ APPROVED ______
TRACED ______

SOUTH RIVER TIDAL DAM SITE
MIDDLESEX COUNTY NEW JERSEY

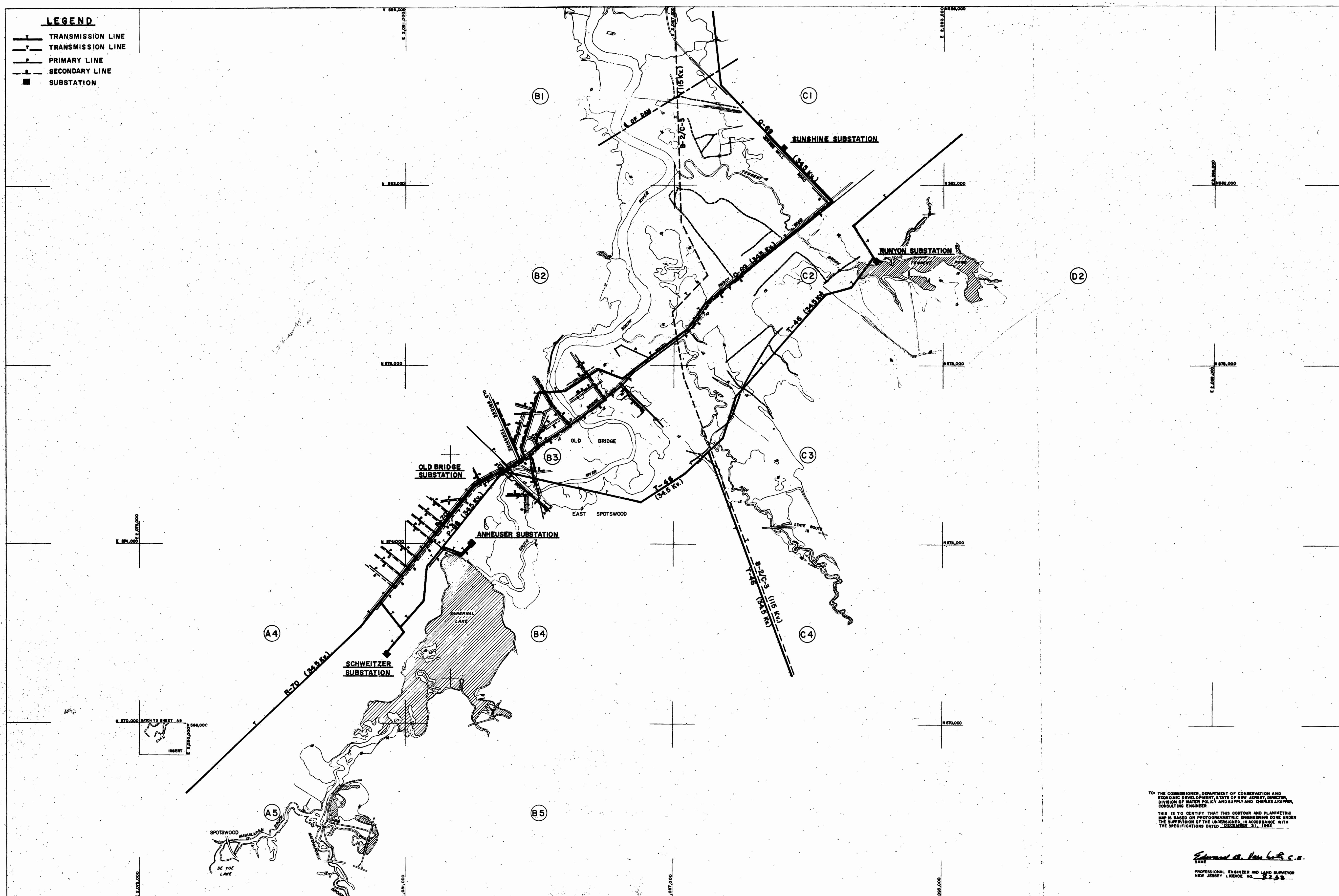
PROPOSED RELOCATION OF ROADS, BRIDGES AND DETAILS

SCALE: AS NOTED DATE: SEPT. 1963

CHARLES J. KUPPER
REG. PROF. ENGR. NO. 1556
15 STELTON ROAD NEW MARKET, N.J.

CONTRACT NO. WR-16 SHEET NO. 22 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



TO: THE COMMISSIONER, DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT, STATE OF NEW JERSEY, DIRECTOR, DIVISION OF WATER POLICY AND SUPPLY AND CHARLES J. KUPPER, CONSULTING ENGINEER.

THIS IS TO CERTIFY THAT THIS CONTOUR AND PLANIMETRIC MAP IS BASED ON PHOTOGRAMMETRIC ENGINEERING DONE UNDER THE SUPERVISION OF THE UNDERSIGNED, IN ACCORDANCE WITH THE SPECIFICATIONS DATED DECEMBER 31, 1962

C.E.
NAME

PROFESSIONAL ENGINEER AND LAND SURVEYOR
NEW JERSEY LICENCE NO. 8233

PREPARED BY
AMERICAN AIR SURVEYS, INC.
907 PENN AVENUE
PITTSBURGH, PA.
772

CHARLES J. KUPPER
CONSULTING ENGINEER
NEW MARKET, N.J.

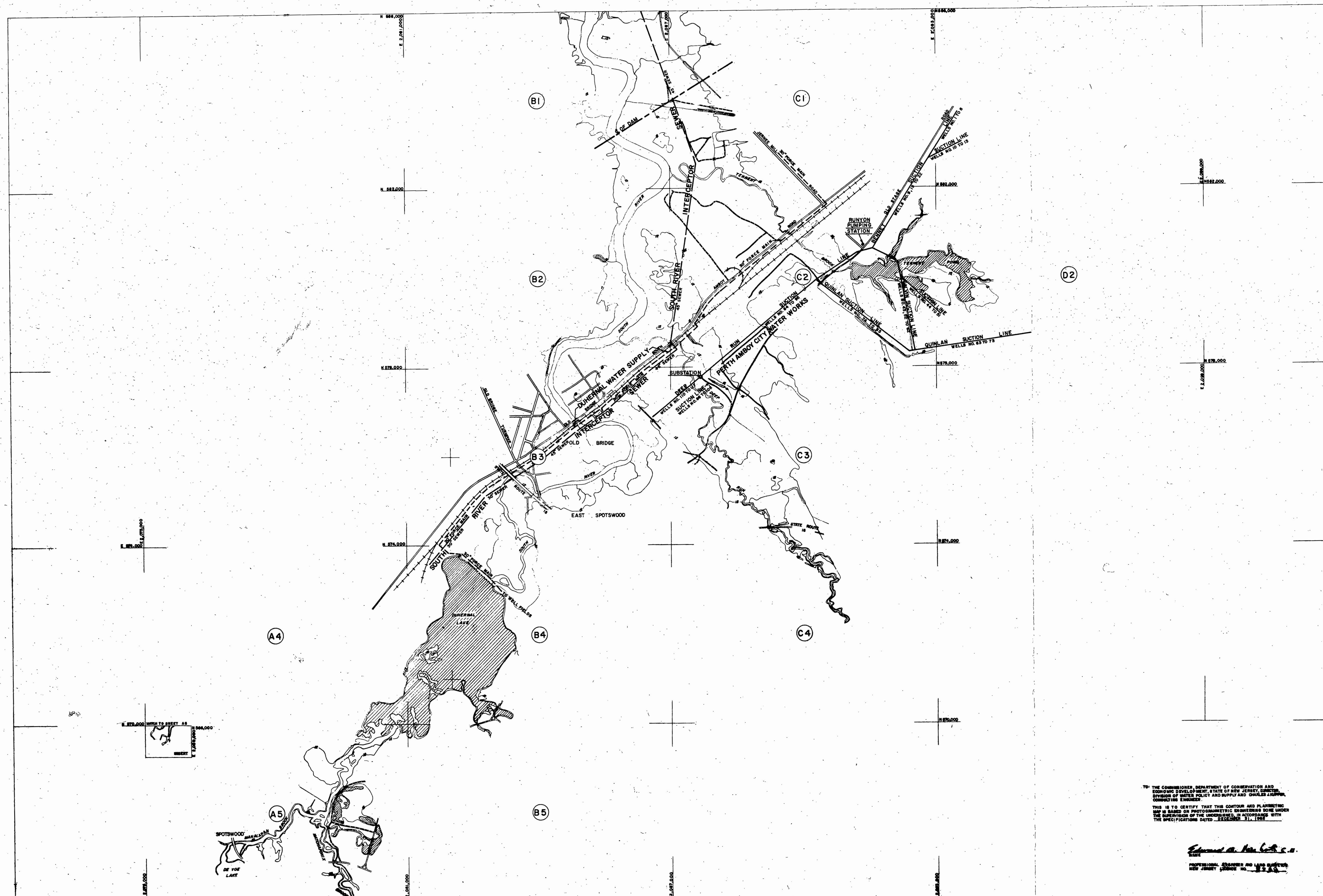
SCALE 1" = 1000' — 1000 500 0 1000 2000 3000 4000 — 12' CONTOUR SHOWN

REVISIONS

NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

SOUTH RIVER TIDAL DAM SITE
JERSEY CENTRAL POWER & LIGHT COMPANY
TRANSMISSION, PRIMARY & SECONDARY LINES & SUBSTATIONS
CONTRACT NO. WR-16 SHEET NO. 23 OF 39
INDEX SHEET

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



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Edward A. [illegible] C.E.
NAME

PROFESSIONAL ENGINEER AND LAND SURVEYOR
NEW JERSEY LICENSE NO. [illegible]

PREPARED BY
AMERICAN AIR SURVEYS, INC.
907 PENN AVENUE
PITTSBURGH, PA.

CHARLES J. KUPPER
CONSULTING ENGINEER
NEW MARKET, N.J.

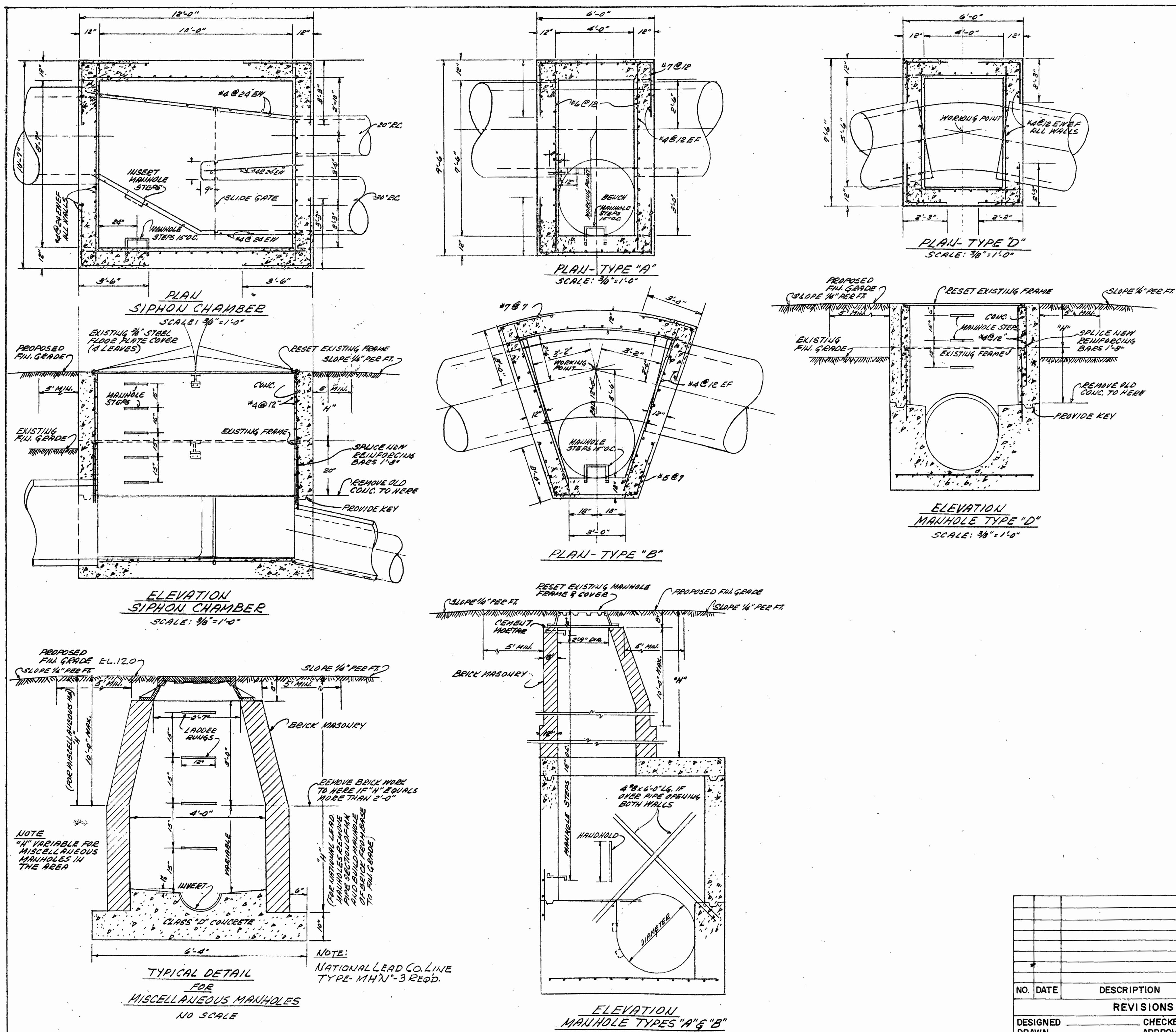
SCALE 1" = 1000'   12' CONTOUR SHOWN

REVISIONS

NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

SOUTH RIVER TIDAL DAM SITE
SOUTH RIVER INTERCEPTOR SEWER,
DUHERNAL AND PERTH AMBOY WATER LINES
CONTRACT NO. WR-16   SHEET NO. 24 OF 39
INDEX SHEET

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



SCHEDULE

LOCATION	STATION	TYPE	EXISTING ELEVATION	PROPOSED ELEVATION	"H"
INTERCEPTOR LINE	151+00	M.H. "A"	8.7'±	12.00'	3'-4"±
" "	156+00	M.H. "A"	9.9'±	12.00'	2'-2"±
" "	165+93	M.H. "B"	9.6'±	12.00'	2'-5"±
TENNETS BROOK CROSSING	167+84	S.C.	7.7'±	12.00'	4'-4"±
" " "	169+34	S.C.	8.1'±	12.00'	3'-11"±
INTERCEPTOR LINE	178+00	M.H. "A"	11.1'±	12.00'	0'-11"±
DEEP RUN CROSSING	206+07	S.C.	7.7'±	12.00'	4'-4"±
" " "	207+99	S.C.	8.4'±	12.00'	3'-7"±
INTERCEPTOR LINE	208+29	M.H. "D"	8.6'±	12.00'	3'-5"±
" "	216+85	M.H. "D"	9.1'±	12.00'	2'-11"±
SOUTH RIVER CROSSING	234+28	S.C.	9.8'±	12.00'	2'-3"±
" " "	237+88	S.C.	11.2'±	12.00'	0'-10"±
NATIONAL LEAD LINE	SEE TYPICAL DETAIL	M.H. "N"	7.8'±	12.00	8'-10"±

NO.	DATE	DESCRIPTION	CHKD.	APPRD.

REVISIONS

DESIGNED ______ CHECKED ______
DRAWN ______ APPROVED ______
TRACED ______

SOUTH RIVER TIDAL DAM SITE
MIDDLESEX COUNTY NEW JERSEY

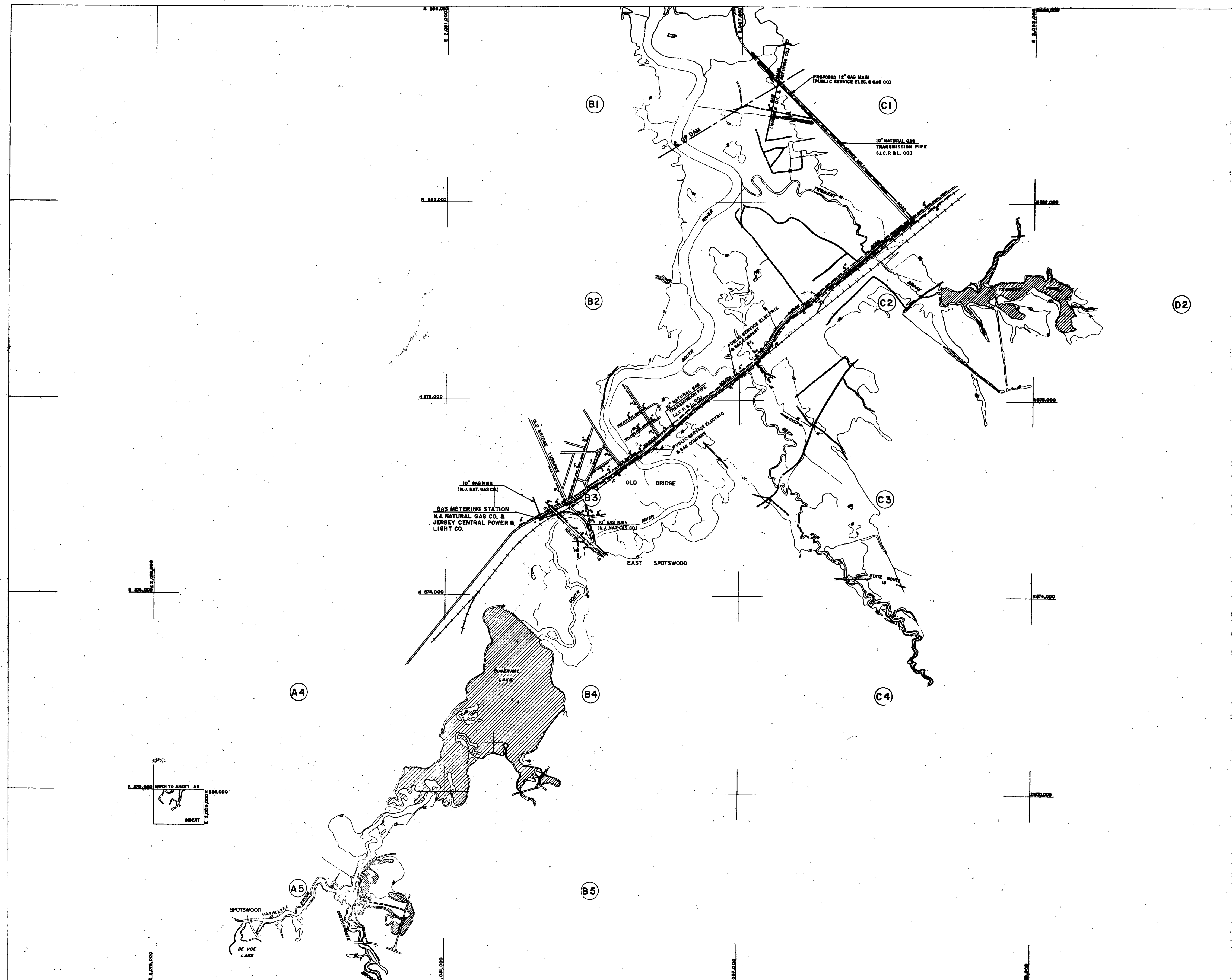
MISCELLANEOUS SEWER DETAILS

SCALE: AS NOTED DATE: SEPT. 1963

CHARLES J. KUPPER
REG. PROF. ENGR. NO. 1556
15 STELTON ROAD NEW MARKET, N.J.

CONTRACT NO. WR-16 SHEET NO. 25 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



TO: THE COMMISSIONER, DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT, STATE OF NEW JERSEY, DIRECTOR, DIVISION OF WATER POLICY AND SUPPLY AND CHARLES J. KUPPER, CONSULTING ENGINEER.

THIS IS TO CERTIFY THAT THIS CONTOUR AND PLANIMETRIC MAP IS BASED ON PHOTOGRAMMETRIC ENGINEERING DONE UNDER THE SUPERVISION OF THE UNDERSIGNED, IN ACCORDANCE WITH THE SPECIFICATIONS DATED DECEMBER 31, 1962

NAME

PROFESSIONAL ENGINEER AND LAND SURVEYOR
NEW JERSEY LICENSE NO. [illegible]

PREPARED BY
AMERICAN AIR SURVEYS, INC.
907 PENN AVENUE
PITTSBURGH, PA.
A 772

CHARLES J. KUPPER
CONSULTING ENGINEER
NEW MARKET, N.J.

SCALE 1" = 1000'

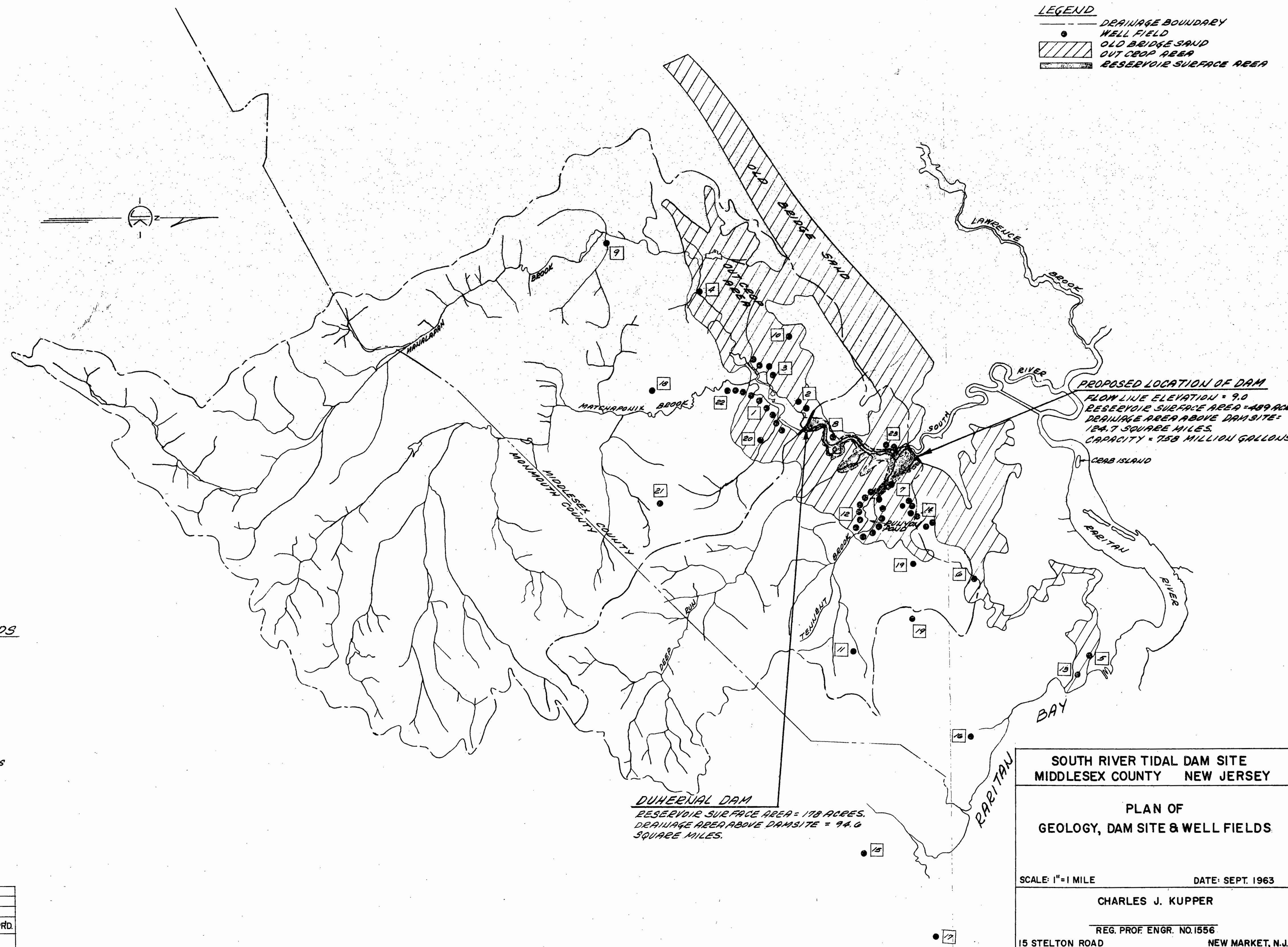
1000 500 0 1000 2000 3000 4000

12' CONTOUR SHOWN

REVISIONS								
NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

SOUTH RIVER TIDAL DAMSITE
GAS LINES AND OIL LINES
CONTRACT NO. WR-16 SHEET NO. 26 OF 39
INDEX SHEET

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



WATER COMPANY WELL FIELDS

1- DUHERNAL WATER CO.
2- ANHEUSER-BUSCH, INC.
3- R.J. SCHWEITZER, INC.
4- G.W. HELME CO.
5- JERSEY CENTRAL P.&L.
6- J.H. MONTEATH CO.
7- SUNSHINE BISCUIT, INC.
8- W. RALSTON & CO.
9- FORSGATE FARMS
10- EAST BRUNSWICK TOWNSHIP
11- WESTBURY WATER CO.
12- PERTH AMBOY CITY WATER WORKS
13- SOUTH AMBOY WATER DEPT.
14- SAYREVILLE WATER DEPT.
15- KEYPORT WATER DEPT.
16- LAWRENCE HARBOR WATER CO.
17- UNION BEACH WATER DEPT.
18- RELIABLE WATER CO.
19- MIDTOWN WATER CO.
20- MADISON WATER CO.
21- BROWNTOWN WATER CO.
22- SPOTSWOOD WATER CO.
23- SOUTH RIVER WATER CO.

NO.	DATE	DESCRIPTION	CHK'D.	APPR'D.

REVISIONS

DESIGNED ______ CHECKED ______
DRAWN ______ APPROVED ______
TRACED ______

SOUTH RIVER TIDAL DAM SITE
MIDDLESEX COUNTY NEW JERSEY

PLAN OF GEOLOGY, DAM SITE & WELL FIELDS

SCALE: 1" = 1 MILE   DATE: SEPT. 1963

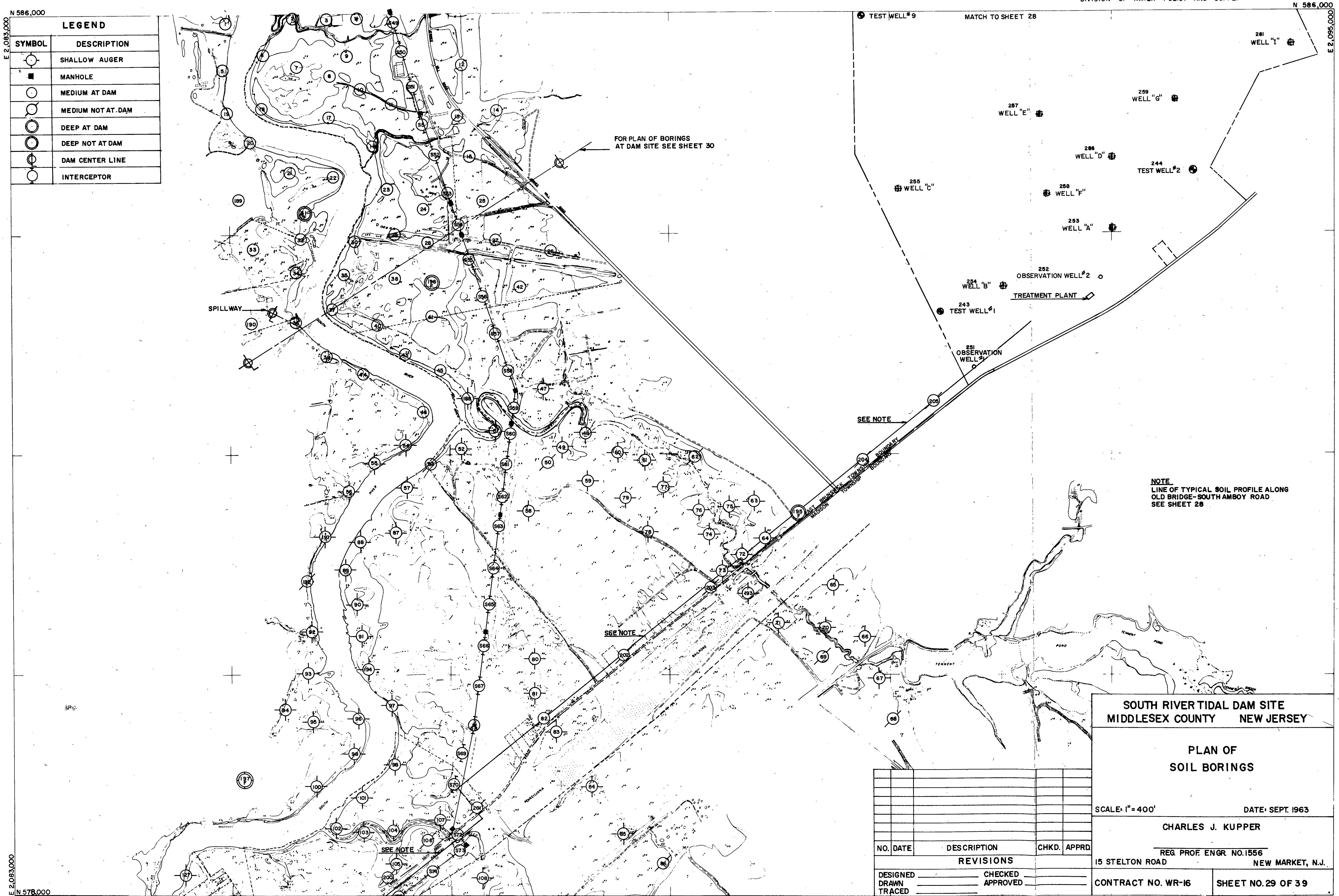
CHARLES J. KUPPER
REG. PROF. ENGR. NO. 1556
15 STELTON ROAD   NEW MARKET, N.J.

CONTRACT NO. WR-16   SHEET NO. 27 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

LEGEND

SYMBOL	DESCRIPTION
	SHALLOW AUGER
	MANHOLE
	MEDIUM AT DAM
	MEDIUM NOT AT DAM
	DEEP AT DAM
	DEEP NOT AT DAM
	DAM CENTER LINE
	INTERCEPTOR



PREPARED BY
AMERICAN AIR SURVEYS, INC.
907 PENN AVENUE
PITTSBURGH, PA.

SCALE 1" = 400'   CONTOUR INTERVAL 4'

NO.	DATE	DESCRIPTION	CHKD.	APPRD.

REVISIONS

DESIGNED ______ CHECKED ______
DRAWN ______ APPROVED ______
TRACED ______

SOUTH RIVER TIDAL DAM SITE
MIDDLESEX COUNTY NEW JERSEY

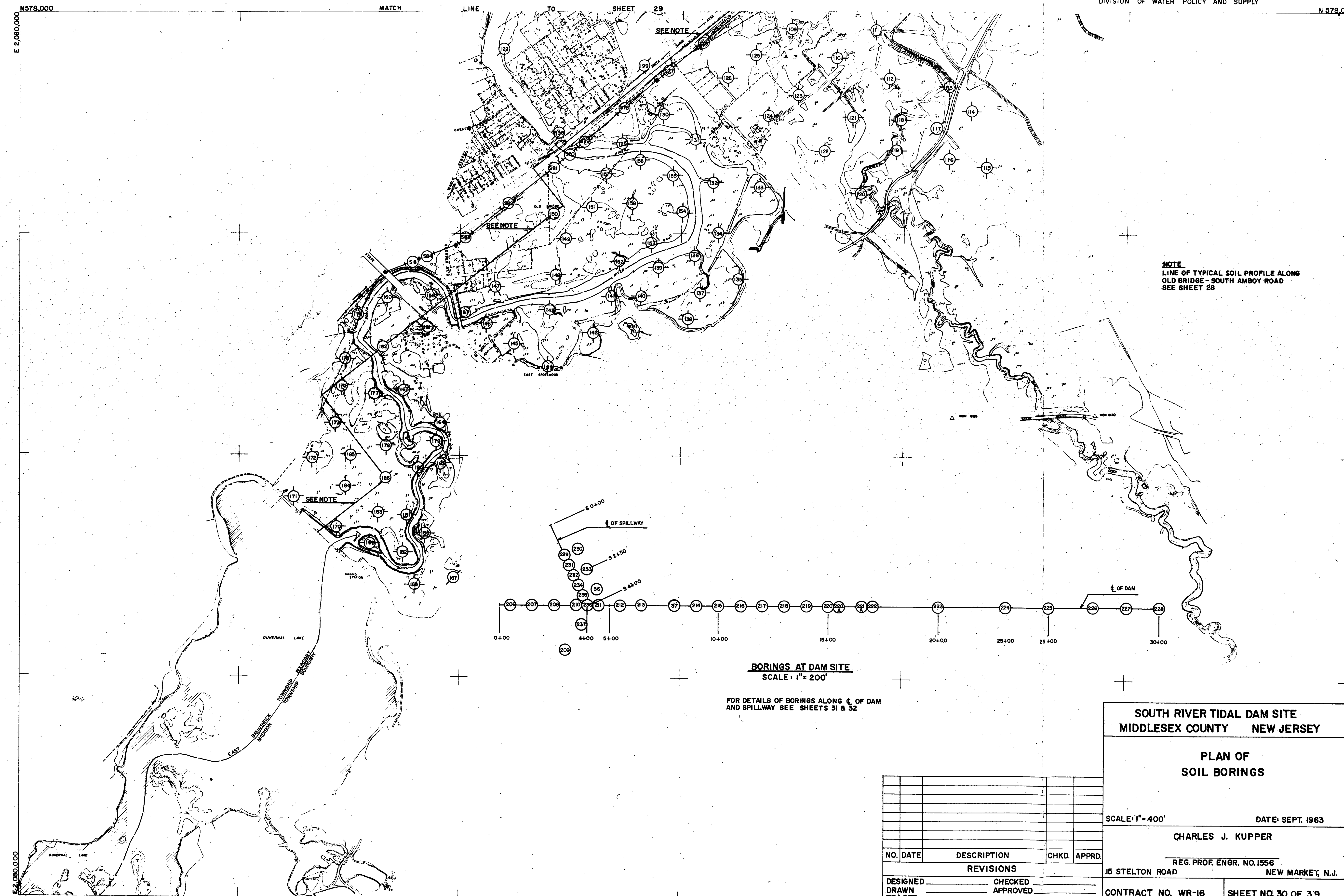
PLAN OF SOIL BORINGS

SCALE: 1" = 400'   DATE: SEPT. 1963

CHARLES J. KUPPER
REG. PROF. ENGR. NO. 1556
15 STELTON ROAD   NEW MARKET, N.J.

CONTRACT NO. WR-16   SHEET NO. 29 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



NOTE
LINE OF TYPICAL SOIL PROFILE ALONG OLD BRIDGE - SOUTH AMBOY ROAD
SEE SHEET 28

BORINGS AT DAM SITE
SCALE: 1" = 200'

FOR DETAILS OF BORINGS ALONG ℄ OF DAM AND SPILLWAY SEE SHEETS 31 & 32

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SCALE 1" = 400'
CONTOUR INTERVAL 4

NO.	DATE	DESCRIPTION	CHKD.	APPRD.
		REVISIONS		

DESIGNED ______ CHECKED ______
DRAWN ______ APPROVED ______
TRACED ______

SOUTH RIVER TIDAL DAM SITE
MIDDLESEX COUNTY NEW JERSEY

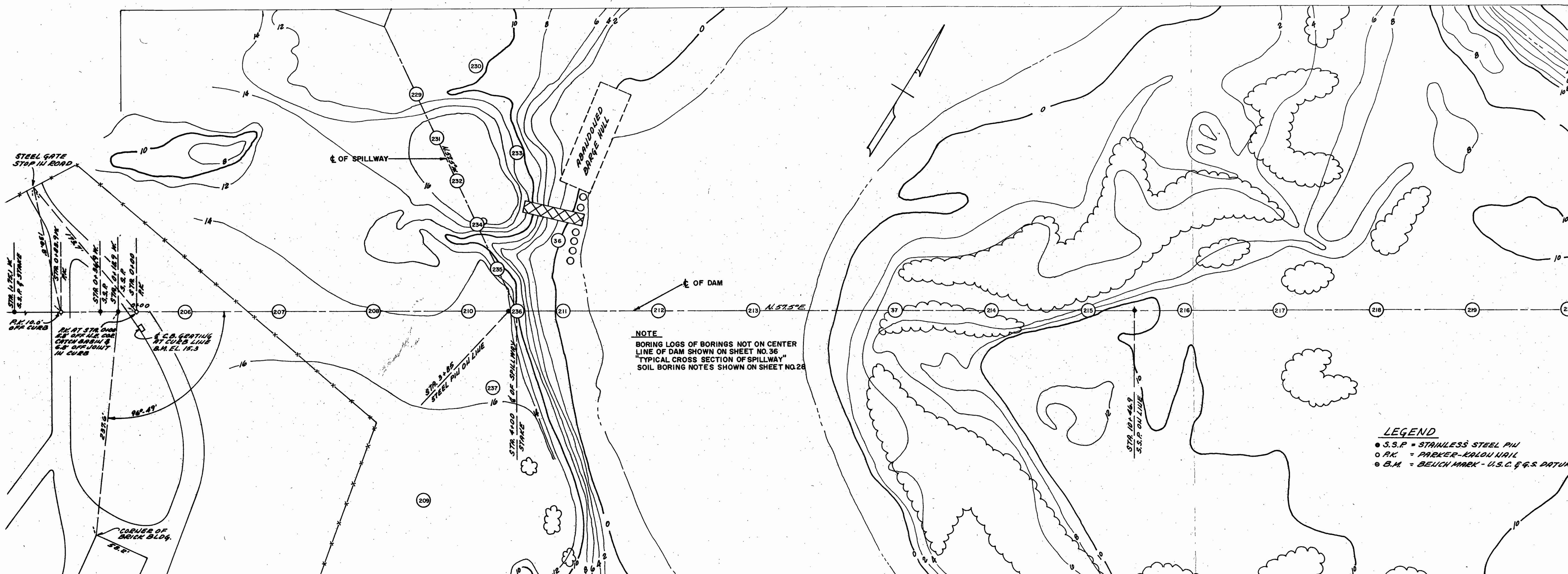
PLAN OF
SOIL BORINGS

SCALE: 1" = 400'
DATE: SEPT. 1963

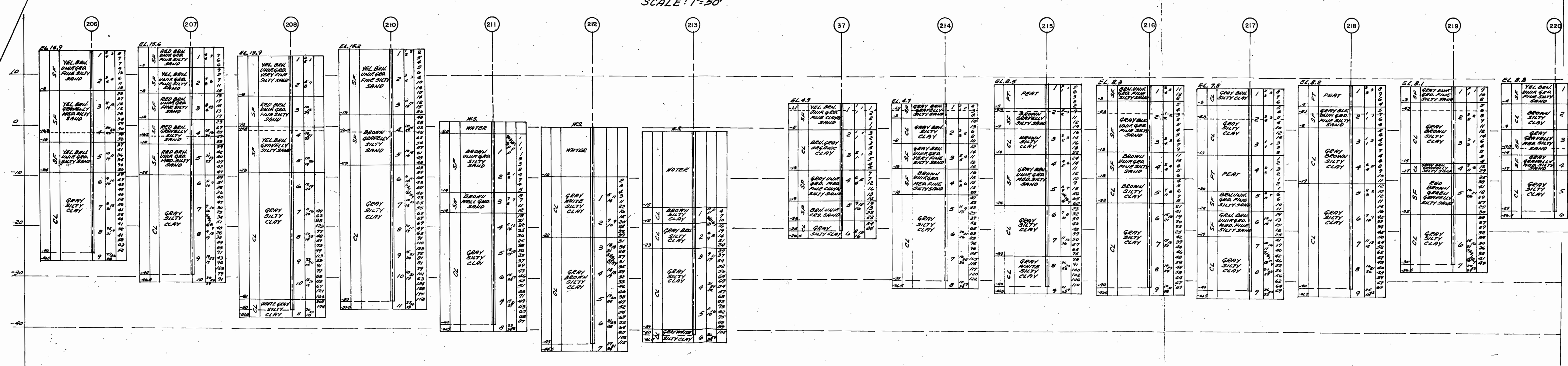
CHARLES J. KUPPER
REG. PROF. ENGR. NO. 1556
15 STELTON ROAD NEW MARKET, N.J.

CONTRACT NO. WR-16
SHEET NO. 30 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



PLAN OF SOIL BORINGS AND SURVEY TIES
SCALE: 1"=50'



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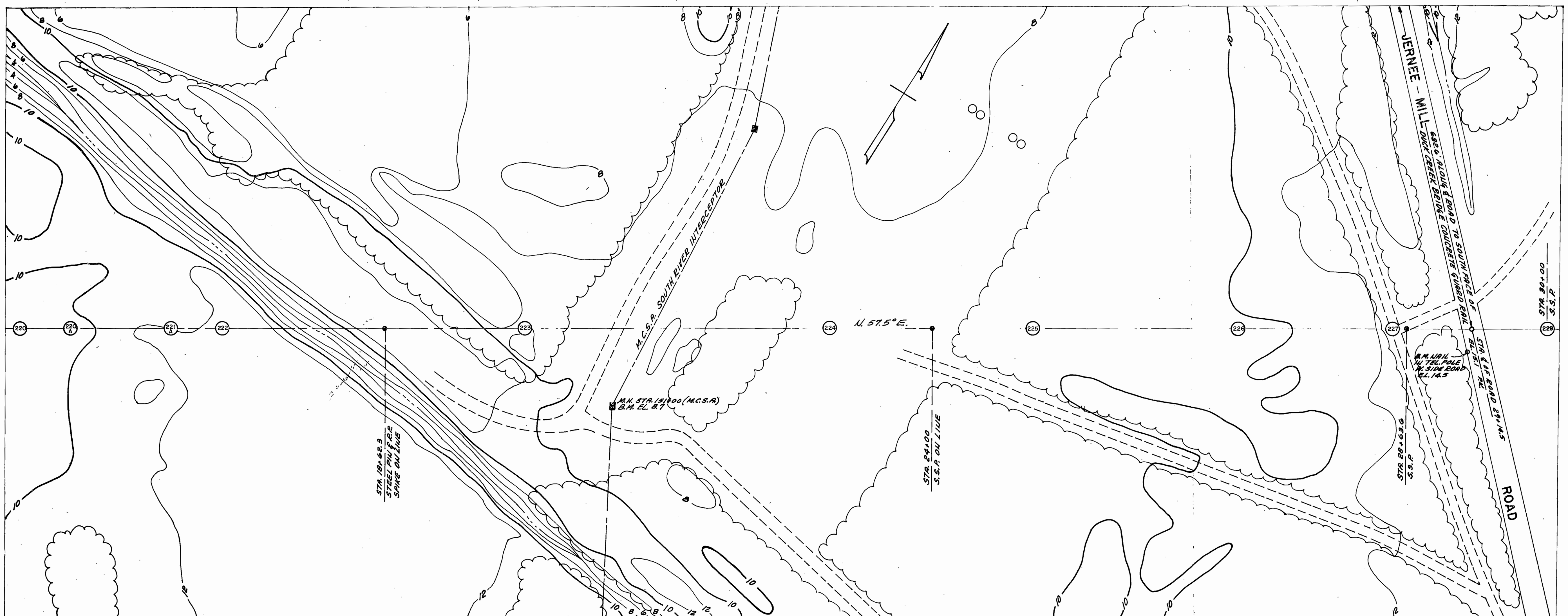
NEW MARKET, N.J.

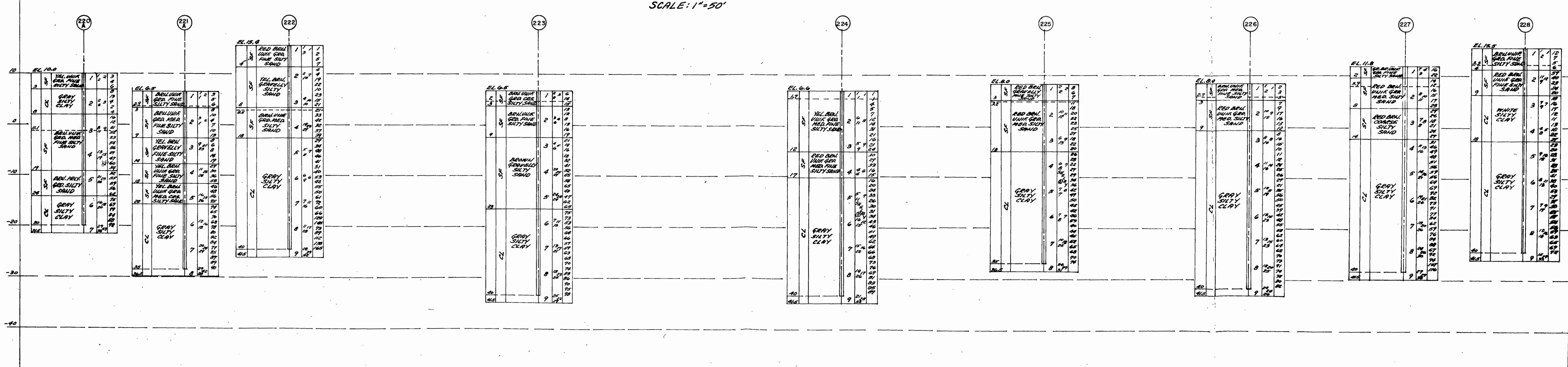
REVISIONS								
NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

SOUTH RIVER TIDAL DAM SITE
SOIL BORINGS ℄ OF DAM
CONTRACT NO. WR-16 SHEET NO. 31 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



PLAN OF SOIL BORINGS AND SURVEY TIES
SCALE: 1" = 50'



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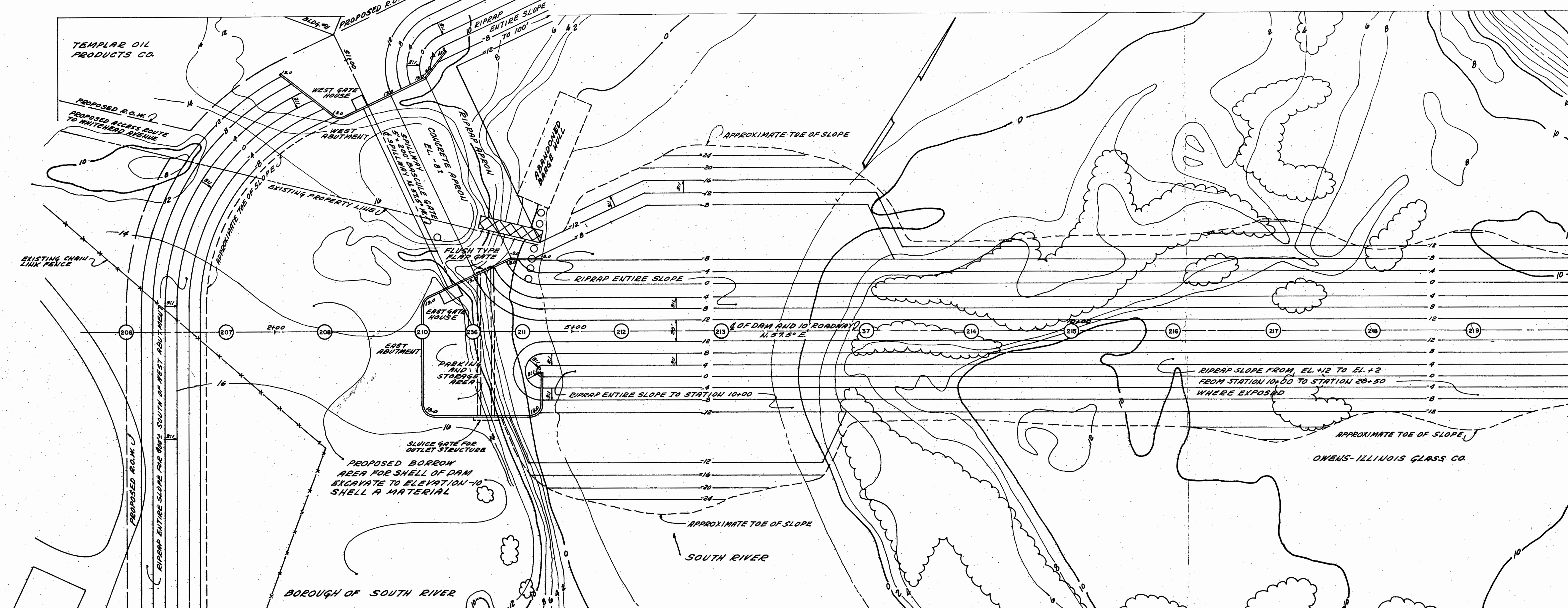
CONSULTING ENGINEER
NEW MARKET, N.J.

REVISIONS

NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

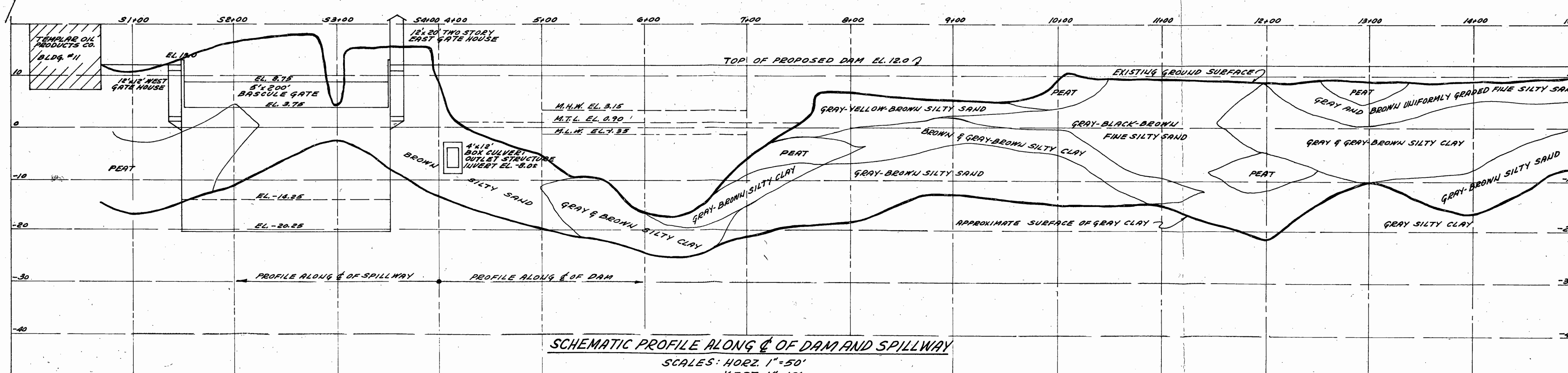
SOUTH RIVER TIDAL DAM SITE
SOIL BORINGS ℄ OF DAM
CONTRACT NO. WR-16 SHEET NO. 32 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



SCHEMATIC PLAN

SCALE: 1"=50'



SCHEMATIC PROFILE ALONG ℄ OF DAM AND SPILLWAY

SCALES: HORZ. 1"=50'
VERT. 1"=10'

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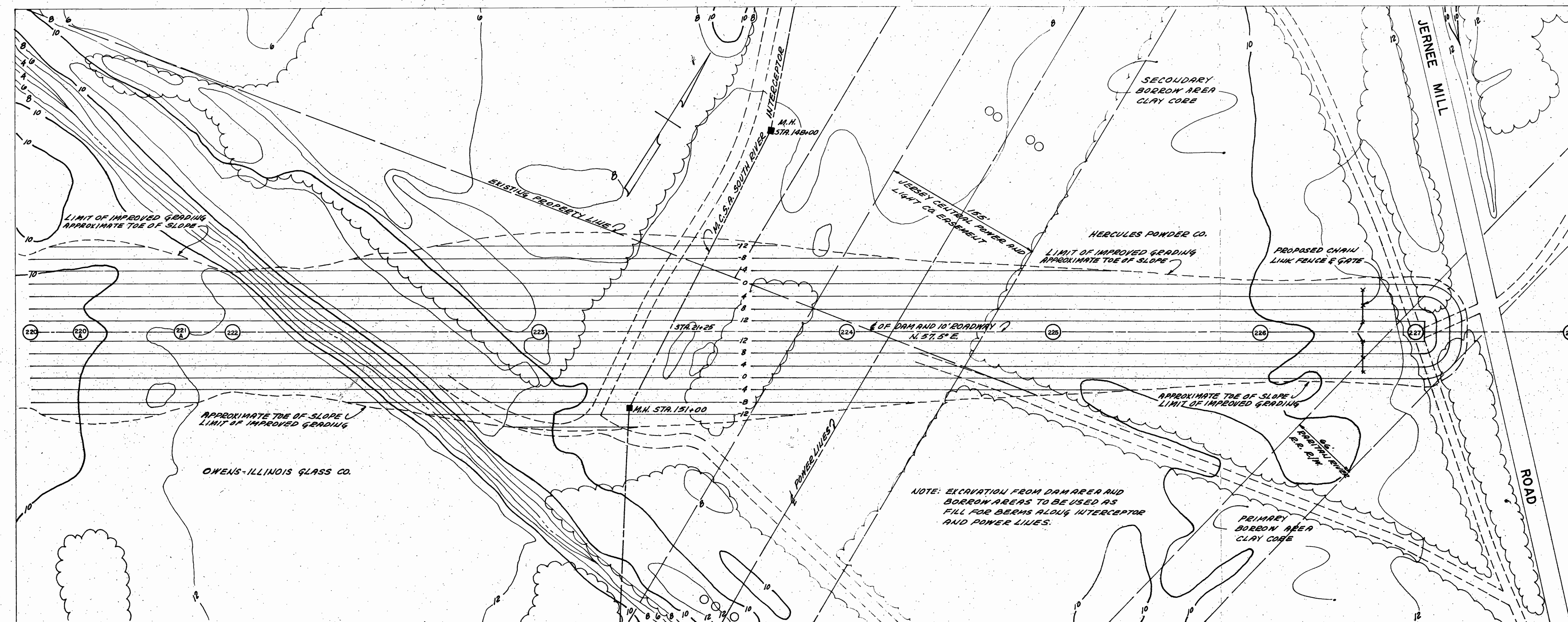
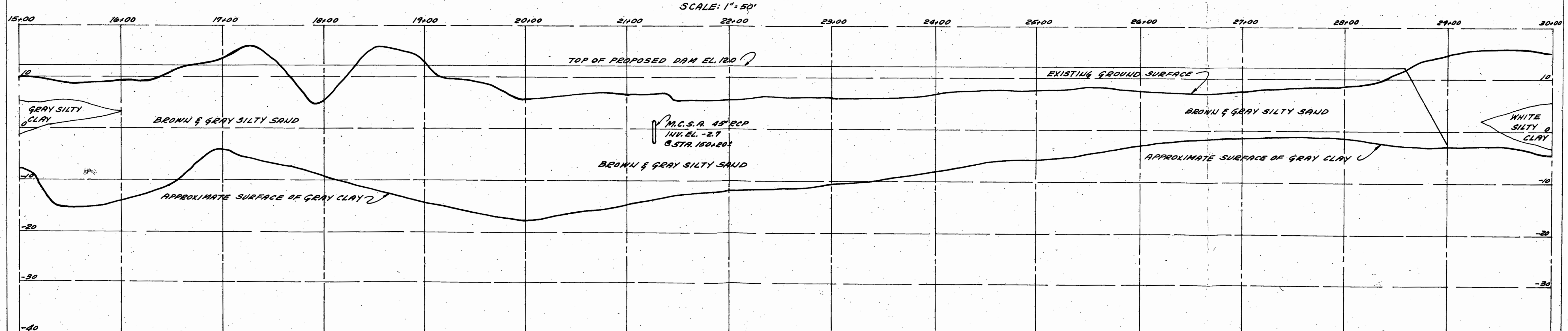
NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

SOUTH RIVER TIDAL DAM SITE
SCHEMATIC PLAN AND PROFILE OF DAM
CONTRACT NO. WR-16 SHEET NO. 33 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



SCHEMATIC PLAN
SCALE: 1" = 50'



SCHEMATIC PROFILE ALONG ℄ OF DAM
SCALES: HORZ. 1" = 50'
VERT. 1" = 10'

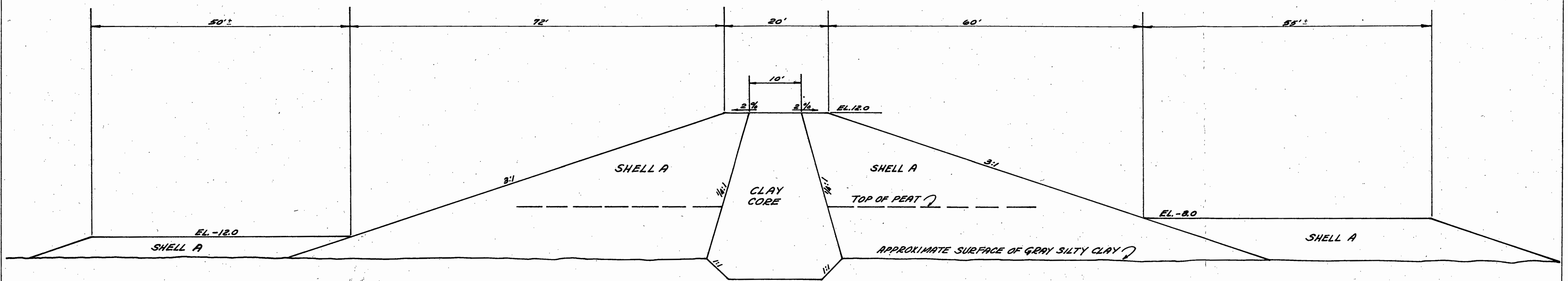
CHARLES J. KUPPER
CONSULTING ENGINEER
NEW MARKET, N.J.

REVISIONS

NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

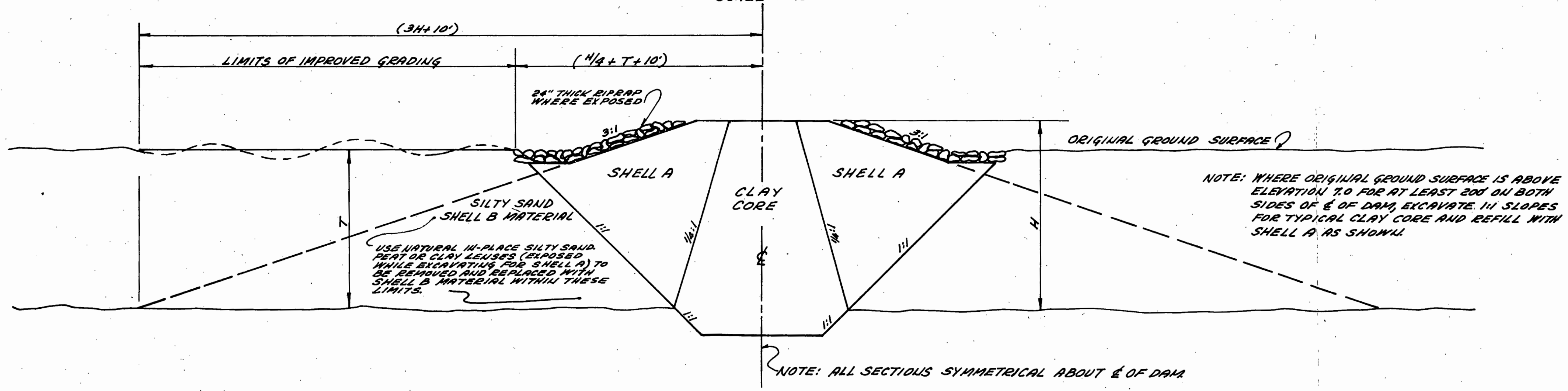
SOUTH RIVER TIDAL DAM SITE
SCHEMATIC PLAN AND PROFILE OF DAM
CONTRACT NO. WR-16 SHEET NO. 34 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



TYPICAL CROSS-SECTION OF EARTH DAM FROM STATION 3+50 TO STATION 16+50

SCALE: 1"=10'



TYPICAL CROSS-SECTION OF EARTH DAM FROM STATION 16+50 TO STATION 28+50

SCALE: 1"=10'

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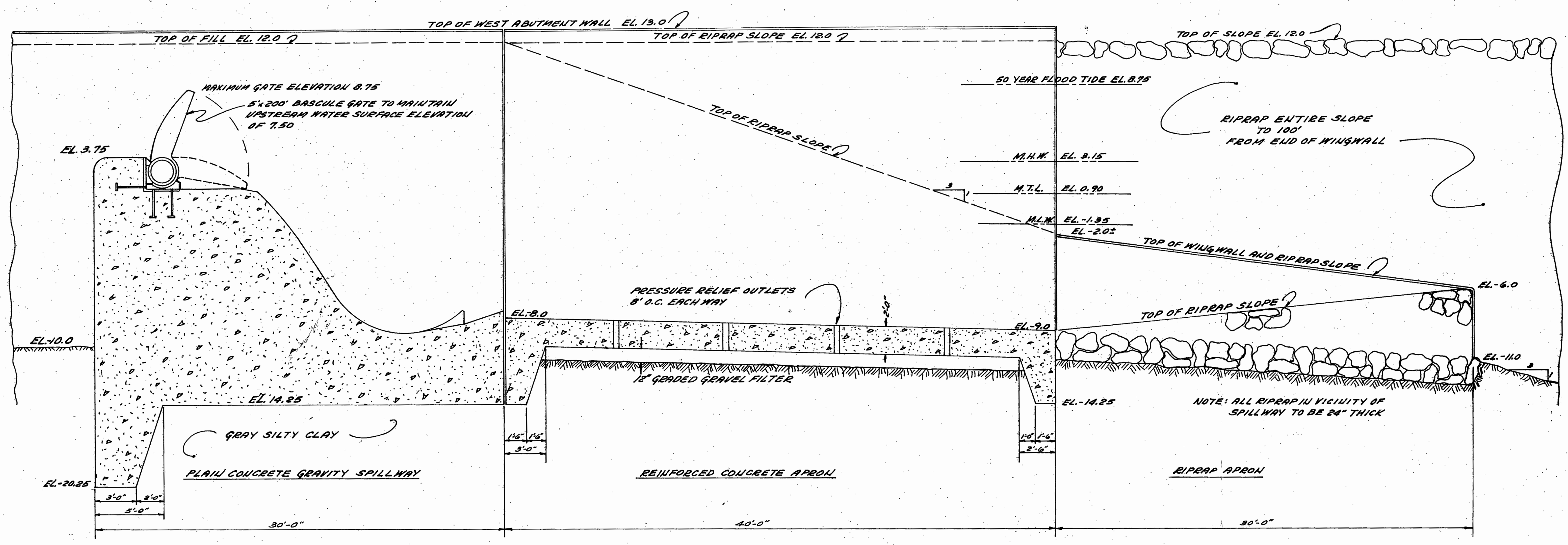
REVISIONS

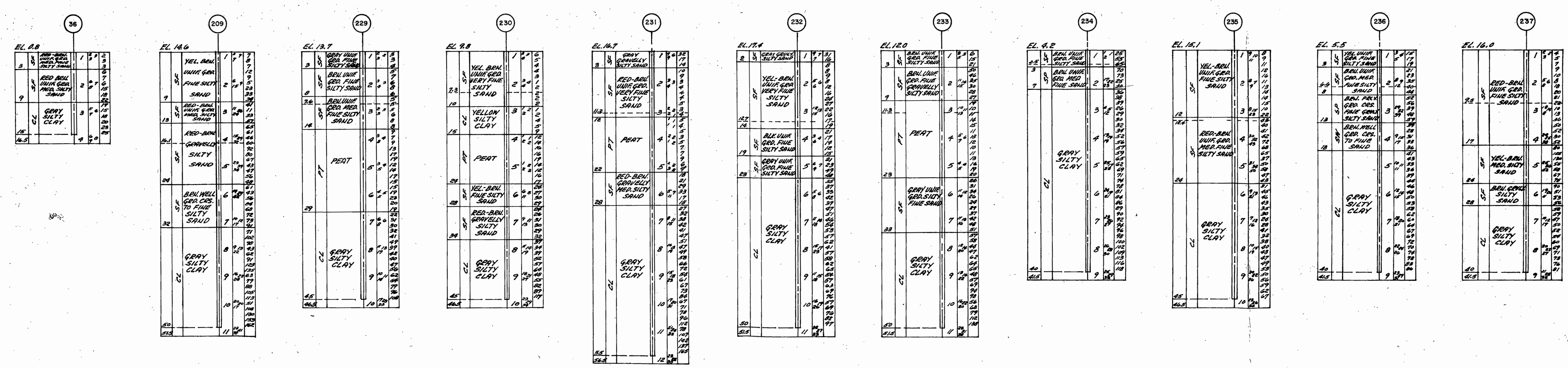
NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

SOUTH RIVER TIDAL DAM SITE
TYPICAL CROSS-SECTION OF EARTH DAM
CONTRACT NO. WR-16 SHEET NO. 35 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



TYPICAL CROSS-SECTION OF SPILLWAY
SCALE: 1/4"=1'-0"



BORINGS ALONG SPILLWAY

CHARLES J. KUPPER
CONSULTING ENGINEER
NEW MARKET, N.J.

REVISIONS								
NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

SOUTH RIVER TIDAL DAM SITE
TYPICAL CROSS-SECTION OF SPILLWAY
CONTRACT NO. WR-16 SHEET NO. 36 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

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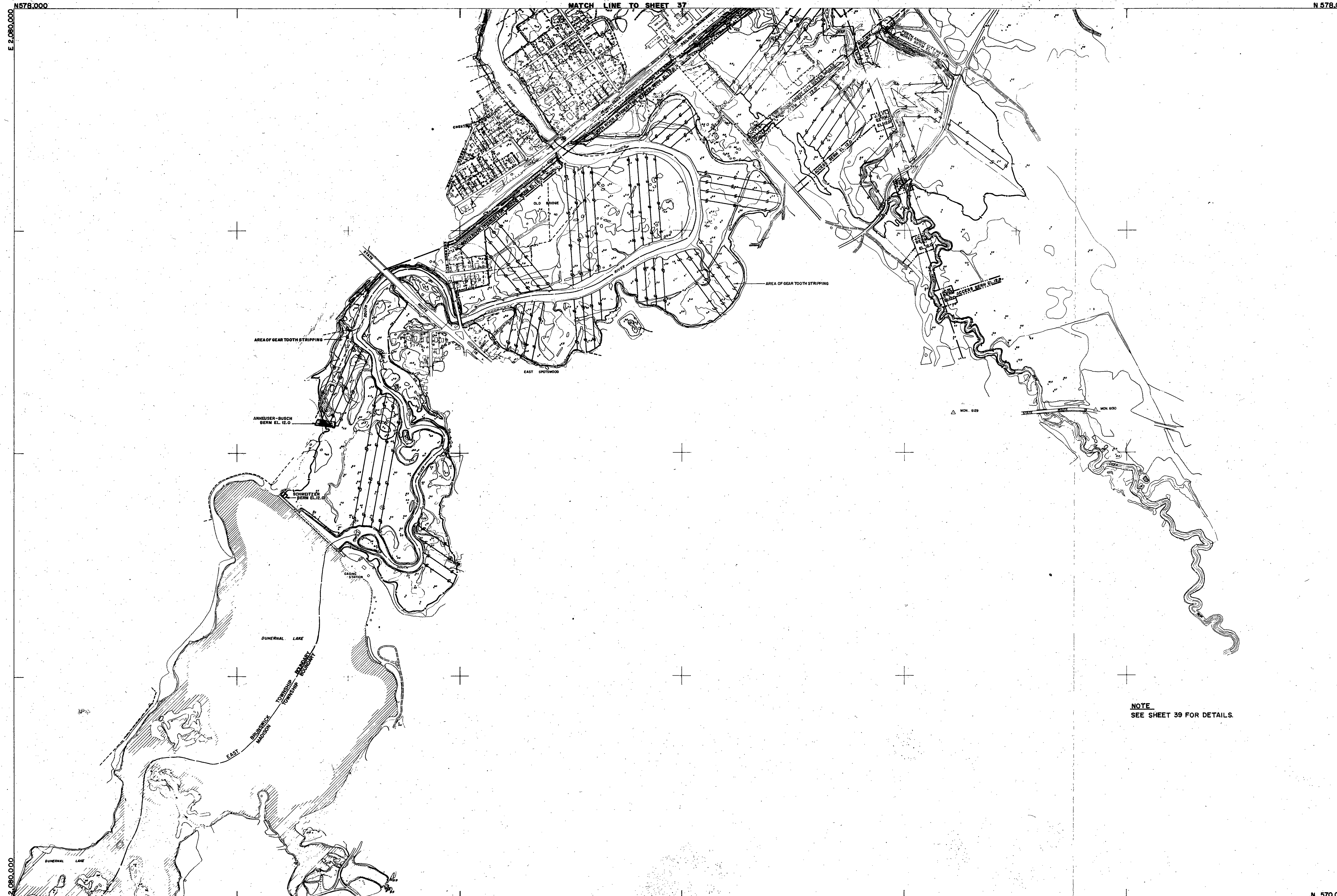
CONSULTING ENGINEER
NEW MARKET, N.J.

400 200 0 400 800 1200 1600
SCALE 1" = 400'
CONTOUR INTERVAL 4'

REVISIONS								
NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

SOUTH RIVER TIDAL DAM SITE
EARTHWORK AND UTILITIES
CONTRACT NO. WR-16 SHEET NO. 37 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY



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PITTSBURGH, PA.
L 772

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CONSULTING ENGINEER
NEW MARKET, N.J.

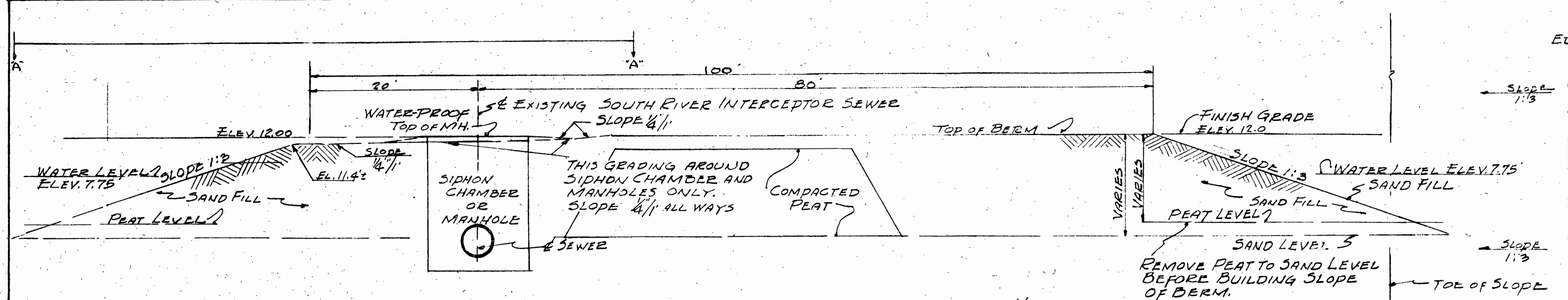
SCALE 1" = 400' — 400 200 0 400 800 1200 1600 — CONTOUR INTERVAL 4'

REVISIONS

NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION

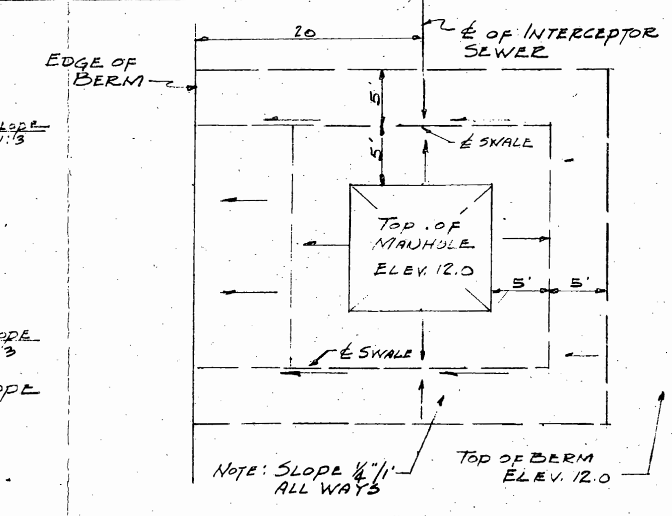
SOUTH RIVER TIDAL DAM SITE
EARTHWORK AND UTILITIES
CONTRACT NO. WR-16 SHEET NO. 38 OF 39

STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF WATER POLICY AND SUPPLY

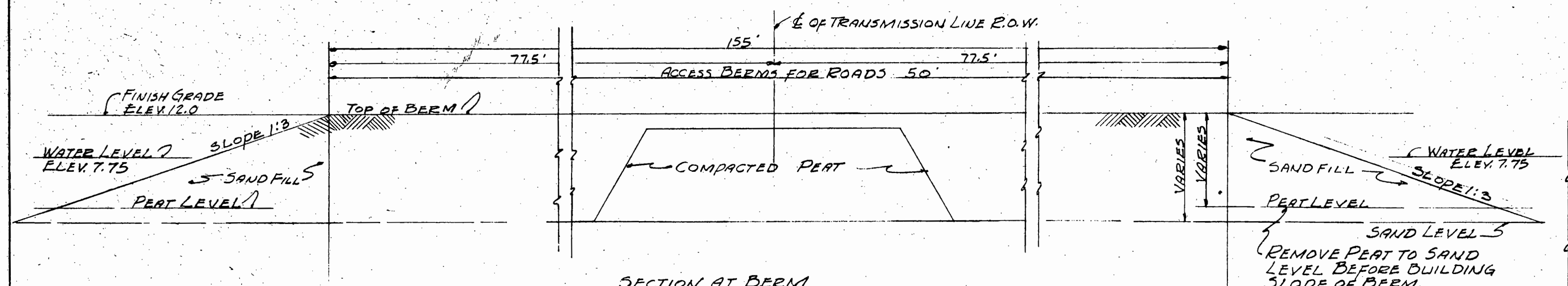


SECTION AT BERM
SOUTH RIVER INTERCEPTOR SEWER
SCALE 1/8"=1'-0"

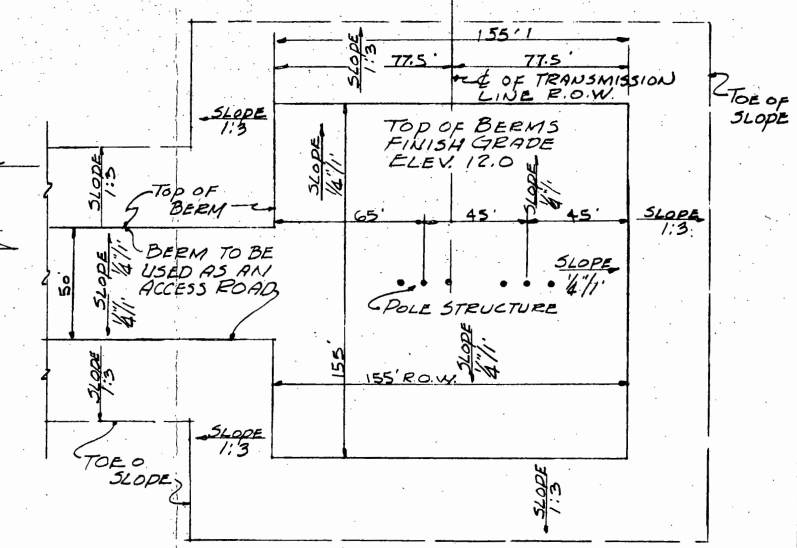
NOTE
1. USE SAME SECTION FOR NATIONAL LEAD CO. CONNECTION LINE TO S.R.I.S.
2. USE SAME SECTION FOR PERTH AMBOY CITY WATER WORKS SUCTION LINES AND WELLS.



PLAN "A" - GRADING AT
SIPHON CHAMBERS AND MANHOLES
SCALE 1/8"=1'

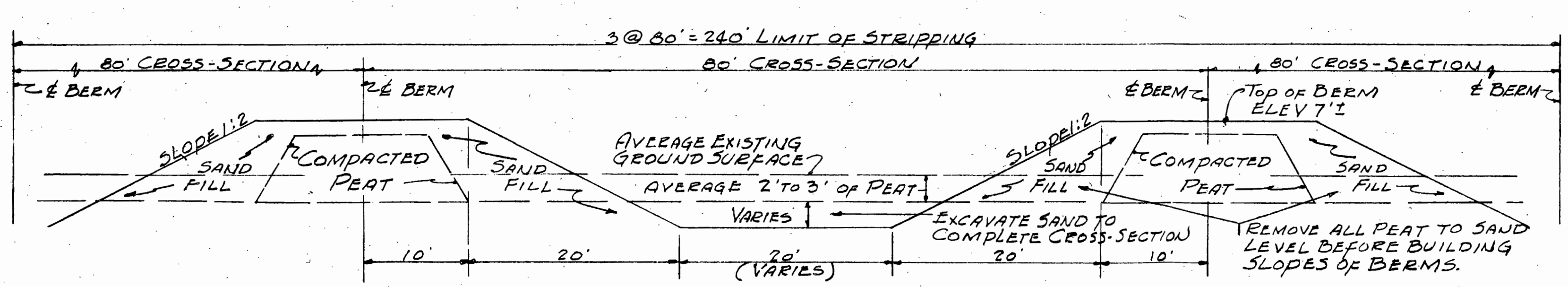


SECTION AT BERM
POWER TRANSMISSION LINES POLE STRUCTURES
AND ACCESS BERMS
SCALE 1/8"=1'-0"

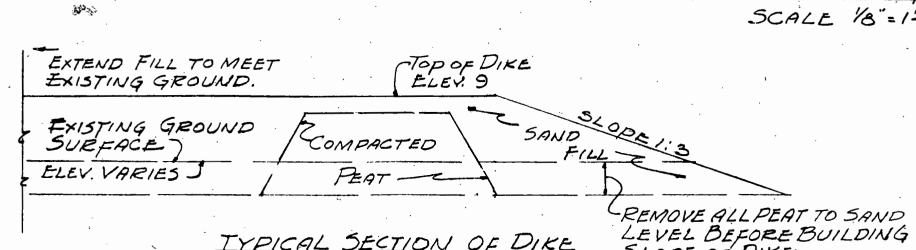


PLAN SHOWING GRADING OF BERM AT
POLE STRUCTURE LOCATIONS AND ACCESS
BERMS FOR POWER TRANSMISSION LINES.
SCALE 1"=40'

NOTE: SEE SHEETS 8, 9, 37 AND 38 FOR LOCATION



TYPICAL CROSS-SECTION
GEAR TOOTH STRIPPING
SCALE 1/8"=1'-0"



TYPICAL SECTION OF DIKE
TO PROTECT LOW LYING AREAS
SCALE 1/8"=1'-0"

NO.	DATE	DESCRIPTION	CHKD.	APPRD.

REVISIONS

DESIGNED ____ CHECKED ____
DRAWN ____ APPROVED ____
TRACED ____

SOUTH RIVER TIDAL DAM SITE
MIDDLESEX COUNTY NEW JERSEY

TYPICAL EARTHWORK CROSS-SECTIONS

SCALE: AS NOTED DATE: SEPT. 1963

CHARLES J. KUPPER
REG. PROF. ENGR. NO. 1556
15 STELTON ROAD NEW MARKET, N.J.

CONTRACT NO. WR-16 SHEET NO. 39 OF 39

PART III

LAND ACQUISITION REPORT

SOUTH RIVER TIDAL DAM PROJECT

PREPARED BY

DIVISION OF WATER POLICY AND SUPPLY

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT

STATE OF NEW JERSEY

January 1965

PART III

LAND ACQUISITION

Introduction

This section presents an estimate of cost and extent of land required for the South River Tidal Dam Project. A more detailed description of the area and costs involved are given here to amplify the lump sum of one million dollars given in Part II as "real estate and dikes."

The acquisition of lands will be conducted as an administrative function of the Department of Conservation and Economic Development in conformance with policies adopted and procedures followed for the acquisition of the Round Valley and Spruce Run Reservoir properties wherein, when practicable, partial taking of properties required in part for the project will be considered during acquisition negotiations.

The over-all taking line will be defined by the flood high water contour line, Elevation 9.0 modified as indicated herein by the construction of protective works, where practicable and economical, to reduce the dislocations and displacements in adjoining built-up areas. The land to be acquired will include the areas required for the dam, road and utility relocations and protective works and the area to be flooded by the design flood as modified by protective works plus a strip of variable width around the recharge pond as determined to be equitable to the property owners involved. It will not and cannot under the real estate acquisition provisions of the Water Supply Act of 1958 include lands required specifically for the development of a series of wells around the recharge pond discussed and recommended in this report as an alternate method for utilizing the recharge potentials of this project.

The tentative taking area was determined after consideration of the above-mentioned factors, on an accurate, large scale, 2-foot contour topographic map on which the properties involved are designated for use in negotiating acquisition of the required lands and in determining in consultation with local officials, the extent of protective works for adjoining built-up areas. A list of the designated properties was prepared by Robert J. Baier, Land Surveyor, as subcontractor for Charles J. Kupper, Consulting Engineer, for such acquisition negotiations. The land and improvement values estimated herein were ascertained from municipal tax records by personnel of the Division.

Authority

The necessity for research, planning and acquiring reservoir sites in advance of the actual development is recognized in the Water Supply Act of 1958 wherein under Section 4 (d) thereof, $3,000,000 of the State Water Development Bonds authorized by referendum approval of the 1958 Water Bond Act are allocated for that purpose within the Raritan-Millstone watershed, subject to prior approval of any specified acquisition by the Legislature. Thus, funds are available, subject to the approval as aforesaid, for the immediate acquisition of the lands, including riparian grants and leases, required for the proposed tidal dam and recharge pond, estimated herein to approximate $480,000 including costs of acquisition but excluding cost of riparian rights. The estimated cost of $450,000 for protective works of adjoining lands not recommended for acquisition, such as dikes, fills, storm drain relocations, local storm water drainage pumping stations, etc., is a construction cost item to be included in funds authorized for the development of this project by specific legislation.

Whereas, not specified in the Water Supply Act of 1958, it is to be anticipated that provisions for annual payments in lieu of taxes would be incorporated in legislation authorizing the acquisition of these lands in conformance with the requirements specified therefor in Chapter 60, P. L. 1956 and Chapter 33, P. L. 1958 authorizing the acquisition of the Round Valley and Spruce Run Reservoir properties respectively.

Under the provisions of Section 10 of the Water Supply Act of 1958, all bond indebtedness incurred by the use of State Water Development Bond funds in the acquisition of these lands, including tax lieu payments if authorized, would have to be reimbursed to the State within the period of said bond issue from sale of water developed by the project unless provisions are incorporated in the legislation authorizing the development of this project for reimbursement of such indebtedness from construction funds authorized for such development.

Description of Basin

The proposed dam is to be located 1600 feet downstream on South River from the confluence with Tennent Brook. The area of the lake formed at the 9-foot Contour is about 490 acres and lies within the Boroughs of Sayreville and South River and the Townships of East Brunswick and Madison. Other municipalities within the 124.7-square mile drainage basin are Monroe Township, the Boroughs of Jamesburg, Helmetta and Spotswood in Middlesex County, and Manalapan, Marlboro, Freehold and Millstone Townships, and the Borough of Freehold in Monmouth County.

Relatively flat to rolling terrain characterizes the topography of the basin.

Built up areas in Sayreville, East Brunswick, and Madison lie within the flood plain of the river and have been subjected to several floods.

Protection by Dikes and Fill

It is proposed to construct dikes and/or fill to above the flood high water contour 9.0 to protect the above mentioned built up areas. This would provide protection of considerable value when measured by damage experienced in the past.

Property Required

Land to be acquired lies primarily in the flood plain of the easterly bank of the South River consisting mostly of swampy areas of Tennent Brook and Deep Run.

The acreage required is as follows:

Borough of Sayreville	116
Borough of South River	15
East Brunswick Township	96
Madison Township	155
Total	382 Acres

Property improvements to be acquired lie in the Borough of South River having a value of approximately $18,500.

Summary of Costs

1. Property to be purchased:

	Assessed Value	Estimated True Value
Sayreville	$ 21,965	$ 108,000
South River	8,880	18,150
East Brunswick	32,255	142,000
Madison	28,426	169,000
Total	$ 91,526	$ 437,150

2. Property value to be protected by dikes/fill:

Sayreville	$ 98,550	$ 468,000
East Brunswick	105,160	463,000
Madison	37,300	221,000
Total	$ 241,010	$ 1,152,000

3. Estimated cost of dikes/fill

		Estimated Cost
5500 lin. feet of dike		$ 72,500
5000 cu. yds. fill		4,500
	Total	$ 77,000

Additional Charges:

Storm drain relocation)		
Pump stations)		373,000
Property-dike location)		
	Total	$ 450,000

From the above, the estimated cost of land acquisition:		$ 437,150
Cost of acquisition		42,850
Estimated cost of dikes/fill		450,000
	Total Cost	$ 930,000

Value of property protected by dikes/fill is estimated at $1,152,000 which is to be protected at a cost of 39 percent of that value.

PART IV

REPORT
On
DIGITAL COMPUTER AQUIFER MODEL ANALYSIS
Of The
EXTENT AND CHARACTER OF BENEFITS
From
SOUTH RIVER TIDAL DAM PROJECT

Prepared by

Division of Water Policy and Supply

Department of Conservation and Economic Development

State of New Jersey

In Cooperation With

Ground Water Branch, Water Resources Division

U. S. Geological Survey

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PART IV

DIGITAL COMPUTER - OLD BRIDGE AQUIFER MODEL ANALYSIS

INTRODUCTION

With the construction of a dam to impound surface water which is to be used directly as a water supply, it is quite evident as to what the benefit is and who are the beneficiaries. However, a tidal dam and the impoundment of water for ground-water aquifer recharge presents a unique situation. We cannot determine readily who benefits from it, nor to what extent.

We do know that a barrier may be built to prevent the brackish water in the tidal South River from infiltrating into the Old Bridge Sand, there being a certain degree of hydraulic continuity between the aquifer and the river. It is therefore evident that as a salt-water barrier protecting this aquifer from intrusion, the dam would be beneficial to all present and future users of ground water from the aquifer.

In reference to ground-water recharge, the problem is to determine the nature and magnitude of the benefits and who the beneficiaries are in ascertaining who should help pay for the construction of the South River Tidal Dam.

The Division of Water Policy and Supply has been engaged for many years in a statewide program of ground-water investigations in cooperation with the Ground Water Branch of the U. S. Geological Survey. As part of this program, a digital computer aquifer model analysis of the Old Bridge Sand member of the Raritan Formation has been made. The results of this

analysis will be published in the near future by the Hydraulics Division, American Society of Civil Engineers, in a paper entitled "Ground-Water Models Solved by Finite-Difference Digital-Computer Methods," by Irwin Remson, Charles A. Appel, and Raymond A. Webster.

DESCRIPTION OF AQUIFER MODEL

In ground-water hydrologic studies, the U. S. Geological Survey has used several methods of analyzing aquifers. Two of these methods were considered for the present study. One of these would be the use of an electric analog model which consists of electrical components simulating aquifer characteristics. These models are developed by the Survey in Arizona. The other method, which was the method used in this study, consists of assembling aquifer data on punch cards, and running the cards through a digital electronic computer programmed especially for this study. The availability of a number of computers in this area capable of handling this program, influenced the selection of this method for the analysis of this problem. The accuracy of results from both methods are comparable.

The location of the points of Old Bridge aquifer withdrawals and the pond created by the dam were indicated in a 50 x 50 grid system laid on a map of this study area. Aquifer characteristics and pumpage data where known and where applicable, were programmed into the computer for the corresponding nodes of the grid system.

An analysis was made of the water levels in the aquifer under two conditions: First, under the estimated conditions that existed in 1962; then, under the conditions that would exist after the pond is developed behind

the proposed dam, assuming the same distribution of pumpage used in the previous case.

RESULTS OF THE COMPUTER ANALYSIS

Figure 1 shows estimated average water levels relative to mean sea level in the Old Bridge Sand without the proposed surface-water reservoir. Figure 2 shows estimated water levels with the impoundment reservoir. The water levels were predicted by digital-computer analyses of mathematical models of the aquifer. The distribution and average intensity of pumpage that occurred in 1962 was used in determining these water levels.

If the models duplicated aquifer conditions exactly, Figures 1 and 2 would be exact solutions. However, adequate data are not available in all parts of the Old Bridge Sand to prepare such exact models. For example, little information was available for truly accurate estimates of water levels along parts of the boundary of the area. Fortunately, these inaccuracies have little effect on the validity of the results for two reasons:

1. Better data are available in the most critical parts of the aquifer, along the South River.

2. Prime interest is not in the absolute values of the water levels. It is in the changes in water levels resulting from the tidal dam and the impoundment reservoir. As long as the models (with and without the reservoir) are consistent, the effects of the dam may be simulated fairly accurately regardless of relatively minor inaccuracies in other parts of the models.

The water levels of some of the wells in Figure 1 are below those of nearby surface-water bodies. Such wells are deriving substantial discharge from these surface-water bodies. If pumping is increased, water levels will decline further in these areas, and greater volumes of water will be derived from surface water. Obviously, it will be a prime function of the tidal salt-water barrier to guarantee the freshness of these surface-water bodies and of the ground water derived from them.

Comparison of Figures 1 and 2 shows the effect of the proposed reservoir on ground-water levels. The 5-foot contour (dotted) illustrates this effect most clearly. Water levels are below (enclosed by) the 5-foot contour over a much larger area in Figure 1 than in Figure 2. This is essentially the area over which water levels will be raised by the proposed reservoir.

Figures 1 and 2 show the water-level rises that are to be expected from the reservoir under present pumping rates. These are the minimum benefits to be expected. The model showing present conditions was based upon the assumption that the surface-water bodies are supplying all of the ground-water demands on them. This requires that there be complete hydraulic continuity between the surface-water bodies and the aquifer which is not the case at present. Site preparation during construction of the reservoir is proposed to provide much greater degree of hydraulic continuity than presently exists. Although the model with the reservoir simply raised water levels in the recharging surface-water bodies from 0.0 feet to 7.5 feet above mean sea level, water levels in heavily-pumped areas have been raised more than 7.5 feet. For example, the water level in one of the wells in the Perth Amboy well field was raised from -4.5 feet to +7.5 feet.

The areal extent of this benefit, predicted by the analysis using existing ground-water discharges (diversion), is from near the impoundment to about 5 miles from the proposed dam site, mainly down-dip (southeasterly) with the Old Bridge aquifer, which coincides with the area of influence.

Table 1 shows the change in water levels with the reservoir and the distance of discharge from the dam site.

TABLE 1

No.***	Owner	Distance from Dam Site, Mi.	Average plus change in Level****	1962 Discharge Rate per Node, MGD
115	Geo. Helme Co.	5.30	0.10	0.023
120	Spotswood Water Co.	3.30	0	0.220
11	P. J. Schweitzer Co.	2.50	0.60	2.828
100	Duhernal System	2.00	0.34 *	4.670
114	Anheuser Busch	2.00	2.20	0.761
1	Perth Amboy Water Dept.	1.20	5.70 **	0.910
29	Sayreville Borough	1.40	0.20	1.824
41	Browntown Water Co.	4.00	0.10	0.504
6	South Amboy	5.00	0	0.953

* Average of 3 nodes used to represent well field.
** Average of 8 nodes used to represent well field.
*** Indicated on map, Figure 3.
**** Average change in water level at node or nodes used in analysis.

Consider the effects of increased ground-water discharge without the proposed reservoir. The water levels in Figure 1 would continue to decline as pumping increased. Increased ground-water demands would induce greater amounts of water from the nearby surface-water bodies which presently contain salty water. Thus, the greatest benefit of the proposed reservoir is that it would permit increased ground-water discharge of fresh water.

It has been pointed out by Remson and Appel in an administrative report prepared for the Division that under present or increased pumping rates, it is only a matter of time before a large portion of the Farrington Sand becomes saline and that any additional economic development will require additional sources of water. Thus, the additional water available from the proposed reservoir could be used for the reclamation of the Farrington Sand as well as for the protection of the Old Bridge Sand.

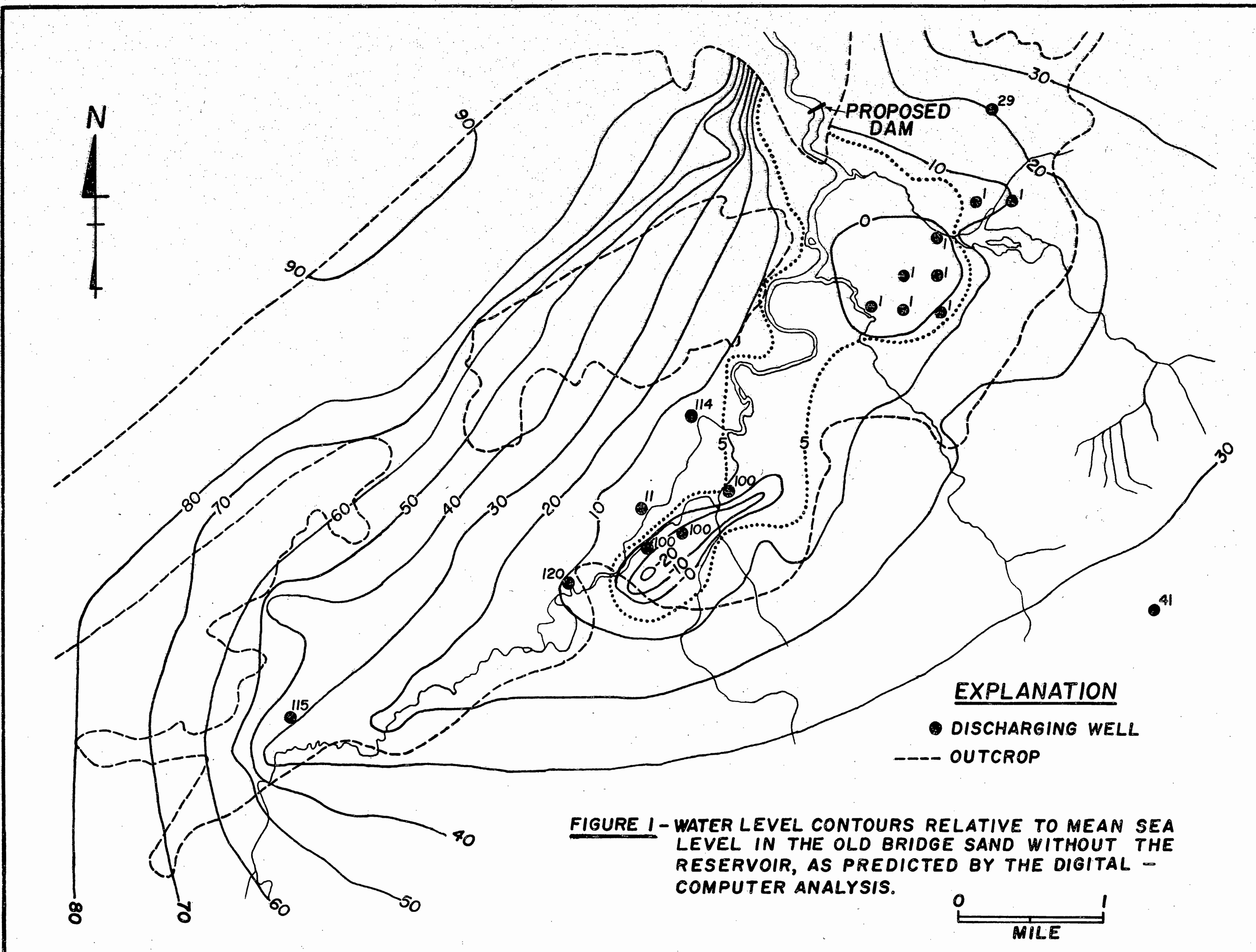
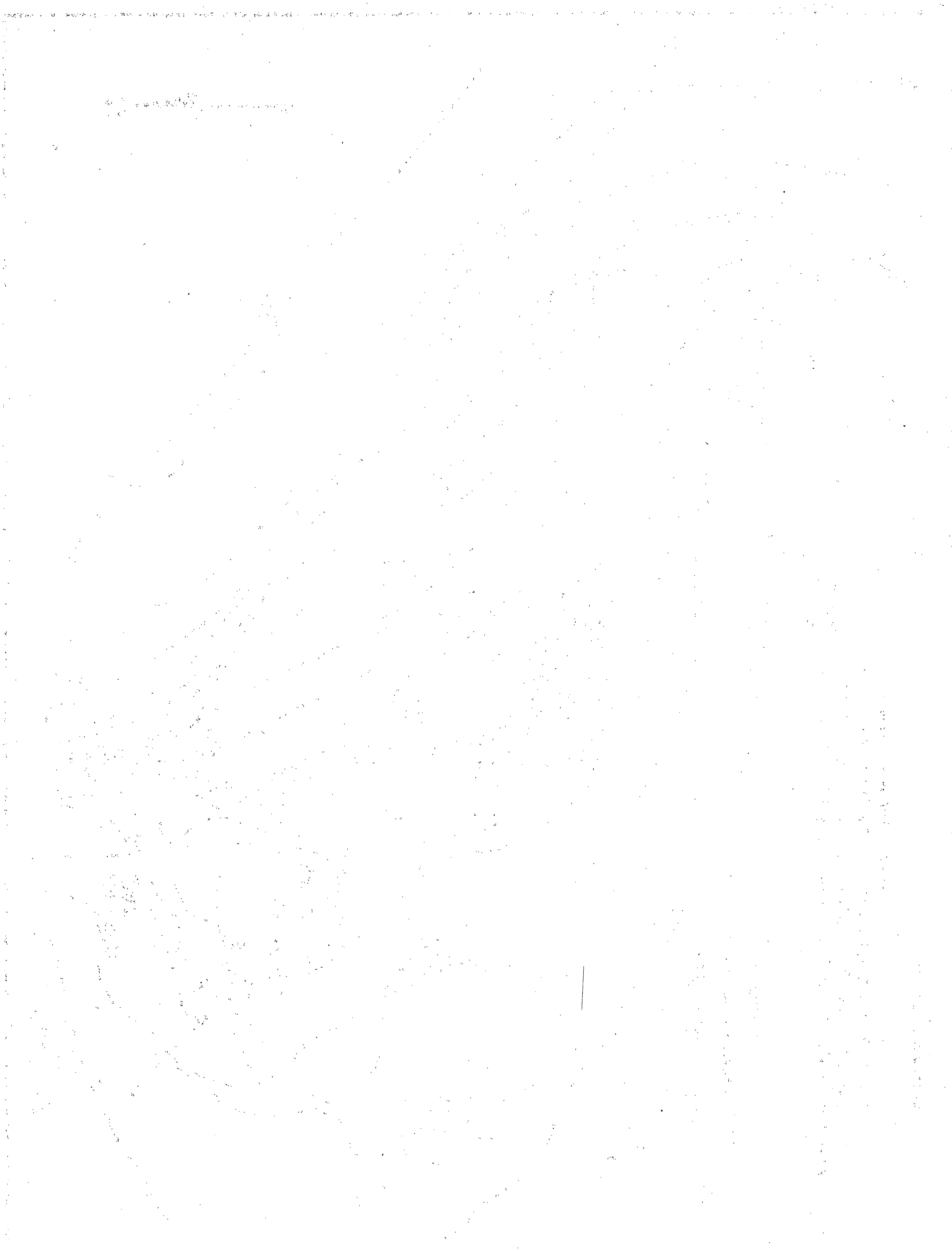


FIGURE 1 - WATER LEVEL CONTOURS RELATIVE TO MEAN SEA LEVEL IN THE OLD BRIDGE SAND WITHOUT THE RESERVOIR, AS PREDICTED BY THE DIGITAL - COMPUTER ANALYSIS.

FIGURE-1



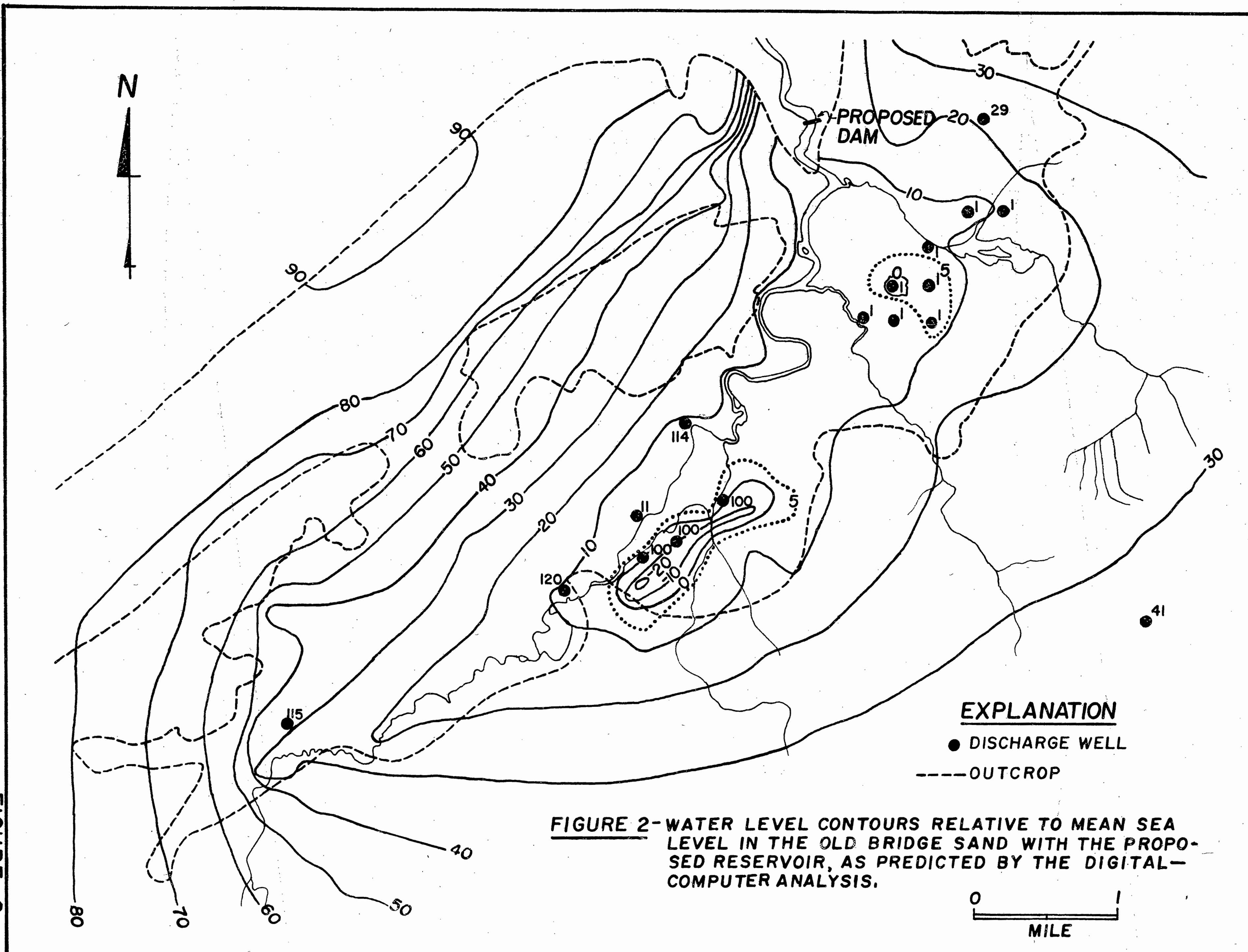


FIGURE 2- WATER LEVEL CONTOURS RELATIVE TO MEAN SEA LEVEL IN THE OLD BRIDGE SAND WITH THE PROPOSED RESERVOIR, AS PREDICTED BY THE DIGITAL-COMPUTER ANALYSIS.

FIGURE-2

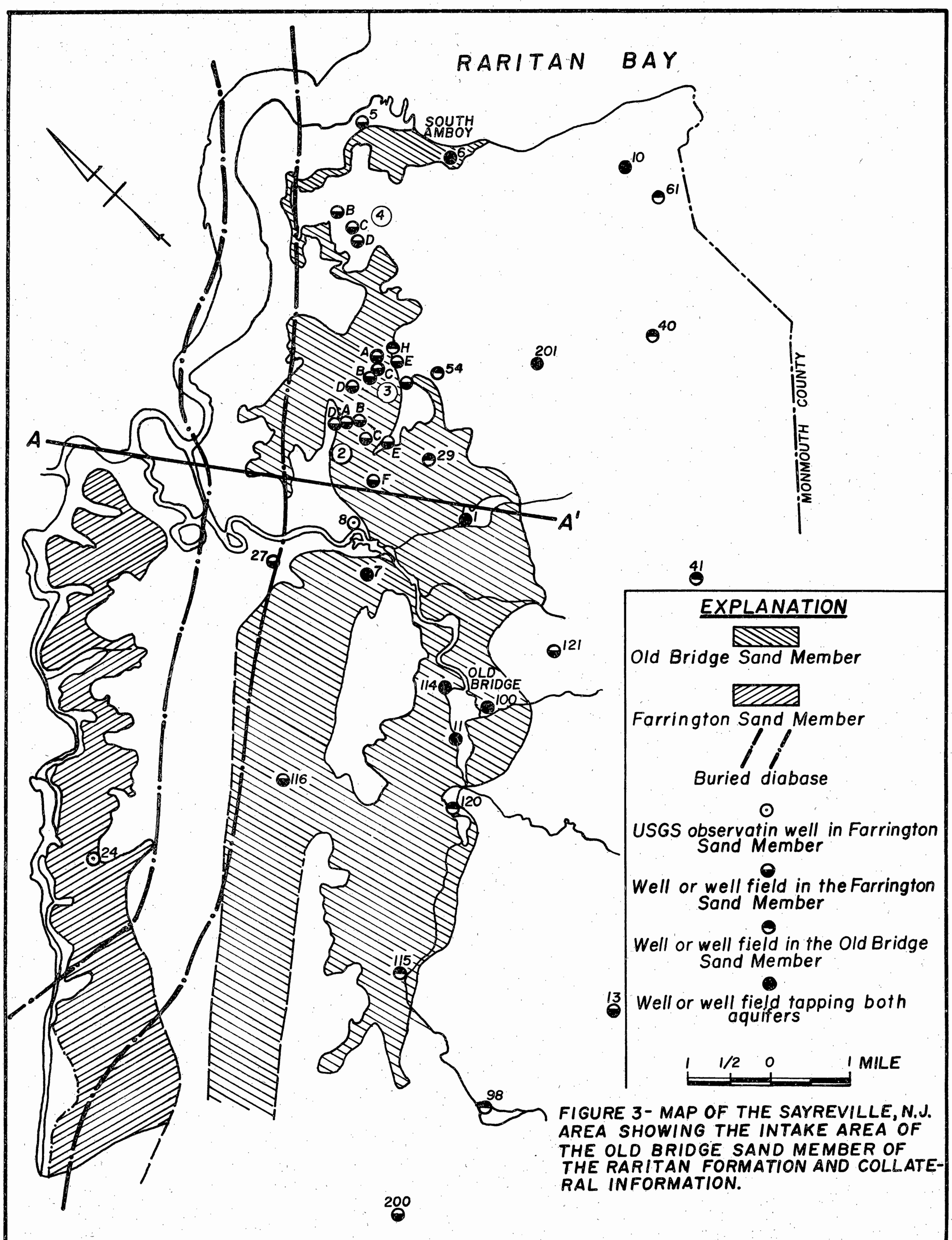


FIGURE 3- MAP OF THE SAYREVILLE, N.J. AREA SHOWING THE INTAKE AREA OF THE OLD BRIDGE SAND MEMBER OF THE RARITAN FORMATION AND COLLATERAL INFORMATION.